STANDARD SPECIFICATIONS

STATE OF CALIFORNIA

BUSINESS, TRANSPORTATION AND HOUSING AGENCY

DEPARTMENT OF TRANSPORTATION

MAY 2006

ISSUED BY

DEPARTMENT OF TRANSPORTATION

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STATE OF CALIFORNIA

DEPARTMENT OF TRANSPORTATION

STANDARD SPECIFICATIONS

GENERAL PROVISIONS

SECTION 1: DEFINITIONS AND TERMS

1-1.01 GENERAL

- Unless the context otherwise requires, wherever in the specifications and other contract documents the following abbreviations and terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as provided in this Section One.
- Working titles having a masculine gender, such as "workman" and "journeyman" and the pronoun "he", are utilized in the specifications for the sake of brevity, and are intended to refer to persons of either gender.

1-1.02 ABBREVIATIONS

AAN	American Association of Nurserymen.
AASHTO	American Association of State Highway and Transportation Officials.
AISC	American Institute of Steel Construction.
AISI	American Iron and Steel Institute.
ANSI	American National Standards Institute.
APHA	American Public Health Association.
API	American Petroleum Institute.
AREMA	American Railway Engineering and Maintenance-of-Way Association.
ASME	American Society of Mechanical Engineers.
ASTM	American Society for Testing and Materials.
AWG	American Wire Gage.
AWPA	American Wood-Preservers' Association.
AWS	American Welding Society.
AWWA	American Water Works Association.
EIA	Electronic Industries Association.
IEEE	Institute of Electrical and Electronics Engineers.
NEMA	National Electrical Manufacturers Association.
UL	Underwriters' Laboratories Inc.

UNITS OF MEASUREMENT

Some of the symbols for U. S. Customary units of measurement used in the specifications and in the Engineer's Estimate are defined as follows:

Symbols as used in the Specifications	Symbols as used in the Engineer's Estimate	Definitions
A	—	amperes
	ACRE	acre
	CF	cubic foot
	CY	cubic yard
—	EA	each
g	—	gram
ksi	—	kips per square inch
	GAL	gallon
h	H	hour
	LB	pound
—	LS	lump sum
	LF	linear foot
	LNMI	lane mile
	MFBM	thousand foot board measure
	MI	mile
	MSYD	thousand station yard
Ω	—	ohm
pcf	—	pounds per cubic foot
s	—	second
	STA	100 feet
	SQFT	square foot
	SQYD	square yard
	TAB	tablet
ton	TON	2,000 pounds
W	—	watt
V	—	volt

1-1.03 ACCEPTANCE

The formal written acceptance by the Director of Transportation of an entire contract which has been completed in all respects in accordance with the plans and specifications and any modifications thereof previously approved.

1-1.04 (BLANK)

1-1.05 BASE

A layer of specified material of planned thickness placed immediately below the pavement or surfacing.

1-1.06 BASEMENT MATERIAL

The material in excavation or embankments underlying the lowest layer of subbase, base, pavement, surfacing or other specified layer which is to be placed.

1-1.07 BIDDER

- Any individual, firm, partnership, corporation, or combination thereof, submitting a proposal for the work contemplated, acting directly or through a duly authorized representative.

1-1.08 BRIDGE

- Any structure, with a bridge number, which carries a utility facility, or railroad, highway, pedestrian or other traffic, over a water course or over or under or around any obstruction.

1-1.085 CONDUIT

- A pipe or tube in which smaller pipes, tubes or electrical conductors are inserted or are to be inserted.

1-1.09 CONTRACT

- The written agreement covering the performance of the work and the furnishing of labor, materials, tools and equipment in the construction of the work. The contract shall include the notice to contractors, proposal, plans, specifications, special provisions and contract bonds; also any and all supplemental agreements amending or extending the work contemplated and which may be required to complete the work in a substantial and acceptable manner. Supplemental agreements are written agreements covering alterations, amendments or extensions to the contract and include contract change orders.

1-1.10 CONTRACTOR

- The person or persons, firm, partnership, corporation, or combination thereof, private or municipal, who have entered into a contract with the Department of Transportation, as party or parties of the second part or their legal representatives.

1-1.11 CULVERT

- Any structure, other than a bridge, which provides an opening under a roadway for drainage or other purposes.

1-1.12 DAYS

- Unless otherwise designated, days as used in the specifications will be understood to mean calendar days.

1-1.13 DEPARTMENT

- The Department of Transportation of the State of California, as created by law.

1-1.14 DETOUR

- A temporary route for traffic around a closed portion of a road.

1-1.15 DIRECTOR

- The executive officer of the Department of Transportation, as created by law.

1-1.16 DIVIDED HIGHWAY

- A highway with separated traveled ways for traffic, generally in opposite directions.

1-1.17 (BLANK)

1-1.18 ENGINEER

- The Chief Engineer, Department of Transportation, acting either directly or through properly authorized agents, the agents acting within the scope of the particular duties delegated to them.

1-1.19 ENGINEER'S ESTIMATE

- The list of estimated quantities of work to be performed as contained in the "Proposal Form."

1-1.20 FEDERAL AGENCIES

- Whenever, in the specifications, reference is made to any Federal agency or officer, the reference shall be deemed made to any agency or officer succeeding in accordance with law to the powers, duties, jurisdiction and authority of the agency or officer mentioned.

1-1.21 FIXED COSTS

- Any necessary labor, material and equipment costs directly expended on the item or items under consideration which remain constant regardless of the quantity of the work done.

1-1.22 FRONTAGE ROAD

- A local street or road auxiliary to and located generally on the side of an arterial highway for service to abutting property and adjacent areas and for control of access.

1-1.23 GRADING PLANE

- The surface of the basement material upon which the lowest layer of subbase, base, pavement, surfacing or other specified layer is placed.

1-1.24 HIGHWAY

- The whole right of way or area which is reserved for and secured for use in constructing the roadway and its appurtenances.

1-1.25 LABORATORY

- The Division of Engineering Services - Materials Engineering and Testing Services and Division of Engineering Services - Geotechnical Services of the Department of Transportation, or established laboratories of the various Districts of the Department, or other laboratories authorized by the Department to test materials and work involved in the contract. When a reference is made in the specifications to the "Transportation Laboratory", the reference shall mean Division of Engineering Services - Materials Engineering and Testing Services and Division of Engineering Services - Geotechnical Services, located at 5900 Folsom Boulevard, Sacramento, CA 95819, Telephone (916) 227-7000.

1-1.255 LEGAL HOLIDAYS

- Those days designated as State holidays in the Government Code.

1-1.26 LIQUIDATED DAMAGES

- The amount prescribed in the specifications, pursuant to the authority of Public Contract Code Section 10226, to be paid to the State or to be deducted from any payments due or to become due the Contractor for each day's delay in completing the whole or any specified portion of the work beyond the time allowed in the specifications.

1-1.265 MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES

- The Manual on Uniform Traffic Control Devices for Streets and Highways, 2003 Edition (MUTCD) is administered by the Federal Highway Administration.

1-1.266 MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES CALIFORNIA SUPPLEMENT

- The MUTCD 2003 California Supplement (MUTCD California Supplement) is issued by the Department of Transportation to provide amendments to the MUTCD. The MUTCD and MUTCD California Supplement supersede the Department's Manual of Traffic Controls.

1-1.27 MEDIAN

- That portion of a divided highway separating the traveled ways for traffic in opposite directions including inside shoulders.

1-1.275 OFFICES OF STRUCTURE DESIGN

- The Offices of Structure Design of the Department of Transportation. When the specifications require working drawings to be submitted to the Offices of Structure Design, the drawings shall be submitted to: Offices of Structure Design, Documents Unit, Mail Station 9-4/4I, 1801 30th Street, Sacramento, CA 95816, Telephone (916) 227-8252.

1-1.28 PAVEMENT

- The uppermost layer of material placed on the traveled way or shoulders. This term is used interchangeably with surfacing.

1-1.29 PLANS

- The official project plans and Standard Plans, profiles, typical cross sections, working drawings and supplemental drawings, or reproductions thereof, approved by the Engineer, which show the location, character, dimensions and details of the work to be performed. These documents are to be considered as a part of the plans.
- In the above definition, the following terms are defined as follows:

Standard Plans

- The Standard Plans issued by the Department of Transportation.

Project Plans

- The project plans are specific details and dimensions peculiar to the work and are supplemented by the Standard Plans insofar as the same may apply.

1-1.30 PROCESSING

- Any operation or operations of whatever nature and extent required to produce a specified material.

1-1.31 PROPOSAL

- The offer of the bidder for the work when made out and submitted on the prescribed proposal form, properly signed and guaranteed.

1-1.32 PROPOSAL FORM

- The approved form upon which the Department of Transportation requires formal bids be prepared and submitted for the work.

1-1.33 PROPOSAL GUARANTY

- The cash, cashier's check, certified check or bidder's bond accompanying the proposal submitted by the bidder, as a guaranty that the bidder will enter into a contract with the Department of Transportation for the performance of the work if the contract is awarded to the bidder.

1-1.34 ROADBED

- The roadbed is that area between the intersection of the upper surface of the roadway and the side slopes or curb lines. The roadbed rises in elevation as each increment or layer of subbase, base, surfacing or pavement is placed. Where the medians are so wide as to include areas of undisturbed land, a divided highway is considered as including 2 separate roadbeds.

1-1.35 ROADWAY

- That portion of the highway included between the outside lines of sidewalks, or curbs, slopes, ditches, channels, waterways, and including all the appertaining structures, and other features necessary to proper drainage and protection.

1-1.36 SHOULDERS

- The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

1-1.37 SPECIAL PROVISIONS

- The special provisions are specific clauses setting forth conditions or requirements peculiar to the work and supplementary to these Standard Specifications. The Department of Transportation publication entitled Labor Surcharge And Equipment Rental Rates is to be considered as a part of the special provisions.

1-1.38 SPECIFICATIONS

- The directions, provisions and requirements contained in these Standard Specifications as supplemented by the special provisions. Whenever the term "these specifications" or "these Standard Specifications" is used in this book, it means the provisions set forth in this book.

1-1.39 STATE

- The State of California, including the Department, California Highway Patrol, or any other State of California agency whose action or oversight is related to the work.

1-1.40 STATE CONTRACT ACT

- Chapter 1, Part 2, Division 2 of the Public Contract Code. The provisions of this act and other applicable laws form and constitute a part of the provisions of this contract to the same extent as if set forth herein in full.

1-1.41 SUBBASE

- A layer of specified material of planned thickness between a base and the basement material.

1-1.42 SUBGRADE

- That portion of the roadbed on which pavement, surfacing, base, subbase, or a layer of any other material is placed.

1-1.43 SUBSTRUCTURE

- All that part of the bridge below the bridge seats, tops of piers, haunches of rigid frames, or below the spring lines of arches. Backwalls and parapets of abutments and wingwalls of bridges shall be considered as parts of the substructure.

1-1.44 SUPERSTRUCTURE

- All that part of the bridge except the bridge substructure.

1-1.45 SURFACING

- The uppermost layer of material placed on the traveled way, or shoulders. This term is used interchangeably with pavement.

1-1.46 TRAFFIC LANE

- That portion of a traveled way for the movement of a single line of vehicles.

1-1.47 TRAVELED WAY

- That portion of the roadway for the movement of vehicles, exclusive of shoulders.

1-1.48 WORK

- All the work specified, indicated, shown or contemplated in the contract to construct the improvement, including all alterations, amendments or extensions thereto made by contract change order or other written orders of the Engineer.

SECTION 2: PROPOSAL REQUIREMENTS AND CONDITIONS

2-1.01 CONTENTS OF PROPOSAL FORMS

- Prospective bidders will be furnished with proposal forms which will refer to the special provisions and project plans for the work to be done and will include a schedule of items for which bid prices are asked, showing the approximate estimate of the various quantities and kinds of work to be performed or materials to be furnished.

2-1.02 APPROXIMATE ESTIMATE

- The quantities given in the proposal and contract are approximate only, being given as a basis for the comparison of bids. The Department does not, expressly or by implication, agree that the actual amount of work will correspond therewith, and reserves the right to increase or decrease the amount of any class or portion of the work, or to omit portions of the work, as may be deemed necessary or advisable by the Engineer.

2-1.03 EXAMINATION OF PLANS, SPECIFICATIONS, CONTRACT, AND SITE OF WORK

- The bidder shall examine carefully the site of the work contemplated, the plans and specifications, and the proposal and contract forms therefor. The submission of a bid shall be conclusive evidence that the bidder has investigated and is satisfied as to the general and local conditions to be encountered, as to the character, quality and scope of work to be performed, the quantities of materials to be furnished and as to the requirements of the proposal, plans, specifications and the contract.
- The submission of a bid shall also be conclusive evidence that the bidder is satisfied as to the character, quality and quantity of surface and subsurface materials or obstacles to be encountered insofar as this information was reasonably ascertainable from an inspection of the site and the records of exploratory work done by the Department as shown in the bid documents, as well as from the plans and specifications made a part of the contract.
- Where the Department has made investigations of site conditions including subsurface conditions in areas where work is to be performed under the contract, or in other areas, some of which may constitute possible local material sources, bidders or contractors may, upon written request, inspect the records of the Department as to those investigations subject to and upon the conditions hereinafter set forth.
- Where there has been prior construction by the Department or other public agencies within the project limits, records of the prior construction that are currently in the possession of the Department and which have been used by, or are known to, the designers and administrators of the project will be made available for inspection by bidders or contractors, upon written request, subject to the conditions hereinafter set forth. The records may include, but are not limited to, as-built drawings, design calculations, foundation and site studies, project reports and other data assembled in connection with the investigation, design, construction and maintenance of the prior projects.

- Inspection of the records of investigations and project records may be made at the office of the district in which the work is situated, or in the case of records of investigations related to structure work, at the Transportation Laboratory in Sacramento, California.
- When a log of test borings or other record of geotechnical data obtained by the Department's investigation of surface and subsurface conditions is included with the contract plans, it is furnished for the bidders' or Contractor's information and its use shall be subject to the conditions and limitations set forth in this Section 2-1.03.
- In some instances, information considered by the Department to be of possible interest to bidders or contractors has been compiled as "Materials Information." The use of the "Materials Information" shall be subject to the conditions and limitations set forth in this Section 2-1.03 and Section 6-2, "Local Materials."
- When cross sections are not included with the plans, but are available, bidders or contractors may inspect the cross sections and obtain copies for their use, at their expense.
- When cross sections are included with the contract plans, it is expressly understood and agreed that the cross sections do not constitute part of the contract, do not necessarily represent actual site conditions or show location, character, dimensions and details of work to be performed, and are included in the plans only for the convenience of bidders and their use is subject to the conditions and limitations set forth in this Section 2-1.03.
- When contour maps were used in the design of the project, the bidders may inspect those maps, and if available, they may obtain copies for their use.
- The availability or use of information described in this Section 2-1.03 is not to be construed in any way as a waiver of the provisions of the first paragraph in this Section 2-1.03 and bidders and contractors are cautioned to make independent investigations and examinations as they deem necessary to be satisfied as to conditions to be encountered in the performance of the work and, with respect to possible local material sources, the quality and quantity of material available from the property and the type and extent of processing that may be required in order to produce material conforming to the requirements of the specifications.
- The Department assumes no responsibility for conclusions or interpretations made by a bidder or contractor based on the information or data made available by the Department. The Department does not assume responsibility for representation made by its officers or agents before the execution of the contract concerning surface or subsurface conditions, unless that representation is expressly stated in the contract.
- No conclusions or interpretations made by a bidder or contractor from the information and data made available by the Department will relieve a bidder or contractor from properly fulfilling the terms of the contract.

2-1.04 (BLANK)

2-1.05 PROPOSAL FORMS

- The Department will furnish to each bidder a standard proposal form, which, when filled out and executed may be submitted as that bidder's bid. Bids not

presented on forms so furnished, and copies or facsimiles of the bidder's completed and executed proposal forms submitted as a bid will be rejected.

- The proposal form is bound together with the contract in a book entitled "Proposal and Contract." The proposal shall set forth the item prices and totals, in clearly legible figures, in the respective spaces provided, and shall be signed by the bidder, who shall fill out all blanks in the proposal form as therein required.
- The proposal shall be submitted as directed in the "Notice to Contractors" under sealed cover plainly marked as a proposal, and identifying the project to which the proposal relates and the date of the bid opening therefor. Proposals which are not properly marked may be disregarded.
- All proposal forms other than for "District Opening" projects shall be obtained from the Department of Transportation, Plans and Bid Documents, Room 0200, Transportation Building, 1120 N Street, Sacramento, California 95814, or as otherwise designated in the "Notice to Contractor."
- Proposals for "District Opening" projects shall be made on forms obtained from the District Director of Transportation in whose district the work is to be performed, but in all other respects the provisions in this Section 2-1.05 shall apply.

2-1.054 REQUIRED LISTING OF PROPOSED SUBCONTRACTORS

- Each proposal shall have listed therein the name and address of each subcontractor to whom the bidder proposes to subcontract portions of the work in an amount in excess of one-half of one percent of the total bid or $10,000, whichever is greater, in accordance with the Subletting and Subcontracting Fair Practices Act, commencing with Section 4100 of the Public Contract Code. The bidder's attention is invited to other provisions of the Act related to the imposition of penalties for a failure to observe its provisions by using unauthorized subcontractors or by making unauthorized substitutions.
- A sheet for listing the subcontractors, as required herein, is included in the "Proposal and Contract" book.

2-1.056 STATE EMPLOYEES AND DESIGN ENGINEERS MAY NOT BID ON CONSTRUCTION CONTRACT

- No employee of the State shall be eligible to submit a proposal for, nor to subcontract for any portion of, nor to supply any materials for any contract administered by the Department.
- No engineering or architectural firm which has provided design services for a project shall be eligible to submit a proposal for the contract to construct the project nor to subcontract for any portion of the work. The ineligible firms include the prime contractor for design, subcontractors of portions of the design and affiliates of either. An affiliate is a firm which is subject to the control of the same persons, through joint ownership or otherwise.

2-1.06 REJECTION OF PROPOSALS

- Proposals may be rejected if they have been transferred to another bidder, or if they show any alteration of form, additions not called for, conditional bids, incomplete bids, erasures, or irregularities of any kind.
- When proposals are signed by an agent, other than the officer or officers of a corporation authorized to sign contracts on its behalf or a member of a partnership,

a "Power of Attorney" must be on file with the Department prior to opening bids or shall be submitted with the proposal; otherwise, the proposal may be rejected as irregular and unauthorized.

2-1.07 PROPOSAL GUARANTY

- All bids shall be presented under sealed cover and accompanied by one of the following forms of bidder's security:

  Cash, a cashier's check, a certified check, or a bidder's bond executed by an admitted surety insurer, made payable to the Director of Transportation.

- The security shall be in an amount equal to at least 10 percent of the amount bid. A bid will not be considered unless one of the forms of bidder's security is enclosed with it.
- The bidder's bond shall conform to the bond form in the book entitled "Proposal and Contract" for the project and shall be properly filled out and executed. The bidder's bond form included in that book may be used. Upon request "Bidder's Bond" forms may be obtained from the Department.

2-1.08 WITHDRAWAL OF PROPOSALS

- Any bid may be withdrawn at any time prior to the date and time fixed for the opening of bids only by written request for the withdrawal of the bid filed at the location at which the bid was received by the Department. The request shall be executed by the bidder or the bidder's duly authorized representative. The withdrawal of a bid does not prejudice the right of the bidder to file a new bid. Whether or not bids are opened exactly at the time fixed for opening bids, a bid will not be received after that time, nor may any bid be withdrawn after the time fixed for the opening of bids.

2-1.09 PUBLIC OPENING OF PROPOSALS

- Proposals will be opened and read publicly at the time and place indicated in the "Notice to Contractors." Bidders or their authorized agents are invited to be present.

2-1.095 RELIEF OF BIDDERS

- Attention is directed to the provisions of Public Contract Code Sections 5100 to 5107, inclusive, concerning relief of bidders and in particular to the requirement therein, that if the bidder claims a mistake was made in the bid presented, the bidder shall give the Department written notice within 5 days after the opening of the bids of the alleged mistake, specifying in the notice in detail how the mistake occurred.

2-1.10 DISQUALIFICATION OF BIDDERS

- More than one proposal from an individual, firm, partnership, corporation, or combination thereof under the same or different names will not be considered. Reasonable grounds for believing that any individual, firm, partnership, corporation or combination thereof is interested in more than one proposal for the work contemplated may cause the rejection of all proposals in which that individual, firm, partnership, corporation or combination thereof is interested. If there is

reason for believing that collusion exists among the bidders any or all proposals may be rejected. Proposals in which the prices obviously are unbalanced may be rejected.

2-1.105 PREVIOUS DISQUALIFICATION, REMOVAL OR OTHER PREVENTION OF BIDDING

- Pursuant to Section 10162 of the Public Contract Code the bidder shall complete, under penalty of perjury, the questionnaire in the Proposal relating to previous disqualification, removal or other prevention of bidding of the bidder, or officers or employees of the bidder because of violation of law or a safety regulation.
- A bid may be rejected on the basis of a bidder, any officer of the bidder, or any employee of the bidder who has a proprietary interest in the bidder, having been disqualified, removed, or otherwise prevented from bidding on, or completing a federal, state or local project because of a violation of law or a safety regulation.

2-1.108 COMPLIANCE WITH ORDERS OF THE NATIONAL LABOR RELATIONS BOARD

- Pursuant to Public Contract Code Section 10232, the Contractor shall swear by a statement, under penalty of perjury, that no more than one final, unappealable finding of contempt of court by a Federal court has been issued against the Contractor within the immediately preceding 2-year period because of the Contractor's failure to comply with an order of a Federal court which orders the Contractor to comply with an order of the National Labor Relations Board. For purposes of Section 10232, a finding of contempt does not include any finding which has been vacated, dismissed, or otherwise removed by the court because the Contractor has complied with the order which was the basis for the finding. The State may rescind any contract in which the Contractor falsely swears to the truth of the statement required by Section 10232.
- The statement required by Public Contract Code Section 10232 is on the page preceding the signature page of the Proposal.

2-1.11 INELIGIBILITY TO CONTRACT

- Public Contract Code Section 10285.1 provides as follows:

> Any state agency may suspend, for a period of up to three years from the date of conviction, any person from bidding upon, or being awarded, a public works or services contract with the agency under this part or from being a subcontractor at any tier upon the contract, if that person, or any partner, member, officer, director, responsible managing officer, or responsible managing employee thereof, has been convicted by a court of competent jurisdiction of any charge of fraud, bribery, collusion, conspiracy, or any other act in violation of any state or federal antitrust law in connection with the bidding upon, award of, or performance of any public works contract, as defined in Section 1101, with any public entity, as defined in Section 1100, including, for the purposes of this article, the Regents of the University of California or the Trustees of the California State University. A state agency may determine the eligibility of any person to enter into a contract under this

article by requiring the person to submit a statement under penalty of perjury declaring that neither the person nor any subcontractor to be engaged by the person has been convicted of any of the offenses referred to in this section within the preceding three years.

- A form for the statement required by Section 10285.1 is included in the Proposal.

2-1.12 MATERIAL GUARANTY

- The successful bidder may be required to furnish a written guaranty covering certain items of work for varying periods of time from the date of acceptance of the contract. The work to be guaranteed, the form and the time limit of the guaranty will be specified in the special provisions. The guaranty shall be signed and delivered to the Engineer before acceptance of the contract. Upon completion of the contract the amounts of the 2 contract bonds required in Section 3-1.02, "Contract Bonds," may be reduced to conform to the total amount of the contract bid prices for the items of work to be guaranteed, and this amount shall continue in full force and effect for the duration of the guaranty period. The payment bond shall not be reduced until the expiration of the time required by Section 3249 of the Civil Code.

SECTION 3: AWARD AND EXECUTION OF CONTRACT

3-1.01 AWARD OF CONTRACT

- The right is reserved to reject any and all proposals.
- The award of the contract, if it be awarded, will be to the lowest responsible bidder whose proposal complies with all the requirements prescribed. The award, if made, will be made within 30 days after the opening of the proposals. This period will be subject to extension for such further period as may be agreed upon in writing between the Department and the bidder concerned.
- All bids will be compared on the basis of the Engineer's Estimate of the quantities of work to be done.

3-1.02 CONTRACT BONDS

- The successful bidder shall furnish the 2 bonds required by the State Contract Act. One bond shall secure the payment of the claims of laborers, mechanics or materialmen employed on the work under the contract, and the other bond shall guarantee the faithful performance of the contract. The bond forms will be furnished to the successful bidder by the Department.
- Except as otherwise provided in Section 3248 of the Civil Code and Section 30154 of the Streets and Highways Code, the payment bond shall be in a sum equal to the contract price and the performance bond shall be in a sum equal to at least one-half of the contract price.
- All alterations, extensions of time, extra and additional work, and other changes authorized by these specifications or any part of the contract may be made without securing the consent of the surety or sureties on the contract bonds.

3-1.025 INSURANCE POLICIES

- The successful bidder shall submit:

  A. Copy of its commercial general liability policy and its excess policy, including the declarations page, all amendments, riders, endorsements, and other modifications in effect at the time of contract execution. Standard ISO form No. CG 0001 or similar exclusions are allowed if not inconsistent with Section 7-1.12, "Indemnification and Insurance." Allowance of any additional exclusions is at the discretion of the Department.

  B. Certificate of Insurance showing all other required coverages. Certificates of Insurance, as evidence of required insurance for the auto liability and any other required policy shall set forth deductible amounts applicable to each policy and all exclusions that are added by endorsement to each policy. The evidence of insurance shall provide that no cancellation, lapse, or reduction of coverage will occur without 30 days prior written notice to the Department.

- If the successful bidder uses any form of self-insurance, it shall submit:

  A. A notice of election to self-insure.

B. The coverages for which self-insurance applies.
C. The amount of self-insurance.
D. Declaration under the penalty of perjury by a certified public accountant certifying the accountant has applied Generally Accepted Accounting Principles (GAAP) guidelines and the successful bidder has sufficient funds or other resources to cover the self-insurance amounts.
E. Copy of its commercial general liability policy and its excess policy, including the declarations page, all amendments, riders, endorsements and other modifications in effect at the time of contract execution, for those amounts not covered by self-insurance.

3-1.03 EXECUTION OF CONTRACT

The contract shall be signed by the successful bidder and returned, together with the contract bonds, copy of insurance policies, and Certificates of Insurance, with documents to verify any self-insurance coverage within 10 days, not including Saturdays, Sundays and legal holidays, after the bidder has received the contract for execution.

3-1.04 FAILURE TO EXECUTE CONTRACT

Failure of the lowest responsible bidder, the second lowest responsible bidder, or the third lowest responsible bidder to execute the contract and file acceptable bonds as provided herein within 10 days, not including Saturdays, Sundays and legal holidays, after that bidder has received the contract for execution shall be just cause for the forfeiture of the proposal guaranty. The successful bidder may file with the Department a written notice, signed by the bidder or the bidder's authorized representative, specifying that the bidder will refuse to execute the contract if it is presented. The filing of this notice shall have the same force and effect as the failure of the bidder to execute the contract and furnish acceptable bonds within the time hereinbefore prescribed.

3-1.05 RETURN OF PROPOSAL GUARANTIES

The proposal guaranties accompanying the proposals of the first, second and third lowest responsible bidders will be retained until the contract has been finally executed, after which those proposal guaranties, except bidders' bonds and any guaranties which have been forfeited, will be returned to the respective bidders whose proposals they accompany. The proposal guaranties, other than bidder's bonds, submitted by all other unsuccessful bidders will be returned upon determination, by the Department, of the first, second and third lowest responsible bidders.

SECTION 4: SCOPE OF WORK

4-1.01 INTENT OF PLANS AND SPECIFICATIONS

The intent of the plans and specifications is to prescribe the details for the construction and completion of the work which the Contractor undertakes to perform in accordance with the terms of the contract. Where the plans or specifications describe portions of the work in general terms, but not in complete detail, it is understood that only the best general practice is to prevail and that only materials and workmanship of the first quality are to be used. Unless otherwise specified, the Contractor shall furnish all labor, materials, tools, equipment, and incidentals, and do all the work involved in executing the contract in a satisfactory and workmanlike manner.

4-1.02 FINAL CLEANING UP

Before final inspection of the work, the Contractor shall clean the highway, material sites and all ground occupied by the Contractor in connection with the work of all rubbish, excess materials, falsework, temporary structures and equipment. All parts of the work shall be left in a neat and presentable condition. Full compensation for final cleaning up will be considered as included in the prices paid for the various contract items of work and no separate payment will be made therefor.

Nothing herein, however, shall require the Contractor to remove warning, regulatory, and guide signs prior to formal acceptance by the Director.

4-1.03 CHANGES

The Department reserves the right to make such alterations, deviations, additions to or deletions from the plans and specifications, including the right to increase or decrease the quantity of any item or portion of the work or to delete any item or portion of the work, as may be deemed by the Engineer to be necessary or advisable and to require such extra work as may be determined by the Engineer to be required for the proper completion or construction of the whole work contemplated.

Those changes will be set forth in a contract change order which will specify, in addition to the work to be done in connection with the change made, adjustment of contract time, if any, and the basis of compensation for that work. A contract change order will not become effective until approved by the Engineer.

Upon receipt of an approved contract change order, the Contractor shall proceed with the ordered work. If ordered in writing by the Engineer, the Contractor shall proceed with the work so ordered prior to actual receipt of an approved contract change order therefor. In those cases, the Engineer will, as soon as practicable, issue an approved contract change order for the ordered work and the provisions in Section 4-1.03A, "Procedure and Protest," shall be fully applicable to the subsequently issued contract change order.

When the compensation for an item of work is subject to adjustment under the provisions of this Section 4-1.03, the Contractor shall, upon request, furnish the Engineer with adequate detailed cost data for that item of work. If the Contractor

requests an adjustment in compensation for an item of work as provided in Sections 4-1.03B(1) or 4-1.03B(2), the cost data shall be submitted with the request.

4-1.03A Procedure and Protest

- A contract change order approved by the Engineer may be issued to the Contractor at any time. Should the Contractor disagree with any terms or conditions set forth in an approved contract change order not executed by the Contractor, the Contractor shall submit a written protest to the Engineer within 15 days after the receipt of the approved contract change order. The protest shall state the points of disagreement, and, if possible, the contract specification references, quantities and costs involved. If a written protest is not submitted, payment will be made as set forth in the approved contract change order, and that payment shall constitute full compensation for all work included therein or required thereby. Unprotested approved contract change orders will be considered as executed contract change orders as that term is used in Sections 4-1.03B to 4-1.03D, inclusive.
- Where the protest concerning an approved contract change order relates to compensation, the compensation payable for all work specified or required by that contract change order to which the protest relates will be determined as provided in Sections 4-1.03B to 4-1.03D, inclusive. The Contractor shall keep full and complete records of the cost of that work and shall permit the Engineer to have access thereto as may be necessary to assist in the determination of the compensation payable for that work.
- Where the protest concerning an approved contract change order relates to the adjustment of contract time for the completion of the work, the time to be allowed therefor will be determined as provided in Section 8-1.07, "Liquidated Damages."
- Proposed contract change orders may be presented to the Contractor for consideration prior to approval by the Engineer. If the Contractor signifies acceptance of the terms and conditions of the proposed contract change order by executing the document and if the change order is approved by the Engineer and issued to the Contractor, payment in accordance with the provisions as to compensation therein set forth shall constitute full compensation for all work included therein or required thereby. A contract change order executed by the Contractor and approved by the Engineer is an executed contract change order as that term is used in Sections 4-1.03B to 4-1.03D, inclusive. An approved contract change order shall supersede a proposed, but unapproved, contract change order covering the same work.
- The Engineer may provide for an adjustment of compensation as to a contract item of work included in a contract change order determined as provided in Sections 4-1.03B to 4-1.03D, inclusive, if that item of work is eligible for an adjustment of compensation thereunder.

4-1.03B Increased or Decreased Quantities

- Increases or decreases in the quantity of a contract item of work will be determined by comparing the total pay quantity of that item of work with the Engineer's Estimate therefor.

- If the total pay quantity of any item of work required under the contract varies from the Engineer's Estimate therefor by 25 percent or less, payment will be made for the quantity of work of the item performed at the contract unit price therefor, unless eligible for adjustment pursuant to Section 4-1.03C, "Changes in Character of Work."
- If the total pay quantity of any item of work required under the contract varies from the Engineer's Estimate therefor by more than 25 percent, in the absence of an executed contract change order specifying the compensation to be paid, the compensation payable to the Contractor will be determined in accordance with Sections 4-1.03B(1), 4-1.03B(2), or 4-1.03B(3), as the case may be.

4-1.03B(1) Increases of More Than 25 Percent

- Should the total pay quantity of any item of work required under the contract exceed the Engineer's Estimate therefor by more than 25 percent, the work in excess of 125 percent of the estimate and not covered by an executed contract change order specifying the compensation to be paid therefor will be paid for by adjusting the contract unit price, as hereinafter provided, or at the option of the Engineer, payment for the work involved in the excess will be made on the basis of force account as provided in Section 9-1.03.
- The adjustment of the contract unit price will be the difference between the contract unit price and the actual unit cost, which will be determined as hereinafter provided, of the total pay quantity of the item. If the costs applicable to the item of work include fixed costs, the fixed costs will be deemed to have been recovered by the Contractor by the payments made for 125 percent of the Engineer's Estimate of the quantity for the item, and in computing the actual unit cost, the fixed costs will be excluded. Subject to the above provisions, the actual unit cost will be determined by the Engineer in the same manner as if the work were to be paid for on a force account basis as provided in Section 9-1.03; or the adjustment will be as agreed to by the Contractor and the Engineer.
- When the compensation payable for the number of units of an item of work performed in excess of 125 percent of the Engineer's Estimate is less than $5,000 at the applicable contract unit price, the Engineer reserves the right to make no adjustment in the contract unit price if the Engineer so elects, except that an adjustment will be made if requested in writing by the Contractor.

4-1.03B(2) Decreases of More Than 25 Percent

- Should the total pay quantity of any item of work required under the contract be less than 75 percent of the Engineer's Estimate therefor, an adjustment in compensation pursuant to this Section will not be made unless the Contractor so requests in writing. If the Contractor so requests, the quantity of the item performed, unless covered by an executed contract change order specifying the compensation payable therefor, will be paid for by adjusting the contract unit price as hereinafter provided, or at the option of the Engineer, payment for the quantity of the work of the item performed will be made on the basis of force account as provided in Section 9-1.03, provided however, that in no case shall the payment for that work be less than that which would be made at the contract unit price.

- The adjustment of the contract unit price will be the difference between the contract unit price and the actual unit cost, which will be determined as hereinafter provided, of the total pay quantity of the item, including fixed costs. The actual unit cost will be determined by the Engineer in the same manner as if the work were to be paid for on a force account basis as provided in Section 9-1.03; or the adjustment will be as agreed to by the Contractor and the Engineer.
- The payment for the total pay quantity of the item of work will in no case exceed the payment which would be made for the performance of 75 percent of the Engineer's Estimate of the quantity for the item at the original contract unit price.

4-1.03B(3) Eliminated Items

- Should any contract item of the work be eliminated in its entirety, in the absence of an executed contract change order covering the elimination, payment will be made to the Contractor for actual costs incurred in connection with the eliminated contract item if incurred prior to the date of notification in writing by the Engineer of the elimination.
- If acceptable material is ordered by the Contractor for the eliminated item prior to the date of notification of the elimination by the Engineer, and if orders for that material cannot be canceled, the material will be paid for at the actual cost to the Contractor. In this case, the material paid for shall become the property of the State, and the actual cost of any further handling will be paid for. If the material is returnable to the vendor and if the Engineer so directs, the material shall be returned and the Contractor will be paid for the actual cost of charges made by the vendor for returning the material. The actual cost of handling returned material will be paid for.
- The actual costs or charges to be paid by the Department to the Contractor as provided in this Section 4-1.03B(3) will be computed in the same manner as if the work were to be paid for on a force account basis as provided in Section 9-1.03.

4-1.03C Changes in Character of Work

- If an ordered change in the plans or specifications materially changes the character of the work of a contract item from that on which the Contractor based the bid price, and if the change increases or decreases the actual unit cost of the changed item as compared to the actual or estimated actual unit cost of performing the work of that item in accordance with the plans and specifications originally applicable thereto, in the absence of an executed contract change order specifying the compensation payable, an adjustment in compensation therefor will be made in accordance with the following.
- The basis of the adjustment in compensation will be the difference between the actual unit cost to perform the work of that item or portion thereof involved in the change as originally planned and the actual unit cost of performing the work of the item or portion thereof involved in the change, as changed. Actual unit costs will be determined by the Engineer in the same manner as if the work were to be paid for on a force account basis as provided in Section 9-1.03; or the adjustment will be as agreed to by the Contractor and the Engineer. The adjustment will apply only to the portion of the work of the item actually changed in character. At the option of

the Engineer, the work of the item or portion of item which is changed in character will be paid for by force account as provided in Section 9-1.03.

- If the compensation for an item of work is adjusted under this Section 4-1.03C, the costs recognized in determining that adjustment shall be excluded from consideration in making an adjustment for that item of work under the provisions in Section 4-1.03B, "Increased or Decreased Quantities."
- Failure of the Engineer to recognize a change in character of the work at the time the approved contract change order is issued shall in nowise be construed as relieving the Contractor of the duty and responsibility of filing a written protest within the 15 day limit as provided in Section 4-1.03A, "Procedure and Protest."

4-1.03D Extra Work

- New and unforeseen work will be classed as extra work when determined by the Engineer that the work is not covered by any of the various items for which there is a bid price or by combinations of those items. In the event portions of this work are determined by the Engineer to be covered by some of the various items for which there is a bid price or combinations of those items, the remaining portion of the work will be classed as extra work. Extra work also includes work specifically designated as extra work in the plans or specifications.
- The Contractor shall do the extra work and furnish labor, material and equipment therefor upon receipt of an approved contract change order or other written order of the Engineer, and in the absence of an approved contract change order or other written order of the Engineer, the Contractor shall not be entitled to payment for the extra work.
- Payment for extra work required to be performed pursuant to the provisions in this Section 4-1.03D, in the absence of an executed contract change order, will be made by force account as provided in Section 9-1.03; or as agreed to by the Contractor and the Engineer.

4-1.04 DETOURS

- The Contractor shall construct and remove detours and detour bridges for the use of public traffic as provided in the special provisions, or as shown on the plans, or as directed by the Engineer. Payment for this work will be made as set forth in the special provisions or at the contract prices for the items of work involved if the work being performed is covered by contract items of work and no other method of payment therefor is provided in the special provisions, otherwise the work will be paid for as extra work as provided in Section 4-1.03D.
- The cost of repairing damage to detours caused by public traffic will be paid for as extra work as provided in Section 4-1.03D.
- When public traffic is routed through the work, provision for a passageway through construction operations will not be considered as detour construction or detour maintenance, and this work shall conform to and be paid for as provided in Section 7-1.08, "Public Convenience," unless otherwise specified in the special provisions.
- Detours used exclusively by the Contractor for hauling materials and equipment shall be constructed and maintained by the Contractor at the Contractor's expense.

- The failure or refusal of the Contractor to construct and maintain detours at the proper time shall be sufficient cause for closing down the work until the detours are in satisfactory condition for use by public traffic.
- Where the Contractor's hauling is causing such damage to the detour that its maintenance in a condition satisfactory for public traffic is made difficult and unusually expensive, the Engineer shall have authority to regulate the Contractor's hauling over the detour.

4-1.05 USE OF MATERIALS FOUND ON THE WORK

- Unless designated as selected material as provided in Section 19-2.07, "Selected Material," the Contractor, with the approval of the Engineer, may use in the proposed construction such stone, gravel, sand or other material suitable in the opinion of the Engineer as may be found in excavation. The Contractor will be paid for the excavation of those materials at the contract price for the excavation, but the Contractor shall replace at the Contractor's expense with other suitable material all of that portion of the material so removed and used which was contemplated for use in the work, except that the Contractor need not replace at the Contractor's expense, any material obtained from structure excavation used as structure backfill. No charge for materials so used will be made against the Contractor. The Contractor shall not excavate or remove any material from within the highway location that is not within the excavation, as indicated by the slope and grade lines, without written authorization from the Engineer.

SECTION 5: CONTROL OF WORK

5-1.01 AUTHORITY OF ENGINEER

The Engineer shall decide all questions which may arise as to the quality or acceptability of materials furnished and work performed and as to the manner of performance and rate of progress of the work; all questions which may arise as to the interpretation of the plans and specifications; all questions as to the acceptable fulfillment of the contract on the part of the Contractor; and all questions as to compensation. The Engineer's decision shall be final, and the Engineer shall have authority to enforce and make effective those decisions and orders which the Contractor fails to carry out promptly.

5-1.02 PLANS AND WORKING DRAWINGS

The contract plans furnished consist of general drawings and show such details as are necessary to give a comprehensive idea of the construction contemplated. All authorized alterations affecting the requirements and information given on the contract plans shall be in writing.

The contract plans shall be supplemented by such working drawings prepared by the Contractor as are necessary to adequately control the work. No change shall be made by the Contractor in any working drawing after it has been approved by the Engineer.

Working drawings for any part of the permanent work shall include, but not be limited to stress sheets, anchor bolt layouts, shop details, erection plans, equipment lists and any other information specifically required elsewhere in the specifications.

Working drawings for cribs, cofferdams, falsework, temporary support systems, haul bridges, centering and form work and for other temporary work and methods of construction the Contractor proposes to use, shall be submitted when required by the specifications or ordered by the Engineer. Working drawings shall be subject to approval insofar as the details affect the character of the finished work and for compliance with design requirements applicable to the construction when specified or called for, but details of design will be left to the Contractor who shall be responsible for the successful construction of the work.

Working drawings shall be approved by the Engineer before any work involving the drawings is performed. It is expressly understood that approval of the Contractor's working drawings shall not relieve the Contractor of any responsibility under the contract for the successful completion of the work in conformity with the requirements of the plans and specifications. Approval of working drawings shall not operate to waive any of the requirements of the plans and specifications or relieve the Contractor of any obligation thereunder, and defective work, materials and equipment may be rejected notwithstanding the approval.

Full compensation for furnishing all working drawings shall be considered as included in the prices paid for the contract items of work to which the drawings relate and no additional compensation will be allowed therefor.

5-1.02A Excavation Safety Plans

The Construction Safety Orders of the Division of Occupational Safety and Health shall apply to all excavations. For all excavations 5 feet or more in depth,

the Contractor shall submit to the Engineer a detailed plan showing the design and details of the protective systems to be provided for worker protection from the hazard of caving ground during excavation. The detailed plan shall include any tabulated data and any design calculations used in the preparation of the plan. Excavation shall not begin until the detailed plan has been reviewed and approved by the Engineer.

- Detailed plans of protective systems for which the Construction Safety Orders require design by a registered professional engineer shall be prepared and signed by an engineer who is registered as a Civil Engineer in the State of California, and shall include the soil classification, soil properties, soil design calculations that demonstrate adequate stability of the protective system, and any other design calculations used in the preparation of the plan.
- No plan shall allow the use of a protective system less effective than that required by the Construction Safety Orders.
- If the detailed plan includes designs of protective systems developed only from the allowable configurations and slopes, or Appendices, contained in the Construction Safety Orders, the plan shall be submitted at least 5 days before the Contractor intends to begin excavation. If the detailed plan includes designs of protective systems developed from tabulated data, or designs for which design by a registered professional engineer is required, the plan shall be submitted at least 3 weeks before the Contractor intends to begin excavation.
- Attention is directed to Section 7-1.01E, "Trench Safety."

5-1.03 CONFORMITY WITH CONTRACT DOCUMENTS AND ALLOWABLE DEVIATIONS

- Work and materials shall conform to the lines, grades, typical cross sections, dimensions and material requirements, including tolerances, shown on the plans or indicated in the specifications. Although measurement, sampling and testing may be considered evidence as to conformity, the Engineer shall be the sole judge as to whether the work or materials deviate from the plans and specifications, and the Engineer's decision as to any allowable deviations therefrom shall be final.

5-1.04 COORDINATION AND INTERPRETATION OF PLANS, STANDARD SPECIFICATIONS, AND SPECIAL PROVISIONS

- These Standard Specifications, the Standard Plans, project plans, special provisions, contract change orders and all supplementary documents are essential parts of the contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary, and to describe and provide for a complete work.
- Project plans shall govern over Standard Plans; Standard Plans and project plans shall govern over these Standard Specifications; and the special provisions shall govern over both these Standard Specifications and the plans.
- Should it appear that the work to be done or any of the matters relative thereto are not sufficiently detailed or explained in these specifications, the special provisions or the plans, the Contractor shall apply to the Engineer for such further explanations as may be necessary and shall conform to them as part of the contract. In the event of any doubt or question arising respecting the true meaning of these

specifications, the special provisions or the plans, reference shall be made to the Engineer, whose decision thereon shall be final.

- In the event of any discrepancy between any drawing and the figures written thereon, the figures shall be taken as correct. Detail drawings shall prevail over general drawings.

5-1.05 ORDER OF WORK

- When required by the special provisions or plans, the Contractor shall follow the sequence of operations as set forth therein.
- Full compensation for conforming to those requirements will be considered as included in the prices paid for the various contract items of work and no additional compensation will be allowed therefor.

5-1.06 SUPERINTENDENCE

- The Contractor shall designate in writing before starting work, an authorized representative who shall have the authority to represent and act for the Contractor.
- When the Contractor is comprised of 2 or more persons, firms, partnerships or corporations functioning on a joint venture basis, the Contractor shall designate in writing before starting work, the name of one authorized representative who shall have the authority to represent and act for the Contractor.
- The authorized representative shall be present at the site of the work at all times while work is actually in progress on the contract. When work is not in progress and during periods when work is suspended, arrangements acceptable to the Engineer shall be made for any emergency work which may be required.
- Whenever the Contractor or the Contractor's authorized representative is not present on any particular part of the work where it may be desired to give direction, orders will be given by the Engineer, which shall be received and obeyed by the superintendent or foreman who may have charge of the particular work in reference to which the orders are given.
- Any order given by the Engineer, not otherwise required by the specifications to be in writing, will on request of the Contractor, be given or confirmed by the Engineer in writing.

5-1.07 LINES AND GRADES

- Stakes or marks will be set by the Engineer as the Engineer determines to be necessary to establish the lines and grades required for the completion of the work specified in these specifications, on the plans and in the special provisions.
- When the Contractor requires the stakes or marks, the Contractor shall notify the Engineer of the requirements in writing a reasonable length of time in advance of starting operations that require the stakes or marks. In no event, shall a notice of less than 2 working days be considered a reasonable length of time.
- Stakes and marks set by the Engineer shall be carefully preserved by the Contractor. In case the stakes and marks are destroyed or damaged, the stakes and marks will be replaced at the Engineer's earliest convenience. The Contractor will be charged for the cost of necessary replacement or restoration of stakes and marks which in the judgment of the Engineer were carelessly or willfully destroyed or damaged by the Contractor's operations. This charge will be deducted from any moneys due or to become due the Contractor.

5-1.08 INSPECTION

- The Engineer shall, at all times, have safe access to the work during its construction, and shall be furnished with every reasonable facility for ascertaining that the materials and the workmanship are in accordance with the requirements and intentions of these specifications, the special provisions and the plans. All work done and all materials furnished shall be subject to the Engineer's inspection.
- The inspection of the work or materials shall not relieve the Contractor of any of the Contractor's obligations to fulfill the contract as prescribed. Work and materials not meeting the requirements shall be made good, and unsuitable work or materials may be rejected, notwithstanding that the work or materials have been previously inspected by the Engineer or that payment therefor has been included in a progress estimate.
- Projects financed in whole or in part with Federal funds shall be subject to inspection at all times by the Federal agency involved.

5-1.09 REMOVAL OF REJECTED AND UNAUTHORIZED WORK

- All work which has been rejected shall be remedied, or removed and replaced by the Contractor in an acceptable manner, and no compensation will be allowed to the Contractor for the removal, replacement or remedial work.
- Any work done beyond the lines and grades shown on the plans or established by the Engineer, or any extra work done without written authority will be considered as unauthorized work and will not be paid for. Upon order of the Engineer unauthorized work shall be remedied, removed or replaced at the Contractor's expense.
- Upon failure of the Contractor to comply promptly with any order of the Engineer made under this Section 5-1.09, the Department may cause rejected or unauthorized work to be remedied, removed or replaced, and to deduct the costs from any moneys due or to become due the Contractor.

5-1.10 EQUIPMENT AND PLANTS

- Only equipment and plants suitable to produce the quality of work and materials required will be permitted to operate on the project.
- Plants shall be designed and constructed in accordance with general practice for the equipment and shall be of sufficient capacity to ensure the production of sufficient material to carry the work to completion within the time limit.
- The Contractor shall provide adequate and suitable equipment and plants to meet the above requirements, and when ordered by the Engineer shall remove unsuitable equipment from the work and discontinue the operation of unsatisfactory plants.
- The Contractor shall identify each piece of equipment, other than hand tools, by means of an identifying number plainly stenciled or stamped on the equipment at a conspicuous location, and shall furnish to the Engineer a list giving the description of each piece of equipment and its identifying number. In addition, the make, model number and empty gross weight of each unit of compacting equipment shall be plainly stamped or stenciled in a conspicuous place on the unit. The gross weight shall be either the manufacturer's rated weight or the scale weight, expressed in pounds.

- The make, model, serial number and manufacturer's rated capacity in pounds for each scale shall be clearly stamped or stenciled on the load receiving element and its indicator or indicators. All meters shall be similarly identified, rated and marked. Upon request of the Engineer, the Contractor shall furnish a statement by the manufacturer, designating sectional and weighbridge capacities of portable vehicle scales.

5-1.11 ALTERNATIVE EQUIPMENT

- While certain of these specifications may provide that equipment of a particular size and type is to be used to perform portions of the work, it is to be understood that the development and use of new or improved equipment is to be encouraged.
- The Contractor may request, in writing, permission from the Engineer to use equipment of a different size or type in place of the equipment specified.
- The Engineer, before considering or granting the request, may require the Contractor to furnish, at the Contractor's expense, evidence satisfactory to the Engineer that the equipment proposed for use by the Contractor is capable of producing work equal to, or better than, that which can be produced by the equipment specified.
- If permission is granted by the Engineer, it shall be understood that the permission is granted for the purpose of testing the quality of work actually produced by the equipment and is subject to continuous attainment of results which, in the opinion of the Engineer, are equal to, or better than, that which can be obtained with the equipment specified. The Engineer shall have the right to withdraw permission at any time that the Engineer determines that the alternative equipment is not producing work that is equal, in all respects, to that which can be produced by the equipment specified. Upon withdrawal of permission by the Engineer, the Contractor will be required to use the equipment originally specified and shall, in accordance with the directions of the Engineer, remove and dispose of or otherwise remedy, at the Contractor's expense, any defective or unsatisfactory work produced with the alternative equipment.
- Neither the State nor the Contractor shall have any claim against the other for either the withholding or the granting of permission to use alternative equipment, or for the withdrawal of the permission.
- Permission to use alternative equipment in place of equipment specified will only be granted where the equipment is new or improved and its use is deemed by the Engineer to be in furtherance of the purposes of this Section 5-1.11. The approval for use of particular equipment on any project shall in no way be considered as an approval of the use of the equipment on any other project.
- Nothing in this Section 5-1.11 shall relieve the Contractor of the responsibility for furnishing materials or producing finished work of the quality specified in these specifications or in the special provisions.

5-1.115 ALTERNATIVE METHODS OF CONSTRUCTION

- Whenever the plans or specifications provide that more than one specified method of construction or more than one specified type of material or construction equipment may be used to perform portions of the work and leave the selection of

the method of construction or the type of material or equipment to be used up to the Contractor, it is understood that the State does not guarantee that every specified method of construction or type of material or equipment can be used successfully throughout all or any part of any project. It shall be the Contractor's responsibility to select and use the alternative or alternatives which will satisfactorily perform the work under the conditions encountered. In the event some of the alternatives are not feasible or it is necessary to use more than one of the alternatives on any project, full compensation for any additional cost involved shall be considered as included in the contract price paid for the item of work involved and no additional compensation will be allowed therefor.

5-1.116 DIFFERING SITE CONDITIONS

- During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the contract, are encountered at the site, the party discovering those conditions shall promptly notify the other party in writing of the specific differing conditions before they are disturbed and before the affected work is performed.
- Upon written notification, the Engineer will investigate the conditions, and if the Engineer determines that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the contract, an adjustment, excluding loss of anticipated profits, will be made and the contract modified in writing accordingly. The Engineer will notify the Contractor of the Engineer's determination whether or not an adjustment of the contract is warranted.
- No contract adjustment which results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice.
- No contract adjustment will be allowed under the provisions specified in this section for any effects caused on unchanged work.
- Any contract adjustment warranted due to differing site conditions will be made in conformance with the provisions in Section 4-1.03, "Changes," except as otherwise provided.

5-1.12 CHARACTER OF WORKERS

- If any subcontractor or person employed by the Contractor shall appear to the Engineer to be incompetent or to act in a disorderly or improper manner, they shall be discharged immediately on the request of the Engineer, and that person shall not again be employed on the work.

5-1.13 FINAL INSPECTION

- When the work has been completed, the Engineer will make the final inspection.

5-1.14 COST REDUCTION INCENTIVE

- The Contractor may submit to the Engineer, in writing, proposals for modifying the plans, specifications or other requirements of the contract for the sole purpose of reducing the total cost of construction. The cost reduction proposal

shall not impair, in any manner, the essential functions or characteristics of the project, including but not limited to service life, economy of operation, ease of maintenance, desired appearance, or design and safety standards.

- Cost reduction proposals shall contain the following information:

    1. A description of both the existing contract requirements for performing the work and the proposed changes.
    2. An itemization of the contract requirements that must be changed if the proposal is adopted.
    3. A detailed estimate of the cost of performing the work under the existing contract and under the proposed change. The estimates of cost shall be determined in the same manner as if the work were to be paid for on a force account basis as provided in Section 9-1.03, "Force Account Payment."
    4. A statement of the time within which the Engineer must make a decision thereon.
    5. The contract items of work affected by the proposed changes, including any quantity variation attributable thereto.

- The provisions of this Section 5-1.14 shall not be construed to require the Engineer to consider any cost reduction proposal which may be submitted hereunder; proposed changes in basic design of a bridge or of a pavement type will not be considered as an acceptable cost reduction proposal; and the Department will not be liable to the Contractor for failure to accept or act upon any cost reduction proposal submitted pursuant to this section nor for any delays to the work attributable to any cost reduction proposal. If a cost reduction proposal is similar to a change in the plans or specifications, under consideration by the Department for the project, at the time the proposal is submitted or if the proposal is based upon or similar to Standard Specifications, standard special provisions or Standard Plans adopted by the Department after the advertisement for the contract, the Engineer will not accept the proposal, and the Department reserves the right to make the changes without compensation to the Contractor under the provisions of this section.
- The Contractor shall continue to perform the work in accordance with the requirements of the contract until an executed change order, incorporating the cost reduction proposal has been issued. If an executed change order has not been issued by the date upon which the Contractor's cost reduction proposal specifies that a decision thereon should be made, or such other date as the Contractor may subsequently have specified in writing, the cost reduction proposal shall be deemed rejected.
- The Engineer shall be the sole judge of the acceptability of a cost reduction proposal and of the estimated net savings in construction costs from the adoption of all or any part of the proposal. In determining the estimated net savings, the right is reserved to disregard the contract bid prices if in the judgment of the Engineer, those prices do not represent a fair measure of the value of work to be performed or to be deleted.

- The Department reserves the right where it deems such action appropriate, to require the Contractor to share in the Department's costs of investigating a cost reduction proposal submitted by the Contractor as a condition of considering the proposal. Where this condition is imposed, the Contractor shall indicate acceptance thereof in writing, and that acceptance shall constitute full authority for the Department to deduct amounts payable to the Department from any moneys due or that may become due to the Contractor under the contract.
- If the Contractor's cost reduction proposal is accepted in whole or in part the acceptance will be by a contract change order, which shall specifically state that it is executed pursuant to this Section 5-1.14. The change order shall incorporate the changes in the plans and specifications which are necessary to permit the cost reduction proposal or that part of it as has been accepted to be put into effect, and shall include any conditions upon which the Department's approval thereof is based if the approval of the Department is conditional. The change order shall also set forth the estimated net savings in construction costs attributable to the cost reduction proposal effectuated by the change order, and shall further provide that the Contractor be paid 50 percent of that estimated net savings amount. The Contractor's cost of preparing the cost reduction incentive proposal and the Department's costs of investigating a cost reduction incentive proposal, including any portion thereof paid by the Contractor, shall be excluded from consideration in determining the estimated net savings in construction costs.
- Acceptance of the cost reduction proposal and performance of the work thereunder shall not extend the time of completion of the contract unless specifically provided for in the contract change order authorizing the use of the cost reduction proposal.
- The amount specified to be paid to the Contractor in the change order which effectuates a cost reduction proposal shall constitute full compensation to the Contractor for the cost reduction proposal and the performance of the work thereof pursuant to the change order.
- The Department expressly reserves the right to adopt a cost reduction proposal for general use on contracts administered by the Department when it determines that the proposal is suitable for application to other contracts. When an accepted cost reduction proposal is adopted for general use, only the Contractor who first submitted that proposal will be eligible for compensation pursuant to this section, and in that case, only as to those contracts awarded to that Contractor prior to submission of the accepted cost reduction proposal and as to which the cost reduction proposal is also submitted and accepted. Cost reduction proposals identical or similar to previously submitted proposals will be eligible for consideration and compensation under the provisions of this Section 5-1.14 if the identical or similar previously submitted proposals were not adopted for general application to other contracts administered by the Department. Subject to the provisions contained herein, the State or any other public agency shall have the right to use all or any part of any submitted cost reduction proposal without obligation or compensation of any kind to the Contractor.
- This Section 5-1.14 of the specifications shall apply only to contracts awarded to the lowest bidder pursuant to competitive bidding.

SECTION 6: CONTROL OF MATERIALS

6-1 GENERAL

6-1.01 SOURCE OF SUPPLY AND QUALITY OF MATERIALS

- The Contractor shall furnish all materials required to complete the work, except materials that are designated in the specifications to be furnished by the State and materials furnished by the State in conformance with the provisions in Section 9-1.03, "Force Account Payment."
- Only materials conforming to the requirements of the specifications shall be incorporated in the work.
- The materials furnished and used shall be new, except as may be provided elsewhere in these specifications, on the plans or in the special provisions. The materials shall be manufactured, handled and used in a workmanlike manner to ensure completed work in accordance with the plans and specifications.
- Materials to be used in the work will be subject to inspection and tests by the Engineer or the Engineer's designated representative. The Contractor shall furnish without charge such samples as may be required.
- The Contractor shall furnish the Engineer a list of the Contractor's sources of materials and the locations at which those materials will be available for inspection. The list shall be submitted on a State-furnished form and shall be furnished to the Engineer in sufficient time to permit inspecting and testing of materials to be furnished from the listed sources in advance of their use. The Engineer may inspect, sample or test materials at the source of supply or other locations, but the inspection, sampling or testing will not be undertaken until the Engineer is assured by the Contractor of the cooperation and assistance of both the Contractor and the supplier of the material. The Contractor shall assure that the Engineer or the Engineer's authorized representative has free access at all times to the material to be inspected, sampled or tested. It is understood that the inspections and tests if made at any point other than the point of incorporation in the work in no way shall be considered as a guaranty of acceptance of the material nor of continued acceptance of material presumed to be similar to that upon which inspections and tests have been made, and that inspection and testing performed by the State shall not relieve the Contractor or the Contractor's suppliers of responsibility for quality control.
- Manufacturers' warranties, guaranties, instruction sheets and parts lists, which are furnished with certain articles or materials incorporated in the work, shall be delivered to the Engineer before acceptance of the contract.
- Reports and records of inspections made and tests performed, when available at the site of the work, may be examined by the Contractor.

6-1.02 STATE-FURNISHED MATERIALS

- Materials which are listed as State-furnished materials in the special provisions will be available to the Contractor free of charge.
- The Contractor shall submit a written request to the Engineer for the delivery of State-furnished material at least 15 days in advance of the date of its intended use, except that the written request for the delivery of State-furnished sign panels for roadside signs and overhead sign structures shall be submitted at least 30 days

in advance of their intended installation. The request shall state the quantity and the type of each material.

- The locations at which State-furnished materials will be available to the Contractor free of charge will be designated in the special provisions. In those cases the materials shall be hauled to the site of the work by the Contractor at the Contractor's expense, including any necessary loading and unloading that may be involved. If the locations are not designated in the special provisions, the State-furnished materials will be furnished to the Contractor free of charge at the site of the project. In either case, all costs of handling and placing State-furnished material shall be considered as included in the price paid for the contract item involving the State-furnished material.
- The Contractor shall be responsible for all State-furnished materials furnished to the Contractor, and shall pay all demurrage and storage charges. State-furnished materials lost or damaged from any cause whatsoever shall be replaced by the Contractor at the Contractor's expense. The Contractor shall be liable to the Department for the cost of replacing State-furnished material, and those costs may be deducted from any moneys due or to become due the Contractor. All State-furnished material that is not used on the work shall remain the property of the State and shall be delivered to the Engineer.
- The Engineer may increase the number of sign panels in any shipment to provide economical use of the State's transportation facilities.
- The quantity of each type of State-furnished paint required shall be determined by the Contractor subject to verification by the Engineer.

6-1.03 STORAGE OF MATERIALS

- Articles or materials to be incorporated in the work shall be stored in such a manner as to ensure the preservation of their quality and fitness for the work, and to facilitate inspection.

6-1.04 DEFECTIVE MATERIALS

- All materials which the Engineer has determined do not conform to the requirements of the plans and specifications will be rejected whether in place or not. The rejected materials shall be removed immediately from the site of the work, unless otherwise permitted by the Engineer. No rejected material, the defects of which have been subsequently corrected, shall be used in the work, unless approval in writing has been given by the Engineer. Upon failure of the Contractor to comply promptly with any order of the Engineer made under the provisions in this Section 6-1.04, the Engineer shall have authority to cause the removal and replacement of rejected material and to deduct the cost thereof from any moneys due or to become due the Contractor.

6-1.05 TRADE NAMES AND ALTERNATIVES

- For convenience in designation on the plans or in the specifications, certain articles or materials to be incorporated in the work may be designated under a trade name or the name of a manufacturer and the manufacturer's catalog information. The use of an alternative article or material which is of equal quality and of the required characteristics for the purpose intended will be permitted, subject to the following requirements:

The burden of proof as to the quality and suitability of alternatives shall be upon the Contractor, and the Contractor shall furnish all information necessary as required by the Engineer. The Engineer shall be the sole judge as to the quality and suitability of alternative articles or materials, and the Engineer's decision shall be final.

Whenever the specifications permit the substitution of a similar or equivalent material or article, no tests or action relating to the approval of the substitute material will be made until the request for substitution is made in writing by the Contractor accompanied by complete data as to the equality of the material or article proposed. The request shall be made in ample time to permit approval without delaying the work, but need not be made in less than 35 days after award of the contract.

6-1.06 PLANT INSPECTION

- The Engineer may inspect the production of material or the manufacture of products at the source of supply.
- Plant inspection, however, will not be undertaken until the Engineer is assured of the cooperation and assistance of both the Contractor and the material producer. The Engineer or the Engineer's authorized representative shall have free entry at all times to those parts of the plant as concerns the manufacture or production of the materials. Adequate facilities shall be furnished free of charge to make the necessary inspection. The State assumes no obligation to inspect materials at the source of supply.

6-1.07 CERTIFICATES OF COMPLIANCE

- A Certificate of Compliance shall be furnished prior to the use of any materials for which these specifications or the special provisions require that a certificate be furnished. In addition, when so authorized in these specifications or in the special provisions, the Engineer may permit the use of certain materials or assemblies prior to sampling and testing if accompanied by a Certificate of Compliance. The certificate shall be signed by the manufacturer of the material or the manufacturer of assembled materials and shall state that the materials involved comply in all respects with the requirements of the specifications. A Certificate of Compliance shall be furnished with each lot of material delivered to the work and the lot so certified shall be clearly identified in the certificate.
- Materials used on the basis of a Certificate of Compliance may be sampled and tested at any time. The fact that material is used on the basis of a Certificate of Compliance shall not relieve the Contractor of responsibility for incorporating material in the work which conforms to the requirements of the plans and specifications, and any material not conforming to the requirements will be subject to rejection whether in place or not.
- The Department reserves the right to refuse to permit the use of material on the basis of a Certificate of Compliance.
- The form of the Certificate of Compliance and its disposition shall be as directed by the Engineer.

6-1.08 FOREIGN MATERIALS

- Materials which are manufactured, produced or fabricated outside of the United States shall be delivered to a distribution point in California, unless otherwise required in these specifications or the special provisions, where they shall be retained for a sufficient period of time to permit inspection, sampling and testing.
- Attention is directed to the provisions in Section 8-1.07, "Liquidated Damages." The Contractor shall not be entitled to an extension of time for acts or events occurring outside of the United States, and it shall be the Contractor's responsibility to deliver materials obtained from outside of the United States to the point of entry into the continental United States in sufficient time to permit timely delivery to the job site.
- The Contractor, at no cost to the State, shall supply the facilities and arrange for any testing required in California which the State is not equipped to perform. All testing by the Contractor shall be subject to witnessing by the Engineer.
- The manufacturer, producer or fabricator of foreign material shall furnish to the Engineer a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance." In addition, certified mill test reports clearly identifiable to the lot of material shall be furnished where required in these specifications or otherwise requested by the Engineer.
- If the welding of steel for structural steel members or the casting and prestressing of precast prestressed concrete members is to be performed outside of the United States, the following requirements shall apply:

1. The fabrication shall be performed only within the plants and by fabricators who have previously established, to the satisfaction of the Engineer, that they have the experience, knowledge, trained manpower, quality controls, equipment and other facilities required to produce the quality and quantity of work required. At the option of the Engineer, prequalification of the plant and fabricator will be established either by the submission of detailed written proof thereof or through in-plant inspection by the Engineer or the Engineer's representative, or both.
2. The Contractor shall make written application to the Engineer for approval for the foreign fabrication at the earliest possible time and in no case later than 50 days in advance of the planned start of fabrication. The application shall list the specific units or portion of a work which will be fabricated outside of the United States.
3. The Contractor shall advise the Engineer, in writing, at least 20 days in advance of the actual start of any of the foreign fabrication.
4. All documents pertaining to the contract, including but not limited to, correspondence, bid documents, working drawings and data shall be written in the English language and all numerical data shall use the U.S. Customary units of measurement.

- The use of steel manufactured outside of the United States as unidentified stock material, as provided in Section 55-2.07, "Unidentified Stock Material," will not be allowed.

6-1.09 STATE SPECIFICATION NUMBERS

- The State Specification number of material furnished on the contract shall conform to the number specified in these specifications or the special provisions for the material involved, except that material conforming to a later specification issue will be acceptable.

6-2 LOCAL MATERIALS

6-2.01 GENERAL

- Local material is rock, sand, gravel, earth or other mineral material, other than local borrow or selected material, obtained or produced from sources in the vicinity of the work specifically for use on the project. Local material does not include materials obtained from established commercial sources.
- Local materials shall be furnished by the Contractor from any source the Contractor may elect, except that when mandatory local material sources of certain materials are designated in the special provisions, the Contractor shall furnish material from those designated mandatory sources.
- The Contractor shall be responsible for making all arrangements necessary to obtain materials from any local material source other than a mandatory local material source. If the Contractor elects to obtain materials from a possible local material source, subject to the provisions in Section 6-2.02, "Possible Local Material Sources," the Contractor shall comply with the requirements of that section. If the Contractor elects to obtain material from any other non-mandatory source, the Contractor shall furnish the Engineer with satisfactory evidence that the Contractor has entered into an agreement with the property owner for obtaining material from that source and with copies of any necessary permits, licenses and environmental clearances before removing any material from those sources.
- The furnishing of local materials from any source is subject to the provisions in Section 2-1.03, "Examination of Plans, Specifications, Contract, and Site of Work," and in Section 6-2, "Local Materials."
- Unless described in the special provisions as a mandatory local material source, or approved in writing by the Engineer, material sources shall not be excavated at locations where the resulting scars will present an unsightly appearance from any highway. No payment will be made for material obtained in violation of this provision.
- The Contractor shall, at the Contractor's expense, make any arrangements necessary for hauling over local public and private roads from any source.
- When requested by the Contractor in writing, the Department will test materials from any local material source, which has not been previously tested. If satisfactory material from that local source is used in the work, the Contractor will not be charged for the costs of the tests.
- In all other cases, the cost of the testing requested by the Contractor shall be at the Contractor's expense, and deductions will be made from any moneys due or to become due the Contractor, sufficient to cover the costs of the tests.

- Full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in conforming to the provisions in this Section 6-2.01, for furnishing and producing materials from any source shall be considered as included in the price paid for the contract item of work involving the material and no additional compensation will be allowed therefor.

6-2.02 POSSIBLE LOCAL MATERIAL SOURCES

- Where the Department has made arrangements with owners of land in the vicinity of a project for the obtaining of material from an owner's property, the arrangements are made solely for the purpose of providing all bidders an equal opportunity to obtain material from that property. Bidders or Contractors may, upon written request, inspect the documents evidencing those arrangements between property owners and the Department. The Contractor may, if the Contractor so elects, exercise any rights that have been obtained, which may be exercised by a Contractor under the arrangements, subject to and upon the conditions hereinafter set forth.
- Arrangements made by the Department are not a part of the contract, and it is expressly understood and agreed that the Department assumes no responsibility to the bidder or Contractor whatsoever in respect to the arrangements made with the property owner to obtain materials therefrom and that the Contractor shall assume all risks in connection with the use of the property, the terms upon which the use shall be made, and there is no warranty or guaranty, either express or implied, as to the quality or quantity of materials that can be obtained or produced from the property or the type or extent of processing that may be required in order to produce material conforming to the requirements of the specifications.
- In those instances in which the Department has compiled "Materials Information" as referred to in Section 2-1.03, "Examination of Plans, Specifications, Contract, and Site of Work," the compilation may include the documents setting forth the arrangement made with some of the property owners for the obtaining of material from those owners' properties. The inclusion of these documents therein shall not in any respect operate as a waiver of any of the provisions in this Section 6-2.02 concerning the documents.
- All necessary permits, licenses and environmental clearances needed to enable the Contractor to use a possible local material source for which the "Materials Information" compilation for the project does not include permits, licenses and environmental clearances issued to the Department (whether or not the arrangement made by the Department with the owner of the property is included in the compilation) shall be obtained by the Contractor, and copies thereof shall be furnished the Engineer before any material is removed from the source.
- The bidder or Contractor is cautioned to make such independent investigation and examination as the Contractor deems necessary to be satisfied as to the quality and quantity of materials available from the property, the type and extent of processing that may be required in order to produce material conforming to the requirements of the specifications and the rights, duties and obligations acquired or undertaken under the arrangement with the property owner.

• Notwithstanding that the Contractor may elect to obtain materials from any such property owner's property, no material may be obtained from the property unless the Contractor has first either:

1. Executed a document that will guarantee to hold the owner harmless from all claims for injury to persons or damage to property resulting from the Contractor's operations on the property owner's premises and also agree to conform to all other provisions set forth in the arrangement made between the Department and the property owner. The document will be prepared by the Engineer for execution by the Contractor, or
2. Entered into an agreement with the owner of the material source on any terms mutually agreeable to the owner and the Contractor, provided that the Contractor shall furnish to the Engineer a release, in a form satisfactory to the Engineer, executed by the owner, relieving the Department of any and all obligations under the Department's arrangement with the owner.

• If the Contractor elects to obtain material under (1), the use of the site shall be subject to the terms, conditions and limitations of the arrangement made between the property owner and the Department, and the Contractor shall pay the charges as are provided for in the arrangement made by the Department with the property owner. Deductions will be made from any moneys due or that may become due the Contractor under the contract sufficient to cover the charges for the material removed.

• If the Contractor elects to obtain material under (2), the Contractor shall pay the charges as are provided for in the agreement between the owner and the Contractor, and deductions will not be made from any moneys due or that may become due the Contractor under the contract to cover the charges.

• Before acceptance of the contract, the Engineer may require the Contractor to submit written evidence that the owner of the material source is satisfied that the Contractor has satisfactorily complied with the provisions of either— (1), the arrangement between the Department and the owner, or (2), the agreement between the owner and the Contractor, as the case may be.

• Full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and producing specified materials from possible local material sources, including the construction of any access roads or fences and any clearing, grubbing and stripping of material sources, and all processing of whatever nature and extent required, shall be considered as included in the price paid for the contract item of work involving the material and no additional compensation will be allowed therefor.

6-2.03 MANDATORY LOCAL MATERIAL SOURCES

• The Contractor shall perform all work required to obtain and produce acceptable materials from the mandatory local material sources designated in the special provisions and shall have no right to obtain the materials from any other source or sources. As part of the work in producing acceptable materials from the mandatory sources, it will be necessary for the Contractor to perform certain

processing of the material as set forth in the special provisions. Any processing of the material required in addition to that specified in the special provisions which, in the opinion of the Engineer, is necessary to produce acceptable material from the mandatory sources will be paid for as extra work as provided in Section 4-1.03D.

- If the Engineer determines that the designated mandatory local material source or sources are no longer to be used because they are exhausted or for other reasons, the Engineer will designate an alternative mandatory local material source or sources from which the Contractor shall obtain the balance of the material required.
- In this case the Department will pay the Contractor for the cost of moving the Contractor's plant to the new mandatory source and erecting the plant as extra work as provided in Section 4-1.03D. Construction of access roads, fences, clearing and grubbing or stripping of the new mandatory source, ordered by the Engineer to be performed, will be paid for as extra work as provided in Section 4-1.03D. The Department will also allow or deduct, as the case may be, the increase or decrease in haul cost due to an increase or decrease in the length of haul involved. Increased haul costs will be paid for as extra work as provided in Section 4-1.03D, and deductions for decreased haul will be determined in the same manner. No allowance or additional compensation will be made for lost time or for delay in completing the work due to moving the Contractor's plant from the designated mandatory source to the alternative mandatory source, other than an extension of time pursuant to the provisions in Section 8-1.07, "Liquidated Damages." Any processing of the material required in addition to that specified in the special provisions for the originally designated mandatory source which, in the opinion of the Engineer, is necessary to produce acceptable material from the alternative mandatory source will be paid for as extra work as provided in Section 4-1.03D. The Contractor will be charged the same royalty as provided in the special provisions for the original designated mandatory local material source.
- The Contractor shall, prior to entering a mandatory local material source or an alternative mandatory local material source, execute a document that will guarantee to hold the owner of the property harmless from all claims for injury to persons or damage to property resulting from the Contractor's operations on the property owner's premises. The document will be prepared by the Engineer for execution by the Contractor.
- Full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in obtaining and producing specified materials from mandatory sources, including the construction of any access roads or fences and any clearing, grubbing and stripping of mandatory local material sources, except as otherwise provided for in this Section 6-2.03, shall be considered as included in the price paid for the contract item of work involving the material and no additional compensation will be allowed therefor.

6-3 TESTING

6-3.01 GENERAL

- Unless otherwise specified, all tests shall be performed in accordance with the methods used by the Department of Transportation and shall be made by the Engineer or the Engineer's designated representative.

- The Department has developed methods for testing the quality of materials and work. These methods are identified by number and are referred to in the specifications as California Test. Copies of individual California Tests are available at the Transportation Laboratory, Sacramento, California, and will be furnished to interested persons upon request.
- Whenever the specifications require compliance with specified values for the following properties, tests will be made by the California Test indicated unless otherwise specified:

Properties	California Test
Relative Compaction	216 or 231
Sand Equivalent	217
Resistance (R-value)	301
Grading (Sieve Analysis)	202
Durability Index	229

- Whenever a reference is made in the specifications to a California Test by number, it shall mean the California Test in effect on the day the Notice to Contractors for the work is dated.
- Whenever the specifications provide an option between 2 or more tests, the Engineer will determine the test to be used.
- Whenever a reference is made in the specifications to a specification, manual or test designation either of the American Society for Testing and Materials, the American Association of State Highway and Transportation Officials, Federal Specifications or any other recognized national organization, and the number or other identification representing the year of adoption or latest revision is omitted, it shall mean the specification, manual or test designation in effect on the day the Notice to Contractors for the work is dated. Whenever the specification, manual or test designation provides for test reports (such as certified mill test reports) from the manufacturer, copies of those reports, identified as to the lot of material, shall be furnished to the Engineer. The manufacturer's test reports shall supplement the inspection, sampling and testing provisions in Section 6, "Control of Materials," and shall not constitute a waiver of the State's right to inspect. When material which cannot be identified with specific test reports is proposed for use, the Engineer may, at the Engineer's discretion, select random samples from the lot for testing. Test specimens from the random samples, including those required for retest, shall be prepared in accordance with the referenced specification and furnished by the Contractor at the Contractor's expense. The number of the samples and test specimens shall be entirely at the discretion of the Engineer. Unidentified metal products, such as sheet, plate and hardware shall be subject to the requirements of Section 55-2.07, "Unidentified Stock Material."
- When requested by the Engineer, the Contractor shall furnish, without charge, samples of all materials entering into the work, and no material shall be used prior to approval by the Engineer, except as provided in Section 6-1.07, "Certificates of Compliance." Samples of material from local sources shall be taken by or in the presence of the Engineer; otherwise, the samples will not be considered for testing.

6-3.02 TESTING BY CONTRACTOR

- The Contractor shall be responsible for controlling the quality of the material entering the work and of the work performed, and shall perform testing as necessary to ensure control. The test methods used for quality control testing shall be as determined by the Contractor. The results of the testing shall be made available to the Engineer upon request. These tests are for the Contractor's use in controlling the work and will not be accepted for use as acceptance tests.
- Full compensation for performing quality control tests and making the results available to the Engineer shall be considered as included in the contract prices paid for the various items of work involved and no additional compensation will be allowed therefor.

SECTION 7: LEGAL RELATIONS AND RESPONSIBILITY

7-1.01 LAWS TO BE OBSERVED

The Contractor shall keep fully informed of all existing and future State and Federal laws and county and municipal ordinances and regulations which in any manner affect those engaged or employed in the work, or the materials used in the work, or which in any way affect the conduct of the work, and of all orders and decrees of bodies or tribunals having any jurisdiction or authority over the same. The Contractor shall at all times observe and comply with, and shall cause all the Contractor's agents and employees to observe and comply with all existing and future laws, ordinances, regulations, orders and decrees of bodies or tribunals having any jurisdiction or authority over the work; and shall protect and indemnify the State of California, and all officers and employees thereof connected with the work, including but not limited to the Director and the Engineer, against any claim or liability arising from or based on the violation of any law, ordinance, regulation, order or decree, whether by the Contractor or the Contractor's employees. If any discrepancy or inconsistency is discovered in the plans, drawings, specifications or contract for the work in relation to any law, ordinance, regulation, order or decree, the Contractor shall forthwith report the same to the Engineer in writing.

7-1.01A Labor Code Requirements

Attention is directed to the following requirements of the Labor Code:

7-1.01A(1) Hours of Labor

Eight hours labor constitutes a legal day's work. The Contractor or any subcontractor under the Contractor shall forfeit, as a penalty to the State of California, twenty-five dollars ($25) for each worker employed in the execution of the contract by the respective Contractor or subcontractor for each calendar day during which that worker is required or permitted to work more than 8 hours in any one calendar day and 40 hours in any one calendar week in violation of the requirements of the Labor Code, and in particular, Section 1810 to Section 1815, thereof, inclusive, except that work performed by employees of Contractors in excess of 8 hours per day, and 40 hours during any one week, shall be permitted upon compensation for all hours worked in excess of 8 hours per day at not less than one and one-half times the basic rate of pay, as provided in Section 1815 thereof.

7-1.01A(2) Prevailing Wage

The Contractor and any subcontractor under the Contractor shall comply with Labor Code Sections 1774 and 1775. Pursuant to Section 1775, the Contractor and any subcontractor under the Contractor shall forfeit to the State or political subdivision on whose behalf the contract is made or awarded a penalty of not more than fifty dollars ($50) for each calendar day, or portion thereof, for each worker paid less than the prevailing rates as determined by the Director of Industrial Relations for the work or craft in which the worker is employed for any public work done under the contract by the Contractor or by any subcontractor under the Contractor in violation of the requirements of the Labor Code and in particular, Labor Code Sections 1770 to 1780, inclusive. The amount of this forfeiture shall

be determined by the Labor Commissioner and shall be based on consideration of the mistake, inadvertence, or neglect of the Contractor or subcontractor in failing to pay the correct rate of prevailing wages, or the previous record of the Contractor or subcontractor in meeting their respective prevailing wage obligations, or the willful failure by the Contractor or subcontractor to pay the correct rates of prevailing wages. A mistake, inadvertence, or neglect in failing to pay the correct rate of prevailing wages is not excusable if the Contractor or subcontractor had knowledge of the obligations under the Labor Code. In addition to the penalty and pursuant to Labor Code Section 1775, the difference between the prevailing wage rates and the amount paid to each worker for each calendar day or portion thereof for which each worker was paid less than the prevailing wage rate shall be paid to each worker by the Contractor or subcontractor. If a worker employed by a subcontractor on a public works project is not paid the general prevailing per diem wages by the subcontractor, the prime contractor of the project is not liable for the penalties described above unless the prime contractor had knowledge of that failure of the subcontractor to pay the specified prevailing rate of wages to those workers or unless the prime contractor fails to comply with all of the following requirements:

1. The contract executed between the contractor and the subcontractor for the performance of work on the public works project shall include a copy of the requirements in Sections 1771, 1775, 1776, 1777.5, 1813 and 1815 of the Labor Code.
2. The contractor shall monitor the payment of the specified general prevailing rate of per diem wages by the subcontractor to the employees, by periodic review of the certified payroll records of the subcontractor.
3. Upon becoming aware of the subcontractor's failure to pay the specified prevailing rate of wages to the subcontractor's workers, the contractor shall diligently take corrective action to halt or rectify the failure, including, but not limited to, retaining sufficient funds due the subcontractor for work performed on the public works project.
4. Prior to making final payment to the subcontractor for work performed on the public works project, the contractor shall obtain an affidavit signed under penalty of perjury from the subcontractor that the subcontractor has paid the specified general prevailing rate of per diem wages to the subcontractor's employees on the public works project and any amounts due pursuant to Section 1813 of the Labor Code.

- Pursuant to Section 1775 of the Labor Code, the Division of Labor Standards Enforcement shall notify the Contractor on a public works project within 15 days of the receipt by the Division of Labor Standards Enforcement of a complaint of the failure of a subcontractor on that public works project to pay workers the general prevailing rate of per diem wages. If the Division of Labor Standards Enforcement determines that employees of a subcontractor were not paid the general prevailing rate of per diem wages and if the Department did not retain sufficient money under the contract to pay those employees the balance of wages owed under the general prevailing rate of per diem wages, the contractor shall withhold an amount of

moneys due the subcontractor sufficient to pay those employees the general prevailing rate of per diem wages if requested by the Division of Labor Standards Enforcement. The Contractor shall pay any money retained from and owed to a subcontractor upon receipt of notification by the Division of Labor Standards Enforcement that the wage complaint has been resolved. If notice of the resolution of the wage complaint has not been received by the Contractor within 180 days of the filing of a valid notice of completion or acceptance of the public works project, whichever occurs later, the Contractor shall pay all moneys retained from the subcontractor to the Department. These moneys shall be retained by the Department pending the final decision of an enforcement action.

- Pursuant to the requirements in Section 1773 of the Labor Code, the Department has obtained the general prevailing rate of wages (which rate includes employer payments for health and welfare, pension, vacation, travel time and subsistence pay as provided for in Section 1773.8 of the Labor Code, apprenticeship or other training programs authorized by Section 3093 of the Labor Code, and similar purposes) applicable to the work to be done, for straight time, overtime, Saturday, Sunday and holiday work. The holiday wage rate listed shall be applicable to all holidays recognized in the collective bargaining agreement of the particular craft, classification or type of workmen concerned.
- The general prevailing wage rates and any applicable changes to these wage rates are available at the Labor Compliance Office at the offices of the District Director of Transportation for the district in which the work is situated. General prevailing wage rates are also available from the California Department of Industrial Relations' Internet Web Site at: http://www.dir.ca.gov.
- The wage rates determined by the Director of Industrial Relations for the project refer to expiration dates. Prevailing wage determinations with a single asterisk after the expiration date are in effect on the date of advertisement for bids and are good for the life of the contract. Prevailing wage determinations with double asterisks after the expiration date indicate that the wage rate to be paid for work performed after this date has been determined. If work is to extend past this date, the new rate shall be paid and incorporated in the contract. The Contractor shall contact the Department of Industrial Relations as indicated in the wage rate determinations to obtain predetermined wage changes.
- Pursuant to Section 1773.2 of the Labor Code, general prevailing wage rates shall be posted by the Contractor at a prominent place at the site of the work.
- Changes in general prevailing wage determinations which conform to Labor Code Section 1773.6 and Title 8 California Code of Regulations Section 16204 shall apply to the project when issued by the Director of Industrial Relations at least 10 days prior to the date of the Notice to Contractors for the project.
- The State will not recognize any claim for additional compensation because of the payment by the Contractor of any wage rate in excess of the prevailing wage rate set forth in the contract. The possibility of wage increases is one of the elements to be considered by the Contractor in determining the bid, and will not under any circumstances be considered as the basis of a claim against the State on the contract.

7-1.01A(2)(a) Travel and Subsistence Payments

Attention is directed to the requirements in Section 1773.8 of the Labor Code. The Contractor shall make travel and subsistence payments to each workman, needed to execute the work, in conformance with the requirements in Labor Code Section 1773.8.

7-1.01A(3) Payroll Records

Attention is directed to the requirements in Labor Code Section 1776, a portion of which is quoted below. Regulations implementing Labor Code Section 1776 are located in Sections 16016 through 16019 and Sections 16207.10 through 16207.19 of Title 8, California Code of Regulations.

"(a) Each contractor and subcontractor shall keep accurate payroll records, showing the name, address, social security number, work classification, straight time and overtime hours worked each day and week, and the actual per diem wages paid to each journeyman, apprentice, worker, or other employee employed by him or her in connection with the public work. Each payroll record shall contain or be verified by a written declaration that it is made under penalty of perjury, stating both of the following:

(1) The information contained in the payroll record is true and correct.
(2) The employer has complied with the requirements of Sections 1771, 1811, and 1815 for any work performed by his or her employees on the public works project.

"(b) The payroll records enumerated under subdivision (a) shall be certified and shall be available for inspection at all reasonable hours at the principal office of the contractor on the following basis:

(1) Acertified copy of an employee's payroll record shall be made available for inspection or furnished to the employee or his or her authorized representative on request.
(2) A certified copy of all payroll records enumerated in subdivision (a) shall be made available for inspection or furnished upon request to a representative of the body awarding the contract, the Division of Labor Standards Enforcement, and the Division of Apprenticeship Standards of the Department of Industrial Relations.
(3) A certified copy of all payroll records enumerated in subdivision (a) shall be made available upon request by the public for inspection or for copies thereof. However, a request by the public shall be made through either the body awarding the contract, the Division of Apprenticeship Standards, or the Division of Labor Standards Enforcement. If the requested payroll records have not been provided pursuant to paragraph (2), the requesting party shall, prior to being provided the records, reimburse the costs of preparation by the contractor, subcontractors, and the entity through which the request

was made. The public shall not be given access to the records at the principal office of the contractor.

"(c) The certified payroll records shall be on forms provided by the Division of Labor Standards Enforcement or shall contain the same information as the forms provided by the division.

"(d) A contractor or subcontractor shall file a certified copy of the records enumerated in subdivision (a) with the entity that requested the records within 10 days after receipt of a written request.

"(e) Any copy of records made available for inspection as copies and furnished upon request to the public or any public agency by the awarding body, the Division of Apprenticeship Standards, or the Division of Labor Standards Enforcement shall be marked or obliterated in a manner so as to prevent disclosure of an individual's name, address and social security number. The name and address of the contractor awarded the contract or the subcontractor performing the contract shall not be marked or obliterated.

"(f) The contractor shall inform the body awarding the contract of the location of the records enumerated under subdivision (a), including the street address, city and county, and shall, within five working days, provide a notice of a change of location and address.

"(g) The contractor or subcontractor shall have 10 days in which to comply subsequent to receipt of a written notice requesting the records enumerated in subdivision (a). In the event that the contractor or subcontractor fails to comply within the 10-day period, he or she shall, as a penalty to the state or political subdivision on whose behalf the contract is made or awarded, forfeit twenty-five dollars ($25) for each calendar day, or portion thereof, for each worker, until strict compliance is effectuated. Upon the request of the Division of Apprenticeship Standards or the Division of Labor Standards Enforcement, these penalties shall be withheld from progress payments then due. A contractor is not subject to a penalty assessment pursuant to this section due to the failure of a subcontractor to comply with this section."

- The penalties specified in subdivision (g) of Labor Code Section 1776 for noncompliance with the requirements in Section 1776 may be deducted from any moneys due or which may become due to the Contractor.
- A copy of all payrolls shall be submitted weekly to the Engineer. Payrolls shall contain the full name, address and social security number of each employee, the employee's correct classification, rate of pay, daily and weekly number of hours worked, itemized deductions made and actual wages paid. They shall also indicate apprentices and ratio of apprentices to journeymen. The employee's address and social security number need only appear on the first payroll on which that name appears. The payroll shall be accompanied by a "Statement of Compliance" signed by the employer or the employer's agent indicating that the payrolls are correct and complete and that the wage rates contained therein are not less than those required by the contract. The "Statement of Compliance" shall be on forms furnished by the

Department or on any form with identical wording. The Contractor shall be responsible for the submission of copies of payrolls of all subcontractors.

- If by the 15th of the month, the Contractor has not submitted satisfactory payrolls for all work performed during the monthly period ending on or before the first of that month, the Department will retain an amount equal to 10 percent of the estimated value of the work performed (exclusive of Mobilization) during the month from the next monthly estimate, except that this retention shall not exceed $10,000 nor be less than $1,000. Retentions for failure to submit satisfactory payrolls shall be additional to all other retentions provided for in the contract. The retention for failure to submit payrolls for any monthly period will be released for payment on the monthly estimate for partial payments next following the date that all the satisfactory payrolls for which the retention was made are submitted.
- The Contractor and each subcontractor shall preserve their payroll records for a period of 3 years from the date of completion of the contract.

7-1.01A(4) Labor Nondiscrimination

- Attention is directed to Section 1735 of the Labor Code, which reads as follows:

> "No discrimination shall be made in the employment of persons upon public works because of the race, religious creed, color, national origin, ancestry, physical handicap, medical condition, marital status, or sex of such persons, except as provided in Section 12940 of the Government Code, and every contractor for public works violating this section is subject to all the penalties imposed for a violation of this chapter."

- Attention is directed to the following "Nondiscrimination Clause" that is required by Chapter 5 of Division 4 of Title 2, California Code of Regulations.

NONDISCRIMINATION CLAUSE

1. During the performance of this contract, contractor and its subcontractors shall not unlawfully discriminate against any employee or applicant for employment because of race, religion, color, national origin, ancestry, physical handicap, medical condition, marital status, age (over 40) or sex. Contractors and subcontractors shall ensure that the evaluation and treatment of their employees and applicants for employment are free of such discrimination. Contractors and subcontractors shall comply with the provisions of the Fair Employment and Housing Act (Gov. Code, Section 12990 et seq.) and the applicable regulations promulgated thereunder (California Code of Regulations, Title 2, Section 7285.0 et seq.). The applicable regulations of the Fair Employment and Housing Commission implementing Government Code, Section 12990, set forth in Chapter 5 of Division 4 of Title 2 of the California Code of Regulations are incorporated into this contract by reference and made a part hereof as if set forth in full. Contractor and its subcontractors shall give written notice of

their obligations under this clause to labor organizations with which they have a collective bargaining or other agreement.

2. This Contractor shall include the nondiscrimination and compliance provisions of this clause in all subcontracts to perform work under the contract.

STANDARD CALIFORNIA NONDISCRIMINATION CONSTRUCTION CONTRACT SPECIFICATIONS (GOV. CODE, SECTION 12990).

These specifications are applicable to all state contractors and subcontractors having a construction contract or subcontract of $5,000, or more.

1. As used in the specifications:

   a. "Administrator" means Administrator, Office of Compliance Programs, California Department of Fair Employment and Housing, or any person to whom the Administrator delegates authority;
   b. "Minority" includes:

      (i) Black (all persons having primary origins in any of the black racial groups of Africa, but not of Hispanic origin);
      (ii) Hispanic (all persons of primary culture or origin in Mexico, Puerto Rico, Cuba, Central or South America or other Spanish derived culture or origin regardless of race);
      (iii) Asian / Pacific Islander (all persons having primary origins in any of the original peoples of the Far East, Southeast Asia, the Indian Subcontinent or the Pacific Islands); and
      (iv) American Indian / Alaskan Native (all persons having primary origins in any of the original peoples of North America and who maintain culture identification through tribal affiliation or community recognition).

2. Whenever the contractor or any subcontractor subcontracts a portion of the work, it shall physically include in each subcontract of $5,000 or more the nondiscrimination clause in this contract directly or through incorporation by reference. Any subcontract for work involving a construction trade shall also include the Standard California Construction Contract Specifications, either directly or through incorporation by reference.
3. The contractor shall implement the specific nondiscrimination standards provided in paragraph 6(a) through (e) of these specifications.
4. Neither the provisions of any collective bargaining agreement, nor the failure by a union with whom the contractor has a collective bargaining agreement, to refer either minorities or women shall excuse the contractor's obligations under these specifications, Government Code, Section 12990, or the regulations promulgated pursuant thereto.
5. In order for the nonworking training hours of apprentices and trainees to be counted, such apprentices and trainees must be employed by the

contractor during the training period, and the contractor must have made a commitment to employ the apprentices and trainees at the completion of their training, subject to the availability of employment opportunities. Trainees must be trained pursuant to training programs approved by the U.S. Department of Labor or the California Department of Industrial Relations.

6. The contractor shall take specific actions to implement its nondiscrimination program. The evaluation of the contractor's compliance with these specifications shall be based upon its effort to achieve maximum results from its actions. The contractor must be able to demonstrate fully its efforts under Steps a. through e. below:

    a. Ensure and maintain a working environment free of harassment, intimidation, and coercion at all sites, and at all facilities at which the contractor's employees are assigned to work. The contractor, where possible, will assign two or more women to each construction project. The contractor shall specifically ensure that all foremen, superintendents, and other on-site supervisory personnel are aware of and carry out the contractor's obligations to maintain such a working environment, with specific attention to minority or female individuals working at such sites or in such facilities.
    b. Provide written notification within seven days to the director of DFEH when the union or unions with which the Contractor has a collective bargaining agreement has not referred to the Contractor a minority person or woman sent by the Contractor, or when the Contractor has other information that the union referral process has impeded the Contractor's efforts to meet its obligations.
    c. Disseminate the Contractor's equal employment opportunity policy by providing notice of the policy to unions and training, recruitment and outreach programs and requesting their cooperation in assisting the Contractor to meet its obligations; and by posting the company policy on bulletin boards accessible to all employees at each location where construction work is performed.
    d. Ensure all personnel making management and employment decisions regarding hiring, assignment, layoff, termination, conditions of work, training, rates of pay or other employment decisions, including all supervisory personnel, superintendents, general foremen, on-site foremen, etc., are aware of the Contractor's equal employment opportunity policy and obligations, and discharge their responsibilities accordingly.
    e. Ensure that seniority practices, job classifications, work assignments and other personnel practices, do not have a discriminatory effect by continually monitoring all personnel and employment related activities to ensure that the equal employment opportunity policy and the Contractor's obligations under these specifications are being carried out.

7. Contractors are encouraged to participate in voluntary associations which assist in fulfilling their equal employment opportunity obligations. The efforts of a contractor association, joint contractor-union, contractor-community, or other similar group of which the contractor is a member and participant, may be asserted as fulfilling any one or more of its obligations under these specifications provided that the contractor actively participates in the group, makes every effort to assure that the group has a positive impact on the employment of minorities and women in the industry, ensures that the concrete benefits of the program are reflected in the Contractor's minority and female workforce participation, and can provide access to documentation which demonstrates the effectiveness of actions taken on behalf of the Contractor. The obligation to comply, however, is the Contractor's.
8. The Contractor is required to provide equal employment opportunity for all minority groups, both male and female, and all women, both minority and non-minority. Consequently, the Contractor may be in violation of the Fair Employment and Housing Act (Gov. Code, Section 12990 et seq.) if a particular group is employed in a substantially disparate manner.
9. Establishment and implementation of a bona fide affirmative action plan pursuant to Section 8104 (b) of this Chapter shall create a rebuttal presumption that a contractor is in compliance with the requirements of Section 12990 of the Government Code and its implementing regulations.
10. The Contractor shall not use the nondiscrimination standards to discriminate against any person because of race, color, religion, sex, national origin, ancestry, physical handicap, medical condition, marital status or age over 40.
11. The Contractor shall not enter into any subcontract with any person or firm decertified from state contracts pursuant to Government Code Section 12990.
12. The Contractor shall carry out such sanctions and penalties for violation of these specifications and the nondiscrimination clause, including suspension, termination and cancellation of existing subcontracts as may be imposed or ordered pursuant to Government Code Section 12990 and its implementing regulations by the awarding agency. Any Contractor who fails to carry out such sanctions and penalties shall be in violation of these specifications and Government Code Section 12990.
13. The Contractor shall designate a responsible official to monitor all employment related activity to ensure that the company equal employment opportunity policy is being carried out, to submit reports relating to the provisions hereof as may be required by OCP and to keep records. Records shall at least include for each employee the name, address, telephone numbers, construction trade, union affiliation if any, employee identification number when assigned, social security number, race, sex, status, (e.g., mechanic, apprentice trainee, helper, or laborer), dates of changes in status, hours worked per week in the indicated trade, rate of

pay, and locations at which the work was performed. Records shall be maintained in any easily understandable and retrievable form; however, to the degree that existing records satisfy this requirement, contractors shall not be required to maintain separate records.

NOTE: Authority cited: Sections 12935(a) and 12990(d), Government Code. References: Section 12990, Government Code.

7-1.01A(5) Apprentices

- Attention is directed to Sections 1777.5, 1777.6 and 1777.7 of the California Labor Code and Title 8, California Code of Regulations Section 200 et seq. To ensure compliance and complete understanding of the law regarding apprentices, and specifically the required ratio thereunder, each contractor or subcontractor should, where some question exists, contact the Division of Apprenticeship Standards, 455 Golden Gate Avenue, San Francisco, CA 94102, or one of its branch offices prior to commencement of work on the public works contract. Responsibility for compliance with this section lies with the Contractor.
- It is State policy to encourage the employment and training of apprentices on public works contracts as may be permitted under local apprenticeship standards.

7-1.01A(6) Workers' Compensation

- Pursuant to the requirements in Section 1860 of the Labor Code, the Contractor will be required to secure the payment of workers' compensation to the Contractor's employees in conformance with the requirements in Section 3700 of the Labor Code.
- Prior to the commencement of work, the Contractor shall sign and file with the Engineer a certification in the following form:

"I am aware of the provisions of Section 3700 of the Labor Code which require every employer to be insured against liability for workers' compensation or to undertake self-insurance in accordance with the provisions of that code, and I will comply with such provisions before commencing the performance of the work of this contract."

- This certification is included in the contract, and signature and return of the contract as provided in Section 3-1.03, "Execution of Contract," shall constitute signing and filing of the certificate.

7-1.01A(7) Suits to Recover Penalties and Forfeitures

- Attention is directed to Sections 1730 to 1733, inclusive, of the Labor Code concerning suits to recover amounts withheld from payment for failure to comply with requirements of the Labor Code or contract provisions based on those laws.
- Those sections provide that a suit on the contract for alleged breach thereof in not making the payment is the exclusive remedy of the Contractor or the Contractor's assignees with reference to amounts withheld for those penalties or forfeitures; and that the suit must be commenced and actual notice thereof received by the awarding authority prior to 90 days after completion of the contract and the formal acceptance of the job.

- Submission of a claim under Section 9-1.07B, "Final Payment and Claims," for the amounts withheld from payment for those penalties and forfeitures is not a prerequisite for those suits, and these claims will not be considered.

7-1.01B Fair Labor Standards Act

- The attention of bidders is invited to the fact that the State of California, Department of Transportation, has been advised by the Wage and Hour Division, U.S. Department of Labor, that contractors engaged in highway construction work are required to meet the provisions of the Fair Labor Standards Act of 1938 and as amended (52 Stat. 1060).

7-1.01C Contractor's Licensing Laws

- Attention is directed to the provisions of Chapter 9 of Division 3 of the Business and Professions Code concerning the licensing of contractors.
- All bidders and contractors shall be licensed in accordance with the laws of this State and any bidder or contractor not so licensed is subject to the penalties imposed by those laws.
- Attention is also directed to the requirements in Public Contract Code Section 10164. In all projects where Federal funds are involved, the Contractor shall be properly licensed at the time the contract is awarded.

7-1.01D Vehicle Code

- Pursuant to the authority contained in Vehicle Code Section 591, the Department has determined that within those areas that are within the limits of the project and are open to public traffic, the Contractor shall comply with all the requirements set forth in Divisions 11, 12, 13, 14 and 15 of the Vehicle Code.
- Attention is directed to the statement in Vehicle Code Section 591 that this section shall not relieve the Contractor or any person from the duty of exercising due care. The Contractor shall take all necessary precautions for safe operation of the Contractor's equipment and the protection of the public from injury and damage from the Contractor's equipment.

7-1.01E Trench Safety

- Attention is directed to the requirements in Section 6705 of the Labor Code concerning trench excavation safety plans.

7-1.01F Air Pollution Control

- The Contractor shall comply with all air pollution control rules, regulations, ordinances and statutes which apply to any work performed pursuant to the contract, including any air pollution control rules, regulations, ordinances and statutes, specified in Section 11017 of the Government Code.
- Unless otherwise provided in the special provisions, material to be disposed of shall not be burned, either inside or outside the highway right of way.

7-1.01G Water Pollution

- The Contractor shall exercise every reasonable precaution to protect streams, lakes, reservoirs, bays, and coastal waters from pollution with fuels, oils, bitumens, calcium chloride and other harmful materials and shall conduct and schedule operations so as to avoid or minimize muddying and silting of streams, lakes,

reservoirs, bays and coastal waters. Care shall be exercised to preserve roadside vegetation beyond the limits of construction.

- Water pollution control work is intended to provide prevention, control and abatement of water pollution to streams, waterways and other bodies of water, and shall consist of constructing those facilities which may be shown on the plans, specified herein or in the special provisions, or directed by the Engineer.
- In order to provide effective and continuous control of water pollution it may be necessary for the Contractor to perform the contract work in small or multiple units, on an out of phase schedule, and with modified construction procedures. The Contractor shall provide temporary water pollution control measures, including but not limited to, dikes, basins, ditches, and applying straw and seed, which become necessary as a result of the Contractor's operations. The Contractor shall coordinate water pollution control work with all other work done on the contract.
- Before starting any work on the project, the Contractor shall submit, for acceptance by the Engineer, a program to control water pollution effectively during construction of the project. The program shall show the schedule for the erosion control work included in the contract and for all water pollution control measures which the Contractor proposes to take in connection with construction of the project to minimize the effects of the operations upon adjacent streams and other bodies of water. The Contractor shall not perform any clearing and grubbing or earthwork on the project, other than that specifically authorized in writing by the Engineer, until the program has been accepted.
- If the measures being taken by the Contractor are inadequate to control water pollution effectively, the Engineer may direct the Contractor to revise the operations and the water pollution control program. The directions will be in writing and will specify the items of work for which the Contractor's water pollution control measures are inadequate. No further work shall be performed on those items until the water pollution control measures are adequate and, if also required, a revised water pollution control program has been accepted.
- The Engineer will notify the Contractor of the acceptance or rejection of any submitted or revised water pollution control program in not more than 5 working days.
- The State will not be liable to the Contractor for failure to accept all or any portion of an originally submitted or revised water pollution control program, nor for any delays to the work due to the Contractor's failure to submit an acceptable water pollution control program.
- The Contractor may request the Engineer to waive the requirement for submission of a written program for control of water pollution when the nature of the Contractor's operation is such that erosion is not likely to occur. Waiver of this requirement will not relieve the Contractor from responsibility for compliance with the other provisions of this section. Waiver of the requirement for a written program for control of water pollution will not preclude requiring submittal of a written program at a later time if the Engineer deems it necessary because of the effect of the Contractor's operations.
- Unless otherwise approved by the Engineer in writing, the Contractor shall not expose a total area of erosible earth material, which may cause water pollution,

exceeding 750,000 square feet for each separate location, operation or spread of equipment before either temporary or permanent erosion control measures are accomplished.

- Where erosion which will cause water pollution is probable due to the nature of the material or the season of the year, the Contractor's operations shall be so scheduled that permanent erosion control features will be installed concurrently with or immediately following grading operations.
- Nothing in the terms of the contract nor in the provisions in this Section 7-1.01G shall relieve the Contractor of the responsibility for compliance with Sections 5650 and 12015 of the Fish and Game Code, or other applicable statutes relating to prevention or abatement of water pollution.
- When borrow material is obtained from other than commercially operated sources, erosion of the borrow site during and after completion of the work shall not result in water pollution. The material source shall be finished, where practicable, so that water will not collect or stand therein.
- The requirements of this section shall apply to all work performed under the contract and to all non-commercially operated borrow or disposal sites used for the project.
- The Contractor shall also conform to the following provisions:

1. Where working areas encroach on live streams, barriers adequate to prevent the flow of muddy water into streams shall be constructed and maintained between working areas and streams, and during construction of the barriers, muddying of streams shall be held to a minimum.
2. Removal of material from beneath a flowing stream shall not be commenced until adequate means, such as a bypass channel, are provided to carry the stream free from mud or silt around the removal operations.
3. Should the Contractor's operations require transportation of materials across live streams, the operations shall be conducted without muddying the stream. Mechanized equipment shall not be operated in the stream channels of the live streams except as may be necessary to construct crossings or barriers and fills at channel changes.
4. Water containing mud or silt from aggregate washing or other operations shall be treated by filtration, or retention in a settling pond, or ponds, adequate to prevent muddy water from entering live streams.
5. Oily or greasy substances originating from the Contractor's operations shall not be allowed to enter or be placed where they will later enter a live stream.
6. Portland cement or fresh portland cement concrete shall not be allowed to enter flowing water of streams.
7. When operations are completed, the flow of streams shall be returned as nearly as possible to a meandering thread without creating possible future bank erosion, and settling pond sites shall be graded so they will drain and will blend in with the surrounding terrain.
8. Material derived from roadway work shall not be deposited in a live stream channel where it could be washed away by high stream flows.

9. Where there is possible migration of anadromous fish in streams affected by construction on the project, the Contractor shall conduct work operations so as to allow free passage of the migratory fish.

- Compliance with the provisions in this section shall in no way relieve the Contractor from the responsibility to comply with the other provisions of the contract, in particular the responsibility for damage and for preservation of property.
- Full compensation for conforming to the provisions in this section shall be considered as included in the prices paid for the various items of work and no additional compensation will be allowed therefor.

7-1.01H Use of Pesticides

- The Contractor shall comply with all rules and regulations of the Department of Food and Agriculture, the Department of Health, the Department of Industrial Relations and all other agencies which govern the use of pesticides required in the performance of the work on the contract.
- Pesticides shall include but shall not be limited to herbicides, insecticides, fungicides, rodenticides, germicides, nematocides, bactericides, inhibitors, fumigants, defoliants, desiccants, soil sterilants and repellents.
- Any substance or mixture of substances intended for preventing, repelling, mitigating, or destroying weeds, insects, diseases, rodents, or nematodes and any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant shall be considered a pesticide.

7-1.01I Sound Control Requirements

- The Contractor shall comply with all local sound control and noise level rules, regulations and ordinances which apply to any work performed pursuant to the contract.
- Each internal combustion engine, used for any purpose on the job or related to the job, shall be equipped with a muffler of a type recommended by the manufacturer. No internal combustion engine shall be operated on the project without the muffler.

7-1.01J Assignment of Antitrust Actions

- The Contractor's attention is directed to the following requirements in Public Contract Code 7103.5 and Government Code Sections 4553 and 4554, which shall be applicable to the Contractor and the Contractor's subcontractors:

> "In entering into a public works contract or a subcontract to supply goods, services, or materials pursuant to a public works contract, the contractor or subcontractor offers and agrees to assign to the awarding body all rights, title, and interest in and to all causes of action it may have under Section 4 of the Clayton Act (15 U.S.C. Sec. 15) or under the Cartwright Act (Chapter 2 (commencing with Section 16700) of Part 2 of Division 7 of the Business and Professions Code), arising from purchases of goods, services, or materials pursuant to the public works contract or the subcontract. This assignment shall

be made and become effective at the time the awarding body tenders final payment to the contractor, without further acknowledgment by the parties.

"If an awarding body or public purchasing body receives, either through judgment or settlement, a monetary recovery for a cause of action assigned under this chapter, the assignor shall be entitled to receive reimbursement for actual legal costs incurred and may, upon demand, recover from the public body any portion of the recovery, including treble damages, attributable to overcharges that were paid by the assignor but were not paid by the public body as part of the bid price, less the expenses incurred in obtaining that portion of the recovery.

"Upon demand in writing by the assignor, the assignee shall, within one year from such demand, reassign the cause of action assigned under this part if the assignor has been or may have been injured by the violation of law for which the cause of action arose and (a) the assignee has not been injured thereby, or (b) the assignee declines to file a court action for the cause of action."

7-1.02 LOAD LIMITATIONS

Unless expressly permitted in the special provisions, construction equipment or vehicles of any kind which, laden or unladen, exceed the maximum weight limitations set forth in Division 15 of the Vehicle Code, shall not be operated over completed or existing treated bases, surfacing, pavement or structures in any areas within the limits of the project, whether or not the area is subject to weight limitations under Section 7-1.01D, "Vehicle Code," except as hereinafter provided in this Section 7-1.02.

After application of the curing seal, no traffic or Contractor's equipment will be permitted on cement treated base or lean concrete base for a period of 72 hours. After 72 hours, traffic and equipment operated on the base shall be limited to that used in paving operations and placing additional layers of cement treated base. No traffic or Contractor's equipment will be permitted on treated permeable base except for that equipment required to place the permeable base and the subsequent layer of pavement. Trucks used to haul treated base, portland cement concrete, or asphalt concrete shall enter onto the base to dump at the nearest practical entry point ahead of spreading equipment. Empty haul trucks shall exit from the base at the nearest practical exit point. Entry and exit points shall not be more than 1,000 feet ahead of spreading equipment except in locations where specifications prohibit operation of trucks outside the area occupied by the base or where steep slopes or other conditions preclude safe operation of hauling equipment. In those locations, entry and exit points shall be established at the nearest point ahead of spreading equipment permitted by specifications and allowing safe operation of hauling equipment. Damage to curing seal or base shall be repaired promptly by the Contractor, at the Contractor's expense, as directed by the Engineer.

Within the limits of the project and subject to the control of the Engineer, and provided that the Contractor, at the Contractor's expense, shall provide such protective measures as are deemed necessary by the Engineer and shall repair any damage caused by the operations, the Contractor will be permitted to:

(1) Make transverse crossings of those portions of an existing public road or street that are within the highway right of way, with construction equipment which exceeds the size or weight limitations set forth in Division 15 of the Vehicle Code.

(2) Make transverse crossings of treated bases, surfacing or pavement which are under construction or which have been completed, with construction equipment which exceeds the size or weight limitations set forth in Division 15 of the Vehicle Code.

(3) Cross bridge structures that are not open to public traffic and which are designed for HS20-44 Live Loading (culverts and pipes excluded), with construction equipment which exceeds the size or weight limitations set forth in Division 15 of the Vehicle Code, but not exceeding the load limitations hereinafter specified, provided that the Contractor furnishes to the Engineer the dimensions and maximum axle loadings of equipment proposed for use on bridge structures:

(a) The maximum loading on bridge structures due to pneumatic-tired truck and trailer combinations shall not exceed (1) 28,000 pounds for single axles, (2) 48,000 pounds for tandem axles, nor (3) 60,000 pounds total gross load for single vehicles or 110,000 pounds total gross load for truck and trailer or semi-trailer combinations.

(b) The loading on bridge structures due to 2 and 3 axle pneumatic-tired earthmovers shall not exceed that shown in the following table.

Allowable Construction Loading On Bridges
For 2 and 3 Axle Earthmovers

Spacing of Bridge Girders (center to center in feet)	Maximum Axle Loading (in pounds)
4	28,000
5	29,000
6	30,000
7	32,000
8	34,000
9	37,000
10 and over	40,000

Minimum axle spacing:
For 3-axle earthmovers
Axles 1 to 2 = 8 feet
Axles 2 to 3 = 20 feet
For 2-axle earthmovers
Axles 1 to 2 = 20 feet

(4) Move equipment within the limits of the projectover completed or existing base, surfacing, pavement and structures, whether or not open to the public, in accordance with the limitations and conditions in the "Permit Policy" of the Department of Transportation.

Within the limits of the project and subject to the condition that the Contractor shall repair, at the Contractor's expense, any damage caused thereby, the Contractor will be permitted to cross culverts and pipes with construction equipment which exceeds the size or weight limitations set forth in Division 15 of the Vehicle Code in accordance with the conditions set forth on the plans. If the conditions are not set forth on the plans, the provisions in the first paragraph in this Section 7-1.02 will apply.

Should the Contractor desire to increase the load carrying capacity of a structure or structures which are to be constructed as a part of the contract, in order to facilitate the Contractor's own operations, the Contractor may request the Engineer to consider redesigning the structure or structures. Proposals by the Contractor to increase the load carrying capacity of structures above 130,000 pounds per single axle or pair of axles less than 8 feet apart, or above 330,000 pounds total gross vehicle weight, will not be approved. The request shall include a description of the structure or structures involved and a detailed description of the overloads to be carried, the date the revised plans would be required, and a statement that the Contractor agrees to pay all costs involved in the strengthening of the structure or structures, including the cost of revised plans, and further that the Contractor agrees that no extension of time will be allowed by reason of any delay to the work which may be due to the alteration of the structure or structures. If the Engineer determines that strengthening the structure or structures will be permitted, the Engineer will inform the Contractor of the estimated cost of the alterations, including engineering, and the date that revised plans could be furnished. If the cost and date are satisfactory to the Contractor, the Engineer will prepare a change order providing for the agreed upon alterations.

7-1.03 PAYMENT OF TAXES

The contract prices paid for the work shall include full compensation for all taxes which the Contractor is required to pay, whether imposed by Federal, State or local government, including, without being limited to, Federal excise tax. No tax exemption certificate nor any document designed to exempt the Contractor from payment of any tax will be furnished to the Contractor by the Department, as to any tax on labor, services, materials, transportation, or any other items furnished pursuant to the contract.

7-1.04 PERMITS AND LICENSES

The Contractor shall procure all permits and licenses, pay all charges and fees, and give all notices necessary and incident to the due and lawful prosecution of the work.

The Environmental Quality Act (Public Resources Code, Sections 21000 to 21176, inclusive) may be applicable to permits, licenses and other authorizations which the Contractor must obtain from local agencies in connection with performing the work of the contract. The Contractor shall comply with the provisions of those statutes in obtaining the permits, licenses and other authorizations and they shall be obtained in sufficient time to prevent delays to the work.

- In the event that the Department has obtained permits, licenses or other authorizations, applicable to the work, in conformance with the requirements in the Environmental Quality Act, the Contractor shall comply with the provisions of those permits, licenses and other authorizations.

7-1.05 PATENTS

- The Contractor shall assume all costs arising from the use of patented materials, equipment, devices or processes used on or incorporated in the work, and agrees to indemnify and save harmless the State of California, the Director, the Engineer, and their duly authorized representatives, from all suits at law, or actions of every nature for, or on account of the use of any patented materials, equipment, devices or processes.

7-1.06 SAFETY AND HEALTH PROVISIONS

- The Contractor shall conform to all applicable occupational safety and health standards, rules, regulations and orders established by the State of California.
- Working areas utilized by the Contractor to perform work during the hours of darkness, shall be lighted to conform to the minimum illumination intensities established by California Division of Occupational Safety and Health Construction Safety Orders.
- All lighting fixtures shall be mounted and directed in a manner precluding glare to approaching traffic.
- Full compensation for conforming to the provisions in this section shall be considered as included in the contract prices paid for the various items of work involved and no separate payment will be made therefor.

7-1.07 (BLANK)

7-1.08 PUBLIC CONVENIENCE

- This Section 7-1.08 defines the Contractor's responsibility with regard to convenience of the public and public traffic in connection with the Contractor's operations.
- Attention is directed to Section 4-1.04, "Detours," for provisions relating to the passage of traffic around the work over detours.
- Attention is directed to Section 7-1.09, "Public Safety," for provisions relating to the Contractor's responsibility for the safety of the public. The provisions in Section 7-1.09 are in addition to the provisions in this Section 7-1.08, and the Contractor will not be relieved of the responsibilities as set forth in Section 7-1.09 by reason of conformance with any of the provisions in this Section 7-1.08.
- Attention is directed to Section 12, "Construction Area Traffic Control Devices," for provisions concerning flagging and traffic-handling equipment and devices used in carrying out the provisions in this Section 7-1.08 and Section 7-1.09.
- In the event of a suspension of the work, attention is directed to Section 8-1.05, "Temporary Suspension of Work."
- The Contractor shall so conduct operations as to offer the least possible obstruction and inconvenience to the public and shall have under construction no

greater length or amount of work than can be prosecuted properly with due regard to the rights of the public.

- Unless otherwise provided in the special provisions, all public traffic shall be permitted to pass through the work with as little inconvenience and delay as possible. Where possible, public traffic shall be routed on new or existing paved surfaces.
- Spillage resulting from hauling operations along or across any public traveled way shall be removed immediately by the Contractor at the Contractor's expense.
- Existing traffic signals and highway lighting shall be kept in operation for the benefit of the traveling public during progress of the work, and other forces will continue routine maintenance of existing systems.
- Construction operations shall be conducted in such a manner as to cause as little inconvenience as possible to abutting property owners.
- Convenient access to driveways, houses, and buildings along the line of the work shall be maintained and temporary approaches to crossings or intersecting highways shall be provided and kept in good condition. When the abutting property owner's access across the right of way line is to be eliminated, or to be replaced under the contract by other access facilities, the existing access shall not be closed until the replacement access facilities are usable.
- The Contractor may be required to cover certain signs which regulate or direct public traffic to roadways that are not open to traffic. The Engineer will determine which signs shall be covered. Except as otherwise provided for construction area signs in Section 12, "Construction Area Traffic Control Devices," furnishing, installing and removing covers will be paid for as extra work as provided in Section 4-1.03D.
- Roadway excavation and the construction of embankments shall be conducted in such a manner as to provide a reasonably smooth and even surface satisfactory for use by public traffic at all times; sufficient fill at culverts and bridges to permit traffic to cross shall be placed in advance of other grading operations; and if ordered by the Engineer roadway cuts shall be excavated in lifts and embankments constructed part width at a time, construction being alternated from one side to the other and traffic routed over the side opposite the one under construction. Culvert installation or culvert construction shall be conducted on but one-half the width of the traveled way at a time, and that portion of the traveled way being used by public traffic shall be kept open and unobstructed until the opposite side of the traveled way is ready for use by traffic.
- Upon completion of rough grading at the grading plane, or placing any subsequent layer thereon, the surface of the roadbed shall be brought to a smooth, even condition free of humps and depressions, satisfactory for the use of public traffic.
- After the surface of the roadbed has been brought to a smooth and even condition for the passage of public traffic as above provided, any work ordered by the Engineer for the accommodation of public traffic prior to commencing subgrade operations will be paid for as extra work as provided in Section 4-1.03D. After subgrade preparation for a specified layer of material has been completed, the Contractor shall, at the Contractor's expense, repair any damage to the roadbed or

completed subgrade, including damage caused by the Contractor's operations or use by public traffic.

- While subgrade and paving operations are underway, public traffic shall be permitted to use the shoulders and, if half-width paving methods are used, shall also be permitted to use the side of the roadbed opposite the one under construction. When sufficient width is available, a passageway wide enough to accommodate at least 2 lanes of traffic shall be kept open at locations where subgrade and paving operations are in active progress. Any shaping of shoulders or reshaping of subgrade necessary for the accommodation of public traffic thereon during subgrade preparation and paving operations will be paid for as extra work as provided in Section 4-1.03D.
- When ordered by the Engineer, the Contractor shall furnish a pilot car and driver and flaggers for the purpose of expediting the passage of public traffic through the work under one-way controls, and the cost thereof will be paid for as extra work as provided in Section 4-1.03D, except that the cost of flaggers furnished for this purpose will be paid for as provided in Section 12-2.02, "Flagging Costs." At locations where traffic is being routed through construction under one-way controls and when ordered by the Engineer, the movement of the Contractor's equipment from one portion of the work to another shall be governed in accordance with the one-way controls.
- Water or dust palliative shall be applied if ordered by the Engineer for the alleviation or prevention of dust nuisance as provided in Section 10, "Dust Control."
- In order to expedite the passage of public traffic through or around the work and where ordered by the Engineer, the Contractor shall install signs, lights, flares, temporary railing (Type K), barricades and other facilities for the sole convenience and direction of public traffic. Also where directed by the Engineer, the Contractor shall furnish competent flaggers whose sole duties shall consist of directing the movement of public traffic through or around the work. The cost of furnishing and installing the signs, lights, flares, temporary railing (Type K), barricades, and other facilities, not to be paid for as separate contract items, will be paid for as extra work as provided in Section 4-1.03D.
- The cost of furnishing flaggers for the sole convenience and direction of public traffic will be paid for as provided in Section 12-2.02, "Flagging Costs."
- The Contractor will be required to pay the cost of replacing or repairing all facilities installed under extra work for the convenience or direction or warning of public traffic that are lost while in the Contractor's custody, or are damaged by reason of the Contractor's operations to such an extent as to require replacement or repair, and deductions from any moneys due or to become due the Contractor will be made to cover the cost.
- Whenever a section of surfacing, pavement or the deck of a structure has been completed, the Contractor shall open it to use by public traffic if the Engineer so orders or may open it to use by public traffic if the Engineer so consents. In either case the Contractor will not be allowed any compensation due to any delay, hindrance or inconvenience to the Contractor's operations caused by public traffic, but will thereupon be relieved of responsibility for damage to completed permanent

facilities caused by public traffic, within the limits of that use. The Contractor will not be relieved of any other responsibility under the contract nor will the Contractor be relieved of cleanup and finishing operations.

- Except as otherwise provided in this Section 7-1.08 or in the special provisions, full compensation for conforming to the provisions in this Section 7-1.08 shall be considered as included in the prices paid for the various contract items of work and no additional compensation will be allowed therefor.

7-1.09 PUBLIC SAFETY

- It is the Contractor's responsibility to provide for the safety of traffic and the public during construction.
- Attention is directed to Section 7-1.12, "Idemnification and Insurance."
- Attention is directed to Section 7-1.08, "Public Convenience," for provisions relating to the Contractor's responsibility for providing for the convenience of the public in connection with the Contractor's operations.
- Attention is directed to Section 12, "Construction Area Traffic Control Devices," for provisions concerning flagging and traffic-handling equipment and devices used in carrying out the provisions of Section 7-1.08 and this Section 7-1.09.
- Whenever the Contractor's operations create a condition hazardous to traffic or to the public, the Contractor shall, at the Contractor's expense and without cost to the State, furnish, erect and maintain those fences, temporary railing (Type K), barricades, lights, signs and other devices and take such other protective measures that are necessary to prevent accidents or damage or injury to the public.
- Fences, temporary railing (Type K), barricades, lights, signs, and other devices furnished, erected and maintained by the Contractor, at the Contractor's expense, are in addition to any construction area traffic control devices for which payment is provided for elsewhere in the specifications.
- The Contractor shall also furnish such flaggers as are necessary to give adequate warning to traffic or to the public of any dangerous conditions to be encountered, and payment therefor will be made as provided in Section 12-2.02, "Flagging Costs."
- Signs, lights, flags, and other warning and safety devices and their use shall conform to the requirements set forth in Part 6 of the MUTCD and of the MUTCD California Supplement. Signs or other protective devices furnished and erected by the Contractor, at the Contractor's expense, as above provided, shall not obscure the visibility of, nor conflict in intent, meaning and function of either existing signs, lights and traffic control devices or any construction area signs and traffic control devices for which furnishing of, or payment for, is provided elsewhere in the specifications. Signs furnished and erected by the Contractor, at the Contractor's expense, shall be approved by the Engineer as to size, wording and location.
- The installation of general roadway illumination shall not relieve the Contractor of the responsibility for furnishing and maintaining any of the protective facilities herein before specified.
- Construction equipment shall enter and leave the highway via existing ramps and crossovers and shall move in the direction of public traffic. All movements of

workmen and construction equipment on or across lanes open to public traffic shall be performed in a manner that will not endanger public traffic.

- The Contractor's trucks or other mobile equipment which leave a freeway lane, that is open to public traffic, to enter the construction area, shall slow down gradually in advance of the location of the turnoff to give following public traffic an opportunity to slow down.
- When leaving a work area and entering a roadway carrying public traffic, the Contractor's equipment, whether empty or loaded, shall in all cases yield to public traffic.
- Lanes, ramps and shoulders shall be closed in accordance with the details shown on the plans, the provisions of Section 12, "Construction Area Traffic Control Devices," and as provided in the special provisions.
- The Contractor shall notify the Engineer not less than 18 days and not more than 90 days prior to the anticipated start of an operation that will change the vertical or horizontal clearance available to public traffic (including shoulders).
- Pedestrian openings through falsework shall be paved or provided with full width continuous wood walks and shall be kept clear. Pedestrians shall be protected from falling objects and curing water for concrete. Overhead protection for pedestrians shall extend not less than 4 feet beyond the edge of the bridge deck. All pedestrian openings through falsework shall be illuminated in conformance with the provisions in Section 86-6.11, "Falsework Lighting."
- When vertical clearance is temporarily reduced to 15 feet, or less, low clearance warning signs shall be placed in accordance with Part 2 of the MUTCD and the MUTCD California Supplement, and as directed by the Engineer. Signs shall conform to the dimensions, color, and legend requirements of the MUTCD, the MUTCD California Supplement, and these specifications except that the signs shall have black letters and numbers on an orange retroreflective background. W12-2P signs shall be illuminated so that the signs are clearly visible.
- No material or equipment shall be stored where it will interfere with the free and safe passage of public traffic, and at the end of each day's work and at other times when construction operations are suspended for any reason, the Contractor shall remove all equipment and other obstructions from that portion of the roadway open for use by public traffic.
- Temporary facilities which the Contractor uses to perform the work shall not be installed or placed where they will interfere with the free and safe passage of public traffic.
- Temporary facilities which could be a hazard to public safety if improperly designed shall comply with design requirements specified in the contract for those facilities or, if none are specified, with standard design criteria or codes appropriate for the facility involved. Working drawings and design calculations for the temporary facilities shall be prepared and signed by an engineer who is registered as a Civil Engineer in the State of California and shall be submitted to the Engineer for approval pursuant to Section 5-1.02, "Plans and Working Drawings." The submittals shall designate thereon the standard design criteria or codes used. Installation of the temporary facilities shall not start until the Engineer has reviewed and approved the drawings.

- Should the Contractor appear to be neglectful or negligent in furnishing warning devices and taking protective measures as above provided, the Engineer may direct attention to the existence of a hazard and the necessary warning devices shall be furnished and installed and protective measures taken by the Contractor at the Contractor's expense. Should the Engineer point out the inadequacy of warning devices and protective measures, that action on the part of the Engineer shall not relieve the Contractor from responsibility for public safety or abrogate the obligation to furnish and pay for these devices and measures.
- Provision for the payment for signs, lights, flares, temporary railing (Type K), barricades, and other facilities by extra work as provided in Section 7-1.08, "Public Convenience," or by contract item as provided in Section 12, "Construction Area Traffic Control Devices," shall in nowise relieve the Contractor from the responsibility as provided in this Section 7-1.09.
- Except as otherwise provided in this Section 7-1.09 or in the special provisions, full compensation for conforming to all of the provisions in this Section 7-1.09 shall be considered as included in the prices paid for the various contract items of work and no additional compensation will be allowed therefor.

7-1.10 USE OF EXPLOSIVES

- When explosives are used, the Contractor shall exercise the utmost care not to endanger life or property.
- In advance of doing any blasting work within 200 feet of any railroad's tracks or structures, the Contractor shall notify the railroad of the location, date, time and approximate duration of the blasting operations.

7-1.11 PRESERVATION OF PROPERTY

- Attention is directed to Section 7-1.12, "Idemnification and Insurance," and to Section 8-1.10, "Utility and Non-Highway Facilities." Due care shall be exercised to avoid injury to existing highway improvements or facilities, utility facilities, adjacent property, and roadside trees, shrubs and other plants that are not to be removed.
- Roadside trees, shrubs and other plants that are not to be removed, and pole lines, fences, signs, markers and monuments, buildings and structures, conduits, pipelines under or above ground, sewer and water lines, all highway facilities and any other improvements or facilities within or adjacent to the highway shall be protected from injury or damage, and if ordered by the Engineer, the Contractor shall provide and install suitable safeguards, approved by the Engineer, to protect the objects from injury or damage. If the objects are injured or damaged by reason of the Contractor's operations, the objects shall be replaced or restored at the Contractor's expense. The facilities shall be replaced or restored to a condition as good as when the Contractor entered upon the work, or as good as required by the specifications accompanying the contract, if any of the objects are a part of the work being performed under the contract. The Engineer may make or cause to be made those temporary repairs that are necessary to restore to service any damaged highway facility. The cost of the repairs shall be borne by the Contractor and may be deducted from any moneys due or to become due to the Contractor under the contract.

- The fact that any underground facility is not shown upon the plans shall not relieve the Contractor of the responsibility under Section 8-1.10, "Utility and Non-Highway Facilities." It shall be the Contractor's responsibility, pursuant thereto, to ascertain the location of those underground improvements or facilities which may be subject to damage by reason of the Contractor's operations.
- Full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in protecting or repairing property as specified in this Section 7-1.11, shall be considered as included in the prices paid for the various contract items of work and no additional compensation will be allowed therefor.

7-1.12 INDEMNIFICATION AND INSURANCE

- The Contractor's obligations regarding indemnification of the State of California and the requirements for insurance shall conform to the provisions in Section 3-1.025, "Insurance Policies," and Sections 7-1.12A, "Indemnification," and 7-1.12B, "Insurance," of this Section 7-1.12.

7-1.12A Indemnification

- With the exception that this section shall in no event be construed to require indemnification by the Contractor to a greater extent than permitted by law, the Contractor shall defend, indemnify and save harmless the State, including its officers, directors, agents (excluding agents who are design professionals), and employees, and each of them (Indemnitees), from any and all claims, demands, causes of action, damages, costs, expenses, actual attorneys' fees, losses or liabilities, in law or in equity, of every kind and nature whatsoever (Claims), arising out of or in connection with the Contractor's performance of this contract for:

A. Bodily injury including, but not limited to, bodily injury, sickness or disease, emotional injury or death to persons, including, but not limited to, the public, any employees or agents of the Contractor, State, Department, or any other contractor and;
B. Damage to property of anyone including loss of use thereof; caused or alleged to be caused in whole or in part by any negligent or otherwise legally actionable act or omission of the Contractor or anyone directly or indirectly employed by the Contractor or anyone for whose acts the Contractor may be liable.

- Except as otherwise provided by law, the indemnification provisions above shall apply regardless of the existence or degree of fault of Indemnitees. The Contractor, however, shall not be obligated to indemnify Indemnitees for Claims arising from conduct delineated in Civil Code Section 2782. Further, the Contractor's indemnity obligation shall not extend to Claims to the extent they arise from any defective or substandard condition of the roadway which existed at or prior to the time the Contractor commenced work, unless this condition has been changed by the work or the scope of the work requires the Contractor to maintain existing Roadway facilities and the claim arises from the Contractor's failure to maintain. The Contractor's indemnity obligation shall extend to Claims arising

after the work is completed and accepted only if these Claims are directly related to alleged acts or omissions of the Contractor which occurred during the course of the work. No inspection by the Department, its employees or agents shall be deemed a waiver by the Department of full compliance with the requirements of this section.

- The Contractor's obligation to defend and indemnify shall not be excused because of the Contractor's inability to evaluate liability or because the Contractor evaluates liability and determines that the Contractor is not liable to the claimant. The Contractor will respond within 30 days to the tender of any claim for defense and indemnity by the State, unless this time has been extended by the State. If the Contractor fails to accept or reject a tender of defense and indemnity within 30 days, in addition to any other remedy authorized by law, so much of the money due the Contractor under and by virtue of the contract as shall reasonably be considered necessary by the Department, may be retained by the State until disposition has been made of the claim or suit for damages, or until the Contractor accepts or rejects the tender of defense, whichever occurs first.
- With respect to third party claims against the Contractor, the Contractor waives any and all rights of any type to express or implied indemnity against the State, its directors, officers, employees, or agents (excluding agents who are design professionals).

7-1.12B Insurance

- Insurance shall conform to the following requirements:

7-1.12B(1) Casualty Insurance

- The Contractor shall, at the Contractor's expense, procure and maintain insurance on all of its operations with companies acceptable to the Department as follows. All insurance shall be kept in full force and effect from the beginning of the work through final acceptance by the State. In addition, the Contractor shall maintain completed operations coverage with a carrier acceptable to the Department through the expiration of the patent deficiency in construction statute of repose set forth in Section 337.1 of the Code of Civil Procedure.

7-1.12B(1)(a) Workers' Compensation and Employer's Liability Insurance

- Workers' Compensation insurance shall be provided as specified in Section 7-1.01A(6), "Workers' Compensation." Employer's Liability Insurance shall be provided in amounts not less than:

(a) $1,000,000 for each accident for bodily injury by accident.
(b) $1,000,000 policy limit for bodily injury by disease.
(c) $1,000,000 for each employee for bodily injury by disease.

- If there is an exposure of injury to the Contractors' employees under the U.S. Longshoremen's and Harbor Workers' Compensation Act, the Jones Act or under laws, regulations or statutes applicable to maritime employees, coverage shall be included for such injuries or claims.

7-1.12B(1)(b) Liability Insurance

- The Contractor shall carry General Liability and Umbrella or Excess Liability Insurance covering all operations by or on behalf of the Contractor providing insurance for bodily injury liability, and property damage liability for the limits of liability indicated below and including coverage for:

(a) premises, operations and mobile equipment.
(b) products and completed operations.
(c) broad form property damage (including completed operations).
(d) explosion, collapse and underground hazards.
(e) personal injury.
(f) contractual liability.

7-1.12B(1)(c) Liability Limits/Additional Insureds

- The limits of liability shall be at least:

(a) $2,000,000 for each occurrence (combined single limit for bodily injury and property damage).
(b) $2,000,000 aggregate for products-completed operations.
(c) $4,000,000 general aggregate. This general aggregate limit shall apply separately to the Contractor's work under this Contract.
(d) $15,000,000 umbrella or excess liability. For projects over $25,000,000 only, an additional $10,000,000 umbrella or excess liability (for a total of $25,000,000). Umbrella or excess policy shall include products liability completed operations coverage and may be subject to $15,000,000 or $25,000,000 aggregate limits. Further, the umbrella or excess policy shall contain a clause stating that it takes effect (drops down) in the event the primary limits are impaired or exhausted.

- The State and the Department, including their officers, directors, agents (excluding agents who are design professionals), and State employees, shall be named as additional insureds under the General Liability and Umbrella Liability Policies with respect to liability arising out of or connected with work or operations performed by or on behalf of the Contractor under this contract. Coverage for such additional insureds shall not extend to liability:

(1) arising from any defective or substandard condition of the Roadway which existed at or prior to the time the Contractor commenced work, unless such condition has been changed by the work or the scope of the work requires the Contractor to maintain existing Roadway facilities and the claim arises from the Contractor's failure to maintain; or
(2) for claims occurring after the work is completed and accepted unless these claims are directly related to alleged acts or omissions of the Contractor which occurred during the course of the work; or
(3) to the extent prohibited by Section 11580.04 of the Insurance Code.

- The policy shall stipulate that the insurance afforded the additional insureds shall apply as primary insurance. Any other insurance or self-insurance maintained by the Department or State will be excess only and shall not be called upon to contribute with this insurance. Such additional insured coverage shall be provided by a policy provision or by an endorsement providing coverage at least as broad as Additional Insured (Form B) endorsement form CG 2010, as published by the Insurance Services Office (ISO).

7-1.12B(2) Automobile Liability Insurance

- The Contractor shall carry automobile liability insurance, including coverage for all owned, hired and non-owned automobiles. The primary limits of liability shall be not less than $1,000,000 combined single limit each accident for bodily injury and property damage. The umbrella or excess liability coverage required under Section 7-1.12B(1)(c), "Liability Limits/Additional Insureds," shall also apply to automobile liability.

7-1.12B(3) Policy Forms, Endorsements and Certificates

- The Contractor's General Liability Insurance shall be provided under Commercial General Liability policy form No. CG 0001 as published by the Insurance Services Office (ISO) or under a policy form at least as broad as policy form No. CG 0001.
- Evidence of insurance in the form of copies of insurance policies, Certificates of Insurance and any self-insurance coverage documentaion, including the required "additional insured" endorsements, shall be furnished by the Contractor to the Department as specified in Sections 3-1.025, "Insurance Policies," and 3-1.03, "Execution of Contract." The evidence of insurance shall provide that there will be no cancellation, lapse, or reduction of coverage without thirty (30) days' prior written notice to the Department. Insurance policies and Certificates of Insurance, furnished as evidence of required insurance, for the General Liability, Auto Liability and Umbrella-Excess Liability policies shall set forth deductible amounts applicable to each policy and all exclusions which are added by endorsement to each policy. The Department may expressly allow deductible clauses, which it does not consider excessive, overly broad, or harmful to the interests of the State. Standard ISO form No. CG 0001 or similar exclusions will be allowed provided they are not inconsistent with the requirements of Section 3-1.025, "Insurance Policies," and this section. Allowance of any additional exclusions is at the discretion of the Department. Regardless of the allowance of exclusions or deductions by the Department, the Contractor shall be responsible for any deductible amount and shall warrant that the coverage provided to the Department is consistent with the requirements of this section.

7-1.12B(4) Enforcement

- The Department may take any steps as are necessary to assure Contractor's compliance with its obligations. Should any insurance policy lapse or be canceled during the contract period the Contractor shall, within thirty (30) days prior to the effective expiration or cancellation date, furnish the Department with evidence of renewal or replacement of the policy. Failure to continuously maintain insurance coverage as herein provided is a material breach of contract. In the event the

Contractor fails to maintain any insurance coverage required, the Department may, but is not required to, maintain this coverage and charge the expense to the Contractor or terminate this Contract. The required insurance shall be subject to the approval of Department, but any acceptance of copies of insurance policies, insurance certificates and self-insurance documentation by the Department shall in no way limit or relieve the Contractor of the Contractor's duties and responsibilities under the Contract to indemnify, defend and hold harmless the State, its officers, agents, and employees. Insurance coverage in the minimum amounts set forth herein shall not be construed to relieve the Contractor for liability in excess of such coverage, nor shall it preclude the State from taking other actions as is available to it under any other provision of the contract or law. Failure of the Department to enforce in a timely manner any of the provisions of this section shall not act as a waiver to enforcement of any of these provisions at a later date.

7-1.12B(5) Self-Insurance

Self-insurance programs and self-insured retentions in insurance policies are subject to separate annual review and approval by the State of evidence of the Contractor's financial capacity to respond. Additionally, self-insurance programs or retentions must provide the State with at least the same protection from liability and defense of suits as would be afforded by first-dollar insurance.

7-1.12B(6) Miscellaneous

Nothing contained in the Contract is intended to make the public or any member thereof a third party beneficiary of the Insurance or Indemnity provisions of these Standard Specifications, nor is any term, condition or other provision of the Contract intended to establish a standard of care owed to the public or any member thereof.

7-1.125 Legal Actions Against the Department

In the event litigation is brought against the Department concerning compliance by the Department with State or Federal laws, rules or regulations applicable to highway work, the provisions of this Section 7-1.125 shall apply.

(A) If, pursuant to court order, the Department prohibits the Contractor from performing all or any portion of the work, the delay will be considered a right of way delay within the meaning of Section 8-1.09, "Right of Way Delays," unless the contract is terminated as hereinafter provided.

(B) If, pursuant to court order (other than anorder to show cause) the Department is prohibited from requiring the Contractor to perform all or any portion of the work, the Department may, if it so elects, eliminate the enjoined work pursuant to Section 4-1.03, "Changes," or terminate the contract.

(C) If the final judgment in the action prohibits the Department from requiring the Contractor to perform all or any portion of the work, the Department will either eliminate the enjoined work pursuant to Section 4-1.03, "Changes," or terminate the contract.

(D) If the contract is to be terminated, the termination and the determination of the total compensation payable to the Contractor shall be governed by the provisions in Section 8-1.11, "Termination of Contract."

7-1.13 DISPOSAL OF MATERIAL OUTSIDE THE HIGHWAY RIGHT OF WAY

- If the Contractor elects to dispose of materials at locations other than those where arrangements have been made by the Department, or, if material is to be disposed of and the Department has not made arrangements for disposal of the material, the Contractor shall make arrangements for disposing of the materials outside the highway right of way and shall pay all costs involved. Arrangements shall include, but not be limited to, entering into agreements with property owners and obtaining necessary permits, licenses and environmental clearances. Before disposing of any material outside the highway right of way, the Contractor shall furnish to the Engineer satisfactory evidence that the Contractor has entered into agreements with the property owners of the site involved and has obtained the permits, licenses and clearances.
- When any material is to be disposed of outside the highway right of way, and the Department has not made arrangements for disposal of the material, the Contractor shall first obtain written authorization from the property owner on whose property the disposal is to be made and the Contractor shall file with the Engineer the authorization or a certified copy thereof together with a written release from the property owner absolving the State from any and all responsibility in connection with the disposal of material on the property. Before any material is disposed of on the property, the Contractor shall obtain written permission from the Engineer to dispose of the material at the location designated in the authorization.
- When material is disposed of as above provided and the disposal location is visible from a highway, the Contractor shall dispose of the material in a neat and uniform manner to the satisfaction of the Engineer.
- Where the Department has made arrangements with owners of land in the vicinity of a project for the disposal of materials on an owner's property, the arrangements are made solely for the purpose of providing all bidders an equal opportunity to dispose of the materials on the property. Bidders or Contractors may, upon written request, inspect the documents evidencing the arrangements between property owners and the Department. The Contractor may, if the Contractor so elects, exercise any rights that have been obtained, which may be exercised by a Contractor under the arrangements, subject to and upon the conditions hereinafter set forth.
- Such arrangements are not a part of the contract and it is expressly understood and agreed that the Department assumes no responsibility to the bidder or Contractor whatsoever in respect to the arrangements made with the property owner to dispose of materials thereon and that the Contractor shall assume all risks in connection with the use of the property, the terms upon which the use shall be made, and there is no warranty or guaranty, either express or implied, as to the quantity or types of materials that can be disposed of on the property.
- In those instances in which the Department has compiled "Materials Information" as referred to in Section 2-1.03, "Examination of Plans,

Specifications, Contract, and Site of Work," the compilation will include the documents setting forth the arrangement made with some of the property owners for the disposal of material on those owners' properties. The inclusion of the documents therein shall not in any respect operate as a waiver of any of the provisions in this Section 7-1.13 concerning the documents.

- The bidder or Contractor is cautioned to make such independent investigation and examination as the Contractor deems necessary to be satisfied as to the quantity and types of materials which may be disposed of on the property and the rights, duties and obligations acquired or undertaken under the arrangement with the property owner.
- Notwithstanding that the Contractor may elect to dispose of materials on any such property owner's property, no material may be disposed of on that property unless the Contractor has first either:

(1) Executed a document that will guarantee to hold the owner harmless from all claims for injury to persons or damage to property resulting from the Contractor's operations on the property owner's premises and also agree to conform to all other provisions set forth in the arrangement made between the Department and the property owner. The document will be prepared by the Engineer for execution by the Contractor, or
(2) Entered into an agreement with the owner of the disposal site on any terms mutually agreeable to the owner and the Contractor; provided that the Contractor shall furnish to the Engineer a release, in a form satisfactory to the Engineer, executed by the owner, relieving the Department of any and all obligations under the Department's arrangement with the owner.

- If the Contractor elects to dispose of material under (1), the use of the site shall be subject to the terms, conditions and limitations of the arrangement made between the property owner and the Department and the Contractor shall pay those charges that are provided for in the arrangement made by the Department with the property owner, and deductions will be made from any moneys due or that may become due the Contractor under the contract sufficient to cover the charges for the material disposed of.
- If the Contractor elects to dispose of material under (2), the Contractor shall pay those charges that are provided for in the agreement between the owner and the Contractor and deductions will not be made from any moneys due or that may become due the Contractor under the contract to cover the charges.
- Before acceptance of the contract, the Engineer may require the Contractor to submit written evidence that the owner of the disposal site is satisfied that the Contractor has satisfactorily complied with the provisions of either - (1), the arrangement between the Department and the owner, or (2), the agreement between the owner and the Contractor, as the case may be.
- Full compensation for all costs involved in disposing of materials as specified in this Section 7-1.13, including all costs of hauling, shall be considered as included in the price paid for the contract item of work involving the materials and no additional compensation will be allowed therefor.

7-1.14 COOPERATION

- Should construction be under way by other forces or by other contractors within or adjacent to the limits of the work specified or should work of any other nature be under way by other forces within or adjacent to those limits, the Contractor shall cooperate with all the other contractors or other forces to the end that any delay or hindrance to their work will be avoided. The right is reserved to perform other or additional work at or near the site (including material sources) at any time, by the use of other forces.
- When 2 or more contractors are employed on related or adjacent work, or obtain materials from the same material source, as provided in Section 6-2.02, "Possible Local Material Sources," or Section 6-2.03, "Mandatory Local Material Sources," each shall conduct their operations in such a manner as not to cause any unnecessary delay or hindrance to the other.
- Each contractor shall be responsible to the other for all damage to work, to persons or property caused to the other by their operations, and for loss caused the other due to unnecessary delays or failure to finish the work within the time specified for completion.

7-1.15 RELIEF FROM MAINTENANCE AND RESPONSIBILITY

- Upon the request of the Contractor, the Director may relieve the Contractor of the duty of maintaining and protecting certain portions of the work as described below, which have been completed in all respects in accordance with the requirements of the contract and to the satisfaction of the Engineer, and thereafter except with the Contractor's consent, the Contractor will not be required to do further work thereon. In addition, the action by the Director will relieve the Contractor of responsibility for injury or damage to those completed portions of the work resulting from use by public traffic or from the action of the elements or from any other cause but not from injury or damage resulting from the Contractor's own operations or from the Contractor's negligence.
- Portions of the work for which the Contractor may be relieved of the duty of maintenance and protection as provided in the above paragraph include, but are not limited to, the following:

(1) The completion of 0.3-mile of roadway or 0.3-mile of one roadway of a divided highway or a frontage road including the traveled way, shoulders, drainage control facilities, planned roadway protection work, lighting and any required traffic control and access facilities.
(2) A bridge or other structure of major importance.
(3) A complete unit of a traffic control signal system or of a highway lighting system.
(4) Non-highway facilities constructed for other agencies.

- However, nothing in this Section 7-1.15 providing for relief from maintenance and responsibility will be construed as relieving the Contractor of full responsibility for making good any defective work or materials found at any time before the formal written acceptance of the entire contract by the Director.

7-1.16 CONTRACTOR'S RESPONSIBILITY FOR THE WORK AND MATERIALS

Until the acceptance of the contract, the Contractor shall have the charge and care of the work and of the materials to be used therein (including materials for which the Contractor has received partial payment as provided in Section 9-1.06, "Partial Payments," or materials which have been furnished by the State) and shall bear the risk of injury, loss or damage to any part thereof by the action of the elements or from any other cause, whether arising from the execution or from the non-execution of the work, except as provided in Sections 7-1.08, "Public Convenience," and 7-1.15, "Relief From Maintenance and Responsibility." The Contractor shall rebuild, repair, restore, and make good all injuries, losses or damages to any portion of the work or the materials occasioned by any cause before its completion and acceptance and shall bear the expense thereof, except as otherwise expressly provided in Section 7-1.165, "Damage by Storm, Flood, Tsunami or Earthquake," and in Section 19-2.04, "Slides and Slipouts," and except for those injuries, losses, or damages that are directly and proximately caused by acts of the Federal Government or the public enemy. Where necessary to protect the work or materials from damage, the Contractor shall, at the Contractor's expense, provide suitable drainage of the roadway and erect those temporary structures that are necessary to protect the work or materials from damage. The suspension of the work from any cause whatever shall not relieve the Contractor of the responsibility for the work and materials as herein specified. If ordered by the Engineer, the Contractor shall, at the Contractor's expense, properly store materials which have been partially paid for by the State or which have been furnished by the State. Storage by the Contractor shall be on behalf of the State and the State shall at all times be entitled to the possession of the materials, and the Contractor shall promptly return the materials to the site of the work when requested. The Contractor shall not dispose of any of the materials so stored except on written authorization from the Engineer.

7-1.165 DAMAGE BY STORM, FLOOD, TSUNAMI OR EARTHQUAKE

Attention is directed to Section 7-1.16, "Contractor's Responsibility for the Work and Materials." In the event damage to the work is caused by a storm, flood, tsunami, earthquake or other natural disaster which constitutes an "Occurrence," as hereinafter defined, the provisions in this Section 7-1.165 shall be applicable, and the Contractor may apply in writing to the Engineer for the State to pay or participate in the cost of repairing damage to the work from that cause or, in lieu thereof, and at the sole discretion of the Department, terminate the contract and relieve the Contractor of further obligation to perform the work, subject to the following:

A. Occurrence— "Occurrence" shall include tsunamis, earthquakes in excess of a magnitude of 3.5 on the Richter Scale, and storms, floods and other natural disasters as to which the Governor has proclaimed a state of emergency when the damaged work is located within the territorial limits to which the proclamation is applicable or, which were, in the opinion of the Engineer, of a magnitude at the site of the work sufficient to have

caused such a proclamation had they occurred in a populated area or in an area in which such a proclamation was not already in effect.

B. Application by Contractor— The Contractor's written request for the State to pay or to participate in the cost of rebuilding, repairing, restoring or otherwise remedying the damage to the work caused by the Occurrence shall be submitted to the Engineer before performing any work other than emergency work, including emergency work necessary to provide for passage of public traffic.

C. Protecting the Work from Damage— Nothing in this section shall be construed to relieve the Contractor of the responsibility to protect the work from damage. The Contractor shall bear the entire cost of repairing damage to the work caused by the Occurrence which the Engineer determines was due to the failure of the Contractor to comply with the requirements of the Plans and Specifications, take reasonable and adequate measures to protect the work or exercise sound engineering and construction practices in the conduct of the work, and those repair costs shall be excluded from consideration under the provisions of this section.

D. Repair Work— Repair of damaged work under the provisions of this section shall be pursuant to a contract change order issued hereunder and specifying the repair work to be performed on the damaged facility. The repair work shall consist of restoring the in-place construction (for the purposes of this section erected falsework and formwork shall be considered in-place construction) to the same state of completion to which the work had advanced prior to the Occurrence. Emergency work which the Engineer determines would have been part of the repair work if it had not previously been performed, will be considered to be part of the repair work.

The Department reserves the right to make changes in the plans and specifications applicable to the portions of the work to be repaired, and if those changes will increase the cost of repairing the damage over the Engineer's estimate of the cost of repair without the changes, the Contractor will be paid for the increased costs in accordance with Subsection E and the increased cost amount shall not be considered in determining the cost of repair to be borne by the Contractor under Subsection F.

Nothing in this section shall be construed to relieve the Contractor of full responsibility for the risk of injury, loss or damage to materials not yet incorporated in the work and to materials, tools and equipment (except erected falsework and formwork) used to perform the work, or to relieve the Contractor of responsibility under Section 7-1.12, "Idemnification and Insurance." The provisions of this section shall not be applicable to the repair of damage caused by an Occurrence to any portion of the work as to which the Contractor has been granted relief from maintenance and responsibility pursuant to Section 7-1.15, "Relief From Maintenance and Responsibility," or to the removal of slides and slipouts or the repair and

restoration of damage to the work resulting from slides and slipouts pursuant to Section 19-2.04, "Slides and Slipouts."

E. Determination of Costs— Unless otherwise agreed between the Engineer and the Contractor, the cost of the work performed pursuant to this Section 7-1.165 will be determined in conformance with the provisions in Section 9-1.03, "Force Account Payment," except there shall be no markup allowance pursuant to Section 9-1.03A, "Work Performed by Contractor," unless the Occurrence that caused the damage was a tsunami or earthquake. The cost of emergency work, which the Engineer determines would have been part of the repair work if it had not previously been performed, will be determined in the same manner as the authorized repair work. The cost of repairing damaged work which was not in compliance with the requirements of the plans and specifications shall be borne solely by the Contractor, and those costs shall not be considered in determining the cost of repair under this Subsection E.

F. Payment for Repair Work— When the Occurrence that caused the damage was a tsunami or earthquake, the State will pay the cost of repair determined as provided in Subsection E, that exceeds 5 percent of the amount of the Contractor's bid for bid comparison purposes.

When the Occurrence that caused the damage was a storm, flood or other natural disaster, the State will participate in the cost of the repair determined as provided in Subsection E in accordance with the following:

1. On projects for which the amount of the Contractor's bid for bid comparison purposes is $2,000,000 or less, the State will pay 90 percent of the cost of repair that exceeds 5 percent of the amount of the Contractor's bid for bid comparison purposes.
2. On projects for which the Contractor's bid for bid comparison purposes is greater than $2,000,000, the State will pay 90 percent of the cost of repair that exceeds $100,000.

G. Termination of Contract— If the Department elects to terminate the contract, the termination and the determination of the total compensation payable to the Contractor shall be governed by the provisions of Section 8-1.11, "Termination of Contract."

7-1.17 ACCEPTANCE OF CONTRACT

When the Engineer has made the final inspection as provided in Section 5-1.13, "Final Inspection," and determines that the contract work has been completed in all respects in accordance with the plans and specifications, the Engineer will recommend that the Director formally accept the contract, and immediately upon and after the acceptance by the Director, the Contractor will be relieved of the duty of maintaining and protecting the work as a whole, and the Contractor will not be required to perform any further work thereon; and the Contractor shall be relieved of the responsibility for injury to persons or property or damage to the work which occurs after the formal acceptance by the Director.

7-1.18 PROPERTY RIGHTS IN MATERIALS

Nothing in the contract shall be construed as vesting in the Contractor any right of property in the materials used after they have been attached or affixed to the work or soil or after partial payment has been made as provided in Section 9-1.06, "Partial Payments," for material delivered on the ground or stored subject to or under the control of the State and unused. All the material shall become the property of the State of California upon being so attached or affixed or upon payment for materials delivered on the ground or stored subject to or under the control of the State and unused, as provided in Section 9-1.06.

7-1.19 RIGHTS IN LAND AND IMPROVEMENTS

Nothing in these specifications shall be construed as allowing the Contractor to make any arrangements with any person to permit occupancy or use of any land, structure, or building within the limits of the contract for any purpose whatsoever, either with or without compensation, in conflict with any agreement between the State and any owner, former owner, or tenant of the land, structure, or building.

The Contractor shall not occupy State-owned property outside the right of way as shown on the plans or maps available in the office of the district in which the work is situated, unless the Contractor enters into a rental agreement with the Department. The agreement will be based on the fair rental values.

7-1.20 PERSONAL LIABILITY

Neither the Director, the Engineer nor any other officer or authorized employee of the State of California, nor any officer or employee of any county, city or district shall be personally responsible for any liability arising under or by virtue of the contract.

7-1.21 REPAIR OF EQUIPMENT

The work of installing, assembling, repairing or reconditioning, or other work of any nature on machinery, equipment or tools used in or upon the work shall be considered a part of the work to be performed under the contract and any laborers, workers or mechanics working on the machinery, equipment or tools, unless employed by bona fide commercial repair shops, garages, blacksmith shops or machine shops, which have been established and operating on a commercial basis for a period of at least 2 months prior to the award of the contract, shall be subject to all the requirements relating to labor set forth in these specifications and in the special provisions.

7-1.22 MATERIAL PLANTS

The construction, erection and operation of material production, proportioning or mixing plants from which material is used wholly on the contract or on contracts under the supervision of the Department shall be considered a part of the work to be performed under the contract and any laborers, workers or mechanics working on those plants shall be subject to all of the requirements relating to labor set forth in these specifications and in the special provisions.

SECTION 8: PROSECUTION AND PROGRESS

8-1.01 SUBCONTRACTING

- The Contractor shall give personal attention to the fulfillment of the contract and shall keep the work under the Contractor's control.
- No subcontractor will be recognized as such, and all persons engaged in the work of construction will be considered as employees of the Contractor and the Contractor will be held responsible for their work, which shall be subject to the provisions of the contract and specifications.
- The Contractor shall perform, with the Contractor's own organization, contract work amounting to not less than 50 percent of the original total contract price, except that any designated "Specialty Items" may be performed by subcontract and the amount of any designated "Specialty Items" performed by subcontract may be deducted from the original total contract price before computing the amount of work required to be performed by the Contractor with the Contractor's own organization. When items of work in the Engineer's Estimate are preceded by the letters (S) or (S-F), those items are designated as "Specialty Items." Where an entire item is subcontracted, the value of work subcontracted will be based on the contract item bid price. When a portion of an item is subcontracted, the value of work subcontracted will be based on the estimated percentage of the contract item bid price, determined from information submitted by the Contractor, subject to approval by the Engineer.
- Subcontracts shall include provisions that the contract between the State and the Contractor is part of the subcontract, and that all terms and provisions of the contract are incorporated in the subcontract. Subcontracts shall also contain certification by the subcontractor that the subcontractor is experienced in and qualified to do, and knowledgeable about, the subcontracted work. Copies of subcontracts shall be available to the Engineer upon written request, and shall be provided to the Engineer at the time any litigation against the State concerning the project is filed.
- Before work is started on a subcontract, the Contractor shall file with the Engineer a written statement showing the work to be subcontracted, the names of the subcontractors and the description of each portion of the work to be subcontracted.
- Pursuant to the provisions of Section 6109 of the Public Contract Code, the Contractor shall not perform work on a public works project with a subcontractor who is ineligible to perform work on the public works project pursuant to Section 1777.1 or 1777.7 of the Labor Code.
- When a portion of the work which has been subcontracted by the Contractor is not being prosecuted in a manner satisfactory to the Department, the subcontractor shall be removed immediately on the requisition of the Engineer and shall not again be employed on the work.
- The roadside production of materials produced by other than the Contractor's forces shall be considered as subcontracted. Roadside production of materials shall be construed to be production of aggregates of all kinds with portable, semiportable or temporary crushing or screening, proportioning and mixing plants established or

reopened for the purpose of supplying aggregate or material for a particular project or projects. The erection, establishment or reopening of the plants and the operation thereof in the production of materials for use on the work shall conform to the requirements relating to labor set forth in these specifications and in the special provisions.

8-1.02 ASSIGNMENT

- The performance of the contract may not be assigned, except upon the written consent of the Director. Consent will not be given to any proposed assignment which would relieve the original Contractor or the Contractor's surety of their responsibilities under the contract nor will the Director consent to any assignment of a part of the work under the contract.
- The Contractor may assign moneys due or to become due the Contractor under the contract and the assignment will be recognized by the Department, if given proper notice thereof, to the extent permitted by law, but any assignment of moneys shall be subject to all proper set-offs in favor of the Department and to all deductions provided for in the contract and particularly all money withheld, whether assigned or not, shall be subject to being used by the Department for the completion of the work in the event that the Contractor should be in default therein.

8-1.03 BEGINNING OF WORK

- The Contractor shall begin work within 15 calendar days after receiving notice that the contract has been approved by the Attorney General or the attorney appointed and authorized to represent the Department, and shall diligently prosecute the same to completion within the time limit provided in the special provisions.
- The Contractor shall notify the Engineer, in writing, of the Contractor's intent to begin work at least 72 hours before work is begun. The notice shall be delivered to the Office of the District Director of Transportation in the district in which the work is situated and shall specify the date the Contractor intends to start. If the project has more than one location of work, a separate notice shall be given for each location.
- Should the Contractor begin work in advance of receiving notice that the contract has been approved as above provided, any work performed by the Contractor in advance of the date of approval shall be considered as having been done by the Contractor at the Contractor's own risk and as a volunteer unless the contract is approved.
- The delivery to the State for execution and approval of the contract properly executed on behalf of the Contractor and surety and the minimum 72 hours advance written notice as required above shall constitute the Contractor's authority to enter upon the site of the work and to begin operations, subject to the Contractor's assumption of the risk of the disapproval of the contract, as above provided, and subject also to the following:

(1) The Contractor shall, on commencing operations, take all precautions required for public safety and shall observe all the provisions in these specifications and the special provisions.

(2) In the event of disapproval, the Contractor shallat the Contractor's expense do that work that is necessary to leave the site in a neat condition to the satisfaction of the Engineer. If the work done affects any existing road or highway, the Contractor shall at the Contractor's expense restore it to its former condition, or the equivalent thereof, to the satisfaction of the Engineer.

(3) All work done according to the contract prior to its approval, will, when the contract is approved, be considered authorized work and will be paid for as provided in the contract.

(4) The Contractor shall not be entitled to any additional compensation or an extension of time for any delay, hindrance or interference caused by or attributable to commencement of work prior to the date on which the contract was approved by the Attorney General or the attorney appointed and authorized to represent the Department, except to the extent the delay, hindrance or interference would have been compensable hereunder had work been commenced on the date of the approval and the progress thereof been the same as that actually made.

8-1.04 PROGRESS SCHEDULE

When required by the special provisions, the Contractor shall submit to the Engineer a practicable progress schedule within 20 working days of approval of the contract, and within 10 working days of the Engineer's written request at any other time.

The Contractor may furnish the schedule on a form of the Contractor's choice or, if requested, the Engineer will furnish a form for the Contractor's use. If the Engineer furnishes a form, the Engineer will also furnish to the Contractor, on request, on or before the last day of each month a copy of the form showing the status of work actually completed during the preceding estimate period.

The schedule shall show the order in which the Contractor proposes to carry out the work, the dates on which the Contractor will start the several salient features of the work (including procurement of materials, plant, and equipment), and the contemplated dates for completing those salient features.

The progress schedules submitted shall be consistent in all respects with the time and order of work requirements of the contract.

Subsequent to the time that submittal of a progress schedule is required in accordance with these specifications, no progress payments will be made for any work until a satisfactory schedule has been submitted to the Engineer.

8-1.05 TEMPORARY SUSPENSION OF WORK

The Engineer shall have the authority to suspend the work wholly or in part, for any time period as the Engineer deems necessary, due to unsuitable weather, or to such other conditions considered unfavorable for the suitable prosecution of the work, or for any time period as the Engineer deems necessary due to the failure on the part of the Contractor to carry out orders given, or to perform any provision of the contract. The Contractor shall immediately comply with the written order of the Engineer to suspend the work wholly or in part. The suspended work shall be

resumed when conditions are favorable and methods are corrected, as ordered or approved in writing by the Engineer.

- In the event that a suspension of work is ordered as provided above, and should that suspension be ordered by reason of the failure of the Contractor to carry out orders or to perform any provision of the contract; or by reason of weather conditions being unsuitable for performing any item or items of work, which work, in the sole opinion of the Engineer, could have been performed prior to the occurrence of the unsuitable weather conditions had the Contractor diligently prosecuted the work when weather conditions were suitable; the Contractor, at the Contractor's expense, shall do all the work necessary to provide a safe, smooth, and unobstructed passageway through construction for use by public traffic during the period of that suspension as provided in Sections 7-1.08, "Public Convenience," and 7-1.09, "Public Safety," and as specified in the special provisions for the work. In the event that the Contractor fails to perform the work above specified, the Department will perform that work and the cost thereof will be deducted from moneys due or to become due the Contractor.
- In the event that a suspension of work is ordered by the Engineer due to unsuitable weather conditions, and in the sole opinion of the Engineer, the Contractor has prosecuted the work with energy and diligence prior to the time that operations were suspended, the cost of providing a smooth and unobstructed passageway through the work will be paid for as extra work as provided in Section 4-1.03D or, at the option of the Engineer, that work will be performed by the Department at no cost to the Contractor.
- If the Engineer orders a suspension of all of the work or a portion of the work which is the current controlling operation or operations, due to unsuitable weather or to other conditions considered unfavorable to the suitable prosecution of the work, the days on which the suspension is in effect shall not be considered working days as defined in Section 8-1.06, "Time of Completion." If a portion of work at the time of the suspension is not a current controlling operation or operations, but subsequently does become the current controlling operation or operations, the determination of working days will be made on the basis of the then current controlling operation or operations.
- If a suspension of work is ordered by the Engineer, due to the failure on the part of the Contractor to carry out orders given or to perform any provision of the contract, the days on which the suspension order is in effect shall be considered working days if those days are working days within the meaning of the definition set forth in Section 8-1.06, "Time of Completion."
- In addition to the requirements specified above, the following shall apply:

  If the performance of all or any portion of the work is suspended or delayed by the Engineer in writing for an unreasonable period of time (not originally anticipated, customary, or inherent to the construction industry) and the Contractor believes that additional compensation or contract time or additional compensation and contract time is due as a result of that suspension or delay, the Contractor shall submit to the Engineer in writing a request for

adjustment within 7 calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for the adjustment.

Upon receipt, the Engineer will evaluate the Contractor's request. If the Engineer agrees that the cost or time or cost and time required for the performance of the contract has increased as a result of the suspension and the suspension was caused by conditions beyond the control of and not the fault of the Contractor, its suppliers, or subcontractors at any approved tier, and not caused by weather, the Engineer will make an adjustment (excluding profit) and modify the contract in writing accordingly. The Engineer will notify the Contractor of the Engineer's determination whether or not an adjustment of the contract is warranted.

No contract adjustment will be allowed unless the Contractor has submitted the request for adjustment within the time prescribed.

No contract adjustment will be allowed under the provisions specified in this section to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided for or excluded under any term or condition of this contract.

Any contract adjustment warranted due to suspension of work ordered by the Engineer will be made in the same manner as provided for right of way delays in Section 8-1.09, "Right of Way Delays."

- In the event of a suspension of work under any of the conditions set forth in this Section 8-1.05, the suspension of work shall not relieve the Contractor of the responsibilities as set forth in Section 7, "Legal Relations and Responsibility."

8-1.06 TIME OF COMPLETION

- The Contractor shall complete all or any designated portion of the work called for under the contract in all parts and requirements within the time set forth in the special provisions.
- A working day is defined as any day, except as follows:

(a) Saturdays, Sundays and legal holidays;
(b) Days on which the Contractor is prevented by inclement weatheror conditions resulting immediately therefrom adverse to the current controlling operation or operations, as determined by the Engineer, from proceeding with at least 75 percent of the normal labor and equipment force engaged on that operation or operations for at least 60 percent of the total daily time being currently spent on the controlling operation or operations; or
(c) Days on which the Contractor is prevented, by reason of requirements in "Maintaining Traffic" of the special provisions, from working on the controlling operation or operations for at least 60 percent of the total daily time being currently spent on the controlling operation or operations.

- Should the Contractor prepare to begin work at the regular starting time of any day on which inclement weather, or the conditions resulting from the weather, or the condition of the work, prevents the work from beginning at the usual starting

time and the crew is dismissed as a result thereof and the Contractor does not proceed with at least 75 percent of the normal labor and equipment force engaged in the current controlling operation or operations for at least 60 percent of the total daily time being currently spent on the controlling operation or operations, the Contractor will not be charged for a working day whether or not conditions should change thereafter during that day and the major portion of the day could be considered to be suitable for those construction operations.

- The current controlling operation or operations is to be construed to include any feature of the work (e.g., an operation or activity, or a settlement or curing period) considered at the time by the Engineer and the Contractor, which, if delayed or prolonged, will delay the time of completion of the contract.
- Determination that a day is a non-working day by reason of inclement weather or conditions resulting immediately therefrom, shall be made by the Engineer. The Contractor will be allowed 15 days from the issuance of the weekly statement of working days in which to file a written protest setting forth in what respects the Contractor differs from the Engineer; otherwise, the decision of the Engineer shall be deemed to have been accepted by the Contractor as correct. The Engineer will furnish the Contractor a weekly statement showing the number of working days charged to the contract for the preceding week, the number of working days of time extensions being considered or approved, the number of working days originally specified for the completion of the contract and the number of working days remaining to complete the contract and the extended date for completion thereof, except when working days are not being charged in conformance with the provisions in Section 8-1.05, "Temporary Suspension of Work."

8-1.07 LIQUIDATED DAMAGES

- It is agreed by the parties to the contract that in case all the work called for under the contract in all parts and requirements is not finished or completed within the number of working days as set forth in the special provisions, damage will be sustained by the State of California, and that it is and will be impracticable and extremely difficult to ascertain and determine the actual damage which the State will sustain in the event of and by reason of the delay; and it is therefore agreed that the Contractor will pay to the State of California, the sum set forth in the special provisions per day for each and every calendar day's delay in finishing the work in excess of the number of working days prescribed; and the Contractor agrees to pay the liquidated damages herein provided for, and further agrees that the Department may deduct the amount thereof from any moneys due or that may become due the Contractor under the contract.
- It is further agreed that in case the work called for under the contract is not finished and completed in all parts and requirements within the number of working days specified, the Director shall have the right to increase the number of working days or not, as the Director may deem best to serve the interest of the State, and if the Director decides to increase the number of working days, the Director shall further have the right to charge to the Contractor, or the Contractor's heirs, assigns or sureties and to deduct from the final payment for the work all or any part, as the Director may deem proper, of the actual cost of engineering, inspection, superintendence, and other overhead expenses which are directly chargeable to the

contract, and which accrue during the period of the extension, except that cost of final surveys and preparation of final estimate shall not be included in the charges.

- The Contractor will be granted an extension of time and will not be assessed with liquidated damages or the cost of engineering and inspection for any portion of the delay in completion of the work beyond the time named in the special provisions for the completion of the work caused by acts of God or of the public enemy, fire, floods, tsunamis, earthquakes, epidemics, quarantine restrictions, strikes, labor disputes, shortage of materials and freight embargoes, provided that the Contractor shall notify the Engineer in writing of the causes of delay within 15 days from the beginning of that delay. The Engineer shall ascertain the facts and the extent of the delay, and the Engineer's findings thereon shall be final and conclusive.
- No extension of time will be granted for a delay caused by a shortage of materials unless the Contractor furnishes to the Engineer documentary proof that the Contractor has made every effort to obtain the materials from all known sources within reasonable reach of the work in a diligent and timely manner, and further proof in the form of supplementary progress schedules, as required in Section 8-1.04, "Progress Schedule," that the inability to obtain the materials when originally planned, did in fact cause a delay in final completion of the entire work which could not be compensated for by revising the sequence of the Contractor's operations. The term "shortage of materials," as used in this section, shall apply only to materials, articles, parts or equipment which are standard items and are to be incorporated in the work. The term "shortage of materials," shall not apply to materials, parts, articles or equipment which are processed, made, constructed, fabricated or manufactured to meet the specific requirements of the contract. Only the physical shortage of material will be considered under these provisions as a cause for extension of time. Delays in obtaining materials due to priority in filling orders will not constitute a shortage of materials.
- If the Contractor is delayed in completion of the work by reason of changes made under Section 4-1.03, "Changes," or by failure of the Department to acquire or clear right of way, or by moving the Contractor's plant pursuant to Section 6-2.03, "Mandatory Local Material Sources," or by any act of the Engineer or of the Department, not contemplated by the contract, an extension of time commensurate with the delay in completion of the work thus caused will be granted, and the Contractor shall be relieved from any claim for liquidated damages, or engineering and inspection charges or other penalties for the period covered by that extension of time; provided that the Contractor shall notify the Engineer in writing of the causes of delay within 15 days from the beginning of the delay. The Engineer shall ascertain the facts and the extent of the delay, and the Engineer's findings thereon shall be final and conclusive.
- Except for the additional compensation provided for in Section 8-1.09, "Right of Way Delays," and except as provided in Public Contract Code Section 7102, the Contractor shall have no claim for damage or compensation for any delay or hindrance.
- It is the intention of the above provisions that the Contractor shall not be relieved of liability for liquidated damages or engineering and inspection charges

for any period of delay in completion of the work in excess of that expressly provided for in this Section 8-1.07.

8-1.08 TERMINATION OF CONTROL

- Failure to supply an adequate working force, or material of proper quality, or failure to comply with Section 10262 of the State Contract Act, or in any other respect to prosecute the work with the diligence and force specified by the contract, is grounds for termination of the Contractor's control over the work and for taking over the work by the State as provided in the State Contract Act.
- If the Contractor's control of the work is terminated or the Contractor abandons the work and the contract work is completed in conformance with the provisions in Section 10255 of the State Contract Act, any dispute concerning the amount to be paid by the State to the Contractor or the Contractor's surety or to be paid to the State by the Contractor or the Contractor's surety, under the provisions in Section 10258 of the State Contract Act, shall be subject to arbitration in conformance with the provisions in Section 9-1.10, "Arbitration." The surety shall be bound by the arbitration award and is entitled to participate in the arbitration proceedings.

8-1.09 RIGHT OF WAY DELAYS

- If, through the failure of the State to acquire or clear right of way, the Contractor sustains loss which could not have been avoided by the judicious handling of forces, equipment and plant, there shall be paid to the Contractor that amount that the Engineer may find to be a fair and reasonable compensation for that part of the Contractor's actual loss, that, in the opinion of the Engineer, was unavoidable, determined as follows:

Compensation for idle time of equipment will be determined in the same manner as determinations are made for equipment used in the performance of extra work paid for on a force account basis, as provided in Section 9-1.03A(3), "Equipment Rental," with the following exceptions:

(1) The right of way delay factor for each classification of equipment shown in the Department of Transportation publication entitled Labor Surcharge And Equipment Rental Rates, which is a part of the contract, will be applied to that equipment rental rate.
(2) The time for which the compensation will be paid will be the actual normal working time during which the delay condition exists, but in no case will exceed 8 hours in any one day.
(3) The days for which compensation will be paid will be the calendar days, excluding Saturdays, Sundays and legal holidays, during the existence of the delay, except that when rental of equipment is paid for under the provisions in Section 9-1.03A (3b), "Equipment not on the Work," no payment will be made for right of way delays in conformance with the provisions in this Section 8-1.09.

Actual loss shall be understood to include no items of expense other than idle time of equipment and necessary payments for idle time of workers, cost

of extra moving of equipment and cost of longer hauls. Compensation for idle time of equipment will be determined as provided in this Section 8-1.09 and compensation for idle time of workers will be determined as provided in Section 9-1.03A(1), "Labor," and no markup will be added in either case for overhead and profit. The cost of extra moving of equipment and the cost of longer hauls will be paid for as extra work as provided in Section 4-1.03D.

If performance of the Contractor's work is delayed as the result of the failure of the Department to acquire or clear right of way, an extension of time determined pursuant to the provisions in Section 8-1.07, "Liquidated Damages," will be granted.

8-1.10 UTILITY AND NON-HIGHWAY FACILITIES

Attention is directed to Section 7-1.11, "Preservation of Property," and Section 7-1.12, "Indemnification and Insurance." The Contractor shall protect from damage utility and other non-highway facilities that are to remain in place, be installed, relocated or otherwise rearranged.

It is anticipated that some or all of the utility and other non-highway facilities, both above ground and below ground, that are required to be rearranged (as used herein, rearrangement includes installation, relocation, alteration or removal) as a part of the highway improvement will be rearranged in advance of construction operations. Where it is not anticipated that the rearrangement will be performed prior to construction, or where the rearrangement must be coordinated with the Contractor's construction operations, the existing facilities that are to be rearranged will be indicated on the plans or in the special provisions. Where a rearrangement is indicated on the plans or in the special provisions, the Contractor will have no liability for the costs of performing the work involved in the rearrangement.

The right is reserved to the Department and the owners of facilities, or their authorized agents, to enter upon the highway right of way for the purpose of making those changes that are necessary for the rearrangement of their facilities or for making necessary connections or repairs to their properties. The Contractor shall cooperate with forces engaged in this work and shall conduct operations in such a manner as to avoid any unnecessary delay or hindrance to the work being performed by the other forces. Wherever necessary, the work of the Contractor shall be coordinated with the rearrangement of utility or other non-highway facilities, and the Contractor shall make arrangements with the owner of those facilities for the coordination of the work.

Attention is directed to the possible existence of underground main or trunk line facilities not indicated on the plans or in the special provisions and to the possibility that underground main or trunk lines may be in a location different from that which is indicated on the plans or in the special provisions. The Contractor shall ascertain the exact location of underground main or trunk lines whose presence is indicated on the plans or in the special provisions, the location of their service laterals or other appurtenances, and of existing service lateral or appurtenances of any other underground facilities which can be inferred from the presence of visible facilities such as buildings, meters and junction boxes prior to doing work that may damage any of the facilities or interfere with their service.

- If the Contractor cannot locate an underground facility whose presence is indicated on the plans or in the special provisions, the Contractor shall so notify the Engineer in writing. If the facility for which the notice is given is in a substantially different location from that indicated on the plans or in the special provisions, the additional cost of locating the facility will be paid for as extra work as provided in Section 4-1.03D.
- If the Contractor discovers underground main or trunk lines not indicated on the plans or in the special provisions, the Contractor shall immediately give the Engineer and the Utility Company written notification of the existence of those facilities. The main or trunk lines shall be located and protected from damage as directed by the Engineer, and the cost of that work will be paid for as extra work as provided in Section 4-1.03D. The Contractor shall, if directed by the Engineer, repair any damage which may occur to the main or trunk lines. The cost of that repair work, not due to the failure of the Contractor to exercise reasonable care, will be paid for as extra work as provided in Section 4-1.03D. Damage due to the Contractor's failure to exercise reasonable care shall be repaired at the Contractor's cost and expense.
- Where it is determined by the Engineer that the rearrangement of an underground facility is essential in order to accommodate the highway improvement and the plans and specifications do not provide that the facility is to be rearranged, the Engineer will provide for the rearrangement of the facility by other forces or the rearrangement shall be performed by the Contractor and will be paid for as extra work as provided in Section 4-1.03D.
- When ordered by the Engineer in writing, the Contractor shall rearrange any utility or other non-highway facility necessary to be rearranged as a part of the highway improvement, and that work will be paid for as extra work as provided in Section 4-1.03D.
- Should the Contractor desire to have any rearrangement made in any utility facility, or other improvement, for the Contractor's convenience in order to facilitate the Contractor's construction operations, which rearrangement is in addition to, or different from, the rearrangements indicated on the plans or in the special provisions, the Contractor shall make whatever arrangements are necessary with the owners of the utility or other non-highway facility for the rearrangement and bear all expenses in connection therewith.
- The Contractor shall immediately notify the Engineer of any delays to the Contractor's operations as a direct result of underground main or trunk line facilities which were not indicated on the plans or in the special provisions or were located in a position substantially different from that indicated on the plans or in the special provisions, or as a direct result of utility or other non-highway facilities not being rearranged as herein provided (other than delays in connection with rearrangements made to facilitate the Contractor's construction operations or delays due to a strike or labor dispute). These delays will be considered right of way delays within the meaning of Section 8-1.09, "Right of Way Delays," and compensation for the delay will be determined in conformance with the provisions in Section 8-1.09. The Contractor shall be entitled to no other compensation for that delay.

- Any delays to the Contractor's operations as a direct result of utility or other non-highway facilities not being rearranged as provided in this Section 8-1.10, due to a strike or labor dispute, will entitle the Contractor to an extension of time as provided in Section 8-1.07, "Liquidated Damages." The Contractor shall be entitled to no other compensation for that delay.

8-1.11 TERMINATION OF CONTRACT

- The contract may be terminated by the Director when termination is authorized by Section 7-1.125, "Legal Actions Against the Department," Section 7-1.165, "Damage by Storm, Flood, Tsunami or Earthquake," or by other provisions of the contract which authorize termination. The Department also reserves the right to terminate the contract at any time upon a determination by the Director that termination of the contract is in the best interest of the State.
- If the Director elects to terminate the contract, the termination of the contract and the total compensation payable to the Contractor shall be governed by the following:

(A) The Engineer will issue the Contractor a written notice signed by the Director, specifying that the contract is to be terminated. Upon receipt of the written notice, the Contractor will be relieved of further responsibility for damage to the work (excluding materials) as specified in Section 7-1.16, "Contractor's Responsibility for the Work and Materials," and, except as otherwise directed in writing by the Engineer, the Contractor shall:

(1) Stop all work under the contract except that specifically directed to be completed prior to acceptance.
(2) Perform work the Engineer deems necessary to secure the project for termination.
(3) Remove equipment and plant from the site of the work.
(4) Take action that is necessary to protect materials from damage.
(5) Notify all subcontractors and suppliers that the contract is being terminated and that their contracts or orders are not to be further performed unless otherwise authorized in writing by the Engineer.
(6) Provide the Engineer with an inventory list of all materials previously produced, purchased or ordered from suppliers for use in the work and not yet used in the work, including its storage location, and such other information as the Engineer may request.
(7) Dispose of materials not yet used in the work as directed by the Engineer. It shall be the Contractor's responsibility to provide the State with good title to all materials purchased by the State hereunder, including materials for which partial payment has been made as provided in Section 9-1.06, "Partial Payments," and with bills of sale or other documents of title for those materials.
(8) Subject tothe prior written approval of the Engineer, settle all outstanding liabilities and all claims arising out of subcontracts or orders for materials terminated hereunder. To the extent directed by

the Engineer, the Contractor shall assign to the Department all the right, title and interest of the Contractor under subcontracts or orders for materials terminated hereunder.

(9) Furnish the Engineer with the documentation required to be furnished by the Contractor under the provisions of the contract including, on projects as to which Federal funds are involved, all documentation required under the Federal requirements included in the contract.

(10) Take other actions directed by the Engineer.

(B) Acceptance of the contract as hereinafter specified shall not relieve the Contractor of responsibility for damage to materials. The Contractor shall continue to be responsible for damage to materials after issuance of the Notice of Termination, except as follows:

(1) The Contractor's responsibility for damage to materials for which partial payment has been made as provided in Section 9-1.06, "Partial Payments," and for materials furnished by the State for use in the work and unused shall terminate when the Engineer certifies that those materials have been stored in the manner and at the locations the Engineer has directed.

(2) The Contractor's responsibility for damage to materials purchased by the State subsequent to the issuance of the notice that the contract is to be terminated shall terminate when title and delivery of those materials has been taken by the State.

When the Engineer determines that the Contractor has completed the work under the contract directed to be completed prior to termination and such other work as may have been ordered to secure the project for termination, the Engineer will recommend that the Director formally accept the contract, and immediately upon and after the acceptance by the Director, the Contractor will not be required to perform any further work thereon and shall be relieved of the contractual responsibilities for injury to persons or property which occurs after the formal acceptance of the project by the Director.

(C) Termination of the contract shall not relieve the surety of its obligation for any just claims arising out of the work performed.

(D) The total compensation to be paid to the Contractor shall be determined by the Engineer on the basis of the following:

(1) The reasonable cost to the Contractor, without profit, for all work performed under the contract, including mobilization, demobilization and work done to secure the project for termination. In determining the reasonable cost, deductions will be made for the cost of materials to be retained by the Contractor, amounts realized by the sale of materials, and for other appropriate credits against the cost of the work. Deductions will also be made, when the contract is terminated

under the authority of Section 7-1.165, "Damage by Storm, Flood, Tsunami or Earthquake," for the cost of materials damaged by the "occurrence."

When, in the opinion of the Engineer, the cost of a contract item of work is excessively high due to costs incurred to remedy or replace defective or rejected work, the reasonable cost to be allowed will be the estimated reasonable cost of performing that work in compliance with the requirements of the plans and specifications and the excessive actual cost shall be disallowed.

(2) A reasonable allowance for profit on the cost of the work performed as determined under Subsection (1), provided the Contractor establishes to the satisfaction of the Engineer that it is reasonably probable that the Contractor would have made a profit had the contract been completed and provided further, that the profit allowed shall in no event exceed 4 percent of the cost.

(3) The reasonable cost to the Contractor of handling material returned to the vendor, delivered to the Department or otherwise disposed of as directed by the Engineer.

(4) A reasonable allowance for the Contractor's administrative costs in determining the amount payable due to termination of the contract.

All records of the Contractor and the Contractor's subcontractors, necessary to determine compensation in conformance with the provisions in this Section 8-1.11, shall be open to inspection or audit by representatives of the Department at all times after issuance of the notice that the contract is to be terminated and for a period of 3 years, thereafter, and those records shall be retained for that period.

After acceptance of the work by the Director, the Engineer may make payments on the basis of interim estimates pending issuance of the Final Estimate in conformance with the provisions in Section 9-1.07B, "Final Payment and Claims," when, in the Engineer's opinion, the amount thus paid, together with all amounts previously paid or allowed, will not result in total compensation in excess of that to which the Contractor will be entitled. All payments, including payment upon the Final Estimate shall be subject to deduction for prior payments and amounts, if any, to be kept or retained under the provisions of the contract.

- The provisions in this Section 8-1.11 shall be included in all subcontracts.

SECTION 9: MEASUREMENT AND PAYMENT

9-1.01 MEASUREMENT OF QUANTITIES

- All work to be paid for at a contract price per unit of measurement will be measured by the Engineer in accordance with the U.S. Customary units of measurement. A ton shall consist of 2,000 pounds avoirdupois.
- Unless shipped by rail, material paid for by weight shall be weighed on scales furnished by and at the expense of the Contractor or on other sealed scales regularly inspected by the Division of Measurement Standards or its designated representative.
- Weighing, measuring and metering devices used to measure the quantity of materials used in the work shall be suitable for the purpose intended and shall conform to the tolerances and specifications as outlined in Title 4, Chapter 9 of the California Code of Regulations, the provisions of the California Business and Professions Code, Division 5, and these specifications. Devices not Type-approved by the Division of Measurement Standards shall be Type-approved in conformance with the requirements in California Test 109.
- Elements of the material plant controller which affect the accuracy or delivery of data shall be made available for the application of security seals. These devices will be inspected and adjusting elements sealed prior to the first production of materials for the contract. The security seals will be furnished by the Engineer. Material production shall cease when alteration, disconnection or otherwise manipulation of the security seals occur, and production shall not resume until the device is inspected and resealed by the Engineer.
- Weighing, measuring or metering devices used to determine the quantity of materials to be paid for will be considered to be "commercial devices" and shall be sealed by the Division of Measurement Standards or its authorized representative as often as the Engineer may deem necessary. The installation of all portable vehicle scales must be approved by the Engineer prior to sealing.
- Vehicle scales shall be of sufficient size to permit the entire vehicle or combination of vehicles to rest on the scale deck while being weighed. Combination vehicles may be weighed as separate units provided they are disconnected while being weighed. The maximum concentrated load shall not exceed the manufacturer's designed sectional capacity of the scale.
- Weighing, measuring or metering devices required by these specifications for the purpose of proportioning a material or product will be considered to be "non-commercial devices" and shall be tested and approved in conformance with the requirements in California Test 109. This testing shall be done by one of the following, in the presence of the Engineer, as often as the Engineer deems necessary:

    1. A County Sealer of Weights and Measures;
    2. A Scale Service Agency; or
    3. A Division of Measurement Standards Official.

- The Contractor shall notify the Engineer at least 24 hours in advance of testing the device.
- Undersupports for scale bearing points shall be constructed of portland cement concrete produced from commercial quality aggregates and cement, which contains not less than 470 pounds of cement per cubic yard. Undersupports shall be constructed in a manner to prevent any shifting or tilting of the support and shall have a minimum height of 14 inches above ground line. The footings shall have a minimum depth of 6 inches below the ground line. The bearing surface of the footings shall have a minimum width of 30 inches and shall be of sufficient area so the pressure does not exceed 4,000 pounds per square foot. Adequate drainage shall be provided to prevent saturation of the ground under the scale. Scale bulkheads shall be of adequate material and strength to resist displacement. If timber bulkheads are used, the minimum cross section shall be 8" x 8". Wedges shall not be used to shim the supports. If shimming is necessary, the shimming shall be done by securely attached metal shims, or by grouting. Shimming shall not exceed 3 inches. The approach ramps shall be level with the scale deck for a distance of not less than one-half the length of the scale deck. The mechanical indicating elements shall be installed level and plumb and shall be rigidly mounted upon a concrete foundation.
- The lever system and mechanical indicating elements of hopper scales shall be rigidly attached to non-yielding supports in such a manner as to prevent any loss in weight due to bending and distortion of the supports.
- When a multiple beam type scale is used in proportioning materials, an over and under indicator shall be provided which will give positive visible evidence of the amount of any over and under weight. The indicator shall be so designed that the indicator will operate during the addition of the last 200 pounds of any weighing. The over-travel of the indicator shall be at least one-third of the loading travel. Indicators shall be enclosed against moisture and dust.
- Over and under dials, and other indicators for weighing and measuring systems used in proportioning materials shall be grouped so that the smallest increment for each indicator can be accurately read from the point at which the proportioning operation is controlled.
- The Contractor shall bear the expense of all service fees for testing and approving of "non-commercial devices." The cost of the equipment, labor and materials furnished by the Contractor to assist in the testing of weighing, measuring or metering devices will be considered as included in the contract prices paid for the various contract items of work requiring the weighing, measuring or metering and no separate payment will be made therefor.
- Whenever pay quantities of material are determined by weighing, the scales shall be operated by a weighmaster licensed in conformance with the requirements in the California Business and Professions Code, Division 5, Chapter 7. The Contractor shall furnish a Public weighmasters certificate or certified daily summary weigh sheets. A representative of the Department may, at the discretion of the Engineer, be present to witness the weighing and to check and compile the daily record of the scale weights.

- When required by the Engineer, the operator of each vehicle weighed shall obtain a weight or load slip from the weigher and deliver that slip to the Engineer at the point of delivery of the material.
- If material is shipped by rail, the car weight will be accepted provided that actual weight of material only will be paid for and not minimum car weight used for assessing freight tariff, and provided further that car weight will not be acceptable for material to be passed through mixing plants.
- Vehicles used to haul material being paid for by weight shall be weighed empty daily and at additional times as the Engineer may direct. Each vehicle shall bear a plainly legible identification mark. Vehicles may from time to time be required by the Engineer to have the weight of the material to be paid for verified by weighing the empty and loaded vehicle on such other scales as the Engineer may designate.
- Materials which are specified for measurement by the cubic yard "measured in the vehicle" shall be hauled in vehicles of such type and size that the actual contents may be readily and accurately determined. Unless all vehicles are of uniform capacity, each vehicle must bear a plainly legible identification mark indicating its water level capacity. Vehicles shall be loaded to at least their water level capacity, and all loads shall be leveled when the vehicles arrive at the point of delivery. Loads hauled in vehicles not meeting the above requirements or loads of a quantity less than the capacity of the vehicle, measured after being leveled off as above provided, will be subject to rejection, and no compensation will be allowed for that material.
- When material is to be measured and paid for on a volume basis and it is impractical to determine the volume by the specified method of measurement, or when requested by the Contractor in writing and approved by the Engineer in writing, the material will be weighed in accordance with the requirements specified for weight measurement and the weight will be converted to volume measurement for payment purposes. Factors for conversion from weight measurement to volume measurement will be determined by the Engineer and shall be agreed to by the Contractor before that method of measurement of pay quantities will be adopted.
- Quantities of material wasted or disposed of in a manner not called for under the contract; or rejected loads of material, including material rejected after it has been placed by reason of the failure of the Contractor to conform to the provisions of the contract; or material not unloaded from the transporting vehicle; or material placed outside of the lines indicated on the plans or established by the Engineer; or material remaining on hand after completion of the work will not be paid for, and those quantities will be deducted from the final total quantities. No compensation will be allowed for hauling and disposing of rejected material.
- The weight of all aggregate or other roadway material which is to be paid for on a weight basis, except imported borrow, imported topsoil, straw, fiber, aggregate subbases, aggregate bases or aggregate for cement treated bases, will be determined by deducting from the weight of material, the weight of water in the material at the time of weighing in excess of 3 percent of the dry weight of the material. When imported borrow, imported topsoil or aggregate subbase is being paid for on a weight basis, the weight to be paid for will be determined by deducting from the

weight of the material, the weight of water in the material at the time of weighing in excess of 6 percent of the dry weight of the material. When straw is being paid for on a weight basis, the weight to be paid for will be determined by deducting from the weight of straw, the weight of water in the straw at the time of weighing in excess of 15 percent of the dry weight of the straw. When fiber is being paid for on a weight basis, the weight of water in the fiber at the time of weighing shall not exceed 15 percent of the dry weight of the fiber. No deduction will be made for the weight of water in fiber. The percentage of water in the material shall be determined by California Test 226. The weight of aggregate base and aggregate for cement treated bases which are to be paid for on a weight basis, will be determined as provided in Section 26, "Aggregate Bases," and Section 27, "Cement Treated Bases," respectively.

- The weight of water deducted as provided in this Section 9-1.01 will not be paid for.
- Full compensation for all expense involved in conforming to the requirements specified in this Section 9-1.01 shall be considered as included in the unit prices paid for the materials being measured or weighed and no additional compensation will be allowed therefor.

9-1.015 FINAL PAY ITEMS

- When an item of work is designated as (F) or (S-F) in the Engineer's Estimate, the estimated quantity for that item of work shall be the final pay quantity, unless the dimensions of any portion of that item are revised by the Engineer, or the item or any portion of the item is eliminated. If the dimensions of any portion of the item are revised, and the revisions result in an increase or decrease in the estimated quantity of that item of work, the final pay quantity for the item will be revised in the amount represented by the changes in the dimensions, except as otherwise provided for minor structures in Section 51-1.22, "Measurement." If a final pay item is eliminated, the estimated quantity for the item will be eliminated. If a portion of a final pay item is eliminated, the final pay quantity will be revised in the amount represented by the eliminated portion of the item of work.
- The estimated quantity for each item of work designated as (F) or (S-F) in the Engineer's Estimate shall be considered as approximate only, and no guarantee is made that the quantity which can be determined by computations, based on the details and dimensions shown on the plans, will equal the estimated quantity. No allowance will be made in the event that the quantity based on computations does not equal the estimated quantity.
- In case of discrepancy between the quantity shown in the Engineer's Estimate for a final pay item and the quantity or summation of quantities for the same item shown on the plans, payment will be based on the quantity shown in the Engineer's Estimate.

9-1.02 SCOPE OF PAYMENT

- The Contractor shall accept the compensation provided in the contract as full payment for furnishing all labor, materials, tools, equipment, and incidentals necessary to the completed work and for performing all work contemplated and embraced under the contract; also for loss or damage arising from the nature of the

work, or from the action of the elements, or from any unforeseen difficulties which may be encountered during the prosecution of the work until the acceptance by the Director and for all risks of every description connected with the prosecution of the work, also for all expenses incurred in consequence of the suspension or discontinuance of the work as provided in the contract; and for completing the work according to the plans and specifications. Neither the payment of any estimate nor of any retained percentage shall relieve the Contractor of any obligation to make good any defective work or material.

- No compensation will be made in any case for loss of anticipated profits.

9-1.03 FORCE ACCOUNT PAYMENT

- When extra work is to be paid for on a force account basis, the labor, materials and equipment used in the performance of that work shall be subject to the approval of the Engineer and compensation will be determined as follows:

9-1.03A Work Performed by Contractor

- The Contractor will be paid the direct costs for labor, materials and equipment used in performing the work determined as hereinafter provided in Sections 9-1.03A(1), "Labor," 9-1.03A(2), "Materials," and 9-1.03A(3), "Equipment Rental," except where agreement has been reached to pay in conformance with the provisions in Section 9-1.03B, "Work Performed by Special Forces or Other Special Services."
- To the total of the direct costs computed as provided in Sections 9-1.03A(1), "Labor," 9-1.03A(2), "Materials," and 9-1.03A(3), "Equipment Rental," there will be added a markup of 33 percent to the cost of labor, 15 percent to the cost of materials and 15 percent to the equipment rental.
- The above markups shall constitute full compensation for all delay costs, overhead costs and profit which shall be deemed to include all items of expense not specifically designated as cost or equipment rental in Sections 9-1.03A(1), "Labor," 9-1.03A(2), "Materials," and 9-1.03A(3), "Equipment Rental." The total payment made as provided above shall be deemed to be the actual cost of the work and shall constitute full compensation therefor.
- When extra work to be paid for on a force account basis is performed by a subcontractor, approved in conformance with the provisions in Section 8-1.01, "Subcontracting," an additional markup of 5 percent will be added to the total cost of that extra work including all markups specified in this Section 9-1.03A. The additional 5 percent markup shall reimburse the Contractor for additional administrative costs, and no other additional payment will be made by reason of performance of the extra work by a subcontractor.

9-1.03A(1) Labor

- The Contractor will be paid the cost of labor for the workers (including foremen when authorized by the Engineer), used in the actual and direct performance of the work. The cost of labor, whether the employer is the Contractor, subcontractor or other forces, will be the sum of the following:

9-1.03A(1a) Actual Wages

- The actual wages paid shall include any employer payments to or on behalf of the workers for health and welfare, pension, vacation and similar purposes.

9-1.03A(1b) Labor Surcharge

- To the actual wages, as defined in Section 9-1.03A(1a), will be added a labor surcharge set forth in the Department of Transportation publication entitled Labor Surcharge And Equipment Rental Rates, which is in effect on the date upon which the work is accomplished and which is a part of the contract. The labor surcharge shall constitute full compensation for all payments imposed by State and Federal laws and for all other payments made to, or on behalf of, the workers, other than actual wages as defined in Section 9-1.03A(1a) and subsistence and travel allowance as specified in Section 9-1.03A(1c).

9-1.03A(1c) Subsistence and Travel Allowance

- The actual subsistence and travel allowance paid to the workers.

9-1.03A(2) Materials

- The Department reserves the right to furnish any materials it deems advisable, and the Contractor shall have no claims for costs and markup on those materials.
- Only materials furnished by the Contractor and necessarily used in the performance of the work will be paid for. The cost of those materials will be the cost to the purchaser, whether Contractor, subcontractor or other forces, from the supplier thereof, except as the following are applicable:

9-1.03A(2a)

- If a cash or trade discount by the actual supplier is offered or available to the purchaser, it shall be credited to the State notwithstanding the fact that the discount may not have been taken.

9-1.03A(2b)

- If materials are procured by the purchaser by any method which is not a direct purchase from and a direct billing by the actual supplier to the purchaser, the cost of those materials shall be deemed to be the price paid to the actual supplier as determined by the Engineer plus the actual costs, if any, incurred in the handling of the materials.

9-1.03A(2c)

- If the materials are obtained from a supply or source owned wholly or in part by the purchaser, the cost of those materials shall not exceed the price paid by the purchaser for similar materials furnished from that source on contract items or the current wholesale price for those materials delivered to the jobsite, whichever price is lower.

9-1.03A(2d)

- If the cost of the materials is, in the opinion of the Engineer, excessive, then the cost of the material shall be deemed to be the lowest current wholesale price at which the materials were available in the quantities concerned delivered to the jobsite, less any discounts as provided in Section 9-1.03A(2a).

9-1.03A(2e)

- If the Contractor does not furnish satisfactory evidence of the cost of the materials from the actual supplier thereof within 60 days after the date of delivery of the material or within 15 days after acceptance of the contract, whichever occurs first, the Department reserves the right to establish the cost of the materials at the lowest current wholesale prices at which the materials were available in the quantities concerned delivered to the location of the work, less any discounts as provided in Section 9-1.03A(2a).

9-1.03A(3) Equipment Rental

- The Contractor will be paid for the use of equipment at the rental rates listed for that equipment in the Department of Transportation publication entitled Labor Surcharge And Equipment Rental Rates, which is in effect on the date upon which the work is accomplished and which is a part of the contract, regardless of ownership and any rental or other agreement, if they may exist, for the use of that equipment entered into by the Contractor, except that for those pieces of equipment with a rental rate of $10.00 per hour or less as listed in the Labor Surcharge And Equipment Rental Rates publication and which are rented from a local equipment agency, other than Contractor owned, the Contractor will be paid at the hourly rate shown on the rental agency invoice or agreement for the time used on force account work as provided in Section 9-1.03A(3a), "Equipment on the Work." If a minimum equipment rental amount is required by the local equipment rental agency, the actual amount charged will be paid to the Contractor.
- If it is deemed necessary by the Engineer to use equipment not listed in the Labor Surcharge And Equipment Rental Rates publication, a suitable rental rate for that equipment will be established by the Engineer. The Contractor may furnish any cost data which might assist the Engineer in the establishment of the rental rate. If the rental rate established by the Engineer is $10.00 per hour or less, the provisions above concerning rental of equipment from a local equipment agency shall apply.
- The rental rates paid as above provided shall include the cost of fuel, oil, lubrication, supplies, small tools, necessary attachments, repairs and maintenance of any kind, depreciation, storage, insurance and all incidentals.
- Operators of rented equipment will be paid for as provided in Section 9-1.03A(1), "Labor."
- All equipment shall, in the opinion of the Engineer, be in good working condition and suitable for the purpose for which the equipment is to be used.
- Unless otherwise specified, manufacturer's ratings and manufacturer approved modifications shall be used to classify equipment for the determination of applicable rental rates. Equipment which has no direct power unit shall be powered by a unit of at least the minimum rating recommended by the manufacturer.
- Individual pieces of equipment or tools not listed in the Labor Surcharge and Equipment Rental Rate publication and having a replacement value of $500 or less, whether or not consumed by use, shall be considered to be small tools and no payment will be made therefor.
- Rental time will not be allowed while equipment is inoperative due to breakdowns.

9-1.03A(3a) Equipment on the Work

The rental time to be paid for equipment on the work shall be the time the equipment is in operation on the extra work being performed, and in addition, shall include the time required to move the equipment to the location of the extra work and return the equipment to the original location or to another location requiring no more time than that required to return the equipment to its original location, except that moving time will not be paid for if the equipment is used at the site of the extra work on other than the extra work. Loading and transporting costs will be allowed, in lieu of moving time, when the equipment is moved by means other than its own power, except that no payment will be made if the equipment is used at the site of the extra work on other than the extra work.

The following shall be used in computing the rental time of equipment on the work:

(1) When hourly rates are listed, less than 30 minutes of operation shall be considered to be 0.5-hour of operation.
(2) When daily rates are listed, less than4 hours of operation shall be considered to be 0.5-day of operation.

9-1.03A(3b) Equipment not on the Work

For the use of equipment moved in on the work and used exclusively for extra work paid for on a force account basis, the Contractor will be paid the rental rates listed in the Department of Transportation publication entitled Labor Surcharge And Equipment Rental Rates, which is in effect on the date upon which the work is accomplished and which is a part of the contract, or determined as provided in Section 9-1.03A(3) and for the cost of transporting the equipment to the location of the work and its return to its original location, all in accordance with the following provisions:

(1) The original location of the equipment to be hauled to the location of the work shall be agreed to by the Engineer in advance.
(2) The State will pay the costs of loading and unloading the equipment.
(3) The cost of transporting equipment in low bed trailers shall not exceed the hourly rates charged by established haulers.
(4) The rental period shall begin at the time the equipment is unloaded at the site of the extra work, shall include each day that the equipment is at the site of the extra work, excluding Saturdays, Sundays and legal holidays unless the equipment is used to perform the extra work on those days, and shall terminate at the end of the day on which the Engineer directs the Contractor to discontinue the use of the equipment. The rental time to be paid per day will be in accordance with the following:

Hours Equipment is in Operation	Hours to be Paid
0	4
0.5	4.25
1	4.5
1.5	4.75
2	5
2.5	5.25
3	5.5
3.5	5.75
4	6
4.5	6.25
5	6.5
5.5	6.75
6	7
6.5	7.25
7	7.5
7.5	7.75
8	8
Over 8	hours in operation

The hours to be paid for equipment which is operated less than 8 hours due to breakdowns, shall not exceed 8 less the number of hours the equipment is inoperative due to breakdowns.

When hourly rates are listed, less than 30 minutes of operation shall be considered to be 0.5-hour of operation.

When daily rates are listed, payment for 0.5-day will be made if the equipment is not used. If the equipment is used, payment will be made for one day.

The minimum rental time to be paid for the entire rental period on an hourly basis shall not be less than 8 hours or if on a daily basis shall not be less than one day.

(5) Should the Contractor desire the return of the equipment to a location other than its original location, the State will pay the cost of transportation in accordance with the above provisions, provided the payment shall not exceed the cost of moving the equipment to the work.

(6) Payment for transporting, and loading and unloading equipment, as above provided, will not be made if the equipment is used on the work in any other way than upon extra work paid for on a force account basis.

- When extra work, other than work specifically designated as extra work in the plans and specifications, is to be paid for on a force account basis and the Engineer determines that the extra work requires the Contractor to move on to the work equipment which could not reasonably have been expected to be needed in the performance of the contract, the Engineer may authorize payment for the use of the equipment at equipment rental rates in excess of those listed as applicable for the use of that equipment subject to the following additional conditions:

(1) The Engineer shall specifically approve thenecessity for the use of particular equipment on that work,
(2) The Contractor shall establish to the satisfaction of the Engineer that the equipment cannot be obtained from the Contractor's normal equipment source or sources and those of the Contractor's subcontractors,
(3) The Contractor shall establish to the satisfaction of the Engineer that the proposed equipment rental rate for the equipment from the proposed source is reasonable and appropriate for the expected period of use.
(4) The Engineer shall approve the equipment source and the equipment rental rate to be paid by the State before the Contractor begins work involving the use of that equipment.

9-1.03A(3c) Owner-Operated Equipment

When owner-operated equipment is used to perform extra work to be paid for on a force account basis, the Contractor will be paid for the equipment and operator, as follows:

Payment for the equipment will be made in conformance with the provisions in Section 9-1.03A(3), "Equipment Rental."

Payment for the cost of labor and subsistence or travel allowance will be made at the rates paid by the Contractor to other workers operating similar equipment already on the project or, in the absence of other workers operating similar equipment, at the rates for that labor established by collective bargaining agreements for the type of workers and location of the work, whether or not the owner-operator is actually covered by an agreement. A labor surcharge will be added to the cost of labor described herein, in conformance with the provisions in Section 9-1.03A(1b), "Labor Surcharge."

To the direct cost of equipment rental and labor, computed as provided herein, will be added the markups for equipment rental and labor as provided in Section 9-1.03A, "Work Performed by Contractor."

9-1.03A(3d) Dump Truck Rental

Dump truck rental shall conform to the provisions in Sections 9-1.03A(3), "Equipment Rental," 9-1.03A(3a), "Equipment on the Work," and 9-1.03A(3b), "Equipment not on the Work," except as follows:

Fully maintained and operated rental dump trucks used in the performance of extra work paid for on a force account basis will be paid for at the same hourly rate paid by the Contractor for use of fully maintained and operated rental dump trucks in performing contract item work.

In the absence of contract item work requiring dump truck rental, the Engineer will establish an hourly rental rate to be paid. The Contractor shall provide the Engineer with complete information on the hourly rental rates available for rental of fully maintained and operated dump trucks.

The provisions in Section 9-1.03A(1), "Labor," shall not apply to operators of rented dump trucks.

The rental rates listed for dump trucks in the Department of Transportation publication entitled Labor Surcharge And Equipment Rental Rates shall not apply.

To the total of the rental costs for fully maintained and operated dump trucks, including labor, there will be added a markup of 15 percent. An additional markup of 5 percent will be added by reason of performance of the work by a subcontractor. No separate markup will be made for labor.

- The provisions in Section 9-1.03A(3c), "Owner-Operated Equipment," shall not apply to dump truck rentals.

9-1.03B Work Performed by Special Forces or Other Special Services

- When the Engineer and the Contractor, by agreement, determine that a special service or an item of extra work cannot be performed by the forces of the Contractor or those of any of the Contractor's subcontractors, that service or extra work item may be performed by a specialist. Invoices for the service or item of extra work on the basis of the current market price thereof may be accepted without complete itemization of labor, material and equipment rental costs when it is impracticable and not in accordance with the established practice of the special service industry to provide a complete itemization.
- In those instances wherein a Contractor is required to perform extra work necessitating a fabrication or machining process in a fabrication or machine shop facility away from the jobsite, the charges for that portion of the extra work performed in the facility may, by agreement, be accepted as a specialist billing.
- To the specialist invoice price, less a credit to the State for any cash or trade discount offered or available, whether or not the discount may have been taken, will be added 15 percent in lieu of the percentages provided in Section 9-1.03A, "Work Performed by Contractor."

9-1.03C Records

- The Contractor shall maintain records in such a manner as to provide a clear distinction between the direct costs of extra work paid for on a force account basis and the costs of other operations.
- From the above records, the Contractor shall furnish the Engineer completed daily extra work reports, either on forms furnished by the Department or on computerized facsimiles of the Department's forms acceptable to the Engineer, for each day's extra work to be paid for on a force account basis. The daily extra work reports shall itemize the materials used, and shall cover the direct cost of labor and the charges for equipment rental, whether furnished by the Contractor, subcontractor or other forces, except for charges described in Section 9-1.03B, "Work Performed by Special Forces or Other Special Services." The daily extra work reports shall provide names or identifications and classifications of workers, the hourly rate of pay and hours worked, and also the size, type and identification number of equipment, and hours operated.
- Material charges shall be substantiated by valid copies of vendor's invoices. The invoices shall be submitted with the daily extra work reports, or if not available, the invoices shall be submitted with subsequent daily extra work reports.

Should the vendor's invoices not be submitted within 60 days after the date of delivery of the material or within 15 days after the acceptance of the contract, whichever occurs first, the Department reserves the right to establish the cost of the materials at the lowest current wholesale prices at which those materials were available in the quantities concerned delivered to the location of work less any discounts as provided in Section 9-1.03A(2a).

- Daily extra work reports shall be signed by the Contractor or the Contractor's authorized representative.
- The Engineer will compare the Engineer's records with the completed daily extra work reports furnished by the Contractor and make any necessary adjustments. When these daily extra work reports are agreed upon and signed by both parties, the reports shall become the basis of payment for the work performed, but shall not preclude subsequent adjustment based on a later audit by the Department.
- The Contractor's cost records pertaining to work paid for on a force account basis shall be open to inspection or audit by representatives of the Department, during the life of the contract and for a period of not less than 3 years after the date of acceptance thereof, and the Contractor shall retain those records for that period. Where payment for materials or labor is based on the cost thereof to forces other than the Contractor, the Contractor shall make every reasonable effort to ensure that the cost records of those other forces will be open to inspection and audit by representatives of the Department on the same terms and conditions as the cost records of the Contractor. If an audit is to be commenced more than 60 days after the acceptance date of the contract, the Contractor will be given a reasonable notice of the time when the audit is to begin.

9-1.03D Payment

- Payment as provided in Sections 9-1.03A, "Work Performed by Contractor," and 9-1.03B, "Work Performed by Special Forces or Other Special Services," shall constitute full compensation to the Contractor for performance of work paid for on a force account basis and no additional compensation will be allowed therefor. The payment will be made in conformance with the provisions in Section 9-1.06, "Partial Payments."

9-1.04 NOTICE OF POTENTIAL CLAIM

- It is the intention of this section that disputes between the parties arising under and by virtue of the contract be brought to the attention of the Engineer at the earliest possible time in order that the matters may be resolved, if possible, or other appropriate action promptly taken.
- Disputes will not be considered unless the Contractor has first complied with specified notice or protest requirements, including Section 4-1.03, "Changes," Section 5-1.116, "Differing Site Conditions," Section 8-1.06, "Time of Completion," Section 8-1.07, "Liquidated Damages," and Section 8-1.10, "Utility and Non-Highway Facilities."
- For disputes arising under and by virtue of the contract, including an act or failure to act by the Engineer, the Contractor shall provide a signed written initial notice of potential claim to the Engineer within 5 days from the date the dispute

first arose. The initial notice of potential claim shall provide the nature and circumstances involved in the dispute which shall remain consistent through the dispute. The initial notice of potential claim shall be submitted on Form CEM-6201A furnished by the Department and shall be certified with reference to the California False Claims Act, Government Code Sections 12650-12655. The Contractor shall assign an exclusive identification number for each dispute, determined by chronological sequencing, based on the date of the dispute.

- The exclusive identification number for each dispute shall be used on the following corresponding documents:

A. Initial notice of potential claim.
B. Supplemental notice of potential claim.
C. Full and final documentation of potential claim.
D. Corresponding claim included in the Contractor's written statement of claims.

- The Contractor shall provide the Engineer the opportunity to examine the site of work within 5 days from the date of the initial notice of potential claim. The Contractor shall proceed with the performance of contract work unless otherwise specified or directed by the Engineer.
- Throughout the disputed work, the Contractor shall maintain records that provide a clear distinction between the incurred direct costs of disputed work and that of undisputed work. The Contractor shall allow the Engineer access to the Contractor's project records deemed necessary by the Engineer to evaluate the potential claim within 20 days of the date of the Engineer's written request.
- Within 15 days of submitting the initial notice of potential claim, the Contractor shall provide a signed supplemental notice of potential claim to the Engineer that provides the following information:

A. The complete nature and circumstances of the dispute which caused the potential claim.
B. The contract provisions that provide the basis of claim.
C. The estimated cost of the potential claim, including an itemized breakdown of individual costs and how the estimate was determined.
D. A time impact analysis of the project schedule that illustrates the effect on the scheduled completion date due to schedule changes or disruptions where a request for adjustment of contract time is made.

- The information provided in items A and B above shall provide the Contractor's complete reasoning for additional compensation or adjustments.
- The supplemental notice of potential claim shall be submitted on Form CEM-6201B furnished by the Department and shall be certified with reference to the California False Claims Act, Government Code Sections 12650-12655. The Engineer will evaluate the information presented in the supplemental notice of potential claim and provide a written response to the Contractor within 20 days of its receipt. If the estimated cost or effect on the scheduled completion date

changes, the Contractor shall update information in items C and D above as soon as the change is recognized and submit this information to the Engineer.

- Within 30 days of the completion of work related to the potential claim, the Contractor shall provide the full and final documentation of potential claim to the Engineer that provides the following information:

A. A detailed factual narration of events fully describing the nature and circumstances that caused the dispute, including, but not limited to, necessary dates, locations, and items of work affected by the dispute.
B. The specific provisions of the contract that support the potential claim and a statement of the reasons these provisions support and provide a basis for entitlement of the potential claim.
C. When additional monetary compensation is requested, the exact amount requested calculated in conformance with Section 9-1.03, "Force Account Payment," or Section 8-1.09, "Right of Way Delays," including an itemized breakdown of individual costs. These costs shall be segregated into the following cost categories:

    1. Labor – A listing of individuals, classifications, regular hours and overtime hours worked, dates worked, and other pertinent information related to the requested reimbursement of labor costs.
    2. Materials – Invoices, purchase orders, location of materials either stored or incorporated into the work, dates materials were transported to the project or incorporated into the work, and other pertinent information related to the requested reimbursement of material costs.
    3. Equipment – Listing of detailed description (make, model, and serial number), hours of use, dates of use and equipment rates. Equipment rates shall be at the applicable State rental rate as listed in the Department of Transportation publication entitled "Labor Surcharge and Equipment Rental Rates," in effect when the affected work related to the dispute was performed.
    4. Other categories as specified by the Contractor or the Engineer.

D. When an adjustment of contract time is requested the following information shall be provided:

    1. The specific dates for which contract time is being requested.
    2. The specific reasons for entitlement to a contract time adjustment.
    3. The specific provisions of the contract that provide the basis for the requested contract time adjustment.
    4. A detailed time impact analysis of the project schedule. The time impact analysis shall show the effect of changes or disruptions on the scheduled completion date to demonstrate entitlement to a contract time adjustment.

E. The identification and copies of the Contractor's documents and the substance of oral communications that support the potential claim.

- The full and final documentation of the potential claim shall be submitted on Form CEM-6201C furnished by the Department and shall be certified with reference to the California False Claims Act, Government Code Sections 12650-12655.
- Pertinent information, references, arguments, and data to support the potential claim shall be included in the full and final documentation of potential claim. Information submitted subsequent to the full and final documentation submittal will not be considered. Information required in the full and final documentation of potential claim, as listed in items A to E above, that is not applicable to the dispute may be exempted as determined by the Engineer. No full and final documentation of potential claim will be considered that does not have the same nature and circumstances, and basis of claim as those specified on the initial and supplemental notices of potential claim.
- The Engineer will evaluate the information presented in the full and final documentation of potential claim and provide a written response to the Contractor within 30 days of its receipt unless otherwise specified. The Engineer's receipt of the full and final documentation of potential claim shall be evidenced by postal receipt or the Engineer's written receipt if delivered by hand. If the full and final documentation of potential claim is submitted by the Contractor after acceptance of the work by the Director, the Engineer need not provide a written response.
- Provisions in this section shall not apply to those claims for overhead costs and administrative disputes that occur after issuance of the proposed final estimate. Administrative disputes are disputes of administrative deductions or retentions, contract item quantities, contract item adjustments, interest payments, protests of contract change orders as provided in Section 4-1.03A, "Procedure and Protest," and protests of the Weekly Statement of Working Days as provided in Section 8-1.06, "Time of Completion." Administrative disputes that occur prior to issuance of the proposed final estimate shall follow applicable requirements of this section. Information listed in the supplemental notice and full and final documentation of potential claim that is not applicable to the administrative dispute may be exempted as determined by the Engineer.
- Unless otherwise specified in the special provisions, the Contractor may pursue the administrative claim process pursuant to Section 9-1.07B, "Final Payment and Claims," for any potential claim found by the Engineer to be without merit.
- Failure of the Contractor to conform to specified dispute procedures shall constitute a failure to pursue diligently and exhaust the administrative procedures in the contract, and is deemed as the Contractor's waiver of the potential claim and a waiver of the right to a corresponding claim for the disputed work in the administrative claim process in conformance with Section 9-1.07B, "Final Payment of Claims," and shall operate as a bar to arbitration pursuant to Section 10240.2 of the California Public Contract Code.

9-1.05 STOP NOTICES

The State of California, by and through the Department or other appropriate State office or officers, may at its option and at any time retain out of any amounts due the Contractor, sums sufficient to cover claims, filed pursuant to Section 3179 et seq. of the Civil Code. Stop notice information may be obtained from the Departmental Disbursing Office at 1801 30th Street, East Building, Sacramento, California.

9-1.06 PARTIAL PAYMENTS

The Department, once in each month, shall cause an estimate in writing to be made by the Engineer. The estimate shall include the total amount of work done and acceptable materials furnished, provided the acceptable materials are listed as eligible for partial payment as materials in the special provisions and are furnished and delivered by the Contractor on the ground and not used or are furnished and stored for use on the contract, if the storage is within the State of California and the Contractor furnishes evidence satisfactory to the Engineer that the materials are stored subject to or under the control of the Department, to the time of the estimate, and the value thereof. The estimate shall also include any amounts payable for mobilization. Daily extra work reports furnished by the Contractor less than 5 calendar days, not including Saturdays, Sundays and legal holidays, before the preparation of the monthly progress estimate shall not be eligible for payment until the following month's estimate.

The amount of any material to be considered in making an estimate will in no case exceed the amount thereof which has been reported by the Contractor to the Engineer on State-furnished forms properly filled out and executed, including accompanying documentation as therein required, less the amount of the material incorporated in the work to the time of the estimate. Only materials to be incorporated in the work will be considered. The estimated value of the material established by the Engineer will in no case exceed the contract price for the item of work for which the material is furnished.

The Department shall retain 10 percent of the estimated value of the work done and 10 percent of the value of materials so estimated to have been furnished and delivered and unused or furnished and stored as aforesaid as part security for the fulfillment of the contract by the Contractor, except that at any time after 20 percent of the work has been completed, if the Engineer finds that satisfactory progress is being made, the Department may reduce the total amount being retained from payment pursuant to the above requirements to 5 percent of the total estimated value of the work and materials and may also reduce the amount retained from any of the remaining partial payments to 5 percent of the estimated value of the work and materials. In addition, on any partial payment made after 95 percent of the work has been completed, the Department may reduce the amount withheld from payment pursuant to the requirements of this Section 9-1.06, to such lesser amount as the Department determines is adequate security for the fulfillment of the balance of the work and other requirements of the contract, but in no event will that amount be reduced to less than 125 percent of the estimated value of the work yet to be completed as determined by the Engineer. The reduction will only be made upon the written request of the Contractor and shall be approved in writing by the surety

on the Performance Bond and by the surety on the Payment Bond. The approval of the surety shall be submitted to the Disbursing Officer of the Department; the signature of the person executing the approval for the surety shall be properly acknowledged and the power of attorney authorizing the person to give that consent must either accompany the document or be on file with the Department.

- The Department shall pay monthly to the Contractor, while carrying on the work, the balance not retained, as aforesaid, after deducting therefrom all previous payments and all sums to be kept or retained under the provisions of the contract. No monthly estimate or payment shall be required to be made when, in the judgment of the Engineer, the work is not proceeding in accordance with the provisions of the contract.
- No monthly estimate or payment shall be construed to be an acceptance of any defective work or improper materials.
- Attention is directed to the prohibitions and penalties pertaining to unlicensed contractors as provided in Business and Professions Code Sections 7028.15(a) and 7031.

9-1.065 PAYMENT OF WITHHELD FUNDS

- Attention is directed to Section 9-1.06, "Partial Payments," and in particular to the retention provisions of that section.
- Upon the Contractor's request, pursuant to Public Contract Code Section 10263, the Department will make payment of funds withheld from progress payments to ensure performance of the contract if the Contractor deposits in escrow with the State Treasurer, or with a bank acceptable to the Department, securities equivalent to the amount withheld. The Contractor shall be beneficial owner of any securities substituted for moneys withheld and shall receive any interest thereon. Upon satisfactory completion of the contract, the securities shall be returned to the Contractor.
- Alternatively, upon the Contractor's request, the Department will make payment of retentions earned directly to the escrow agent. The Contractor may direct the investment of the payments into securities, and the Contractor shall receive the interest earned on the investments upon the same terms provided for securities deposited by the Contractor. Upon satisfactory completion of the contract, the Contractor shall receive from the escrow agent all securities, interest and payments received by the escrow agent from the Department, pursuant to the terms in Section 10263 of the Public Contract Code.
- Alternatively, and subject to the approval of the Department, the payment of retentions earned may be deposited directly with a person licensed under Division 6 (commencing with Section 17000) of the Financial Code as the escrow agent. Upon written request of an escrow agent that has not been approved by the Department under subdivision (c) of Section 10263 of the Public Contract Code, the Department will provide written notice to that escrow agent within 10 business days of receipt of the request indicating the reason or reasons for not approving that escrow agent. The payments will be deposited in a trust account with a Federally chartered bank or savings association within 24 hours of receipt by the escrow agent. The Contractor shall not place any retentions with the escrow agent in excess of the coverage provided to that escrow agent pursuant to subdivision (b) of

Section 17314 of the Financial Code. In all respects not inconsistent with subdivision (c) of Section 10263 of the Public Contract Code, the remaining provisions of Section 10263 of the Public Contract Code shall apply to escrow agents acting pursuant to subdivision (c) of Section 10263 of the Public Contract Code.

- Securities eligible for investment shall include those listed in Section 16430 of the Government Code, bank or savings and loan certificates of deposit, interest-bearing demand deposit accounts, standby letters of credit or any other security mutually agreed to by the Contractor and the Department.
- The escrow agreement used pursuant to this Section 9-1.065 shall be substantially similar to the "Escrow Agreement for Security Deposits In Lieu of Retention" in Section 10263 of the Public Contract Code, deemed as incorporated herein by reference.
- The Contractor shall obtain the written consent of the surety to the agreement.

9-1.07 PAYMENT AFTER ACCEPTANCE

- After the work has been accepted by the Director, as provided in Section 7-1.17, "Acceptance of Contract," payments will be made to the Contractor subject to the provisions in this Section 9-1.07.

9-1.07A Payment Prior to Proposed Final Estimate

- After acceptance of the work by the Director, the Engineer will make an estimate of the total amount of work done under the contract and the Department will make a final monthly payment pending issuance of the proposed final estimate. The Department will pay the balance thereon found to be due after deduction of all previous payments, all amounts to be kept or retained under the provisions of the contract and those further amounts that the Engineer determines to be necessary pending issuance of the proposed final estimate and payment thereon.

9-1.07B Final Payment and Claims

- After acceptance by the Director, the Engineer will make a proposed final estimate in writing of the total amount payable to the Contractor, including an itemization of the total amount, segregated by contract item quantities, extra work and other basis for payment, and shall also show each deduction made or to be made for prior payments and amounts to be kept or retained under the provisions of the contract. Prior estimates and payments shall be subject to correction in the proposed final estimate. The Contractor shall submit written approval of the proposed final estimate or a written statement of claims arising under or by virtue of the contract so that the Engineer receives the written approval or statement of claims no later than close of business of the thirtieth day after receiving the proposed final estimate. If the thirtieth day falls on a Saturday, Sunday or legal holiday, then receipt of the written approval or statement of claims by the Engineer shall not be later than close of business of the next business day. The Contractor's receipt of the proposed final estimate shall be evidenced by postal receipt. The Engineer's receipt of the Contractor's written approval or statement of claims shall be evidenced by postal receipt or the Engineer's written receipt if delivered by hand.

- On the Contractor's approval, or if the Contractor files no claim within the specified period of 30 days, the Engineer will issue a final estimate in writing in conformance with the proposed final estimate submitted to the Contractor, and within 30 days thereafter the State will pay the entire sum so found to be due. That final estimate and payment thereon shall be conclusive and binding against both parties to the contract on all questions relating to the amount of work done and the compensation payable therefor, except as otherwise provided in Sections 9-1.03C, "Records," and 9-1.09, "Clerical Errors."
- If the Contractor within the specified period of 30 days files claims, the Engineer will issue a semifinal estimate in conformance with the proposed final estimate submitted to the Contractor and within 30 days thereafter the State will pay the sum found to be due. The semifinal estimate and corresponding payment shall be conclusive and binding against both parties to the contract on each question relating to the amount of work done and the compensation payable therefor, except insofar as affected by the claims filed within the time and in the manner required hereunder and except as otherwise provided in Sections 9-1.03C, "Records," and 9-1.09, "Clerical Errors."
- Except for claims for overhead costs and administrative disputes that occur after issuance of the proposed final estimate, the Contractor shall only provide the following two items of information for each claim:

  A. The exclusive identification number that corresponds to the supporting full and final documentation of potential claim.
  B. The final amount of requested additional compensation.

- If the final amount of requested additional compensation is different than the amount of requested compensation included in the full and final documentation of potential claim, the Contractor shall provide in the written statement of claims the reasons for the changed amount, the specific provisions of the contract which support the changed amount, and a statement of the reasons the provisions support and provide a basis for the changed amount. If the Contractor's claim fails to provide an exclusive identification number or if there is a disparity in the provided exclusive identification number, the Engineer will notify the Contractor of the omission or disparity. The Contractor shall have 15 days after receiving notification from the Engineer to correct the omission or disparity. If after the 15 days has elapsed, there is still an omission or disparity of the exclusive identification number assigned to the claim, the Engineer will assign the number. No claim will be considered that has any of the following deficiencies:

  A. The claim does not have the same nature, circumstances, and basis as the corresponding full and final documentation of potential claim.
  B. The claim does not have a corresponding full and final documentation of potential claim.
  C. The claim was not included in the written statement of claims.
  D. The Contractor did not comply with applicable notice or protest requirements of Sections 4-1.03, "Changes," 5-1.116, "Differing Site

Conditions," 8-1.06, "Time of Completion," 8-1.07, "Liquidated Damages," 8-1.10, "Utility and Non-Highway Facilities," and 9-1.04, "Notice of Potential Claim."

- Administrative disputes that occur after issuance of the proposed final estimate shall be included in the Contractor's written statement of claims in sufficient detail to enable the Engineer to ascertain the basis and amounts of those claims.
- The Contractor shall keep full and complete records of the costs and additional time incurred for work for which a claim for additional compensation is made. The Engineer or designated claim investigators or auditors shall have access to those records and any other records as may be required by the Engineer to determine the facts or contentions involved in the claims. Failure to permit access to those records shall be sufficient cause for denying the claims.
- The written statement of claims submitted by the Contractor shall be accompanied by a notarized certificate containing the following language:

Under the penalty of law for perjury or falsification and with specific reference to the California False Claims Act, Government Code Section 12650 et. seq., the undersigned,

.

(name)

of

(title)

.

(company)

hereby certifies that the claim for the additional compensation and time, if any, made herein for the work on this contract is a true statement of the actual costs incurred and time sought, and is fully documented and supported under the contract between parties.

Dated

/s/

Subscribed and sworn before me this day

of .

(Notary Public)
My Commission
Expires

- Failure to submit the notarized certificate will be sufficient cause for denying the claim.
- Any claim for overhead, in addition to being certified as stated above, shall be supported and accompanied by an audit report of an independent Certified Public Accountant. Omission of a supporting audit report of an independent Certified

Public Accountant shall result in denial of the claim and shall operate as a bar to arbitration, as to the claim, in conformance with the requirements in Section 10240.2 of the California Public Contract Code. Any claim for overhead shall be subject to audit by the State at its discretion. The costs of performing an audit examination and submitting the report shall be borne by the Contractor. The Department will deduct an offset amount for field and home office overhead paid on all added work from any claim for overhead as appropriate, as determined by the Department. The value of the added work equals the value of the work completed minus the total bid. The home office overhead offset equals 5 percent of the added work. The field office overhead offset equals $5^1/_2$ percent of the added work. The Certified Public Accountant's audit examination shall be performed in conformance with the requirements of the American Institute of Certified Public Accountants Attestation Standards. The audit examination and report shall depict the Contractor's project and company-wide financial records and shall specify the actual overall average daily rates for both field and home office overhead for the entire duration of the project, and whether the costs have been properly allocated. The rates of field and home office overhead shall exclude unallowable costs as determined in Title 48 of the Federal Acquisition Regulations, Chapter 1, Part 31. The audit examination and report shall determine if the rates of field and home office overhead are:

A. Allowable in conformance with the requirements in Title 48 of the Federal Acquisition Regulations, Chapter 1, Part 31.
B. Adequately supported by reliable documentation.
C. Related solely to the project under examination.

- Costs or expenses incurred by the State in reviewing or auditing claims that are not supported by the Contractor's cost accounting or other records shall be deemed to be damages incurred by the State within the meaning of the California False Claims Act.
- If the Engineer determines that a claim requires additional analysis, the Engineer will schedule a board of review meeting. The Contractor shall meet with the review board or person and make a presentation in support of the claim. Attendance by the Contractor at the board of review meeting shall be mandatory.
- The District Director of the District that administered the contract will make the final determination of any claims which remain in dispute after completion of claim review by the Engineer or board of review meeting.
- The final determination of claims will be sent to the Contractor by hand delivery or deposit in the U.S. mail. The Engineer will then make and issue the Engineer's final estimate in writing and within 30 days thereafter the State will pay the entire sum, if any, found due thereon. That final estimate shall be conclusive and binding against both parties to the contract on all questions relating to the amount of work done and the compensation payable therefor, except as otherwise provided in Sections 9-1.03C, "Records," and 9-1.09, "Clerical Errors."
- Failure of the Contractor to conform to the specified dispute procedures shall constitute a failure to pursue diligently and exhaust the administrative procedures in

the contract and shall operate as a bar to arbitration in conformance with the requirements in Section 10240.2 of the California Public Contract Code.

9-1.08 ADJUSTMENT OF OVERHEAD COSTS

- When the final estimate of the contract cost of the work, including extra work, is made and the total of the final estimate is less than 90 percent of the total bid price for performing the contract work, as submitted by the Contractor in the bid proposal, an adjustment in the final payment to the Contractor to cover overhead costs will be made as set forth below. No adjustment for overhead costs will be made when the total of the final estimate is 90 percent or more of the total bid price for performing the contract work.
- Additional payment to the Contractor to cover overhead costs as above provided shall be 10 percent of the difference between a computed amount representing 90 percent of the estimated cost of the work as submitted by the Contractor in the bid proposal and the final estimate of cost of the work, including extra work.
- The provisions of this Section 9-1.08 shall not apply to contracts which have been terminated pursuant to Sections 7-1.125, "Legal Actions Against the Department," 7-1.165, "Damage by Storm, Flood, Tsunami or Earthquake," 8-1.11, "Termination of Contract," or other provisions for terminating the contract.

9-1.09 CLERICAL ERRORS

- Notwithstanding the provisions in Section 9-1.07, "Payment After Acceptance," for a period of 3 years after acceptance of the work, all estimates and payments made pursuant to Section 9-1.07, including the final estimate and payment, shall be subject to correction and adjustment for clerical errors in the calculations involved in the determination of quantities and payments. The Contractor and the Department agree to pay to the other any sum due under the provisions of this Section 9-1.09, provided, however, if the total sum to be paid is less than $200, no payment shall be made.

9-1.10 ARBITRATION

- Article 7.1, (Sections 10240-10240.13, inclusive) of Chapter 1, Division 2 of the Public Contract Code provides for the resolution of contract claims by arbitration.
- Claims (demands for monetary compensation or damages) arising under or related to performance of the contract shall be resolved by arbitration unless the Department and the Contractor agree in writing, after the claim has arisen, to waive arbitration and to have the claim litigated in a court of competent jurisdiction. Arbitration shall be pursuant to Public Contract Code Sections 10240-10240.13, inclusive, and applicable regulations (see Subchapter 3 [Sections 301-382, inclusive] of Chapter 2 of Title 1 of the California Code of Regulations). The arbitration decision shall be decided under and in accordance with the law of this State, supported by substantial evidence and, in writing, contain the basis for the decision, findings of fact and conclusions of law.
- Arbitration shall be initiated by a Complaint in Arbitration made in compliance with the requirements of those regulations. A Complaint in Arbitration by the Contractor shall be made not later than 90 days after the date of service in person or

by mail on the Contractor of the final written decision by the Department on the claim.

MISCELLANEOUS

SECTION 10: DUST CONTROL

10-1.01 DESCRIPTION

- This work shall consist of applying either water or dust palliative, or both, for the alleviation or prevention of dust nuisance.
- Dust resulting from the Contractor's performance of the work, either inside or outside the right of way, shall be controlled by the Contractor in conformance with the provisions in Section 7, "Legal Relations and Responsibility."
- It is understood that the provisions in Section 10, "Dust Control," will not prevent the Contractor from applying water or dust palliative for the Contractor's convenience if the Contractor so desires.

10-1.02 APPLICATION

- Water shall be applied as provided in Section 17, "Watering," and dust palliative shall conform to and be applied as provided in Section 18, "Dust Palliative."

10-1.03 (BLANK)

10-1.04 PAYMENT

- No separate payment will be made for work performed or material used to control dust resulting from the Contractor's performance of the work, either inside or outside the right of way. Full compensation for this dust control will be considered as included in the prices paid for the various items of work involved.
- When the Engineer orders the application of water for the purpose of controlling dust caused by public traffic only, the work will be paid for as extra work as provided in Section 4-1.03D, "Extra Work", except as otherwise provided in Section 8-1.05, "Temporary Suspension of Work."

SECTION 11: MOBILIZATION

11-1.01 DESCRIPTION

Mobilization shall consist of preparatory work and operations, including, but not limited to, those necessary for the movement of personnel, equipment, supplies and incidentals to the project site; for the establishment of all offices, buildings and other facilities necessary for work on the project; and for all other work and operations which must be performed or costs incurred prior to beginning work on the various contract items on the project site.

11-1.02 PAYMENT

Attention is directed to Sections 9-1.06, "Partial Payments," and 9-1.07, "Payment After Acceptance." Payments for mobilization will be made as follows:

A. When the monthly partial payment estimate of the amount earned, not including the amount earned for mobilization, is 5 percent or more of the original contract amount, 50 percent of the contract item price for mobilization or 5 percent of the original contract amount, whichever is the lesser, will be included in the estimate for payment.
B. When the monthly partial payment estimate of the amount earned, not including the amount earned for mobilization, is 10 percent or more of the original contract amount, the total amount earned for mobilization shall be 75 percent of the contract item price for mobilization or 7.5 percent of the original contract amount, whichever is the lesser, and that amount will be included in the estimate for payment.
C. When the monthly partial payment estimate of the amount earned, not including the amount earned for mobilization, is 20 percent or more of the original contract amount, the total amount earned for mobilization shall be 95 percent of the contract item price for mobilization or 9.5 percent of the original contract amount, whichever is the lesser, and that amount will be included in the estimate for payment.
D. When the monthly partial payment estimate of the amount earned, not including the amount earned for mobilization, is 50 percent or more of the original contract amount, the total amount earned for mobilization shall be 100 percent of the contract item price for mobilization or 10 percent of the original contract amount, whichever is the lesser, and that amount will be included in the estimate for payment.
E. After acceptance of the contract pursuant to Section 7-1.17, "Acceptance of Contract," the amount, if any, of the contract item price for mobilization in excess of 10 percent of the original contract amount will be included for payment in the first estimate made in conformance with the provisions in Section 9-1.07.

The contract lump sum price paid for mobilization shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in mobilization as specified herein.

- The adjustment provisions in Section 4-1.03, "Changes," and the retention of funds provisions in Section 9-1.06, "Partial Payments," shall not apply to the contract lump sum item of mobilization.
- When other contract items are adjusted as provided in Section 4-1.03, "Changes," if the costs applicable to an item of work include mobilization costs, those mobilization costs will be deemed to have been recovered by the Contractor by the payments made for mobilization, and will be excluded from consideration in determining compensation under Section 4-1.03.
- When the contract does not include a contract pay item for mobilization as above specified, full compensation for any necessary mobilization required shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefor.

SECTION 12: CONSTRUCTION AREA TRAFFIC CONTROL DEVICES

12-1 GENERAL

12-1.01 DESCRIPTION

- Sections 7-1.08, "Public Convenience," and 7-1.09, "Public Safety," set forth the Contractor's responsibilities for public convenience and public safety. This Section 12 sets forth requirements concerning flagging and traffic-handling equipment and devices used in carrying out the provisions in Sections 7-1.08 and 7-1.09 and the special provisions.
- Attention is directed to Part 6 of the MUTCD and of the MUTCD California Supplement. Nothing in this Section 12 is to be construed as to reduce the minimum standards in these manuals.

12-2 FLAGGING

12-2.01 FLAGGERS

- Flaggers while on duty and assigned to traffic control or to give warning to the public that the highway is under construction and of any dangerous conditions to be encountered as a result thereof, shall perform their duties and shall be provided with the necessary equipment in conformance with Part 6 of the MUTCD and of the MUTCD California Supplement. The equipment shall be furnished and kept clean and in good repair by the Contractor at the Contractor's expense.

12-2.02 FLAGGING COSTS

- The cost of furnishing all flaggers, including transporting flaggers, to provide for passage of public traffic through the work under the provisions in Sections 7-1.08, "Public Convenience," and 7-1.09, "Public Safety," will be borne equally by the State and the Contractor. The cost of providing stands or towers for use of flaggers shall be considered as part of the cost of furnishing flaggers. The division of cost will be made by determining the cost of furnishing flaggers in conformance with the provisions in Section 9-1.03, "Force Account Payment," and paying to the Contractor one-half of that cost.
- The provisions in this Section 12-2.02 shall in nowise relieve the Contractor from the responsibility of providing for the safety of the public as provided in Section 7-1.09, "Public Safety," nor relieve the Contractor from the responsibility for damage as provided in Section 7, "Legal Relations and Responsibility."

12-3 TRAFFIC-HANDLING EQUIPMENT AND DEVICES

12-3.01 GENERAL

- In addition to the requirements in Part 6 of the MUTCD and of the MUTCD California Supplement, all devices used by the Contractor in the performance of the work shall conform to the provisions in this Section 12-3.
- Traffic-handling equipment and devices damaged from any cause during the progress of the work shall be repaired, including painting if necessary, or replaced by the Contractor at the Contractor's expense.
- When traffic control devices furnished by the Contractor are no longer needed for controlling traffic, they shall be removed from the site of the work.

- Whenever the term "hours of darkness" is used in the specifications it shall be deemed to mean the hours of darkness as defined in Division 1, Section 280, of the California Vehicle Code.
- Retroreflective sheeting shall conform to the requirements in ASTM Designation: D 4956 and to the special provisions.

12-3.02 BARRICADES

- Barricades shall conform to the details shown on the plans and shall be as specified in this Section 12-3.02.
- Barricades shall be constructed of lightweight commercial quality materials, as approved by the Engineer. Stay bracing for "A"-frame designs shall not be rigid.
- Markings for barricade rails shall be alternate orange and white stripes. The entire area of orange and white stripes shall be Type-I, engineering grade, or Type-II, super engineering grade, retroreflective sheeting. The color of the orange retroreflective sheeting shall conform to PR No. 6, Highway Orange, of the Federal Highway Administration's Color Tolerance Chart. Retroreflective sheeting shall be placed on rail surfaces in such a manner that no air bubbles or voids are present between the rail surface and retroreflective sheeting. The predominate color for barricade components other than rails shall be white, except that unpainted galvanized metal or aluminum may be used.
- Owner identification shall not be imprinted on the reflectorized face of any rail, but may be imprinted elsewhere.
- Ballasting shall be by means of sand filled bags placed on the lower parts of the frame or stays, but shall not be placed on top of the barricade nor over any reflectorized barricade rail face facing traffic.
- If the barricades are displaced or are not in an upright position, from any cause, the barricades shall immediately be replaced or restored to their original location, in an upright position, by the Contractor.

12-3.03 FLASHING ARROW SIGNS

- Flashing arrow signs shall be finished with commercial quality flat black enamel and shall be equipped with yellow or amber lamps that form arrows or arrowheads as required. Each lamp shall be provided with a visor and the lamps shall be controlled by an electronic circuit that will provide between 30 and 45 complete operating cycles per minute in each of the displays and modes specified. The control shall include provisions for dimming the lamps by reducing the voltage to 50 percent, ±5 percent, for nighttime use. Type I signs shall have both manual and automatic photoelectric dimming controls. Dimming in both modes shall be continuously variable over the entire dimming range.

- Flashing arrow signs shall conform to the following legibility requirements. The minimum legibility distance is the distance at which flashing arrow signs shall be legible at noon on a cloudless day and at night by persons with vision of or corrected to 20/20.

Type	Min. Size	Min. Number of Panel Lights	Min. Legibility Distance
I	48" x 96"	15	one mile
II	36" x 72"	13	3/4 mile

- Flashing arrow signs shall be capable of being operated in 4 different display modes as follows. The display to be used shall be as directed by the Engineer:

1. Pass Left Display
2. Pass Right Display
3. Simultaneous Display
4. Caution Display

- Flashing arrow signs shall also be capable of operating in one or both of the following modes, at the option of the Contractor:

1. Flashing Arrow Mode
2. Sequential Mode

- In the flashing arrow mode, all lamps forming the arrowhead and shaft shall flash on and off simultaneously.
- In the sequential mode, either arrowheads or arrows shall flash sequentially in the direction indicated.
- In the simultaneous display mode, the lamps forming both right and left arrowheads and the lamps of the arrowshaft (center 3 on Type I signs) shall flash simultaneously. On Type II signs, the lamps forming the right and left arrowhead, except the center lamp, may be continuously illuminated while the lamps forming the shaft and the center lamp of the arrowheads flash on and off simultaneously.
- In the caution display mode, a combination of lamps not resembling any other display or mode shall flash.
- Each flashing arrow sign shall be mounted on a truck or on a trailer and shall be capable of operating while the vehicle is moving and shall be capable of being placed and maintained in operation at locations as shown on the plans, as specified in the special provisions or as directed by the Engineer.
- Flashing arrow signs shall be mounted to provide a minimum of 7 feet between the bottom of the sign and the roadway.
- Trailers on which flashing arrow signs are mounted shall be equipped so that they can be leveled and plumbed.
- Electrical energy to operate the sign shall be obtained from the vehicle on which the sign is mounted or from a generating plant mounted on the vehicle.

Regardless of the source, the supply of electrical energy shall be capable of operating the sign in the manner specified.

12-3.04 PORTABLE DELINEATORS

- Portable delineators, including the base, shall be composed of a material that has sufficient rigidity to remain upright when unattended and shall be either flexible or collapsible upon impact by a vehicle. The base shall be of such shape as to preclude roll after impact. The base shall be of sufficient weight or shall be anchored in a manner such that the delineator shall remain in an upright position. Ballast, if used for the bases of portable delineators, shall be sand or water.
- If the portable delineators are displaced or are not in an upright position, from any cause, the delineators shall immediately be replaced or restored to their original location, in an upright position, by the Contractor.
- The vertical portion of the portable delineators shall be of a fluorescent orange or predominantly orange color. The posts shall be not less than 3 inches in width or diameter. The minimum height shall be 36 inches above the traveled way.
- A minimum of 2 retroreflective bands, each not less than 3 inches wide, shall be mounted a minimum of $1^1/_2$ inches apart and at a height on the post so that one retroreflective band will be between 2.5 feet and 3 feet above the roadway surface.
- Retroreflective bands shall be white and shall be fabricated from flexible reflective sheeting as specified in the special provisions. The retroreflective bands shall be visible at 1,000 feet at night under illumination of legal high beam headlights, by persons with vision of or corrected to 20/20.
- Only one type of portable delineator shall be used on the project. The type of portable delineator proposed for use on the project shall be submitted to the Engineer for approval prior to placement on the project.

12-3.05 PORTABLE FLASHING BEACONS

- Each portable flashing beacon unit shall consist of a lighting unit, a flasher unit, a standard, a battery power source and a base. The units shall be assembled to form a complete, self-contained, flashing beacon which can be delivered to the site of use and placed in immediate operation.
- The lens for the beacon lighting unit shall have a visible diameter of 12 inches. The lens shall be glass or plastic conforming to the requirements in ANSI Standard: D-10.1 for yellow traffic signal lens.
- The beacon lighting unit shall be provided with a 8-inch minimum length visor and a backplate. Visors will not be required during the hours of darkness.
- The flasher unit shall provide 50 flashes to 60 flashes per minute with 250 milliseconds to 350 milliseconds dwell time.
- The standard shall be adjustable to provide a variable mounting of the lighting unit between 6 feet and 10 feet, measured from the bottom of the base to the center of the lens, with provisions for securing the standard at the desired height. The standard shall be securely attached to the base and a sufficient length of multi-conductor, neoprene jacketed cable as required for full vertical height shall be provided.

- The base shall be large enough to accommodate a minimum of two 12-V automotive type storage batteries, and shall be of such shape and mass that the beacon will not roll in the event it is struck by a vehicle or pushed over.
- The lamp shall be rated at 25 W for operation on 12-V battery current.
- The flashing beacon assembly shall be weatherproof and shall be capable of operating a minimum of 150 hours between battery recharging or other routine maintenance.
- The standard and base shall be finished with 2 applications of a commercial quality orange enamel similar in color to No. 12473 of Federal Standard 595B. The interior of the visor and the front face of the backplate shall be finished with 2 applications of commercial quality flat black enamel.

12-3.06 CONSTRUCTION AREA SIGNS

- The term "Construction Area Signs" shall include all temporary signs required for the direction of public traffic through or around the work during construction. Construction area signs are shown in or referred to in Part 6 of the MUTCD and of the MUTCD California Supplement.
- Construction area signs shall be installed at the locations shown on the plans as directed by the Engineer.
- Construction area signs designated as stationary mounted on the plans shall conform to the provisions in Section 12-3.06A, "Stationary Mounted Signs," and construction area signs designated as portable signs on the plans shall conform to the provisions in Section 12-3.06B, "Portable Signs." Construction area signs not designated as stationary mounted nor as portable on the plans shall be, at the Contractor's option, either stationary mounted or portable signs conforming to the provisions in Sections 12-3.06A or 12-3.06B.
- All construction area signs shall conform to the dimensions, color and legend requirements of the plans, Part 6 of the MUTCD, Part 6 of the MUTCD California Supplement, and these specifications. All sign panels shall be the product of a commercial sign manufacturer, and shall be as specified in these specifications.
- Sign panels for all construction area signs shall be visible at 500 feet and legible at 300 feet, at noon on a cloudless day and at night under illumination of legal low beam headlights, by persons with vision of or corrected to 20/20, except that the nighttime requirement shall not apply to fabric sign panels for portable signs.
- The Contractor may be required to cover certain signs during the progress of the work. Covers for construction area signs shall be of sufficient size and density to completely block out the message so that it is not visible either during the day or at night. Covers shall be fastened securely to prevent movement caused by wind action.
- The Contractor shall clean all construction area sign panels at the time of installation and as often thereafter as the Engineer determines to be necessary, but at least once every 4 months.
- Used signs with the specified sheeting material will be considered satisfactory if they conform to the requirements for visibility and legibility and the colors conform to the requirements in Part 6 of the MUTCD and of the MUTCD

California Supplement. A significant difference between day and nighttime retroreflective color will be grounds for rejecting signs.

- To properly provide for changing traffic conditions and damage caused by public traffic or otherwise, the Contractor shall be prepared to furnish on short notice additional construction area sign panels, posts and mounting hardware or portable sign mounts. The Contractor shall maintain an inventory of the commonly required items at the jobsite or shall make arrangements with a supplier who is able, on a daily basis, to furnish the items on short notice.

12-3.06A Stationary Mounted Signs

- Stationary mounted signs shall be installed on wood posts in the same manner shown on the plans for installation of roadside signs, except as follows:

1. Back braces and blocks for sign panels will not be required.
2. The height to the bottom of the sign panel above the edge of traveled way shall be at least 7 feet.
3. Construction area sign posts may be installed on above ground temporary platform sign supports as approved by the Engineer, or the signs may be installed on existing lighting standards or other supports as approved by the Engineer. When construction area signs are installed on existing lighting standards, holes shall not be made in the standards to support the sign.
4. The post embedment shall be 2.5 feet if post holes are backfilled around the posts with portland cement concrete produced from commercial quality aggregates and cement with not less than 295 pounds of cement per cubic yard.

- Post size and number of posts shall be as shown on the plans, except that when stationary mounted signs are installed and the type of sign installation is not shown on the plans, post size and the number of posts will be determined by the Engineer. Posts shall be good sound wood posts, suitable for the purpose intended.
- Sign panel fastening hardware shall be commercial quality.

12-3.06B Portable Signs

- Each portable sign shall consist of a base, standard or framework and a sign panel. The units shall be capable of being delivered to the site of use and placed in immediate operation.
- Sign panels for portable signs shall conform to the provisions for sign panels for stationary mounted signs in Section 12-3.06A, "Stationary Mounted Signs," or shall be Type VI retroreflective sheeting, or shall be cotton drill fabric, flexible industrial nylon fabric or other approved fabric. Fabric signs shall not be used during the hours of darkness. Size, color and legend requirements for portable signs shall be as described for stationary mounted sign panels in Section 12-3.06A. The height to the bottom of the sign panel above the edge of traveled way shall be at least one foot.

- If portable signs are displaced or overturned, from any cause, during the progress of the work, the Contractor shall immediately replace the signs in their original locations.

12-3.07 CHANNELIZERS

- Channelizers shall conform to the provisions in the special provisions and these specifications.
- Channelizer posts shall be orange in color.
- Channelizers shall have affixed white retroreflective sheeting as specified in the special provisions. The retroreflective sheeting shall be 3" x 12" in size. The retroreflective sheeting shall be visible at 1,000 feet at night under illumination of legal high beam headlights, by persons with vision of or corrected to 20/20.
- The channelizer bases shall be cemented to the pavement in the same manner as provided for cementing pavement markers to pavement in Section 85-1.06, "Placement." Channelizers shall be applied only on a clean, dry surface.
- Channelizers shall be placed on the alignment and location shown on the plans, or directed by the Engineer. The channelizers shall be placed uniformly, straight on tangent alignment and on a true arc on curved alignment. All layout work necessary to place the channelizers to the proper alignment shall be performed by the Contractor.
- If the channelizers are displaced or fail to remain in an upright position, from any cause, the channelizers shall immediately be replaced or restored to their original location, by the Contractor.

12-3.08 TEMPORARY RAILING (TYPE K)

- Temporary railing (Type K) shall consist of interconnected new or undamaged used precast concrete barrier units as shown on the plans. Exposed surfaces of new and used units shall be freshly coated with a white color paint prior to their first use on the project. The paint shall conform to the provisions in Section 91-4.05, "Paint; Acrylic Emulsion, Exterior White and Light and Medium Tints." Repainting of units, when ordered by the Engineer after the units are in place, will be paid for as extra work in conformance with the provisions in Section 4-1.03D.
- Concrete shall conform to the provisions in Section 90-10, "Minor Concrete." Load tickets and a Certificate of Compliance will not be required.
- Reinforcing steel shall conform to the provisions in Section 52, "Reinforcement."
- Steel bars to receive bolts at ends of concrete panels shall conform to the requirements in ASTM Designation: A 36/A 36M. The bolts shall conform to the requirements in ASTM Designation: A 307.
- A round bar of the same diameter may be substituted for the end-connecting bolt shown on the plans. The bar shall conform to the requirements in ASTM Designation: A 36/A 36M, shall have a minimum length of 26 inches and shall have a 3-inch diameter by $^{3}/_{8}$ inch thick plate welded on the upper end with a $^{3}/_{16}$ inch fillet weld.
- The final surface finish of temporary railings (Type K) shall conform to the provisions in Section 51-1.18A, "Ordinary Surface Finish."

- Exposed surfaces of concrete elements shall be cured by the water method, the forms-in-place method, or the pigmented curing compound method. The pigmented curing compound shall be curing compound (1) as specified in Section 90-7.01B, "Curing Compound Method."
- The Contractor shall furnish a Certificate of Compliance to the Engineer in conformance with the provisions in Section 6-1.07, "Certificates of Compliance," for all new or used temporary railing (Type K) that is not cast on the project.
- Temporary railing (Type K) may have the Contractor's name or logo on each panel. The name or logo shall not be more than 4 inches in height and shall be located not more than 12 inches above the bottom of the rail panel.
- Temporary railing (Type K) shall be set on firm, stable foundation. The foundation shall be graded to provide a uniform bearing throughout the entire length of the railing.
- Any excavation and backfill shall conform to the provisions in Section 19-3, "Structure Excavation and Backfill," except that compaction of earth fill placed behind the temporary railing (Type K) in a curved layout will not be required.
- Abutting ends of precast concrete units shall be placed and maintained in alignment without substantial offset to each other. The precast concrete units shall be positioned straight on tangent alignment and on a true arc on curved alignment .
- At the locations required on the plans, threaded rods or dowels shall be bonded in holes drilled in the existing concrete. Drilling of holes and bonding of threaded rods or dowels shall conform to the provisions for bonding dowels in Section 83-2.02D(1), "General." After removal of the temporary railing (Type K), all threaded rods or dowels shall be removed to a depth of at least one inch below the surface of the concrete. The resulting holes shall be filled with mortar in conformance with the provisions in Section 51-1.135, "Mortar," except that the mortar shall be cured by either the water method or by the curing compound method. If the curing compound method is used, the curing shall conform to the provisions for curing concrete barrier in Section 83-2.02D(5), "Curing."
- Each rail unit placed within 10 feet of a traffic lane shall have a reflector installed on top of the rail. Reflectors shall be as specified in the special provisions, and adhesive shall conform to the reflector manufacturer's recommendations. A Type P marker panel shall also be installed at each end of railing installed adjacent to a two-lane, two-way highway and at the end facing traffic of railing installed adjacent to a one-way roadbed. If the railing is placed on a skew, the marker shall be installed at the end of the skew nearest the traveled way. Type P marker panels shall conform to the provisions in Section 82, "Markers and Delineators," except that the Contractor shall furnish the marker panels.
- When temporary railings (Type K) are removed, any area where temporary excavation or embankment was used to accommodate the temporary railing shall be restored to its previous condition or constructed to its planned condition.

12-3.09 TELESCOPING FLAG TREES

- Telescoping flag trees shall be of good commercial quality material, suitable for the purpose intended and shall be capable of maintaining an upright position at all times while in use.

12-3.10 TRAFFIC CONES

- Traffic cones shall be fluorescent and of good commercial quality, flexible material suitable for the purpose intended. The outer section of the portion above the base of the cone shall be translucent and be of a highly pigmented fluorescent orange polyvinyl compound. The overall height of the cone shall be at least 28 inches and the bottom inside diameter shall be not less than 10.5 inches. The base shall be of sufficient mass and size or shall be anchored in a manner that the traffic cone will remain in an upright position.
- During the hours of darkness traffic cones shall be affixed with retroreflective cone sleeves. The retroreflective sheeting of sleeves on the traffic cones shall be visible at 1,000 feet at night under illumination of legal high beam headlights, by persons with vision of or corrected to 20/20.
- Retroreflective cone sleeves shall conform to one of the following:

1. Removable flexible retroreflective cone sleeves shall be fabricated from the retroreflective sheeting specified in the special provisions, have a minimum height of 13 inches and shall be placed a maximum of 3 inches from the top of the cone. The sleeves shall not be in place during daylight hours;
2. Permanently affixed semitransparent retroreflective cone sleeves shall be fabricated from the semitransparent retroreflective sheeting specified in the special provisions, have a minimum height of 13 inches, and shall be placed a maximum of 3 inches from the top of the cone. Traffic cones with semitransparent retroreflective cone sleeves may be used during daylight hours; or
3. Permanently affixed double band retroreflective cone sleeves shall have 2 white retroreflective bands. The top band shall be 6 inches in height, placed a maximum of 4 inches from the top of the cone. The lower band shall be 4 inches in height, placed 2 inches below the bottom of the top band. Traffic cones with double band retroreflective cone sleeves may be used during daylight hours.

- The type of retroreflective cone sleeve used shall be at the option of the Contractor. Only one type of retroreflective cone sleeve shall be used on the project.

12-3.11 (BLANK)

12-3.12 PORTABLE CHANGEABLE MESSAGE SIGNS

- Each portable changeable message sign unit shall consist of a controller unit, a power supply and a structural support system, all mounted on a trailer. The unit shall be assembled to form a complete self-contained portable changeable message sign which can be delivered to the site of the work and placed in immediate operation. The complete message sign unit shall be capable of operating in an ambient air temperature range of -4° F to 158° F and shall not be affected by unauthorized mobile radio transmissions. The trailer shall be equipped so that it can be leveled and plumbed.

- The message displayed on the sign shall be visible from a distance of 1,500 feet and shall be legible from a distance of 750 feet, at noon on a cloudless day, by persons with vision of or corrected to 20/20. The sign panel shall be 3-line matrix and shall display not less than 7 characters per line. Sign messages to be displayed shall be as approved by the Engineer.
- The sign face shall be flat black and shall be protected from glare of the sun by a method which does not interfere with the clarity of the sign message. The sign shall be raised and lowered by means of a power driven lifting mechanism.
- The matrix sign shall be capable of complete alphanumeric selection.
- Lamp matrix type signs shall be equipped with an automatic dimming operational mode that automatically compensates for the influence of a temporary light source or other abnormal lighting conditions. The sign shall have manual dimming operation modes of 3 or more different lamp intensities.
- Matrix signs not utilizing lamps shall be either internally or externally illuminated at night.
- The controller shall be an all solid-state unit containing all the necessary circuitry for the storage of at least 5 preprogrammed messages. The controller shall be installed in a location allowing the operator to perform all functions from one position. A keyboard entry system shall be provided to allow an operator to generate an infinite number of additional messages over the preprogrammed stored messages. The keyboard shall be equipped with a security lockout feature to prevent unauthorized use of the controller.
- The controller shall contain a nonvolatile memory to hold the keyboard created messages in memory during periods when the power is not activated. The controller shall provide for a variable message display rate which allows the operator to match the information display to the speed of the approaching traffic. The flashing off time shall be operator adjustable within the control cabinet.
- Full operation height shall be with the bottom of the sign at least 7 feet above the ground and the top no more than 14.5 feet above the ground.
- After initial placement, portable changeable message signs shall be moved from location to location as directed by the Engineer.
- Portable changeable message signs shall be furnished, placed, operated, and maintained at locations shown on the plans, specified in the special provisions, or designated by the Engineer.

12-4 MEASUREMENT AND PAYMENT

12-4.01 MEASUREMENT AND PAYMENT

- Furnishing and installing construction area traffic control devices, as ordered by the Engineer, for the sole convenience and direction of public traffic as specified in Section 7-1.08, "Public Convenience," will be paid for as provided in Section 7-1.08 and this Section 12-4.01.
- Except as provided for flagging costs in Section 12-2.02, "Flagging Costs," no separate payment will be made for construction area traffic control devices which are used to fulfill the Contractor's responsibility to provide for the safety of traffic and the public during construction in conformance with the provisions in Section 7-1.09, "Public Safety."

- When the Engineer's Estimate includes a contract item or items for barricades, the barricades will be measured as units from actual count of the number of barricades designated on the plans or ordered by the Engineer. After initial placement of barricades, and if ordered by the Engineer, the barricades shall be moved from location to location and the cost thereof will be paid for as extra work as provided in Section 4-1.03D. The contract unit prices paid for barricades of the type or types shown in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing, placing, maintaining, repairing, replacing and removing the barricades, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- When the Engineer's Estimate includes a contract item for temporary railing (Type K), the temporary railing (Type K) will be measured by the linear foot along the top of the railing, at each location shown on the plans, specified, or ordered by the Engineer. If the Engineer orders a lateral move of the temporary railing (Type K), and the repositioning is not shown on the plans, moving the temporary railing will be paid for as extra work as provided in Section 4-1.03D and the temporary railing will not be measured in the new position. Temporary railing (Type K) placed in excess of the length shown, specified, or ordered will not be paid for. The contract price paid per linear foot for temporary railing (Type K) shall include full compensation for furnishing all labor, materials (including reinforcement, Type P marker panels and reflectors), tools, equipment and incidentals, and for doing all the work involved in furnishing, placing, maintaining, repairing, replacing, and removing the temporary railing, including excavation and backfill, drilling holes and bonding threaded rods or dowels when required, removing threaded rods or dowels and filling the drilled holes with mortar and moving and replacing removable panels as required, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Portable changeable message signs will be measured by the unit from actual count. The contract unit price paid for portable changeable message sign shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing, placing, operating, maintaining, repairing, replacing, transporting from location to location and removing the portable changeable message signs, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- When a traffic control system is required by the special provisions, the construction area traffic control devices used as part of the traffic control system will be measured and paid for as provided in the special provisions.
- Furnishing flaggers will be paid for as provided in Section 12-2.02, "Flagging Costs." Furnishing and operating pilot cars, when ordered by the Engineer, will be paid for as extra work as provided in Section 4-1.03D.
- Construction area signs shown on the plans, except those signs required for traffic control system for lane closure and unless otherwise specified in the special provisions, will be paid for on a lump sum basis, which lump sum price shall

include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing construction area signs required for the direction of public traffic through or around the work and for erecting or placing, maintaining (including covering and uncovering as needed) and, when no longer required, removing construction area signs at locations shown on the plans.

- Full compensation for furnishing, erecting, maintaining and removing any additional construction area signs the Contractor may deem necessary will be considered as included in the lump sum price paid for construction area signs and no additional compensation will be allowed therefor.
- Furnishing, erecting, maintaining, moving, and removing any additional construction area signs ordered by the Engineer will be paid for as extra work as provided in Section 4-1.03D.
- Channelizers (surface mounted) will be measured by the unit from actual count designated on the plans or ordered by the Engineer. The contract unit price paid for channelizer (surface mounted) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing, placing, maintaining, repairing, replacing and removing channelizers, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTIONS 13 AND 14: (BLANK)

SECTION 15: EXISTING HIGHWAY FACILITIES

15-1 GENERAL

15-1.01 DESCRIPTION

This work shall consist of removing existing highway facilities which interfere with construction within the area to be cleared and grubbed as specified in Section 16, "Clearing and Grubbing." Removed facilities shall be disposed of, salvaged, relaid, reset, relocated or reconstructed as specified in these specifications and in the special provisions.

15-1.02 PRESERVATION OF PROPERTY

Existing facilities which are to remain in place shall be protected in conformance with the provisions in Sections 7-1.11, "Preservation of Property," and 7-1.12, "Indemnification and Insurance," and in Section 8-1.10, "Utility and Non-Highway Facilities."

Trenches, holes, depressions and pits caused by the removal of highway facilities shall be backfilled with embankment material as provided in Section 19, "Earthwork." Trenches, holes, depressions and pits caused by the removal of highway facilities that are in surfaced areas, otherwise to remain undisturbed, shall be backfilled with materials equal to or better in quality and to the same thicknesses as the surrounding materials.

15-2 MISCELLANEOUS HIGHWAY FACILITIES

15-2.01 DESCRIPTION

Miscellaneous highway facilities shall include all structures, drainage, irrigation and sewer facilities, right of way and traffic control facilities, and any other miscellaneous improvements or facilities not mentioned in Section 15-2, "Miscellaneous Highway Facilities," but located within the area to be cleared and grubbed, except concrete and bridges which are provided for in Sections 15-3 and 15-4, "Removing Concrete" and "Bridge Removal," respectively.

15-2.02 REMOVAL METHODS

Removing highway facilities which interfere with construction or which are directed to be removed by the Engineer shall be performed as specified in this Section 15-2.02 and in the special provisions, or as shown on the plans, or as directed by the Engineer.

15-2.02A Obliterating Roads and Detours

Unless otherwise specified in the special provisions, obliteration shall consist of placing an earth cover of not less than 0.5-foot in thickness or shall consist of rooting, plowing, pulverizing, or scarifying to a minimum depth of 0.5-foot or to the bottom of the impermeable underlying base, whichever is the greater.

When obliteration is accomplished by rooting, plowing, pulverizing, or scarifying, the bituminous material shall be broken up into pieces not larger than 4 inches in greatest dimension and mixed with an equal amount of underlying material. After obliteration, the area shall be graded, as directed by the Engineer, so that it will blend in with the surrounding terrain and be well-drained.

- If the Contractor elects to obliterate surfacing by placing an earth cover, the existing base and surfacing shall be scarified for its full depth and broken up so that the material contains no lumps larger than 12 inches in greatest dimension before the earth cover is placed.
- Wherever a portion of existing surfacing is to be obliterated, the outside edge of the existing surfacing, which is to remain in place, shall be sawed to a neat line, prior to obliteration operations.

15-2.02B Traffic Stripes and Pavement Markings

- Traffic stripes and pavement markings shall be removed by any method that does not materially damage the existing pavement. Pavement marking images shall be removed in such a manner that the old message cannot be identified. Where grinding is used, the pavement marking image shall be removed by grinding a rectangular area. The minimum dimensions of the rectangle shall be the height and width of the pavement marking. Residue resulting from removal operations shall be removed from pavement surfaces by sweeping or vacuuming before the residue is blown by the action of traffic or wind, migrates across lanes or shoulders, or enters into drainage facilities.
- Traffic stripes shall be removed before any change is made in the traffic pattern.

15-2.02C Pavement Markers

- Pavement markers, including underlying adhesive, shall be removed by such methods that will cause the least possible damage to the pavement or surfacing. Damage to the pavement or surfacing caused by pavement marker removal shall be repaired by the Contractor at the Contractor's expense by methods acceptable to the Engineer.
- During the removal of ceramic type pavement markers, screens or other protective devices shall be furnished to contain any fragments as provided for in Section 7-1.09, "Public Safety."
- Fragments resulting from the removal of pavement markers shall be removed from the highway before the lane or lanes are opened to public traffic.

15-2.03 DISPOSAL

- Removed highway facilities that are not to be salvaged or reused in the work shall become the property of the Contractor and shall be disposed of as provided in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."

15-2.04 SALVAGE

- Materials from existing facilities which are specified in the special provisions or shown on the plans to be salvaged, shall remain the property of the State. Salvaging shall include the removal, disassembly, preparation, marking, bundling, packaging, tagging, hauling and stockpiling of salvaged materials or facilities to the location specified in the special provisions. Materials include parts, articles and equipment of assembled facilities. Salvaging does not include the preparation of existing material that is to be reused in the work.

- Materials from an existing facility to be salvaged shall be salvaged; except, when only specific materials from the facility are designated to be salvaged, the remaining materials from that facility shall be removed and disposed of.
- Materials to be salvaged shall not be removed until their use is no longer required as determined by the Engineer.
- Salvaged materials shall be cleaned of earth and other foreign materials. Adhering concrete shall be removed from salvaged materials.
- When practicable, salvaged materials shall be hauled directly to the location specified in the special provisions and stockpiled; however, salvaged materials may be temporarily stored at a location selected by the Contractor and approved by the Engineer, and later hauled to and stockpiled at the final location. Materials which are lost for any reason before stockpiling at the final location shall be either replaced by the Contractor at the Contractor's expense, or, at the discretion of the Engineer, the estimated cost of replacement may be deducted from any moneys due or to become due to the Contractor.
- Materials designated to be salvaged that are damaged, as determined by the Engineer, shall be segregated from undamaged material. The damaged material shall become the property of the Contractor and shall be disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."
- Materials to be salvaged that are damaged as a result of the Contractor's operations shall be repaired by the Contractor, at the Contractor's expense, to the satisfaction of the Engineer. Materials that are damaged beyond repair as a result of the Contractor's operations shall be disposed of outside the highway right of way, as provided in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way." and replaced at the Contractor's expense, or, at the discretion of the Engineer, the estimated cost of replacement may be deducted from any moneys due or to become due to the Contractor.
- Replacements for lost or damaged materials shall be of the same kind and of the same or better quality and condition as the lost or damaged materials were prior to removal.
- Salvaged material shall be packaged and bundled as follows:

Metal Beam Guard Railing:

Rail elements - 25 elements per bundle
Wood posts (6" x 8") - 30 per bundle
Wood posts (10" x 10") - 20 per bundle
Steel posts - 10 per bundle
Blocks (8" x 8" x 14") - 50 per bundle

Fence:

Chain Link Fabric - 50 linear feet per pallet
Corner Posts and End Posts - one assembly per bundle

Frames and covers or frames and grates of existing manholes, inlets, or other facilities shall be matchmarked in pairs.

- Incomplete bundles or pallets shall be tagged with the quantity contained.
- Single sheet aluminum signs shall be banded on pallets, total weight not to exceed 500 pounds.
- Packaged, bundled and individual salvaged material shall be tagged with State-furnished tags which shall contain the following information as applicable :

Name or description of the material.
Type or model number.
Dimensions.
Quantity, if more than one.

15-2.05 RECONSTRUCTION

- Highway facilities that are to be reconstructed or installed at existing or new locations shall conform to the design of the existing facilities and shall be equal in all respects to the best portions of the existing facilities. The work of reconstruction shall be performed in accordance with the requirements of these specifications for new work of similar character, which apply to the type of facility to be reconstructed, adjusted, modified, remodeled, relaid, relocated or reset.
- Materials to be reused shall not be removed until their use is no longer required as determined by the Engineer.
- Materials to be reused in the work shall be cleaned of earth and other foreign materials. Adhering concrete shall be removed from materials to be reused in the work.
- Materials shown on the plans or specified in the special provisions to be reused in the work that are damaged as a result of the Contractor's operations shall be repaired by the Contractor, at the Contractor's expense, to the satisfaction of the Engineer. Materials that are damaged beyond repair as a result of the Contractor's operations shall be disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way," and replaced at the Contractor's expense.
- Material from existing facilities to be reused in the work that, in the opinion of the Engineer, is unsuitable for use in the work shall become the property of the Contractor and shall be disposed of in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way." The unsuitable material shall be replaced with material of a kind and quality equal to the best material in the existing facility. Furnishing of material to replace unsuitable materials as ordered by the Engineer will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."

15-2.05A Frames, Covers, Grates, and Manholes

- Frames, covers or grates of existing manholes, inlets or other facilities shall be adjusted to grade with new materials similar in character to those in the original structure in accordance with the provisions of these specifications and the special provisions.

- After the existing cover or grate frame has been removed, the top of the structure to be raised shall be trimmed to provide a suitable foundation for the new material.
- When reconstruction or adjustment of a concrete drainage facility requires partial removal of concrete, sufficient concrete shall be removed to permit new reinforcing steel to be spliced to existing reinforcing steel as specified in Section 52-1.08, "Splicing." Existing reinforcement that is to be incorporated in new work shall be protected from damage and shall be thoroughly cleaned of adhering material before being embedded in new concrete.
- Concrete removal shall be performed without damage to the portion that is to remain in place. Damage to the existing concrete, which is to remain in place, shall be repaired to a condition equal to that existing prior to the beginning of removal operations. The cost of repairing existing concrete damaged by the Contractor's operations shall be at the Contractor's expense.
- At the option of the Contractor, raising devices may be used in place of adjusting manholes to grade with new materials similar in character to those in the original structure.
- Materials, workmanship and finish of the raising device and adjusted manhole shall conform to the provisions in Section 75-1.02, "Miscellaneous Iron and Steel," except that galvanizing of raising devices will not be required.
- The shape and size of the raising devices shall match the existing frame and shall produce an installation which is equal to or better than the existing installation in stability, support and non-rocking characteristics. Each section of the raising device shall be fastened securely to the existing frame without projections above the surface of the street or into the clear opening.
- Manholes and inlets to be adjusted by means of raising devices shall be measured sufficiently in advance of the paving to permit fabrication of the raising devices prior to paving operations. For identification, matching numbers shall be painted on each structure and the raising device to be installed thereon.
- If the manhole cover is unstable or noisy under traffic, the conditions shall be corrected by placing a coil of asphalt saturated rope, a plastic-type washer or asphaltic compounds approved by the Engineer, on the cover seat.
- A structure located in the pavement area shall not be constructed to final grade until the adjacent pavement or surfacing has been completed.
- Existing manholes shall be remodeled as shown on the plans and in accordance with these specifications and the special provisions.
- Manholes that are to be lowered shall be removed as directed by the Engineer, to an approximate depth of 3.5 feet below finished grade and shall then be reconstructed with the proper taper to finished grade.
- When existing manholes or inlets are to be abandoned, pipes entering the manhole or inlet shall be securely closed by a tight fitting plug or wall of minor concrete not less than 0.5-foot thick, or by a tight brick wall not less than 0.67-foot thick with cement mortar joints. Minor concrete shall conform to the provisions in Section 90-10, "Minor Concrete." The bases of manholes or inlets shall be broken in a manner to prevent entrapment of water. The manhole or inlet shall be

demolished to an elevation 3.5 feet below finished grade and backfilled in conformance with the provisions in Section 19-3.06, "Structure Backfill."

15-2.05B Fences

- Corner posts with braces shall be placed at the junctions of reconstructed fences and existing cross fences and the 2 fences properly fastened thereto.
- Gates to be reused shall be installed in reconstructed fences at the locations designated by the Engineer.
- Clearing required for reconstructed fences shall conform to the provisions in Section 80-1.03, "Clearing."
- Removing and reconstructing fence shall be performed in a manner that will prevent the escape of livestock.

15-2.05C Extending Pipes

- Existing pipes shall be extended in accordance with the requirements for installing new pipes.
- Existing headwalls or endwalls shall be removed and disposed of or moved to the extended location as shown on the plans or directed by the Engineer.
- When headwalls or endwalls are to be moved, the pipe shall be cut with smooth edges at a point about one foot back of the headwall or endwall along a plane perpendicular to the center line of the pipe. The headwall or endwall shall then be moved and placed in its new location and the new pipe shall be connected to the existing pipe.

15-2.06 MEASUREMENT

- The work performed under Section 15-2, "Miscellaneous Highway Facilities," will be measured by units, by the linear foot or mile, by area in square feet or square yards or by any other unit designated in the contract item for abandoning, obliterating, removing, salvaging, reconstructing, adjusting, modifying, remodeling, relaying, relocating or resetting the various highway facilities specified in these specifications and the special provisions, and as shown on the plans.
- When existing facilities are to be reconstructed, relaid, relocated or reset, no measurement or separate payment will be made for removing and reusing the facilities and full compensation for the work involved in removing and reusing will be considered as included in the contract price paid for reconstructing, relaying, relocating or resetting the facility.
- When existing facilities are to be salvaged, no separate measurement or payment will be made for removing the facilities.

Removing traffic stripes and pavement markings will be measured by the linear foot or by area in square feet. When stripes are measured by the linear foot, double or triple traffic stripes will be measured as 2 or 3 traffic stripes, respectively, and 6-inch wide or 8-inch wide traffic stripes will be measured as 1.5 or 2 traffic stripes, respectively. When the removal of traffic stripes is to be paid for by the linear foot, each square foot of pavement markings will be considered as 3 linear feet of traffic stripe. In measuring traffic stripes, deduction will be made for gaps in the broken traffic stripes. Paint which is evident in these gaps shall be removed to the fullest extent possible and full compensation therefor will be considered as

included in the contract price paid for removing traffic stripes and no additional compensation will be allowed therefor.

- Quantities of remove, salvage, reset, relocate and reconstruct items designated to be measured as units will be determined from actual count.
- Removing, salvaging, reconstructing, relocating or resetting of railing and barrier (except concrete barrier) will be measured by the linear foot in the same manner specified for measuring the construction of new railing or barrier of the same type as the railing or barrier involved.
- Removing, salvaging, reconstructing, relocating or resetting the various types of fence will be measured by the linear foot or by the mile, measured parallel to the top of the fence. Gates to be removed, salvaged, reconstructed, relocated or reset will be measured as units and the lengths of gate openings will not be included in the measured length of removed, salvaged, reconstructed, relocated or reset fence.
- Removing, salvaging, reconstructing, relocating or resetting of roadside signs will be measured by the unit, and each individual sign installation will be considered one unit regardless of the number of posts or sign panels involved.
- Quantities of markers and monuments removed, salvaged, relocated or reset will be determined as units from actual count.
- Salvaging, relaying, relocating or resetting drainage facilities will be measured by the linear foot for the various types of pipe, underdrains, downdrains and downdrain flumes (the type of facility to be designated in the contract item), and by units for spillway assemblies, entrance tapers, tapered inlets, headwalls, endwalls, flared end sections, slip joints and anchor assemblies.
- Quantities of adjusting manholes and inlets to grade, reconstructing, remodeling, or abandoning manholes and inlets will be determined as units from actual count.
- Obliterating roads and detours will be measured by the square yard.
- Quantities involved in removing all types of existing subbases, bases, surfacing, and pavements of any thickness will be measured and paid for as the item of excavation in which they are located and no separate payment will be made therefor.

15-2.07 PAYMENT

- When the contract includes separate items, and unit or lump sum prices for removing, salvaging, adjusting, modifying, remodeling, abandoning, obliterating, relaying, reconstructing, relocating or resetting any of the miscellaneous highway facilities, the quantities will be paid for at the contract unit or lump sum price for the item of work involved.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in completing the operations as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- Full compensation for all excavation and backfill required to remove, dispose of, salvage, relay, reset, relocate and reconstruct highway facilities, for which payment is not otherwise provided, shall be considered as included in the contract unit or lump sum price paid for the item of work involved and no separate payment will be made therefor.

- Full compensation for additional grinding outside the limits of the existing pavement marking image to obtain a rectangular area shall be considered as included in the contract price paid for the item of work involved and no additional compensation will be allowed therefor.
- Full compensation for removing, preparing, disassembling, packaging, bundling, tagging, hauling and stockpiling of salvaged materials including any temporary storage prior to stockpiling and disposal of unwanted portions of facilities or damaged materials, shall be considered as included in the contract price paid for the item involved and no separate payment will be made therefor.
- Full compensation for removing, salvaging, reconstructing, relocating or resetting end caps, return caps, terminal sections, and buried post anchors, for metal beam guard railings and thrie beam barriers, and for connecting reconstructed, relocated or reset railings and barriers to new and existing facilities, including connections to concrete, shall be considered as included in the contract price paid per linear foot for the type of railing or barrier work involved and no additional compensation will be allowed therefor.
- When the contract does not include separate items for removing any of the existing highway facilities encountered within the area to be cleared and grubbed or the removal is not included in another item, then payment for removing the facilities shall be considered as included in the contract prices paid for clearing and grubbing or excavation of the type in which the facilities are located. If the contract does not include items for clearing and grubbing or excavation, then removing the existing highway facilities within the area to be cleared and grubbed will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."
- When an existing highway facility which is outside the area to be cleared and grubbed is shown on the plans or specified in the special provisions to be removed and the contract does not include an item for its removal, or its removal is not included in another item, then payment for removing the facility will be considered as included in the contract price paid for clearing and grubbing. If the contract does not include an item for clearing and grubbing or if the Engineer orders the removal of a highway facility which is outside the area to be cleared and grubbed, then removing the existing highway facility will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."

15-3 REMOVING CONCRETE

15-3.01 DESCRIPTION

- Concrete shall be removed at the locations shown on the plans or described in the special provisions, or where directed by the Engineer. Removal shall be to the lines and elevations shown, specified, or determined by the Engineer.
- Concrete shall be defined as all or portions of mortared rubble masonry, brick or stone curbs, gutters and sidewalks; and portland cement concrete curbs, gutters, sidewalks, gutter depressions, driveways, aprons, slope paving, island paving, barriers, retaining walls, spillways, dams, structures, foundations, footings, and all other portland cement concrete or masonry construction, except bridges and pavement which are provided for in Section 15-4, "Bridge Removal," and Section 19-1.01, "Description," respectively.

- Types of existing subbase, base, surfacing and pavement to be removed will be classified for payment as the type of excavation in which the subbase, base, surfacing and pavement are located.
- Concrete pipe and clay pipe will be considered as miscellaneous highway facilities to be removed, salvaged, relaid or disposed of as provided in Section 15-2, "Miscellaneous Highway Facilities," and will not be paid for as removing concrete.
- Attention is directed to Section 7-1.01, "Laws to be Observed," regarding local ordinances to be observed when breaking and removing concrete.

15-3.02 REMOVAL METHODS

- Existing concrete shall be removed to a depth of at least 3 feet below finished grade.
- Existing concrete shall be cut to a true line where new concrete is to join existing concrete.
- Concrete removal operations shall be performed without damage to any portion that is to remain in place. Damage to the existing concrete, which is to remain in place, shall be repaired to a condition equal to that existing prior to the beginning of removal operations. The cost of repairing existing concrete damaged by the Contractor's operations shall be at the Contractor's expense.
- Existing reinforcement that is to be incorporated in new work shall be protected from damage and shall be thoroughly cleaned of adhering material before being embedded in new concrete.
- Unless otherwise provided in the special provisions, removed concrete may be buried in adjacent embankments, provided the removed concrete is broken into pieces which can be readily handled and incorporated into embankments and is placed at a depth of not less than 3 feet below finished grade and slope lines. The removed concrete shall not be buried in areas where piling is to be placed or within 10 feet of trees, pipelines, poles, buildings or other permanent objects or structures. Removed concrete may also be disposed of at such locations and in such manner that it will not present an unsightly appearance from the highway. Should the Contractor elect or be required by the special provisions to dispose of the material outside the highway right of way, the disposal shall conform to the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."
- The floors of concrete basements, pits and structures, that are not required to be removed and which are located within the roadway shall be broken in a manner that will prevent the entrapment of water. Full compensation for breaking up concrete will be considered as included in the prices paid for the various contract items of work and no separate payment will be made therefor.
- When there is a contract item for shattering concrete, concrete pavement and similar slabs upon which embankments are to be constructed, the concrete shall be broken up into pieces not larger than 2 feet in greatest dimension and left in place.

15-3.03 MEASUREMENT

- The work performed under Section 15-3, "Removing Concrete," and paid for by contract items will be measured by the cubic yard, by the linear foot, or by the square yard of surface area, or by any other method specified in the special provisions.

- No deductions will be made from any excavation quantities for the volume of concrete removed.

15-3.04 PAYMENT

- Items of work, measured as specified above, will be paid for at the price per cubic yard or lump sum price for remove concrete; or the price per square yard for shatter concrete; or the price per linear foot for remove concrete barrier; unless otherwise provided in the special provisions.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in the operations as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- Reinforcing or other steel may be encountered in portions of concrete to be removed and no additional compensation will be allowed for the removal of concrete containing steel.

15-4 BRIDGE REMOVAL

15-4.01 DESCRIPTION

- This work shall consist of removing existing bridges, or portions thereof. The type and general dimensions of the bridges or portions of bridges to be removed will be shown on the plans or described in the special provisions.
- When portions of bridges are to be removed, the removal operations shall be conducted so that there will be the least interference to public traffic using the structure involved. When complete bridges are to be removed, removal operations shall not be started until public traffic is no longer routed over the structure to be removed.

15-4.02 REMOVAL METHODS

- At least 10 days before beginning bridge removal over or adjacent to public traffic or railroad property, the Contractor shall submit to the Engineer details of the removal operations showing the methods and sequence of removal and equipment to be used.
- Materials that are to be salvaged shall be carefully removed and stockpiled near the site at a location designated by the Engineer.
- Material which is to be used in the reconstructed bridge work and has been damaged or destroyed as a result of the Contractor's operations, shall be repaired or replaced by the Contractor at the Contractor's expense.
- Piling, piers, abutments and pedestals shall be removed to at least one foot below ground line or 3 feet below finished grade, whichever is lower.
- Flame cutting and saw cutting may be used for removing, widening, or modifying bridges provided the Contractor complies with all protection, safety and damage requirements.
- Explosives shall not be used for bridge removal.
- When portions of a bridge are to be removed, the removal operations shall be performed without damage to any portion of the structure that is to remain in place. In these cases, tools with a manufacturer's rated striking energy in excess of 1,200 foot pounds per blow, a freely falling mass or a falling mass attached to a

cable, rope or chain shall not be used for breaking or removing concrete which is attached to or supported by the bridge. Existing reinforcement that is to be incorporated in new work shall be protected from damage and shall be thoroughly cleaned of all adhering material before being imbedded in new concrete.

- A freely falling mass or a falling mass attached to a cable, rope or chain shall not be used above any area open to the public. Falling masses shall not be used within 30 feet horizontally of any area open to the public unless adequate protective shields are in place. Protective shields shall be of sufficient size and strength to prevent any debris or equipment from endangering the public. The shields shall be designed and proportioned as required by the size of equipment and method of operations employed, but in no case shall the shields have a strength less than that provided by good, sound 2-inch thick Douglas fir planking supported on posts at 5-foot centers.
- Before beginning concrete removal operations involving the removal of a portion of a monolithic concrete element, a saw cut approximately one inch deep shall be made to a true line along the limits of removal on faces of the element which will be visible in the completed work.
- Broken concrete may be disposed of in embankments as provided in Section 15-3, "Removing Concrete." Other materials that are not to be salvaged shall become the property of the Contractor and shall be removed and disposed of away from the site in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."

15-4.03 PAYMENT

- The work to be performed in Section 15-4, "Bridge Removal," will be paid for on a lump sum basis for bridge removal, or for bridge removal (portion).
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in removing bridges or portions thereof, including excavation, backfill, and salvaging materials not to be reused in the project when salvaging is specified and not otherwise paid for, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Full compensation for removing materials that are to be reused in the project shall be considered as included in the contract prices paid for reconstructing, relocating or resetting the items involved, or in such other contract pay items that may be designated in the special provisions, and no additional compensation will be allowed therefor.

GRADING

SECTION 16: CLEARING AND GRUBBING

16-1.01 DESCRIPTION

This work shall consist of removing objectionable material from within the highway right of way, bridge construction areas, road approaches, material sites within the right of way, areas through which ditches and channels are to be excavated, and other areas as may be specified in the special provisions. Clearing and grubbing shall be performed in advance of grading operations and in accordance with the requirements specified in these specifications.

16-1.02 PRESERVATION OF PROPERTY

Attention is directed to Sections 7-1.11, "Preservation of Property," 7-1.12, "Indemnification and Insurance," and 8-1.10, "Utility and Non-Highway Facilities." Existing highway improvements and facilities, adjacent property, utility and non-highway facilities, and trees and plants that are not to be removed, shall be protected from injury or damage resulting from the Contractor's operations. Only trees and plants that are designated or marked for removal by the Engineer shall be removed.

16-1.03 CONSTRUCTION

Unless otherwise specified in the special provisions or shown on the plans, the entire length of the project to the widths specified below shall be cleared and grubbed. No payment will be made to the Contractor for clearing and grubbing outside these limits, unless the work is authorized by the Engineer.

The area above the natural ground surface shall be cleared of all vegetation, such as trees, logs, upturned stumps, roots of down trees, brush, grass, weeds and other objectionable material including concrete or masonry, within the following limits:

A. Highway construction areas, including structures, frontage roads, or streets, ramps, approaches, ditches and channels having a bottom width of 12 feet or more, and other accessory roads and connections that are to be constructed. These areas shall extend to a width of 5 feet outside of structures and excavation and embankment slope lines, except that where slopes are to be rounded, the areas shall extend to the outside limits of slope rounding.
B. Ditches and channels having a bottom width of less than 12 feet. These areas shall extend to a width of 2 feet outside the slope lines.
C. Material sites within the right of way.
D. Areas enclosed by interchange loops and ramps.

Within the limits of clearing, the areas below the natural ground surface, except in embankment areas where the grading plane is 2 feet or more above the natural ground, shall be grubbed to a depth necessary to remove all stumps, roots, buried logs, and all other objectionable material. Objectionable material shall not be left in or under embankments or dikes.

- All trees, existing stumps and roots within embankment areas where the grading plane is 2 feet or more above the natural ground shall be cut off not more than one foot above the natural ground at any point, or completely removed where a structure is to be constructed, piles are to be placed or driven, subdrainage trenches are to be excavated, unsuitable material is to be removed, or where the slopes of original hillsides, old or new fill, are cut into in conformance with the provisions in Section 19-6.01, "Placing."
- Where the construction is to be performed through orchard, vineyard and other cultivated areas, all orchard trees, vines and other vegetation shall be removed from the entire right of way area.
- If specified by the special provisions or directed by the Engineer that certain shade and ornamental trees and plants shall be preserved, those trees and plants shall be fully protected from injury by the Contractor at the Contractor's expense. Trees shall be felled in such a manner as not to injure standing trees, plants, and improvements which are to be preserved.
- Tree branches extending over the roadway and which hang within 20 feet of finished grade shall be cut off close to the trunks in accordance with recognized standards of good arboricultural practices. In connection with the removal of tree branches that extend over the new or widened roadway, the Contractor shall remove other tree branches under the direction of the Engineer, in such a manner that the tree will present a balanced appearance.

16-1.04 REMOVAL AND DISPOSAL OF MATERIALS

- Materials removed shall be disposed of at locations not visible from the roadway. In connection with the disposal of material outside the highway right of way, attention is directed to Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."
- Combustible material may be reduced to chips of a maximum thickness of 1/2 inch. The chips may be disposed of in areas enclosed by interchange loops and ramps or between the slope lines and right of way lines as determined by the Engineer. The chips disposed of in the above areas may either be buried or distributed uniformly on the ground surface and mixed with the underlying earth to the extent that the chips will not support combustion.
- The roadway and adjacent areas shall be left with a neat and finished appearance. No accumulation of flammable material shall remain on or adjacent to the right of way.

16-1.05 MEASUREMENT

- Clearing and grubbing will be paid for at a lump sum price or by the acre as designated in the Engineer's Estimate.
- Unless otherwise specified in the special provisions, the work of clearing and grubbing disposal sites or material sites, will not be paid for when the sites are outside the right of way and the Contractor is permitted to exercise the option as to whether or not the Contractor elects to use the disposal sites or material sites.

16-1.06 PAYMENT

- The contract lump sum price, or the contract price per acre, paid for clearing and grubbing shall include full compensation for furnishing all labor, materials,

tools, equipment, and incidentals, and for doing all the work involved in clearing and grubbing as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer, including the removal and disposal of the resulting material.

When the contract does not include a contract pay item for clearing and grubbing as specified above, full compensation for any necessary clearing and grubbing required to perform the construction operations specified shall be considered as included in the prices paid for the earthwork involved, or in the prices paid for the contract items of work requiring clearing and grubbing when earthwork is not involved, and no additional compensation will be allowed therefor.

16-1.07 ADJUSTMENT OF LUMP SUM ITEM

The adjustment provisions in Section 4-1.03, "Changes," shall not apply to the item of clearing and grubbing when payment is to be made on a lump sum basis. When the item of clearing and grubbing is paid for on a lump sum basis, any adjustment in compensation due to an increase or decrease in the quantity of work to be performed which is ordered by the Engineer, will be made on the basis of the cost of the increased or decreased work and will be paid for as force account as provided in Section 9-1.03, "Force Account Payment," for increased work and estimated on the same basis in the case of decreased work.

SECTION 17: WATERING

17-1.01 DESCRIPTION

- This work shall consist of developing a water supply and furnishing all water required for the work, including water used in the performance of work paid for as extra work, and applying all water.
- Water for use in the work shall, at the option of the Contractor, be potable or nonpotable. Nonpotable water shall consist of reclaimed waste water or nonpotable water developed from other sources.
- If the Contractor uses reclaimed waste water in the work, the sources and discharge of reclaimed waste water shall meet the California Department of Health Services water reclamation criteria and the Regional Water Quality Control Board requirements. The Contractor shall obtain either a waste water discharge permit or a waiver from the Regional Water Quality Control Board. Copies of permits or waivers from the Regional Water Quality Control Board shall be delivered to the Engineer before using reclaimed waste water in the work.
- Nonpotable water used in the mixing and curing of concrete shall conform to the provisions in Section 90-2.03, "Water."
- Nonpotable water, if used, shall not be conveyed in tanks or drain pipes which will be used to convey potable water. There shall be no connection between nonpotable water supplies and potable water supplies. Nonpotable water supply, tanks, pipes and any other conveyances of nonpotable water shall be labeled :

NONPOTABLE WATER

DO NOT DRINK

17-1.02 APPLICATION

- Water shall be applied in the amounts, at the locations, and for the purposes designated in the special provisions and these specifications, and as ordered by the Engineer.
- Water for compacting embankment material, subbase, base and surfacing material, and for laying dust shall be applied by means of pressure-type distributors or pipe lines equipped with a spray system or hoses with nozzles that will ensure a uniform application of water.
- Equipment used for the application of water shall be equipped with a positive means of shut-off.
- Unless otherwise permitted by the Engineer or unless all the water is applied by means of pipe lines, at least one mobile unit with a minimum capacity of 1,000 gallons shall be available for applying water on the project at all times.

17-1.025 CHEMICAL ADDITIVES

- If the Contractor elects to do so, chemical additives may be used in water for compaction. If chemical additives are used, furnishing and applying the additives shall be at the Contractor's expense.

- The right is reserved by the Engineer to prohibit the use of a particular type of additive, to designate the locations where a particular type of additive may not be used, or to limit the amount of a particular type of additive to be used at certain locations, all if the Engineer has reasonable grounds for believing that such use will in any way be detrimental.

17-1.03 (BLANK)

17-1.04 PAYMENT

- The lump sum price paid for develop water supply shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in developing a sufficient supply of water and furnishing pipe lines or other necessary equipment to supply water to the water application equipment for all water required for the work, including work paid for as extra work.
- Full compensation for the quantity of water used in the performance of the work, including work paid for as extra work, will be considered as included in the lump sum price paid for develop water supply and no separate payment will be made therefor.
- No adjustment of compensation will be made for the lump sum item of develop water supply for increase or decrease in the quantity of water required, regardless of the reason for such increase or decrease. The provisions in Section 4-1.03, "Changes," shall not apply to the item of develop water supply.
- Full compensation for applying water will be considered as included in the prices paid for the various contract items requiring water and no separate payment will be made therefor, except that applying water for work paid for as extra work on a force account basis, as provided in Section 9-1.03, "Force Account Payment," will be paid for as a part of that extra work.
- When the contract does not include a contract pay item for develop water supply, full compensation for developing a sufficient supply of water required for the work shall be considered as included in the prices paid for the various contract items of work involving the use of water and no separate payment will be made therefor.

SECTION 18: DUST PALLIATIVE

18-1.01 DESCRIPTION

- This work shall consist of applying a dust palliative for the prevention of dust nuisance. The dust palliative shall be applied in the amount and at the locations as directed by the Engineer.

18-1.02 MATERIALS

- The binder shall be either miscible in water or be some form of material that is directly applied to the surface without mixing with water.
- Binders that are miscible in water shall be either a resin emulsion, an SS1 type asphaltic emulsion, materials composed essentially of lignin sulfonate, or any other binder that is miscible in water in the proportions provided in Section 18-1.03, "Application," is non-corrosive, and is effective as a dust palliative.
- Binders that are directly applied to the surface without mixing with water shall be a product prepared from crude petroleum that is effective as a dust palliative.
- Resin emulsion shall be composed of from 57 percent to 63 percent of semi-liquid petroleum resin and the remainder water to which a suitable emulsifying agent has been added. The resin emulsion shall be readily miscible with water and when diluted with any hard water in the proportions of one part of emulsion to 10 parts water shall show no signs of breakdown or separation of the petroleum resin base. Resin emulsion which has been stored in closed containers at temperatures above freezing for a period up to 3 months shall show no signs of separation. Any resin emulsion which has been stored for more than 3 months shall not be used until tested and approved.
- SS1 type asphaltic emulsion shall conform to the provisions in Section 94, "Asphaltic Emulsions."

18-1.03 APPLICATION

- Binders that are miscible in water shall be mixed with additional water at the rate of from 4 parts to 19 parts of water to one part of binder, the exact rate to be determined by the Engineer. Mixing shall be accomplished by placing the binder and water in the spreading equipment simultaneously or by some other mixing method that will produce equivalent results.
- The resulting mixture shall be applied with pressure type water distributor trucks equipped with a spray system or pressure type asphalt distributors in conformance with the provisions in Section 93-1.03, "Mixing and Applying," at an approximate rate of from 0.2-gallon to 0.8-gallon per square yard.
- Binders that are directly applied to the surface without mixing with water shall be applied with equipment approved by the Engineer. The binder shall be applied at a rate of from 0.10-gallon to 0.25-gallon per square yard.
- The exact rate and number of applications of binders will be determined by the Engineer.

18-1.04 MEASUREMENT

- Quantities of binder required for dust palliative to be paid for will be determined prior to the addition of water as provided in Section 94-1.07, "Measurement."

18-1.05 PAYMENT

- Binder for dust palliative will be paid for by the ton for binder (dust palliative) which price shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in adding water, mixing, and applying the dust palliative as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Dust palliative ordered by the Engineer to be applied on Saturdays, Sundays or holidays will be paid for at the contract price for dust palliative and no additional compensation will be allowed therefor.
- No adjustment of compensation will be made for any increase or decrease in the quantity of dust palliative required, regardless of the reason for such increase or decrease. The provisions in Section 4-1.03B, "Increased or Decreased Quantities," shall not apply to the item of binder (dust palliative).

SECTION 19: EARTHWORK

19-1 GENERAL

19-1.01 DESCRIPTION

- This work shall consist of performing all operations necessary to excavate all materials, regardless of character and subsurface conditions, from the roadway prism or adjacent thereto; to excavate all materials, of whatever nature, necessary for the construction of foundations for structures and other facilities; to excavate trenches for culverts and other facilities; to excavate drainage and irrigation ditches; to excavate drainage channels; to excavate selected material from the roadway and borrow material for use as specified; to construct embankments, including the placing of selected material in connection therewith as specified; to place backfill for structures, culverts, and other facilities; to backfill trenches and depressions resulting from the removal of obstructions; to backfill holes, pits and other depressions within the roadway area; to apply water; to remove and replace unsuitable material; to excavate and grade road approaches, driveways, and connections; to construct protection dikes; to remove unstable material outside the roadway prism, slide material which has come into the roadway prism, and material which has slipped from embankments; to prepare basement material for the placing of other material thereon; all as shown on the plans and as specified in these specifications and the special provisions, and as directed by the Engineer; and furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work that may be required to construct and maintain the roadway facilities.
- Whenever reference to finished grade is made, it shall be considered to be the finished surface of the completed facility. When the work covered by the contract is stage construction, the relation between finished grade and the work covered by the contract will be shown on the plans.
- Quantities of all types of existing subbase, base, surfacing or pavement removed will be included in the quantities of the type of excavation in which they are located, and no separate payment will be made therefor.
- Clearing and grubbing for earthwork operations shall conform to the provisions in Section 16, "Clearing and Grubbing."
- Applying water for earthwork operations shall conform to the provisions in Section 17, "Watering."

19-1.02 PRESERVATION OF PROPERTY

- Attention is directed to Section 7-1.11, "Preservation of Property," to Section 7-1.12, "Indemnification and Insurance," to Section 7-1.16, "Contractor's Responsibility for the Work and Materials," and to Section 8-1.10, "Utility and Non-Highway Facilities."
- Operations shall be conducted in such a manner that existing highway facilities, utilities, railroad tracks, and other non-highway facilities which are to remain in place, and settlement platforms, slope indication devices, piezometers and Engineer's instrumentation, will not be damaged. The Contractor, at the Contractor's expense, shall furnish and install sheet piling, cribbing, bulkheads, shores or whatever means may be necessary to adequately support material

carrying the facilities, or to support the facilities themselves and shall maintain the supports until they are no longer needed. Temporary pavements, facilities, utilities and installations shall also be protected until they are no longer required. When temporary supports and other protective means are no longer required, they shall be removed and disposed of as provided in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."

In addition to the provisions in Sections 5-1.02, "Plans and Working Drawings," and 5-1.02A, "Excavation Safety Plans," detailed plans of the protective systems for excavations on or affecting railroad property will be reviewed for adequacy of protection provided for railroad facilities, property, and traffic. These plans shall be submitted at least 9 weeks before the Contractor intends to begin excavation requiring the protective systems. Approval by the Engineer of the detailed plans for the protective systems will be contingent upon the plans being satisfactory to the railroad company involved.

When hauling is done over highways or city streets and when directed by the Engineer, the loads shall be trimmed and all material removed from shelf areas of vehicles in order to eliminate spilling of material. If directed by the Engineer, the loads shall be watered after trimming to eliminate dust as provided in Section 10, "Dust Control."

19-1.03 GRADE TOLERANCE

Immediately prior to placing subsequent layers of material thereon, the grading plane shall conform to one of the following:

A. When asphalt concrete or asphalt concrete base is to be placed on the grading plane, the grading plane at any point shall not vary more than 0.05-foot above or below the grade established by the Engineer.
B. When subbase or base material (other than asphalt concrete base) to be placed on the grading plane is to be paid for by the ton, the grading plane at any point shall not vary more than 0.10-foot above or below the grade established by the Engineer.
C. When the material to be placed on the grading plane is to be paid for by the cubic yard, the grading plane at any point shall be not more than 0.05-foot above the grade established by the Engineer.

19-1.04 REMOVAL AND DISPOSAL OF BURIED MAN-MADE OBJECTS

If a buried man-made object encountered in excavation is to be removed and its removal and disposal is not included in another item of work, the removal and disposal will be paid for at the contract price per cubic yard for the type of excavation in which the object is encountered. However, if the presence of the object is not indicated on the plans or in the special provisions and its presence could not have been ascertained by visual inspection, the removal and disposal of the object will be paid for as extra work as provided in Section 4-1.03D, "Extra Work," instead of at the applicable contract item price if the Contractor so requests in writing. The request shall be made prior to removal.

19-2 ROADWAY EXCAVATION

19-2.01 DESCRIPTION

Roadway excavation shall consist of all excavation involved in the grading and construction of the roadway, except structure excavation, ditch excavation and any excavation separately designated and paid for as a separate item.

19-2.02 UNSUITABLE MATERIAL

Unsuitable material encountered below the natural ground surface in embankment areas or below the grading plane in excavation areas shall be excavated and disposed of as directed by the Engineer. Unsuitable material is defined as material the Engineer determines to be:

A. of such unstable nature as to be incapable of being compacted to specified density using ordinary methods at optimum moisture content; or
B. too wet to be properly compacted and circumstances prevent suitable in-place drying prior to incorporation into the work; or
C. otherwise unsuitable for the planned use.

The presence of excessive moisture in a material is not, by itself, sufficient cause for determining that the material is unsuitable.

The removal and disposal of unsuitable material will be paid for as roadway excavation for the quantities involved if the removal of the unsuitable material is shown on the plans or specified in the special provisions.

If the removal of the unsuitable material is not shown on the plans or specified in the special provisions, the removal and disposal of the unsuitable material will be paid for at the contract price for roadway excavation for the quantities involved unless either the Engineer, prior to removal of any unsuitable material, orders the unsuitable material to be removed and disposed of and paid for as extra work as provided in Section 4-1.03D, "Extra Work," or the Contractor, prior to removal of the unsuitable material, requests in writing that the removal and disposal of the unsuitable material be paid for as extra work as provided in Section 4-1.03D.

When unsuitable material is removed and disposed of, the resulting space shall be filled with material suitable for the planned use. The suitable material shall be placed and compacted in layers as hereinafter specified for constructing embankments.

19-2.03 BLASTING

Excessive blasting will not be permitted. Any material outside the authorized cross section which may be shattered or loosened because of blasting shall be removed by the Contractor at the Contractor's expense. The Contractor shall discontinue any method of blasting which leads to overshooting or is dangerous to the public or destructive to property or to natural features.

19-2.04 SLIDES AND SLIPOUTS

Material outside the planned roadway or ditch slopes which is unstable and constitutes potential slides in the opinion of the Engineer, material from slides which has come into the roadway or ditch, and material which has slipped out of

new or old embankments shall be excavated and removed. The material shall be excavated to designated lines or slopes either by benching or in the manner directed by the Engineer. The material shall be used in the construction of the embankments or disposed of as directed by the Engineer.

- Except as provided in the last paragraph in this Section 19-2.04, the removal, haul and disposal of slide and slipout material, as above specified, will be paid for at the contract price for roadway excavation for the quantities involved unless the Engineer, prior to the removal of the material, orders the slide or slipout material to be removed and disposed of and paid for as extra work as provided in Section 4-1.03D, or the Contractor, prior to removal of the material, requests in writing that the removal and disposal of the slide or slipout material be paid for as extra work as provided in Section 4-1.03D, "Extra Work."
- Where slopes previously have been completed by the Contractor, the cost of resloping required in areas where unstable or stable material is removed at the direction of the Engineer will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."
- The cost of pioneering work necessary to make slide or slipout areas accessible to normal excavation equipment and the cost of necessary clearing and grubbing will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."
- Only slide or slipout material which is actually removed as ordered by the Engineer will be paid for. Quantities of slide or slipout material to be paid for as roadway excavation will be measured as provided in Section 19-2.08, "Measurement."
- The above provisions shall not be so construed as to relieve the Contractor from the duty of maintaining all slopes true and smooth. Erosion, regardless of amount or extent, caused by the action of the elements which results in damage to the work or materials, shall in no case be considered a slide or slipout.
- Any damage to work resulting from slides or slipouts shall be repaired or restored by the Contractor as directed by the Engineer. Except as provided in the following paragraph, payment for the repairs or restorations will be made at the contract prices for the work involved, where applicable, subject however to the adjustment provisions in Section 4-1.03B, "Increased or Decreased Quantities," or as extra work as provided in Section 4-1.03D, "Extra Work."
- Full compensation for removing, hauling and disposing of any material which may come into any excavation where the pay limits of those excavations are vertical planes; or which may come into any excavations as to which the Contractor has not complied with the provisions in Sections 7-1.11, "Preservation of Property," 7-1.16, "Contractor's Responsibility for the Work and Materials," or 19-1.02, Preservation of Property;" or for removing, hauling and disposing of material resulting from overshooting as provided in Section 19-2.03, "Blasting," and for repair and restoration of any damages to the work resulting from movement of the material or by overshooting shall be considered as included in the contract price paid per cubic yard for structure excavation or ditch excavation or roadway excavation, as the case may be, within the authorized lines and elevations and no separate payment will be made therefor.

19-2.05 SLOPES

- Excavation slopes shall be constructed in conformance with the lines and grades established by the Engineer. When completed, the average plane of the slopes shall conform to the slopes indicated on the plans and no point on the completed slopes shall vary from the designated slopes by more than 0.5-foot measured at right angles to the slope, except where excavation is in rock no point shall vary more than 2 feet from the designated slope. In no case shall any portion of the slope encroach on the roadbed.
- The tops of excavation slopes and the ends of excavations shall be rounded as shown on the plans.
- Embankment slopes shall be constructed in conformance with the lines and grades established by the Engineer. The completed slopes within 4 feet of shoulder grade shall not vary more than 0.5-foot from the designated slope, measured at right angles to the slope. Slopes below 4 feet shall not vary more than one foot from the designated slope, measured at right angles to the slope.
- Median and side slopes which are on a 6:1 (horizontal:vertical) or flatter slope, whether in excavation or embankment, shall be finished in conformance with the lines and grades established by the Engineer. The completed slopes shall not vary more than 0.2-foot from the designated slope, measured at right angles to the slope. Flowlines within medians shall be graded to drain and shall not vary more than 0.1-foot from the grade line established by the Engineer.
- If the slope is to be cultivated or straw is to be incorporated into the surface, all loose rocks larger than $2^1/_2$ inches in maximum dimension, roots and other debris on the surface of the slope shall be removed and disposed of prior to cultivation or incorporation of straw.
- If embankments are constructed of large rock, the Engineer may permit the slopes more than 4 feet below shoulder grade to vary from the designated slope more than one foot, but in no case more than 2 feet, if the size of the rock makes it impracticable to construct the slopes within one foot of the designated slope.

19-2.06 SURPLUS MATERIAL

- Unless otherwise shown on the plans or specified in the special provisions, surplus excavated material shall be used to widen embankments uniformly, or to flatten slopes, or shall be disposed of along the roadway or in other locations as directed by the Engineer. No surplus material shall be disposed of above the grade of the adjacent roadbed nor shall the Contractor borrow or waste material unless authorized in writing by the Engineer.
- If the quantity of surplus material is shown on the plans or specified in the special provisions, the quantity shown or specified is approximate only. The Contractor shall be satisfied that there is sufficient material available for the completion of the embankments before disposing of any material inside or outside the right of way. Any shortage of material, caused by premature disposal of any material by the Contractor, shall be replaced by the Contractor and no compensation will be allowed the Contractor for such replacement.

19-2.065 DEFICIENCY MATERIAL

- If the quantity of acceptable material from excavation is not sufficient to construct the embankments required by the work, the quantity of material needed to complete the embankments shall consist of local borrow or imported borrow, as determined by the Engineer.
- The Contractor shall obtain the local borrow or imported borrow in conformance with the provisions in Section 19-7, "Borrow Excavation." If the contract does not include an item for imported borrow, payment for the required imported borrow will be made by extra work as provided in Section 4-1.03D, "Extra Work."

19-2.07 SELECTED MATERIAL

- Selected material shall be defined as material which is excavated from a location within the right of way as specified in the special provisions or shown on the plans, and the Contractor shall have no choice in the selection.
- Selected material shall be used as shown on the plans or specified in the special provisions. Topsoil excavated within the limits of the project shall be considered as selected material.
- Selected material not used for topsoil or as a specified layer shall be placed in the roadway prism in conformance with the provisions in Section 19, "Earthwork," for placing embankment material or structure backfill.
- When selected material is shown on the plans or designated in the special provisions as a specified layer, spreading and compacting the material shall conform to the provisions in Section 25, "Aggregate Subbases."
- When practicable, and processing is not specified, selected material shall be hauled directly from excavation to its final position in the roadway prism and compacted in place and the work will be paid for at the contract price for roadway excavation.
- Selected material shall remain in place until it can be placed in final position as provided above. No additional compensation will be allowed for any delay or inconvenience in excavation operations, except that if ordered in writing by the Engineer, selected material may be excavated and stockpiled at locations designated by the Engineer and later placed in final position in the roadway prism.
- Excavating selected material and stockpiling, if required, will be paid for at the contract price for roadway excavation. Removing the selected material from stockpiles and placing it in final position in the roadway prism will again be paid for at the contract price for roadway excavation, except that the quantities to be paid for will be determined from measurements of the material in the stockpiles prior to removal. No payment for stockpiling of selected material will be made, unless the stockpiling is ordered by the Engineer.
- Topsoil placed along the tops of slopes in connection with erosion control work will not be considered as stockpiled material when determining quantities of earthwork to be paid for.

19-2.08 MEASUREMENT

- The following earthwork operations will be measured and paid for as roadway excavation for the quantities of material involved and no additional compensation will be allowed therefor:

  Excavating the roadway prism including slope rounding, public and private road approaches, connections and driveways; excavating unsuitable material when shown on the plans or specified in the special provisions; excavating surplus material; excavating selected material and topsoil from within the limits of the project and removing those materials from stockpiles when stockpiling is ordered; excavating channels having a bottom width of 12 feet or more as provided in Section 19-4, "Ditch Excavation;" and excavating local borrow as provided in Section 19-7, "Borrow Excavation."

- Quantities of roadway excavation will be computed by means of average areas and distances between these areas, except as provided in the following paragraph.
- Where due to changed conditions or the nature of a particular operation or for any other reason, it is impossible or impractical to measure quantities of roadway excavation by means of average areas, the Engineer will compute the quantities of material excavated by a method which in the Engineer's opinion is best suited to obtain an accurate determination.
- When quantities of roadway excavation are computed by means of average end areas and center line distances, a correction for curvature will not be applied to quantities within the roadway prism. In computing the quantity of material outside the original roadway prism, where the roadway center line is used as a base, correction will be made for curvature if the center line radius is 1,000 feet or less.
- Excavation in excess of the planned or authorized cross section will not be paid for, except as provided in Section 19-2.04, "Slides and Slipouts." The Contractor shall backfill and compact as directed by the Engineer unauthorized excavated areas to the original ground elevation or authorized section at the Contractor's expense.

19-2.09 PAYMENT

- Quantities of roadway excavation, measured as specified in Section 19-2.08, "Measurement," will be paid for at the contract price per cubic yard. That price shall include excavating, sloping, rounding tops and ends of excavations, loading, hauling, depositing, spreading and compacting the material complete in place, and preparing subgrade at the grading plane as specified in Section 19-1.03, "Grade Tolerance."
- The above price and payment shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in performing roadway excavation work completely as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

19-3 STRUCTURE EXCAVATION AND BACKFILL

19-3.01 DESCRIPTION

- Structure excavation shall consist of excavation for the construction of foundations for structures; excavation of trenches for the construction of culverts, pipes, rods, deadmen, cutoff walls and other facilities; other excavation designated on the plans or in these specifications or in the special provisions as structure excavation; the control and removal of water and the construction or installation of cofferdams and other facilities as necessary to accomplish construction of the work; and the subsequent removal of those facilities, except when the facilities are required or permitted by the plans and specifications to remain in place.
- Structure backfill shall consist of furnishing, placing and compacting backfill material around structures to the lines designated on the plans or specified or directed by the Engineer.
- Structure excavation and structure backfill may be classified on the plans or in the Engineer's Estimate into various types or classifications. When there is a contract pay item for structure excavation (Type A), that excavation shall include all excavation for footings where seal courses are shown on the plans. The requirements of the specifications pertaining specifically to earthwork for culverts shall apply only to earthwork which is classified on the plans as structure excavation (culvert) and structure backfill (culvert).
- Material from structure excavation not used as structure backfill shall be deposited in roadway embankments as provided in Section 19-6, "Embankment Construction," or disposed of as provided in Section 19-2.06, "Surplus Material," all as directed by the Engineer.

19-3.02 EXCAVATION FOR CULVERTS

- When the plans require embankment construction prior to culvert excavation the embankment shall first be constructed to the required height as shown on the plans, and for a distance each side of the culvert of not less than 5 times the diameter or height of the culvert, after which the trench shall be excavated and the culvert installed. Where the embankments are to be constructed on a steep slope or at a difficult location, the height of new embankments may be varied as directed by the Engineer before installing culverts.

19-3.025 CULVERT BEDDINGS

- Culvert beddings shall consist of shaped bedding, sand bedding, or soil cement bedding and shall be constructed, where shown or specified, in accordance with the details shown on the plans and these specifications. When more than one type of bedding is permitted, the same bedding shall be used throughout the length of the culvert.
- Culvert beddings shall conform to the following requirements:

19-3.025A Shaped Bedding

- The trench bed shall be shaped to fit the bottom of the culvert, as shown on the plans, and shall provide uniform support throughout the entire length of the culvert. The trench may be excavated below the bottom of the culvert and the shaped bedding constructed by backfilling and compacting culvert backfill material to the

required line, grade and shape. Shaping shall be accomplished by use of a template conforming to the outside shape of the culvert and guided by headers set parallel to the grade of the culvert established by the Engineer. The headers may be left in place.

19-3.025B Sand Bedding

- Sand shall be free from clay or organic material, suitable for the purpose intended, and shall be of such size that 90 percent to 100 percent will pass a No. 4 sieve and not more than 5 percent will pass a No. 200 sieve.

19-3.025C Soil Cement Bedding

- Portland cement used in soil cement bedding shall conform to the provisions in Section 90, "Portland Cement Concrete," except that testing will not be required.
- Water used for soil cement bedding shall be free from oil, salts and other impurities which would have an adverse effect on the quality of the bedding material.
- Aggregate for soil cement bedding shall be either material selected from the excavation, imported material, or a combination thereof; be free of organic material and other deleterious substances; and meet the following grading requirements:

Sieve Sizes	Percentage Passing
$1^1/_2$"	100
1"	80 - 100
$^3/_4$"	60 - 100
$^3/_8$"	50 - 100
No. 4	40 - 80
No. 100	10 - 40

- The aggregate, cement and water shall be proportioned either by weight or by volume. Not less than 282 pounds of cement shall be used for each cubic yard of material produced. The water content shall be sufficient to produce a fluid, workable mix that will flow and can be pumped without segregation of the aggregate while being placed.
- Materials for soil cement bedding shall be thoroughly machine-mixed in a pugmill, rotary drum or other approved mixer. Mixing shall continue until the cement and water are thoroughly dispersed throughout the material. Soil cement bedding shall be placed in the work within one hour after mixing.
- Soil cement bedding shall be placed in a uniform manner that will prevent voids in, or segregation of, the bedding, and will not float or shift the culvert. Foreign material which falls into the trench prior to or during placing of the soil cement bedding shall be immediately removed.
- Backfilling with earth on culverts set in soil cement bedding shall not commence until 8 hours after the soil cement bedding has been placed.

19-3.03 COFFERDAMS

- Cofferdams for foundation construction shall be carried well below the bottom of the footings and shall be well braced and as watertight as practical. The interior

dimensions of cofferdams shall provide sufficient clearance inside the wales for constructing forms and driving piles and to permit pumping outside the forms.

- If in the judgment of the Contractor, the clearance provided on the plans between the outside line of the footing and any pile or interior wall or surface is not sufficient to permit the driving of piles or building of forms, the Contractor may provide the necessary clearance by constructing the cofferdam sufficiently large to provide such clearance as the Contractor may deem necessary. Any enlargement in excess of one foot outside the dimensions of the footing as shown on the plans shall be considered as being for the sole purpose of expediting the work of the Contractor, and the quantities of any additional excavation and backfill will not be included in the quantities to be paid for.
- Cofferdams which are tilted or moved out of position by any cause during the process of sinking shall be righted or enlarged so as to provide the necessary clearance and proper pier location, and that work shall be done by the Contractor at the Contractor's expense.
- In tidal waters or in streams at a time of probable flood, cofferdam walls shall be vented at low water elevation to ensure equal hydrostatic head both inside and outside of the cofferdam during the period of placing and setting of seals.
- No shoring will be permitted in cofferdams which will induce stress, shock or vibration in the permanent structure.
- When permitted by the Engineer, cross struts or bracing may extend through foundation concrete. Struts or bracing below low water will be permitted to remain in place, except in navigable streams or when specified in the special provisions or shown on the plans, to be removed. Struts or bracing above low water shall be removed and the resulting space filled with concrete of the same mix as that specified for the surrounding concrete.
- In conformance with the provisions in Section 5-1.02, "Plans and Working Drawings," the Contractor shall submit to the Engineer, for approval, drawings showing the Contractor's proposed method of cofferdam construction and other details left open to the Contractor's choice or not fully shown on the plans. Working drawings for cofferdams shall include all design calculations and shall be signed by an Engineer who is licensed as a Civil Engineer in the State of California. Except for drawings of cofferdams on or affecting railroad property, the drawings shall be submitted at least 3 weeks in advance of the time the Contractor begins construction of the cofferdams. Drawings of cofferdams on or affecting railroad property shall be submitted at least 12 weeks in advance of the time the Contractor begins construction of the cofferdams. Approval by the Engineer of the drawings for the cofferdams will be contingent upon the plans being satisfactory to the railroad company involved.
- After completion of the substructure, the cofferdams with all sheeting and bracing shall be removed at least to 2 feet below the level of the streambed, by the Contractor at the Contractor's expense, and the removal shall be performed in a manner that will not disturb or mar the finished concrete or masonry.

19-3.04 WATER CONTROL AND FOUNDATION TREATMENT

- The methods to be used to control and remove water at excavations where seal courses are not shown on the plans shall be at the option of the Contractor and may

include, but are not limited to, well point systems, pumping sumps, cofferdams or concrete seal courses. If the Contractor elects to use a concrete seal course at those locations, the provisions of the fourth paragraph and the first 2 sentences of the fifth paragraph of Section 51-1.10, "Concrete Deposited Under Water," shall not apply for spread footings and the entire Section 51-1.10 shall not apply to pile footings. The successful performance of the seals, if used, shall be solely the responsibility of the Contractor.

- At locations where concrete seal courses are shown on the plans, and the Engineer determines that a seal course shall be used, control and removal of water shall be accomplished by the use of a cofferdam, a concrete seal course placed in conformance with the provisions in Section 51-1.10, "Concrete Deposited Under Water," and dewatering pumps.
- When no piles are used and footing concrete, culverts or other structures are to rest on an excavated surface other than rock, the following shall apply:

  Care shall be taken during excavation to prevent disturbing the foundation. If ground water is encountered during excavation and a concrete seal course is not to be used, dewatering shall be commenced and shall proceed in advance of or concurrently with further excavation. The foundation shall be free of water at the time footing concrete or pipes are placed, and water control shall continue as necessary to prevent damage to the work.

  If suitable foundation material has been disturbed by the Contractor's operations, has been damaged by water or has been removed for the Contractor's convenience in dewatering the foundation, the foundation shall be restored by the Contractor, at the Contractor's expense, to a condition at least equal to the undisturbed foundation as determined by the Engineer. For culverts, the material used to replace the damaged or removed foundation material shall be Class 2 aggregate base, conforming to the provisions in Section 26, "Aggregate Bases," and shall be compacted as required for structure backfill, unless the Engineer determines that a different type of material is required to provide the equivalent bearing capacity.

  When undisturbed original material at the planned grade of the excavation is determined by the Engineer to be unsuitable material, as defined in Section 19-2.02, "Unsuitable Material," the Engineer will direct corrective work and the cost of the corrective work, other than structure excavation and backfill within the limits described in Section 19-3.07, "Measurement," will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."

- When footing concrete or masonry is to rest upon rock, the rock shall be fully uncovered and the surface thereof shall be removed to a depth sufficient to expose sound rock. The rock shall be roughly leveled or cut to steps, and shall be roughened. Seams in the rock shall be grouted under pressure or treated as the Engineer may direct and the cost thereof will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."
- When excavating for culverts, other than arch culverts, and solid rock or other unyielding material is encountered at the planned elevation of the bottom of the

culvert, the material shall be removed below the bottom of the culvert to a depth of 1/24 of the height of embankment over the top of culvert, but in no case less than one foot nor more than 5 feet. The resulting trench below the bottom of the culvert shall be backfilled with structure backfill material in conformance with the provisions in Section 19-3.06, "Structure Backfill." The excavation and backfill below the planned elevation of the bottom of the culvert will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."

- When footings are to be supported on piles, excavations shall be completed to the bottom of the footings before any piles are drilled or driven therein. When swell or subsidence results from driving piles, the Contractor shall, at the Contractor's expense, excavate or backfill with suitable material, the footing area to the grade of the bottom of the footing as shown on the plans. If material under footings is such that it would mix into the concrete during footing placement or would not support the weight of the fluid concrete, the Contractor shall, at the Contractor's expense, replace the material with suitable material, install soffit forms or otherwise provide a suitable platform on which to cast the footing.

19-3.05 INSPECTION

- In order to determine the character of the foundation material, the Contractor shall, if directed by the Engineer, dig test pits and make test borings and foundation bearing tests, and the cost thereof will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."
- Whenever any structure excavation is completed substantially to grade, the Contractor shall notify the Engineer who will make an inspection of the foundation. No concrete or masonry shall be placed until the foundation has been approved by the Engineer.

19-3.06 STRUCTURE BACKFILL

- Backfill material shall be placed in uniform layers and shall be brought up uniformly on all sides of the structure or facility. The thickness of each layer of backfill shall not exceed 0.67-foot before compaction except that when compaction is done by ponding and jetting, the thickness shall not exceed 4 feet.
- Compaction equipment or methods which may cause excessive displacement or may damage structures, shall not be used.
- Structure backfill shall not be placed until the structure footings or other portions of the structure or facility have been inspected by the Engineer and approved for backfilling. No backfill material shall be deposited against the back of concrete abutments, concrete retaining walls, or the outside walls of cast-in-place concrete structures until the concrete has developed a strength of not less than 2,500 psi in compression, or until the concrete has been in place for 28 days, whichever occurs first.
- Backfill at the inside of bridge wingwalls and abutments shall be placed before curbs or sidewalks are constructed over the backfill and before railings on the wingwalls are constructed.
- Compaction of structure backfill by ponding and jetting will be permitted when, as determined by the Engineer, the backfill material is of such character that it will be self-draining when compacted and that foundation materials will not

soften or be otherwise damaged by the applied water and no damage from hydrostatic pressure will result to the structure. Ponding and jetting of the upper 4 feet below finished grade will not be permitted. The work shall be performed without damage to the structure and embankment, and in such a manner that water will not be impounded. Ponding and jetting methods shall be supplemented by the use of vibratory or other compaction equipment when necessary to obtain the required compaction.

- Unless otherwise shown on the plans or specified in these specifications or the special provisions, structure backfill shall be compacted to a relative compaction of not less than 95 percent.
- Structure backfill placed at the following locations shall be compacted to a relative compaction of not less than 90 percent:

1. Overside drains.
2. Footings for slope protection, slope paving, and aprons.
3. All headwalls, endwalls, and culvert wingwalls.
4. Retaining walls, except for portions under any surfacing.
5. Inlets in median areas or in traffic interchange loops.
6. Footings and pumping plants not beneath any surfacing.

- Unless otherwise shown on the plans or specified in these specifications or the special provisions, material for structure backfill to be compacted to a relative compaction of not less than 95 percent and material to be placed behind retaining walls shall have a Sand Equivalent value of not less than 20 and shall conform to the following grading:

Sieve Sizes	Percentage Passing
3"	100
No. 4	35 - 100
No. 30	20 - 100

- Unless otherwise shown on the plans or specified in these specifications or the special provisions, material for structure backfill to be compacted to a relative compaction of not less than 90 percent, except material to be placed behind retaining walls, shall consist of material free of stones or lumps exceeding 3 inches in greatest dimension, organic or other unsatisfactory material.
- At locations where directed by the Engineer, the material used to backfill the outer 2-foot portion of structure backfill adjacent to pipe and culvert inlets and outlets, and structure backfill placed within 2 feet of finished grade around abutments, abutment wingwalls, retaining walls, and other portions of structures shall be a compacted impervious material. The impervious backfill shall be an earthy material, as determined by the Engineer to be suitable for such purpose. The Sand Equivalent requirement shall not apply to the impervious material used for structure backfill.
- The cells formed by the crib members of crib walls and the space between the crib wall and the limits designated for structure excavation, as shown on the plans or specified, including any space due to material being removed outside those

limits, shall be backfilled with material conforming to the following grading, quality, placement and compaction requirements:

Structure backfill placed for crib walls shall be of such character that it will not sift or flow through the openings in the wall and shall conform to the type or types listed below for the height of wall.

Backfilling shall progress simultaneously with the erection of the crib wall. Backfill material shall be so placed as to not disturb or damage the crib members, shall be placed in uniform layers before compaction not exceeding the thickness listed in the following table, and shall be compacted by hand tamping, mechanical compaction or other means approved by the Engineer.

Wall Height	Backfill Material Type	Loose Thickness of each Layer of Backfill Material Before Compaction
Under 10 feet	C, D or E	1 foot
10-25 feet	D or E	2 feet
Over 25 feet	E	4 feet

Backfill Material Type	Grading		Sand Equivalent	Relative Compaction
	Sieve Size	Percentage Passing		
C	3"	100	None	90% Min.
D	3"	100	30 Min.	90% Min.
	No. 4	35 - 100		
E	3"	100	None	90% Min.
	No. 4	25 - 70		
	No. 50	5 - 20		
	No. 200	0 - 5		

- Structure backfill placed at bridge supports in waterways and water channels, and not beneath any embankment, pavement or slope protection, need not be compacted, shall consist of soil which is free of organic matter, trash or other unsatisfactory material, and shall be placed to the level of the original ground or finished grade.
- Where structure excavation is performed and material is removed outside the pay limits designated for structure excavation, as shown on the plans or specified in these specifications or the special provisions, backfill material placed in those excavation areas shall conform to the material and compaction requirements of the adjacent structure backfill.
- Material for structure backfill shall be furnished by the Contractor except that the Contractor may use material found in excavation in conformance with the provisions in Section 4-1.05, "Use of Materials Found on the Work." When there is an item for imported borrow, imported borrow meeting the requirements of structure backfill may be used as structure backfill and no deduction in the quantities of imported borrow to be paid for will be made provided that an equivalent amount of material conforming to the requirements of imported borrow

is replaced by the Contractor. Material from structure excavation which is not suitable for use as structure backfill may be used to replace imported borrow or other excavated material.

19-3.062 SLURRY CEMENT BACKFILL

- Slurry cement backfill shall consist of a fluid, workable mixture of aggregate, cement and water.
- At the option of the Contractor, slurry cement backfill may be used as structure backfill for pipe culverts, except that slurry cement backfill shall not be used as structure backfill for aluminum and aluminum-coated pipe culverts.
- When slurry cement backfill is used for structure backfill, the width of the excavation shown on the plans may be reduced so that the clear distance between the outside of the pipe and the side of the excavation, on each side of the pipe, is a minimum of 6 inches for pipes up to and including 42 inches in diameter or span, or one foot for pipes over 42 inches in diameter or span.
- Slurry cement backfill shall be placed only for that portion of the structure backfill below the original ground or the grading plane or the top of the embankment placed prior to excavating for the culvert pipe. Where necessary, earth plugs shall be compacted at each end of the pipe prior to placing backfill in a manner that will completely contain the slurry in the pipe trench.
- Cement shall be portland cement conforming to the provisions in Section 90-2.01, "Cement," except that testing will not be required.
- Water used for slurry cement backfill shall be free from oil, salts and other impurities which would have an adverse effect on the quality of the backfill material.
- At the option of the Contractor, aggregate shall be either (1) material selected from excavation, imported material or a combination thereof, which is free of organic material and other deleterious substances, or (2) commercial quality concrete sand. Material selected from excavation, imported material or a combination thereof, shall meet the following grading:

Sieve Sizes	Percentage Passing
$1^1/_2$"	100
1"	80 - 100
$^3/_4$"	60 - 100
$^3/_8$"	50 - 100
No. 4	40 - 80
No. 100	10 - 40

- The aggregate, cement and water shall be proportioned either by weight or by volume. Not less than 188 pounds of cement shall be used for each cubic yard of material produced. The water content shall be sufficient to produce a fluid, workable mix that will flow and can be pumped without segregation of the aggregate while being placed.
- Materials for slurry cement backfill shall be thoroughly machine-mixed in a pugmill, rotary drum, or other approved mixer. Mixing shall continue until the

cement and water are thoroughly dispersed throughout the material. Slurry cement backfill shall be placed in the work within one hour after mixing.

- Slurry cement backfill shall be placed in a uniform manner that will prevent voids in, or segregation of, the backfill, and will not float or shift the culvert. Foreign material which falls into the trench prior to or during placing of the slurry cement backfill shall be immediately removed.
- Backfilling over or placing any material over slurry cement backfill shall not commence until 4 hours after the slurry cement backfill has been placed, except that when concrete sand is used for the aggregate and the in-place material is free draining, backfilling may commence as soon as the surface water is gone.
- Slurry cement backfill used as structure backfill for pipe culverts will be considered structure backfill for compensation purposes.

19-3.065 PERVIOUS BACKFILL MATERIAL

- Pervious backfill material shall be placed behind bridge abutments, wingwalls and retaining walls as shown on the plans and in accordance with the following requirements.
- Pervious backfill material shall consist of gravel, crushed gravel, crushed rock, natural sands, manufactured sand or combinations thereof. Pervious backfill material, except for sacked material at wall drain outlets, shall conform to the following grading requirements:

Sieve Sizes	Percentage Passing
2"	100
No. 50	0 - 100
No. 100	0 - 8
No. 200	0 - 4

- Wall drain outlets shall be backed with sacked pervious backfill material, except that the grading for the sacked material shall conform to the grading for the $1^1/_2$" x $^3/_4$" primary aggregate size specified in Section 90-3.02, "Coarse Aggregate Grading."
- Pervious backfill material shall be placed in layers along with and by the same methods specified for structure backfill. Pervious backfill material at any one location shall be approximately the same grading, and at locations where the material would otherwise be exposed to erosion shall be covered with at least a one foot layer of earthy material approved by the Engineer.

19-3.07 MEASUREMENT

- Quantities of earthwork to be paid for as structure excavation, structure backfill and pervious backfill material will be measured by the cubic yard.
- The quantities for payment will be determined from limits shown on the plans or specified or directed by the Engineer.
- No deduction in structure excavation or structure backfill pay quantities will be made where the Contractor does not elect to excavate material which is outside the limits of the actual structure but within the limits shown on the plans or specified or directed by the Engineer.

- No compensation will be made for the removal and use or disposal of material which may come into an excavation from outside the designated limits or for the volume of backfill occupied by the new structure or for the removal and disposal of material resulting from swell caused by the driving of piles in an excavation or for furnishing and placing backfill material in an excavation that is below or outside the designated limits, and these quantities will not be included in the quantities of structure excavation and structure backfill to be paid for.
- In the absence of plans showing pay limits for structure excavation and backfill for structures other than culverts, the quantities will be computed within the following limits:

A. The horizontal limits for computing pay quantities will be vertical planes one foot outside of the neat lines of footings or structures without footings.
B. The upper limit for payment of structure excavation shall be the ground surface as it existed prior to the start of construction operations, except where structure excavation is performed within roadway excavation or ditch excavation areas, the upper limit shall be the planes of the bottom and side slopes of those excavated areas. Also, where it is required that the structure excavation be made in new embankment, the upper limit shall be the planes of the new embankment at the elevation specified or directed for construction in advance of performing the required structure excavation, but in no case shall the upper limit be above the planes of the new embankment.
C. The upper limit for payment of structure backfill when not shown or specified, shall be the finished grading plane or the finished slope lines, as directed by the Engineer. If structure backfill is ordered to a higher limit by the Engineer the limit for payment shall be the higher limit ordered.
D. The lower limit for computing pay quantities of structure excavation or structure backfill shall be a plane at the bottom of the completed footings or structures or the lower outside surface of rods or deadmen.

- If it is necessary, as determined by the Engineer, to increase the depth or width of structure excavation beyond the limits shown on the plans for structures other than culverts, excavation to a depth of 2 feet below the depth and for a width up to 3 times the outside width of the footing as determined by the Engineer will be paid for at the contract price per cubic yard for structure excavation. Excavation to depths or widths greater than above provided will be paid for at the contract price for structure excavation, unless the Engineer prior to the removal of excavation outside the above limits orders the excavation to be removed and paid for as extra work as provided in Section 4-1.03D, "Extra Work," or the Contractor, prior to removal of the excavation requests in writing that the removal of excavation outside those limits be paid for as extra work as provided in Section 4-1.03D, "Extra Work." When the limits of structure excavation are so increased, the pay limits for structure backfill will be similarly increased and the additional backfill within said limits will be paid for at the contract price for structure backfill.

- Structure excavation for footings, where a seal course is shown on the plans, will be paid for at the contract price per cubic yard for structure excavation (Type A). If the depth of the structure excavation (Type A) at any footing is reduced because site dewatering efforts or lower than anticipated water levels permit a reduction or elimination of the seal course, such decrease will not be considered to be a change in the dimensions of structure excavation (Type A) within the meaning of Section 9-1.015, "Final Pay Items," and no decrease in the quantity of structure excavation (Type A) will be made.
- The volume of pervious backfill material, measured and paid for within the limits of payment for structure backfill, will be deducted from the pay quantities of structure backfill.
- Whenever an alternative or option, which affects earthwork quantities, is shown or noted on the plans, or permitted by these specifications or the special provisions, the quantities of earthwork will be computed on the basis of the dimensions and details shown on the plans and no change in the quantities to be paid for will be made because of the use by the Contractor of such alternatives or options.

19-3.08 PAYMENT

- Unless otherwise provided, quantities of earthwork, measured as specified in Section 19-3.07, "Measurement," will be paid for by the cubic yard for structure excavation, for structure backfill, and for pervious backfill material of the types shown in the Engineer's Estimate.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in excavating for and backfilling structures completely, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- The quantities of structure excavation, structure backfill and culvert beddings required for the installation of culverts, will not be paid for as separate items. Full compensation for structure excavation, structure backfill and culvert beddings for culvert installations shall be considered as included in the contract prices paid per linear foot for pipe culverts or per cubic yard for the concrete involved in constructing reinforced concrete box and arch culverts, whichever applies.
- The quantities of structure excavation, structure backfill, and pervious backfill material required for the construction of concrete headwalls, endwalls, and wingwalls for culverts will not be paid for as separate items. Full compensation for structure excavation, structure backfill, and pervious backfill material for concrete headwalls, endwalls and wingwalls for culverts shall be considered as included in the contract price paid per cubic yard for the concrete involved in constructing the headwalls, endwalls and wingwalls.
- No adjustment in compensation will be made if the actual depth of structure excavation for a culvert is within 0.5-foot of the planned depth as calculated from the data shown on the plans. The actual depth of structure excavation shall be the vertical distance between the ground line prior to excavating for the culvert and the bottom of the culvert trench. If the increase or decrease in structure excavation depth is greater than 0.5-foot from the planned depth as calculated from the data

shown on the plans, an adjustment in compensation will be made in conformance with the provisions in Section 4-1.03C, "Changes in Character of Work," provided the Contractor requests an adjustment, in writing, due to the increased depth of structure excavation or the Engineer orders an adjustment due to the decreased depth of structure excavation. Any increased depth of excavation due to the removal of unsuitable material, or rock or other unyielding material below the planned grade of the bottom of the culvert as provided in Section 19-3.04, "Water Control and Foundation Treatment," will not be considered in determining the actual depth of structure excavation for a culvert.

- Full compensation for controlling and removing water from excavations and for furnishing and installing or constructing all cofferdams and all other facilities necessary to the operations (except concrete seal courses when shown on the plans) and their subsequent removal, if required by the Engineer, shall be considered as included in the contract price paid for structure excavation or the contract price paid for the item of work requiring the excavation when the excavation is not paid for separately.
- Full compensation for hauling, placing and compacting surplus structure excavation in roadway embankments or otherwise disposing of the material along the roadway as directed by the Engineer, shall be considered as included in the contract price paid for excavating the material, or the contract price paid for the item of work requiring the excavation when the excavation is not paid for separately.
- The quantities of structure excavation and structure backfill required for minor structures as provided in Section 51-1.02, "Minor Structures," will not be paid for as separate items and full compensation therefor will be considered as included in the contract price paid per cubic yard for minor concrete (minor structure) or for concrete (minor structure) of the class specified in the Engineer's Estimate.
- Where compaction is not required, full compensation for furnishing and placing structure backfill shall be considered as included in the contract price paid per cubic yard for the type of structure excavation involved.

19-4 DITCH EXCAVATION

19-4.01 DESCRIPTION

- Ditch excavation shall consist of excavating ditches within or outside the right of way, including channels for changing the course of streams, all as shown on the plans or specified or directed by the Engineer.
- The excavation required to construct a ditch or channel designated with a bottom width of less than 12 feet will be classed as ditch excavation.
- The excavation required to construct a ditch or channel designated with a bottom width of 12 feet or more will be classed as roadway excavation.
- Material resulting from excavating ditches or channels shall be used to construct roadway embankments, dikes or for other purposes, or disposed of, all as directed by the Engineer.
- Care shall be exercised to prevent excavating below the grade for the bottom of the ditch or water channel, and areas excavated below grade shall be filled with

suitable material and thoroughly compacted by the Contractor at the Contractor's expense.

19-4.02 MEASUREMENT

- Quantities of ditch excavation to be paid for will be computed by means of average areas and the distances between these areas.

19-4.03 PAYMENT

- The excavation of ditches and channels which have a bottom width of less than 12 feet, as shown on the plans, except as hereinafter provided, will be paid for at the contract price per cubic yard for ditch excavation.
- The above price and payment shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in excavating ditches completely, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- The excavation of gutters within the median area of a divided highway, and gutters between the roadbed shoulder and an adjacent excavation slope, and gutters in excavation benches, and side gutters contiguous to embankment slopes, all as shown on the plans, will be paid for as roadway excavation and payment will not be made as ditch excavation for that work.

19-5 COMPACTION

19-5.01 DESCRIPTION

- Earthwork compaction consists of obtaining the required compaction in all earthwork described in these specifications or the special provisions, except structure backfill.

19-5.02 GENERAL

- Embankments shall be constructed in layers. The loose thickness of each layer of embankment material before compaction shall not exceed 0.67-foot, except as provided in the following paragraph for rocky material.
- When embankment material contains rock, the loose thickness of each layer of embankment material before compaction below a plane 3 feet below finished grade shall conform to the following:

A. When embankment material contains, by volume, over 50 percent of rock larger than 8 inches in greatest dimension, the loose layers of embankment shall not exceed the maximum size of rock in the material.
B. When embankment material contains, by volume, between 25 percent and 50 percent of rock larger than 8 inches in greatest dimension, the loose layers of embankment shall not exceed 3 feet in thickness; however, the layers are not to exceed the maximum size of rock in the material.
C. When embankment material contains, by volume, up to 25 percent of rock larger than 8 inches in greatest dimension, the loose layers of embankment shall not exceed 0.67-foot thickness in the area between the rocks larger than 8 inches.

- The interstices around the rock in each layer shall be filled to the greatest extent practicable with earth or other fine material, after which the layer shall be compacted until there is no visible evidence of further consolidation of the material being compacted.

19-5.03 RELATIVE COMPACTION (95 PERCENT)

- Relative compaction of not less than 95 percent shall be obtained for a minimum depth of 0.5-foot below the grading plane for the width between the outer edges of shoulders, whether in excavation or embankment.
- In addition, relative compaction of not less than 95 percent shall be obtained for a minimum depth of 2.5 feet below finished grade for the width of the traveled way plus 3 feet on each side thereof, whether in excavation or in embankment.
- Except for the outer 5 feet measured horizontally from the embankment side slopes, the full width of embankment within 150 feet of bridge abutments shall be compacted to a relative compaction of not less than 95 percent. The 150-foot limit of 95 percent compaction will be measured horizontally from the bridge abutment and either parallel or concentric with the roadway centerline. In addition, a relative compaction of not less than 95 percent shall be obtained for embankment under retaining wall footings without pile foundations within the limits established by inclined planes sloping 1.5:1 (horizontal:vertical) out and down from lines one foot outside the bottom edges of the footing.

19-5.04 RELATIVE COMPACTION (90 PERCENT)

- Relative compaction of not less than 90 percent shall be obtained in all material in embankment, except as specified herein to be 95 percent.

19-5.05 FOUNDATION PREPARATION

- Preparation of the foundation to receive material shall be the responsibility of the Contractor. If the Contractor elects to excavate and replace basement material to facilitate compaction, before replacement has begun and when ordered by the Engineer, a layer of material below the excavated material shall be compacted to the depth, width and degree of compaction ordered by the Engineer, and the ordered work will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."

19-5.06 PAYMENT

- Payment for earthwork compaction will be considered as included in the various contract items of work requiring compaction of earthwork and no separate payment will be made therefor. If the Contractor elects to excavate and replace basement material to facilitate compaction, full compensation for that work will be considered as included in the contract items of work requiring the compaction of earthwork and no separate payment will be made therefor. If the basement material is placed in embankment or used in other planned or authorized work, and is replaced with planned excavated material or imported borrow, payment will be made for the quantity of replacement material used at the contract price for the type of excavation involved or imported borrow, as the case may be.

19-6 EMBANKMENT CONSTRUCTION

19-6.01 PLACING

- Embankment construction shall consist of constructing roadway embankments, including the preparation of the areas upon which embankment materials are to be placed; the construction of temporary surcharge embankment above the grading plane; the construction of dikes within or outside the right of way; the placing and compacting of approved material within roadway areas where unsuitable material has been removed; and the placing and compacting of embankment material in holes, pits and other depressions within the roadway area.
- Attention is directed to Sections 19-5, "Compaction," and 19-2.05, "Slopes."
- Rocks, broken concrete or other solid materials, which are larger than 0.33-foot in greatest dimension, shall not be placed in embankment areas where piles are to be placed or driven.
- When embankment is to be made and compacted on hillsides or where new embankment is to be compacted against existing embankments or where embankment is built one-half width at a time, the slopes of original hillsides and old or new embankments shall be cut into a minimum of 6 feet horizontally as the work is brought up in layers. Material thus cut out shall be recompacted along with the new embankment material at the Contractor's expense, unless the width of excavation required by the Engineer exceeds 6 feet, in which case the excavation of material in excess of 6 feet horizontally will be measured and paid for as roadway excavation.
- Where embankment is to be made and compacted on original hillsides, old or new embankments, and end dumping is permitted, the slopes of the original ground or embankment shall be plowed or cut into before starting end dumping.
- When embankment is to be placed on an existing roadway, the existing roadbed shall be scarified, watered, graded and rolled in advance of placing new material thereon.
- Whenever selection is possible, borrow or excavation material having a Sand Equivalent value less than 10 shall not be placed within 2.5 feet of finished grade and shall be placed in the lower portions of embankments.
- Clods or hard lumps of earth over 8 inches in greatest dimension shall be broken up before compacting the material in embankment, except as provided in the following paragraph.
- When the embankment material consists of large rocky material, or hard lumps, such as hardpan or cemented gravel which cannot be broken readily, such material shall be well distributed throughout the embankment. Sufficient earth or other fine material shall be placed around the larger material as it is deposited so as to fill the interstices and produce a dense, compact embankment.
- Embankment construction shall not be performed when material is frozen or a blanket of snow prevents proper compaction.
- When bridge footings are to be constructed in embankment, the embankment shall be constructed to the elevations of the grading plane and the finished slope extended to the grading plane before excavating for the footing, or when foundation piling is shown on the plans, before driving the piles or excavating for the footing.

19-6.02 COMPACTING

- Embankments shall be constructed in layers of uniform thickness, and each layer shall be compacted in conformance with the provisions in Section 19-6.02 with the following 2 exceptions:

A. Sidehill embankments, where the width including bench cuts for bonding existing and new embankments is too narrow to accommodate compacting equipment, may be constructed by end dumping if permitted by the Engineer, until the embankment, including benching, is wide enough to permit the use of compacting equipment, after which the remainder of the embankment shall be placed in layers and compacted as specified.
B. Where embankments are to be constructed across low, swampy ground which will not support the weight of hauling equipment, the lower part of the embankment may be constructed by dumping successive loads in a uniformly distributed layer of a thickness not greater than that necessary to support the equipment while placing subsequent layers, after which the remainder of the embankment shall be constructed in layers and compacted as specified.

- Unless specified herein, or in the special provisions, or directed by the Engineer, the construction of dikes, the placing and compacting of approved material within the right of way where unsuitable material has been removed, and the filling of holes, pits and other depressions within the right of way, shall conform to the provisions herein and in conformance with the provisions in Section 19-5, "Compaction." Trenches, holes, depressions and pits outside of areas where embankments are to be constructed shall be graded to provide a presentable and well-drained area.
- Embankments shall be constructed so that each layer shall have a cross fall not to exceed 5 percent.
- At locations where it would be impractical to use mobile power compacting equipment, embankment layers shall be compacted to the specified requirements by any method that will obtain the specified compaction.
- At the time of compaction, the moisture content of embankment material shall be such that the specified relative compaction will be obtained and the embankment will be in a firm and stable condition. Embankment material which contains excessive moisture shall not be compacted until the material is dry enough to obtain the required compaction. Full compensation for any additional work involved in drying embankment material to the required moisture content shall be considered as included in the contract price paid for excavating or furnishing the material and no additional compensation will be allowed therefor.
- Embankments shall be maintained to the grade and cross section shown on the plans until the acceptance of the contract.
- Surcharge material when required shall be placed in uniform layers and shall be compacted by routing the grading equipment over the full width of the embankment. Following removal of surcharge material above the grading plane, and before placing subsequent layers of subbase or base, the embankment below

the grading plane shall conform to the relative compaction provisions in Section 19-5, "Compaction."

19-6.025 SETTLEMENT PERIOD

- Where an embankment settlement period is provided for in the special provisions, the embankment shall remain in place for the required settlement period before excavating for the abutment, wingwall, or retaining wall footings or driving the foundation piles at each location.
- Where an embankment settlement period is specified, the embankment shall be constructed at least to the grading plane and to the other limits shown on the plans or specified in the special provisions, for a distance of at least 150 feet, measured parallel to the center line of roadway from the bridge abutments, and for the entire length of the retaining walls and a width of not less than 30 feet from the face of wall.
- Where a settlement period for a surcharge embankment is shown on the plans or provided for in the special provisions, the surcharge shall be constructed to the height and to the limits shown or specified. The surcharge shall remain in place until the end of the settlement period.
- The duration of the required settlement period at each location will be provided for in the special provisions.
- Where settlement periods are required, embankments and surcharge embankments shall not encroach upon traveled ways nor upon existing improvements that are subject to damage, and if necessary, the Contractor shall furnish and install bulkheads or whatever means may be necessary to retain the embankment material as provided in Section 19-1.02, "Preservation of Property."
- Settlement platforms shall be constructed if directed by the Engineer, and the cost of initial construction will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."

19-6.03 PAYMENT

- Full compensation for constructing embankments; preparing subgrade at the grading plane, as specified in Section 19-1.03, "Grade Tolerance;" doing necessary plowing, scarifying or benching; constructing dikes; placing and compacting approved material where unsuitable and unstable embankment foundation material has been removed; filling and compacting holes, pits and other depressions; backfilling excavations resulting from the removal of structures and other facilities; placing selected material where required; placing topsoil excavated from within the project limits on slopes; placing selected material and topsoil in stockpiles; all as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer, shall be considered as included in the contract price paid per cubic yard for excavating the material or the contract price paid for furnishing and placing the material, as the case may be, and no additional compensation will be allowed therefor.

19-7 BORROW EXCAVATION

19-7.01 LOCAL BORROW

Local borrow shall consist of material excavated and used in the construction of embankments or for use as selected material or for other highway construction purposes. Local borrow shall be obtained by widening cuts or by excavating from other sources outside the planned or authorized cross section within the right of way or slope easements and within the limits of the project. Local borrow shall be material which is excavated from sources specified in the special provisions, or designated by the Engineer. The Contractor will have no choice or selection of the source of material to be excavated. Local borrow shall be excavated to the lines and grades established by the Engineer.

19-7.02 IMPORTED BORROW

Imported borrow shall consist of material required for the construction of embankments and may be obtained from sources in conformance with the provisions in Section 6-2, "Local Materials," or from any other source the Contractor may elect. Unless otherwise designated in the special provisions, the Contractor shall make the arrangements for obtaining imported borrow and shall pay all costs involved.

Imported borrow shall be of a quality suitable for the purpose intended, free of organic matter or other unsatisfactory material.

The Contractor shall notify the Engineer sufficiently in advance of opening any material sites so that cross section elevations and measurements of the ground surface after stripping may be taken and the material may be tested.

19-7.03 PLACING AND COMPACTING

Local borrow and imported borrow shall be placed and compacted to designated dimensions as specified in Sections 19-1.03, "Grade Tolerance," and 19-6, "Embankment Construction," and the special provisions.

The Contractor shall be satisfied that there is sufficient space available in embankment locations for placing any excavated material, before placing imported borrow in embankments. Any excess excavation which develops as a result of placing imported borrow in advance of completing excavations shall be disposed of at the Contractor's expense in conformance with the provisions in Section 19-2.06, "Surplus Material," and a corresponding reduction in the quantity of imported borrow to be paid for will be made, for which the Contractor will have no claim for compensation.

19-7.04 MEASUREMENT

Quantities of local borrow will be measured as roadway excavation as specified in Section 19-2, "Roadway Excavation."

Quantities of imported borrow to be paid for by the ton will be determined as provided in Section 9-1.01, "Measurement of Quantities."

Quantities of imported borrow to be paid for by the cubic yard will be computed by means of average areas and distances between these areas determined from measurements of the material site before and after removal of the material. Only material used on the work will be paid for and quantities of material

excavated at the material site and not used on the work will be deducted from the computed quantities and will not be paid for.

19-7.05 PAYMENT

- Imported borrow will be paid for by the cubic yard or ton, which price shall include full compensation for clearing and stripping the material sites, if necessary; excavating, loading, hauling, depositing, spreading and compacting the material, complete in place, within the roadway as specified.
- The above price and payment shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in obtaining and placing imported borrow, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- Local borrow will be paid for as roadway excavation as provided in Section 19-2, "Roadway Excavation."

SECTION 20: EROSION CONTROL AND HIGHWAY PLANTING

20-1 GENERAL

20-1.01 DESCRIPTION

- This work shall consist of performing erosion control, highway planting (including installing or modifying irrigation facilities), and other work necessary for improving the appearance of the roadside and preserving and rehabilitating the highway investment.
- Erosion control and highway planting shall be performed in conformance with these specifications, the special provisions, the details shown on the plans, and as directed by the Engineer.

20-2 MATERIALS

20-2.01 TOPSOIL

- Topsoil shall be obtained from sources within the project or shall consist of imported topsoil obtained from sources outside the highway right of way or a combination of both sources, whichever is provided in the special provisions.
- Topsoil obtained from sources within the right of way shall be excavated to the lines and depths as directed by the Engineer. All lumps or clods shall be broken up before the topsoil is spread. Topsoil obtained from within the project will be considered as selected material within the meaning in Section 19-2.07, "Selected Material."
- Imported topsoil shall consist of material obtained from sources outside the limits of the project in conformance with the provisions in Section 6-2, "Local Materials." Unless designated in the special provisions, the Contractor shall make the arrangements for obtaining imported topsoil and the Contractor shall pay all costs involved.
- Imported topsoil shall consist of fertile, friable soil of loamy character, and shall contain an amount of organic matter normal to the region. It shall be obtained from well-drained arable land and shall be reasonably free from subsoil, refuse, roots, heavy or stiff clay, stones larger than one inch in size, coarse sand, noxious seeds, sticks, brush, litter and other deleterious substances. Imported topsoil shall be capable of sustaining healthy plant life.

20-2.02 COMMERCIAL FERTILIZER

- Commercial fertilizer shall conform to the requirements of the California Food and Agricultural Code.
- Commercial fertilizer for erosion control work shall be in pelleted or granular form and shall have a guaranteed chemical analysis of 16 percent nitrogen, 20 percent phosphoric acid and 0 percent water soluble potash, and shall contain a minimum of 12 percent sulfur.
- Commercial fertilizer for highway planting work shall be in pelleted, granular or tablet form and shall have the chemical analysis specified in the special provisions.

20-2.03 SOIL AMENDMENT

- Soil amendment shall be a wood or bark product, treated to absorb water quickly, or a relatively dry organic compost derived from sewage sludge, plant material or rice hulls; shall be friable and pass a one inch sieve and shall comply with the requirements in the California Food and Agricultural Code.
- Rice hull compost and plant material compost shall not contain living vegetation, dirt or other objectionable material, pathogenic viruses, fly larvae, insecticides, herbicides, fungicides nor poisonous chemicals that would inhibit plant growth.
- Soil amendment shall be packaged so that compliance can be readily determined, or shall be accompanied by a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."

20-2.04 (BLANK)

20-2.05 IRON SULFATE

- Iron sulfate shall be ferrous sulfate in pelleted or granular form containing not less than 18.5 percent iron expressed as metallic iron. Iron sulfate shall conform to the requirements of the California Food and Agricultural Code.

20-2.06 STRAW

- Straw shall be derived from wheat, rice, or barley. The Contractor shall furnish evidence that clearance has been obtained from the County Agricultural Commissioner, as required by law, before straw obtained from outside the county in which it is to be used is delivered to the site of the work. Straw that has been used for stable bedding shall not be used.

20-2.07 FIBER

- Fiber shall be produced from natural or recycled (pulp) fiber, such as wood chips or similar wood materials or from newsprint, chipboard, corrugated cardboard or a combination of these processed materials, and shall be free of synthetic or plastic materials. Fiber shall not contain more than 7 percent ash as determined by the Technical Association of the Pulp and Paper Industry (TAPPI) Standard T 413, shall contain less than 250 parts per million boron and shall be otherwise nontoxic to plant or animal life.
- Fiber shall have a water-holding capacity by weight of not less than 1200 percent as determined by the procedure designated in the Department's Final Report, CA-DOT-TL-2176-1-76-36, "Water-Holding Capacity for Hydromulch," available at the Transportation Laboratory.
- Fiber shall be of such character that the fiber will disperse into a uniform slurry when mixed with water. Water content of the fiber before mixing into slurry shall not exceed 15 percent of the dry weight of the fiber. The percentage of water in the fiber shall be determined by California Test 226. Fiber shall have the moisture content of the fiber marked on the package. Fiber shall be colored to contrast with the area on which the fiber is to be applied, and shall not stain concrete or painted surfaces.
- A Certificate of Compliance for fiber shall be furnished to the Engineer in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."

20-2.08 MULCH

- Unless otherwise specified in the special provisions or shown on the plans, mulch shall consist of wood chips, tree bark, or shredded bark, or any combination thereof, at the Contractor's option.
- Mulch materials produced from pine trees grown in Alameda, Monterey, Santa Clara, Santa Cruz, San Luis Obispo or San Mateo Counties shall not be used.
- Wood chips shall be manufactured from clean wood. The particle size of the chips shall be between $^1/_2$ inch and 3 inches in length, and not less than $^3/_8$ inch in width and $^1/_{16}$ inch in thickness.
- At least 85 percent, by volume, of wood chips shall conform to the sizes specified.
- Wood chips produced from tree trimmings which contain leaves or small twigs will not be accepted.
- Tree bark shall have a particle size between $^1/_2$ inch and $1^1/_2$ inches and shall be free of salt and foreign materials such as clods, coarse objects, sticks, rocks, weeds or weed seeds.
- Shredded bark shall be a mixture of shredded bark and wood; shall have a particle size between $^1/_8$ inch and $1^1/_2$ inches in thickness and one inch to 8 inches in length; and shall be free of salt and deleterious materials such as clods, coarse objects and rocks. At least 75 percent, by volume, of shredded bark shall conform to the sizes specified.
- A Certificate of Compliance for mulch shall be furnished to the Engineer in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."

20-2.09 (BLANK)

20-2.10 SEED

- Seed required to be labeled under the California Food and Agricultural Code, shall be labeled by the vendors supplying the seed. Seed shall have been tested for purity and germination not more than 12 months prior to the application of the seed. The test results from seed testing shall be delivered to the Engineer prior to applying the seed. Seed labels furnished by the seed vendors supplying the seed shall indicate the purity, germination and pure live seed as determined by testing.
- Seed with a germination rate lower than the minimum rate specified may be used when approved by the Engineer in writing.
- Before seeding, the Contractor shall furnish written evidence (seed label or letter) to the Engineer that seed, not required to be labeled under the California Food and Agricultural Code, has been tested for purity and germination by a seed laboratory certified by the Association of Official Seed Analysts, or a seed technologist certified by the Society of Commercial Seed Technologists.
- The percentage of seed germination shall include the germination percentage of any hard and dormant seed.
- Seed specified without a germination requirement, at the time of sowing, shall be from the previous or current year's harvest, and shall be labeled to include the name, date (month and year) collected and the name and address of the seed supplier.

- All shipments of seed not accompanied by a valid California Nursery Stock Certificate shall be reported to the County Agricultural Commissioner at the point of destination for inspection and shall be held until released by the Commissioner.
- Seed treated with mercury compounds shall not be used.
- Legume seed shall be pellet-inoculated with a viable bacteria compatible for use with that species of seed. All inoculated seed shall be labeled to show the weight of seed, the date of inoculation and the weight and source of inoculant materials.
- Legume seed shall be pellet-inoculated in conformance with the requirements in Bulletin 1842, "Range-Legume Inoculation and Nitrogen Fixation by Root-Nodule Bacteria," of the University of California, Division of Agriculture and Natural Resources. Inoculant shall be added at the rate of 2 pounds of inoculant per 100 pounds of legume seed.
- Inoculated seed shall be sown within 90 days of inoculation.

20-2.11 STABILIZING EMULSION

- Stabilizing emulsion shall be a concentrated liquid chemical that forms a plastic film upon drying and allows water and air to penetrate.
- Stabilizing emulsion shall be nontoxic to plant or animal life and nonstaining to concrete or painted surfaces. In the cured state, the stabilizing emulsion shall not be re-emulsifiable. The material shall be registered with and licensed by the State of California, Department of Food and Agriculture, as an "auxiliary soil chemical."
- Stabilizing emulsion shall be miscible with water at the time of mixing and application.
- A Certificate of Compliance for stabilizing emulsion shall be furnished to the Engineer in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."

20-2.12 LUMBER

- Lumber shall be construction grade cedar, pressure treated Douglas fir, or heart redwood, rough cut, from sound timber, and shall be straight and free from loose or unsound knots, shakes in excess of one-third the thickness of the lumber, splits longer than the thickness of the lumber or other defect which would render the lumber unfit structurally for the purpose intended. Knots in all lumber shall be sound, tight, well spaced and shall not exceed 2 inches in size on any face. Sweep shall not exceed one inch in 6 feet.

20-2.13 PLANTS

- Plants shall be the variety and size shown on the plans or in the special provisions and shall conform to the provisions of these specifications.
- No plant shall be transported to the planting area that is not thoroughly wet throughout the ball of earth surrounding the roots. Any plant that, in the opinion of the Engineer, has a damaged root ball or is dry or in a wilted condition when delivered to the planting area will not be accepted, and shall be replaced by the Contractor at the Contractor's expense.
- Each plant shall be handled and packed in the approved manner for that species or variety, and all necessary precautions shall be taken to ensure that the plants will arrive at the site of the work in proper condition for successful growth. Trucks

used for transporting plants shall be equipped with covers to protect plants from windburn.

- All plants furnished by the Contractor shall be true to type or name as shown on the plans and shall be tagged identifying the plants by species or variety; however, determination of plant species or variety will be made by the Engineer and the Engineer's decision shall be final. Plants shall be individually tagged or tagged in groups by species or variety. Carpobrotus cuttings need not be tagged.
- All plants shall comply with Federal and State laws requiring inspection for plant diseases and infestations. Inspection certificates required by law shall accompany each shipment of plants, and certificates shall be delivered to the Engineer.
- The Contractor shall obtain clearance from the County Agricultural Commissioner, as required by law, before planting plants delivered from a source outside the County in which the plants are to be planted. Evidence that clearance has been obtained shall be filed with the Engineer.
- Plants furnished by the Contractor shall be healthy, shapely and well-rooted, and roots shall show no evidence of having been restricted or deformed at any time. Plants shall be well-grown, free from insect pests and disease, and shall be grown in nurseries which have been inspected by the State Department of Food and Agriculture and have complied with the regulations thereof.
- Root condition of plants furnished by the Contractor in containers will be determined by removal of earth from the roots of not less than 2 plants nor more than 2 percent of the total number of plants of each species or variety, except when container-grown plants are from several sources, the roots of not less than 2 plants of each species or variety from each source will be inspected by the Engineer. In case the sample plants inspected are found to be defective, including but not limited to, root bound or underdeveloped root ball, the State reserves the right to reject the entire lot or lots of plants represented by the defective samples. Plants rendered unsuitable for planting because of this inspection will be considered as samples and will not be paid for.
- The Contractor shall notify the Engineer when plants are to be shipped to the project site. The notification shall be given not less than 10 days prior to the actual shipment date.
- Carpobrotus cuttings shall be 10 inches or more in length and shall not be rooted. Delosperma cuttings shall be 6 inches or more in length and shall not be rooted. Cuttings shall be tip cuttings from healthy, vigorous and strong-growing plants, and shall be insect and disease free. Mature or brown-colored stem growths or cuttings which have been trimmed will not be accepted. Cuttings shall be planted not more than 2 days after cutting and shall not be allowed to dry or wither.
- Carpobrotus cuttings shall not be taken from any plants that indicate the presence of ice plant scale (Pulvinaria species).
- The Contractor shall notify the Engineer of the location where cuttings are to be taken at least 10 days prior to taking the cuttings and shall be responsible for all permit and inspection fees involved in obtaining cuttings.
- Carpobrotus and Delosperma cuttings, to the extent available, may be taken from existing plantings within the State highway right of way under permit if the

Contractor elects. The State makes no guarantee that there will be sufficient cuttings available from existing plantings on State highway right of way to complete the work. Information concerning areas from which the Contractor will be permitted to remove cuttings may be obtained at the office of the Permit Engineer of the district in which the work is situated.

20-2.13A Foliage Protector

- Foliage protectors shall be fabricated from one inch, hexagonal pattern, 20-gage mesh wire. Foliage protectors shall be approximately 4 feet high and 2 feet in diameter. Wire edges at the top of the cylinder shall be uncut (manufactured finished edge) and free of sharp points. Other wire edges that are cut shall be free of sharp points.
- The top of the cylinder shall be fastened as shown on the plans.
- Support stakes shall be 3/4 inch reinforcing steel bar a minimum of 5 feet long.

20-2.13B Root Protector

- Root protectors shall be fabricated from one inch, hexagonal pattern, 20-gage, mesh wire. The wire edge at the top of the cylinder shall be uncut (manufactured finished edge) and shall be free of sharp points. Galvanized mesh wire shall be treated in a chemical solution that will remove the galvanized material prior to installation.
- Root protectors shall be of a closed bottom design, and shall be of the height and diameter that will have a minimum 6 inches clearance between the root ball and the sides and bottom of the wire cylinder.

20-2.14 WATER

- Water shall be of such quality that it will promote germination of seeds and growth of plants.

20-2.15 PIPE

- Pipe and fittings for irrigation systems shall be as specified in these specifications and the special provisions.
- Unless otherwise shown on the plans, risers and threaded nipples for irrigation facilities shall be Schedule 80, PVC 1120 or PVC 1220, polyvinyl chloride (PVC) pipe conforming to the requirements in ASTM Designation: D 1785.

20-2.15A Steel Pipe

- Steel pipe and couplings and wrought iron couplings shall conform to the requirements in ASTM Designation: A 53, standard weight, galvanized, except that the zinc coating shall be not less than 90 percent of the amount specified in that ASTM Designation. Fittings, except couplings, shall be galvanized malleable iron, banded and threaded, conforming to the requirements in ANSI Standard: B16.3, Class 150.

20-2.15B Plastic Pipe

- Plastic pipe for irrigation systems will be shown on the plans as plastic pipe supply line and plastic pipe irrigation line.

20-2.15B(1) Plastic Pipe Supply Line

- Plastic pipe supply line shall be polyvinyl chloride (PVC) of the types and classifications shown on the plans or specified in the special provisions. Plastic pipe supply line shall be approved by the National Sanitation Foundation, and shall conform to the requirements in either ASTM Designation: D 2241 or D 2672, except that plastic pipe supply line with a bell socket formed as an integral part of the pipe for use with rubber ring gaskets shall conform to the requirements in ASTM Designation: D 2241. The belled portion of the pipe for use with rubber ring gaskets shall conform to the requirements in ASTM Designation: D 3139, except for the dimensional ratio, shall be formed to maintain uniformity in alignment and roundness and shall be free of irregularities and defects.
- The wall thickness of the bell shall be not less than the specified minimum wall thickness of the pipe or not less than the minimum thickness that will provide a joint assembly with a Hydrostatic Design Basis Category not lower than that of the Hydrostatic Design Basis Category of the pipe.
- For pipe with wall thickness of the bell less than the specified minimum wall thickness of the pipe the Contractor shall furnish to the Engineer the following:

  a. A Certificate of Compliance from the manufacturer of the pipe, conforming to the provisions in Section 6-1.07, "Certificates of Compliance," certifying that the joint assembly conforms to the requirements in ASTM Designation: D 3139.
  b. Detailed drawings of the joints, including all dimensions, along with certified copies of the tests performed to verify that the Hydrostatic Design Basis Category for the joint assembly is not lower than the Hydrostatic Design Basis Category of the pipe.
  c. Certified copies of the laboratory qualifying tests for the Internal Pressure Test and for the Vacuum Test.
  d. A minimum of 2 samples of each size and each Class of pipe, not less than 2 feet long, together with gaskets.

- Items b and c above may be submitted to the Transportation Laboratory on an annual basis or more often when required because of manufacturer's design changes. The Certificate of Compliance for pipe used on a specific project may refer to prior submittals, giving date of original submittal and any other information needed to identify the documents.
- The wall thickness of the bell end of the pipe may exceed maximum allowable wall thickness of the pipe for a length not to exceed 24 inches from the end of the pipe.
- Bell end pipe conforming to the requirements in ASTM Designation: D 2672 may be marked with either ASTM Designation: D 2672 or D 2241. Gasketed bell end pipe shall be marked in conformance with the requirements in ASTM Designation: D 2241.
- Plastic pipe supply line and fittings that are on the supply side of control valves and are 2 inches or larger in diameter shall be either the rubber ring gasket type or the solvent cemented type, except that all pipe and fittings installed in conduits

shall be the solvent cemented type. All other plastic pipe supply line and fittings shall be the solvent cemented type.

- Schedule 40 plastic pipe supply lines shall conform to the requirements in ASTM Designation D1785.
- Threaded fittings and fittings to be solvent cemented to plastic pipe supply line shall be injection molded PVC, Schedule 40, conforming to the requirements in ASTM Designation: D 2466.
- Fittings equipped with rubber ring gaskets for supply line shall be either injection molded PVC plastic pipe fittings, conforming to the requirements in ASTM Designation: D 2466 or D 3139, or machined pipestock fittings, conforming to the requirements in ASTM Designation: D 2241, with the exception in both applications of the dimensions and configurations of the barrel portion which receives the rubber ring. Rubber rings shall conform to the requirements in ASTM Designation: F 477.
- Solvent cement and primer for PVC plastic pipe and fittings for supply line shall be of commercial quality specifically manufactured for use with rigid PVC plastic pipe and fittings and shall be applied separately. Solvent cement shall conform to the requirements of the local Air Quality Management District. The solvent cement and primer used shall be made by the same manufacturer. The color of the primer shall contrast with the color of the pipe and fittings.

20-2.15B(2) Plastic Pipe Irrigation Line

- Plastic pipe irrigation line shall be polyethylene pipe conforming to the provisions in this Section 20-2.15B(2), as shown on the plans or as specified in the special provisions.
- Polyethylene pipe shall conform to the requirements in ASTM Designation: D 1248, Type I, Class C and shall withstand a 60-minute hydrostatic pressure of 50 psi when tested in conformance with the requirements in ASTM Designation: D 1598.
- Wall thicknesses of polyethylene pipe shall conform to the following when determined in conformance with the requirements in ASTM Designation: D 2122.

Pipe Size Nominal (Inch)	Minimum* (Inch)	Maximum* (Inch)	Range (Percent)
1/2	0.050	0.070	12
5/8	0.055	0.075	12
3/4	0.060	0.080	12

* as measured at any point on the cross section

- The polyethylene pipe shall provide leak-free, non-separating connections suitable for the purpose intended when connected to the fittings specified herein.
- Polyethylene pipe shall show no evidence of failure when tested by the following environmental test:

Environmental Stress Cracking Test - For each test, use 6 randomly selected 10-inch long specimens. Insert a 10 percent oversized barbed fitting into one end of each specimen. The barbed fitting shall have an outside

diameter which is 10 percent greater than the maximum outside barb diameter specified in Table 1 of ASTM Designation: D 2609 for the pipe size being tested. Place the specimens in a 10 percent "Igepal CO-630" solution at 122° F for a 24-hour period. After 24 hours, examine the specimens for failure.

- Utility grade polyethylene pipe will not be acceptable.
- A Certificate of Compliance for the polyethylene pipe shall be furnished to the Engineer in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."
- Fittings to be used with polyethylene pipe shall be the compression type, shall be of commercial quality, and shall be recommended by the manufacturer of the polyethylene pipe. Fittings shall have female sockets with an internal barb to provide a positive pipe-to-fitting connection that will not separate at the designed pressure.

20-2.16 CONDUIT

- Conduit for irrigation crossovers shall conform to the provisions in this Section 20-2.16.
- Conduit placed by jacking or drilling shall be welded steel pipe conforming to the requirements in ASTM Designation: A 53. Welded steel pipe shall be either black or galvanized pipe and shall have welded or threaded joints.
- The minimum wall thickness for the various sizes of welded steel pipe shall conform to the following:

Nominal Pipe Size (Inches)	Minimum Wall Thickness (Inch)
3	0.216
4	0.237
6 and larger	0.250

- Pipe with wall thickness greater than above specified may be required to withstand jacking or drilling operations. Additional wall thickness required shall be determined by the Contractor and shall be furnished at the Contractor's expense.
- Conduit placed in open trenches shall be corrugated high density polyethylene pipe (CHDPE), corrugated steel pipe, corrugated aluminum pipe or acrylonitrile-butadiene-styrene (ABS) composite pipe. The size and kind of conduit to be installed will be designated in the Engineer's Estimate or specified in the special provisions. When alternative conduit is designated in the Engineer's Estimate or specified in the special provisions, the kind of conduit to be installed shall be selected by the Contractor from the allowable kinds of alternative conduit specified in the special provisions.
- Corrugated high density polyethylene pipe shall conform to the requirements in ASTM Designation: F 667, or shall be Type S conforming to the requirements in AASHTO Designation: M 294. Couplings and fittings shall be as recommended by the pipe manufacturer.
- Corrugated steel pipe and corrugated aluminum pipe shall conform to the provisions in Section 66, "Corrugated Metal Pipe." The nominal thickness of metal

sheets for the pipe shall be 0.064-inch for corrugated steel pipe and 0.060-inch for corrugated aluminum pipe. Coupling bands and coupling band hardware for corrugated steel pipe and corrugated aluminum pipe shall conform to the provisions in Section 66.

- Acrylonitrile-butadiene-styrene (ABS) composite pipe and couplings shall conform to the requirements in ASTM Designation: D 2680. Couplings shall be Type SC (solvent cemented).

20-2.17 SPRINKLERS

- Sprinklers shall conform to the requirements in the special provisions and as shown on the plans.

20-2.18 EMITTERS

- Emitters shall conform to the requirements in the special provisions and as shown on the plans.

20-2.19 FLUSH VALVES

- Flush Valves shall be garden valves. Garden valves shall conform to the provisions in Section 20-2.22 "Garden Valves."

20-2.20 PLASTIC PIPE (LOCATOR)

- Plastic Pipe (locator) shall be Schedule 40 white polyvinyl chloride (PVC) pipe.

20-2.21 QUICK COUPLING VALVES

- Quick coupling valves shall be $^{3}/_{4}$ inch double slot type, with self-closing cap unless otherwise shown on the plans. Except for the cap, quick coupling valves shall be of brass or bronze construction.

20-2.22 GARDEN VALVES

- Garden valves shall be the inverted nose type of brass or bronze construction with female thread inlet, replaceable seat washer, rising valve stem within a protective collar, male thread hose outlet and furnished with a loose key (handle).

20-2.23 CONTROL VALVES

- Control valves shall be electric remote control or the manual type, straight or angle pattern globe valves, and shall be of glass filled nylon, brass, bronze, or cast iron construction as shown on the plans or specified in the special provisions. All metal parts of glass filled nylon valves shall be stainless steel or brass. Cast iron bodied valves shall have replaceable, nonferrous, metallic seats. Compression disks or diaphragms in valves shall be replaceable. Valves shall be of the same size as the pipeline which the valves serve, unless otherwise shown on the plans. Control valves shall be capable of withstanding a cold water working pressure of 150 psi. Valve handles shall be brass, bronze or steel.
- Electric remote control valves shall conform to the following:

  A. Valves shall be normally closed type.
  B. Valves shall be completely serviceable from the top without removing the valve body from the system.

C. Valves shall be equipped with a device that will regulate and adjust the flow of water and shall be provided with a manual shutoff. The manual shutoff for valves larger than 3/4 inch shall be operated by a cross handle.
D. Valves for each irrigation controller shall be the same model series and shall be compatible with the model series of the irrigation controller.
F. Valve solenoids shall operate on the low voltage AC current supplied from the irrigation controller.
G. Valves shall be provided with manual bleeding devices.
H. Valves shall be equipped with internal diaphragms installed in the valve body casting.
I. Valve inlets and outlets shall have threaded fittings.

20-2.24 VALVE BOXES

- Valve boxes and valve box covers shall be precast portland cement concrete, fiberglass or reinforced plastic and shall conform to the special provisions. Valve box covers shall be marked "WATER" in cast-in letters not less than one inch high.
- Valve boxes shall not have side openings.

20-2.25 BACKFLOW PREVENTERS

- Backflow preventers shall be one of the reduced pressure principle devices as specified in these specifications and the special provisions.
- Backflow preventers shall be factory assembled and shall include 2 check valves, one pressure differential relief valve, 2 shut-off valves and 4 test cocks. Backflow preventer and valves shall be the same size as the pipeline in which they are installed, unless otherwise shown on the plans.
- Backflow preventer shut-off valves shall be manufactured from iron or bronze and shall be either resilient wedged gate valves, resilient seated and fully ported ball valves, or resilient seated butterfly valves. Threaded type shut-off valves shall be provided with a union on one side of each valve. Unions shall be brass or malleable iron.

20-2.26 CONCRETE

- Concrete for irrigation facilities, unless otherwise specified, shall be produced from commercial quality aggregates and cement and shall contain not less than 463 pounds of cement per cubic yard. Hand mixing of the concrete will be permitted.

20-2.265 FILTER ASSEMBLY UNITS

- Filter assembly units shall conform to the requirements in the special provisions.

20-2.27 FLEXIBLE HOSE

- Flexible hose shall be nonrigid polyvinyl chloride (nonrigid PVC) hose conforming to the requirements in ASTM Designation: D 2287, Cell-type 6464500.
- Wall thicknesses of nonrigid PVC hose shall conform to the following when determined in conformance with the requirements in ASTM Designation: D 2122.

Hose Size Nominal (Inch)	Minimum Wall Thickness* (Inch)	Range (Percent)
1/2	0.147	12
3/4	0.154	12
1	0.179	12

* as measured at any point on the cross section

- The hose shall provide leak-free, non-separating connections suitable for the purpose intended when connected to the fittings specified herein.
- Fittings for flexible hose shall be injection molded PVC, Schedule 40, conforming to the requirements in ASTM Designation: D 2466. Fittings shall be solvent cemented type.
- Solvent cement for flexible hose and fittings shall be of commercial quality specifically manufactured for use with nonrigid PVC hose. Primer for flexible hose fittings shall be the same as specified for plastic pipe supply line fittings.

20-2.28 GATE VALVES

- Gate valves shall be either flanged, threaded or ring type, iron or bronze body, bronze trimmed valves with rising (internally threaded) or non-rising stem, and shall withstand a cold water working pressure of 150 psi. Gate valves shall be of the same size as the pipeline which the valves serve, unless otherwise shown on the plans.

20-2.29 UNIONS

- Unions shall be brass or malleable iron. Unions shall withstand the working pressure range provisions for the pipes with which the unions are used.

20-2.30 WYE STRAINERS

- Wye strainers shall have a cast iron or all-bronze body with a removable stainless steel or monel strainer. Wye strainers shall be capable of withstanding a cold water working pressure of 150 psi. Wye strainers at backflow preventer assemblies shall be equipped with a gate valve at the outlet. All other wye strainers shall be equipped with a garden valve at the outlet.
- The strainer screen for the wye strainer in a backflow preventer assembly shall have an open area equal to at least 3 times the cross-sectional area of the pipe based on an iron pipe size and shall be 20-mesh woven wire mesh or perforated sheet with 0.045-inch diameter holes.
- All other wye strainers shall be equipped with 40-mesh strainer screens.

20-2.31 ELECTRICAL EQUIPMENT AND MATERIALS

- All electrical equipment and materials shall conform to the provisions in Section 86-1.02, "Regulations and Code," and these specifications.

20-2.31A Irrigation Controllers

- Irrigation controllers shall conform to the provisions specified herein and the special provisions.
- Irrigation controllers (battery) shall operate on batteries of the type and size recommended by the manufacturer of the controllers. Other irrigation controllers

shall operate on 120-V, 60 Hz AC, and shall supply 24-V to 30-V, 60 Hz AC for operating electric remote control valves.

- Irrigation controllers shall be housed in pedestal or wall-mounted enclosures as designated in the Engineer's Estimate, or as specified in the special provisions or as shown on the plans.
- Irrigation controllers not installed in irrigation controller enclosure cabinets shall be weatherproof, shall be constructed of fiberglass or metal and shall have a door lock for which 2 keys shall be provided.

20-2.31B Electrical Conduit

- Electrical conduit shall conform to the provisions in Sections 86-2.05A, "Material," and 86-2.05B, "Use."

20-2.31C Pull Boxes

- Pull boxes shall be No. 5 or larger unless otherwise shown on the plans, and shall conform to the provisions in Section 86-2.06A, "Materials." Pull box covers for pull boxes used solely for electrical service shall be marked in conformance with the provisions in Section 86-2.06B, "Cover Marking." All other irrigation system pull box covers shall be marked "SPRINKLER CONTROL" in conformance with the provisions in Section 86-2.06B.

20-2.31D Conductors

- Conductors shall conform to the provisions in Section 86-2.08, "Conductors," and the provisions specified herein.
- Conductors for operation below 50-V shall be rated for direct burial and shall be the underground feeder type identified as (UF) with a minimum thickness of polyvinyl chloride insulation of 56 mils for conductors No. 10 and smaller and 70 mils for conductors No. 8 and larger.

20-2.31E Electric Remote Control Valves

- Electric remote control valves shall conform to the provisions in Section 20-2.23, "Control Valves," and the provisions in the special provisions.

20-2.32 PRIMERS AND PAINTS

- Primers and paints for application on metal and wood surfaces shall be the best quality grade of the type specified in the special provisions and shall be manufactured by a recognized paint manufacturer. Thinners and coloring tints shall conform to the paint manufacturer's recommendations. Coatings shall not be thinned except as recommended by the paint manufacturer for application. Each application of paint shall be compatible with the previous application and shall be from paint made by the same manufacturer. Testing of primers and paints will not be required.

20-3 EROSION CONTROL

20-3.01 DESCRIPTION

- This work shall consist of furnishing and applying erosion control materials, including preparing areas to receive erosion control materials, placing topsoil, applying and incorporating straw and applying fertilizer, seed, fiber, stabilizing

emulsion and other materials to the areas shown on the plans, as specified in these specifications and the special provisions.

20-3.015 MATERIALS

- Materials shall conform to the provisions in Section 20-2, "Materials."

20-3.02 PREPARATION

- Preparation shall include all the work required to make ready the areas for application of topsoil and erosion control materials. Loose rocks larger than $2^1/_2$ inches in maximum dimension and debris shall be removed and disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13, unless otherwise permitted by the Engineer.
- Topsoil shall be spread uniformly at the rate specified in the special provisions or shown on the plans. The finished surface after spreading topsoil shall be approximately one inch below the top of adjacent curbs or pavement.
- Topsoil shall not be placed until all equipment, except equipment required for spreading topsoil, is through working in an area.

20-3.03 APPLYING AND INCORPORATING STRAW

- Straw shall be uniformly spread at the rate specified in the special provisions.
- When weather conditions are suitable, straw may be pneumatically applied by means of equipment which will not render the straw unsuitable for incorporation into the soil.
- Straw shall be incorporated into the soil with a roller equipped with straight studs, made of approximately $^7/_8$ inch steel plate, placed approximately 8 inches apart and staggered. The studs shall not be less than 6 inches long nor more than 6 inches wide and shall be rounded to prevent withdrawing the straw from the soil. The roller shall be of such weight as to incorporate the straw sufficiently into the soil so that the straw will not support combustion, and will leave a uniform surface.

20-3.04 SEEDING AND FERTILIZING

- Seeding and fertilizing shall conform to the following provisions.

20-3.04A General

- Seed and commercial fertilizer shall be uniformly spread over the area at the rates specified in the special provisions.
- Unless otherwise specified in the special provisions, seed shall be either applied mechanically in a dry condition or with hydro-seeding equipment, at the Contractor's option. If the Contractor elects to hydro-seed, a minimum of 525 pounds of fiber per acre shall be mixed and applied with the seed, and fertilizer (if required) may be mixed with the seed and fiber and applied in the hydro-seeding operation. The fiber shall be furnished and applied at the Contractor's expense and shall be in addition to incorporating straw when an application or applications of straw are specified.
- The application rate for pellet-inoculated seed shall be determined using the seed weight exclusive of inoculant materials.

20-3.04B Hydro-Seeding

- Hydro-seeding shall consist of mixing and applying seed, commercial fertilizer, stabilizing emulsion and other materials, or any combination thereof, with fiber and water.
- The materials and the quantities thereof to be mixed with water will be specified in the special provisions. The quantity of water shall be as needed for application, except that when stabilizing emulsion is specified, the ratio of total water to total stabilizing emulsion in the mixture shall be as recommended by the manufacturer of the emulsion.
- Mixing of materials for application with hydro-seeding equipment shall be performed in a tank with a built-in continuous agitation system of sufficient operating capacity to produce a homogeneous mixture and a discharge system which will apply the mixture at a continuous and uniform rate. The tank shall have a minimum capacity of 1,000 gallons. The Engineer may authorize use of equipment of smaller capacity if it is demonstrated that the equipment is capable of performing all operations satisfactorily.
- A dispersing agent may be added to the mixture provided the Contractor furnishes evidence that the additive is not harmful. Any material considered harmful, as determined by the Engineer, shall not be used.
- Any mixture containing stabilizing emulsion shall not be applied during rainy weather or when soil temperatures are below 40° F. Pedestrians or equipment shall not be permitted to enter areas where mixtures containing stabilizing emulsion have been applied.

20-3.05 (BLANK)

20-3.06 MEASUREMENT

- Topsoil obtained from within the project limits will be considered as selected material and will be measured and paid for in conformance with the provisions in Section 19-2.07, "Selected Material."
- Imported topsoil will be measured by the ton or cubic yard, and quantities of fiber and straw will be measured by the pound or ton, determined in conformance with the provisions in Section 9-1.01, "Measurement of Quantities." When paid for by the cubic yard, imported topsoil will be measured in the vehicle at the point of delivery.
- Stabilizing emulsion will be measured by the pound or ton as the weight of solids applied. The weight of solids per gallon of stabilizing emulsion will be determined by multiplying the percent of solids in the emulsion by the weight per gallon of the emulsion. The percent of solids and the weight per gallon of the emulsion will be determined by California Test 402, in the same manner as provided for determining the percent of nonvolatile content and the weight per gallon of paint.
- Commercial fertilizer will be measured by the pound or ton, determined from marked weight and sack count.
- Pure live seed will be measured by the pound, determined by multiplying the percentage of purity by the percentage of germination by the bulk weight of the seed.

20-3.07 PAYMENT

- Items of work, measured in conformance with the provisions in Section 20-3.06, "Measurement," and Section 9-1.01, "Measurement of Quantities," will be paid for at the contract prices per ton or cubic yard for imported topsoil, and per pound or ton for straw, commercial fertilizer, pure live seed, fiber and stabilizing emulsion.
- Full compensation for temporarily placing topsoil along the tops of the slopes and later spreading the topsoil over the prepared slopes shall be considered as included in the contract price paid per cubic yard for roadway excavation or the contract price paid for imported topsoil or erosion control, as the case may be, and the material will not be considered as stockpiled within the meaning of Section 19-2.07, "Selected Material."
- Full compensation for removing and disposing of rocks and debris from embankments constructed as part of the work shall be considered as included in the contract prices paid for the various items of earthwork involved and no additional compensation will be allowed therefor.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all erosion control work, complete in place, including applying water, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

20-4 HIGHWAY PLANTING

20-4.01 DESCRIPTION

- This work shall consist of furnishing highway planting materials, clearing planting areas, preparing planting areas, planting plants, establishing plants and maintaining existing plants as shown on the plans and as specified in these specifications and the special provisions.

20-4.02 MATERIALS

- Materials shall conform to the provisions in Section 20-2, "Materials."

20-4.025 ROADSIDE CLEARING

- Roadside clearing shall consist of removing trash and debris, removing and controlling weeds, and removing existing plants as specified in these specifications and the special provisions.
- Roadside clearing shall be performed in those areas specified in the special provisions or shown on the plans.
- At the time of planting, each area to be planted shall be free of trash and debris.
- Existing trees and shrubs, where specified in the special provisions or designated on the plans to be removed, shall be removed. Removal of existing trees and shrubs shall include removing their stumps and roots 2 inches or larger in diameter to a minimum depth of 12 inches below finished grade. Holes resulting from stump removal shall be backfilled to finished grade with material obtained from adjacent areas.

- Weeds shall be controlled by killing or by mowing as specified in the special provisions. Killing weeds shall be performed by hand, by the use of pesticides or by other methods approved by the Engineer.
- Trash and debris shall be disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13.

20-4.026 PESTICIDES

- Unless prohibited by the County Agricultural Commissioner, pesticides may be used for highway planting work. If the Contractor elects to use pesticides, such usage shall conform to the requirements of the California Food and Agricultural Code, these specifications and the special provisions.
- The pesticides used to control weeds shall be limited to those specified in the special provisions.
- Oil and granular or pelleted forms of pesticides for weed control shall not be used.
- Attention is directed to Section 7-1.01H, "Use of Pesticides."
- The Contractor shall obtain recommendations for the use of all pesticides from a licensed Pest Control Adviser in conformance with the requirements of the California Food and Agricultural Code. At least 15 days prior to using any pesticides, a copy of the recommendations shall be submitted to the Engineer for approval. The recommendations shall include, but not be limited to, the pesticides to be used, rates of application, methods of application and areas to which pesticides are to be applied.
- Before using any pesticides, the Contractor shall obtain the Engineer's written approval of the Pest Control Adviser's recommendations.
- When used, pesticides shall be used in conformance with the approved Pest Control Adviser's recommendations.
- The Contractor shall notify the Engineer at least 24 hours prior to each application of pesticide and shall indicate the hours of application. No application of pesticides shall be made on Saturdays, Sundays or legal holidays, unless otherwise approved by the Engineer in writing.
- Pesticides shall be mixed in conformance with the instructions provided on the applicable registered label. Prior to mixing any pesticide, a copy of the registered label for the pesticide to be mixed shall be given to the Engineer or, when the copy is unavailable, the Engineer shall be permitted to read the label on the container.
- Pesticides for weed control shall be applied with a photosensitive dye which will produce a contrasting color when sprayed upon the ground. The color shall disappear between 2 and 3 days after being applied. The dye shall not stain any surfaces nor injure plant or animal life, when applied at the manufacturer's recommended application rate.
- Pesticides shall not be applied when weather conditions, including wind conditions, are unsuitable for application work.
- Any new or existing plants and soil which, in the opinion of the Engineer, have been damaged by the application of pesticides shall be replaced by the Contractor at the Contractor's expense.

- At the end of each work week, a written report of that week's applications of all pesticides shall be submitted to the Engineer on forms furnished by the Department.

20-4.03 PREPARING PLANTING AREAS

- Preparing planting areas shall consist of preparing holes, preparing trenches, cultivating, germinating weeds, constructing basins and doing any other work necessary to prepare areas for planting, except roadside clearing work, as specified in these specifications and the special provisions and as shown on the plans. Constructing basins shall be considered as part of the work involved in preparing holes and trenches.
- Unless otherwise specified, a planting or planted area shall be any area in which the Contractor is required to do planting work.
- The Engineer will designate the ground location of all plants by directing the placing of the plants or by directing the placing of stakes or other suitable markers. The Contractor shall furnish all labor, materials and transportation required to adequately indicate the various plant locations.
- The work involved in preparing planting areas shall be so conducted that the existing flow line in drainage ditches will be maintained. Material displaced by the Contractor's operations which interferes with drainage shall be removed and disposed of as directed by the Engineer.
- Unless larger planting holes are specified in the special provisions or shown on the plans, plants shall be planted in holes large enough to receive the root ball, backfill, amendments and fertilizer. Where rock or other hard material prohibits holes from being excavated to the depth specified, new holes shall be excavated and the abandoned holes shall be filled with the excavated material.
- Planting holes may be excavated by hand digging or by drilling. Water shall not be used for the excavation of planting holes.
- At the locations shown on the plans, longitudinal basins shall be formed by constructing a continuous dike on each side of the planting line. Cross checks shall be formed to pond irrigation water around each plant.
- The planting areas to be cultivated will be designated in the special provisions or shown on the plans. The outer limits of the areas to be cultivated shall extend 12 inches beyond the outer rows of plants requiring cultivation, unless otherwise specified or shown on the plans.
- Cultivation shall be performed until the soil is in a loose condition to a minimum depth of 6 inches. Soil clods shall not be larger than 2 inches in any dimension after cultivation.
- The use of rubber-tired equipment will be permitted for cultivating operations, provided the equipment used completely eradicates any compaction caused by the tires. Rubber-tired equipment of any kind will not be allowed on cultivated areas after cultivation.
- Planting areas that have been cultivated and become compacted for any reason shall be recultivated by the Contractor at the Contractor's expense.
- Rocks and other debris encountered during soil preparation in planting areas shall be brought to the surface of the ground at the Contractor's expense. Removing and disposing of the rocks and debris will be paid for as extra work as

provided in Section 4-1.03D. The size of rocks and the quantity of rocks and debris to be disposed of will be determined by the Engineer.

- Pavement, sidewalk and similar paved areas encountered on or beneath the surface of the ground and not shown on the plans in areas to be prepared for planting, and if ordered by the Engineer, shall be removed and disposed of as directed by the Engineer. Excavating through these paved areas, furnishing and placing topsoil to fill these holes, and removing and disposing of all this pavement will be paid for as extra work as provided in Section 4-1.03D.
- Existing pavement shown on the plans where planting holes or trenches are to be excavated, or where cultivation is to be done, shall be removed and, unless otherwise permitted by the Engineer, disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13.

20-4.04 HEADER BOARDS

- Header boards shall conform to the provisions in Section 20-2.12, "Lumber," and be constructed as shown on the plans.
- Header board stakes shall be of the size and shape shown on the plans. Each stake shall be driven flush with the top edge of the header board and the stake top shall be beveled away from the header board on a 45-degree angle. Stakes shall be attached to header boards with a minimum of two 12-penny hot-dip galvanized common nails per stake.
- Where asphalt concrete or portland cement concrete surfacing must be removed to permit the installation of header boards, and no joint exists between the surfacing to be removed and surfacing to remain in place, the surfacing shall be cut in a neat line to a minimum depth of 2 inches with a power driven saw before the surfacing is removed.

20-4.05 PLANTING

- Planting work shall consist of planting plants, applying fertilizer, iron sulfate and mulch and staking plants as specified in this Section 20-4.05 and the special provisions.
- No planting shall be done in any area until the area concerned has been prepared in conformance with these specifications and the special provisions and presents a neat and uniform appearance satisfactory to the Engineer. When an irrigation system is required, the irrigation system shall be installed and checked for coverage to the satisfaction of the Engineer prior to planting plants.
- Nursery stakes in plant containers stored at the project site shall be removed before transporting the plants to the planting areas, unless otherwise directed by the Engineer.
- Plant locations for trees and shrubs shall be adjusted so that no plant is closer than 8 feet to an impact, rotary, gear driven or pop-up type sprinkler.
- Where shrubs are shown on the plans to be planted in groups, the outer rows shall be parallel to the nearest roadway or right of way fence. Shrubs in adjacent rows shall be staggered. Adjustment in the number or alignment of plants shall be made between the outer rows.
- Where vines are to be planted against walls or fences, the vines shall be planted as close as possible to the wall or fence as shown on the plans.

- No more plants shall be distributed along the roadside on any day than can be planted and watered on that day.
- Plants shall be removed from their containers in such a manner that the ball of earth surrounding the roots is not broken. Plants shall be planted and watered as hereinafter specified immediately after removal from their containers. Plant containers shall not be cut prior to delivery of the plants to the planting area.
- Roots of plants not in containers shall be kept moist and covered until the plants are planted.
- Root protectors shall be installed at the time the plant holes are prepared in conformance with the details shown on the plans and these specifications. Root protectors shall be placed in the plant holes with approximately 3 inches of the wire cylinder extending above finished grade.
- Before planting in holes or trenches, water shall be applied to the backfill with a pipe or tube inserted to the bottom of the hole or trench until the backfill material is saturated for the full depth.
- Plants shall be set in the backfill material in flat bottomed holes, to such a depth that, after the backfill has settled, the soil shall be even with the top of the root ball as shown on the plans. If the backfill material settles below the top of the root ball after planting and watering, additional soil shall be added to bring the backfill even with the top of the root ball as shown on the plans.
- Plants shall be planted in such a manner that the roots are not restricted or distorted. Encircling roots shall be removed.
- Any plants which have settled deeper than as shown on the plans shall be raised back to the required level, or replaced, at the option of the Contractor.
- Planting done in soil that is too wet or too dry or not properly conditioned, as provided in these specifications, or in a condition not generally accepted as satisfactory for planting from an agricultural standpoint will not be accepted. No payment will be made for this planting and any further planting work will be suspended until the Contractor has complied in every way with the specifications.
- Ground cover plants in areas with an irrigation system shall be planted in blocks which conform to the design of the irrigation system. Each ground cover planting area covered by one control valve shall be completely planted and watered before planting other ground cover planting areas with ground cover plants.
- Ground cover plants shall be planted in moist soil and in neat, straight rows parallel to the nearest roadway. Plants in adjacent rows shall be staggered. Ground cover plants shall not be planted closer than 5 feet to trees or shrubs, nor closer than $6^1/_2$ feet to curbs, dikes, paved areas, walls and fences, unless otherwise shown on the plans or specified in the special provisions.
- Carpobrotus cuttings shall be planted to such depth that not less than 2 nodes are covered with soil. The basal end of Delosperma cuttings shall be not less than 2 inches below the surface of the soil and the basal end of Carpobrotus cuttings shall be not less than 4 inches below the surface of the soil.
- A root stimulant solution shall be applied to Delosperma cuttings prior to planting. The solution shall be applied by spraying or dipping the ends to be rooted in conformance with the printed instructions of the root stimulant manufacturer. A

copy of the instructions shall be furnished to the Engineer prior to applying the stimulant.

- No Carpobrotus or Delosperma cuttings shall be planted in soil that does not contain sufficient moisture at an average depth of 2 inches below the surface.
- Trees, shrubs and vines, to be planted in ground cover areas, shall be planted before ground cover plants or cuttings are planted.
- Commercial fertilizer and iron sulfate shall be applied or placed at the time of planting and at the rates and amounts shown on the plans.
- When iron sulfate is required by the special provisions or plans, the iron sulfate shall be evenly distributed within the plant basin and mixed into the plant soil a minimum depth of 2 inches.
- Commercial fertilizer (pelleted and granular) required during planting by the special provisions or plans, shall be mixed into the plant hole soil a minimum depth of 2 inches near the root ball.
- Commercial fertilizer (tablet) required by the special provisions or plans, shall be placed approximately half the depth of the root ball.
- Commercial fertilizer required during planting by the special provisions or plans, shall be applied to ground cover plants planted from cuttings or flats immediately after planting, and watered into the soil.
- Mulch shall be applied at the rate shown on the plans or specified in the special provisions and placed in the plant basins or spread in areas as shown on the plans after the plants have been planted. Mulch placed in plant basins shall not come in contact with the plant crown and stem.
- Plants shall be watered in conformance with the provisions in Section 20-4.06, "Watering."
- Vines planted next to fences shall be tied to the fences with tree tie material at the time of planting. Vines planted next to walls shall be staked and tied thereto as shown on the plans, at the time of planting.
- Foliage protectors shall be installed over the plants within 2 days after the plants have been planted in conformance with the details shown on the plans and these specifications.
- Support stakes for foliage protectors shall be installed vertically a minimum of 12 inches deep on opposite sides of the plant in a direction transverse to the prevailing winds. Support stakes shall be either woven through the wire cylinder mesh or fastened to the wire cylinder at 6 inches maximum centers. If the support stakes are woven through the wire cylinder mesh, the support stakes shall be woven in such a manner that holds the wire cylinder against the support stakes at 6-inch maximum centers. The cylinder shall be snug on the support stakes, yet loose enough to be raised for application of pesticides or to perform weeding within the plant basin.
- Foliage protectors shall be installed vertically and centered over the plant. When foliage protectors are not installed in plant basins, the bottom of the cylinder shall be cut to match the slope of the ground. Cuts shall be free from sharp points. Sharp points of wire shall be bent-over or blunted.
- Plants to be staked shall be staked at the time of planting as shown on the plans or specified in the special provisions. Two plant stakes shall be installed on

opposite sides of the plant in a transverse direction to the prevailing wind against but not through the root ball of the plant to a minimum depth of 18 inches below finished grade, unless otherwise directed by the Engineer.

- Plant stakes installed at trees and shrubs shall be of sufficient lengths to support each plant in an upright position. Plant stakes shall be either 2-inch nominal diameter round stakes or 2-inch x 2-inch nominal size square stakes, at the Contractor's option. The cross-sectional dimensions of the plant stakes may be reduced if the strength and durability of the smaller dimensioned stake is not less than a corresponding 2-inch redwood stake as determined by the Engineer. In no case shall stakes have a cross-section dimension of less than $1^1/_4$-inches, unless otherwise shown on the plans.
- After installation of plant stakes, the height of each stake shall be a maximum of 2 inches above the tree tie.
- Each plant requiring stakes shall be tied with one tie to each stake. The ties shall be installed at the lowest position which will support the plant in an upright position. Ties should provide trunk flexibility but not allow the trunk to rub against the stakes. Ties shall be extruded vinyl-base tape, one inch wide and a minimum of 10 mils thick. Each tie shall form a figure eight by crossing the tie between the plant and stake, and the figure eight shall be formed twice. Each end of the tie then shall be wrapped one and one-half turns around the stake and securely tied. Other materials and methods approved by the Engineer may be used for ties.
- From the time plants are planted until the beginning of the plant establishment period, damage caused by erosion shall be repaired in conformance with the provisions in Section 7-1.16, "Contractor's Responsibility for the Work and Materials;" plants shall be watered in conformance with the provisions in Section 20-4.06, "Watering;" unsuitable plants shall be replaced as provided in Section 20-4.07, "Replacement;" and trash and debris shall be removed and weeds shall be controlled in conformance with the provisions in Section 20-4.025, "Roadside Clearing."
- In addition to other provisions, planted areas shall be neat and clean before the Contractor is allowed to begin the plant establishment period.

20-4.055 PRUNING

- Pruning of plants shall be consistent with American National Standards Institute (ANSI) A300-1995, "Tree, Shrub and Other Woody Plant Maintenance-Standard Practices," and "Tree-Pruning Guidelines," published by the International Society of Arboriculture (ISBN 1-881956-07-5).

20-4.06 WATERING

- If water is available from an irrigation system to be installed under the contract or an existing State-owned facility within the limits of the project, water for highway planting work may be obtained from these facilities free of charge. Where water is not available from these facilities, the Contractor shall make the arrangements for furnishing and applying water and shall pay all costs involved.
- Existing plants within the limits of a project, designated to be maintained by the Contractor, shall be watered in conformance with the provisions specified herein for watering new plants.

- Trees, shrubs and vines shall be watered immediately after planting. Water shall be applied until the backfill soil around and below the roots or ball of earth around the roots of each plant is thoroughly saturated. Where watering is done with a hose, a water disbursement device or pressure reducing device approved by the Engineer shall be used. Under no circumstances shall the full force of the water from the open end of a hose be allowed to fall within the basin around any plant.
- Ground cover plants in areas provided with an irrigation system shall be watered by sprinklers. Several consecutive waterings may be necessary to thoroughly saturate the soil around each plant.
- Water shall be applied to plants as often and in sufficient amount as conditions may require to keep the plants in a healthy, growing condition during the life of the contract.
- Remote control valves shown as remote control valves (master) or gate valves on the discharge side of backflow preventers shall be kept closed at all times, except while the irrigation system is actually in use.
- Precautions shall be taken to prevent water from wetting vehicles, pedestrians, and pavement. Any erosion or slippage of the soil caused by watering shall be repaired by the Contractor at the Contractor's expense.
- Compliance with the provisions in this Section 20-4.06 shall not relieve the Contractor of the responsibility for the replacement of plants in conformance with the provisions in Section 20-4.07, "Replacement." Any additional watering measures required to maintain the plants in a healthy, growing condition shall be furnished by the Contractor at the Contractor's expense.

20-4.07 REPLACEMENT

- Plants that show signs of failure to grow at any time, or which are so injured or damaged as to render them unsuitable for the purpose intended, as determined by the Engineer, shall be removed and replaced. Unless otherwise permitted by the Engineer, the Contractor shall complete replacement of unsuitable plants within 2 weeks after the Engineer marks or otherwise indicates that the plants shall be replaced.
- Replacement planting shall conform to the original spacing and size provisions specified for the plants being replaced.
- Replacement ground cover plants shall be the same species as specified for the ground cover being replaced. Other replacement plants shall be either the same species as the plants being replaced, or the Contractor and Engineer may agree to the substitution of alternative species of plants to be used as replacements in conformance with the provisions in this Section 20-4.07.
- Replacement plants shall be furnished and planted by the Contractor at the Contractor's expense. At the option of the Contractor, plants of a larger container size than those originally specified may be used for replacement plants during the plant establishment period. The use of plants of a larger container size than those originally specified for replacement plants shall be at the Contractor's expense.

20-4.08 PLANT ESTABLISHMENT WORK

- Plant establishment work shall consist of caring for the highway planting as specified in this Section 20-4.08 and in the special provisions.

- The Engineer will notify the Contractor in writing of the start of the following plant establishment periods and will furnish statements regarding days credited to the plant establishment work after the notification:

  A. Type 1 plant establishment period shall be the number of working days specified for plant establishment in the special provisions and shall begin after all work has been completed, except plant establishment work and other items of work specified to be performed for the life of the contract.
  B. Type 2 plant establishment period shall be the time between completion of all planting work (except plant establishment work and other items of work specified to be performed for the life of the contract) and acceptance of the contract, provided however, that the contract will not be accepted unless the plant establishment work has been satisfactorily performed for at least the number of working days specified for plant establishment in the special provisions.
     If relief from maintenance and responsibility is granted for a completed portion of the work, in conformance with the provisions in Section 7-1.15, "Relief From Maintenance and Responsibility," Type 2 plant establishment period for the completed portion shall be the time between completion of all planting work (except plant establishment work) and the granting of relief from maintenance and responsibility, provided however, that the relief will not be granted unless the plant establishment work in the completed portion of the work has been satisfactorily performed for at least the number of working days specified for plant establishment in the special provisions.

- The time required for plant establishment work shall be considered as included in the total time limit specified for the contract.
- The Contractor will be required to adequately water plants; replace unsuitable plants; do weed, rodent and other pest control; and perform other work, as determined necessary by the Engineer, every working day during the plant establishment period.
- During the plant establishment period, damage caused by erosion shall be repaired in conformance with the provisions in Section 7-1.16, "Contractor's Responsibility for the Work and Materials."
- Working days upon which no work will be required, as determined by the Engineer, will be credited as one of the plant establishment working days, regardless of whether or not the Contractor performs plant establishment work.
- Working days when the Contractor fails to adequately perform plant establishment work, including but not limited to watering plants, replacing unsuitable plants, repairing erosion damage, removing and disposing of trash and debris and doing weed, rodent and other pest control, determined to be necessary by the Engineer, will not be credited as plant establishment working days.
- When ground cover plant growth extends onto sidewalks, curbs, or dikes, all ground cover plant growth within 2 feet of the sidewalk, curb or dike shall be

removed. Ground cover plant growth within 2 feet of shoulders, walls or fences shall be removed.

- Ground cover also shall be kept removed from within the basins, including the basin walls, and from planting areas within header boards.
- Commercial fertilizer shall be applied to trees, shrubs, vines and ground cover areas as specified in the special provisions and shall be watered into the soil after each application. The Contractor shall notify the Engineer at least 5 days prior to applying each application of commercial fertilizer.
- Basins and basin walls shall be kept well formed and free of weeds.
- Plants shall be kept watered in conformance with the provisions in Section 20-4.06, "Watering," and unsuitable plants shall be replaced in conformance with the provisions in Section 20-4.07, "Replacement."
- During the plant establishment period, electric automatic irrigation systems shall be operated in the automatic mode, unless otherwise permitted by the Engineer. When any electric automatic irrigation component is operated manually on a working day, the day will not be credited as a plant establishment working day unless such manual operation has been permitted in writing by the Engineer.
- As part of the plant establishment work, 30 days prior to completion of the plant establishment period, instructions shall be given to the Engineer by a qualified person from the Contractor's personnel on the use and adjustment of the irrigation controllers installed.
- Vines next to walls and fences shall be kept staked and tied in conformance with the provisions in Section 20-4.05, "Planting."
- Weeds in all roadside clearing and planting areas as designated in the special provisions or shown on the plans shall be controlled as specified in the special provisions and as directed by the Engineer.
- Where pesticides are used to control weeds in conformance with the provisions in Section 20-4.026, "Pesticides," weeds shall be killed before they exceed 2 inches in length.
- Where weeds are to be mowed as specified in the special provisions, they shall be mowed as close to the ground as possible before they exceed 6 inches in length.
- Where weeds are to be pulled by hand as specified in the special provisions, they shall be pulled before they exceed 4 inches in length and disposed of outside the highway right of way, in conformance with the provisions in Section 7-1.13, on the same day in which they are pulled.
- Dead weed growth which, in the opinion of the Engineer, will interfere with subsequent plant establishment or become unsightly shall be removed and disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13.
- Weed control, as specified in this Section 20-4.08, shall be performed as often as required to maintain the project in a neat and uniform condition at all times.
- Surplus earth, papers, trash and debris, which accumulate in the roadside clearing and planting areas as designated in the special provisions shall be removed and disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13. The areas shall be so cared for as to present a neat and clean condition at all times.

- During the plant establishment period, trees, shrubs, vines and ground cover plants, planted as part of the contract, shall be pruned or headed back by the Contractor at the Contractor's expense, when and as directed by the Engineer.
- When the Engineer determines that the plant stakes are inadequate to support the plants during the plant establishment period, the plant stakes shall be replaced, at the Contractor's expense, with a larger diameter stake adequate to support the plant. Plant stakes shall be removed at any time during the plant establishment period when determined by the Engineer.
- A watering schedule program for each irrigation controller shall be submitted to the Engineer for approval not less than 40 working days prior to the completion of the plant establishment period. If the Engineer determines that the submitted watering schedule is unacceptable, a revised watering schedule shall be submitted to the Engineer for approval within 5 working days after receiving notice that the previously submitted schedule is unacceptable.
- Written instructions on the use and adjustment of the installed irrigation controllers shall be given to the Engineer during the plant establishment period. The approved watering schedule program shall be implemented by the Contractor not less than 10 working days prior to the completion of the plant establishment period. The programming shall not relieve the Contractor of the responsibility to apply sufficient water as conditions may require to keep the plants in a healthy condition.
- In order to carry out the plant establishment work, the Contractor shall furnish sufficient personnel and adequate equipment to perform the work during the plant establishment period.

20-4.09 MEASUREMENT

- The work performed under these specifications will be measured by the unit designated in the contract item, and unless otherwise provided, will be determined as units from actual count or measurement of the items in place in the completed work.
- Items to be paid for by the square yard will be calculated on the basis of actual or computed slope measurements.
- Quantities of cultivation to be paid for by the square yard will be calculated on the basis of the area shown on the plans to be planted with plants requiring cultivation as specified in the special provisions, plus the area 12 inches beyond the outer row of the plants in each area. Planting areas for plants within cultivation areas that do not require cultivation will not be deducted from the cultivation area to be paid for.
- Quantities of imported topsoil to be paid for by the ton or cubic yard will be determined in conformance with the provisions in Section 9-1.01, "Measurement of Quantities." When paid for by the cubic yard, imported topsoil will be measured in the vehicle at the point of delivery.
- Quantities of granular and slow release commercial fertilizer and iron sulfate to be paid for by the pound or ton will be determined from marked weight and sack count.
- Quantities of commercial fertilizer tablets to be paid for will be measured by the tablet.

- Quantities of soil amendment and mulch to be paid for by the cubic yard will be determined in conformance with the provisions in Section 9-1.01, "Measurement of Quantities," and will be measured in the vehicle at the point of delivery.
- Quantity of header boards to be paid for will be measured by the linear foot as determined from the actual length of the header boards in the finished work.
- Quantities of the various sizes and types of plants to be paid for by the unit will be determined, at the option of the Engineer, either by the product of the average plant density and the total area planted, or by actual count of the living plants in place. The average plant density will be the number of living plants per square yard, as determined by actual count of test areas chosen as representative of the total planted area. The size and location of the test areas shall be determined by the Engineer by consultation with the Contractor, except that the total area tested shall be equal to not less than 3 percent nor more than 5 percent of the planted area being determined. In case of disagreement, the Engineer will make the final determination of areas to be tested.

20-4.10 PAYMENT

- When the contract includes separate items and unit or lump sum prices for performing highway planting, the quantities will be paid for at the contract unit or lump sum price or prices for the item of work involved and identified.
- The contract lump sum price paid for plant establishment work shall include full compensation for furnishing all labor, materials (including pesticides, commercial fertilizer and replacement plants), tools, equipment, and incidentals, and for doing all the work involved in establishing plants, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract lump sum price paid for maintain existing plants shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in maintaining existing plants, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- All other highway planting work will be paid for at a single contract lump sum price for highway planting, or at the contract lump sum or item prices for separate items of roadside clearing, imported topsoil, prepare hole, prepare trench, cultivate, iron sulfate, soil amendment, mulch, header board, commercial fertilizer, root protector, foliage protector, and plant (of the group indicated). The item or items to be paid for and the unit of measure will be designated in the Engineer's Estimate.
- Full compensation for preparing planting areas in conformance with the provisions in Section 20-4.03, "Preparing Planting Areas," except as otherwise provided, shall be considered as included in the prices paid for the various contract items of work involved in planting and no additional compensation will be allowed therefor.
- The above prices and payments shall include full compensation for furnishing all labor, materials (including pesticides and replacement plants), tools, equipment, and incidentals, and for doing all the work involved in highway planting, complete in place, including watering, removing and disposing of trash, debris and weeds, and removing and disposing of existing pavement shown on the plans where

planting holes or trenches are to be excavated, and excavation and backfill for setting header boards, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

20-5 IRRIGATION SYSTEMS

20-5.01 DESCRIPTION

- This work shall consist of furnishing and installing manual and automatic irrigation systems as shown on the plans and in conformance with these specifications and the special provisions.

20-5.02 MATERIALS

- Materials shall be commercial quality unless otherwise specified. Materials containing asbestos fibers shall not be used. Materials shall conform to the provisions in Section 20-2, "Materials."

20-5.024 IRRIGATION CROSSOVERS

- Irrigation crossovers shall include conduits, water line crossovers, sprinkler control crossovers and appurtenances. Sizes of the conduits, water line crossovers and sprinkler control crossovers shall be as shown on the plans or as specified in the special provisions.

20-5.025 MAINTAIN EXISTING WATER SUPPLY

- The Contractor shall notify the Engineer at least 4 days prior to shutting off the water supply to any portion of an existing irrigation system. The Engineer shall also be notified when the water supply is returned to that portion of the irrigation system.
- Water supply for maintaining existing plantings shall be maintained as specified herein until the permanent water supply or a temporary water supply system, approved by the Engineer, has been provided. If existing plantings are to be maintained by the State and Contractor from the same water supply, sufficient water shall be supplied to State landscape maintenance forces for watering plantings (within and outside the project limits) as necessary to maintain a healthy condition throughout the life of the contract.
- If the work causes a continuous interruption of water supply for more than 3 consecutive days, the Contractor shall water at the Contractor's expense all existing plantings, including those being maintained by State landscape maintenance forces, in the area irrigated from that water supply as often as necessary to maintain healthy plant growth. At the option of the Contractor, temporary connections to the existing irrigation system may be provided until the water service has been restored to the irrigation system.
- Existing irrigation facilities shown on the plans or specified in the special provisions to be removed, relocated or salvaged shall remain in place until their use is no longer required as determined by the Engineer.
- Existing irrigation facilities that are to remain or are to be maintained, relocated or salvaged as part of this contract, shall be protected from damage. If the Contractor's operations damage the existing irrigation facilities, the damaged facilities shall be repaired or replaced, at the Contractor's expense, as follows:

Repair or replacement of damaged facilities shall be completed within 10 working days of the damage.

Replaced irrigation facilities shall be new and of equal or better quality than the damaged facility. Replacement irrigation facilities shall be compatible with the irrigation systems to remain.

After repair or replacement of the facilities is complete, the Contractor shall demonstrate to the Engineer that the repaired or replaced facilities operate properly. When remote control valves are repaired or replaced, the valves shall be tested with the irrigation controller in the automatic mode.

- Where work is performed on an existing irrigation system, the system shall be checked by the Contractor for proper operation after the work is completed and any malfunctions resulting from the Contractor's operations shall be corrected at the Contractor's expense.
- When ordered by the Engineer, gate valves shall be installed at various locations in the existing irrigation system as directed by the Engineer. Furnishing and installing gate valves, except gate valves shown on the plans, will be paid for as extra work as provided in Section 4-1.03D.

20-5.026 REMOVE EXISTING PLANTS FOR TRENCHING

- Where trenching for new irrigation facilities is performed in areas planted with existing trees or shrubs, the trenching alignment shall be adjusted as necessary to avoid damage to the trees or shrubs.
- Where trenching for new irrigation facilities is performed in existing ground cover, sufficient ground cover shall be removed to permit the proper installation of the facilities, but in no case shall the removal width exceed 6 feet. Removed ground cover shall be disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13.
- The Contractor may, as an option, rototill existing Carpobrotus and Delosperma ground cover in lieu of removing the ground cover provided the backfill for the trenches will not contain plants longer than 6 inches in length.
- Ground cover removed or rototilled within the maximum 6-foot wide removal area shall be replaced with new plants of the same variety as the existing ground cover. Carpobrotus and Delosperma replacement plants shall be cuttings conforming to the provisions in Section 20-2.13, "Plants," and shall be planted 12 inches on center. Other ground cover replacement plants shall be from flats and shall be planted 12 inches on center.
- All ground cover replacement planting shall be performed before the start of the plant establishment period or at least 15 days prior to the acceptance of the contract if there is no plant establishment period.
- Planting of ground cover plants shall conform to the provisions in Section 20-4.05, "Planting."
- Replacement ground cover plantings shall be watered, at the Contractor's expense, in conformance with the provisions in Section 20-4.06, "Watering."

20-5.027 ELECTRICAL INSTALLATIONS FOR ELECTRIC AUTOMATIC IRRIGATION SYSTEMS

- Electrical installations for electric automatic irrigation systems shall conform to the provisions in Section 86-1.02, "Regulations and Code," and these specifications.

20-5.027A Components

- Electrical components for electric automatic irrigation systems shall include irrigation controllers with enclosures; base stations; field units; remote control valves; valve boxes; pull boxes; electrical conduits; conductors between controllers, pumps and valves; moisture sensors; flow sensors; remote control valve actuators; and all appurtenances, incidentals and accessories required for proper installation and operation of the electrical portions of the systems. Electrical components for electric automatic irrigation systems shall not include electrical service.
- All voltages shown on the plans or specified in these specifications or the special provisions for electrical components for electric automatic irrigation systems shall be considered as nominal.
- Electrical components requiring modifications to conform to the specified provisions shall have those modifications made by the manufacturer before shipment to the project.

20-5.027B Wiring Plans and Diagrams

- Working drawings for the electrical components of the irrigation system (except electrical service) shall be submitted in conformance with the provisions in Section 5-1.02, "Plans and Working Drawings," not less than 30 working days prior to the installation of any electrical materials for an irrigation system (except electrical service). The working drawings shall consist of wiring plans which shall be reproducible, shall conform in scale to the contract plans for irrigation and shall bear the written approval of the controller manufacturer or the manufacturer's authorized agent. Information shown on the wiring plans shall include, but not be limited to, wire and conduit sizes, and the wire routes between electrical components.
- Three copies of the schematic wiring diagram, including any wiring modifications, for each type of controller installed shall be submitted to the Engineer prior to completion of the contract.
- For each controller, one additional copy of the schematic wiring diagram and a copy of the reduced irrigation plan showing the equipment controlled by the controller, including the installed locations and correct station numbers for each electric remote control valve, shall be laminated with clear, mat-finished plastic, not less than 10 mils thick, and placed in a heavy-duty plastic envelope. The envelope shall be attached securely to the inside of the controller enclosure or cabinet door. Where the controller enclosure door is not of sufficient size to secure the plastic envelope to the inside of the door, the envelope and contents shall be furnished to the Engineer.

20-5.027C Electrical Energy

- Electrical energy for automatic irrigation systems may be obtained by the Contractor free of charge from the electrical service points shown on the plans.

20-5.027D Sprinkler Control Crossovers

- Sprinkler control crossover work shall consist of furnishing and installing electrical conduit, pull boxes and appurtenances as shown on the plans and as specified in these specifications and the special provisions.
- Sprinkler control crossovers shall be any electrical conduit for sprinkler controls that is installed inside a larger conduit under a roadway or other facility.
- Electrical conduit for sprinkler control crossovers shall be the rigid non-metallic type. The size of electrical conduit will be specified in the special provisions or shown on the plans.
- A No. 5 pull box, conforming to the provisions in Section 20-2.31C, "Pull Boxes," shall be installed at each end of sprinkler control crossovers as shown on the plans.

20-5.027E Service

- Electric service installations for irrigation controllers shall conform to the provisions in the special provisions.

20-5.027F Excavation and Backfill

- Excavation and backfill for installing irrigation facilities shall conform to the provisions specified for installing pipe in Section 20-5.03D, "Trenching and Backfilling."

20-5.027G Controllers

- Irrigation controllers shall be installed in conformance with the manufacturer's instructions, the details shown on the plans, these specifications, and the special provisions. When irrigation controllers are to be installed in irrigation controller enclosure cabinets, the controllers shall be installed in conformance with the details shown on the plans, these specifications, and the special provisions.
- The installation date and the expiration date of the guarantee for the controllers shall be permanently marked on the inside face of the controllers.
- A complete maintenance and operations manual for each type of controller installed shall be submitted to the Engineer when the schematic wiring diagrams are placed inside of the controller enclosure or cabinet door.

20-5.027H Valves and Valve Boxes

- Remote control valves and valve boxes for valves shall be installed in conformance with the provisions in Section 20-5.03F, "Valves and Valve Boxes."

20-5.027I Conductors, Electrical Conduit and Pull Boxes

- Low voltage control and neutral conductors, electrical conduit and pull boxes for irrigation systems shall be installed in conformance with the details shown on the plans, these specifications and the special provisions.
- Conductors shall be color coded when two or more controllers are located within one irrigation controller enclosure cabinet, or when conductors from more than one controller are installed in a common trench. The color of the conductors shall be uniform from any one controller to its valves. Neutral conductors shall be white. White shall not be used for control conductors. Conductors with green colored insulation shall not be used except as permitted by the National Electric Code.

- Conductors shall be of the size recommended by the manufacturer of the controllers to be installed, unless otherwise specified.
- Each irrigation controller shall have a common neutral conductor to its respective remote control valves.
- Each remote control valve shall have a separate control conductor from the irrigation controller with no other valves connected to the conductor.
- Conductors installed in a common trench, and not in a conduit, shall be wrapped together with electrical tape at 5-foot intervals.
- At least 2 feet of slack shall be left for each conductor at each pull box.
- At each valve box, at least 2 feet of slack shall be left for each conductor that is connected to other facilities within the box or is spliced within the box.
- Splices for low voltage control and neutral conductors shall conform to the provisions in Sections 86-2.09C, "Connectors and Terminals," 86-2.09D, "Splicing and Terminations," and 86-2.09E, "Splice Insulation," except "Method B" splice insulation, as shown on the plans, shall not be used. Tape used for insulating splices shall be a polyvinyl chloride type.
- Splices shall be made only in pull boxes or valve boxes.
- Conductors in irrigation controller cabinets shall not be spliced.
- Temporary splices used for testing valve circuits shall not be used as permanent splices.
- All permanent splice connections shall be made with freshly cut and skinned conductors.
- Conductors shall be buried directly in the ground, except as follows:

  Conductors shall be installed in electrical conduit when conductors are to be surface mounted, installed in or on bridge structures, installed under paved areas, installed in conduit for water line crossovers and sprinkler control crossovers, or placed in concrete. Surface-mounted conduits, conduits installed in or on bridge structures; conduits installed in concrete; and conduits installed by jacking or drilling shall be the rigid steel type. All other electrical conduit, including electrical conduit installed in irrigation crossover conduits for water line crossovers and sprinkler control crossovers and conduits under paved areas shall be non-metallic.

- Where conductors are installed in the same trench or opening as pipe (supply line), the conductors shall be placed at the same depth as the pipe. At other locations the conductors shall be installed not less than 12 inches below finished grade.
- Conductors located adjacent to curbs, dikes and paved shoulders, and not in a pipe (supply line) trench, shall be at least 4 feet from the curbs, dikes and paved shoulders.
- The Contractor, as an option, may install conductors for an irrigation system by methods and with equipment other than by trenching provided the conductors are installed at the depths specified and the conductor insulation is not damaged by the methods and equipment used.

- Pull boxes shall be installed on a continuous piece of 1/4 inch to 1/2 inch mesh, 19 gage minimum galvanized woven wire cloth over a bedding of gravel or crushed rock as shown on the plans for "Valve Box."
- Pull boxes for low voltage conductors shall not have side openings.
- Pull boxes shall be installed at the following locations:

1. At all conductor splices, except splices made in valve boxes.
2. At intervals not to exceed 500 feet along any low voltage, neutral and control conductor runs. Valve boxes installed along a conductor run shall not be considered as pull boxes in determining the spacing. When approved by the Engineer, the Contractor may, at the Contractor's expense, install additional pull boxes to facilitate the work.
3. Within 5 feet of irrigation controllers or within 5 feet of cabinets housing one or more controllers.
4. At ends of electrical conduits.
5. Other locations shown on the plans.

- The tops of pull boxes installed in walkway and paved areas shall be flush with the surrounding finished grade. The tops of pull boxes in other areas shall be installed 2 inches above the surrounding finished grade.

20-5.027J Testing

- Attention is directed to Section 6-3, "Testing."
- Field tests and a functional test shall be performed by the Contractor to demonstrate that all electrical components of the irrigation systems function as specified.
- Field tests shall be performed on all conductors in conformance with the provisions for lighting circuits in Section 86-2.14B, "Field Testing." Where the conductors are installed by trenching and backfilling, field tests shall be performed after at least 6 inches of backfill material has been placed over the conductors and the material has been compacted in conformance with the provisions in Section 20-5.03D, "Trenching and Backfilling."
- The functional test for each irrigation controller and associated automatic irrigation system served by a single electric service point, or a group of irrigation controllers and associated automatic irrigation systems served by a single electric service point, shall consist of not less than one complete cycle of operation The length of the cycle will be determined by the Engineer. If unsatisfactory performance of any system develops, the condition shall be corrected and the test repeated until one complete cycle of satisfactory operation is obtained.
- The functional test shall be satisfactorily completed prior to the start of the plant establishment period or prior to acceptance of the contract if there is no plant establishment period.

20-5.03 INSTALLATION

- Irrigation systems shall be installed in conformance with the provisions in Section 20-5.027, "Electrical Installations for Electric Automatic Irrigation Systems," and these specifications.

- The irrigation systems as shown on the plans, except for sprinkler locations, are diagrammatic.

20-5.03A General

- Underground metallic pipes, valves or fittings made of dissimilar metals shall be connected through a dielectric coupling or bushing. Pipe installed in this manner shall be physically separated from other metal objects. Dielectric couplings shall physically separate the pipes a minimum of $^1/_8$ inch in all directions. Non-conducting spacers which will ensure physical separation of pipe from foreign objects may be required as determined by the Engineer.
- Repair of irrigation systems shall be made within 5 working days after a malfunction or damage to any portion of the system has occurred.
- Supply lines, control and neutral conductors and electrical conduits installed in common trenches shall not be installed above each other.
- Risers for sprinklers on slopes shall be set perpendicular to the plane of the slope.
- If the location of a supply line interferes with the excavation of plant holes, the plant holes shall be so located as to clear the supply lines. Supply lines shall not be installed through plant holes unless otherwise shown on the plans.
- Control valves and sprinklers shall be installed $6^1/_2$ feet to 8 feet from curbs, dikes, sidewalks and paved shoulders and 3 feet from fences and walls. If control valves and sprinklers cannot be installed within these limits, control valves and sprinklers shall be located as directed by the Engineer.
- Foreign material shall be prevented from entering the irrigation system during installation. Immediately prior to assembling, all pipes, valves, and fittings shall be cleaned. All unattached ends of pipe, fittings and valves shall be plugged or capped pending attachment of additional pipe or fittings. All lines shall be thoroughly flushed out prior to attachment of sprinklers, emitters and other terminal fittings.

20-5.03B Conduit for Irrigation Crossovers

- The installation of conduit for irrigation crossovers shall conform to the provisions in this Section 20-5.03B.
- Conduits for irrigation crossovers shall conform to the provisions in Section 20-2.16, "Conduit."
- Conduits shall be installed not less than $1^1/_2$ feet below the top of curb grade in sidewalk areas and not less than 40 inches below finished grade in all other areas measured to the top of the conduit. Conduits shall extend 2 feet beyond all paving unless otherwise shown on the plans.
- Conduits shall be installed under existing pavement by jacking or drilling methods. Pavement shall not be disturbed without the approval of the Engineer, and then only in the event obstructions are encountered. When permitted by the Engineer, small holes may be cut in the pavement to locate or remove obstructions. Jacking or drilling pits shall be kept at least 2 feet from pavement edge wherever possible. Excessive use of water that will soften subgrade or undermine the pavement will not be permitted.
- Where conduits are installed in open trenches, excavation and backfill shall conform to the provisions in Section 20-5.03D, "Trenching and Backfilling," and

these specifications. The bottom of the trench shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of the conduit. During backfilling operations, the conduit shall be rigidly supported so that no movement of, or damage to, the conduit or joints will result.

- Couplings for conduits shall be installed in conformance with the manufacturer's written instructions; a copy of which shall be furnished to the Engineer prior to installation.
- After installation of conduits for water line crossovers and sprinkler control crossovers and placing of base and surfacing is completed, the Contractor shall demonstrate that such conduits are free of obstructions and restrictions.
- The ends of conduits shall be capped with a No. 30 asphalt-saturated felt secured with galvanized wire.
- Ground cover plants removed or damaged by the Contractor's operations shall be replaced at the Contractor's expense, in conformance with the provisions in Section 20-4.07, "Replacement," regardless of the type of installation involved.
- The location of each conduit shall be designated by cementing a Type A pavement marker to the paved shoulder near each end and over the center line of the conduit using a standard set type adhesive. Type A pavement markers and adhesive shall conform to the provisions in Section 85, "Pavement Markers."
- When existing conduits are to be incorporated in new work, exploratory holes for locating existing conduits shall be excavated at the locations indicated by existing markers or where directed by the Engineer. The Contractor shall excavate and backfill exploratory holes at any location to a maximum size of $2^1/_2$ feet in width, 5 feet in depth and 10 feet parallel with the roadway (5 feet on each side of the marker or directed location). If it is necessary or advisable, as determined by the Engineer, to increase the size of the exploratory holes beyond the dimensions specified above, the additional excavation and backfill will be paid for as extra work as provided in Section 4-1.03D.
- Before existing Type A pavement markers indicating the location of the existing crossover conduit are removed or disturbed, the location of the existing crossover conduit shall be marked on the pavement by the Contractor. Existing pavement markers, that are damaged or removed by the Contractor, shall be replaced by the Contractor at the Contractor's expense.

20-5.03C Water Line Crossovers

- Water line crossovers are supply line pipes installed in conduits.
- The work of installing water line crossovers shall include furnishing and installing appurtenances shown on the plans or specified in these specifications or the special provisions.
- Water line crossovers shall be polyvinyl chloride (PVC) plastic pipe with a minimum pressure rating (PR) of 315 and shall be of the sizes shown on the plans or specified in the special provisions.
- After completing conduit backfill and prior to performing the pressure test on a water line crossover, the Contractor shall demonstrate that the water line crossover can be moved longitudinally within the conduit. The water line crossover shall then be positioned to extend at least one foot beyond each end of the conduit.

- Where water line crossovers are not to be connected to other supply lines, the ends of the crossovers shall be capped immediately after testing.

20-5.03D Trenching and Backfilling

- Trenching and backfilling for installation of pipe, fittings and appurtenances; and electrical facilities, including removing and replacing improvements, shall conform to the details shown on the plans, and the provisions in Section 86-2.01, "Excavating and Backfilling," Section 86-2.02, "Removing and Replacing Improvements," and these specifications.
- Trenches for pipe, fittings and appurtenances, and electrical facilities shall be smooth and free of jagged rubble or sharp objects which will cause abrupt bending stresses and uneven load distribution to pipes, conduits and conductors during backfilling operations.
- Trenches for solvent cemented plastic pipe supply lines shall be of sufficient width to permit snaking of the pipe. Other trenches shall not be excavated wider than necessary for the proper installation of pipe supply lines.
- The backfilling of pipe trenches shall be accomplished in a manner that will protect the pipe from damage by sharp objects. Rocks shall not be placed directly on the pipe.
- Rocks and other debris encountered during trenching operations shall be brought to the surface of the ground at the Contractor's expense. Removing and disposing of the rocks and debris will be paid for as extra work as provided in Section 4-1.03D. The size of rocks and the quantity of rocks and debris to be disposed of will be determined by the Engineer.
- Pavement, sidewalk and similarly paved areas encountered on or beneath the surface of the ground and not shown on the plans in areas to be trenched, and if ordered by the Engineer, shall be removed and disposed of as directed by the Engineer. Excavating through the paved areas, furnishing and placing topsoil to fill resulting holes, and removing and disposing of all the pavement will be paid for as extra work as provided in Section 4-1.03D.
- Existing pavement shown on the plans where trenches are to be excavated shall be removed and, unless otherwise permitted by the Engineer, disposed of outside the highway right of way as provided in Section 7-1.13.
- Except as otherwise specified in this Section 20-5.03D, backfill material shall be material excavated from the trenches and shall be compacted by ponding or jetting with water until the backfill material, after settlement, is level with the surrounding soil.
- The backfill for excavations outside the right of way and excavations within surfaced areas shall be compacted in conformance with the provisions in Section 19-3, "Structure Excavation and Backfill."
- If for any reason the soil taken from the trench is determined by the Engineer to be unsuitable for a bedding material against the pipe, a suitable material, such as sand or topsoil, shall be furnished and placed as a bedding for the pipe before backfilling with the original soil taken from the trench. Furnishing and placing bedding material for pipe when ordered by the Engineer will be paid for as extra work as provided in Section 4-1.03D.

- When any backfilled area has settled, the area shall be refilled and compacted by the Contractor at the Contractor's expense, including furnishing, placing and compacting the fill material.

20-5.03E Pipe

- Plastic pipe supply lines, thrust blocks, plastic pipe irrigation lines, and fittings shall be installed in conformance with the pipe and fitting manufacturers' printed instructions and these specifications. A copy of such manufacturer's instructions shall be furnished to the Engineer before any pipe is installed.
- The Contractor may as an option install plastic pipe supply line with solvent cemented fittings and plastic pipe irrigation line by methods and with equipment other than by trenching, provided the pipes are installed at the depths specified.
- Where connection is made to existing supply lines, compression type fittings may be used.
- Pipe from water meters through a backflow preventer assembly to plastic pipe supply lines shall be galvanized steel or as otherwise shown on the plans.
- Supply lines shall be installed under paved ditches which are 3 feet deep or less at the flow line. Supply lines that cross paved ditches more than 3 feet deep shall be galvanized steel pipe and shall span the ditches.
- Supply line trenches located adjacent to curbs, dikes and paved shoulders shall be at least 4 feet from the curbs, dikes and paved shoulders.
- Plastic pipe supply lines with rubber ring gasket type joints shall be installed not less than 18 inches below the finished grade, measured to the top of the pipe.
- Plastic pipe supply lines with solvent cemented type joints shall be installed not less than 12 inches below the finished grade, measured to the top of the pipe.
- Pipe shall be cut straight and true. After cutting, the ends shall be reamed out to the full inside diameter of the pipe.
- PVC pipe $1^1/_2$ inches or less in diameter shall not be cut by sawing. PVC pipe $1^1/_2$ inches or less in diameter shall be cut with "PVC cutters."
- Male pipe threads on galvanized steel pipe shall be coated with a joint compound that is non-hardening and non-corrosive.
- Solvent cement welding shall be done in conformance with the printed instructions of the solvent cement manufacturer. A copy of the printed instructions shall be furnished to the Engineer before any joints are made.
- The male portion of each threaded plastic pipe and fitting shall be wrapped with at least 2 layers of approved pipe thread sealant tape.
- All plastic pipe installed by trenching and backfilling methods, except pipe connected with rubber ring-type fittings, shall be snaked when installed. Pipe connected with rubber ring-type fittings need not be snaked.

20-5.03F Valves and Valve Boxes

- Remote control valves, remote control valves (master), manual control valves, flow sensor, gate valves, pressure reducing valves, pressure regulating valves, pressure relief valves, ball valves, wye strainers and filter assembly units shall be installed in valve boxes in conformance with the details shown on the plans and these specifications.

- Spring action check valves (anti-drain valves) shall be installed at the locations shown on the plans. If locations for check valves are not shown on the plans and a contract item for the valves is included in the Engineer's Estimate, the valves shall be located as directed by the Engineer. The check valve spring shall be factory set at 10 psi.
- Valve boxes installed in paved areas or on slopes steeper than 4:1 (horizontal:vertical) shall be precast portland cement concrete.
- Valve boxes shall be installed on a continuous piece of 1/4 inch to 1/2 inch mesh, 19 gage minimum galvanized woven wire cloth on a bedding of gravel or crushed rock as shown on the plans.
- Covers for valve boxes shall be one piece, except when the weight of a valve box cover exceeds 35 pounds the cover shall be cut into equal sections so that no section exceeds 35 pounds in weight. Cuts on valve box covers shall be straight, uniform and smooth.
- Valve boxes that contain remote control valves shall be identified on the top surface of the valve box covers by the appropriate letters and numbers as shown on the plans. Valve boxes shall be identified by attaching to the covers labels that contain the appropriate abbreviations. The identifying abbreviations (letters and numbers for controller and station numbers of the irrigation facility contained in the valve box) shall be as shown on the plans.
- Labels for valve boxes identified by labels shall consist of engraved letters and numbers on a 2-layer white over black, exterior-sign-plate plastic or integrally molded or heat-embossed black letters and numbers on ultraviolet-resistant yellow polyurethane material. The dimensions of the labels shall be a minimum of 2" x 3" x 1/8" thick. The letters and numbers shall be a minimum of 1 1/8 inches in height. Polyurethane material shall be neatly trimmed to the proper shape. Labels shall be attached to the valve box covers with commercial quality brass or stainless steel machine screws, nuts and washers as shown on the plans. Screws and nuts shall not be over tightened. Valve boxes shall be provided with valve box extensions when required.
- The tops of valve boxes installed in walkway and paved areas shall be flush with finished grade. The tops of valve boxes in other areas shall be installed 2 inches above finished grade.

20-5.03G Backflow Preventer Assembly

- Backflow preventer assembly shall consist of a backflow preventer, wye strainer, gate valves, pipe, fittings, portland cement concrete supports and portland cement concrete pad for the assembly, and shall conform to the details shown on the plans, these specifications and the special provisions. Components of backflow preventer assemblies shall conform to the provisions in Section 20-2, "Materials," and shall be capable of withstanding a cold water working pressure of 150 psi.
- Gate valves attached to the outlets of the wye strainers shall be threaded, have a brass or bronze body, stem and wedge, be the same size as the outlet and be modified so that attachments can not be made to the outlet valves. Seating rings on the discharge side of the valves shall be Teflon. Valve wedges shall be driven obliquely by cam action into the seating rings.

- Exposed top surfaces of concrete foundations and pads shall have a medium broom finish applied parallel to the long dimension of foundations and pads.

20-5.03H Pressure Testing

- Pressure testing for leakage shall be performed on all pipe supply lines installed by the Contractor, except for nonrigid pipelines and pipelines with spray nozzles installed into the pipe. Pipelines to be tested shall be installed, and all open ends of the pipeline and fittings shall be plugged or capped prior to testing.
- Pressure tests shall be performed in one or more operations.
- Pipelines installed by trenching and backfilling and pipelines which are completely visible after installation shall be tested by either Method A or Method B as specified below. The method used will be at the Contractor's option. All other pipelines, including those installed in the ground by methods other than trenching and backfilling, shall be tested by Method A as specified below. Water line crossovers shall be tested by Method A as specified below except the testing period and allowable drop in pressure shall be modified from one hour to 0.5-hour and from 5 psi to no drop in pressure, respectively.

20-5.03H(1) Method A

- Method A pressure testing procedure for leakage shall conform to the following:

The Contractor shall notify the Engineer at least 24 hours prior to performing any pressure test. Pressure tests shall be performed only between the hours of 8:00 a.m. and 5:00 p.m. except that no pressure tests shall be made on Saturdays, Sundays or legal holidays, unless otherwise approved in writing by the Engineer. Each pressure test shall be observed by the Engineer.

Pipelines to be tested shall be filled with water, and a pressure gage shall be connected to the pipeline. The pipeline shall then be placed under a pressure of 125 psi except as otherwise specified below, by air or water pressure, after which the source of pressure shall be cut off leaving the line under the required pressure.

The pressure gage shall be calibrated from 0 psi to 200 psi in 5 psi increments and shall be accurate within a tolerance of 2 psi.

The pipeline shall be tested under the required pressure for a period of one hour. The pressure gage shall remain in place until each test period has been completed. Leaks that develop in the tested portion of the system shall be located and repaired after each test period when a drop of more than 5 psi is indicated by the pressure gage. After the leaks have been repaired, the one hour pressure test shall be repeated and additional repairs made until the drop in pressure is 5 psi or less.

When a system consists of new pipelines installed as part of this contract and existing pipelines, the new pipelines shall be isolated from the existing pipelines, at the Contractor's expense, and the new pipelines shall be tested at 125 psi in conformance with these specifications.

20-5.03H(2) Method B

- Method B pressure testing procedure for leakage shall conform to the following:

The Contractor shall notify the Engineer at least 24 hours prior to performing any pressure test. Pressure tests shall be so performed that the testing periods end between the hours of 8:00 a.m. and 5:00 p.m. except that no pressure test period shall end on Saturdays, Sundays or legal holidays, unless otherwise approved in writing by the Engineer. Each pressure test shall be observed by the Engineer.

Before any portion of the pipeline on the supply side of a control valve is backfilled, water shall be turned into that portion of the line and maintained at full pressure from the water source for a period of not less than 8 consecutive hours after all air has been expelled from the line. Before any portion of the pipeline on the discharge side of a control valve is backfilled, a similar test shall be performed, except the test shall be for a duration of one hour. Leaks that develop in a tested portion of the system shall be repaired. After the leaks have been repaired, the pressure test shall be repeated and additional repairs made until no leaks occur as determined by the Engineer.

20-5.03I Repairs and Coverage

- Leaks that develop and defective material in any portion of the irrigation system installed by the Contractor shall be repaired or replaced by the Contractor.
- The entire system shall be checked and, if necessary, adjusted for uniform and complete coverage after installing the sprinklers. Emitters shall be checked for proper operation and, if necessary, cleaned or replaced.
- Any revision of the proposed irrigation systems ordered by the Engineer and necessary to achieve complete and adequate coverage of the areas to be watered will be paid for as extra work as provided in Section 4-1.03D.

20-5.03J Check and Test Backflow Preventers

- Backflow preventers shall be checked and tested for proper operation by a certified Backflow Preventer Tester. The tester shall hold a valid certification as a Backflow Preventer Tester from the local governing authority in which the device to be tested is located. The local governing authority shall be the county, city or water purveyor having the governing authority over testing of backflow preventers involved. If the local governing authority does not have a certification program for Backflow Preventer Testers, the tester shall have a certificate from one of the following:

A. The American Water Works Association.
B. A county which has a certification program for Backflow Preventer Testers.

- Tests for proper operation shall conform to the requirements of the governing authority.
- The Engineer shall be notified at least 5 days prior to testing backflow preventers.

- One copy of the test results for each backflow preventer tested shall be furnished to the Engineer.
- Backflow preventers, installed by the Contractor, failing required tests shall be repaired at the Contractors expense.

20-5.04 MEASUREMENT

- The work performed under these specifications for installing irrigation systems will be measured by units, by the linear foot, by the lump sum price or by any other unit designated in the contract item and will be listed in the Engineer' Estimate by type, classification, size, or whatever information is necessary.
- Quantities of galvanized steel pipe and plastic pipe supply lines and irrigation lines, and the quantities of extend conduit, corrugated high density polyethylene pipe conduit, high density polyethylene pipe conduit, welded steel pipe conduit, corrugated steel pipe conduit, corrugated aluminum pipe conduit, acrylonitrile-butadiene-styrene (ABS) composite pipe conduit and alternative conduit to be paid for by the linear foot will be determined from the slope length designated by the Engineer. Pipe and conduit placed in excess of the lengths designated will not be paid for.
- Quantities of control valves, flow sensors, gate valves, garden valves, pressure relief valves, pressure reducing valves, quick coupling valves, check valves, filter assembly units, irrigation controllers, base stations, field units, backflow preventer assemblies, sprinklers and wye strainers to be paid for by the unit will be determined from actual count in place.

20-5.05 PAYMENT

- When the contract includes separate items for performing irrigation system work, the irrigation system work will be paid for at the contract lump sum or item prices for the items of work involved and identified.
- Irrigation system work will be paid for at a single contract lump sum price for irrigation system, or irrigation system work will be paid for as individual items as follows:

> The contract lump sum price for control and neutral conductors; the contract prices per linear foot for galvanized steel pipe and plastic pipe supply lines, and irrigation lines; the contract prices per linear foot for extend conduit, corrugated high density polyethylene pipe conduit, high density polyethylene pipe conduit, welded steel pipe conduit, corrugated steel pipe conduit, corrugated aluminum pipe conduit, acrylonitrile-butadiene-styrene (ABS) composite pipe conduit and alternative conduit; and the contract unit prices for control valves, flow sensors, gate valves, garden valves, pressure relief valves, pressure reducing valves, quick coupling valves, check valves, filter assembly units, irrigation controllers, base stations, field units, backflow preventer assemblies, sprinklers and wye strainers.

- The item or items to be paid for will be designated in the Engineer's Estimate.
- When irrigation system work is to be paid for at a contract lump sum price for irrigation system, the price shall include full compensation for furnishing all labor,

materials, tools, equipment, and incidentals, and for doing all the work involved in installing the irrigation system, complete in place, including excavation and backfill, replacing subbase, base, and pavement where pipe supply lines and conduits are installed through paved areas, testing and checking the irrigation system, maintaining existing water supply, salvaging, relocating or removing existing irrigation facilities and removing existing plants for trenching, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

- When the various components of the irrigation system work are to be paid for as individual items as described above, the following shall apply:

Remote control valves (master) will be paid for as electric remote control valves of the sizes involved.

Water line crossovers will be paid for at the contract prices per linear foot for the various sizes and types of supply line involved, which prices shall include full compensation for testing, checking, and furnishing and installing water line crossover appurtenances.

Full compensation for furnishing and installing electrical conduit for control and neutral conductors shall be considered as included in the contract lump sum price paid for control and neutral conductors and no separate payment will be made therefor.

Full compensation for sprinkler control crossovers, water line crossovers, pavement markers, pull wires, pull boxes and appurtenances, and for pressure testing the water line crossover in the conduit shall be considered as included in the contract prices paid per linear foot for the various sizes and types of conduit for irrigation crossovers in which the sprinkler control crossovers and water line crossovers are installed and no separate payment will be made therefor.

Full compensation for maintaining existing water supply shall be considered as included in the contract prices paid per linear foot for the various sizes of plastic pipe (supply line) involved and no additional compensation will be allowed therefor.

Full compensation for removing or rototilling, disposing and replacing existing ground cover to install irrigation pipes and conductors in existing ground cover shall be considered as included in the contract prices paid per linear foot for the various sizes of plastic pipe (supply line) or in the contract lump sum price paid for control and neutral conductors involved, and no additional compensation will be allowed therefor.

Full compensation for locating and marking the locations of conduits and capping the ends of conduits shall be considered as included in the contract prices paid per linear foot for the various sizes and types of conduit for water line crossovers and sprinkler control crossovers involved and no separate payment will be made therefor.

Full compensation for locating existing conduits shall be considered as included in the contract prices paid per linear foot for the various sizes of

plastic pipe (supply line) involved and no additional compensation will be allowed therefor.

Full compensation for replacing subbase, base and paving where supply lines or conduits are installed through existing paved areas shall be considered as included in the contract prices paid per linear foot for the various sizes of plastic pipe (supply line) and for the various sizes and types of conduit for water line crossovers and sprinkler control crossovers involved and no separate payment will be made therefor.

Full compensation for removing and disposing of existing pavement shown on the plans where trenches for irrigation facilities are to be excavated shall be considered as included in the contract prices paid for the items of work requiring the trenching and no separate payment will be made therefor.

Full compensation for performing the functional tests for electric automatic irrigation systems as specified herein shall be considered as included in the contract unit prices paid for the various types of irrigation controllers involved and no additional compensation will be allowed therefor.

Full compensation for furnishing and installing flexible risers, swing joints and pipe used for risers shall be considered as included in the price paid for the contract item requiring the riser or swing joint and riser and no separate payment will be made therefor.

Full compensation for furnishing and installing flow shutoff and pressure compensation devices on risers shall be considered as included in the contract unit price paid for the type of sprinkler involved and no separate payment will be made therefor.

Full compensation for checking and cleaning emitters and for checking and adjusting the various types of sprinklers for proper rate of flow and coverage, after installation, shall be considered as included in the contract unit prices paid for the various types of sprinklers involved and no separate payment will be made therefor.

Full compensation for testing new backflow preventers shall be considered as included in the contract unit price paid for the size of backflow preventer assembly involved and no separate payment will be made therefor.

Full compensation for retesting new and existing backflow preventers shall be considered as included in the contract lump sum price paid for plant establishment work and no additional compensation will be allowed therefor.

Full compensation for abandoning or removing and disposing of existing irrigation facilities shall be considered as included in the contract prices paid per linear foot for the various sizes of plastic pipe (supply line) involved and no separate payment will be made therefor.

Full compensation for relocating existing irrigation facilities shall be considered as included in the contract prices paid per linear foot for the various sizes of plastic pipe (supply line) involved and no separate payment will be made therefor.

Full compensation for salvaging existing irrigation facilities shall be considered as included in the contract prices paid per linear foot for the various

sizes of plastic pipe (supply line) involved and no additional compensation will be allowed therefor.

Full compensation for removing existing plants for trenching work shall be considered as included in the contract prices paid per linear foot for the various sizes of plastic pipe (supply line) involved and no additional compensation will be allowed therefor.

Full compensation for furnishing and installing pipe supply lines from water meters through the backflow preventers to plastic pipe supply lines shall be considered as included in the contract unit price paid for the size of the backflow preventer assembly involved and no separate payment will be made therefor.

Full compensation for furnishing flush valves and plastic pipe (locator) shall be considered as included in the contract price paid per linear foot for the size of plastic pipe (supply line) involved and no additional compensation will be allowed therefor.

When there are no separate contract items for materials necessary to complete a unit of the irrigation system, the materials shall be furnished and installed. Full compensation for furnishing and installing the materials shall be considered as included in the contract price or prices paid for the unit of the irrigation system requiring the materials and no additional compensation will be allowed therefor.

The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in installing the irrigation systems, complete in place, including any structure excavation, structure backfill, concrete, and water involved, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 21: (BLANK)

SECTION 22: FINISHING ROADWAY

22-1.01 DESCRIPTION

- Upon completion of all construction operations, the entire roadway or roadways shall be finished as specified in these specifications.
- The roadbed shoulders shall be trimmed and shaped to the finished cross section to produce smooth surfaces and slopes, and uniform cross sections. In the case of a graded roadbed without surfacing or pavement, the entire roadbed shall be trimmed and shaped to uniform cross sections and slopes.
- Stockpiling of material on the finished pavement and drifting of material across the pavement will not be permitted. The finished pavement shall be cleaned of all dirt and foreign material.
- The slopes of embankments, excavations, road approaches, road connections, ditches, channel changes and material sites within or adjacent to the highway right of way shall be finished to the lines and grades called for by the plans and in conformance with the provisions in Section 19, "Earthwork." Ditches and channels within or adjacent to the highway right of way shall be cleared of debris and obstructions. Slopes of gutters shall be trimmed to the required grade and cross section. Sewers, culverts and other drainage facilities and appurtenant structures constructed under the contract shall be cleaned out. Excess earth, debris or other waste material adjacent to culvert headwalls and endwalls, bridge ends, poles, posts, trees or other objects shall be removed and the areas shaped as directed by the Engineer and left in a neat and orderly condition. Stones, roots and other waste material exposed on slopes, which are liable to become loosened, shall be removed and disposed of. Materials and debris resulting from clearing and grubbing operations not previously removed, shall be disposed of. Loose rock larger than $2^1/_2$ inches in maximum dimension shall be removed from the finished roadbed and disposed of.
- Materials resulting from the above specified finishing operations shall become the property of the Contractor and shall be disposed of outside the highway right of way unless otherwise permitted by the special provisions. Disposal of materials outside the highway right of way shall be in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way," except that when permitted by the Engineer, earth and rocky material may be disposed of along the roadway as directed by the Engineer.
- The entire roadway and right of way shall be left in a neat and presentable condition.

22-1.02 MEASUREMENT

Finishing roadway will be paid for on a lump sum basis.

22-1.03 PAYMENT

- The contract lump sum price paid for finishing roadway shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in finishing the entire project, including all ramps, connecting roads and streets, frontage roads, road approaches, and channelized intersections, whether inside or outside the highway right of way, and

all other areas disturbed by the Contractor's operations, all as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

- When the contract does not include a contract pay item for finishing roadway as above specified, and unless otherwise provided in the special provisions, full compensation for any necessary finishing shall be considered as included in the prices paid for the various contract items of work requiring finishing and no additional compensation will be allowed therefor.

SECTION 23: (BLANK)

SUBBASES AND BASES

SECTION 24: LIME STABILIZATION

24-1.01 DESCRIPTION

- This work shall consist of mixing lime and water with soil and compacting the mixture to the lines, grades and dimensions shown on the plans and as specified in these specifications and the special provisions.

24-1.02 MATERIALS

- Material to be stabilized shall be the native soil or embankment, containing no rocks or solids, other than soil clods, larger than $2^1/_2$ inches in any dimension. Removing and disposing of rocks and solids larger than $2^1/_2$ inches, from native soil or embankment other than imported borrow, will be paid for as extra work as provided in Section 4-1.03D. Removing and disposing of rocks and solids larger than $2^1/_2$ inches from imported borrow shall be at the expense of the Contractor.
- Lime shall conform to the requirements in ASTM Designation: C 977 with the exception that when a 250-gram test sample of quicklime is dry sieved in a mechanical sieve shaker for 10 minutes ±30 seconds it shall conform to the following grading requirements:

Sieve Sizes	Percentage Passing
$^3/_8$"	98-100
No. 100	0-25
No. 200	0-15

- A Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance," shall be furnished with each delivery of lime and shall be submitted to the Engineer with a certified copy of the weight of each delivery.
- Water for mixing with soil and lime shall be free from oil and shall contain not more than 650 parts per million of chlorides as Cl, nor more than 1,300 parts per million of sulfates as SO_4. The water shall not contain an amount of impurities that will cause a reduction in the strength of the stabilized material.

24-1.03 GENERAL

- The amount of lime to be added to the material to be stabilized shall be as specified in the special provisions.
- Handling, spreading and mixing operations shall be conducted in such a manner that a hazard is not presented to construction personnel or the public. Lime shall be prevented from blowing by suitable means selected by the Contractor.
- If lime of more than one type or from more than one source are used on the project, separate application rates will be determined for lime of each source or type. Lime from more than one source or of more than one type shall not be mixed.
- The lime shall be protected from exposure to moisture until used and shall be sufficiently dry to flow freely when handled.

- Lime shall not be spread while the ambient temperature is below 35° F, nor when the ambient temperature is expected to drop below 35° F before mixing and compacting are to be completed.
- The in-place moisture of the material to be stabilized shall be maintained above the optimum moisture, as determined by California Test 373, during the mixing operation. During compaction, finish rolling and grading, sufficient water shall be added to the surface of the material to prevent the surface from drying until curing seal is applied.
- No traffic other than the equipment performing the work will be allowed to pass over the spread lime, the mixed material or the compacted surface of the lime stabilized material. After application of the curing seal, no traffic will be permitted on the lime stabilized material for a period of 3 days. Damage to curing seal or lime stabilized material shall be repaired promptly by the Contractor at the Contractor's expense, as directed by the Engineer.

24-1.04 PREPARING MATERIAL

- Unless otherwise ordered or approved by the Engineer, the material to be stabilized shall be placed to the lines, grades and dimensions shown on the plans and compacted to a relative compaction of not less than 90 percent, before lime is added. The surface of the material to be stabilized shall not vary more than 0.08-foot above or below the grade established by the Engineer, before lime is added.

24-1.05 SPREADING

- Lime shall be spread using equipment which will uniformly distribute the lime over the area to be stabilized.
- Tailgate spreading of lime will not be permitted.
- Lime shall be spread uniformly on the roadbed, and the rate of spread per square foot shall not vary by more than 10 percent of the rate designated by the Engineer.
- Lime may be spread on the prepared material in either a slurry or dry form at the option of the Contractor. Hydrated lime shall not be spread in dry form. Either hydrated lime or quicklime may be used to prepare the slurry.
- The distance which lime may be spread ahead of the mixing operation will be determined by the Engineer. In no case shall spread lime be allowed to remain exposed at the end of the work day.
- Lime applied in slurry form shall be prepared and distributed using equipment and procedures capable of keeping the slurried lime in suspension and spreading the slurry uniformly over the area to be stabilized. The lime content of the slurry shall be as approved by the Engineer.

24-1.06 MIXING

- Mixing lime and the material to be stabilized shall be conducted using equipment capable of mixing the materials uniformly to the depth specified.
- Lime and the material to be stabilized may be mixed off site.
- Mixing or remixing operations, regardless of the equipment used, shall continue until the material is uniformly mixed and free of streaks or pockets of lime. Prior to compaction, all mixed material other than rock or aggregate

previously treated with asphalt, lime or cement shall comply with the following grading requirements:

Sieve Sizes	Percentage Passing
1"	98 min.
No. 4	60 min.

- When granular lime in dry form is used, the material shall be mixed at least twice. The first and final mixings shall not be performed on the same day.
- When the stabilized material, exclusive of one-inch or larger clods, is sprayed with a phenolphthalein alcohol indicator solution, areas showing no color reaction will be considered evidence of inadequate mixing.
- The depth of mixing of the lime stabilized material shall not vary more than 0.1-foot from the planned depth at any point. Mixing to a depth that exceeds the planned depth by 10 percent or more shall be considered evidence of an inadequate amount of lime and additional lime shall be added at the Contractor's expense.
- The entire mixing operation shall be completed within 7 days of the initial spreading of lime, unless otherwise permitted by the Engineer.

24-1.07 COMPACTION

- Compaction shall begin as soon as possible, but not more than 24 hours after final mixing.
- Prior to initial compaction, maximum density will be determined on a composite of material from 5 random locations within the test area by California Test 216. The composite sample will be obtained after all mixing has been completed. The moisture content of the composite sample will be determined by California Test 226.
- Initial compaction shall be by means of sheepsfoot or segmented wheel rollers and shall be immediately followed with final compaction by rolling with steel drum or pneumatic-tired rollers. Vibratory rollers will not be allowed.
- Where the required thickness is 0.50-foot or less, the mixture shall be compacted in one layer. Where the required thickness is more than 0.50-foot, the mixture shall be compacted in 2 or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 0.50-foot, except that the maximum compacted thickness of a single layer may be increased provided the Contractor can demonstrate to the Engineer that the equipment and method of operation will provide uniform distribution of the lime and the required compacted density throughout the layer.
- Areas inaccessible to rollers shall be compacted to the required relative compaction by other means satisfactory to the Engineer.
- The lime stabilized soil shall be compacted to a relative compaction of not less than 95 percent, except that the minimum relative compaction may be reduced to 92 percent provided the Contractor increases the lime content 0.5-percent at the Contractor's expense.
- The relative compaction will be calculated on the dry weight basis.
- In-place density of the compacted lime stabilized material will be determined by California Test 231. A composite of material from a minimum of 5 random

selected sites, taken at the time in-place density is determined, will be used to determine the in-place moisture content, by California Test 226.

24-1.08 FINISH ROLLING AND GRADING

- The finished surface of the lime stabilized material shall be the grading plane and at any point shall not vary more than 0.08-foot above or below the grade established by the Engineer, except that when the lime stabilized material is to be covered by material which is paid for by the cubic yard, the surface of the finished lime stabilized material shall not extend above the grade established by the Engineer.
- If the compacted material is above the grade tolerances specified in this section, the excess material shall be trimmed, removed, and disposed of. No loose material shall be left on the finished plane. Trimming of excess material shall not be conducted unless finish rolling can be completed within 2 hours after trimming.
- Trimmed surfaces shall receive finish rolling consisting of at least one complete coverage with steel drum or pneumatic-tired rollers. Vibratory rollers will not be allowed. Minor indentations may remain in the surface of the finished material after final trimming and rolling. Under no circumstances will it be permissible to add new or trimmed lime stabilized material to fill low areas or to raise the grade of compacted lime stabilized material.

24-1.09 CURING

- A curing seal, consisting of SS or CSS grade asphaltic emulsion, shall be furnished and applied to the surface of the top layer of lime stabilized material in conformance with the provisions in Section 94, "Asphaltic Emulsions."
- Curing seal shall be applied at a rate of between 0.10-gallon and 0.20-gallon per square yard of surface. The exact rate will be determined by the Engineer.
- Curing seal shall be applied within 48 hours of completion of initial compaction and on the same day as trimming and finish rolling are completed. The curing seal shall be applied as soon after finish rolling as is practicable. The lime stabilized material shall be at optimum moisture when the curing seal is applied.
- Curing seal shall not be placed when the atmospheric temperature is below 40° F.
- Curing by water will not be allowed, unless authorized by the Engineer.
- Damage to the curing seal shall be promptly repaired by the Contractor at the Contractor's expense, as directed by the Engineer.

24-1.10 MEASUREMENT

- Lime stabilization will be measured by the square yard, determined from horizontal measurements of the planned surface of the lime stabilized material.
- Lime will be measured by the ton in conformance with the provisions in Section 9-1.01, "Measurement of Quantities," except that if the minimum relative compaction is reduced to 92 percent, the quantity of lime to be paid for will be the weight of lime multiplied by the factor $X / (X+0.5)$ where X equals the percent of lime ordered by the Engineer.
- Bituminous curing seal will be measured in conformance with the provisions in Section 94, "Asphaltic Emulsions."

24-1.11 PAYMENT

- Items of work, measured as provided in Section 24-1.10, "Measurement," will be paid for at the contract prices per square yard for lime stabilization, per ton for lime, and per ton for asphaltic emulsion (curing seal).
- The above contract prices and payments shall include full compensation for furnishing all labor, materials, tool, equipment, and incidentals, and for doing all the work involved in constructing the lime stabilization complete in place, as shown on the plans, and as specified in the specifications and the special provisions, and as directed by the Engineer.
- Full compensation for preparing material, spreading lime and mixing and compacting the lime stabilized material shall be considered as included in the contract price paid per square yard for lime stabilization and no additional compensation will be allowed therefor.
- No adjustment of compensation will be made for any increase or decrease in the quantity of lime required, regardless of the reason for such increase or decrease. The provisions in Section 4-1.03B, "Increased or Decreased Quantities," shall not apply to the item of lime.

SECTION 25: AGGREGATE SUBBASES

25-1.01 DESCRIPTION

- This work shall consist of furnishing, spreading and compacting aggregate subbases as specified in these specifications and the special provisions.
- Aggregate subbases are designated as Class 1, Class 2, Class 3, Class 4 and Class 5. The class of aggregate subbase will be shown on the plans or specified in the special provisions.

25-1.02 MATERIALS

- Aggregate for the various classes of aggregate subbases at the time it is deposited on the roadbed shall conform to the following requirements:

25-1.02A Class 1, Class 2, and Class 3 Aggregate Subbases

- Aggregate for Class 1, Class 2 and Class 3 aggregate subbases shall be clean and free from organic matter and other deleterious substances, and shall be of such nature that it can be compacted readily under watering and rolling to form a firm, stable base. Aggregate may include material processed from reclaimed asphalt concrete, portland cement concrete, lean concrete base, cement treated base or a combination of any of these materials. The amount of reclaimed material shall not exceed 50 percent of the total volume of the aggregate used.
- Aggregate shall conform to the grading and quality requirements shown in the following tables for the Class specified:

AGGREGATE GRADING REQUIREMENTS

Sieve Size	Percentage Passing					
	Class 1		Class 2		Class 3	
	Operating Range	Contract Compliance	Operating Range	Contract Compliance	Operating Range	Contract Compliance
3"	100	100	100	100	100	100
$2^1/_2$"	90-100	87-100	90-100	87-100	90-100	87-100
No. 4	35-70	30-75	40-90	35-95	50-100	45-100
No. 200	0-20	0-23	0-25	0-29	0-30	0-34

QUALITY REQUIREMENTS

Test	Percentage Passing					
	Class 1		Class 2		Class 3	
	Operating Range	Contract Compliance	Operating Range	Contract Compliance	Operating Range	Contract Compliance
Sand Equivalent	21 Min.	18 Min.	21 Min.	18 Min.	21 Min.	18 Min.
Resistance (R-value)	—	60 Min.	—	50 Min.	—	40 Min.

- If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Operating Range" but meet the "Contract Compliance" requirements, placement of the aggregate subbase may be continued for the remainder of that day. However, another day's work may not be started until tests, or other information, indicate to the satisfaction of the Engineer

that the next material to be used in the work will comply with the requirements specified for "Operating Range."

- If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Contract Compliance," the aggregate subbase which is represented by the tests shall be removed. However, if requested by the Contractor and approved by the Engineer, the aggregate subbase may remain in place and the Contractor shall pay to the State $2.00 per cubic yard for the aggregate subbase represented by the tests and left in place. The Department may deduct this amount from any moneys due, or that may become due, the Contractor under the contract. If both the aggregate grading and Sand Equivalent do not conform to the "Contract Compliance" requirements, only one adjustment shall apply.
- No single aggregate grading or Sand Equivalent test shall represent more than 500 cubic yards or one day's production, whichever is smaller.
- When aggregate subbase is to be measured by the ton, the weight will be converted to volume for the purpose of the above paragraphs. Factors for converting tons to cubic yards will be determined by the Engineer.

25-1.02B Class 4 Aggregate Subbase

- Aggregate for Class 4 aggregate subbase shall be clean and free from organic matter and other deleterious substances and shall conform to the grading and quality requirements set forth in the special provisions. Aggregate may include material processed from reclaimed asphalt concrete, portland cement concrete, lean concrete base, cement treated base or a combination of any of these materials. The amount of reclaimed material shall not exceed 50 percent of the total volume of the aggregate used.

25-1.02C Class 5 Aggregate Subbase

- Aggregate for Class 5 aggregate subbase shall be selected from excavation at the locations designated on the plans or in the special provisions and processed to the grading specified in the special provisions.
- The Contractor may break up, crush, screen, waste material or any combination thereof, or use another process that will produce the required grading.
- Excess material resulting from processing shall be used in the construction of embankments or otherwise disposed of within the right of way as directed by the Engineer and full compensation therefor will be considered as included in the contract price paid for excavation.

25-1.03 SUBGRADE

- The subgrade to receive aggregate subbase, immediately prior to spreading, shall conform to the compaction and elevation tolerance specified for the material involved and shall be free of loose or extraneous material.
- Preparation of subgrade for aggregate subbase to be paid for by the ton will not be required, provided the following conditions are complied with:

A. The material placed immediately below the grading plane conforms to all the requirements for the class of aggregate subbase specified in the special provisions.

B. No material of any kind shall project above the grade established by the Engineer at the time placement of aggregate subbase material is started.
C. The pay quantity of aggregate subbase will be the planned volume, adjusted by the amount of any authorized changes, as determined by the Engineer from the dimensions shown on the plans and that volume will be converted to weight measurement. The factor for conversion from volume to weight will be determined by the Engineer, and the Contractor shall agree to the use of that factor prior to furnishing and placing aggregate subbase.
D. No compensation will be allowed for additional aggregate subbase placed by reason of the grading plane being lower than the grade established by the Engineer.

- When aggregate subbase is paid for by the cubic yard, areas of the grading plane which are lower than the grade established by the Engineer may be filled with aggregate subbase. Volumes of aggregate subbase so placed will not be included in the volume calculated for payment. If basement material consists of imported borrow, subbase placed below the grade established by the Engineer will not be measured or paid for as imported borrow.

25-1.04 SPREADING

- Aggregates for subbases shall be delivered to the roadbed as uniform mixtures and shall be deposited in layers or windrows. Segregation shall be avoided and the material shall be free from pockets of coarse or fine material.
- The layers or windrows of aggregate subbase shall be shaped to a thickness that after watering and compacting, the completed subbase shall conform to the required grade and cross section within the tolerance specified in Section 25-1.05, "Compacting."
- When the subgrade for aggregate subbases consists of cohesionless sand, and written permission is granted by the Engineer, a portion of the aggregate subbase may be dumped in piles upon the subgrade and spread ahead in sufficient quantity to stabilize the subgrade. Segregation of aggregates shall be avoided and the material as spread shall be free from pockets of large or fine material.
- Where the required thickness is 0.50-foot or less, the aggregate subbase may be spread and compacted in one layer. Where the required thickness is more than 0.50-foot, the aggregate subbase shall be spread and compacted in 2 or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 0.50-foot. At locations where the aggregate subbase is to be placed over areas inaccessible to the spreading equipment, the aggregate subbase may be spread and compacted by any means to obtain the specified results.

25-1.05 COMPACTING

- Aggregate subbases shall be watered in conformance with the provisions in Section 17, "Watering."
- The relative compaction of each layer of compacted subbase material shall be not less than 95 percent.

- When aggregate subbase is not to be covered, or is to be covered by material which is paid for by the ton, the surface of the finished subbase at any point shall not vary more than 0.08-foot above or below the grade established by the Engineer.
- When aggregate subbase is to be covered by material which is paid for by the cubic yard, the surface of the finished subbase shall not project above the grade established by the Engineer at any point. At locations where the planned thickness of aggregate subbase, less allowable tolerance, is not obtained and is not compensated for by an equivalent thickness of aggregate base or treated base, the Contractor shall take such corrective measures as are necessary to obtain that thickness. If requested by the Contractor and permitted by the Engineer, a deduction will be made from contract payment for aggregate subbase in lieu of correcting the deficient thickness. The deduction will be computed as the product of (a) the deficient thickness less allowable tolerance; (b) the planned width; and (c) the longitudinal distance between locations showing specified thickness, all as determined by the Engineer, multiplied by a fixed price of $11.00 per cubic yard, or the contract bid price, whichever is higher.
- Subbase which does not conform to the above requirements shall be reworked, watered and thoroughly recompacted to conform with the specified requirements.

25-1.06 MEASUREMENT

- Quantities of aggregate subbase to be paid for by the ton will be determined in conformance with the provisions in Section 9-1.01, "Measurement of Quantities."
- Quantities of aggregate subbase to be paid for by the cubic yard will be calculated on the basis of the dimensions shown on the plans adjusted by the amount of any change ordered by the Engineer. No allowance will be made for aggregate subbase placed outside those dimensions unless otherwise ordered by the Engineer.
- No deduction will be made from contract pay quantities of excavation from which material is obtained for Class 5 aggregate subbase. No payment will be made for any stockpiling or additional handling of the material. The quantity of Class 5 aggregate subbase to be paid for shall be the actual quantity placed after deducting excess material in conformance with the provisions in Section 25-1.02C, "Class 5 Aggregate Subbase."

25-1.07 PAYMENT

- Quantities of aggregate subbase will be paid for at the contract price per ton or cubic yard, whichever unit is designated in the contract item, for the class or classes involved.
- The above prices and payments shall include full compensation for furnishing all labor, materials (or processing selected materials), tools, equipment, and incidentals, and for doing all the work involved in hauling and constructing aggregate subbase, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 26: AGGREGATE BASES

26-1.01 DESCRIPTION

- This work shall consist of furnishing, spreading and compacting aggregate bases as specified in these specifications and the special provisions.
- Aggregate bases are designated as Class 2 and Class 3. The class of aggregate base will be shown on the plans or specified in the special provisions.

26-1.02 MATERIALS

- Aggregate for the various classes of aggregate base at the time it is deposited on the roadbed shall conform to the following requirements:

26-1.02A Class 2 Aggregate Base

- Aggregate for Class 2 aggregate base shall be free from organic matter and other deleterious substances, and shall be of such nature that it can be compacted readily under watering and rolling to form a firm, stable base. Aggregate may include material processed from reclaimed asphalt concrete, portland cement concrete, lean concrete base, cement treated base or a combination of any of these materials. The amount of reclaimed material shall not exceed 50 percent of the total volume of the aggregate used.
- Aggregate shall conform to the grading and quality requirements shown in the following tables. At the option of the Contractor, the grading for either the $1^1/_2$-inch maximum or $^3/_4$-inch maximum shall be used, except that once a grading is selected the grading shall not be changed without the Engineer's written approval.

AGGREGATE GRADING REQUIREMENTS

Sieve Sizes	Percentage Passing			
	$1^1/_2$" Maximum		$^3/_4$" Maximum	
	Operating Range	Contract Compliance	Operating Range	Contract Compliance
2"	100	100	—	—
$1^1/_2$"	90-100	87-100	—	—
1"	—	—	100	100
$^3/_4$"	50-85	45-90	90-100	87-100
No. 4	25-45	20-50	35-60	30-65
No. 30	10-25	6-29	10-30	5-35
No. 200	2-9	0-12	2-9	0-12

QUALITY REQUIREMENTS

Test	Operating Range	Contract Compliance
Resistance (R-value)	—	78 Min.
Sand Equivalent	25 Min.	22 Min.
Durability Index	—	35 Min.

- The aggregate shall not be treated with lime, cement or other chemical material before the Durability Index test is performed. Untreated reclaimed asphalt concrete

and portland cement concrete will not be considered to be treated with lime, cement or other chemical material for purposes of performing the Durability Index test.

- If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Operating Range" but meet the "Contract Compliance" requirements, placement of the aggregate base may be continued for the remainder of that day. However, another day's work may not be started until tests, or other information, indicate to the satisfaction of the Engineer that the next material to be used in the work will comply with the requirements specified for "Operating Range."
- If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Contract Compliance," the aggregate base which is represented by these tests shall be removed. However, if requested by the Contractor and approved by the Engineer, the aggregate base may remain in place, and the Contractor shall pay to the State $2.25 per cubic yard for the aggregate base represented by the tests and left in place. The Department may deduct this amount from any moneys due, or that may become due, the Contractor under the contract. If both the aggregate grading and Sand Equivalent do not conform to the "Contract Compliance" requirements, only one adjustment shall apply.
- No single aggregate grading or Sand Equivalent test shall represent more than 500 cubic yards or one day's production, whichever is smaller.
- When aggregate base is to be measured by the ton, the weight will be converted to volume for the purpose of the above paragraphs. Factors for converting tons to cubic yards will be determined by the Engineer.

26-1.02B Class 3 Aggregate Base

- Aggregate for Class 3 aggregate base shall conform to the requirements set forth in the special provisions. Aggregate may include material processed from reclaimed asphalt concrete, portland cement concrete, lean concrete base, cement treated base or a combination of any of these materials. The amount of reclaimed material shall not exceed 50 percent of the total volume of the aggregate used.
- The grading of aggregate for Class 3 aggregate base shall, at the option of the Contractor, conform either to the grading specified in the special provisions or to either the $1^1/_2$-inch maximum or the $^3/_4$-inch maximum grading for Class 2 aggregate base specified in Section 26-1.02A, "Class 2 Aggregate Base." Once a grading is selected, the grading shall not be changed without written approval of the Engineer.

26-1.03 SUBGRADE

- The subgrade to receive aggregate base, immediately prior to spreading shall conform to the compaction and elevation tolerance specified for the material involved, and shall be free of loose or extraneous material.
- When aggregate base is paid for by the cubic yard, areas of the finished surface of aggregate subbase which are lower than the grade established by the Engineer shall be filled with aggregate base. Volumes of aggregate base so placed will not be included in the volume calculated for payment.

- When aggregate subbase is not specified and aggregate base is paid for by the cubic yard, areas of the grading plane which are lower than the grade established by the Engineer may be filled with aggregate base. Volumes of aggregate base so placed will not be included in the volume calculated for payment as stated above. If basement material consists of imported borrow, aggregate base placed below the grade established by the Engineer will not be measured or paid for as imported borrow.

26-1.035 ADDING WATER

- At the time aggregate base is spread it shall have a moisture content sufficient to obtain the required compaction. The moisture shall be uniformly distributed throughout the material.

26-1.04 SPREADING

- Aggregate bases shall be delivered to the roadbed as uniform mixtures. The mixture shall be deposited and spread to the required compacted thickness within the tolerances specified in Section 26-1.05, "Compacting," by means which will maintain the uniformity of the mixture. Each layer shall be free from pockets of coarse or fine material.
- Where the required thickness is 0.50-foot or less, the base material may be spread and compacted in one layer. Where the required thickness is more than 0.50-foot, the base material shall be spread and compacted in 2 or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 0.50-foot.
- Aggregate bases, placed on road approaches and connections, street intersection areas, median strip areas, shoulder areas, and at locations which are inaccessible to the spreading equipment, may be spread in one or more layers by any means to obtain the specified results.
- When the subgrade for aggregate base consists of cohesionless sand, and written permission is granted by the Engineer, a portion of the aggregate base may be dumped in piles upon the subgrade and spread ahead from the dumped material in sufficient quantity to stabilize the subgrade. Segregation of aggregate shall be avoided and each layer shall be free from pockets of coarse or fine material.

26-1.05 COMPACTING

- Aggregate bases, after compaction, shall be watered in conformance with the provisions in Section 17, "Watering."
- The relative compaction of each layer of compacted base material shall be not less than 95 percent.
- The surface of the finished aggregate base at any point shall not vary more than 0.05-foot above or below the grade established by the Engineer.
- When aggregate base is paid for by the cubic yard, and at locations where the planned thickness of aggregate base, less allowable tolerance, is not obtained, the Contractor shall take such corrective measures as are necessary to obtain that thickness. If requested by the Contractor and permitted by the Engineer, a deduction will be made from contract payment for aggregate base in lieu of correcting the deficient thickness. The deduction will be computed as the product of (a) the deficient thickness less allowable tolerance; (b) the planned width; and

(c) the longitudinal distance between locations showing specified thickness, all as determined by the Engineer, multiplied by a fixed price of $17.00 per cubic yard, or the contract bid price, whichever is higher.

- Base which does not conform to the above requirements shall be reshaped or reworked, watered and thoroughly recompacted to conform to the specified requirements.

26-1.06 MEASUREMENT

- Quantities of aggregate base to be paid for by the ton will be measured in conformance with the provisions in Section 9-1.01, "Measurement of Quantities," and in this Section 26-1.06.
- The weight of material to be paid for will be determined by deducting from the weight of material delivered to the work, the weight of water in the material, at the time of weighing, as determined by California Test 226, in excess of one percentage point more than the optimum moisture content as determined by California Test 216. The weight of water deducted in conformance with the provisions in this Section 26-1.06 will not be paid for.
- Quantities of aggregate base to be paid for by the cubic yard will be calculated on the basis of the dimensions shown on the plans adjusted by the amount of any change ordered by the Engineer. No allowance will be made for aggregate base placed outside those dimensions unless otherwise ordered by the Engineer.

26-1.07 PAYMENT

- Quantities of aggregate base will be paid for at the contract price per ton or cubic yard, whichever unit is designated in the contract item, for the class or classes involved.
- The above prices and payments shall include full compensation for furnishing all labor, materials (including water in the material at the time of weighing as provided in Section 26-1.06, "Measurement"), tools, equipment, and incidentals, and for doing all the work involved in constructing aggregate base, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 27: CEMENT TREATED BASES

27-1.01 DESCRIPTION

- This work shall consist of furnishing and mixing aggregate, cement and water, and spreading and compacting the mixture, all as specified in these specifications and the special provisions.
- Cement treated bases are designated as Class A or Class B, and as road-mixed or plant-mixed. The class and type of cement treated base will be shown on the plans or designated in the contract item.
- The portland cement content of Class A or Class B cement treated base shall be as specified in the special provisions.
- The Engineer may order an increase or decrease in the specified portland cement content. If an increase or decrease is ordered, the compensation payable to the Contractor for cement treated base will be increased or decreased in conformance with the provisions in Section 27-1.12, "Payment."

27-1.02 MATERIALS

- Portland cement shall be Type II Modified in conformance with the provisions in Section 90-2.01, "Cement." Mineral admixtures shall not be substituted for portland cement.
- Water shall conform to the provisions in Section 90-2.03, "Water."
- Aggregate for use in Class A cement treated base shall be of such quality that when mixed with Type II Modified portland cement in an amount not to exceed 5 percent by weight of the dry aggregate and compacted at optimum moisture content, the compressive strength of a sample of the compacted mixture shall not be less than 750 psi at 7 days, when tested by California Test 312.
- Aggregate for use in Class B cement treated base shall have a Resistance (R-value) of not less than 60 before mixing with Type II Modified portland cement and a Resistance (R-value) of not less than 80 after mixing with Type II Modified portland cement in an amount not to exceed 2.5 percent by weight of the dry aggregate.
- Aggregate for cement treated base, immediately prior to mixing, shall conform to the following requirements:

Aggregate shall be clean and free from vegetation and other deleterious substances and shall not be treated with lime, cement or other chemicals before being tested for Sand Equivalent value.

The percentage composition by weight of aggregate shall conform to the following gradings when determined by California Test 202, modified by California Test 105 when there is a difference in specific gravity of 0.2 or more between the coarse and fine portions of the aggregate or between blends of different aggregates. Coarse aggregate is material retained on the No. 4 sieve and fine aggregate is material passing the No. 4 sieve:

Sieve Size	Percentage Passing			
	Class A		Class B	
	Operating Range	Contract Compliance	Operating Range	Contract Compliance
3"	—	—	100	100
$2^1/_2$"	—	—	90-100	87-100
1"	100	100	—	—
$^3/_4$"	90-100	87-100	—	—
No. 4	40-70	35-75	35-70	28-77
No. 30	12-40	7-45	—	—
No. 200	3-15	0-19	3-20	0-24

Aggregate shall have a Sand Equivalent of not less than the following:

Operating Range	21
Contract Compliance	18

If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Operating Range" but meet the "Contract Compliance" requirements, placement of the cement treated base may be continued for the remainder of that day. However, another day's work may not be started until tests, or other information, indicate to the satisfaction of the Engineer that the next material to be used in the work will comply with the requirements specified for "Operating Range."

If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Contract Compliance," the cement treated base which is represented by these tests shall be removed. However, if requested by the Contractor and approved by the Engineer, the cement treated base may remain in place and the Contractor shall pay to the State $2.50 per cubic yard for the cement treated base represented by these tests and left in place. The Department may deduct this amount from any moneys due, or that may become due, the Contractor under the contract. If both the aggregate grading and Sand Equivalent do not conform to the "Contract Compliance" requirements, only one adjustment shall apply.

No single aggregate grading or Sand Equivalent test shall represent more than 500 cubic yards or one day's production, whichever is smaller.

When cement treated base is to be measured by the ton, the weight will be converted to volume for the purpose of the above paragraphs. Factors for converting tons to cubic yards will be determined by the Engineer.

27-1.03 SUBGRADE

The subgrade to receive cement treated base, immediately prior to spreading, shall conform to the compaction and elevation tolerance specified for the material involved, and shall be free of loose or extraneous material.

27-1.04 DEPOSITING AGGREGATE AND MIXING ROAD-MIXED CEMENT TREATED BASE

Aggregates and cement shall be deposited and mixed in accordance with the following:

27-1.04A Depositing Aggregate

Sufficient untreated aggregate for cement treated base shall be deposited on the roadbed to provide a cement treated base conforming to the width and depth specified in Section 27-1.06, "Spreading Treated Mixture," and the grade tolerance specified in Section 27-1.07, "Compacting." Aggregate to be treated shall not be mixed with roadbed material that is not to be treated.

When aggregate for road-mixed cement treated base is deposited on the grade as 2 or more nominal sizes of coarse and fine aggregate, each nominal size shall be accurately and uniformly metered as it is deposited. Before adding cement the nominal sizes shall be mixed by machine as many times as necessary to produce a uniform mixture of aggregate conforming to the specified grading.

When mixing is to be done from windrows, the windrows shall be shaped to a uniform cross section by means of a sizing device. Use of a motor grader for this purpose will not be permitted, unless equipped with a sizing device.

Aggregate mixed with cement and water prior to delivery on the roadbed shall be deposited and spread upon the prepared subgrade as specified in Section 27-1.06, "Spreading Treated Mixture."

27-1.04B Mixing

Road-mixed cement treated base may be mixed either on the roadbed or at a location off the roadbed by the road-mixed method, or by the plant-mixed method as the Contractor may elect.

If the Contractor elects to use the plant-mixed method, all of the provisions in Section 27-1.05, "Proportioning and Mixing Plant-Mixed Cement Treated Base," shall apply, except a Class 2 batch plant may be used.

If the Contractor elects to use the road-mixed method, the road-mixing machine shall be capable of uniformly distributing the cement and water in order to meet the cement content requirements.

The cement shall be uniformly spread by mechanical equipment in the amount necessary to meet the cement content requirements. When cement is added to windrowed aggregates, the top of the windrows shall be flattened or slightly trenched to receive the cement. When cross-shaft mixers are used, the cement shall be spread uniformly over the entire surface of the in-place aggregate. Cement shall not be spread on the aggregate more than 4 hours ahead of the road-mixing operation.

The road-mixing machine shall have provisions for introducing water at the time of mixing, through a metering device or by other approved methods. The water shall be applied by means of controls that will supply the correct quantity of water to produce a completed mixture with a uniform moisture content. Leakage of water from equipment, or application of excessive amounts of water, shall be corrected before proceeding further.

- The moisture content of the completed mixture, as determined by California Test 226, shall be at least optimum moisture content less one percentage point immediately prior to initial compaction. The optimum moisture content will be determined by California Test 312.
- When the material is to be spread and compacted in 2 or more layers, material for each layer shall be mixed separately.
- The resulting mixture shall be uniform and more than one pass of the mixer through the material may be required. If equipment is used that requires more than one pass of the mixer, at least one pass shall be made before any water is added to the material.
- The cement content of the completed mixture of cement treated base, after it has been spread on the subgrade and prior to initial compaction, shall not vary above or below the specified cement content (or ordered cement content) by more than 0.6-percent of the weight of the dry aggregate when sampled and tested in conformance with the requirements in California Test 338.
- The length of treated sections shall be regulated to permit completion within the time requirements provided in Section 27-1.08, "Operation Time Requirement."
- Should the Contractor elect to perform road-mixing operations off the roadbed, the provisions specified in this Section 27-1.04B for mixing on the roadbed shall apply.

27-1.05 PROPORTIONING AND MIXING PLANT-MIXED CEMENT TREATED BASE

- Aggregates and cement shall be proportioned and mixed in conformance with the following:

27-1.05A General Requirements

- Plant-mixed cement treated bases shall be mixed at a central mixing plant by either batch type mixing using revolving blade or rotary drum mixers or by continuous type mixing, at the option of the Contractor. The aggregates and cement may be proportioned either by weight or by volume.
- In all plants, the water shall be proportioned by weight or volume, and there shall be means by which the Engineer may readily verify the amount of water per batch or the rate of flow for continuous mixing. The time of the addition of water or the points at which it is introduced into the mixer shall be as approved by the Engineer.
- The moisture content of the completed mixture, as determined by California Test 226, shall be at least optimum moisture content less one percentage point at the point of delivery to the work. The optimum moisture content will be determined by California Test 312.
- In all plants, cement shall be added in such a manner that it is uniformly distributed throughout the aggregates during the mixing operation.
- Safe, convenient facilities shall be provided for sampling cement in the supply line to the weigh hopper or pugmill.
- The charge in a batch mixer, or the rate of feed to a continuous mixer, shall not exceed that which will permit complete mixing of all of the material. Dead areas in

the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected.

- The cement content of the completed mixture of cement treated base, after it has been spread on the subgrade and prior to initial compaction, shall not vary above or below the specified cement content (or ordered cement content) by more than 0.6-percent of the weight of the dry aggregate when sampled and tested in conformance with the requirements in California Test 338.
- Proportioning scales required by these specifications shall conform to the provisions in Section 9-1.01, "Measurement of Quantities."

27-1.05B Batch Mixing

- Batch mixing plants shall be Class 1 unless Class 2 is specified in the special provisions.
- Class 1 plants shall conform to the provisions in Section 27-1.05A, "General Requirements," and the following requirements:

The mixer shall be equipped with a sufficient number of paddles of a type and arrangement to produce a uniformly mixed batch.

The mixer platform shall be of ample size to provide safe and convenient access to the mixer and other equipment.

The mixer shall be equipped with a timing device which will indicate by a definite audible or visual signal the expiration of the mixing period. The device shall be accurate to within 2 seconds.

The time of mixing a batch shall begin after all ingredients are in the mixer and shall end when the mixer is half emptied. Mixing shall continue until a homogeneous mixture of uniformly distributed and properly coated aggregates of unchanging appearance is produced and tests indicate that the cement content consistently conforms to the provisions in Section 27-1.05A, "General Requirements." The time of mixing shall not be less than 30 seconds.

- Class 1 plants shall be equipped with automatic sampling devices that are actuated by operation of a push button or similar device, and which will simultaneously deliver a representative sample of each size of aggregate or of the combined aggregates to receptacles of adequate size. Each sample shall weigh not less than 55 pounds nor more than 65 pounds. The receptacles shall be in a location which is safely clear of plant operations and to which access by the Engineer is convenient.
- Class 2 plants shall conform to the provisions in Section 27-1.05A, "General Requirements," and this Section 27-1.05B, except as follows:

The timing device will not be required.

The automatic sampling device will not be required, however, sampling facilities which are satisfactory to the Engineer shall be provided. Sampling facilities shall allow representative samples of aggregate and the mixture to be obtained easily and safely.

- When different sizes of aggregates are used, the aggregates shall be blended as they enter the mixer.
- Cement for each batch shall be weighed on scales separate and distinct from the aggregate batching scales. Each cement scale graduation shall be approximately $^{1}/_{1,000}$ of the total capacity of the scale. The total capacity shall not exceed that of the smallest capacity commercially available scales capable of weighing twice the amount of cement to be weighed when the plant is operated at full capacity. No scale will be required to have a total capacity of less than 1,000 pounds nor a scale graduation of less than one pound.

27-1.05C Continuous Mixing

- In addition to the requirements in Section 27-1.05A, "General Requirements," mixing of the materials shall conform to the following requirements:

Aggregate shall be drawn from the storage facility by a feeder or feeders which will continuously supply the correct amount of aggregate in proportion to the cement, and so arranged that the proportion of each aggregate size can be separately adjusted if more than one size is used. Storage facilities containing fine aggregate shall be equipped with a vibrating unit which will effectively vibrate the side walls of the feeder and prevent any "hang-up" of material while the plant is operating.

A control system shall be provided that will automatically close down the plant when the material in any storage facility approaches the strike-off capacity of the feed gate. The plant shall not be permitted to operate unless this automatic control system is in good working condition.

The feeder for the aggregate shall be mechanically or electrically driven.

Aggregate feeders that are driven mechanically shall be connected directly to the drive on the cement feeder. The drive shaft on the feeder shall be equipped with a revolution counter reading to $^{1}/_{10}$ revolution and of sufficient capacity to register the total number of revolutions in a day's run.

Aggregate feeders that are driven electrically shall be actuated from the same circuit that serves the motor driving the cement feeder. A frequency meter shall be connected to the circuit to the cement feeder motor if electric power is obtained from a non-commercial source. The meter shall have a range from 57 Hz to 63 Hz, minimum, and shall be graduated in one-Hz increments, or less.

A voltage regulating transformer shall be installed in the circuit to vibratory-type aggregate feeders. The transformer shall maintain the voltage to the motors for the feeders to within one percent of their nameplate voltage. A voltmeter shall be connected to the secondary of the voltage regulating transformer. The meter shall have a range of from -10 percent to +10 percent of the motor nameplate voltage, and shall be graduated in increments of one percent of the nameplate voltage, or less.

Power to plants equipped with electrically actuated aggregate feeders shall have a frequency of 60 ±1 Hz.

Continuous mix plants shall be equipped with an automatic sampling device specified for Class 1 plants in Section 27-1.05B, "Batch Mixing," of such nature that samples may be obtained while the plant is in full operation.

The cement feeder and the aggregate feeders shall be equipped with devices by which the rate of feed can be determined while the plant is in full operation.

27-1.06 SPREADING TREATED MIXTURE

- Materials mixed at a location off the roadbed shall be transported as a uniform mixture, and, when required by the Engineer, shall be protected against moisture loss by covers. The mixture shall be deposited on the roadbed at a quantity per linear foot, which will provide the compacted thickness for the width being spread without resort to spotting, picking up or otherwise shifting the mixture.
- Immediately prior to depositing plant-mixed cement treated base or spreading road-mixed cement treated base, the area to be covered shall be moistened and kept moist, but not excessively wet.
- Segregation shall be prevented and the mixture shall be free from pockets of coarse or fine material.
- The mixed materials shall be spread in widths of not less than 2 lanes, insofar as the width of cement treated base to be spread permits. Three-lane sections may be spread as a 2-lane width and a one-lane width. Materials shall be spread either by one spreader or by several spreaders operating in a staggered position across the subgrade, unless traffic conditions require that less than 2 lanes be spread. If traffic conditions require that less than 2 lanes be spread, not more than 2 hours shall elapse between the time of placing the material in adjacent lanes to result in a 2-lane width. However, if traffic conditions preclude placement of cement treated base in adjacent lanes within 2 hours, the Engineer may authorize such longer time as may be necessary.
- Longitudinal construction joints shall fall within one foot of lane lines.
- The maximum compacted thickness of any one layer shall not exceed 0.50-foot and the minimum thickness shall not be less than 0.25-foot. When cement treated base is placed in more than one layer the surface of the lower layer of compacted material shall be kept moist until covered with the next layer or with the curing seal. Curing seal, in conformance with the provisions in Section 27-1.10, "Curing," shall be applied to the surface of a lower layer which has not been covered with the next layer on the same day. Full compensation for keeping lower layers moist and for furnishing and applying curing seal to the lower layers as specified will be considered as included in the contract price paid for cement treated base and no separate payment will be made therefor.
- Cement treated base placed on areas inaccessible to mechanical spreading equipment may be spread in one layer by methods approved by the Engineer. After spreading, the material shall be thoroughly compacted to the required lines, grades and cross section by means of pneumatic tampers, or with other compacting equipment which consistently obtains the degree of compaction required in Section 27-1.07, "Compacting."
- Cement treated base shall not be mixed or placed while the atmospheric temperature is below 35° F, and shall not be placed on frozen ground. A curing

seal in conformance with the provisions in Section 27-1.10, "Curing," shall be applied to the surface of the completed cement treated base before the atmospheric temperature falls below 35° F.

• In addition to the above, cement treated base shall be spread in conformance with one of the following types of spreading operations. Unless otherwise specified in the special provisions, Type 3 spreading operation shall be used on ramps and Type 1 shall be used at all other locations.

Type 1 Spreading Operation.— The mixture shall be spread in one operation with a self-propelled mechanical spreader ready for compaction without further shaping. Equipment not propelled by the unloading vehicle will be considered self-propelled. The spreader shall be provided with a screed that strikes off and distributes the material to the full width being spread and to the surface tolerances specified in Section 27-1.07, "Compacting." The screed shall be adjustable to produce the required cross section. Screed action includes any cutting, crowding or other practical motion that produces a finished surface texture of uniform appearance. In addition, mechanical spreader equipment used to spread and trim cement treated base shall be equipped with fully automatic screed and grade sensing controls which shall control the longitudinal grade and transverse slopes of the screed. Screed controls shall be such that compensation for differences from the slope and grade established by the Engineer will be completely automatic.

Type 2 Spreading Operation.— The mixture shall be spread in one operation with a self-propelled mechanical spreader ready for compaction without further shaping. Equipment not propelled by the unloading vehicle will be considered self-propelled. The spreader shall be provided with a screed that strikes off and distributes the material to the full width being spread and to the surface tolerances specified in Section 27-1.07, "Compacting." The screed shall be adjustable to produce the required cross section. Screed action includes any cutting, crowding or other practical motion that produces a finished surface texture of uniform appearance.

Type 3 Spreading Operation.— The treated mixture may be spread by the equipment that the Contractor elects, which will consistently finish the base within the tolerance specified in Section 27-1.07, "Compacting," and which does not result in segregation.

• Except as otherwise provided in this Section 27-1.06, the use of motor graders will not be permitted during spreading and compacting operations. Motor graders may be used to trim the edges and surface of the cement treated base after initial compaction in order to finish the base within the tolerances specified. A motor grader will be considered to be a self-propelled mechanical spreader if it has been equipped with end wings on the blade, has the blade locked in a position normal to the direction of travel, and is equipped with cross slope and automatic grade controls that meets the requirements for the specified type of spreading.

27-1.07 COMPACTING

- Compacting equipment shall produce the required compaction within the operation time limit specified in Section 27-1.08, "Operation Time Requirement."
- Compaction shall follow immediately after the spreading operation, and shall consist of at least one complete coverage of the treated material.
- When the finished surface after initial compaction is outside the tolerance specified hereinafter, high spots shall be trimmed off to within the specified tolerance. Filling of low areas by drifting or hauling of trimmed material is prohibited. Following trimming, trimmed areas shall receive one complete coverage and have such additional compaction performed that the entire layer of cement treated base conforms to the compaction requirements hereinafter specified. Final compaction shall be accomplished in such a manner that no loose material remains on the surface and tear marks are eliminated.
- When cement treated base is spread and compacted in more than one layer, each lower layer shall be compacted to the required degree of compaction before placing the next layer. Only such trimming will be required as is necessary to meet the requirements for layer thickness contained in Section 27-1.06, "Spreading Treated Mixture."
- The relative compaction of cement treated base shall be not less than 95 percent. The compaction shall be determined by California Test 312 or 231 for Class A cement treated base. Each layer of cement treated base may be tested for compaction, or all layers may be tested together, at the option of the Engineer. When all layers are tested together, the Contractor will not be relieved of the responsibility to achieve the required compaction in each layer placed.
- The finished surface of cement treated base shall be uniform and shall not deviate at any point more than 0.03-foot from the bottom of a 12-foot straightedge laid in any direction.
- The surface of the finished cement treated base at any point shall not vary more than 0.05-foot above or below the grade established by the Engineer, except that when portland cement concrete pavement is to be placed on cement treated base, the surface of the cement treated base at any point shall not extend above the grade established by the Engineer.
- Areas of the finished cement treated base which are lower than 0.05-foot below the grade established by the Engineer shall be removed and replaced with cement treated base which complies with requirements of these specifications, or if permitted by the Engineer, shall be filled as hereinafter specified.
- When surfacing material is asphalt concrete, the low areas shall be filled with asphalt concrete conforming to the requirements for the lowest layer of asphalt concrete to be placed as surfacing. This filling shall be done as a separate operation prior to placing the lowest layer of surfacing, and full compensation for this filling will be considered as included in the contract price paid for cement treated base and no additional compensation will be allowed therefor.
- When surfacing material is portland cement concrete, the low areas shall be filled with pavement concrete at the time and in the same operation that the surfacing is placed. Full compensation for this filling will be considered as

included in the contract price paid for portland cement concrete pavement and no additional compensation will be allowed therefor.

- The surface shall be kept moist at all times until the curing seal is applied.
- Excess material may be placed as aggregate for shoulder construction subject to the following conditions:

A. The shoulder subgrade shall be prepared as specified.
B. Hardened chunks of trimmed material shall be removed or reduced to the maximum size specified for shoulder aggregate prior to spreading additional shoulder aggregate.
C. The amount of trimmed material incorporated in the shoulder shall not exceed 25 percent of the planned volume of shoulder aggregate per linear foot of shoulder. When trimmings exceed this limit, the excess shall be removed and may be placed in other shoulder areas, in conformance with the 25 percent limit.
D. The excess material shall be uniformly distributed in the shoulder area prior to spreading additional shoulder aggregate.

- The excess material may also be used at other locations in the work provided the excess material complies with applicable specification requirements, or shall be otherwise disposed of as permitted by the Engineer.
- When excess material is placed in an area in which the item is measured by the ton, payment as the item where placed will not be allowed unless applicable measurement specifications are complied with.
- When cement treated base is paid for by the ton, the quantity of excess material will be deducted from the quantity of cement treated base as measured in Section 27-1.11, "Measurement," except for that quantity used in the shoulders under the conditions specified herein.

27-1.08 OPERATION TIME REQUIREMENT

- Not more than 2 hours shall elapse between the time water is added to the aggregate and cement, and the time of completion of initial compaction prior to trimming. Not more than 2.5 hours shall elapse between the time water is added to the aggregate and cement and the time of completion of final compaction after trimming.

27-1.09 CONSTRUCTION JOINTS

- At the end of each day's work and when cement treated base operations are delayed or stopped for more than 2 hours, a construction joint shall be made in thoroughly compacted material, normal to the centerline of the roadbed, with a vertical face. Additional mixture shall not be placed until the construction joint has been approved by the Engineer.
- Where cement treated base has been finally compacted more than one hour, longitudinal joints shall be constructed by cutting vertically into the existing edge for approximately 3 inches. The material cut away may be disposed of as specified for excess material in Section 27-1.07, "Compacting." The face of the cut joints shall be moistened in advance of placing the adjacent base.

27-1.10 CURING

- The completed cement treated base shall be covered with an asphaltic emulsion curing seal. The curing seal shall be asphaltic emulsion, Grade SS1 or CSS1, conforming to the provisions in Section 94, "Asphaltic Emulsions."
- Asphaltic emulsion for curing seal shall be diluted and mixed thoroughly with additional water on the basis of one part added water to one part asphaltic emulsion. The added water shall be of such quality that it will not cause premature separation of the emulsion. Diluted asphaltic emulsion curing seal shall be applied uniformly at a rate of between 0.20-gallon per square yard and 0.30-gallon per square yard of surface. The exact rate will be determined by the Engineer.
- The curing seal shall be applied on the same day that final compaction is performed and as soon after final compaction as is practicable. The surface shall be kept moist until the seal is applied.
- Damage to the curing seal or cement treated base shall be promptly repaired by the Contractor at the Contractor's expense, as directed by the Engineer, and all loose material shall be removed from the cement treated base surface before placing paving over the cement treated base.

27-1.11 MEASUREMENT

- The quantity of cement treated base to be paid for will be measured either by the cubic yard or ton for each type and class indicated in the Engineer's Estimate.
- The quantity of cement treated base to be paid for by the cubic yard will be determined as follows:

The volume to be paid for will be calculated on the basis of the dimensions shown on the plans adjusted by the amount of any change ordered by the Engineer. No allowance will be made for cement treated base placed outside those dimensions unless otherwise ordered by the Engineer.

The quantity of cement treated base placed below the grade established by the Engineer will not be paid for.

Deduction will be made from contract payment for cement treated base for areas which are deficient in thickness and for which the deficient thickness has not been compensated by filling of low areas as specified in Section 27-1.07, "Compacting." The deduction will be computed as the product of (a) the deficient thickness less allowable tolerance; (b) spread width; and (c) longitudinal distance between locations showing specified thickness, all as determined by the Engineer, multiplied by a fixed price of $28.00 per cubic yard, or the contract bid price, whichever is higher. The longitudinal distance between thickness measurements will not exceed 1,000 linear feet for each direction of travel. When requested by the Contractor, the Engineer will make additional measurements at the Engineer's discretion to define the area of deficient thickness, but the cost of making those measurements will be deducted from moneys due the Contractor.

If an increase or decrease in the specified quantity of portland cement is ordered by the Engineer, the quantity of cement subject to increased or decreased compensation, in conformance with the provisions in Section 27-1.12, "Payment," will be the difference between the specified theoretical

quantity of cement and the theoretical quantity of cement ordered by the Engineer. The theoretical quantity of cement will be determined by use of the following formula:

$$W_c = \frac{1686C \times V(D - M)}{100 + C}$$

Where:

W_c = Theoretical quantity of cement in pounds
C = Percentage of cement in the mix
V = Pay volume of CTB in cubic yards
D = Average in-place wet density in g/cc
M = Average in-place moisture in g/cc

- The quantity of cement treated base to be paid for by the ton will be determined as follows:

The quantity of cement treated base to be paid for will be the sum of the weight of the aggregate used in the mix and the weight of cement to be added to the mix, as provided herein.

The quantity of aggregate for road-mixed cement treated base that is mixed on the roadbed, and is to be paid for by the ton, will be measured before delivery to the roadbed in conformance with the provisions in Section 9-1.01, "Measurement of Quantities," except that the weight to be paid for will be determined by deducting from the weight of the aggregate, the weight of the water in the aggregate at the time of weighing in excess of 3 percent of the dry weight of the aggregate.

When road-mixed cement treated base is mixed by the road-mixed method the quantity of portland cement to be included in the quantity of the combined item of road-mixed cement treated base for payment will be the weight, in tons, calculated by multiplying the specified percentage of cement to be added to the mix by the weight of dry aggregate. The percentage will be specified in the special provisions.

The quantity of plant-mixed cement treated base or road-mixed cement treated base that is mixed by the plant-mixed method will be measured, after mixing, in conformance with the provisions in Section 9-1.01, "Measurement of Quantities," except that moisture in excess of 3 percent of the dry weight of the mixture will be deducted from the weight of the combined aggregate, cement and water. When the specified quantity of portland cement is increased in plant-mixed cement treated base or road-mixed cement treated base mixed by the plant-mixed method, the weight of cement subject to increased compensation, as provided in Section 27-1.01, "Description," shall be deducted from the combined weight of aggregate and cement.

- The quantity of asphaltic emulsion (curing seal) to be paid for will be determined in conformance with the provisions in Section 94, "Asphaltic Emulsions."

27-1.12 PAYMENT

- The items of work, measured as specified in Section 27-1.11, "Measurement," will be paid for at the contract prices per ton for asphaltic emulsion (curing seal) and per cubic yard or ton for cement treated base of each type and class indicated in the Engineer's Estimate.
- If the Engineer orders an increase or decrease in the specified portland cement content in conformance with the provisions in Section 27-1.01, "Description," the compensation payable to the Contractor for cement treated base will be increased or decreased on the basis of the cost of cement per ton, f.o.b. the cement mill (including sales tax) plus the freight cost per ton, for delivery of the cement to the project from the mill. In determining the cost of the cement, any cash or trade discount offered or available will be credited to the State notwithstanding the fact that the discount may not have been taken by the purchaser.
- The Contractor shall furnish to the Engineer satisfactory evidence of the cost of cement used on the project during the period involved in the ordered change in cement content, and the Contractor shall maintain records in such a manner as to enable a clear determination of the cost of cement used during the period. The Contractor's records pertaining to the cost of cement shall be open to inspection or audit by Departmental representatives during the life of the contract and for not less than 3 years after the completion thereof and the Contractor shall retain the records for that period.
- If the price of cement as determined from the Contractor's records is, in the opinion of the Engineer, excessive, or if the Contractor does not furnish satisfactory evidence of the cost of cement, the Engineer will determine the price to be the lowest wholesale cost at which cement would be available in the quantities concerned delivered to the jobsite, less any discounts available.
- No additional adjustment of compensation will be made for variations in the cost of any work resulting from an ordered change in the quantity of portland cement.
- The above prices and payments shall include full compensation for furnishing all labor, materials (including cement in the amount specified), tools, equipment, and incidentals, and for doing all the work involved in constructing cement treated base, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- Full compensation for furnishing water for mixing with asphaltic emulsion shall be considered as included in the contract price paid per ton for asphaltic emulsion (curing seal) and no additional compensation will be allowed therefor.

SECTION 28: LEAN CONCRETE BASE

28-1.01 DESCRIPTION

- This work shall consist of constructing a lean concrete base to the lines, grades, and dimensions shown on the plans and in accordance with these specifications and the special provisions.
- Lean concrete base shall consist of a mixture of aggregate, portland cement, water and, at the option of the Contractor, chemical admixtures (for reducing water) and air-entraining admixtures.
- The air content of lean concrete base shall not exceed 4 percent. An admixture to reduce air entrainment shall be used when the aggregate for the lean concrete base is produced from reclaimed material containing asphalt or other material which would cause the air content in the lean concrete base to exceed 4 percent.
- The portland cement content of lean concrete base shall be not less than 270 pounds per cubic yard except that, after testing samples of the Contractor's proposed aggregate supply, the Engineer may order an increase in the cement content. If an increase is ordered, the compensation payable to the Contractor for lean concrete base will be increased as provided in Section 28-1.10, "Payment."

28-1.02 MATERIALS

- Portland cement shall be Type II Modified conforming to the provisions in Section 90-2.01, "Cement." Mineral admixtures shall not be substituted for portland cement.
- Water shall conform to the provisions in Section 90-2.03, "Water."
- Chemical admixtures for reducing water shall be Type A or Type F conforming to the requirements in ASTM Designation: C 494.
- Air-entraining admixtures shall conform to the provisions in Section 90-4, "Admixtures."
- The Contractor shall notify the Engineer, in writing, of the source and grading of the aggregate to be used in the lean concrete base. The material shall be available to the Engineer for sampling and testing at least 45 days prior to scheduled placing of lean concrete base. Should the Contractor change the source of supply, the Contractor shall notify the Engineer in writing of the new source and grading, and make that material available for sampling and testing at least 45 days prior to intended use.
- Aggregate shall be of such quality that, when mixed with Type II Modified portland cement in an amount not to exceed 300 pounds per cubic yard, and tested in conformance with the requirements in California Test 548, the compressive strength of a sample will be not less than 700 psi at 7 days.
- Aggregate for lean concrete base shall be clean and free from vegetable matter and other deleterious substances and shall not be treated with lime, cement or other chemicals before being tested for Sand Equivalent value.
- At the option of the Contractor, the grading for the $1^1/_2$-inch maximum or the one-inch maximum shall be used, except that once a grading is selected, the grading shall not be changed without the Engineer's written approval.
- The percentage composition by weight of aggregate for the grading selected shall conform to the following when determined by California Test 202, modified

by California Test 105 when there is a difference in specific gravity of 0.2 or more between the coarse and fine portion of the aggregate or between blends of different aggregates. Coarse aggregate is material retained on the No. 4 sieve and fine aggregate is material passing the No. 4 sieve.

Sieve Sizes	Percentage Passing			
	1 1/2" Maximum		1" Maximum	
	Operating Range	Contract Compliance	Operating Range	Contract Compliance
2"	100	100	—	—
1 1/2"	90 - 100	87 - 100	100	100
1"	—	—	90 - 100	87 - 100
3/4"	50 - 85	45 - 90	50 - 100	45 - 100
3/8"	40 - 75	35 - 80	40 - 75	35 - 80
No. 4	25 - 60	20 - 65	35 - 60	30 - 65
No. 30	10 - 30	6 - 34	10 - 30	6 - 34
No. 200	0 - 12	0 - 15	0 - 12	0 - 15

- Aggregate shall have a Sand Equivalent value of not less than the following:

Operating Range	21
Contract Compliance	18

- If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Operating Range" but meet the "Contract Compliance" requirements, placement of the lean concrete base may be continued for the remainder of that day. However, another day's work may not be started until tests, or other information, indicate to the satisfaction of the Engineer that the next material to be used in the work will comply with the requirements specified for "Operating Range."
- If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Contract Compliance," the lean concrete base which is represented by these tests shall be removed. However, if requested by the Contractor and approved by the Engineer, the lean concrete base may remain in place, and the Contractor shall pay to the State $2.50 per cubic yard for the lean concrete base represented by these tests and left in place. The Department may deduct this amount from any moneys due, or that may become due, the Contractor under the contract. If both the aggregate grading and Sand Equivalent do not conform to the "Contract Compliance" requirements, only one adjustment shall apply.
- No single aggregate grading or Sand Equivalent test shall represent more than 500 cubic yards or one day's production, whichever is smaller.

28-1.03 SUBGRADE

- The subgrade to receive lean concrete base, immediately prior to placing the lean concrete base thereon, shall conform to the compaction and elevation

tolerances specified for the material involved, shall be free of loose or extraneous material, and shall be uniformly moist.

- Areas of the subgrade to receive lean concrete base which are lower than the grade established by the Engineer shall be filled with lean concrete base. Volumes of lean concrete base so placed will not be included in the volume calculated for payment.

28-1.04 PROPORTIONING, MIXING AND TRANSPORTING

- Proportioning for lean concrete base shall conform to the provisions for proportioning concrete pavement in Section 90-5, "Proportioning," except that dividing of aggregate into sizes will not be required.
- Mixing and transporting lean concrete base shall conform to the provisions for mixing and transporting concrete in Section 90-6, "Mixing and Transporting," except that the second, third and fourth paragraphs of Section 90-6.06, "Amount of Water and Penetration," shall not apply. Lean concrete base shall have a nominal penetration range of 0 inches to $1^1/_2$ inches, and the maximum penetration shall not exceed 2 inches.

28-1.05 PLACING

- Placing of lean concrete base shall conform to the provisions for placing concrete pavement in Section 40-1.06, "Placing," except that the third paragraph in Section 40-1.06 shall not apply.
- Unless otherwise required by the plans or the special provisions, lean concrete base shall be constructed in not less than 12-foot widths separated by contact joints. Lean concrete base constructed monolithically in widths greater than 26 feet shall be constructed with a longitudinal weakened plane joint offset not more than 3 feet from the centerline of the width being constructed.
- Longitudinal weakened plane joints in lean concrete base shall be the insert type conforming to the provisions in Section 40-1.08B(2), "Insert Method."
- When portland cement concrete pavement is to be placed over lean concrete base, longitudinal contact joints and longitudinal weakened plane joints in the lean concrete base shall not be within one foot of planned longitudinal weakened plane joints nor longitudinal contact joints in the concrete pavement.
- Lean concrete base shall not be mixed nor placed while the atmospheric temperature is below 35° F, and shall not be placed on frozen ground.

28-1.06 SPREADING, COMPACTING AND SHAPING

- Lean concrete base shall be spread, compacted and shaped in conformance with the provisions for spreading, compacting and shaping concrete pavement in the first and fourth paragraphs of Section 40-1.07, "Spreading, Compacting and Shaping."
- In advance of curing operations, lean concrete base to be surfaced with asphalt concrete shall be textured with a drag strip of burlap, a broom or a spring steel tine device which will produce scoring in the finished surface. The scoring shall be parallel with the centerline or transverse thereto. The operation shall be performed at a time and in a manner to produce the coarsest texture practical for the method used.

- Lean concrete base to be surfaced with portland cement concrete pavement shall not be textured and shall be finished to a smooth surface, free of mortar ridges and other projections, before curing compound is applied.
- The finished surface of lean concrete base shall be free from porous areas. It shall not vary at any point more than 0.05-foot above or below the grade established by the Engineer.

28-1.07 CURING

- Lean concrete base shall be cured with pigmented curing compound in conformance with the provisions in Sections 90-7.01B, "Curing Compound Method," and 90-7.02, "Curing Pavement," except that curing compound for lean concrete base to be surfaced with portland cement concrete pavement shall be curing compound (3) as specified in Section 90-7.01B, and shall contain 22 percent minimum nonvolatile vehicles consisting of at least 50 percent paraffin wax. Curing compound shall be applied in 2 separate applications to the area to be surfaced with portland cement concrete pavement. Each application of curing compound shall be applied at the approximate rate of one gallon per 150 square feet.
- Curing compound shall be applied to the surface of the lean concrete base before the atmospheric temperature falls below 40° F.
- Any portion of lean concrete base to be covered with portland cement concrete pavement that is not covered with pavement by the fourth day after the curing compound is applied, shall be given a subsequent application (or applications, if necessary) of curing compound so that curing compound application occurs no more than 4 days in advance of placing the overlying concrete pavement. The surface of the lean concrete base shall be cleaned of all foreign material and then the curing compound applied at a rate of approximately one gallon per 200 square feet per subsequent application.
- Damage to the curing compound or the lean concrete base shall be promptly repaired by the Contractor at the Contractor's expense, as directed by the Engineer.

28-1.08 SURFACES NOT WITHIN TOLERANCE

- Hardened lean concrete base with a surface higher than 0.05-foot above the grade established by the Engineer shall be removed and replaced with lean concrete base which complies with these specifications, or if permitted by the Engineer, high areas may be ground until the surface of lean concrete base conforms to the tolerances specified. Grinding shall be performed with diamond blade or with carborundum blade grinding equipment. The ground area of lean concrete base that is to be covered with portland cement concrete pavement shall be cleaned of all foreign material and grinding residue as soon as any free water has left the surface and curing compound, as specified for curing, shall be applied at the rate of approximately one gallon per 150 square feet.
- Hardened lean concrete base with a surface lower than 0.05-foot below the grade established by the Engineer shall be removed and replaced with lean concrete base which complies with these specifications, or if permitted by the Engineer, the low areas shall be filled with pavement material as follows:

When pavement material is asphalt concrete, the low areas shall be filled with asphalt concrete conforming to the requirements for the lowest layer of asphalt concrete to be placed as pavement. This shall be done as a separate operation prior to placing the lowest layer of pavement, and full compensation for this filling will be considered as included in the contract price paid per cubic yard for lean concrete base and no additional compensation will be allowed therefor.

When pavement material is portland cement concrete, the low areas shall be filled with pavement concrete at the time and in the same operation that the pavement is placed. Full compensation for this filling will be considered as included in the contract price paid per cubic yard for lean concrete base and no additional compensation will be allowed therefor.

28-1.09 MEASUREMENT

The quantity of lean concrete base to be paid for will be measured by the cubic yard. The volume to be paid for will be calculated on the basis of the dimensions shown on the plans adjusted by the amount of any change ordered by the Engineer. No allowance will be made for lean concrete base placed outside those dimensions unless otherwise ordered by the Engineer.

28-1.10 PAYMENT

The contract price paid per cubic yard for lean concrete base shall include full compensation for furnishing all labor, materials (including cement in the amount of 270 pounds per cubic yard of lean concrete base), tools, equipment and incidentals, and for doing all the work involved in constructing lean concrete base as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

If the Engineer orders an increase in the specified portland cement content as provided in Section 28-1.01, "Description," the compensation payable to the Contractor for lean concrete base will be increased on the basis of the cost of cement per ton, f.o.b. the cement mill (including sales tax) plus the freight cost per ton for delivery of the cement to the project from the mill. In determining the cost of the cement, any cash or trade discount offered or available will be credited to the State notwithstanding the fact that the discount may not have been taken by the purchaser.

The Contractor shall furnish to the Engineer satisfactory evidence of the cost of cement used on the project during the period involved in the ordered change in cement content, and the Contractor shall maintain records in such manner as to enable a clear determination of the cost of cement used during that period. The Contractor's records pertaining to the cost of cement shall be open to inspection or audit by Departmental representatives during the life of the contract and for not less than 3 years after the completion thereof and the Contractor shall retain the records for that period.

If the price of cement as determined from the Contractor's records is, in the opinion of the Engineer, excessive, or if the Contractor does not furnish satisfactory evidence of the cost of cement, the Engineer will determine the price to be the

lowest wholesale cost at which cement would be available in the quantities concerned delivered to the jobsite, less any discounts available.

- The quantity of cement to be subject to increased compensation will be the difference between the specified theoretical quantity of cement and the theoretical quantity of cement ordered by the Engineer. No additional adjustment of compensation will be made for variations in the costs of any work resulting from the change in the quantity of portland cement.

SECTION 29: TREATED PERMEABLE BASES

29-1.01 DESCRIPTION

- This work shall consist of constructing an asphalt treated permeable base or a cement treated permeable base to the lines, grades, and dimensions shown on the plans in accordance with these specifications and the special provisions.
- Asphalt treated permeable base shall consist of a mixture of aggregate and asphalt binder conforming to the provisions in these specifications and the special provisions.
- Cement treated permeable base shall consist of a mixture of aggregate, portland cement and water conforming to the provisions in these specifications and the special provisions.
- The type of treatment, asphalt or cement, to be used will be specified in the special provisions.

29-1.02 MATERIALS

- The materials for treated permeable bases shall conform to the following:

29-1.02A Asphalt Treated Permeable Base

- Aggregates shall be clean and free from decomposed materials, organic material and other deleterious substances.
- Aggregate shall conform to the following grading:

Sieve Sizes	Percentage Passing
1"	100
3/4"	90 - 100
1/2"	35 - 65
3/8"	20 - 45
No. 4	0 - 10
No. 8	0 - 5
No. 200	0 - 2

- Aggregate shall conform to the following quality requirements prior to the addition of the asphalt:

Tests	California Test	Requirements
Percentage of Crushed Particles (Min.)	205	90%
Los Angeles Rattler Loss at 500 Rev. (Max.)	211	45%
Cleanness Value (Min.)	227	57
Film Stripping (Max.)	302	25%

- The type of asphalt binder to be mixed with aggregate will be specified in the special provisions.

29-1.02B Cement Treated Permeable Base

- Aggregate shall conform to the provisions in Sections 90-2, "Materials," and 90-3, "Aggregate Gradings." The grading of the aggregate shall conform to the 1" x No. 4 primary aggregate nominal size coarse aggregate grading.
- Portland cement shall be Type II Modified conforming to the provisions in Section 90-2.01, "Cement." Pozzolan shall not be substituted for portland cement.
- Water shall conform to the provisions in Section 90-2.03, "Water."

29-1.03 SUBGRADE

- The subgrade to receive treated permeable base, immediately prior to placing the base thereon, shall conform to the compaction and elevation tolerances specified for the material involved and shall be free of loose or extraneous material. Subgrade to receive cement treated permeable base shall be uniformly moist at the time the base is placed.
- Areas of the subgrade to receive treated permeable base which are lower than the grade established by the Engineer shall be filled with treated permeable base. Volumes of treated permeable base so placed will not be included in the volume calculated for payment.

29-1.04 STORING, PROPORTIONING AND MIXING

- The materials for treated permeable bases shall be stored, proportioned and mixed in accordance with the following:

29-1.04A Asphalt Treated Permeable Base

- Aggregates and asphalt for asphalt treated permeable base shall be stored, proportioned and mixed in the same manner provided for storing, proportioning and mixing aggregates and asphalt for asphalt concrete in Section 39-3, "Storing, Proportioning and Mixing Materials," except as follows:

The aggregate need not be separated into sizes.

The temperature of the aggregate before adding the asphalt binder shall be not less than 275° F nor more than 325° F.

Asphalt treated permeable base stored in excess of 2 hours shall not be used in the work.

The aggregate shall be combined with 2.5 percent paving asphalt by weight of the dry aggregate. After testing samples of the Contractor's proposed aggregate supply, the Engineer may order an increase or decrease in the asphalt content. If an increase or decrease is ordered, and the increase or decrease exceeds the specified amount by more than 0.1-percent by weight of the dry aggregate, the compensation payable to the Contractor for the asphalt treated permeable base will be increased or decreased on the basis of the total increase or decrease in asphalt in the same manner as provided for any increase or decrease in asphalt in asphalt concrete in Section 39-3.03, "Proportioning."

The asphalt content of the asphalt mixture will be determined, at the option of the Engineer, by extraction tests in conformance with the requirements in California Test 310 or 362, or will be determined in conformance with the requirements in California Test 379. The bitumen ratio pounds of asphalt per 100 pounds of dry aggregate shall not vary by more than

0.5-pound of asphalt above or 0.5-pound of asphalt below the amount designated by the Engineer. Compliance with this requirement will be determined either by taking samples from trucks at the plant or from the mat behind the paver before rolling. If the sample is taken from the mat behind the paver, the bitumen ratio shall be not less than the amount designated by the Engineer, less 0.7-pound of asphalt per 100 pounds of dry aggregate.

29-1.04B Cement Treated Permeable Base

- Aggregates for cement treated permeable base shall be stored and aggregates, cement and water for cement treated permeable base shall be proportioned, mixed, and transported in conformance with the provisions in Sections 90-5, "Proportioning," and 90-6, "Mixing and Transporting," except as follows:

Dividing of aggregate into sizes will not be required.

The requirements concerning the amount of water and penetration shall not apply.

- The portland cement content of cement treated permeable base shall be not less than 287 pounds per cubic yard.
- The water-cement ratio (the ratio of the amount of water, exclusive only of that absorbed by the aggregates, to the amount of cement, by weight) shall be approximately 0.37. The exact water-cement ratio will be determined by the Engineer.

29-1.05 SPREADING AND COMPACTING ASPHALT TREATED PERMEABLE BASE

- Asphalt treated permeable base shall be spread and compacted in the same manner as provided for asphalt concrete in Sections 39-5, "Spreading and Compacting Equipment," and 39-6, "Spreading and Compacting," and these specifications.
- Asphalt treated permeable base shall be spread only when the atmospheric temperature is above 40° F.
- Asphalt treated permeable base shall be spread and compacted in one layer. Asphalt treated permeable base shall be compacted in accordance with one of the following methods:

A. One complete coverage with a steel-tired, 2-axle tandem roller which has an operating weight of not more than 110 pounds per linear inch of steel tire width. Compaction shall begin when the temperature of the base mixture is less than 250° F and shall be completed before the base mixture is less than 200° F. Asphalt treated permeable base shall not be cooled with water.

B. One complete coverage with a steel-tired, 2-axle tandem roller with a weight of not less than 8 tons nor more than 12 tons. Compaction shall begin when the temperature of the base mixture is less than 150° F and shall be completed before the base mixture is less than 100° F. Asphalt treated permeable base shall not be cooled with water.

- Vibratory rollers meeting the above requirements may be used provided the vibratory unit is turned off.
- The finished surface of asphalt treated permeable base shall be uniform and shall not vary at any point more than 0.05-foot above or below the grade established by the Engineer.
- Care shall be exercised to prevent contamination of asphalt treated permeable base. Asphalt treated permeable base which, in the opinion of the Engineer, has been contaminated shall be removed and replaced by the Contractor at the Contractor's expense.
- Asphalt treated permeable material for edge drains shall be placed and compacted in conformance with the provisions in Section 68-3.03, "Installation."
- Filter fabric shall be placed on the edge and top of the high side (the side opposite the edge drain side) of the asphalt treated permeable base, and at intermediate cross drain interceptors as shown on the plans. The filter fabric shall conform to the provisions for filter fabric for edge drains in Section 88, "Engineering Fabrics," and shall be placed in conformance with the provisions for placing filter fabric for edge drains in Section 68-3.03, "Installation."
- Damage to the asphalt treated permeable base shall be repaired promptly by the Contractor, at the Contractor's expense, as directed by the Engineer.

29-1.06 PLACING, SPREADING, COMPACTING AND SHAPING CEMENT TREATED PERMEABLE BASE

- Placing of cement treated permeable base shall conform to the provisions for placing concrete pavement in Section 40-1.06, "Placing," except that the third paragraph in Section 40-1.06 shall not apply.
- Cement treated permeable base shall be spread, compacted and shaped in conformance with the provisions for spreading, compacting and shaping concrete pavement in the first and fourth paragraphs of Section 40-1.07, "Spreading, Compacting and Shaping," except that vibrators shall not be used.
- Compaction shall be performed with a 2-axle steel-tired roller with a weight of not less than 6 tons nor more than 10 tons. Compaction shall follow within one-half hour after the spreading operation and shall consist of 2 complete coverages of the cement treated permeable base.
- Cement treated permeable base shall be spread only when the atmospheric temperature is above 40° F.
- The completed cement treated permeable base shall be cured by sprinkling the surface with a fine spray of water every 2 hours for a period of 8 hours. Curing shall start the morning after the base has been placed.
- The finished surface of cement treated permeable base shall be uniform and shall not vary at any point more than 0.05-foot above or below the grade established by the Engineer.
- Care shall be exercised to prevent contamination of cement treated permeable base. Cement treated permeable base which, in the opinion of the Engineer, has been contaminated shall be removed and replaced by the Contractor at the Contractor's expense.

- Cement treated permeable material for edge drains shall be placed and compacted in conformance with the provisions in Section 68-3.03, "Installation."
- Filter fabric shall be placed on the edge and top of the high side (the side opposite the edge drain side) of the cement treated permeable base, and at intermediate cross drain interceptors as shown on the plans. The filter fabric shall conform to the provisions for filter fabric for edge drains in Section 88, "Engineering Fabrics," and shall be placed in conformance with the provisions for placing filter fabric for edge drains in Section 68-3.03, "Installation."
- Damage to the cement treated permeable base shall be repaired promptly by the Contractor at the Contractor's expense, as directed by the Engineer.

29-1.07 SURFACES NOT WITHIN TOLERANCE

- Treated permeable base with a surface higher than 0.05-foot above the grade established by the Engineer shall be removed and replaced with treated permeable base which complies with these specifications, or if permitted by the Engineer, the high spots may be removed to within specified tolerance by any method that does not produce contaminating fines nor damage the base to remain in place. Grinding will not be permitted.
- Hardened treated permeable base with a surface lower than 0.05-foot below the grade established by the Engineer shall be removed and replaced with treated permeable base which complies with these specifications, or if permitted by the Engineer, the low areas shall be filled with pavement material as follows:

When pavement material is asphalt concrete, the low areas shall be filled with asphalt concrete conforming to the requirements for the lowest layer of asphalt concrete to be placed as pavement. This shall be done as a separate operation prior to placing the lowest layer of pavement.

When pavement material is portland cement concrete, the low areas shall be filled with pavement concrete at the time and in the same operation in which the pavement is placed.

Full compensation for filling low areas will be considered as included in the contract price paid per cubic yard for treated permeable base and no additional compensation will be allowed therefor.

29-1.08 MEASUREMENT

- The quantity of treated permeable base to be paid for will be measured by the cubic yard for the type (asphalt or cement) of treated permeable base indicated in the Engineer's Estimate. The volume to be paid for will be calculated on the basis of the dimensions shown on the plans adjusted by the amount of any change ordered by the Engineer. No allowance will be made for treated permeable base placed outside those dimensions unless otherwise ordered by the Engineer.
- Treated permeable material for edge drains installed adjacent to treated permeable base will not be included in the volume of treated permeable base to be paid for.

29-1.09 PAYMENT

- The contract price paid per cubic yard for treated permeable base of the type indicated in the Engineer's Estimate shall include full compensation for furnishing

all labor, materials (including cement or paving asphalt), tools, equipment and incidentals, and for doing all the work involved in constructing treated permeable base, complete in place, including filter fabric, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTIONS 30 THROUGH 36: (BLANK)

SURFACINGS AND PAVEMENTS

SECTION 37: BITUMINOUS SEALS

37-1 SEAL COATS

37-1.01 DESCRIPTION

- This work shall consist of an application or applications of asphaltic emulsion and screenings or an application of a mixture of asphaltic emulsion and added water.
- The Type of seal coat (fog, fine, medium fine, medium, coarse, or double) to be applied will be designated on the plans or specified in the special provisions.
- Fog seal coat shall consist of an application of a mixture of slow-setting type asphaltic emulsion and additional water. The water shall be added and mixed with the asphaltic emulsion (which contains up to 43 percent water) so that the resulting mixture will contain one part asphaltic emulsion and not more than one part added water. The exact quantity of added water will be determined by the Engineer.
- Fine, medium fine, medium and coarse seal coats shall consist of an application of asphaltic emulsion followed with an application of screenings. Double seal coat shall consist of an application of asphaltic emulsion followed with an application of screenings, and another application of asphaltic emulsion followed with another application of screenings.

37-1.02 MATERIALS

- Asphaltic emulsion shall conform to the provisions in Section 94, "Asphaltic Emulsions," and shall be of the grade specified in the special provisions, except that asphaltic emulsion for fog seal coat shall be any of the grades of slow-setting type asphaltic emulsion.
- Liquid asphalt for prime coat, if required, shall be of the grade specified in the special provisions, and shall conform to the provisions in Section 93, "Liquid Asphalts."
- A half-gallon sample of the asphaltic emulsion, as delivered to the project, will be taken in a plastic container from the spray bar of the distributor truck at mid-load.
- The size of screenings for the various types of seal coats shall conform to the following:

Seal Coat Types	Size of Screenings
Fine	1/4" x No. 10
Medium fine	5/16" x No. 8
Medium	3/8" x No. 6
Coarse	1/2" x No. 4
Double	
1st application	1/2" x No. 4
2nd application	1/4" x No. 10

- Screenings shall conform to the following requirements prior to depositing on the roadbed.
- Screenings shall consist of broken stone, crushed gravel or both. At least 90 percent by weight of the screenings shall consist of crushed particles as determined by California Test 205.
- Screenings shall be clean and free from dirt and other deleterious substances.
- The percentage composition by weight of screenings shall conform to one of the following gradings:

Sieve Sizes	Percentage Passing			
	Coarse 1/2" x No. 4	Medium 3/8" x No. 6	Medium Fine 5/16" x No. 8	Fine 1/4" x No. 10
3/4"	100	—	—	—
1/2"	95-100	100	—	—
3/8"	50-80	90-100	100	100
No. 4	0-15	5-30	30-60	60-85
No. 8	0-5	0-10	0-15	0-25
No. 16	—	0-5	0-5	0-5
No. 30	—	—	0-3	0-3
No. 200	0-2	0-2	0-2	0-2

- Screenings shall also conform to the following quality requirements:

Tests	California Tests	Requirements
Los Angeles Rattler Loss at 100 Rev. (max.)	211	10%
Los Angeles Rattler Loss at 500 Rev. (max.)	211	40%
Film Stripping (max.)	302	25%
Cleanness Value (min.)	227	80

- If the results of the aggregate grading for screenings does not meet the gradation specified, the seal coat represented by the test shall be removed. However, if requested in writing by the Contractor and approved by the Engineer, the seal coat may remain in place, and the Contractor shall pay to the State $1.75 per ton for the screenings represented by the test and left in place.
- If the results of the Cleanness Value test for screenings is below 80, the seal coat represented by the test shall be removed. However, if requested in writing by the Contractor and approved by the Engineer, seal coat containing screenings with a Cleanness Value below 80, but not less than 75, may remain in place. The Contractor shall pay to the State the following amount for the screenings represented by the test and left in place.

Cleanness Value	Payment to State
80 or over	None
79	$2.00 per ton
77	$4.00 per ton
75	$6.00 per ton

- When both the aggregate grading and the Cleanness Value for screenings do not conform to the requirements specified, both payments to the State shall apply. The Department may deduct these amounts from any moneys due, or that may become due, the Contractor under the contract. No single aggregate grading or Cleanness Value test shall represent more than 300 tons or one day's production, whichever is smaller.
- Samples for the aggregate grading and Cleanness Value tests will be taken from the conveyor belt of the spreader prior to application.

37-1.03 MAINTAINING TRAFFIC

- At locations where public traffic is being routed over a surface upon which a seal coat is to be applied, the seal coat shall not be applied to more than one-half the width of the traveled way at a time, and the remaining width shall be kept free of obstructions and open for use by public traffic until the seal coat first applied is ready for use by traffic.
- The Contractor shall provide for the passage of public traffic through the work in conformance with the provisions in Sections 7-1.08, "Public Convenience," and 7-1.09, "Public Safety," including the pilot cars, flaggers and equipment necessary to control traffic, as determined by the Engineer.
- Pilot cars utilized by the Contractor or required by Section 37-1.07, "Finishing," to convoy or otherwise control traffic shall have radio contact with other pilot cars and personnel in the work area. The maximum speed of the pilot cars convoying or controlling traffic through the traffic control zone shall be 15 miles per hour on 2-lane two-way roadways and 25 miles per hour on multilane divided and undivided roadways. Pilot cars shall only use traffic lanes open to public traffic.
- On 2-lane two-way roadways, C6 "LOOSE GRAVEL" signs and W6 (35) speed advisory signs shall be furnished and placed adjacent to both sides of the traveled way where screenings are being spread on a traffic lane. The first C6 sign in each direction shall be placed where traffic first encounters loose screenings, regardless of which lane the screenings are being spread on. The W6 (35) signs need not be placed in those areas with posted speed limits of less than 40 MPH. The signs shall be placed at maximum 2,000-foot intervals along each side of the traveled way and at public roads or streets entering the seal coat area as directed by the Engineer.
- On multilane roadways (freeways, expressways and multilane conventional highways) where screenings are being spread on a traffic lane, C6 "LOOSE GRAVEL" signs and W6 (35) speed advisory signs shall be furnished and placed adjacent to the outside edge of the traveled way nearest to the lane being worked on. The first C6 sign shall be placed where the screenings begin with respect to the direction of travel on that lane. The W6 (35) signs need not be placed in those

areas with posted speed limits of less than 40 MPH. The signs shall be placed at maximum 2,000-foot intervals along the edge of traveled way and at on-ramps, public roads or streets entering the seal coat area as directed by the Engineer.

- The C6 and W6 signs shall be maintained in place at each location until final brooming of the seal coat surface at that location is completed. The C6 and W6 signs shall conform to the provisions for construction area signs in Section 12, "Construction Area Traffic Control Devices." The signs may be set on temporary portable supports with the W6 below the C6 or on barricades with the W6 sign alternating with the C6 sign.

37-1.04 PREPARATION FOR SEAL COAT

- Immediately before applying the asphaltic emulsion, the surface to be sealed shall be clean and dry. Cleaning shall be performed by sweeping, flushing or other means necessary to remove all loose particles of paving, all dirt and all other extraneous material.
- When seal coats are to be applied to an untreated material, a prime coat consisting of liquid asphalt shall be applied to the material in place at a rate of from 0.20-gallon to 0.33-gallon per square yard. The exact rate will be determined by the Engineer.

37-1.05 APPLYING ASPHALTIC EMULSION

- Asphaltic emulsion shall be applied in accordance with the provisions in Section 94, "Asphaltic Emulsions," and the provisions specified in this Section 37-1.05.
- The application rate of fog seal coat (asphaltic emulsion and added water) shall be such that the original emulsion will be spread at a rate of 0.05-gallon to 0.10-gallon per square yard. The exact rate of application will be determined by the Engineer.
- The application rates of asphaltic emulsion for the other types of seal coats shall be within the following ranges in gallons per square yard. The exact rates will be determined by the Engineer.

Seal Coat Types	Ranges
Fine	0.15 to 0.30
Medium fine	0.25 to 0.35
Medium	0.25 to 0.40
Coarse	0.30 to 0.40
Double	
1st application	0.20 to 0.35
2nd application	0.20 to 0.30

- Asphaltic emulsion at the time of application shall be between 130° F and 180° F.
- Asphaltic emulsion shall not be applied when weather conditions are unsuitable. Seal coats requiring screenings shall not be applied until sufficient screenings are on hand to immediately cover the asphaltic emulsion, or when the atmospheric temperature is below 65° F or above 110° F, or when the pavement

temperature is below 80° F. Fog seal coat shall not be applied when the atmospheric temperature is below 40° F.

- The Engineer will notify the Contractor, no later than 4:00 p.m., if it is anticipated that the next working day will not be suitable for the application of seal coat. This notice may be given on the day preceding the date the Contractor intends to begin work, any working day after the Contractor has begun work, and any day previously named by the Engineer as a day unsuitable for applying seal coat. When the Engineer has declared a day to be unsuitable by reason of expected low temperature or unsuitable weather conditions, the Contractor shall not apply any new seal coat. If maintenance of previously applied seal coat can be performed, the Contractor shall continue to perform the maintenance. These unsuitable days will not be counted as working days regardless of the actual weather conditions and the fact that seal coat maintenance work are performed by the Contractor.
- If the Contractor has not been notified by the Engineer of an anticipated unsuitable day and at the beginning of the work day the weather is unsuitable for the application of seal coats, but maintenance of previously applied seal coat can be performed, the Contractor shall not apply any seal coat. Binder and screenings brought to the project shall be returned, stored or disposed of as directed by the Engineer. The Contractor shall continue maintenance of previously applied seal coat. The State will compensate the Contractor for show-up by paying for the direct cost of delivery and return, storage or disposal of the binder and screenings and for show-up time for workers who would have applied the seal coat but are not required for seal coat maintenance. The direct cost will be determined in conformance with the provisions in Section 9-1.03, "Force Account Payment," except there will be no markup allowance pursuant to Section 9-1.03A, "Work Performed by Contractor." The day will be considered a nonworking day.
- The provisions for compensation for show-up on unsuitable days will not apply if the Contractor has not provided the Engineer with the name of an authorized representative and a means of communication for providing notice as provided herein.
- After the application of a fog seal coat, asphaltic emulsion that becomes tacky shall be sprinkled with water in the amount ordered and as directed by the Engineer.
- When more than one type of seal coat is to be applied, the fog seal coat shall be applied at least 4 days in advance of the application of an adjoining seal coat requiring screenings. The seal coats shall be applied in such a manner that the joint between 2 types will present a neat and uniform appearance true to the line shown on the typical cross section and established by the Engineer.
- Applying asphaltic emulsion shall be discontinued sufficiently early in the day to permit the termination of traffic control prior to darkness. Asphaltic emulsion shall be applied to only one designated traffic lane at a time, and the entire width of the lane shall be covered in one operation.
- Asphaltic emulsion shall not be applied a greater distance than can be immediately covered by screenings, unless otherwise permitted by the Engineer.

- The cut off of asphaltic emulsion shall be made on building paper or similar material spread over the surface. Paper shall also be placed over the treated surface for a sufficient length at the beginning of a spread to avoid spraying existing pavement or previously placed screenings and so that the nozzles are spreading properly when the uncovered surface is reached. The building paper shall then be removed and disposed of in a manner satisfactory to the Engineer.
- The distribution of asphaltic emulsion shall not vary more than 15 percent transversely from the average as determined by tests, nor more than 10 percent longitudinally from the specified rate of application as determined by California Test 339.

37-1.06 SPREADING SCREENINGS

- Screenings for seal coats shall be spread immediately following the application of the asphaltic emulsion. The spread rate of screenings for the various types of seal coats shall be within the following ranges in pounds per square yard. The exact rate will be determined by the Engineer. The completed spread shall be within 10 percent of the rate determined by the Engineer.

Seal Coat Types	Ranges
Fine	12 to 20
Medium fine	16 to 25
Medium	20 to 30
Coarse	23 to 30
Double	
1st application	23 to 30
2nd application	12 to 20

- Screenings shall be spread by means of a self-propelled chip spreader, equipped with a mechanical device which will spread the screenings at a uniform rate over the full width of a traffic lane in one application. The joint between adjacent applications of screenings shall coincide with the line between designated traffic lanes.
- Operating the chip spreader at speeds which cause the chips to roll over after striking the bituminous covered surface will not be permitted.
- The transverse cut off of screenings shall be complete and any excess screenings shall be removed from the surface prior to resuming operations.
- Stockpiling of screenings prior to placing will be permitted; however, any contamination resulting during storage or from reloading operations will be cause for rejection.
- Screenings shall be surface damp at the time of application, but excess water on the aggregate surface will not be permitted. Screenings shall be redampened in the vehicles prior to delivery to the spreader when directed by the Engineer.
- Asphaltic emulsion shall be covered with screenings before setting or "breaking" of the asphaltic emulsion occurs.

37-1.07 FINISHING

- After the screenings have been spread upon the asphaltic emulsion, piles, ridges or uneven distribution shall be carefully removed to ensure against

permanent ridges, bumps or depressions in the completed surface. Additional screenings shall be spread in whatever quantities may be required to prevent picking up by the rollers or traffic, after which the surface shall be rolled.

- Rollers shall be pneumatic-tired type. A minimum of 2 pneumatic-tired rollers conforming to the provisions in Section 39-5.02, "Compacting Equipment," shall be furnished.
- Initial rolling shall consist of one complete coverage and shall begin immediately behind the spreader. Asphaltic emulsion and screenings shall not be spread more than 2,500 feet ahead of completion of initial rolling operations. Secondary rolling shall begin immediately after completion of the initial rolling. The amount of secondary rolling shall be sufficient to adequately seat the screenings and in no case shall be less than 2 complete coverages.
- Unless otherwise provided in the special provisions or directed by the Engineer, seal coat surfaces shall be maintained, including the traffic control required for maintenance operations, for a period of 4 consecutive calendar days beginning on the day screenings are applied to the asphaltic emulsion. Maintenance of the surface shall include brooming and the distribution of screenings over the surface to absorb any free bituminous material, to cover any area deficient in cover coat material and to prevent formation of corrugations. Clean sand may be used in lieu of screenings to cover any excess of asphaltic emulsion which comes to the surface. The use of roadside material for this purpose will not be permitted.
- Brooms for finishing and maintaining seal coat screenings shall be the self-propelled type. When brooming is required adjacent to curbs, gutters, dikes, berms, railings or other barriers which would prevent loose screenings from being swept completely off the roadway, the self-propelled brooms shall also be capable of removing the loose screenings from the surface during brooming. In addition to the self-propelled brooms required for maintaining previously placed screenings, at each location where screenings are to be spread, a minimum of 3 self-propelled brooms shall be available, prior to the start of spreading the screenings at a location.
- The surface of the seal coat shall be broomed as often as necessary during the 4 calendar day maintenance period to maintain the surface free of loose screenings. At the end of the 4 consecutive calendar day maintenance period, any excess screenings shall be removed from paved areas. Brooming of seal coat surfaces shall be performed in such a manner that the screenings set in the asphaltic emulsion will not be displaced.
- The exact time of brooming will be determined by the Engineer. As a minimum, brooming will be required at the following approximate times:

A. On 2-lane two-way roadways, from 2 hours to 4 hours after traffic, controlled with pilot cars, has been routed on the seal coat.
B. On multilane roadways, from 2 hours to 4 hours after screenings have been placed.
C. In addition to previous brooming, immediately prior to opening any lane to public traffic, not controlled with pilot cars.

D. As a first order of work on the morning following application of screenings, on any lane that has been open to public traffic, not controlled with pilot cars.
E. At the end of the 4 calendar day maintenance period.

- The following shall apply to seal coat operations on 2-lane two-way roadways under one-way traffic control:

  Upon completion of secondary rolling, public traffic shall be controlled with pilot cars and routed over the new seal coat for a period of from 2 hours to 4 hours. The exact time shall be as determined by the Engineer.

  The Contractor shall schedule the operations such that seal coat is placed on both lanes of the traveled way each work shift, and such that one-way traffic control is discontinued before darkness. At the end of the work shift, the end of the seal coat on both lanes shall generally match.

- The following shall apply to seal coat operations on multilane roadways:

  Initial brooming may begin after the screenings have been in place for a period of from 2 hours to 4 hours. When the initial brooming is not completed during the work shift in which the screenings were placed, the initial brooming shall be completed as the first order of work at the beginning of the next work shift.

  Public traffic shall be controlled with pilot cars and shall be routed on the new seal coat surface of a lane, for a minimum of 2 hours after completion of initial brooming and prior to opening the lane to traffic not controlled with pilot cars. When traffic is controlled with pilot cars, a maximum of one lane in the direction of travel shall be open to public traffic. Once traffic, controlled with pilot cars, is routed over the seal coat at a location, continuous control shall be maintained at that location until the seal coat placement and brooming on adjacent lanes to receive seal coat is completed.

- Excess screenings remaining on the surface after the first application of a "double" seal coat shall be removed prior to the second application of asphaltic emulsion.
- When directed by the Engineer, excess screenings shall be salvaged and stockpiled at designated locations.
- Excess screenings which in the opinion of the Engineer are not salvable and which interfere with drainage shall be removed and disposed of by the Contractor at the Contractor's expense. The removed screenings shall be disposed of in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way," or along embankment slopes, or at other suitable locations if permitted by the Engineer.
- The completed surface shall present a uniform appearance and shall be free from ruts, humps, depressions or irregularities due to an uneven distribution of asphaltic emulsion or screenings.

37-1.08 MEASUREMENT

- Quantities of screenings to be paid for by the ton will be determined in conformance with the provisions in Section 9-1.01, "Measurement of Quantities."
- Quantities of liquid asphalt and asphaltic emulsion to be paid for will be determined in conformance with the provisions in Sections 93, "Liquid Asphalts," and 94, "Asphaltic Emulsions," respectively.

37-1.09 PAYMENT

- Seal coat will be paid for at the contract price per ton for screenings, and the contract price per ton for asphaltic emulsion (polymer modified), and for liquid asphalt (prime coat), for whatever items are provided and involved. The prices shall include preparation for seal coat and furnishing and applying asphaltic emulsion and screenings.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in applying seal coat, complete in place, including furnishing, placing, maintaining, and removing C6 and W6 signs, when required, and temporary supports or barricades for the signs, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- Salvaging and stockpiling excess screenings will be paid for as extra work as provided in Section 4-1.03D.
- Water furnished and applied to tacky emulsion and for mixing with an asphaltic emulsion will not be paid for and full compensation therefor will be considered as included in the contract price paid for the asphaltic emulsion.
- When there is a contract item for traffic control system, full compensation for furnishing and using pilot cars to reduce the speed of traffic and convoy or otherwise control traffic, as specified, shall be considered as included in the contract lump sum price paid for traffic control system, and no separate payment will be made therefor. When there is no contract item for traffic control system, full compensation for furnishing and using the pilot cars shall be considered as included in the contract prices paid for the various items of seal coat work, and no separate payment will be made therefor.

37-2 SLURRY SEAL

37-2.01 DESCRIPTION

- This work shall consist of mixing asphaltic emulsion, aggregate, set-control additives and water and spreading the mixture on a surfacing or pavement where shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

37-2.02 MATERIALS

- The materials for slurry seal immediately prior to mixing shall conform to the following requirements:

37-2.02A Asphaltic Emulsion

- Asphaltic emulsion shall be a quick-setting type, Grade QS1h anionic or Grade CQS1h cationic, conforming to the provisions in Section 94, "Asphaltic

Emulsions." The grade of asphaltic emulsion shall be at the option of the Contractor.

37-2.02B Water

- Water shall be of such quality that the asphalt will not separate from the emulsion before the slurry seal is in place in the work. If necessary for workability, a set-control agent that will not adversely affect the slurry seal may be used.

37-2.02C Aggregate

- Aggregate shall consist of rock dust and plaster sand or other sands of similar nature, except that 100 percent of any aggregate or combination of aggregates, larger than the No. 50 sieve size, used in the mixture shall be obtained by crushing rock. The material shall be free from vegetable matter and other deleterious substances. Aggregate shall be free of caked lumps and oversize particles.
- The percentage composition by weight of the aggregate shall conform to the following gradings when determined by California Test 202, modified by California Test 105 when there is a difference in specific gravity of 0.2 or more between blends of different aggregates. The type of aggregate shall be as specified in the special provisions.

Sieve Sizes	Percentage Passing		
	Type I	Type II	Type III
3/8"	—	100	100
No. 4	100	94-100	70-90
No. 8	90-100	65-90	45-70
No. 16	60-90	40-70	28-50
No. 30	40-65	25-50	19-34
No. 200	10-20	5-15	5-15

- The aggregate shall also conform to the following quality requirements:

Tests	California Test	Requirements		
		Type I	Type II	Type III
Sand Equivalent	217	45 min.	55 min.	60 min.
Durability Index	229	55 min.	55 min.	55 min.

- If the results of the aggregate grading do not meet the gradation specified, the slurry seal represented by the test shall be removed. However, if requested in writing by the Contractor and approved by the Engineer, the slurry seal may remain in place and the Contractor shall pay to the State $1.75 per ton for the aggregate represented by the test and left in place.
- If the result of the Sand Equivalent test for aggregate does not meet the requirement specified, the slurry seal represented by the test shall be removed. However, if requested in writing by the Contractor and approved by the Engineer, the slurry seal may remain in place and the Contractor shall pay to the State $1.75 per ton for the aggregate represented by the test and left in place.
- When the results of both the aggregate grading and the Sand Equivalent test do not conform to the requirements specified, both payments to the State shall apply.

The Department may deduct these amounts from any moneys due, or that may become due, the Contractor under the contract. No single aggregate grading or Sand Equivalent test shall represent more than 300 tons or one day's production, whichever is smaller.

37-2.03 MIX DESIGN

At least 7 working days before slurry seal placement commences, the Contractor shall submit to the Engineer for approval a laboratory report of tests and proposed mix design covering the specific materials to be used on the project. The percentage of asphaltic emulsion proposed in the mix design shall be within the percentage range specified in Section 37-2.04, "Proportioning."

The tests and mix design shall be performed by a laboratory capable of performing the applicable International Slurry Seal Association (ISSA) tests. The proposed slurry seal mixture shall conform to the requirements specified when tested in accordance with the following tests:

Test	ISSA Test	Requirement
Slurry Seal Consistency, mm	T106	30 max.
Wet Stripping	T114	Pass
Compatibility	T115	Pass[a]
Cohesion Test[b], kg - mm within one h	T139	200 min.
Wet Track Abrasion, g/m^2	T100	800 max.

a Mixing test must pass at the maximum expected air temperature at the project site during application.

b Using project source aggregate and asphaltic emulsion and set-control agents if used.

The original laboratory report shall be signed by the laboratory that performed the tests and mix design and shall show the results of the tests on individual materials, comparing the test results to those required by the specifications. The report shall clearly show the proportions of aggregate, filler (as determined from the tests, minimum and maximum), water (minimum and maximum), asphalt solids content based on the dry weight of aggregate and set-control agent usage. Previous laboratory reports covering the same materials may be accepted provided they are made during the same calendar year.

Once the proportions of materials to be used are approved by the Engineer, no substitution of other material will be permitted unless the materials proposed for substitution are first tested and a laboratory report is submitted for the substituted design as specified above. Substituted materials shall not be used until the mix design for those materials is approved by the Engineer.

37-2.04 PROPORTIONING

Aggregate, asphaltic emulsion, water and additives, including set-control agent if used, shall be proportioned by volume utilizing the mix design approved by the Engineer. If more than one kind of aggregate is used, the correct amount of each kind of aggregate used to produce the required grading shall be proportioned separately, prior to adding the other materials of the mixture, in a manner that will result in a uniform and homogeneous blend.

- The completed mixture, after addition of water and any set-control agent used, shall be such that the slurry seal mixture has proper workability and (a) will permit traffic, not controlled with pilot cars, on the slurry seal within one hour after placement without the occurrence of bleeding, raveling, separation or other distress, and (b) prevent development of bleeding, raveling, separation or other distress within 15 days after placing the slurry seal.
- Asphaltic emulsion shall be added at a rate within the following ranges of percent by weight of the dry aggregate. The exact rate will be determined by the Engineer from the approved design asphalt binder content, and the asphalt solids content of the asphaltic emulsion furnished.

Type of Aggregate	Range
I	15 - 20
II	12 - 18
III	10 - 15

- The Contractor shall furnish an aggregate moisture determination for every 2 hours of operation or maintain the moisture content to within a maximum daily variation of ±0.5-percent.
- The aggregate shall be proportioned using a belt feeder operated with an adjustable cutoff gate. The height of the gate opening shall be readily determinable. The emulsion shall be introduced into the mixer by a positive displacement pump. Variable rate emulsion pumps, if used, shall be equipped with a means to seal the adjusting unit in its calibrated condition. Water shall be introduced into the mixer through a meter registering in gallons delivered.
- Uniformity of distribution of asphalt will be determined by extraction tests in conformance with the requirements in California Test 310. The bitumen ratio (kilograms of asphalt per 100 kilograms of dry aggregate) shall not vary more than 0.5-kg of asphalt above or 0.5-kg of asphalt below the amount designated by the Engineer. This requirement shall apply to samples taken from any location or operation designated by the Engineer.
- The delivery rate of aggregate and emulsion per revolution of the aggregate feeder shall be calibrated at the appropriate gate settings for each mixer-spreader truck used on the project in conformance with the requirements in California Test 109 and the requirements of these specifications.
- The aggregate belt feeder shall deliver aggregate to the pugmill mixer with such volumetric consistency that the deviation for any individual aggregate delivery rate check-run shall not exceed 2.0 percent of the average of 3 runs of at least 3 tons each in duration. The emulsion pump shall deliver emulsion to the pugmill with such volumetric consistency that the deviation for any individual delivery rate check-run shall be within 2.0 percent of the mathematical average of 3 runs of at least 500 gallons each in duration.
- Check-runs shall be performed for each aggregate source using a vehicle scale that has been tested and approved in conformance with the requirements in California Test 109.
- The emulsion storage located immediately before the emulsion pump shall be equipped with a device which will automatically shut down the power to the

emulsion pump and aggregate belt feeder when the level of stored emulsion is lowered.

- A temperature-indicating device shall be installed in the emulsion storage tank at the pump suction level. The device shall indicate temperature of the emulsion and shall be accurate to ±5° F.
- The belt delivering the aggregate to the pugmill shall be equipped with a device to monitor the depth of aggregate being delivered to the pugmill. The device for monitoring depth of aggregate shall automatically shut down the power to the aggregate belt feeder whenever the depth of aggregate is less than 70 percent of the target depth of flow. An additional device shall monitor movement of the aggregate belt by detecting revolutions of the belt feeder. The devices for monitoring no flow or belt movement, as the case may be, shall automatically shut down the power to the aggregate belt when aggregate belt movement is interrupted. The device to detect revolutions of the belt feeder will not be required when the aggregate delivery belt is an integral part of its drive chain.
- To avoid shutdowns caused by normal fluctuations in delivery rates, a delay of 3 seconds between sensing less than desirable storage levels of aggregate or emulsion and shutdown of the proportioning operation will be permitted.

37-2.05 MIXING AND SPREADING EQUIPMENT

- The slurry seal shall be mixed in continuous pugmill mixers of adequate size and power for the type of slurry seal to be placed. Indicators required in conformance with the provisions in Section 37-2.04, "Proportioning," shall be in working order prior to commencing mixing and spreading operations.
- Mixer-spreader trucks shall be equipped to proportion emulsion, water, aggregate, and set-control additives by volume. Rotating and reciprocating equipment on mixer-spreader trucks shall be covered with metal guards.
- The mixer-spreader truck shall not be operated unless low-flow and no-flow warning devices and revolution counters are in good working condition and functioning and metal guards are in place. Indicators required by these special provisions shall be visible while walking alongside the mixer-spreader truck.
- Aggregate feeders shall be connected directly to the drive on the emulsion pump. The drive shaft of the aggregate feeder shall be equipped with a revolution counter reading to the nearest full revolution of the aggregate delivery belt.
- At least 2 operational spreader trucks shall be available at the job site during the spreading operation except when continuous placement type mixer-spreader trucks are used.
- In addition to conforming to the provisions in Section 5-1.10, "Equipment and Plants," the identifying number of mixer-spreader trucks shall be at least 2 inches in height, located on the front and rear of the vehicle.
- The slurry mixture shall be uniformly spread by means of a controlled spreader box conforming to the following requirements:

The spreader shall be capable of spreading a traffic lane width and shall have strips of flexible rubber belting or similar material on each side of the spreader box and in contact with the pavement to positively prevent loss of slurry from the box. Spreader boxes over 7.5 feet in width shall have baffles,

reversible motor driven augers, or other suitable means, to ensure uniform application on superelevated sections and shoulder slopes. Spreader box skids shall be maintained in such manner as to prevent chatter (wash boarding) in the finished mat.

Rear flexible strike-off blades shall make close contact with the pavement and shall be capable of being adjusted to the various crown shapes so as to apply a uniform slurry seal.

Flexible drags, to be attached to the rear of the spreader box, shall be provided as directed by the Engineer. Drags and strike-off blades shall be cleaned or changed daily if problems with cleanliness and longitudinal scouring occur.

The spreader box shall be clean, free of slurry seal and emulsion, at the start of each work shift.

- Slurry mixture, to be spread in areas inaccessible to the controlled spreader box, may be spread by other approved methods.

37-2.06 PLACING

- The slurry mixture shall be uniformly spread on the existing surfacing within the rate specified without spotting, rehandling or otherwise shifting of the mixture.
- Slurry seal shall not be placed when the atmospheric temperature is below 50° F or during unsuitable weather.
- Before placing the slurry seal, the pavement surface shall be cleaned by sweeping, flushing or other means necessary to remove all loose particles of paving, all dirt and all other extraneous material.
- When there is a contract item of asphaltic emulsion to be used for paint binder, the pavement surface shall be coated with an SS or CSS grade asphaltic emulsion mixed in the proportion of one part of emulsion to 3 parts of water. The mixture shall be applied at the approximate rate of 0.08-gallon to 0.15-gallon per square yard. The exact rate will be determined by the Engineer.
- Slurry seal shall be spread at a rate within the following ranges in pounds of dry aggregate per square yard. The exact rate will be determined by the Engineer. The completed spread shall be within 10 percent of the rate determined by the Engineer.

Type of Aggregate	Ranges
I	8 - 12
II	10 - 15
III	20 - 25

- Longitudinal joints shall correspond with the edges of existing traffic lanes. Other patterns of longitudinal joints may be permitted, if the patterns will not adversely affect the quality of the finished product, as determined by the Engineer.
- Through traffic lanes shall be spread in full lane width units only. Longitudinal joints, common to 2 traffic lanes, shall be butt joints with overlaps not to exceed 3 inches. Building paper shall be placed at transverse joints, over previously placed slurry seal, or, other suitable methods shall be used to avoid

double placement of slurry seal. Hand tools shall be available in order to remove spillage. Ridges or bumps in the finished surface will not be permitted.

- The mixture shall be uniform and homogeneous after spreading on the existing surfacing and shall not show separation of the emulsion and aggregate after setting.
- Adequate means shall be provided to protect the slurry seal from damage by traffic until such time that the mixture has cured sufficiently so that the slurry seal will not adhere to and be picked up by the tires of vehicles.

37-2.07 MEASUREMENT

- Slurry seal will be measured by the ton. The quantity of slurry seal to be paid for will be the combined weight of the aggregate and asphaltic emulsion used in the slurry seal mixture. The weight of added water and set-control additives used in the slurry seal mixture will not be included in the weight of the slurry seal to be paid for. The weight of the aggregate and asphaltic emulsion will be determined as provided in Section 9-1.01, "Measurement of Quantities," except that no deduction will be made for water in the aggregate and asphaltic emulsion.

37-2.08 PAYMENT

- The contract price paid per ton for slurry seal shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in constructing the slurry seal, complete in place, including testing for and furnishing the mix design, cleaning the surface, furnishing added water and set-control additives, mixing water with asphaltic emulsion for coating the pavement, and protecting the seal until it has set, all as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 38: BLANK

SECTION 39: ASPHALT CONCRETE

39-1 GENERAL

39-1.01 DESCRIPTION

- This work shall consist of furnishing and mixing aggregate and asphalt binder at a central mixing plant, spreading and compacting the mixture and furnishing and placing pavement reinforcing fabric, all as specified in these specifications and the special provisions.
- Asphalt concrete is designated as Type A, Type B or Open Graded.
- Asphalt concrete base is designated as Type A or Type B. The type of asphalt concrete or asphalt concrete base will be shown on the plans or specified in the special provisions.
- Asphalt concrete and asphalt concrete base shall be produced in a batch mixing plant, a continuous pugmill mixing plant or a drier-drum mixing plant. Proportioning shall be either by hot-feed control or cold-feed control.

39-2 MATERIALS

39-2.01 ASPHALTS

- Asphalt binder to be mixed with aggregate shall be a steam-refined paving asphalt in conformance with the provisions in Section 92, "Asphalts," and shall be of the grade designated in the special provisions or as determined by the Engineer.
- The amount of asphalt binder to be mixed with the aggregate for asphalt concrete (except Open Graded asphalt concrete) and asphalt concrete base will be determined by the Engineer in conformance with the requirements in California Test 367 using the samples of aggregates furnished by the Contractor in conformance with the provisions in Section 39-3.03, "Proportioning." The amount of asphalt binder to be mixed with the aggregate for Open Graded asphalt concrete will be determined by the Engineer in conformance with the requirements in California Test 368, using the samples of aggregates furnished by the Contractor in conformance with the provisions in Section 39-3.03.
- Liquid asphalt for prime coat shall conform to the provisions in Section 93, "Liquid Asphalts," and shall be of the grade designated by the contract item or specified in the special provisions.
- Asphaltic emulsion for paint binder (tack coat) shall conform to the provisions in Section 94, "Asphaltic Emulsions," for the rapid-setting or slow-setting type and grade selected by the Engineer.
- Paving asphalt to be used as a binder for pavement reinforcing fabric shall be a steam-refined paving asphalt conforming to the provisions in Section 92, "Asphalts," and shall be PG 70-10.

39-2.02 AGGREGATE

- Aggregates shall be clean and free from decomposed materials, organic material and other deleterious substances. Coarse aggregate is material retained on the No. 4 sieve; fine aggregate is material passing the No. 4 sieve; and supplemental fine aggregate is added fine material passing the No. 30 sieve, including, but not limited to, cement and stored fines from dust collectors.

- Unless otherwise specified in the special provisions, the aggregate grading of the various types of asphalt concrete shall conform to the following:

Type	Grading
A	3/4-inch maximum, coarse
B	3/4-inch maximum, medium
Open Graded	3/8-inch maximum

- The combined aggregate, prior to the addition of asphalt binder, shall conform to the requirements of this section. Conformance with the grading requirements will be determined by California Test 202, modified by California Test 105 when there is a difference in specific gravity of 0.2 or more between the coarse and fine portions of the aggregate or between blends of different aggregates.
- In the tables below, the symbol "X" is the gradation which the Contractor proposes to furnish for the specific sieve. The proposed gradation shall meet the gradation shown in the table under "Limits of Proposed Gradation." Changes from one mix design to another shall not be made during the progress of the work unless permitted by the Engineer. However, changes in proportions to conform to the approved mix design shall not be considered changes in mix design.

AGGREGATE GRADING REQUIREMENTS

Types A and B Asphalt Concrete

Percentage Passing

3/4 inch Maximum, Coarse

Sieve Sizes	Limits of Proposed Gradation	Operating Range	Contract Compliance
1"	—	100	100
3/4"	—	90-100	87-100
3/8"	—	60-75	55-80
No. 4	45-50	X±5	X±8
No. 8	32-36	X±5	X±8
No. 30	15-18	X±5	X±8
No. 200	—	3-7	0-10

3/4 inch Maximum, Medium

Sieve Sizes	Limits of Proposed Gradation	Operating Range	Contract Compliance
1"	—	100	100
3/4"	—	95-100	90-100
3/8"	—	65-80	60-85
No. 4	49-54	X±5	X±8
No. 8	36-40	X±5	X±8
No. 30	18-21	X±5	X±8
No. 200	—	3-8	0-11

1/2 inch Maximum, Coarse

Sieve Sizes	Limits of Proposed Gradation	Operating Range	Contract Compliance
3/4"	—	100	100
1/2"	—	95-100	89-100
3/8"	—	75-90	70-95
No. 4	55-61	X±5	X±8
No. 8	40-45	X±5	X±8
No. 30	20-25	X±5	X±8
No. 200	—	3-7	0-10

1/2 inch Maximum, Medium

Sieve Sizes	Limits of Proposed Gradation	Operating Range	Contract Compliance
3/4"	—	100	100
1/2"	—	95-100	89-100
3/8"	—	80-95	75-100
No. 4	59-66	X±5	X±8
No. 8	43-49	X±5	X±8
No. 30	22-27	X±5	X±8
No. 200	—	3-8	0-11

3/8 inch Maximum

Sieve Sizes	Limits of Proposed Gradation	Operating Range	Contract Compliance
1/2"	—	100	100
3/8"	—	95-100	95-100
No. 4	73-77	X±6	X±10
No. 8	58-63	X±6	X±10
No. 30	29-34	X±6	X±10
No. 200	—	3-10	0-14

No. 4 Maximum

Sieve Sizes	Limits of Proposed Gradation	Operating Range	Contract Compliance
3/8"	—	100	100
No. 4	—	95-100	95-100
No. 8	72-77	X±6	X±10
No. 30	37-43	X±7	X±11
No. 200	—	3-12	0-16

Open Graded Asphalt Concrete

Percentage Passing

1/2 inch Maximum

Sieve Sizes	Limits of Proposed Gradation	Operating Range	Contract Compliance
3/4"	—	100	100
1/2"	—	95-100	92-100
3/8"	78-89	X±4	X±7
No. 4	28-37	X±4	X±7
No. 8	7-18	X±4	X±5
No. 16	—	0-10	0-13
No. 200	—	0-3	0-4

3/8 inch Maximum

Sieve Sizes	Limits of Proposed Gradation	Operating Range	Contract Compliance
1/2"	—	100	100
3/8"	—	90-100	88-100
No. 4	29-36	X±4	X±7
No. 8	7-18	X±4	X±5
No. 16	—	0-10	0-12
No. 200	—	0-3	0-4

Types A and B Asphalt Concrete Base

Percentage Passing

Sieve Sizes	Limits of Proposed Gradation	Operating Range	Contract Compliance
1 1/4"	—	100	100
1"	—	95-100	92-100
3/4"	—	80-100	77-100
3/8"	55-60	X±5	X±8
No. 4	40-45	X±5	X±8
No. 30	14-19	X±5	X±8
No. 200	—	2-7	0-10

- The combined aggregate shall conform to the following quality requirements prior to the addition of the asphalt:

Tests	California Test	Asphalt Concrete Type		Open Graded Asphalt Concrete	Asphalt Concrete Base Type	
		A	B		A	B
Percentage of Crushed Particles:	205					
Coarse Aggregate (Min.)		90%	25%	90%	90%	25%
Fine Aggregate Passing No. 4, Retained on No. 8 (Min.)		70%	20%	90%	70%	20%
Los Angeles Rattler:	211					
Loss at 100 Rev. (Max.)		10%	—	10%	10%	—
Loss at 500 Rev. (Max.)		45%	50%	40%	45%	50%
Sand Equivalent:	217					
Contract Compliance (Min.)		47	42	—	47	42
Operating Range (Min.)		50	45	—	50	45
Film Stripping (Max.)[a]	302	—	—	25%	—	—
K_c Factor (Max.)	303	1.7	1.7	—	1.7	1.7
K_f Factor (Max.)	303	1.7	1.7	—	1.7	1.7

a After mixing with asphalt binder

- If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Operating Range" but meet the "Contract Compliance" requirements, placement of the asphalt concrete or asphalt concrete base may be continued for the remainder of that day. However, another day's work may not be started until tests, or other information, indicate to the satisfaction of the Engineer that the next material to be used in the work will comply with the requirements specified for "Operating Range."
- If the results of either or both the aggregate grading and Sand Equivalent tests do not meet the requirements specified for "Contract Compliance," the asphalt concrete or asphalt concrete base which is represented by these tests shall be removed. However, if requested by the Contractor and approved by the Engineer,

the asphalt concrete or asphalt concrete base may remain in place and the Contractor shall pay to the State $1.75 per ton for the asphalt concrete or asphalt concrete base represented by these tests and left in place. The Department may deduct this amount from any moneys due, or that may become due, the Contractor under the contract. If both the aggregate grading and Sand Equivalent do not conform to the "Contract Compliance" requirements, only one adjustment shall apply.

- No single aggregate grading or Sand Equivalent test shall represent more than 500 tons or one day's production, whichever is smaller.
- The asphalt concrete mixture, composed of the aggregate proposed for use and the optimum amount of asphalt as determined by California Test 367, shall conform to the following quality requirements:

Tests	California Test	Asphalt Concrete Type		Open Graded Asphalt Concrete	Asphalt Concrete Base Type	
		A	B		A	B
Swell (Max.) (inch)	305	0.03	0.03	—	0.03	0.03
Moisture Vapor Susceptibility (Min.)	307	30	25	—	30	25
Stabilometer Value (Min.):						
(3/8" & No. 4 Max. AC)	366	30	30	—	—	—
All Others	366	37	35	—	37	35

39-2.03 PAVEMENT REINFORCING FABRIC

- Pavement reinforcing fabric shall conform to the provisions in Section 88, "Engineering Fabrics."

39-3 STORING, PROPORTIONING AND MIXING MATERIALS

39-3.01 STORAGE

- Aggregate shall be stored so that separately sized aggregates will not be intermingled, and asphalt binder shall be stored so that different grades of asphalt will not be intermingled. Any aggregate which has been intermingled with another size of aggregate shall be removed and replaced with aggregate of specified grading. As used in this specification, "cold storage" is the storing of aggregates prior to their having been processed in a drier, and "hot storage" is the storing of aggregates after their having been processed in a drier. "Hot-feed control" and "cold-feed control" indicate the location of measuring devices or controls.
- When the Contractor adds supplemental fine aggregate, each supplemental fine aggregate used shall be stored separately and kept thoroughly dry.
- The measurement and storage requirements of this Section 39-3, shall not apply to the dust collected in skimmers and expansion chambers (knock-out boxes) or to the dust collected in centrifugal (cyclone) collectors. Dust from these collectors may be returned to the aggregate without being measured or stored separately, provided the dust is returned uniformly at a point in advance of the sampling device in batch-mixing plants or is returned at or before mixing in continuous mixing plants.

• Aggregate and asphalt binder shall also be stored in conformance with the following:

39-3.01A Cold Storage

• When aggregate contains material of which at least 20 percent will pass the No. 8 sieve, the material shall be fed from storage by means of a mechanical feeder.

• Before being fed to the drier, aggregate shall be separated into sizes and stored as follows:

39-3.01A(1) Cold Storage for Plants Utilizing Hot-Feed Control

• Aggregate for asphalt concrete base shall be separated into 4 or more sizes and stored separately. Aggregate for Type A or Type B asphalt concrete of the 3/4-inch and 1/2-inch maximum sizes shall be separated into 3 or more sizes and stored separately.

• Aggregate for Type A or Type B asphalt concrete of the 3/8-inch maximum size and the No. 4 maximum size, and aggregate for Open Graded asphalt concrete need not be separated into sizes and stored separately.

39-3.01A(2) Cold Storage for Plants Utilizing Cold-Feed Control

• When the Contractor elects to use a plant equipped with cold-feed control, aggregate for asphalt concrete base shall be separated into 4 or more sizes. Aggregate for asphalt concrete of the 3/4-inch and 1/2-inch maximum sizes shall be separated into 3 or more sizes. Aggregate for asphalt concrete of the 3/8-inch maximum size and aggregate for Open Graded asphalt concrete shall be separated into 2 or more sizes. Aggregate for asphalt concrete of No. 4 maximum size need not be separated.

• After the aggregate is separated, each size shall be stored separately.

39-3.01B Hot Storage

• Aggregate for asphalt concrete and asphalt concrete base to be mixed in batch mixing plants, after being dried, shall be stored in accordance with the following:

Aggregates for asphalt concrete base shall be separated into 4 or more sizes. Aggregates for asphalt concrete of 3/4-inch and 1/2-inch maximum sizes shall be separated into 3 or more sizes. Aggregate for asphalt concrete of 3/8-inch maximum size and aggregate for Open Graded asphalt concrete shall be separated into 2 or more sizes. Aggregate for asphalt concrete of No. 4 maximum size need not be separated.

After the aggregate is separated, each size shall be stored in a separate bin and shall be recombined in conformance with the provisions in Section 39-3.03, "Proportioning," to conform to the gradings specified in Section 39-2, "Materials."

Storage bins shall be provided with chutes to prevent overflow into adjacent bins.

39-3.01C Asphalt Binder Storage

• Asphalt to be used as a binder for asphalt concrete shall be stored in tanks accurately calibrated in uniform intervals of 100 gallon intervals and maintained to

this accuracy. The storage tanks shall be accessible for measuring the volume of asphalt at any time.

- The Contractor shall provide a suitable sampling device in asphalt feed lines connecting plant storage tanks to the asphalt weighing system or spray bar. The sampling device shall consist of a valve with a nominal diameter between 1/2 inch or 3/4 inch valve constructed in a manner that a one-quart sample may be withdrawn slowly at any time during plant operations. The valve shall be maintained in good condition, and if the valve fails to function properly, the valve shall be replaced. The sampling device shall be readily accessible and in an area free of dangerous obstructions and shall be between 24 inches and 30 inches above the platform. A drainage receptacle shall be provided for flushing the device prior to sampling.
- The discharge end of the asphalt binder circulating pipe shall be maintained below the surface of the asphalt binder in the storage tank to prevent discharging hot asphalt binder into open air.
- A temperature-sensing device shall be installed in the asphalt feed line. The device shall measure the temperature of the asphalt and shall be accurate to 10° F. The indicator shall be located and maintained at the point where the proportioning operations are controlled. When a recording type indicator is used, the recording type indicator shall be maintained in working condition and shall be serviced as required.

39-3.02 DRYING

- Aggregate shall be fed directly to a drier-drum mixer or to a drier at a uniform rate.
- Drying shall continue for a sufficient time and at a sufficiently high temperature that, at the time of spreading, the moisture content of the completed mixture shall not exceed one percent. Moisture content will be determined by California Test 310 or 370.
- The drier or drier-drum mixer shall be provided with a device which senses the temperature of the material leaving the drier or the drier-drum mixer. The temperature-sensing device shall be accurate to the nearest 10° F, and shall be installed in such a manner that changes of 10° F in temperature of the material will be shown within one minute. The indicator shall be located and maintained at the point where the proportioning operations are controlled. When a recording type indicator is used, the recording type indicator shall be maintained in working condition and shall be serviced as required.
- The burner used for heating the aggregate shall achieve complete combustion of the fuel.

39-3.03 PROPORTIONING

- Before producing asphalt concrete or asphalt concrete base, the Contractor shall submit in writing to the Engineer the gradation of the aggregate for each mix which he proposes to furnish. If the aggregate is separated into 2 or more sizes, the proposed gradation shall consist of gradations for individual sizes, and the proposed proportions of individual sizes, combined mathematically to indicate one proposed gradation. The gradation shall meet the applicable grading requirements shown in

Section 39-2.02, "Aggregate," and shall show the percentage passing each of the specified sieve sizes.

- At least 2 weeks prior to their intended use, the Contractor shall furnish samples of aggregates, in the quantity requested by the Engineer, from the source the Contractor proposes to use for the project. The samples shall have been processed in a manner representative of that for the material to be used in the work. In batch-mixing plants, these samples shall be obtained from the normal sampling area, just before the weighhopper. In continuous mixing plants, the sample shall be obtained from the normal sampling area, after cold feed proportioning and in advance of the point where the aggregate enters the mixer. The bitumen ratio (pounds of asphalt per 100 pounds of dry aggregate including supplemental fine aggregate, if used) will be determined by the Engineer using California Test 367, or California Test 368 for Open Graded asphalt concrete.
- Should the Contractor change the source of supply, the Contractor shall furnish new samples and proposed proportions, as determined by the Engineer to be necessary, at least 2 weeks before their intended use. A change which affects any portion of the total aggregate in the mix will be considered a change in source and will require a new mix design. Up to 3 mix designs will be performed by the State at State expense when the mix design is utilized for one or more working days. The Contractor shall bear all costs involved in developing any mix design not utilized for one or more days and for all mix designs developed after the first 3 that have been so utilized. The Engineer will determine the cost to the State for the mix designs, and the Department may deduct this amount from any moneys due, or that may become due the Contractor under the contract.
- Where asphalt concrete or asphalt concrete base is to be produced from established sources and if acceptable to the Engineer, the Contractor may advise the Engineer in writing that the source, gradings and proportions of those aggregates proposed to be furnished are the same as those approved for, and used on, another prior or concurrent project. The project shall be identified by contract number. The Engineer will determine if an existing mix design is acceptable for the current project.

39-3.03A Proportioning for Batch Mixing

- When the Contractor elects to use batch mixing equipment, each aggregate storage bin shall be equipped with a suitable, safe sampling device which will provide a sample, representative of actual production, of the aggregate discharged into the weighhopper or volumetric proportioning bin. When the samples are taken from a location above ground level, a means shall be provided for lowering the aggregate samples to the ground.
- The fine material collected in dust control systems, other than centrifugal collectors or knock-out boxes, shall be proportioned as provided for supplemental fine aggregate in this Section 39-3.03A.
- When supplemental fine aggregate is used, it shall be proportioned by weight as provided in "Weight Proportioning" of Section 39-3.03A(1), "Manual Proportioning." A suitable, safe sampling device shall be installed in each feed line or surge tank preceding the weighhopper. The delivery point of samples shall be safe and convenient.

- Aggregate and asphalt shall be proportioned by weight or by volume as follows:

39-3.03A(1) Manual Proportioning

- An automatic plant shall not be operated manually unless the automatic circuitry is disconnected to the extent that the automatic circuitry cannot be activated by the mere operation of a switch, circuit breaker or some other similar routine procedure.
- When manual proportioning is used in the production of asphalt concrete or asphalt concrete base, proportioning shall conform to the following:

Weight Proportioning

- The zero tolerance for aggregate scales shall be 0.5-percent of the total batch weight of the aggregate. The zero tolerance for separate scales for weighing supplemental fine aggregate or asphalt binder shall be 0.05-percent of the total batch weight of the aggregate.
- The indicated weight of material drawn from storage for any draft of material shall not vary from the preselected scale setting by more than the following percentages of the total batch weight of the aggregate:

(1) Aggregate shall be within one percent, except that when supplemental fine aggregate is used and is weighed cumulatively with the aggregate, the draft of aggregate drawn immediately before the supplemental fine aggregate shall be within 0.5-percent.
(2) Supplemental fine aggregate shall be within 0.5-percent.
(3) Asphalt binder shall be within 0.1-percent.

- The asphalt binder shall be measured by a tank scale.

Volumetric Proportioning

- Each size of aggregate, except supplemental fine aggregate, shall be proportioned in a separate bin that is adjustable in size. Each bin shall have a gate or other device so designed that the bin shall be completely filled and struck off in measuring the volume of aggregate to be used in the mix. Means shall be provided for calibrating the weight of material in each measuring bin at any time. The plant shall be operated in such a manner that the material in each aggregate bin is within 2 percent of the weight preselected for the type of mixture being produced.
- Asphalt binder shall be proportioned by a meter or an adjustable calibrated tank. When meters are used, the asphalt lines leading to asphalt meters shall be full-circulating or shall be regulated so that, during plant stoppages, the temperature of the asphalt does not change more than 15° F from the temperature maintained while the plant is in full operation. Asphalt binder shall be proportioned to within 2 percent of the weight preselected for the mixture being produced.

39-3.03A(2) Automatic Proportioning

- When automatic batch mixing is required by the special provisions or when the Contractor elects to use an automatic batching system, the proportioning devices shall be automatic to the extent that the only manual operation required for

proportioning all materials for one batch shall be a single operation of a switch or starter.

Weight Proportioning

- Automatic proportioning devices shall be of a type in which materials discharged from the several bins are controlled by gates or by mechanical conveyors. The batching devices shall be so interlocked that no new batch may be started until all weighhoppers are empty, the scales are at zero, and the discharge gates are closed. The means of withdrawal from the bins and of discharge from the weigh box shall be interlocked so that not more than one bin can discharge onto any given scale at one time, and that the weigh box cannot be tripped until the required quantity from each of the bins has been deposited therein. In addition, automatic proportioning devices shall be interlocked so that the weighing cycle will be interrupted whenever the amount of material drawn from any storage varies from the preselected amount by more than the tolerances specified in Section 39-3.03A(1), "Manual Proportioning." Whenever the weighing cycle is interrupted, that specific batch shall not be used in the work unless it can be manually adjusted to meet the specified tolerances based on the total weight of the batch. When partial batches are batched automatically, the interlock tolerances, except the zero tolerance, shall apply to the total weight of the aggregate in the partial batch.
- Automatic proportioning devices shall be operated so that all weight increments required for a batch are preset on the controls at the same time. Controls shall be designed so that these settings may be changed without delay, and the order of discharge from the several bins can be changed as directed by the Engineer.
- Automatic proportioning controls shall be equipped with means for inspection of the interlock tolerance settings, and instructions for doing so shall be immediately available at the point of operation.
- In order to check the accuracy of proportioning during plant operation, the Contractor shall provide means to check the weight of various proportioned amounts on a separate scale located at the plant.

Volumetric Proportioning

- Asphalt binder shall be proportioned by an adjustable calibrated tank.
- Automatic volumetric proportioning devices shall be of a type which will not allow the bins to discharge into the mixer unless the mixer is empty and the mixer discharge gate is closed and will not operate unless the aggregate bins and asphalt binder tank are full.
- The automatic proportioning device shall operate in such a manner that the material in each aggregate bin and the asphalt binder tank is within 2 percent of the preselected weight.
- In order to check the accuracy of proportioning during plant operation, the Contractor shall provide means to check the weight of various proportioned amounts on a separate scale located at the plant.

39-3.03B Proportioning for Continuous Mixing

- Asphalt binder shall be introduced into the mixer through a meter in conformance with the provisions in Section 9-1.01, "Measurement of Quantities."

The asphalt meter shall automatically compensate for changes in asphalt temperature, unless the meter is of the weight flow, coriolis effect, type. The system shall be capable of varying the rate of delivery of binder proportionate with the delivery of aggregate. During any day's run, the temperature of asphalt binder shall not vary more than 50° F. The meter and lines shall be heated and insulated. The storage for binder shall be equipped with a device for automatic plant cut-off when the level of binder is lowered sufficiently to expose the pump suction line.

- When supplemental fine aggregate is used, it shall be proportioned by weight by a method that uniformly feeds the material within 2 percent of the required amount. Supplemental fine aggregate shall be discharged from the proportioning device directly into the mixer.
- The supplemental fine aggregate proportioning system shall function with such accuracy that, when operated at between 30 percent and 100 percent of maximum operating capacity, the average difference between the indicated weight of material delivered and the actual weight delivered will not exceed one percent of the actual weight for three 15-minute runs. For any of 3 individual 15-minute runs, the indicated weight of material delivered shall not vary from the actual weight delivered by more than 2 percent of the actual weight.
- The fine material collected in all dust control systems may be returned to the aggregate production stream without proportioning if returned at a rate commensurate with overall plant production, and if returned at or before the mixer. Any return rate of less than 100 percent of the collection rate shall be metered as specified above for supplemental fine aggregate.
- The asphalt feeder, each of the aggregate feeders, the supplemental fine aggregate feeder, if used, and the combined aggregate feeder, shall be equipped with devices by which the rate of feed can be determined while the plant is in full operation.
- The combined aggregate shall be weighed using a belt scale. The belt scale shall be of such accuracy that, when the plant is operating between 30 percent and 100 percent of belt capacity, the average difference between the indicated weight of material delivered and the actual weight delivered will not exceed one percent of the actual weight for three 3-minute runs. For any of the 3 individual 3-minute runs, the indicated weight of material delivered shall not vary from the actual weight delivered by more than 2 percent of the actual weight.
- The actual weight of material delivered for proportioning device calibrations shall be determined by a vehicle scale in conformance with the provisions in Section 9-1.01, "Measurement of Quantities." The vehicle scale shall be located at the plant and shall be sealed within 24 hours of checking the plant's proportioning devices. The plant shall be equipped so that this accuracy check can be made prior to the first operation for a project and at any other time as directed by the Engineer.
- The belt scale for the combined aggregate, the proportioning devices for supplemental fine aggregate, if used, and the asphalt proportioning meter shall be interlocked so that the rates of feed of the aggregates and asphalt will be adjusted automatically (at all production rates and production rate changes) to maintain the bitumen ratio (pounds of asphalt per 100 pounds of dry aggregate including supplemental fine aggregate, if used) designated by the Engineer. The plant shall

not be operated unless this automatic system is operating and in good working condition.

- Asphalt meters and aggregate belt scales used for proportioning aggregates and asphalt shall be equipped with rate-of-flow indicators to show the rates of delivery of asphalt and aggregate, and resettable totalizers so that the total amounts of asphalt and aggregate introduced into the mixture can be determined. Rate-of-flow indicators and totalizers for like materials shall be accurate within one percent when compared directly. The asphalt cement totalizer shall not register when the asphalt metering system is not delivering material to the mixer.
- The bin or bins containing the fine aggregate and supplemental fine aggregate, if used, shall be equipped with vibrating units or other equipment which will prevent any hang-up of material while the plant is operating. Each belt feeder shall be equipped with a device to monitor the depth of aggregate between the troughing rollers. The device for monitoring depth of aggregate shall automatically shut down the plant whenever the depth of aggregate is less than 70 percent of the target depth. To avoid erroneous shutdown by normal fluctuation, a delay between sensing less than 70 percent flow and shutdown of the plant will be permitted, as determined by the Engineer, at the time of the initial California Test 109. A second device shall be located either in the stream of aggregate beyond the belt or where it will monitor movement of the belt by detecting revolutions of the tail pulley on the belt feeder. The device for monitoring no flow or belt movement, as the case may be, shall stop the plant automatically and immediately when there is no flow. The plant shall not be operated unless both low-flow and no-flow devices are in good working condition and functioning.
- The Contractor shall determine the moisture content of the aggregate at least once during each 2 hours of production and shall adjust the moisture control equipment accordingly.
- For continuous pugmill mixing plants an aggregate sampling device which will provide a 60-pound to 80-pound sample of the combined aggregate while the plant is in full operation shall be provided in advance of the point where the aggregate enters the mixer.
- For drier-drum mixing plants an aggregate sampling device which will provide a 60-pound to 80-pound sample of the combined aggregate while the plant is in full operation shall be provided in advance of the point where the aggregate enters the drier-drum mixer.
- When the samples are taken from a location above ground level, a means shall be provided for lowering the aggregate samples to the ground.
- When supplemental fine aggregate is used, a suitable, safe sampling device shall be installed in each feed line or surge tank preceding the proportioning device for the supplemental fine aggregate.

39-3.04 MIXING

- Aggregate, supplemental fine aggregate and asphalt binder shall be mixed in a batch mixer, continuous mixing pugmill mixer or continuous mixing drier-drum mixer. The asphalt content of the asphalt mixture will be determined by extraction tests in conformance with the requirements in California Test 310 or 362, or will be determined in conformance with the requirements in California Test 379. The

bitumen ratio (pounds of asphalt per 100 pounds of dry aggregate including supplemental fine aggregate if used) shall not vary by more than 0.5-pound of asphalt above or 0.5-pound of asphalt below the amount designated by the Engineer. Compliance with this requirement, except for Open Graded asphalt concrete, will be determined by testing samples taken from the mat behind the paver before initial or breakdown compaction of the mat.

- For Open Graded asphalt concrete, compliance with this requirement will be determined either by taking samples from trucks at the plant or from the mat behind the paver before initial or breakdown compaction of the mat. If the sample of Open Graded asphalt concrete is taken from the mat behind the paver, the bitumen ratio shall be not less than the amount designated by the Engineer, less 0.7-pound of asphalt per 100 pounds of dry aggregate, nor more than the amount designated by the Engineer, plus 0.5-pound of asphalt per 100 pounds of dry aggregate.
- The charge in a batch mixer, or the rate of feed to a continuous mixer, shall not exceed that which will permit complete mixing of all of the material. Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected by a reduction in the volume of material or by other adjustments.
- Asphalt binder shall be at a temperature of not less than 250° F nor more than 375° F when added to the aggregate.
- The temperature of the aggregate before adding the binder, except for Open Graded mixes, shall be not more than 325° F. The temperature of the aggregate for Open Graded mixtures shall be not more than 275° F.

39-3.04A Batch Mixing

- When asphalt concrete or asphalt concrete base is produced by batch mixing, the mixer shall be equipped with a sufficient number of paddles of a type and arrangement to produce a properly mixed batch.
- The binder shall be introduced uniformly into the mixer along the center of the mixer parallel to the mixer shafts, or by pressure spraying. When a pan is used, the pan shall be equipped with movable vanes in order that the flow of binder may be directed across the width of the pan, as desired. The vanes shall be equipped with a means for quick adjustment, and a positive lock to prevent shifting.
- The mixer platform shall be of ample size to provide safe and convenient access to the mixer and other equipment. The mixer housing and weighbox housing shall be provided with gates of ample size to permit ready sampling of the discharge of aggregate from each of the plant bins and from each feed line or surge tank of supplemental fine aggregate, if used. The Contractor shall provide a sampling device capable of delivering a representative sample of sufficient size to permit the required tests.
- The mixer shall be equipped with a timing device which will indicate by a definite audible or visual signal the expiration of the mixing period. The device shall measure the time of mixing within 2 seconds.
- The time of mixing a batch shall begin on the charging stroke of the weighhopper dumping mechanism and shall end when discharge is started. Mixing shall continue until a homogeneous mixture of uniformly distributed and properly coated aggregates of unchanging appearance is produced. The time of mixing shall be not less than 30 seconds.

- When automatic proportioning or automatic batch mixing is required by the special provisions or when the Contractor elects to use an automatic batching system, an interval timer shall control the time of mixing. The interval timer shall be interlocked so that the mixer cannot be discharged until all of the materials have been mixed for the full time specified.

39-3.04B Continuous Mixing

- Continuous mixing plants shall utilize pugmill or drier-drum mixers.
- When asphalt concrete or asphalt concrete base is produced by pugmill mixing, the mixer shall be equipped with paddles of a type and arrangement to provide sufficient mixing action and movement to the mixture to produce properly mixed asphalt concrete or asphalt concrete base. The combined aggregate shall be fed directly from the drier to the mixer at a uniform and controlled rate.
- Mixing shall continue until a homogeneous mixture of thoroughly and uniformly coated aggregates of unchanging appearance is produced at discharge from the mixer.
- Temperature of the completed mixture shall not exceed 325° F at discharge from the mixer.
- The mixer shall discharge into a storage silo with a capacity of not less than that specified in Section 39-3.05, "Asphalt Concrete and Asphalt Concrete Base Storage." The Contractor shall provide a means of diverting the flow of asphalt concrete or asphalt concrete base away from the silo to prevent incompletely mixed portions of the mixture from entering the silo.

39-3.05 ASPHALT CONCRETE AND ASPHALT CONCRETE BASE STORAGE

- When asphalt concrete or asphalt concrete base is stored, the asphalt concrete or asphalt concrete base shall be stored only in silos. Asphalt concrete or asphalt concrete base shall not be stockpiled. The minimum quantity of asphalt concrete or asphalt concrete base in any one silo during mixing shall be 20 tons except for the period immediately following a shutdown of the plant of 2 hours or more. A means shall be provided to indicate that storage in each silo is being maintained as required.
- Storage silos shall be equipped with a surge-batcher sized to hold a minimum of 2 tons of material. A surge-batcher consists of equipment placed at the top of the storage silo which catches the continuous delivery of the completed mix and changes it to individual batch delivery and prevents the segregation of product ingredients as the completed mix is placed into storage. The surge-batcher shall be center loading and shall be thermally insulated or heated or thermally insulated and heated to prevent material buildup. Rotary chutes shall not be used as surge-batchers.
- The surge-batcher shall be independent and distinct from conveyors or chutes used to collect or direct the completed mixture being discharged into storage silos and shall be the last device to handle the material before it enters the silo. Multiple storage silos shall be served by an individual surge-batcher for each silo. Material handling shall be free of oblique movement between the highest elevation (conveyor outfall) and subsequent placement in the silo. Discharge gates on

surge-batchers shall be automatic in operation and shall discharge only after a minimum of 2 tons of material has been collected and shall close before the last collected material leaves the device. Discharge gate design shall prevent the deflection of material during the opening and closing operation.

- Open Graded asphalt concrete stored in excess of 2 hours, and any other asphalt concrete or asphalt concrete base stored in excess of 18 hours, shall not be used in the work.
- Asphalt concrete or asphalt concrete base with hardened lumps in the mixture shall not be used. Any storage facility which contained the material with the hardened lumps shall not be used for further storage until the cause of the lumps is corrected.

39-3.06 ASPHALT CONCRETE PLANTS

- Any plants, including commercial plants, that produce asphalt concrete or asphalt concrete base that is subject to these specifications shall conform to the provisions in Section 7-1.01F, "Air Pollution Control," and shall be equipped with a wet-tube dust washer or equal and other devices which will reduce the dust emission to the degree that adjacent property is not damaged. The washer and other equipment shall function efficiently at all times when the plant is in operation.
- During production, petroleum products such as diesel fuel and kerosene shall not be used as a release agent on belts, conveyors, hoppers or hauling equipment.
- Plants shall be equipped with an inspection dock so constructed that an inspector standing on the dock can inspect the completed mix and take samples, as necessary, from the hauling vehicle before the vehicle leaves the plant site. This inspection dock shall allow the vehicle to pull alongside and shall meet all applicable safety requirements of the California Division of Occupational Safety and Health. Drivers shall be instructed to stop at the dock whenever an inspector is on the dock and to remain there until directed to leave by the inspector.

39-4. SUBGRADE, PRIME COAT, PAINT BINDER (TACK COAT), AND PAVEMENT REINFORCING FABRIC

39-4.01 SUBGRADE

- Immediately prior to applying prime coat or paint binder (tack coat), or immediately prior to placing the asphalt concrete or asphalt concrete base when a prime coat or paint binder (tack coat) is not required, the subgrade to receive asphalt concrete or asphalt concrete base shall conform to the compaction requirement and elevation tolerances specified for the material involved and shall be free of loose or extraneous material. If the asphalt concrete or asphalt concrete base is to be placed on an existing base or pavement which was not constructed as part of the contract, the Contractor shall clean the surface by sweeping, flushing or other means to remove all loose particles of paving, all dirt and all other extraneous material immediately before applying the prime coat or paint binder (tack coat).

39-4.02 PRIME COAT AND PAINT BINDER (TACK COAT)

- A prime coat of liquid asphalt shall be applied to the areas to be surfaced when there is a contract item for the work or when the work is required by the special provisions.

- Prime coat shall be applied only to those areas designated by the Engineer.
- Prime coat shall be applied at the approximate total rate of 0.25-gallon per square yard of surface covered. The exact rate and number of applications will be determined by the Engineer.
- Prime coat shall be applied at a temperature conforming to the range of temperatures provided in Section 93-1.03, "Mixing and Applying," for distributor application of the grade of liquid asphalt being used.
- A paint binder (tack coat) of asphaltic emulsion shall be furnished and applied in conformance with the provisions in Section 94, "Asphaltic Emulsions," and shall be applied to all vertical surfaces of existing pavement, curbs, gutters and construction joints in the surfacing against which additional material is to be placed, to a pavement to be surfaced and to other surfaces designated in the special provisions.
- Paint binder (tack coat) shall be applied in one application at a rate of from 0.02-gallon to 0.10-gallon per square yard of surface covered. The exact rate of application will be determined by the Engineer.
- Before placing a layer of Open Graded asphalt concrete on any other type of asphalt concrete or on an existing bituminous pavement, paint binder (tack coat) shall be applied in one application at a rate of from 0.05-gallon to 0.10-gallon per square yard of surface covered. The exact rate of application will be determined by the Engineer.
- At the Contractor's option, paving asphalt may be used for paint binder (tack coat) instead of asphaltic emulsion. If paving asphalt is used, the grade to be used and the rate of application will be determined by the Engineer. The paving asphalt shall be applied at a temperature of not less than 285° F nor more than 350° F.
- Prime coat or paint binder (tack coat) shall be applied only so far in advance of placing the surfacing as may be permitted by the Engineer. When asphaltic emulsion is used as a paint binder (tack coat), asphalt concrete shall not be placed until the asphaltic emulsion has cured.
- Immediately in advance of placing asphalt concrete or asphalt concrete base, additional prime coat or paint binder (tack coat) shall be applied as directed by the Engineer to areas where the prime coat or paint binder (tack coat) has been damaged, and loose or extraneous material shall be removed, and no additional compensation will be allowed therefor.

39-4.03 PAVEMENT REINFORCING FABRIC

- Pavement reinforcing fabric shall be placed on existing pavement to be surfaced or between layers of asphalt concrete when the work is shown on the plans or specified in the special provisions, or ordered by the Engineer.
- Before placing the pavement reinforcing fabric, a binder of paving asphalt shall be applied to the surface to receive the pavement reinforcing fabric at an approximate rate of 0.25-gallon per square yard of surface covered. The exact rate will be determined by the Engineer. The binder shall be applied to a width equal to the width of the fabric mat plus 3 inches on each side.
- Before applying binder, large cracks, spalls and chuckholes in existing pavement shall be repaired as directed by the Engineer, and the repair work will be paid for as extra work as provided in Section 4-1.03D.

- The fabric shall be aligned and placed with no wrinkles that lap. The test for lapping shall be made by gathering together the fabric in a wrinkle. If the height of the doubled portion of extra fabric is 1/2 inch or more, the fabric shall be cut to remove the wrinkle, then lapped in the direction of paving. Lap in excess of 2 inches shall be removed.
- Pavement reinforcing fabric shall not be placed in areas of conform tapers where the thickness of the overlying asphalt concrete is 0.10-foot or less.
- If manual laydown methods are used, the fabric shall be unrolled, aligned, and placed in increments of approximately 30 feet.
- Adjacent borders of the fabric shall be lapped 2 inches to 4 inches. The preceding roll shall lap 2 inches to 4 inches over the following roll in the direction of paving at ends of rolls or at any break. At fabric overlays, both the binder and the fabric shall overlap the previously placed fabric by the same amount.
- Seating of the fabric with rolling equipment after placing will be permitted. Turning of the paving machine and other vehicles shall be gradual and kept to a minimum to avoid damage.
- A small quantity of asphalt concrete, to be determined by the Engineer, may be spread over the fabric immediately in advance of placing asphalt concrete surfacing in order to prevent fabric from being picked up by construction equipment.
- Public traffic shall not be allowed on the bare reinforcing fabric, except that public cross traffic shall be allowed to cross the fabric, under traffic control, after the Contractor has placed a small quantity of asphalt concrete over the fabric.
- Care shall be taken to avoid tracking binder material onto the pavement reinforcing fabric or distorting the fabric during seating of the fabric with rolling equipment. If necessary, exposed binder material shall be covered lightly with sand.

39-5 SPREADING AND COMPACTING EQUIPMENT

39-5.01 SPREADING EQUIPMENT

- Asphalt pavers shall be self-propelled mechanical spreading and finishing equipment, provided with a screed or strike-off assembly capable of distributing the material to not less than the full width of a traffic lane. Screed action shall include any cutting, crowding or other practical action which is effective on the mixture without tearing, shoving or gouging, and which produces a surface texture of uniform appearance. The screed shall be adjustable to the required section and thickness. The paver shall be provided with a suitable full width compacting device. Pavers that leave ridges, indentations or other marks in the surface shall not be used unless the ridges, indentations or other marks are eliminated by rolling or prevented by adjustment in operation.
- The asphalt paver shall operate independently of the vehicle being unloaded or shall be capable of propelling the vehicle being unloaded in a satisfactory manner. The load of the haul vehicle shall be limited to that which will ensure satisfactory spreading. While being unloaded the haul vehicle shall be in contact with the machine at all times, and the brakes on the haul vehicle shall not be depended upon to maintain contact between the vehicle and the machine.

- No portion of the weight of hauling or loading equipment, other than the connection, shall be supported by the asphalt paver, and no vibrations or other motions of the loader, which could have a detrimental effect on the riding quality of the completed pavement, shall be transmitted to the paver.
- When asphalt concrete is placed directly upon asphalt treated permeable base, the asphalt concrete shall be placed with a paver equipped with tracks unless the layer being placed is 0.15-foot or less in compacted thickness.

39-5.02 COMPACTING EQUIPMENT

- A minimum of one steel-tired, 2-axle tandem roller weighing not less than 8 tons nor more than 10 tons shall be used for each asphalt paver to compact Open Graded asphalt concrete, and a minimum of 3 rollers consisting of the following shall be used for each asphalt paver to compact all other asphalt concrete and asphalt concrete base:

One steel-tired roller weighing not less than 8 tons;
One steel-tired, 2-axle or 3-axle tandem or 3-wheel roller weighing not less than 12 tons and
One pneumatic-tired roller.

- The 2-axle or 3-axle tandem or 3-wheel roller shall have rolling wheels with a diameter of 40 inches or more.
- Except when leveling or when asphalt concrete less than 0.20-foot in compacted thickness is being placed on existing surfacing, pneumatic-tired rollers will not be required when approved vibratory rollers are furnished and used as specified in Section 39-6.03, "Compacting."
- Each roller shall have a separate operator. Rolling equipment shall be self-propelled and reversible. The minimum number, weight and type of rollers required may be reduced or modified in conformance with the provisions in Section 39-6.03, "Compacting," for low rates of production or when alternative equipment is approved by the Engineer.
- Rollers shall be equipped with pads and water systems which prevent sticking of asphalt mixtures to the pneumatic- or steel-tired wheels. A parting agent, which will not damage the asphalt mixture, as determined by the Engineer, may be used to aid in preventing the sticking of the mixture to the wheels.
- Other equipment, approved by the Engineer in conformance with the requirements in California Test 113, may be substituted for 3-wheel or tandem rollers when used as specified in Section 39-6.03, "Compacting."
- Pneumatic-tired rollers shall be the oscillating type having a width of not less than 4 feet with pneumatic tires of equal size, diameter and having treads satisfactory to the Engineer. Wobble-wheel rollers will not be permitted. The tires shall be spaced so that the gaps between adjacent tires will be covered by the following tires.
- The tires shall be inflated to 90 psi, or a lower pressure as designated by the Engineer, and maintained so that the air pressure will not vary more than 5 psi from the designated pressure. Pneumatic-tired rollers shall be constructed so that the total weight of the roller can be varied to produce an operating weight per tire of

not less than 2,000 pounds. The total operating weight of the roller shall be varied as directed by the Engineer.

39-6 SPREADING AND COMPACTING

39-6.01 GENERAL REQUIREMENTS

- Placing material in a windrow, then picking it up and placing it in the asphalt paver with loading equipment, will be permitted provided:

A. The asphalt paver is of such design that the material will fall into a hopper which has a movable bottom conveyor to feed the screed.
B. The loader (pick-up machine) is constructed and operated so that substantially all of the material deposited on the roadbed is picked up and deposited in the paving machine.
C. The windrow is deposited only so far in advance of the paver to provide for continuous operation of the paver and not so far as to allow the temperature of the asphalt concrete in the windrow to fall below 260° F.

- Unless lower temperatures are directed by the Engineer, all mixtures, except Open Graded asphalt concrete, shall be spread, and the first coverage of initial or breakdown compaction shall be performed when the temperature of the mixture is not less than 250° F, and all breakdown compaction shall be completed before the temperature of the mixture drops below 200° F. Open Graded asphalt concrete shall be spread at a temperature of not less than 200° F, and not more than 250° F, measured in the hopper of the paving machine. Open Graded asphalt concrete shall be compacted as soon as possible after spreading.
- Type A and Type B asphalt concrete shall be placed only when the atmospheric temperature is above 50° F. Asphalt concrete base shall be placed only when the atmospheric temperature is above 40° F.
- Open Graded asphalt concrete shall be placed only when the atmospheric temperature is above 70° F and, where placement is to be on bridges or other structures when the surface temperature of the structure is above 60° F.
- Asphalt concrete and asphalt concrete base shall not be placed when the underlying layer or surface is frozen, or when, in the opinion of the Engineer, weather conditions will prevent the proper handling, finishing or compaction of the mixtures.
- Asphalt concrete shall be spread and compacted in the number of layers of the thicknesses indicated in the following table:

Total Thickness Shown on Plans[a]	No. of Layers	Top Layer Thickness (foot)		Next Lower Layer Thickness (foot)		All Other Lower Layer Thickness (foot)	
		Min.	Max.	Min.	Max.	Min.	Max.
0.20-foot or less	1	—	—	—	—	—	—
0.25-foot	2[b]	0.12	0.13	0.12	0.13	—	—
0.30- 0.40 foot	2	0.15	0.20	0.15	0.25	—	—
0.45-foot or more	c	0.15	0.20	0.15	0.25	0.15	0.40

a When pavement reinforcing fabric is shown to be placed between layers of asphalt concrete, the thickness of asphalt concrete above the pavement reinforcing fabric shall be considered to be the "Total Thickness Shown on Plans" for the purpose of spreading and compacting the asphalt concrete above the pavement reinforcing fabric.

b At the option of the Contractor, one layer 0.25-foot thick may be placed.

c At least 2 layers shall be placed if total thickness is 0.45-foot. At least 3 layers shall be placed if total thickness is more than 0.45-foot and less than 0.90-foot. At least 4 layers shall be placed if total thickness is 0.90-foot or more.

- Asphalt concrete base shall be spread and compacted in one or more layers. Each layer of asphalt concrete base shall be not less than 0.20-foot nor more than 0.40-foot in compacted thickness, except that where the total thickness of asphalt concrete to be placed over asphalt concrete base is 0.20-foot or less, the layer of asphalt concrete base below the asphalt concrete shall not exceed 0.25-foot.
- A layer shall not be placed over a layer which exceeds 0.25-foot in compacted thickness until the temperature of the layer which exceeds 0.25-foot in compacted thickness is less than 160° F at mid depth.
- Asphalt concrete and asphalt concrete base to be placed on shoulders, and other areas off the traveled way having a width of 5 feet or more, shall be spread in the same manner as specified above. When the shoulders and other areas are less than 5 feet in width, the material may be deposited and spread in one or more layers by any mechanical means that will produce a uniform smoothness and texture. Unless otherwise shown on the plans, asphalt mixtures shall not be handled, spread or windrowed in a manner that will stain the finished surface of any pavement or other improvements.
- The completed mixture shall be deposited on the roadbed at a uniform quantity per linear foot, as necessary to provide the required compacted thickness without resorting to spotting, picking-up or otherwise shifting the mixture.
- Segregation shall be avoided, and the surfacing shall be free from pockets of coarse or fine material. Asphalt concrete or asphalt concrete base containing hardened lumps shall not be used.
- Longitudinal joints in the top layer shall correspond with the edges of proposed traffic lanes. Longitudinal joints in all other layers shall be offset not less than 0.5-foot alternately each side of the edges of traffic lanes. The Engineer may permit other patterns of placing longitudinal joints if the Engineer considers that those patterns will not adversely affect the quality of the finished product.
- Unless otherwise provided herein or permitted by the Engineer, the top layer of asphalt concrete for shoulders, tapers, transitions, road connections, private drives, curve widenings, chain control lanes, turnouts, left turn pockets, and other such

areas, shall not be spread before the top layer of asphalt concrete for the adjoining through lane has been spread and compacted. At locations where the number of lanes is changed, the top layer for the through lanes shall be paved first. When existing pavement is to be surfaced and the specified thickness of asphalt concrete to be spread and compacted on the existing pavement is 0.25-foot or less, shoulders or other adjoining areas may be spread simultaneously with the through lane provided the completed surfacing conforms to the requirements of these specifications. Tracks or wheels of spreading equipment shall not be operated on the top layer of asphalt concrete in any area until final compaction has been completed.

- At locations shown on the plans, specified in the special provisions or as directed by the Engineer, the asphalt concrete shall be tapered or feathered to conform to existing surfacing or to other highway and non-highway facilities.
- At locations where the asphalt concrete or asphalt concrete base is to be placed over areas inaccessible to spreading and rolling equipment, the asphalt concrete or asphalt concrete base shall be spread by any means to obtain the specified results and shall be compacted thoroughly to the required lines, grades and cross sections by means of pneumatic tampers, or by other methods that will produce the same degree of compaction as pneumatic tampers.

39-6.02 SPREADING

- All layers, except as otherwise provided in Section 39-6.01, “General Requirements,” and in this Section 39-6.02, shall be spread with an asphalt paver. Asphalt pavers shall be operated in such a manner as to ensure continuous and uniform movement of the paver.
- In advance of spreading asphalt concrete over an existing base, surfacing or bridge deck, if there is a contract item for asphalt concrete (leveling) or if ordered by the Engineer, asphalt concrete shall be spread by any mechanical means that will produce a uniform smoothness and texture. Asphalt concrete (leveling) shall include, but is not limited to, the filling and leveling of irregularities and ruts. Asphalt concrete used to change the cross slope or profile of an existing surface shall not be considered as asphalt concrete (leveling).
- When directed by the Engineer, paint binder (tack coat) shall be applied to any layer in advance of spreading the next layer.
- Before placing the top layer adjacent to cold transverse construction joints, the joints shall be trimmed to a vertical face and to a neat line. Transverse joints shall be tested with a 12-foot straightedge and shall be cut back as required to conform to the provisions in Section 39-6.03, "Compacting," for surface smoothness. Connections to existing surfacing shall be feathered to conform to the provisions for smoothness. Longitudinal joints shall be trimmed to a vertical face and to a neat line if the edges of the previously laid surfacing are, in the opinion of the Engineer, in such condition that the quality of the completed joint will be affected.

39-6.03 COMPACTING

- Compacting equipment shall conform to the provisions in Section 39-5.02, "Compacting Equipment."

- A pass shall be one movement of a roller in either direction. A coverage shall be as many passes as are necessary to cover the entire width being paved. Overlap between passes during any coverage, made to ensure compaction without displacement of material in accordance with good rolling practice, shall be considered to be part of the coverage being made and not part of a subsequent coverage. Each coverage shall be completed before subsequent coverages are started.
- Rolling shall commence at the lower edge and shall progress toward the highest portion, except that when compacting layers which exceed 0.25-foot in compacted thickness, and if directed by the Engineer, rolling shall commence at the center and shall progress outwards.
- Compaction of Open Graded asphalt concrete shall consist of 2 coverages. If necessary, only one coverage of the Open Graded asphalt concrete may be ordered by the Engineer to prevent a break in the bond of asphalt between the aggregate particles.
- All other asphalt concrete and asphalt concrete base shall be compacted as follows:

Initial or breakdown compaction shall consist of 3 coverages of a layer of asphalt mixture and shall be performed with a 2-axle or 3-axle tandem or a 3-wheel roller weighing not less than 12 tons. Where the thickness of the layer of asphalt mixture is less than 0.15-foot, fewer coverages than specified above may be ordered by the Engineer if necessary to prevent damage to the layer being compacted.

The initial or breakdown compaction shall be followed immediately by additional rolling consisting of 3 coverages with a pneumatic-tired roller. Coverages with a pneumatic-tired roller shall start when the temperature of the mixture is as high as practicable, preferably above 180° F, and shall be completed while the temperature of the mixture is at or above 150° F.

Each layer of asphalt concrete and asphalt concrete base shall be compacted additionally without delay by a final rolling consisting of not less than one coverage with a steel-tired roller weighing not less than 8 tons. Except as otherwise provided for low rates of production, a separate finish roller will be required.

- Rolling shall be performed so that cracking, shoving or displacement will be avoided.
- Rolling, where 3-axle tandem rollers may be used as specified in this Section 39-6.03, shall be under the control of the Engineer, but in general, no 3-axle tandem roller shall be used in rolling over a crown or on warped sections when the center axle is in the locked position.
- Provided it is demonstrated to the satisfaction of the Engineer that one roller can perform the work, the required minimum rolling equipment specified above may be reduced to one 2-axle tandem roller, weighing at least 8 tons, for each paver under any of the following conditions:

A. When asphalt concrete or asphalt concrete base is placed at a rate of 50 tons, or less, per hour at any location.
B. When asphalt concrete or asphalt concrete base is placed at a rate of 100 tons, or less, per hour and at the locations or under the conditions as follows:

   1. Placed on miscellaneous areas in conformance with the provisions in Section 39-7.01, "Miscellaneous Areas."
   2. When the width to be placed is less than 8 feet.

C. When the total amount of asphalt concrete and asphalt concrete base included in the contract is 1,000 tons, or less.

- When rolling equipment is reduced as provided in this Section 39-6.03, the rolling requirements may be reduced to at least 3 complete coverages with the tandem roller.
- Alternative compacting equipment, approved by the Engineer in conformance with the requirements in California Test 113, may be used for the initial or breakdown compaction if operated according to the procedures and under the conditions designated in the approval. Except when leveling or when asphalt concrete less than 0.20-foot in compacted thickness is being placed on existing surfacing, additional compaction with pneumatic-tired rollers will not be required when approved alternative equipment has been used for the initial compaction. A vibratory roller may be used as the finish roller provided that the vibratory roller meets the requirements for a finish roller and is operated with the vibratory unit turned off.
- Upon completion of rolling operations, if ordered by the Engineer, the asphalt concrete or asphalt concrete base shall be cooled by applying water. Applying water shall conform to the provisions in Section 17, "Watering."
- The completed surfacing shall be thoroughly compacted, smooth and free from ruts, humps, depressions or irregularities. Any ridges, indentations or other objectionable marks left in the surface of the asphalt concrete by blading or other equipment shall be eliminated by rolling or other means. The use of any equipment that leaves ridges, indentations or other objectionable marks in the asphalt concrete shall be discontinued, and acceptable equipment shall be furnished by the Contractor.
- When a straightedge 12 feet long is laid on the finished surface and parallel with the center line, the surface shall not vary more than 0.01-foot from the lower edge of the straightedge. The transverse slope of the finished surface shall be uniform to a degree such that no depressions greater than 0.02-foot are present when tested with a straightedge 12 feet long laid in a direction transverse to the center line and extending from edge to edge of a 12-foot traffic lane.
- Pavement within 50 feet of a structure or approach slab shall conform to the smoothness tolerances specified in Section 51-1.17, "Finishing Bridge Decks."

39-7 MISCELLANEOUS

39-7.01 MISCELLANEOUS AREAS

- Surfacing of miscellaneous areas, such as median areas (exclusive of inside shoulders), island areas, sidewalks, dikes, gutters, gutter flares, ditches, overside drains, aprons at the ends of drainage structures and other areas outside the traveled way which are designated on the plans as miscellaneous areas to be paved with asphalt concrete, shall conform to these specifications.
- The combined aggregate grading for asphalt concrete placed on miscellaneous areas shall conform to that specified for the asphalt concrete placed on the traveled way, unless otherwise directed by the Engineer. The amount of asphalt binder used in the asphalt concrete placed in dikes, gutters, gutter flares, overside drains and aprons at the ends of drainage structures, unless otherwise directed by the Engineer, shall be increased one percent by weight of the aggregate over the amount of asphalt binder used in the asphalt concrete placed on the traveled way.
- The asphalt concrete placed in miscellaneous areas may be spread in one layer. The material shall be compacted to the required lines, grades and cross section.
- Dikes shall be shaped and compacted with an extrusion machine or other equipment capable of shaping and compacting the material to the required cross section.

39-7.02 SEAL COAT

Where shown on the plans or provided in the special provisions, a fog seal coat shall be applied to the surface of Types A and B asphalt concrete in conformance with the provisions in Section 37, "Bituminous Seals."

39-8 MEASUREMENT AND PAYMENT

39-8.01 MEASUREMENT

- Asphalt concrete and asphalt concrete base will be measured by weight. The quantity to be paid for will be the combined weight of the mixture for the various types of asphalt concrete or asphalt concrete base, whichever is designated in the Engineer's Estimate.
- The weight of the materials will be determined as provided in Section 9-1.01, "Measurement of Quantities."
- Quantities of paving asphalt, liquid asphalt and asphaltic emulsion to be paid for as contract items of work will be determined in accordance with the methods provided in Sections 92, "Asphalts," 93, "Liquid Asphalts," or 94, "Asphaltic Emulsions," as the case may be.
- When recorded batch weights are printed automatically, these weights may be used for determining pay quantities providing the following requirements are complied with:

a. Total aggregate and supplemental fine aggregate weight per batch shall be printed. When supplemental fine aggregate is weighed cumulatively with the aggregate, the total batch weight of aggregate shall include the supplemental fine aggregate.
b. Total bitumen weight per batch shall be printed.

c. Zero-tolerance weight shall be printed prior to weighing the first batch and after weighing the last batch of each truckload.
d. Time, date, mix number, load number and truck identification shall be correlated with load slip.
e. A copy of the recorded batch weights shall be certified by a licensed weighmaster and submitted to the Engineer.

- When there is a contract item to place asphalt concrete dikes by the linear foot, the quantity to be paid for will be the length in feet measured along the completed dike. When there is a contract item to place asphalt concrete (miscellaneous area), the quantity to be paid for will be the area in square yards of the asphalt concrete compacted in place. In addition to the quantities for placing asphalt concrete measured on a linear foot or square yard basis, the asphalt concrete to be placed will also be measured for payment.
- Pavement reinforcing fabric will be measured and paid for by the square yard for the actual pavement area covered.

39-8.02 PAYMENT

- Asphalt concrete placed in the work, unless otherwise specified, will be paid for at the contract price per ton for asphalt concrete or asphalt concrete base of the types designated in the Engineer's Estimate.
- When there is a contract item for asphalt concrete (leveling), quantities of asphalt concrete placed for leveling will be paid for at the contract price per ton for asphalt concrete (leveling). When there is no contract item for asphalt concrete (leveling), and leveling is ordered by the Engineer, asphalt concrete so used will be paid for as extra work as provided in Section 4-1.03D.
- When there is a contract item for place asphalt concrete dike by the linear foot, quantities of dikes will be paid for at the contract price per ton for asphalt concrete and also at the contract price per linear foot for place asphalt concrete dike. Full compensation for any necessary excavation, backfill and preparation of the area shall be considered as included in the contract price paid per linear foot for place asphalt concrete dike and no additional compensation will be allowed therefor.
- Quantities of asphalt concrete placed in miscellaneous areas designated in the special provisions or tabulated on the plans to be included in the contract item of place asphalt concrete (miscellaneous area), will be paid for at the contract price per ton for asphalt concrete and also at the contract price per square yard for place asphalt concrete (miscellaneous area). Full compensation for any necessary excavation, backfill and preparation of the area shall be considered as included in the contract price paid per square yard for place asphalt concrete (miscellaneous area) and no additional compensation will be allowed therefor.
- When there is no item for place asphalt concrete dike by the linear foot or for place asphalt concrete (miscellaneous area) by the square yard and the work is shown on the plans, full compensation therefor, including any necessary excavation, backfill, and preparation of the area, shall be considered as included in the contract price paid for the asphalt concrete.
- Quantities of pavement reinforcing fabric placed and paving asphalt applied as a binder for the pavement reinforcing fabric will be paid for at the contract price per

square yard for pavement reinforcing fabric and per ton for paving asphalt (binder-pavement reinforcing fabric). Full compensation for furnishing and spreading sand to cover exposed binder material, if necessary, shall be considered as included in the contract price paid per ton for paving asphalt (binder-pavement reinforcing fabric) and no separate payment will be made therefor.

- Small quantities of asphalt concrete placed on pavement reinforcing fabric to prevent the fabric from being displaced by construction equipment or to allow traffic to cross over the fabric, shall be considered as part of the layer of asphalt concrete to be placed over the fabric and will be measured and paid for by the ton as asphalt concrete.
- When there is a contract item for liquid asphalt (prime coat), the quantity of prime coat will be paid for at the contract price per ton for the designated grade of liquid asphalt (prime coat). When there is no contract item for liquid asphalt (prime coat) and the special provisions require the application of prime coat, full compensation for furnishing and applying prime coat shall be considered as included in the contract price paid per ton for the asphalt concrete, and no separate payment will be made therefor.
- When there is a contract item for asphaltic emulsion (paint binder), the quantity of asphaltic emulsion or paving asphalt used as paint binder (tack coat) will be paid for at the contract price per ton for asphaltic emulsion (paint binder). When there is no contract item for asphaltic emulsion (paint binder), full compensation for furnishing and applying paint binder (tack coat) shall be considered as included in the contract price paid per ton for the asphalt concrete, and no separate payment will be made therefor.
- Fog seal coat will be paid for as provided in Section 37-1, "Seal Coats."
- No adjustment of compensation will be made for any increase or decrease in the quantities of paint binder (tack coat) or fog seal coat required, regardless of the reason for the increase or decrease. The provisions in Section 4-1.03B, "Increased or Decreased Quantities," shall not apply to the items of paint binder or fog seal coat.
- The above contract prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing asphalt concrete and asphalt concrete base, complete in place, as shown on the plans and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 40: PORTLAND CEMENT CONCRETE PAVEMENT

40-1.01 DESCRIPTION

- This work shall consist of constructing a pavement of portland cement concrete on a prepared subgrade as specified in these specifications and the special provisions.
- At the option of the Contractor, pavement shall be constructed with equipment utilizing stationary side forms or by the use of slip-form paving equipment.
- Unless otherwise provided, pavement shall be constructed of Class 3 concrete and shall conform to the provisions in Section 90, "Portland Cement Concrete."

40-1.015 CEMENT CONTENT

- At least 60 days prior to use, the Contractor shall furnish samples of aggregate, in the quantity ordered by the Engineer, from the source from which the Contractor proposes to obtain aggregate for the project. The samples shall be processed in a manner representative of the process to be used in the work and will be tested for recommended cement content in conformance with the requirements in California Test 536. Should the Contractor change the source of supply, the Contractor shall furnish samples from the new source, or sources, at least 60 days before their intended use.
- After testing samples of the Contractor's proposed aggregate supply, the Engineer may order an increase or decrease in the cement content. If an increase or decrease in the specified quantity of portland cement is ordered by the Engineer, the compensation payable to the Contractor for portland cement concrete pavement will be increased or decreased on the basis of the cost of cement per ton, f.o.b. the cement mill (including sales tax) plus the freight cost per ton, for delivery of the cement to the project from the mill. In determining the cost of the cement, any cash or trade discount offered or available will be credited to the State notwithstanding the fact that the discount may not have been taken by the purchaser.
- The Contractor shall furnish to the Engineer satisfactory evidence of the cost of cement used on the project during the period involved in the ordered change in cement content, and the Contractor shall maintain records in such manner as to enable a clear determination of the cost of cement used during the period. The Contractor's records pertaining to the cost of cement shall be open to inspection or audit by Departmental representatives during the life of the contract and for not less than 3 years after the completion thereof, and the Contractor shall retain the records for that period.
- If the price of cement as determined from the Contractor's records is, in the opinion of the Engineer, excessive, or if the Contractor does not furnish satisfactory evidence of the cost of cement, the Engineer will determine the price to be the lowest wholesale cost at which cement would be available in the quantities concerned delivered to the jobsite, less any discounts available.
- The quantity of cement to be subject to increased or decreased compensation will be computed as the difference between the theoretical quantity of cement based on the specified cement content and the theoretical quantity of cement based on the cement content ordered by the Engineer. Reductions in the cement content resulting from the use of chemical admixtures as provided in Section 90-4.05,

"Optional Use of Chemical Admixtures," will not be considered in the computations. No additional adjustment of compensation will be made for variations in the cost of any work resulting from a change in the quantity of portland cement due to an ordered change in cement content.

40-1.02 WATER SUPPLY

- Before placing concrete, the Contractor shall develop a sufficient supply of water and have it available throughout the work.
- An inadequate water supply will be considered sufficient cause for delaying or stopping mixing operations. In case of a deficiency of water, the requirements for subgrade and curing the concrete already placed shall have priority over mixing.

40-1.03 (BLANK)

40-1.04 SUBGRADE

- Immediately prior to placing concrete, subgrade to receive pavement shall conform to compaction and elevation tolerances specified for the material involved. Subgrade shall also be free of all loose and extraneous material when concrete is placed thereon.
- Subgrade shall be uniformly moist, and any excess water standing in pools or flowing on the surface shall be removed prior to placing concrete.
- Excavation for thickened portions of pavement end anchors shall be made in compacted subgrade without disturbing compaction outside neat dimensions of the thickened portions.
- Prior to placing portland cement concrete pavement on cement treated permeable base, the surface of the base shall be covered with asphaltic emulsion to facilitate measuring the thickness of the concrete pavement. The asphaltic emulsion shall be applied uniformly at a rate of between 0.10-gallon and 0.20-gallon per square yard. The exact rate will be determined by the Engineer. The asphaltic emulsion shall be an anionic slow-setting type conforming to the provisions for SSlh grade in Section 94, "Asphaltic Emulsions."
- Damage to the asphaltic emulsion shall be repaired prior to placing concrete pavement over the cement treated permeable base.

40-1.05 PROPORTIONING

- Aggregate and bulk cement for use in pavement shall be proportioned in conformance with the provisions in Section 90-5, "Proportioning."

40-1.06 PLACING

- The Contractor shall make adequate advance arrangements for preventing delay in delivery and placing of the concrete. An interval of more than 45 minutes between placing of any 2 consecutive batches or loads shall constitute cause for stopping paving operations, and the Contractor shall make a contact joint at the Contractor's expense at the location and of the type directed by the Engineer in the concrete already placed.
- Slip-form paving and finishing machines shall be in satisfactory adjustment and operational condition. Prior to placing concrete, the Contractor shall demonstrate proper adjustment of all screeds and floats on slip-form pavers by measurements from grade stakes driven to known elevation. Satisfactory operation

and adjustment of all propulsion and control equipment, including pre-erected grade and alignment lines, shall be demonstrated by moving slip-form pavers and finishing machines over a 500-foot length of prepared subgrade with all propulsion and control equipment fully operational.

- Unless otherwise required by these specifications, the plans or the special provisions, pavement shall be constructed in full lane widths separated by contact joints, or monolithically in multiples of full lane widths with a longitudinal weakened plane joint at each traffic lane line.
- Concrete shall be placed while fresh. The use of water for retempering any concrete will not be permitted.
- Any concrete showing improper proportions of materials, including water, shall not be used in the pavement, and the unsatisfactory concrete shall be removed and disposed of by the Contractor at the Contractor's expense.

40-1.07 SPREADING, COMPACTING AND SHAPING

- Concrete shall be spread, shaped and consolidated so that the completed pavement will conform to the thickness and cross section requirements of the plans and specifications. Sides of pavement may be constructed on a batter not to exceed 6.0 vertical to 1.0 horizontal, provided the top of the pavement is maintained at the specified width.
- Portland cement concrete pavement widening to be constructed contiguous with an existing parallel concrete pavement not constructed as part of the contract shall be spread, compacted, and shaped so that completed pavement will conform to the thickness and cross section requirements of the plans and specifications and to the following:

The elevation of the pavement surface shall be such that water will not pond on either side of the longitudinal contact joint with existing pavement.

The new pavement surface at the longitudinal contact joint shall conform as closely as possible to the elevation of the existing concrete pavement. Any difference in elevation between the new pavement and the existing pavement shall be eliminated by finishing the new pavement within one foot of the existing pavement by hand methods, adding or removing concrete as necessary.

Transverse straightedge, longitudinal straightedge, and Profile Index requirements specified in Section 40-1.10, "Final Finishing," will not apply to the pavement surface within one foot of the existing concrete pavement.

Profiles of the completed pavement surface specified in Section 40-1.10 will not be required within 4 feet of the longitudinal contact joint with the existing concrete pavement.

Thickness measurements specified in Section 40-1.135, "Pavement Thickness," will not be made in pavement within one foot of the existing concrete pavement.

Transverse weakened plane joints in pavement widening shall be constructed to match the spacing and skew of the weakened plane joints in the existing pavement. The provisions in the second and third paragraphs in

Section 40-1.08B, "Weakened Plane Joints," and the provisions in the third paragraph in Section 40-1.08B(1), "Sawing Method," shall not apply.

- Pavement shall be constructed using only that paving equipment which produces a finished surface meeting straightedge and Profile Index requirements, specified in Section 40-1.10, "Final Finishing." Failure of equipment to produce pavement that conforms to those requirements will constitute cause for stopping placement of concrete until the deficiency or malfunction is corrected.
- Spreading, compacting and shaping shall also conform to the following:

40-1.07A Stationary Side Form Construction

- Side form sections shall be straight, free from warps, bends, indentations or other defects. Defective forms shall be removed from the work. Metal side forms shall be used except at end closures and transverse contact joints where straight forms of other suitable materials may be used.
- Side forms may be built up by rigidly attaching a section to either top or bottom of forms. If the build-up is attached to the top of metal forms, the build-up shall be of metal.
- Width of the base of all forms shall be equal to at least 80 percent of specified pavement thickness.
- Side forms shall be of sufficient rigidity, both in the form and in the interlocking connection with adjoining forms, that springing will not occur under the force from subgrading and paving equipment or from the pressure of concrete. The Contractor shall provide sufficient forms so that there will be no delay in placing the concrete due to lack of forms.
- Before placing side forms, the underlying material shall be at the proper grade. Side forms shall have full bearing upon the foundation throughout their length and width of base and shall be placed to the required grade and alignment of the edge of the finished pavement. They shall be firmly supported during the entire operation of placing, compacting and finishing the pavement.
- Immediately in advance of placing concrete and after all subgrade operations are completed, side forms shall be trued and maintained to the required line and grade for a distance sufficient to prevent delay in placing concrete.
- Side forms shall remain in place until the day after placing the concrete, and in all cases until the edge of the pavement no longer requires the protection of the forms.
- Side forms shall be thoroughly cleaned and oiled each time they are used and before concrete is placed against them.
- Concrete shall be spread, screeded, shaped and consolidated by one or more machines. These machines shall uniformly distribute and consolidate concrete without segregation so that completed pavement will conform to required cross section with a minimum of handwork.
- The number and capacity of machines furnished shall be adequate to perform the work required at a rate equal to that of concrete delivery.
- Concrete for the full paving width shall be effectively consolidated by means of surface vibrators, internal vibrators or by some other method of consolidation that produces equivalent results without segregation.

- When vibrators are used to consolidate concrete, the rate of vibration shall be not less than 3,500 cycles per minute for surface vibrators and shall be not less than 5,000 cycles per minute for internal vibrators. Amplitude of vibration shall be sufficient to be perceptible on the surface of concrete more than one foot from the vibrating element. The Contractor shall furnish a tachometer or other suitable device for measuring and indicating frequency of vibration.
- Vibrators shall not rest on new pavement or side forms. Power to vibrators shall be connected so that vibration ceases when forward or backward motion of the machine is stopped.
- When concrete is being placed adjacent to an existing pavement, that part of the equipment supported on existing pavement shall be equipped with protective pads on crawler tracks or rubber-tired wheels with the bearing surface offset to run a sufficient distance from the pavement edge to avoid breaking or cracking that edge.
- Concrete for exit ramp termini, truck weigh stations, ramps and connectors with steep grades and high rates of superelevation, short sections of city or county streets and roads, and concrete required to be placed in short lengths or in widths other than multiples of full traffic lanes shall be spread and shaped by any suitable powered finishing machines, supplemented by handwork as necessary. Consolidation of the concrete shall be by means of high-frequency internal vibrators within 15 minutes after the concrete is deposited on the subgrade. Vibrating shall be done with care and in such manner to assure adequate consolidation adjacent to forms and uniformly across the full paving width. Use of vibrators for extensive shifting of the mass of concrete will not be permitted. Methods of spreading, shaping and compacting that result in segregation, voids or rock pockets shall be discontinued, and the Contractor shall adopt methods which will produce dense homogeneous pavement conforming to the required cross section.

40-1.07B Slip-Form Construction

- Slip-form pavers shall be equipped with traveling side forms of sufficient dimensions, shape and strength to produce pavement of the required cross section. Slip-form paving equipment shall spread, consolidate and screed freshly placed concrete in such a manner that a minimum of handwork will be required to produce a dense homogeneous pavement true to cross section and profile.
- No abrupt changes in longitudinal alignment of the pavement will be permitted. The horizontal deviation shall not exceed 0.10-foot from the alignment established by the Engineer.
- Concrete for the full paving width shall be effectively consolidated by means of high frequency internal vibrators. Vibrators may be mounted with their axes parallel or normal to pavement alignment. When vibrators are mounted with their axes parallel with the pavement alignment, the vibrators shall be spaced at intervals not to exceed 2.5 feet, measured center to center. When vibrators are mounted with their axes normal to pavement alignment, the vibrators shall be spaced so that lateral clearance between individual vibrating units does not exceed 0.5-foot.

- While pavement is being spread, compacted and shaped, vibrating units shall be operated within fresh concrete so that the longitudinal axis, at the center of each unit is not more than 0.5-foot above top of pavement grade.
- The vibration rate of each vibrating unit shall be not less than 5,000 cycles per minute. Amplitude of vibration shall be sufficient to be perceptible on the surface of concrete along the entire length of vibrating units and for a distance of at least one foot therefrom. The Contractor shall furnish a tachometer or other suitable device for measuring and indicating frequency of vibration.
- When concrete is being placed adjacent to an existing pavement, that part of the equipment supported on existing pavement shall be equipped with protective pads on crawler tracks or rubber-tired wheels with the bearing surface offset to run a sufficient distance from the pavement edge to avoid breaking or cracking that edge.

40-1.08 JOINTS

- Joints in pavement will be designated as longitudinal contact joints, transverse contact joints, longitudinal weakened plane joints and transverse weakened plane joints. Joints shall be constructed as shown on the plans and in accordance with the following provisions.
- Transverse joints shall be constructed at the angle to centerline of pavement shown on the plans, and the faces of all joints both transverse and longitudinal shall be normal to the surface of the pavement.
- At all times prior to acceptance of the contract, joints shall be maintained clean and free of all soil, gravel, concrete or asphalt mix and other foreign material except joint filler material.
- Straight tie bars shall be deformed reinforcing steel bars conforming to the requirements in ASTM Designation: A 615/A 615M, Grade 40 or 60; ASTM Designation: A 996/A 996M, Grade 50 or 60; or ASTM Designation: A 706/A 706M.
- Tie bars in existing pavement for longitudinal joints shall not be straightened.

40-1.08A Contact Joints

- Contact joints are those made by placing fresh concrete against hardened concrete.
- A moisture barrier consisting of curing compound, conforming to provisions in Section 90-7.01B, "Curing Compound Method," shall be applied to the face of any contact joint and allowed to dry prior to placing fresh concrete against that joint face. This provision is also applicable to existing portland cement concrete pavement not constructed as part of the work performed under the contract. Application rate shall be as specified in Section 90-7.01B for the compound used.

40-1.08B Weakened Plane Joints

- Longitudinal weakened plane joints shall be constructed at traffic lane lines in multilane monolithic concrete pavement by the sawing method. Transverse weakened plane joints shall be constructed either by the sawing method or by the insert method at the option of the Contractor.

There shall be 4 transverse weakened plane joints in each 54 linear feet of pavement placed, exclusive of approach slabs, pressure relief joints, and end

anchors. All transverse weakened plane joints shall be located within a spacing tolerance of plus or minus one foot, except as otherwise provided.

- No transverse weakened plane joint shall be constructed within 5 feet of another transverse joint under any circumstance. If the planned spacing of transverse weakened plane joints would result in locating a transverse weakened plane joint within 5 feet of another transverse joint, the transverse weakened plane joint shall be relocated so that the a transverse weakened plane joint is not within 5 feet of the transverse joint.
- Final alignment of transverse weakened plane joints shall conform to that shown on the plans and shall be continuous across the full width of pavement being constructed irrespective of the number or types of longitudinal joints crossed. The Contractor shall coordinate the spacing of transverse weakened plane joints in converging and diverging pavements so that the alignment of transverse weakened plane joints is continuous across the full width where converging and diverging pavements are contiguous. Final alignment of longitudinal weakened plane joints shall be uniformly parallel with the pavement centerline. Final alignment of both transverse and longitudinal weakened plane joints shall be free of local irregularities which exceed 0.1-foot measured from either side of a 12-foot straight line, except for normal curvature of centerline with respect to longitudinal joints.
- Volunteer cracks are all cracks and all portions of cracks that are not coincident with constructed joints.
- Spalls shall be repaired as provided in Section 40-1.08B(3), "Repair of Spalls, Ravelling and Tearing."

40-1.08B(1) Sawing Method

- The sawing method shall consist of cutting a groove in the pavement with a power driven concrete saw. Sawed grooves for longitudinal and transverse weakened plane joints shall be cut to the minimum width possible with the type of saw being used, but in no case shall the width exceed 0.02-foot. The minimum depth of cut for each individual lane shall be calculated as follows:

$$d = t/3$$

where:

d = calculated minimum depth of cut rounded up to the nearest 0.01-foot.
t = greatest thickness of pavement in each lane.

- The exact time of sawing longitudinal and transverse weakened plane joints shall be the Contractor's responsibility. Sawing transverse weakened plane joints shall be completed within 24 hours following paving. Sawing longitudinal weakened plane joints shall be completed within 12 hours following paving, unless a later time is ordered or permitted by the Engineer, but in any event before opening the pavement to any traffic. The Contractor shall exert every possible effort to prevent volunteer cracking. To achieve this, the sequence of sawing may be varied, or other measures not detrimental to the pavement surface may be utilized.

- Where a transverse volunteer crack occurs prior to sawing, and any point on the crack is within 5 feet of a planned transverse weakened plane joint location, the transverse weakened plane joint shall be relocated as specified herein. Relocation shall be the minimum amount necessary, but in no event shall it exceed 10 feet. If a relocation not exceeding 10 feet is insufficient to locate the transverse weakened plane joint so that it is not within 5 feet of that transverse volunteer crack or other transverse joint or crack, at any point in the length of joint, the weakened plane joint shall be located at the planned location. The relocation shall be made without otherwise altering the location of remaining transverse weakened plane joints except where they too would be within 5 feet of preexisting transverse volunteer cracks.
- At the Contractor's option, joint filler material may be installed in the sawed groove for longitudinal and transverse weakened plane joints to keep foreign materials out of the joints. The filler material used shall be of such character as to not react adversely with chemical constituents of the concrete or cause physical damage to the pavement. Should the Contractor install joint filler material immediately after sawing the joint, and the filler material is of such composition as to prevent excessive loss of moisture from concrete adjacent to the joint during the 72 hours following paving, spraying the sawed joint with additional curing compound as provided in Section 90-7.02, "Curing Pavement," will not be required. If absorptive filler material is used, it shall be thoroughly moistened either before or immediately after installation in the sawed groove.
- Filler material may be left in sawed joints upon acceptance of the contract providing the material is not such as to constitute a physical hazard should it work out of joints after opening the pavement to public use.
- When filler material is rope, or similar material which does not fill the entire depth of sawed groove, it shall be depressed not less than 0.04-foot below the pavement surface before the pavement is opened to public traffic, but not less than 72 hours following paving.
- Excessive ravelling or tearing of concrete adjacent to saw cuts, shall be repaired as provided in Section 40-1.08B(3), "Repair of Spalls, Ravelling and Tearing." Excessive ravelling or tearing shall be defined as an accumulation of more than one foot of ravelling or tearing which exceeds 0.04-foot in width, exclusive of the saw cut, in a 12-foot lane, or an accumulation of more than 3 feet of ravelling or tearing which exceeds 0.02-foot in width, exclusive of the saw cut, in a 12-foot lane.

40-1.08B(2) Insert Method

- The insert method consists of placing an insert of bond breaking material in freshly placed concrete.
- Joint inserts shall be continuous strips of plastic or other material which will not react adversely with chemical constituents of concrete or bond with the concrete.
- Insert material shall have a minimum thickness of 0.013-inch. The minimum width of the insert material shall be calculated as follows:

$$w = t/3$$

where:

w = calculated minimum width of insert rounded up to the nearest 0.01-foot.
t = greatest thickness of pavement for each separately placed length of insert.

- The maximum width of insert material shall not exceed the calculated minimum width by more than 0.02-foot.
- Inserts shall be installed so that the top edge is not above nor more than 0.03-foot below the finished concrete surface. Inserts shall not be deformed more than 15 degrees from a position perpendicular to the plane of the pavement surface during installation or subsequent finishing operations performed on the concrete. Insert material shall not be spliced.
- Insert material shall be placed by means of a mechanical installation device which shall vibrate the plastic concrete sufficiently to cause an even flow of concrete about the insert. The joint material shall be installed so that each end does not extend beyond the fresh concrete and is within $1^1/_2$ inches, plus or minus one inch, of the corresponding edge of pavement. After installation of joint material, concrete in the joint area shall be free of segregation, rock pockets and voids. In addition to the straightedge requirements in Section 40-1.10, "Final Finishing," the finished pavement surface at transverse insert joints will be tested by means of a straightedge 4 feet long laid on the pavement parallel to centerline with its midpoint at the joint. A minimum length of 10.5 feet in any 12-foot length of joint shall not vary from a true plane enough to permit a 0.008-foot thick shim 0.25-foot wide to pass under the lower edge of the 4-foot straightedge at any point along its length.
- Pavement exceeding these tolerances, when tested within 10 days following placement of concrete, shall be corrected by grinding until the surface does conform thereto. Pavement surface at transverse insert type joints conforming to all the provisions in Section 40-1.10, but failing to conform to the 4-foot straightedge requirements may be corrected by grinding parallel to joint alignment. The provisions in Section 40-1.10 for grinding to neat rectangular areas will not apply to grinding done to comply with 4-foot straightedge requirements. Grinding parallel to the transverse joint need not be extended in each lateral direction to a constant offset from the nearest lane line or edge of pavement nor in each longitudinal direction so that the grinding begins and ends at lines normal to the pavement centerline.

40-1.08B(3) Repair of Spalls, Ravelling and Tearing

- Spalls, and ravelling or tearing at sawed joints, shall be repaired as provided in this Section 40-1.08B(3) prior to opening the pavement to public traffic.
- Any joints or volunteer cracks with spalls more than 0.05-foot deep which exceed 0.04-foot in width and 0.3-foot in length that occur before pavement is open to public traffic, and sawed joints with excessive ravelling or tearing shall be repaired, but only after removing all weak fractured concrete and cleaning surfaces to receive the patch. A prime coat of epoxy resin adhesive conforming to the provisions in Section 95-2.03, shall be applied to the area to be patched using a stiff

bristled brush. A patch consisting of portland cement concrete or mortar, at the Contractor's option, shall be applied immediately following the application of the prime coat. An insert, or other means, shall be used to prevent bonding both sides of planned joints together.

40-1.09 PRELIMINARY FINISHING

- In each day's work the Contractor shall mark the pavement with an approved stamp. This stamp shall be approximately one foot by 2 feet in size and shall be furnished by the Contractor at the Contractor's expense. The stamp mark shall be located 20 ±5 feet from the transverse contact joint formed at the start of each day's work and 1.00 ±0.25-foot from the outside edge of pavement. The stamp mark shall show month, day and year of placement, and Engineer's station for the transverse contact joint and shall be oriented so that the stamp mark can be read from a position at the outside edge of pavement.
- Prior to completion of float finishing and texturing, water shall not be applied to the pavement surface in excess of the amount lost by evaporation.
- Placement of concrete shall cease at such time that finishing operations can be completed during daylight hours, unless lighting facilities provided by the Contractor are determined by the Engineer to be adequate for allowing later placement and finishing.

40-1.09A Stationary Side Form Finishing

- After spreading and compacting, concrete shall be given a preliminary finish by one of the following methods:

40-1.09A(1) Machine Float Method

- Self-propelled machine floats shall be used to finish pavement smooth and true to grade.
- The number and capacity of machine floats furnished shall be adequate to perform all work required at a rate equal to that at which concrete is delivered. Any delay exceeding 30 minutes in performing preliminary finishing shall constitute cause for stopping delivery of concrete until machines performing the work are again in proper position to continue without delay.
- Machine floats shall be capable of running either on side forms or on adjacent lanes of pavement. When machine floats run on adjacent pavement, its surface shall be protected as specified in Section 40-1.07, "Spreading, Compacting and Shaping."
- Floats shall be constructed of hardwood, steel or steel-shod wood. They shall be equipped with devices to permit adjusting the under side to a true flat surface.

40-1.09A(2) Hand Method

- Pavement shall be finished smooth and true to grade with suitable manually operated floats or powered finishing machines.
- Finishing shall take place as far back of concrete spreading operations as concrete remains workable, and the number of passes shall be sufficient to remove all perceptible inequalities.

40-1.09B Slip-Form Finishing

- Pavement shall be given a preliminary float finish by means of devices incorporated in the slip-form paver. These may be supplemented, at the Contractor's option, with suitable machine floats.
- Any edge slump of pavement, exclusive of edge rounding, in excess of 0.02-foot shall be corrected before concrete has hardened.

40-1.10 FINAL FINISHING

- After preliminary finishing has been completed, edges of initial paving widths shall be rounded to 0.04-foot radius. Transverse contact joints and the edge of longitudinal contact joints adjacent to hardened concrete pavement shall be rounded to 0.02-foot radius.
- In advance of curing operations, pavement shall be given an initial and a final texturing. Initial texturing shall be performed with a burlap drag or broom device which will produce striations parallel with centerline. Final texturing shall be performed with a spring steel tine device which will produce grooves parallel with centerline. The spring steel tine device shall be operated within 5 inches, but not closer than 3 inches, of pavement edges.
- Except when texturing areas of pavement finished in conformance with the provisions in Section 40-1.09A(2), "Hand Method," burlap drags, brooms and tine devices shall be installed on self-propelled equipment having external alignment control. The installation shall be such that when texturing, the area of burlap in contact with the pavement surface shall be maintained constant at all times. Broom and tine devices shall be provided with positive elevation control. Down pressure on pavement surface shall be maintained at all times during texturing so as to achieve uniform texturing without measurable variations in pavement profile. Self-propelled texturing machines shall be operated so that travel speed when texturing is maintained constant. Failure of equipment to conform to all provisions in this paragraph shall constitute cause for stopping placement of concrete until the equipment deficiency or malfunction is corrected.
- Spring steel tines of the final texturing device shall be rectangular in cross-section, $^{3}/_{32}$ inch to $^{1}/_{8}$ inch wide, on $^{3}/_{4}$ inch centers, and of sufficient length, thickness and resilience to form grooves approximately $^{3}/_{16}$ inch deep in the fresh concrete surface. Final texture shall be uniform in appearance with substantially all of the grooves having a depth between $^{1}/_{16}$ inch and $^{5}/_{16}$ inch.
- Initial and final texturing shall produce a surface having a coefficient of friction not less than 0.30 as determined by California Test 342.
- Tests to determine coefficient of friction will be made before pavement is opened to public traffic, but not sooner than 7 days after concrete placement. Pavement containing areas that have a coefficient of friction less than 0.30 shall be grooved as directed by the Engineer before opening it to public traffic.
- Finished pavement shall conform to the following provisions in not more than 10 days following placement of concrete:

The surface will be straightedged, at locations to be determined by the Engineer, with a straightedge 12-foot long. When the straightedge is laid on

finished pavement in a direction parallel with centerline or normal to centerline, the surface shall not vary more than 0.02-foot from the lower edge.

Any high points that cause the surface to exceed these tolerances shall be removed by grinding as provided in this Section 40-1.10.

The surface shall be profiled, by the Contractor in the presence of the Engineer, using a California Profilograph or equivalent in conformance with the requirements in California Test 526 and these provisions. Prior to beginning profiles, the profilograph shall be calibrated in the presence of the Engineer. Profiles shall be made 3 feet from and parallel with each edge of pavement and at the approximate location of each longitudinal joint for all pavement areas except those specified herein.

Pavement so profiled shall conform to the following Profile Index requirements:

A. Pavement on tangent alignment and pavement on horizontal curves having a centerline radius of curve 2,000 feet or more shall have a Profile Index of 7 inches per mile or less.
B. Pavement on horizontal curves having a centerline radius of curve 1,000 feet or more but less than 2,000 feet and pavement within the superelevation transition of those curves shall have a Profile Index of 12 inches per mile or less.

Pavement within 50 feet of a transverse joint that separates the pavement from a structure deck or an approach slab shall meet the profile requirements of Section 51-1.17, "Finishing Bridge Decks."

Checking the following areas of pavement surface with the California Profilograph or equivalent will not be required:

A. Pavement on horizontal curves having a centerline radius of curve less than 1,000 feet and pavement within the superelevation transition of those curves.
B. Pavement within 50 feet of a transverse joint that separates the pavement from an existing pavement not constructed under the contract.
C. Pavement for exit ramp termini, truck weigh stations, ramps and connectors with steep grades and high rates of superelevation and short sections of city or county streets and roads.

Individual high points in excess of 0.3-inch, as determined by measurements of the profilogram in conformance with the requirements in California Test 526, shall be reduced by grinding as provided in this Section 40-1.10, until the high points as indicated by reruns of the profilograph do not exceed 0.3-inch.

After grinding has been completed to reduce individual high points in excess of 0.3-inch, additional grinding shall be performed as necessary to reduce the Profile Index to values specified above in any 0.1-mile section

along any line parallel with the pavement edge.

Additional grinding shall be performed as necessary to extend the area ground in each lateral direction so that the lateral limits of grinding are at a constant offset from, and parallel with, the nearest lane line or pavement edge, and in each longitudinal direction so that the grinding begins and ends at lines normal to the pavement centerline, within any one ground area. All ground areas shall be neat rectangular areas of uniform surface appearance.

When pavement is ground or grooved as specified herein, the work shall be performed in conformance with the provisions in Section 42, "Groove and Grind Pavement," except that residue from grinding or grooving operations shall be disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13.

The original of final profilograms that indicate the pavement surface is within the Profile Index specified shall become the property of the State and shall be delivered to the Engineer prior to acceptance of the contract.

40-1.105 EXIT RAMP TERMINI

Concrete pavement shall be constructed at the ends of exit ramps when required by the plans or the special provisions. Texturing for exit ramp termini shall be by means of heavy brooming in a direction normal to ramp centerline. The hardened surface shall have a coefficient of friction not less than 0.35 as determined by California Test 342. Minimum cement content of concrete in pavement for exit ramp termini shall be 590 pounds per cubic yard.

40-1.11 METHODS OF CURING

Pavement shall be cured as provided in Section 90-7.02, "Curing Pavement."

40-1.12 PROTECTING CONCRETE PAVEMENT

Concrete pavement shall be protected in conformance with the provisions in Section 90-8, "Protecting Concrete," and as specified below.

The Contractor shall protect new pavement from damage by any cause, and any damage shall be repaired by the Contractor at the Contractor's expense.

40-1.13 MEASUREMENT

The quantity of concrete pavement to be paid for will be measured by the cubic yard. The volume to be paid for will be calculated on the basis of the dimensions shown on the plans adjusted by the amount of any change ordered by the Engineer. No allowance will be made for concrete pavement placed outside those dimensions unless otherwise ordered by the Engineer.

40-1.135 PAVEMENT THICKNESS

It is the intent of the specifications that concrete pavement shall be constructed in accordance with the thickness requirements of the plans and specifications. Tolerances allowed for subgrade construction and other provisions of these specifications which may affect thickness shall not be construed to modify those thickness requirements. It is agreed by the parties that compliance with the thickness requirements for concrete pavement will be determined by the Engineer in conformance with the provisions in this Section 40-1.135. It is further agreed by the parties that the liability of the Contractor for failure to comply with the

thickness requirements and the rights of the State in the event of that failure shall likewise be governed by the provisions in this Section 40-1.135.

- For the purposes of these specifications, a primary unit of pavement will be the area of pavement placed in each day's paving operations. Within the primary unit of pavement, there may be an area or areas which have been determined to be a secondary unit or units of pavement, as provided in Section 40-1.135B, "Thickness Deficiency Of More Than 0.05-foot." In this case, the primary unit area will be reduced by the secondary unit area included therein.
- At such time after the concrete pavement has been placed, as is determined by the Engineer to be appropriate, thickness measurements will be made in each primary unit of pavement at the rate of not less than one measurement for each 1,000 linear feet of traffic lane, or fraction thereof, of pavement placed. The exact location and number of thickness measurements within each primary unit, both longitudinally and transversely, will be as determined by the Engineer.
- If required, secondary thickness measurements will be made as provided in Section 40-1.135B.
- Pavement thickness measurements will be made in conformance with the requirements in California Test 531, to the nearest 0.01-foot.
- Pavement thickness variation, if any, from the thickness requirements of the plans and specifications will be determined by comparing the actual thickness measurement with the thickness specified at the location where the measurement was made. The variation will be determined to the nearest 0.01-foot as either excess or deficient thickness.
- It is anticipated that when portland cement concrete pavement is placed over treated permeable base, the concrete will penetrate the treated permeable base an average of approximately 0.03-foot. Volumes of portland cement concrete that penetrate the treated permeable base will not be included in the volume of concrete pavement to be paid for.
- When cores are taken to determine the thickness of portland cement concrete pavement, it is anticipated a layer of treated permeable base will adhere to the bottom of the core. Prior to determining the thickness of the portland cement concrete pavement, all particles of treated permeable base will be removed from the bottom of the core.
- All holes remaining in the concrete pavement after the thickness measurements are made shall be completely filled by the Contractor, at the Contractor's expense, with concrete of the same quality as used to construct the pavement.
- The Contractor shall not be entitled to any additional compensation nor extension of time due to any of the provisions in this Section 40-1.135.
- No additional compensation will be allowed the Contractor for any pavement constructed in excess of the thickness requirements of the plans and specifications.
- If the Contractor believes that the number of thickness measurements made in primary unit areas by the Engineer in conformance with the provisions in this Section 40-1.135 are insufficient to fairly indicate the actual thickness of pavement placed, the Contractor may request that additional thickness measurements be made by the Engineer and the additional measurements will be used in determining the average thickness variation. The location of all the additional thickness

measurements will be determined by the Engineer. The cost of all the additional measurements made will be deducted from any moneys due, or that may become due, the Contractor under the contract.

40-1.135A Thickness Deficiency of Not More Than 0.05-foot

- If none of the thickness measurements in a primary unit is deficient in thickness by more than 0.05-foot, thickness variations in that unit will be averaged, algebraically, to determine the average thickness deficiency, if any, in that primary unit. For the purpose of determining the average thickness deficiency, an excess thickness variation of more than 0.02-foot greater than the thickness specified will be considered to be 0.02-foot greater than the specified thickness.
- For each primary unit of pavement which is deficient in average thickness, the Contractor shall pay to the State, and the Department may deduct from any moneys due, or that may become due the Contractor under the contract, a sum computed by applying the deficiency adjustment from the following table to the area of that unit:

Average Thickness Deficiency foot	Deficiency Adjustment (dollars-per square yard)
0.01	0.40
0.02	1.00
0.03	1.80
0.04	2.80
0.05	4.00
0.06	5.80

- If the average thickness deficiency is less than 0.01-foot, no deficiency adjustment will be made.
- If the average thickness deficiency is greater than 0.01-foot, it will be rounded to the nearest 0.01-foot, and the deficiency adjustment will be made according to the above table.

40-1.135B Thickness Deficiency of More Than 0.05-foot

- For each thickness measurement in a primary unit that is deficient by more than 0.05-foot, the Engineer will determine from secondary thickness measurements the dimensions of the secondary unit area where the apparent thickness deficiency is more than 0.05-foot. The determination of the limits of the secondary unit area will be made by making secondary thickness measurements in each panel of pavement adjacent to the panel in which the original measurement in the primary unit was made. This procedure will continue, regardless of unit boundaries, until the secondary unit area is bounded by panels in which the secondary measurement is deficient in thickness by 0.05-foot, or less.
- Panels are the areas bounded by longitudinal and transverse joints and pavement edges. If a transverse weakened plane joint has been omitted at the location where a volunteer crack exists, in conformance with the provisions in Section 40-1.08B, "Weakened Plane Joints," the volunteer crack will be considered as a transverse joint only if the pavement adjacent thereto is not to be removed and replaced. If either longitudinal or transverse joints, or both, are eliminated by the special provisions or plans, the limits of panels will be determined by the Engineer

as if the joints had been constructed. The secondary unit area will be made up of entire panels only.

- Each panel in which secondary thickness measurements are made pursuant to the provisions in this Section 40-1.135B will be deemed to be, in its entirety, of the thickness shown by that measurement.
- After the Engineer has determined the limits of the secondary unit area, the Engineer will further determine, within that area, which panels, if any, will be required to be removed and replaced in accordance with procedure "1." below, and the panels, if any, which will remain in place in accordance with procedure "2." below:

1. The Contractor shall, at the Contractor's expense, remove and replace the concrete pavement in the panels with concrete pavement meeting the thickness and all other requirements of the plans and specifications. If the area to be removed is not bounded by longitudinal or transverse joints, the Contractor shall saw, at the Contractor's expense, weakened plane joints at the locations designated by the Engineer, conforming to the provisions in Section 40-1.08B, "Weakened Plane Joints." Subgrade shall be lowered as necessary to meet the full thickness requirements. Replaced pavement will be tested for thickness compliance by means of additional secondary measurements and will be subject to all of the thickness requirements of the specifications.
2. The Contractor shall leave the panels of pavement in place if they meet all of the other requirements of the plans and specifications, and the Contractor shall pay to the State $27.00 per square yard for the panels of pavement left in place and the Department may deduct that amount from any moneys due, or that may become due, the Contractor under the contract.

- The cost of all secondary thickness measurements made in conformance with the provisions in this Section 40-1.135B will be deducted from any moneys due, or that may become due, the Contractor under the contract.
- After eliminating the secondary unit area, or areas, and the thickness measurements therein from consideration, the average thickness deficiency, if any, of the remainder of primary unit areas will be determined as provided in Section 40-1.135A, "Thickness Deficiency of Not More Than 0.05-foot." Secondary thickness measurements made outside of a secondary unit area shall be used to determine average thickness deficiency, if any, in the remaining primary unit area in which they are taken.

40-1.14 PAYMENT

- The contract price paid per cubic yard for concrete pavement shall include full compensation for furnishing all labor, materials (including cement in the amount specified), tools, equipment, and incidentals, and for doing all the work involved in constructing the portland cement concrete pavement, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

- Full compensation for furnishing and applying asphaltic emulsion prior to placing concrete pavement on cement treated permeable base; for constructing and repairing all joints; for performing all profile checks for Profile Index and furnishing final profilograms to the Engineer; for grooving and grinding required for final finishing; and for removing, replacing and payment for deficient thickness shall be considered as included in the contract price paid per cubic yard for concrete pavement and no separate payment will be made therefor.

SECTION 41: PAVEMENT SUBSEALING AND JACKING

41-1 PAVEMENT SUBSEALING

41-1.01 DESCRIPTION

This work shall consist of filling voids beneath existing portland cement concrete pavement, at the locations shown on the plans, by drilling holes through the existing pavement, injecting grout through the holes and filling the drilled holes with mortar or concrete.

41-1.02 MATERIALS

Grout for filling the voids beneath the existing pavement shall be composed of portland cement, fly ash and water. Portland cement and fly ash shall be proportioned by weight at the rate of one part portland cement to 2.4 to 2.7 parts fly ash. Water shall be added in an amount to provide a grout efflux time of 10 to 16 seconds as determined by California Test 541, Part D.

Portland cement for the grout shall be Type II Modified conforming to the provisions in Section 90-2.01, "Cement."

Fly ash shall conform to the requirements in ASTM Designation: C 618 for either Class C or Class F fly ash, except that the loss on ignition shall not exceed 4 percent. The brand of fly ash used in the work shall conform to the provisions for approval of admixture brands in Section 90-4.03, "Admixture Approval."

When fly ash, cement, or fly ash and cement are delivered in packages, each package shall be marked plainly with the class, type, name and brand of producer, and the weight of material contained therein. Similar information shall be provided in the shipping invoices accompanying the shipment of packaged or bulk fly ash and cement.

Chemical admixtures and calcium chloride conforming to the provisions in Section 90-4, "Admixtures," may be used in the grout mixture, subject to the Engineer's written approval.

In advance of grouting operations, the Contractor shall submit a proposal for the materials to be used in the work accompanied with independent laboratory test data that indicates the initial set time and the one-day, 3-day, and 7-day compressive strengths of the grout at 10-second, 12-second and 14-second efflux times using specimen molds and curing conditions specified in ASTM Designation: C 109.

Grout having a 7-day compressive strength of less than 750 psi at a 12-second efflux time as determined by the independent laboratory tests will not be acceptable.

No change in the grout materials shall be made unless a resubmittal of the above information and requirements is furnished to the Engineer.

Mortar for filling the holes in the concrete pavement shall be composed of one part portland cement to 3 parts fine aggregate, by volume, and only enough water to permit placing and packing of the mortar in the holes. A commercial quality premixed rapid set mortar or concrete may be used to fill the holes.

41-1.03 CONSTRUCTION

- Holes shall be drilled through the pavement and underlying base to a depth of 15 inches to 18 inches below the pavement surface. The holes shall be drilled to the diameter necessary to accommodate the equipment used for injecting the grout. Care shall be taken to protect the pavement surrounding each hole from damage.
- The location of the holes shall conform to the configuration shown on the plans unless otherwise directed or permitted by the Engineer. Before beginning grouting operations, and continuing thereafter to the end of each run or work shift, the holes in at least 2 consecutive slabs requiring subsealing shall be drilled ahead of the grouting operations.
- Open drilled holes shall not remain ungrouted for more than 2 working days.
- The side of the injection hole shall be washed with a minimum water gage pressure of 40 psi just prior to grout injection. The washing device shall be constructed such that a minimum of 4 jets shall direct water horizontally at the slab-base interface.
- The grout plant shall consist of a positive displacement cement injection pump and a high-speed colloidal mixer. The colloidal mixer shall operate between a minimum speed of 800 RPM and a maximum speed of 2,000 RPM. The injection pump shall be capable of sustaining a gage pressure of 150 psi when pumping a grout mixed to a 12-second flow time. A pressure gage shall be located immediately adjacent to the grout hose supply valve and shall be positioned so it can be easily monitored by the Engineer.
- Dry cement and fly ash shall be accurately measured by weight, if in bulk, or shall be packaged in containers of uniform weight.
- Water shall be introduced into the mixing process through a meter or scale.
- Grout not used in the work within one hour after mixing shall be disposed of as directed by the Engineer.
- Grout shall be pressure injected through the holes until all voids under the pavement slab are filled. No portion of the slab shall be moved or raised more than 0.050-inch as a result of pressure grouting. The Engineer will furnish and utilize suitable devices to monitor slab movement during pressure grouting.
- The injection nozzle shall prevent leakage during injection and shall not protrude below the concrete slab. Grout shall be injected into only one hole at a time on any slab. When grout appears at any longitudinal or transverse joint, crack, or adjacent hole, or when monitoring devices indicate slab movement in excess of 0.050-inch, pressure injection of grout shall cease at that hole.
- In the event that grout flow does not occur after 7 seconds of sustained 150 psi injection pump gage pressure and if there is no indication of slab movement, continued injection at that hole shall cease.
- Immediately after the nozzle is removed, the hole shall be temporarily plugged with a round, tapered wooden plug. The plug shall remain in place until pressure grouting at adjacent holes progresses to the point where grout will not be forced up through previously grouted holes.
- In the event the Engineer determines that continued grouting at a location is no longer advantageous, the Engineer may direct the Contractor to cease subsealing operations at that location.

- Grouting shall not be performed when the atmospheric or subgrade temperature is below 40° F, or during inclement weather. When standing rainwater is present in the holes, grouting shall not be performed unless permitted by the Engineer.
- The Contractor shall take necessary precautions to prevent grout from being injected into any drainage facility or other open structure.
- Cracks in the pavement which occur during the injection of grout will be considered as damage to the pavement due to the Contractor's operations. The damage shall be repaired by the Contractor at the Contractor's expense and as directed by the Engineer.
- Upon completion of the grouting operation, grout shall be removed from the drilled holes to a depth of not less than 4 inches below the pavement surface. The holes shall be cleaned and then filled with mortar or premixed, rapid set concrete and finished flush with the concrete pavement surface.
- At the end of each work shift, the work area shall be left in a clean, swept and neat condition.

41-1.04 MEASUREMENT

- The quantity of drilled holes will be measured as units determined by actual count. Any hole drilled that is not shown on the plans or ordered by the Engineer will not be measured nor paid for.
- The quantities of dry cement and fly ash used in the grout mix will be measured by the ton and will be paid for as grout (subsealing). Quantities of grout not used in the work and grout that is wasted by leaking through to the pavement surface because of not taking preventative measures to avoid wasting of grout, will not be paid for. The quantity of grout wasted or disposed of will be determined by the Engineer. Quantities of grout, cement or fly ash remaining on hand after completion of the work will not be paid for.

41-1.05 PAYMENT

- Items of work, measured as specified in Section 41-1.04, "Measurement," will be paid for at the contract unit price for drill hole (subsealing) and the contract price per ton for grout (subsealing).
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in subsealing existing portland cement concrete pavement as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Full compensation for furnishing and placing mortar or concrete for filling the drilled holes shall be considered as included in the contract unit price paid for drill hole (subsealing) and no additional compensation will be allowed therefor.

41-2 PAVEMENT JACKING

41-2.01 DESCRIPTION

- This work shall consist of raising existing portland cement concrete pavement to grade, at the locations shown on the plans, by drilling holes through the existing

pavement, injecting grout through the holes to fill voids beneath the pavement and raise the pavement to grade, and filling the drilled holes with mortar or concrete.

41-2.02 MATERIALS

The grout for pavement jacking and mortar or concrete for filling the drilled holes shall conform to the provisions for grout and mortar or concrete for pavement subsealing in Section 41-1.02, "Materials," except that the grout for pavement jacking shall contain water in an amount to provide a grout efflux time of 16 seconds to 26 seconds. Additional water may be added to reduce the grout efflux time to not less than 10 seconds to initiate the pressure injection of the grout.

41-2.03 CONSTRUCTION

Pavement jacking shall conform to the provisions for pavement subsealing in Section 41-1.03, "Construction," except for the following:

The positive displacement grout injection pump shall be capable of providing a sustained gage pressure of 200 psi. Gage pressures exceeding 200 psi, but not exceeding 600 psi, may be used for brief periods of time to start the movement of the slab.

Slabs shall be raised uniformly to grade. The Contractor shall furnish and utilize stringlines to monitor the movement of the pavement.

The final elevation of the surface of the concrete pavement shall not vary at any point more than 0.01-foot above or below the grade established by the Engineer. If the surface of the pavement at any point is higher than 0.01-foot above the grade established by the Engineer, the surface shall be ground to meet the above specified tolerance; however, the entire slab shall be removed and replaced with new concrete pavement if the surface at any point is higher than 0.10-foot above the grade established by the Engineer. Grinding of the concrete pavement or removal and replacement of the pavement, if necessary, shall conform to the provisions in Section 42-2, "Grinding," except for payment.

Adjacent slabs, not requiring adjustment in grade, shall not be moved. Corrections to grade of adjacent slabs, if necessary, and as determined by the Engineer, shall be made in the same manner that is required for pavement that is raised to grade.

41-2.04 MEASUREMENT

The quantity of drilled holes will be measured as units determined by actual count. Any hole drilled that is not shown on the plans or ordered by the Engineer will not be measured nor paid for.

The quantities of dry cement and fly ash used in the grout mix will be measured by the ton and will be paid for as grout (jacking). Quantities of grout not used in the work and grout that is wasted by leaking through to the pavement surface because of not taking preventative measures to avoid wasting of grout, will not be paid for. The quantity of grout wasted or disposed of will be determined by the Engineer. Quantities of grout, cement or fly ash remaining on hand after completion of the work will not be paid for.

41-2.05 PAYMENT

- Items of work, measured as specified in Section 41-2.04, "Measurement," will be paid for at the contract unit price for drill hole (jacking) and the contract price per ton for grout (jacking).
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in jacking existing portland cement concrete pavement as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Full compensation for furnishing and placing mortar or concrete for filling the drilled holes shall be considered as included in the contract unit price paid for drill hole (jacking) and no additional compensation will be allowed therefor.
- Full compensation for grinding the existing surface of the concrete pavement to meet the specified surface tolerance or for removing and replacing the existing pavement with new pavement shall be considered as included in the contract price paid per ton for grout (jacking) and no separate payment will be made therefor.

SECTION 42: GROOVE AND GRIND PAVEMENT

42-1 GROOVING

42-1.01 DESCRIPTION

This work shall consist of grooving the surface of asphalt concrete or portland cement concrete pavement and bridge decks as shown on the plans and as specified in these specifications and the special provisions.

42-1.02 CONSTRUCTION

Grooved areas shall begin and end at lines normal to the pavement center line and shall be centered within the lane width. If new concrete pavement is grooved, the grooving in any lane shall cover the full lane width.

Grooving blades shall be 0.095-inch ±0.005-inch wide and shall be spaced $^{3}/_{4}$ inch on centers. The grooves shall be cut not less than $^{1}/_{8}$ inch nor more than $^{1}/_{4}$ inch deep. The grooves on bridge decks shall be cut not less than $^{1}/_{8}$ inch nor more than $^{3}/_{16}$ inch deep. Grooves over inductive loop detectors shall be cut not less than $^{1}/_{16}$ inch nor more than $^{1}/_{8}$ inch deep.

At the beginning of each work shift, all grooving machines shall be equipped with a full complement of grooving blades that are capable of cutting grooves of the specified width, depth and spacing.

If during the course of work a single grooving blade on any individual grooving machine becomes incapable of cutting a groove, work will be permitted to continue for the remainder of the work shift, and the Contractor will not be required to otherwise cut the groove omitted because of the failed blade. Should 2 or more grooving blades on any individual grooving machine become incapable of cutting grooves the Contractor shall either:

(a) Discontinue work with the affected grooving machine within 50 feet of the location where more than one blade became incapable, in which event the Contractor will not be required to otherwise cut the grooves omitted because of the failed blades; or

(b) Continue work with the affected grooving machine for the remainder of the work shift and by other means cut all grooves omitted, including grooves omitted because a single blade was incapable, by the affected grooving machine within that work shift. The omitted grooves shall be cut before any of the grooving work performed during the time the grooves were omitted will be accepted.

The actual grooved area of any selected 2' x 100' longitudinal area of pavement specified to be grooved shall be not less than 95 percent of the selected area. Grooves which are omitted as permitted for blades which become incapable will be measured as being actually grooved. No area will be measured until omitted grooves, which are required to be cut before the area is accepted, have been cut. Except as provided for omitted grooves due to an incapable blade, any area within the selected area not grooved shall be due only to irregularities in the pavement surface and for no other reason.

- Residue from grooving operations shall be picked up by means of a vacuum attachment to the grooving machine and shall not be allowed to flow across the pavement nor be left on the surface of the pavement. Residue from grooving portland cement concrete pavement shall be disposed of at the location listed and in the manner specified in the "Materials Information" available to Contractors. Residue from grooving asphalt concrete shall be disposed of in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."
- At the option of the Contractor, the residue from grooving portland cement concrete pavement may be disposed of at a site chosen by the Contractor if the Contractor obtains approval from the California Regional Water Quality Control Board having jurisdiction over the site. A copy of the approval shall be delivered to the Engineer before disposing of residue at the site.
- The noise level created by the combined grooving operation shall not exceed 86 dBA at a distance of 50 feet at right angles to the direction of travel.

42-1.03 MEASUREMENT

- Pavement grooving on existing pavement will be measured by the square yard. The quantity of pavement grooving to be paid for will be determined by multiplying the width of the grooved area by the horizontal length grooved.

42-1.04 PAYMENT

- The contract price paid per square yard for groove existing concrete pavement shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in grooving the existing concrete pavement, including removing and disposing of residue, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

42-2 GRINDING

42-2.01 DESCRIPTION

- This work shall consist of grinding asphalt concrete or portland cement concrete pavement and roadway surfaces of structures as shown on the plans and as specified in these specifications and the special provisions.

42-2.02 CONSTRUCTION

- Grinding shall be performed with abrasive grinding equipment utilizing diamond cutting blades.
- Except on structures, the entire area of pavement in locations designated shall be ground.
- Existing portland cement concrete pavement not constructed as part of the project shall be ground as follows:

> Grinding shall be performed so that the pavement surface on both sides of all transverse joints and cracks has essentially the same depth of texture and does not vary from a true plane enough to permit a 0.006-foot thick shim 0.25-foot wide to pass under a 3-foot straightedge adjacent to either side of the joint or crack when the straightedge is laid on the pavement parallel to

centerline with its midpoint at the joint or crack. After grinding has been completed, the pavement shall conform to the straightedge and profile requirements specified in Section 40-1.10, "Final Finishing."

Abnormally depressed areas due to subsidence or other localized causes will be excluded from testing with the profilograph and 12-foot straightedge specified in Section 40-1.10. The accumulated total of the excluded areas shall not exceed 5 percent of the total area to be ground. Profilograph testing shall end 25 feet prior to excluded areas and shall resume 25 feet following the excluded areas.

- Existing asphalt concrete pavement not constructed as part of the project shall be ground so that the finished surface shall not vary from a true plane enough to permit a 0.01-foot thick shim 0.25-foot wide to pass under a straightedge 12-foot long when the straightedge is laid on the finished surface parallel with the centerline. The transverse slope of the finished surface shall be uniform to a degree such that a 0.02-foot thick shim 0.25-foot wide will not pass under a straightedge 12-foot long when the straightedge is laid on the finished surface in a direction transverse to the centerline and extending from edge to edge of a 12-foot traffic lane.
- Ground areas on structures, approach slabs and the adjacent 50 feet of approach pavement shall conform to the provisions for smoothness and concrete cover over reinforcing steel in Section 51-1.17, "Finishing Bridge Decks."
- Ground surfaces shall not be smooth or polished and, except as otherwise specified in Section 51-1.17, shall have a coefficient of friction of not less than 0.30 as determined by California Test 342.
- Residue from grinding operations shall be picked up by means of a vacuum attachment to the grinding machine and shall not be allowed to flow across the pavement nor be left on the surface of the pavement. Residue from grinding portland cement concrete pavement shall be disposed of at the location listed and in the manner specified in the "Materials Information" available to Contractors. Residue from grinding asphalt concrete shall be disposed of in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."
- At the option of the Contractor, the residue from grinding portland cement concrete pavement may be disposed of at a site chosen by the Contractor if the Contractor obtains approval from the California Regional Water Quality Control Board having jurisdiction over the site. A copy of the approval shall be delivered to the Engineer before disposing of residue at the site.
- The noise level created by the combined grinding operation shall not exceed 86 dBA at a distance of 50 feet at right angles to the direction of travel.

42-2.03 PAVEMENT REPLACEMENT

- In lieu of grinding existing portland cement concrete pavement, the Contractor may remove any section of the existing pavement and replace with new portland cement concrete pavement of the same nominal thickness as the removed pavement. The pavement shall be removed and replaced for the full width between

longitudinal joints or edges of pavement and the full length between transverse joints. Removing and replacing portions of slabs will not be permitted.

- Replacement concrete paving shall conform to the provisions in Section 40, "Portland Cement Concrete Pavement." Replacement pavement may be placed by methods and equipment conforming to the provisions for placing concrete in widths less than a traffic lane in Section 40-1.07, "Spreading, Compacting and Shaping." Finishing may be performed by hand float method, as specified in Section 40-1.09A, "Stationary Side Form Finishing."
- If grinding of replacement pavement is necessary to conform to the provisions of this section, no additional compensation for that grinding will be allowed.
- When pigmented compound is used for the required curing on replacement concrete, the compound may be stirred by manual means during application. Application may be made by hand-held spraying equipment and nozzles may be unshielded.
- The Contractor's attention is directed to Section 7-1.11, "Preservation of Property." Concrete removal and replacement operations shall be performed in such manner that adjacent concrete pavement and subgrade are not disturbed. In the event material underlying removed concrete pavement is disturbed, it shall be recompacted at the Contractor's expense to a relative compaction of not less than 95 percent.
- Concrete pavement removed and replaced in lieu of grinding will be measured and paid for by the square yard as grind existing concrete pavement.
- If the grinding on a section of concrete pavement has begun and the Contractor thereafter elects to remove and replace the section, in lieu of grinding, no payment will be made for grinding performed on that section prior to replacement.

42-2.04 MEASUREMENT

- Pavement grinding on existing pavements will be measured by the square yard. The quantity of pavement grinding to be measured for payment will be determined by multiplying the width of the area ground by the length ground.

42-2.05 PAYMENT

- The contract price paid per square yard for grind existing concrete pavement shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in grinding the existing pavement and removing and disposing of residue, including furnishing water for washing the pavement, as shown on the plans, as specified in these specifications and the special provisions and as directed by the Engineer.

SECTIONS 43 THROUGH 48: (BLANK)

STRUCTURES

SECTION 49: PILING

49-1 GENERAL

49-1.01 DESCRIPTION

This work shall consist of furnishing and drilling for or driving foundation piles for structures in conformance with the details shown on the plans and as specified in these specifications and the special provisions.

Attention is directed to the provisions in Section 7-1.09, "Public Safety." Before performing any pile handling or pile installation operation at any location that is closer than the length of the pile being handled or installed to the edge of any traveled way open to public use, the Contractor shall submit to the Engineer, as provided in Section 5-1.02, "Plans and Working Drawings," a detailed plan of the measures that will be employed to provide for the safety of traffic and the public.

49-1.02 MATERIALS

Foundation piling for structures shall consist of timber piles, precast prestressed or cast-in-place concrete piles, steel piles or piles of such other materials as may be shown on the plans or required by the special provisions.

When the plans or specifications permit the use of more than one type of pile, the same type of pile shall be used for all piles within each individual footing, unless otherwise permitted by the Engineer.

49-1.03 DETERMINATION OF LENGTH

Foundation piles of any material shall be of such length as is required to obtain the specified penetration, and to extend into the cap or footing block as shown on the plans, or specified in the special provisions.

At the Contractor's option, the Contractor may conduct additional foundation investigation, including installing and axial load testing additional non-production indicator piling. The Engineer shall approve locations of additional foundation testing. The Contractor shall notify the Engineer at least 5 working days prior to beginning additional foundation investigation.

Additional foundation investigation shall be completed prior to requesting revised specified pile tip elevations or modification to the installation methods specified herein. Revisions to specified tip elevations and modifications to the specified installation methods will be subject to the provisions in Section 5-1.14, "Cost Reduction Incentive."

Modification to the specified installation methods and specified pile tip elevation will not be considered at locations where tension or lateral load demands control design pile tip elevations or when the plans state that specified pile tip elevation shall not be revised.

The pile structural capacity design is based on the nominal strength as defined in Caltrans Bridge Design Specifications (Article 8.1.3) or the nominal resistance as defined in the Load Resistance Factor Design Bridge Design Specifications (Article 1.3.2.1). The nominal resistance of the pile, as shown on the plans, is the design capacity required to resist the factored axial load demands.

- Indicator compression pile load testing shall conform to the requirements in ASTM Designation: D 1143. The pile shall sustain the first compression test load applied which is equal to the nominal resistance in compression, as shown on the plans, with no more than 1/2 inch total vertical movement at the top of the pile measured relative to the top of the pile prior to the start of compression load testing.
- Indicator tension pile load testing shall conform to the requirements in ASTM Designation: D 3689. The loading apparatus described as "Load Applied to Pile by Hydraulic Jack(s) Acting at One End of Test Beam(s) Anchored to the Pile" shall not be used. The pile shall sustain the first tension test load applied which is equal to the nominal resistance in tension, as shown on the plans, with no more than 1/2 inch total vertical movement at the top of the pile measured relative to the top of the pile prior to the start of tension load testing.
- Indicator piling shall be removed in conformance with the provisions in Section 15-4.02, "Removal Methods," and the remaining holes shall be backfilled with earth or other suitable material approved by the Engineer.
- For driven piling, the Contractor shall furnish piling of sufficient length to obtain the specified tip elevation shown on the plans or specified in the special provisions. For cast-in-drilled-hole concrete piling, the Contractor shall construct piling of such length to develop the nominal resistance in compression and to obtain the specified tip elevation shown on the plans or specified in the special provisions.

49-1.04 LOAD TEST PILES

- When load test piles and anchor piles are shown on the plans or specified in the special provisions for a structure, the loading tests using those piles shall be completed before the remaining piles for that structure or specified control location are drilled, cast, cut to length or driven.
- Load test piles shall be installed with the same type of equipment that is to be used for installation of foundation piles.
- Load test piles which are shown on the plans or specified in the special provisions shall conform to the requirements for piling as specified in these specifications and, unless otherwise shown, shall be so located that they may be cut off and become a part of the completed structure.
- Load test piles and anchor piles which are not to be incorporated in the completed structure shall be removed in conformance with the provisions in Section 15-4.02, "Removal Methods," and the remaining holes shall be backfilled with earth or other suitable material approved by the Engineer.
- Load test anchorages in piles used as anchor piles shall conform to the following requirements:

A. High strength threaded steel rods shall conform to the provisions for bars in Section 50-1.05, "Prestressing Steel," except Type II bars shall be used.
B. High strength steel plates shall conform to the requirements in ASTM Designation: A 709/A 709M, Grade 50 (345).
C. Anchor nuts shall conform to the provisions in the second paragraph in Section 50-1.06, "Anchorages and Distribution."

- The Contractor, at the Contractor's expense, may use additional cement or may use Type III cement in the concrete for the load test and anchor piles.
- Testing of load test piles shown on the plans and specified in the special provisions will be performed by the Engineer without cost to the Contractor. The loading tests will be made when the concrete in the load test and anchor piles has developed a compressive strength of at least 2,000 psi.
- Should the Engineer fail to complete the load tests within the time specified in the special provisions and if, in the opinion of the Engineer, the Contractor's controlling operation is delayed or interfered with by reason of the delay in load testing of piles, the delay will be considered a right of way delay as specified in Section 8-1.09, "Right of Way Delays."
- The Contractor shall furnish labor, materials, tools, equipment, and incidentals as required to assist the Engineer in the installation, operation and removal of State-furnished steel load test beams, State-furnished jacks, bearing plates, drills and other test equipment. This work will be paid for as extra work as provided in Section 4-1.03D.

49-1.05 DRIVING EQUIPMENT

- Driven piles shall be installed with impact hammers that are approved in writing by the Engineer. Impact hammers shall be steam, hydraulic, air or diesel hammers. Impact hammers shall develop sufficient energy to drive the piles at a penetration rate of not less than $^{1}/_{8}$ inch per blow at the specified nominal resistance.
- Vibratory hammers shall not be used for installation of piles, unless otherwise shown on the plans or specified in the special provisions.
- Hammers with an external combustion engine that are not single action shall have a transducer that records ram velocity.
- Double acting diesel hammers with internal combustion engines shall have a transducer that records bounce chamber pressure.
- For hammers with no visual way of observing the ram stroke, a printed readout showing hammer energy during driving operation shall be provided to the Engineer by the Contractor.
- Steam or air hammers shall be furnished with boiler or air capacity at least equal to that specified by the manufacturers of the hammers to be used. The boiler or air compressor shall be equipped with an accurate pressure gage at all times. The valve mechanism and other parts of steam, air or diesel hammers shall be maintained in first class condition so that the length of stroke and number of blows per minute for which the hammer is designed will be obtained. Inefficient steam, air or diesel hammers shall not be used.
- When necessary to obtain the specified penetration and when authorized by the Engineer, the Contractor may supply and operate one or more water jets and pumps, or furnish the necessary drilling apparatus and drill holes not greater than the least dimension of the pile to the proper depth and drive the piles therein. Jets shall not be used at locations where the stability of embankments or other improvements would be endangered. In addition, for steel piles, steel shells, or steel casings, when necessary to obtain the specified penetration or to prevent

damage to the pile during installation, the Contractor shall provide special driving tips or heavier pile sections or take other measures as approved by the Engineer.

- The use of followers or underwater hammers for driving piles will be permitted if authorized in writing by the Engineer. When a follower or underwater hammer is used, its efficiency shall be verified by furnishing the first pile in each bent or footing sufficiently long and driving the pile without the use of a follower or underwater hammer.

49-1.06 PREDRILLED HOLES

- Piles, to be driven through embankment constructed by the Contractor, shall be driven in holes predrilled or spudded through the embankment when the depth of new embankment at the pile location is in excess of 5 feet. The hole shall have a diameter of not less than the greatest dimension of the pile cross section plus 6 inches. After driving the pile, the space around the pile shall be filled to ground surface with dry sand or pea gravel.
- Material resulting from predrilling holes shall be disposed of as provided in Section 19-2.06, "Surplus Material."

49-1.07 DRIVING

- Driving equipment that damages the piling shall not be used. Driving heads or driving blocks which hold the pile in position directly under the hammer during driving shall be used.
- Timber piles shall be fresh-headed and square and when permitted by the Engineer, the heads of the piles may be protected by means of heavy steel or wrought iron rings. During driving operations timber piling shall be restrained from lateral movement at intervals not to exceed 20 feet over the length between the driving head and the ground surface. During driving operations, the timber pile shall be kept moving by continuous operation of the hammer. When the blow count exceeds either 2 times the blow count required in one foot, or 3 times the blow count required in 3 inches for the nominal resistance as shown on the plans, computed in conformance with the provisions in Section 49-1.08, "Pile Driving Acceptance Criteria," additional aids shall be used to obtain the specified penetration. These aids may include the use of water jets or drilling, where permitted, or the use of a larger hammer employing a heavy ram striking with a low velocity.
- The heads of concrete piles or shells shall be protected from direct impact of the hammer by a cushion driving block. The cushion shall be maintained in good condition during the entire driving operation. The cushion driving block shall be so arranged that any reinforcing bars projecting above the piles will not be displaced or injured in driving.
- Precast prestressed concrete piles shall not be driven until 14 days after casting.
- Piles shall be driven to the position and line indicated on the plans. Piles materially out of line will be rejected. Rejected piles which interfere with the work shall be removed. Other rejected piles may either be removed or cut off and abandoned in place.

49-1.08 PILE DRIVING ACCEPTANCE CRITERIA

- Except for piles to be load tested, driven piles shall be driven to a value of not less than the nominal resistance shown on the plans unless otherwise specified in the special provisions or permitted in writing by the Engineer. In addition, when a pile tip elevation is specified, driven piles shall penetrate at least to the specified tip elevation, unless otherwise permitted in writing by the Engineer. Piles to be load tested shall be driven to the specified tip elevation.
- When the pile nominal resistance is omitted from the plans or the special provisions, timber piles shall be driven to a nominal resistance of 180 kips, and steel and concrete piles shall be driven to a nominal resistance of 280 kips.
- The nominal resistance for driven piles shall be determined from the following formula in which "R_u" is the nominal resistance in kips, "E_r" is the manufacturer's rating for foot-pounds of energy developed by the hammer at the observed field drop height, and "N" is the number of hammer blows in the last foot, (maximum value to be used for N is 100):

$$R_u = (1.83 * (E_r)^{1/2} * \log_{10} (0.83 * N)) - 124$$

49-1.09 CUTOFF AND EXTENSION

- Timber piles which are to be capped shall be accurately cut off so that true bearing is obtained on every pile without the use of shims. Piles inaccurately cut off shall be replaced. Splicing of timber piles will not be permitted, except by written permission of the Engineer. Timber piles under concrete footings shall be cut off at the designated elevations and anchor devices shall be installed as shown on the plans.
- Concrete piles shall be cut off at the designated elevations and anchored to the structure as shown on the plans.
- When pile anchor dowels are used, at the option of the Contractor, the dowels shall be anchored in cast or drilled holes in the concrete pile with neat cement paste. If holes are to be drilled, they shall be drilled by methods that will not damage the concrete, reinforcement or prestressing steel. The diameter of the holes shall be the minimum consistent with placing the neat cement paste and dowel. The holes shall be free of dust and other deleterious material when the neat cement paste is placed. Sufficient paste shall be placed in the holes before the dowels are inserted so that no voids remain after the dowels are inserted. The dowels shall be left undisturbed until the paste has hardened.
- When concrete pile extensions are constructed on driven or cast-in-place concrete piles, the piles shall be cut off and extended with a reinforced concrete extension in conformance with the details shown on the plans and the provisions in Section 51, "Concrete Structures."
- Steel shells for cast-in-place concrete piles shall be cut off at the designated elevation.
- The work of cutting off precast prestressed concrete piles shall be performed in such a manner as to avoid spalling or damaging the pile below cut-off. In case of damage, the pile shall be replaced or repaired by the Contractor at the Contractor's expense.

- Steel piles shall be cut off at the designated elevations and anchor devices shall be installed as shown on the plans.
- All cut off lengths of piling shall become the property of the Contractor and shall be disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."

49-1.10 (BLANK)

49-2 TIMBER PILES

49-2.01 DESCRIPTION

- Timber piles shall conform to the requirements in ASTM Designation: D 25 for piles except butt and tip diameters shall be as specified in the following table:

Pile Length (feet)	Butt Diameter		Tip Diameter
	Minimum (inches)	Maximum (inches)	Minimum (inches)
Under 40	12	20	8
40 to 54	12	20	7
55 to 74	13	20	7
75 to 90	13	20	6
Over 90	13	20	5

Butt diameters are measured approximately 3 feet from butt.

- The width of checks in untreated timber piles shall not exceed $^3/_8$ inch. The width of checks in treated timber piles shall not exceed $^3/_8$ inch after treatment or $^1/_2$ inch immediately before driving.

49-2.02 INSPECTION

- Treated timber piles will be inspected by the Engineer after treatment.

49-2.03 REQUIREMENTS

- When preservative treatment of timber piles is required by the plans or specified in the special provisions, the treatment shall conform to the provisions in Section 58, "Preservative Treatment of Lumber, Timber and Piling," and the applicable AWPA Use Category.
- Commercially treated piles from stock may be used for test piles.
- Untreated and treated timber piles shall be of Douglas fir or Southern Pine timber and shall be clean peeled.
- The natural moisture content of any untreated timber foundation pile when delivered to the jobsite shall be not less than 18 percent at 2-inches depth.
- Treated timber piles shall be driven within 6 months after treatment.
- The natural moisture content of any timber pile to be treated shall be not less than 18 percent at 2-inches depth immediately prior to treatment. Inspection prior to treatment shall be by an established inspecting agency. Inspection reports shall be submitted with each individual shipment, and each pile shall be stamped with the date of inspection.

- Timber piling shall be protected with steel straps placed at not more than 10-foot centers along the pile. Five additional straps shall be placed on each pile; one each at 3 inches, 6 inches, 12 inches from the tip, and 2 within 2 feet of the butt.
- Steel strapping shall be approximately $1^1/_2$ inches wide, 0.030-inch in nominal thickness and shall be fabricated from cold-rolled heat-treated high tensile strapping. Strapping shall develop a tensile strength of at least 5,000 pounds. Straps shall be held in place with clips which are secured by crimping twice in the clip length with a notch-type sealer. The clip shall be approximately $2^1/_2$ inches long and fabricated from 0.030-inch thick steel. The clip joint shall develop at least 75 percent of the strap tensile strength. Straps shall encircle the pile once and shall be tensioned as tight as possible either by hand operated or pneumatic tensioning tools.
- All holes, cuts or daps in treated piles shall be treated with 2 applications of wood preservative conforming to the provisions in Section 58-1.04, "Wood Preservative for Brush Treatment."

49-2.04 TREATMENT OF PILE HEADS

- The heads of all treated timber piles which are not embedded in concrete shall be treated by one of the following methods, after the piles have been driven and cut off to the proper elevation:

A. An application of wood preservative conforming to the provisions in Section 58-1.04, "Wood Preservative for Manual Treatment," shall first be applied to the head of the pile and a protective cap shall then be built up by applying alternate layers of loosely woven fabric and hot asphalt or tar similar to membrane waterproofing, using 3 layers of asphalt or tar and 2 layers of fabric. The fabric shall measure at least 6 inches more in each direction than the diameter of the pile and shall be turned down over the pile and the edges secured by binding with 2 turns of No. 10 galvanized wire. The fabric shall be wired in advance of the application of the final layer of asphalt or tar, which shall extend down over the wiring.

B. The sawed surface shall be covered with 3 applications of a hot mixture of 60 percent creosote and 40 percent roofing pitch, or thoroughly brushcoated with 3 applications of hot creosote and covered with hot roofing pitch. A covering of 0.138-inch nominal thickness galvanized steel sheet shall be placed over the coating and bent down over the sides of each pile to shed water.

- The method to be used shall be at the option of the Contractor, unless otherwise provided on the plans or in the special provisions.
- The treatment of pile heads encased in concrete will not be required.

49-3 PRECAST PRESTRESSED CONCRETE PILES

49-3.01 DESCRIPTION

- Precast prestressed concrete piles shall be constructed in conformance with the provisions in Sections 50, "Prestressing Concrete," and 51, "Concrete Structures."

- When requested, the Contractor shall submit 2 sets of working drawings to the Engineer at the jobsite for the Engineer's use in administering the contract. The drawings shall conform to the provisions in Section 5-1.02, "Plans and Working Drawings," and shall show the pile dimensions, materials, prestressing methods, tendon arrangement and working stresses, including any addition or rearrangement of reinforcement from that shown on the plans.
- Precast prestressed concrete piling will be inspected at the fabrication site. The Contractor shall notify the Engineer when materials have been delivered to the fabrication site and shall give the Engineer at least 10 days' notice after delivery before commencing the fabrication of the precast prestressed concrete piling. Materials to be used shall be made available to the Engineer so they can be examined. The Engineer shall have free access at all times to any portion of the fabrication site where the material is stored or where work on the material is being performed.
- Concrete for precast prestressed concrete piles shall be placed in smooth mortar-tight forms, so supported as to prevent appreciable deformation or settlement during placing or curing. Unformed surfaces shall be finished to a smooth surface. When removed from the form, the pile shall present true, smooth, even surfaces free from honeycombs and voids and shall be so straight that a line stretched from butt to tip on any face will not be more than one inch from the face of the pile at any point.
- Except for precast prestressed concrete piles in a corrosive environment, lifting anchors used in precast prestressed concrete piles shall be removed, and the holes filled in conformance with the provisions in Section 51-1.18A, "Ordinary Surface Finish."
- Lifting anchors used in precast prestressed concrete piles in a corrosive environment shall be removed to a depth of at least one inch below the surface of the concrete, and the resulting hole shall be filled with epoxy adhesive before the piles are delivered to the job site. The epoxy adhesive shall conform to the provisions in Sections 95-1, "General," and 95-2.01, "Binder (Adhesive), Epoxy Base."

49-3.02 CURING

- All newly placed concrete for precast prestressed concrete piles shall be cured in conformance with the provisions in Section 90-7.05, "Curing Precast Prestressed Concrete Piles."

49-3.03 HANDLING

- When raising or transporting precast prestressed concrete piles, the Contractor shall provide slings or other equipment to avoid any appreciable bending of the pile or cracking of the concrete. Piles materially damaged in handling or driving shall be replaced by the Contractor at the Contractor's expense. Precast prestressed concrete piles shall be so handled at all times as to avoid breaking or chipping the edges.

49-4 CAST-IN-PLACE CONCRETE PILES

49-4.01 DESCRIPTION

- Cast-in-place concrete piles shall consist of one of the following:

  A. Steel shells driven permanently to the required nominal resistance and penetration and filled with concrete.
  B. Steel casings installed permanently to the required penetration and filled with concrete.
  C. Drilled holes filled with concrete.
  D. Rock sockets filled with concrete.

- The drilling of holes shall conform to the provisions in these specifications. Concrete filling for cast-in-place concrete piles is designated by compressive strength and shall have a minimum 28-day compressive strength of 3,600 psi. At the option of the Contractor, the combined aggregate grading for the concrete shall be either the one-inch maximum grading, the $^{1}/_{2}$-inch maximum grading, or the $^{3}/_{8}$-inch maximum grading. Concrete shall conform to the provisions in Section 90, "Portland Cement Concrete," and Section 51, "Concrete Structures." Reinforcement shall conform to the provisions in Section 52, "Reinforcement."
- Cast-in-place concrete piles shall be constructed so that the excavation methods and the concrete placement procedures shall provide for placing the concrete against undisturbed material in a dry or dewatered hole.
- The concrete filling for cast-in-place concrete piles shall be dense and homogeneous. The methods used to place the concrete shall prevent segregation. Concrete placed in steel shells, dry drilled holes or dewatered drilled holes shall not be permitted to fall from a height greater than 8 feet without the use of adjustable length pipes or tubes unless the flow of concrete is directed into the center of the hole using a hopper and not allowed to strike the reinforcement, reinforcement bracing and other objects in the hole.
- Concrete filling for cast-in-place concrete piles shall be vibrated in the upper 15 feet of the pile.
- Section 51-1.10, "Concrete Deposited Under Water," shall not apply to cast-in-drilled-hole concrete piling.
- After placing concrete, the temporarily exposed surfaces of the cast-in-place concrete piles shall be cured in conformance with the provisions in Section 90-7.03, "Curing Structures."

49-4.02 (BLANK)

49-4.03 DRILLED HOLES

- Except for cast-in-place concrete piling for soundwalls and retaining walls, when cast-in-place concrete piling is less than 2 feet in diameter, the Contractor may propose to increase the diameter and revise the pile tip elevation. The Contractor may propose to increase the diameter of cast-in-place concrete piling for soundwalls and retaining walls, but the pile tip elevations shall not be revised. No

additional compensation or delays will be made for the Contractor's use of increased diameter cast-in-place concrete piling.

- The axis of the hole shall not deviate from plumb more than $1^1/_2$ inches per 10 feet of length.
- Care shall be taken during excavation to prevent disturbing the foundation material surrounding the pile. Equipment or methods used for excavating holes shall not cause quick soil conditions or cause scouring or caving of the hole. After excavation is begun, the pile shall be constructed expeditiously in order to prevent deterioration of the surrounding foundation material from air slaking or from the presence of water. Deteriorated foundation material, including material that has softened, swollen or degraded, shall be removed from the sides and the bottom of the hole and shall be disposed of. The bottom of the drilled hole shall be cleaned just before placing reinforcement or concrete to remove any loose sand, gravel, dirt, and drill cuttings.
- After placing reinforcement and prior to placing concrete in the drilled hole, if caving occurs or deteriorated foundation material accumulates on the bottom of the hole, the bottom of the drilled hole shall be cleaned. The Contractor shall verify that the bottom of the drilled hole is clean.
- Water that has infiltrated the hole shall be removed before placing concrete therein. Fluvial or drainage water shall not be permitted to enter the hole.
- Temporary steel casings shall be furnished and placed tight in the hole where shown on the plans and where necessary to control water or to prevent quick soil conditions or caving of the hole. Temporary casing shall be watertight and of sufficient strength to withstand the loads from installation, removal, lateral concrete pressures and earth pressures. The casing shall be non-corrugated and the surfaces shall be smooth, clean and free from hardened concrete. The casing shall be removed while the concrete is being placed. In a dewatered hole the concrete in the casing shall be maintained at a level at least 5 feet above the bottom of the casing or at a level above the bottom of the casing adequate to prevent displacement of the concrete by material from outside the casing, whichever is greater. Casing may be vibrated or hammered when required to assist in removal of the casing from the hole, to prevent lifting of the reinforcement and to prevent concrete contamination. The withdrawal of casings shall not leave voids or cause contamination of the concrete with soil or other materials.
- Portions of the holes may be enlarged, backfilled with slurry cement backfill, concrete or other material, and redrilled to the specified diameter to control caving. Backfill material at enlarged piles shall be chemically compatible with concrete and steel, shall be drillable and shall have the necessary strength required for the conditions.
- Drill cuttings shall be disposed of in conformance with the provisions in Section 19-2.06, "Surplus Materials." Material resulting from placing concrete in piles shall be disposed of in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way," unless otherwise permitted in writing by the Engineer.
- The reinforcement shall be placed and secured symmetrically about the axis of the pile and shall be securely blocked to clear the sides of the hole.

- Reinforcement for cast-in-drilled-hole concrete piling with increased diameters and revised tip elevations shall conform to the following:

A. The size and number of the reinforcing bars, the percentage of bars required to extend to the pile tip and the size and pitch of the spiral reinforcement shall conform to the details shown on the plans for the original piles.
B. The required length of the spiral reinforcement and of any reinforcing bars which do not extend to the pile tip shall be that length which would have been required for the original specified or ordered tip elevation.
C. The diameter of the spiral reinforcement shall either remain the same as required for the original pile or be increased to provide not less than the concrete cover required for the original pile. Positive means shall be provided to ensure that the reinforcement is centered in the pile.

49-4.04 STEEL SHELLS

- Steel shells shall be sufficiently watertight to exclude water during the placing of concrete. The shells may be cylindrical or tapered, step-tapered, or a combination of either, with cylindrical sections.
- Steel shells shall conform to the provisions for steel pipe piles specified in Section 49-5, "Steel Piles."

49-4.05 INSPECTION

- After being driven and prior to placing reinforcement and concrete therein, the steel shells shall be examined for collapse or reduced diameter at any point. Any shell which is improperly driven or broken or shows partial collapse to such an extent as to materially decrease its nominal resistance will be rejected. Rejected shells shall be removed and replaced, or a new shell shall be driven adjacent to the rejected shell. Rejected shells which cannot be removed shall be filled with concrete by the Contractor at the Contractor's expense. When a new shell is driven to replace a rejected shell, the Contractor, at the Contractor's expense, shall enlarge the footing as determined necessary by the Engineer.
- Driven shells and dewatered drilled holes shall be clean and free of water before reinforcement and concrete are placed.
- The Contractor shall have available at all times a suitable light for inspecting the entire length of the shells or dewatered holes before placing the reinforcement and concrete.

49-5 STEEL PILES

49-5.01 DESCRIPTION

- Steel piles shall include structural shape piles and pipe piles.
- Structural shape steel piles shall be of the rolled section shown on the plans or of the section specified in the special provisions and shall be structural steel conforming to the requirements in ASTM Designation: A 36/A 36M, or at the option of the Contractor, structural steel conforming to the requirements in ASTM Designation: A 572/A 572M.
- Steel pipe piles shall conform to the following requirements:

A. Steel pipe piles less than 14 inches in diameter shall conform to the requirements in ASTM Designation: A 252, Grade 2 or 3.
B. Steel pipe piles 14 inches and greater in diameter shall conform to the requirements in ASTM Designation: A 252, Grade 3.
C. Steel pipe piles shall be of the nominal diameter and nominal wall thickness shown on the plans or specified in the special provisions.
D. The carbon equivalency (CE) of steel for steel pipe piles, as defined in AWS D 1.1, Section XI5.1, shall not exceed 0.45.
E. The sulfur content of steel for steel pipe piles shall not exceed 0.05-percent.
F. Seams in steel pipe piles shall be complete penetration welds.

- Steel piles shall not be joined by welded lap splicing.
- The manufacturer or fabricator of steel piles shall furnish a Certificate of Compliance stating that the piles being supplied conform to these specifications and to the special provisions. The Certificate of Compliance shall include test reports for tensile, chemical, and any specified nondestructive tests. Samples for testing shall be taken from the base metal, steel, coil or from the manufactured or fabricated piles .

49-5.02 SPLICING

- Steel pile splices shall conform to the requirements in AWS D 1.1 and the special provisions. Structural shape steel piling splices shall be complete joint penetration groove welds. Steel pipe pile splices that are made at a permanent manufacturing or fabrication facility, and that are made prior to furnishing the Certificate of Compliance, shall be complete penetration welds. Steel pipe pile splices that are made in the field shall be complete joint penetration groove welds.
- Ends of steel pipe piling to be spliced that have been damaged during driving shall be removed to a sound and uniform section conforming to the tolerances for diameter, edge alignment and roundness required to meet the steel pile splice welding requirements. Pipe ends shall be field cut using automated guided cutting equipment. Manual flame cutting shall not be used.

49-6 MEASUREMENT AND PAYMENT

49-6.01 MEASUREMENT

- The length of timber, steel, and precast prestressed concrete piles, and of cast-in-place concrete piles consisting of driven shells filled with concrete, shall be the greater of the following:

A. The total length in place in the completed work, measured along the longest side, from the tip of the pile to the plane of pile cut-off.
B. The length measured along the longest side, from the tip elevation shown on the plans or the tip elevation ordered by the Engineer, to the plane of pile cut-off.

- The length of each cast-in-drilled-hole concrete pile to be paid for shall be the length, measured along the longest side, from the tip elevation shown on the plans, or the tip elevation ordered by the Engineer for the diameter of pile shown on the plans, to the plane of pile cut-off. No reduction in the length for payment will be made for any cast-in-drilled-hole concrete pile where the tip elevation is revised in conjunction with a request by the Contractor to increase the pile diameter.
- The length of load test piles and adjacent anchor piles to be paid for shall be the length as load tested.
- When concrete piles are extended by means of reinforced concrete extensions as provided in Section 49-1.09, "Cutoff and Extension," the length of the extension from the plane of pile cut-off to the top of the extension will be considered as concrete piling and will be paid for at the price per linear foot for furnish piling, or for cast-in-drilled-hole concrete piling, whichever item applies.

49-6.02 PAYMENT

- Timber, steel, precast prestressed concrete piles, and cast-in-place concrete piles consisting of driven shells filled with concrete, will be paid for at the contract price per linear foot for furnish piling and the contract unit price for drive pile.
- Cast-in-place concrete piles consisting of drilled holes filled with concrete will be paid for at the contract price per linear foot for cast-in-drilled-hole concrete piling. Any pile which has been increased in diameter as provided in Section 49-4.03, "Drilled Holes," will be paid for at the contract price per linear foot for the size of cast-in-drilled-hole concrete piling shown on the plans at that location.
- The contract price paid per linear foot for cast-in-drilled-hole concrete piling shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in drilling holes, disposing of material resulting from drilling holes, temporarily casing holes and removing water when necessary, furnishing and placing concrete and reinforcement, and constructing reinforced concrete extensions, complete in place, to the required penetration, as shown on the plans, as specified in these specifications and in the special provisions, and as directed by the Engineer.
- The contract price paid per linear foot for furnish piling of the type or class shown in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing the timber, steel or concrete piles at the site for driving, including steel shells and the filling materials for cast-in-place concrete piles, constructing reinforced concrete extensions, splicing piles and furnishing and installing pile anchors and lugs, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- Full compensation for furnishing all reinforcement and prestressing steel in concrete piles and concrete pile extensions, including reinforcement required to extend beyond the pile or extension as shown on the plans, shall be considered as included in the contract price paid per linear foot for furnish piling of the type or class shown in the Engineer's Estimate or the contract price paid per linear foot for cast-in-drilled-hole concrete piling, and no additional compensation will be allowed therefor.

- If precast prestressed concrete piling or steel pipe piling is manufactured or fabricated more than 300 air line miles from both Sacramento and Los Angeles, additional shop inspection expenses will be sustained by the State. Whereas it is and will be impractical and extremely difficult to ascertain and determine the actual increase in such expenses, it is agreed that payment to the Contractor for furnishing piling of the types shown in the Engineer's Estimate will be reduced $5,000 for each manufacture or fabrication site located more than 300 air line miles from both Sacramento and Los Angeles and an additional $3,000 ($8,000 total) for each manufacture or fabrication site located more than 3,000 air line miles from both Sacramento and Los Angeles.
- The contract unit price paid for drive pile shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in driving timber, concrete and steel piles, driving steel shells for cast-in-place concrete piles, placing filling materials for cast-in-place concrete piles and cutting off piles, all complete in place to the required nominal resistance and penetration as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Load test piles and adjacent anchor piles that become a part of the completed structure, or are shown on the plans or are specified, will be paid for at the contract prices for the type or class of piling shown in the Engineer's Estimate.
- Full compensation for furnishing and placing additional testing reinforcement, for load test anchorages, and for cutting off test piles, shall be considered as included in the contract price paid for piling of the type or class shown in the Engineer's Estimate, and no additional compensation will be allowed.
- No additional compensation or extension of time will be made for additional foundation investigation, installation and testing of indicator piling, cutting off piling and restoring the foundation investigation and indicator pile sites, and review of request by the Engineer.
- Full compensation for all jetting, drilling, providing special driving tips or heavier sections for steel piles or shells, or other work necessary to obtain the specified penetration and nominal resistance of the piles, for predrilling holes through embankment and filling the space remaining around the pile with sand or pea gravel, for disposing of material resulting from jetting, drilling or predrilling holes, and for all excavation and backfill involved in constructing concrete extensions as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer shall be considered as included in the contract unit price paid for drive pile or in the contract price paid per linear foot for cast-in-drilled-hole concrete piling, and no additional compensation will be allowed therefor.
- No payment will be made for piles driven out of place or for imperfect piles, or for piles which are damaged in handling or driving.
- When, in addition to the requirements of the plans and specifications, lugs are ordered on steel piles, the Contractor shall furnish and place these devices and the cost thereof will be paid for as extra work as provided in Section 4-1.03D. No additional compensation will be allowed for driving piles on account of these additional requirements.

SECTION 50: PRESTRESSING CONCRETE

50-1.01 DESCRIPTION

- This work shall consist of prestressing precast or cast-in-place concrete by furnishing, placing, and tensioning of prestressing steel in conformance with details shown on the plans, and as specified in these specifications and the special provisions.
- This work shall include the furnishing and installation of any appurtenant items necessary for the particular prestressing system to be used, including but not limited to ducts, anchorage assemblies and grout used for pressure grouting ducts.
- For cast-in-place prestressed concrete, the term "member" as used in this Section 50 shall be considered to mean the concrete which is to be prestressed.
- Prestressing shall be performed by either pretensioning or post-tensioning methods unless the plans show only pretensioning details. If the plans show only pretensioning details, the use of a post-tensioning system will be allowed only if complete details of any necessary modifications are approved by the Engineer.

50-1.02 DRAWINGS

- The Contractor shall submit to the Offices of Structure Design for approval in conformance with the provisions in Section 5-1.02, "Plans and Working Drawings," working drawings of the prestressing system proposed for use. For initial review, 6 sets of the drawings shall be submitted for railroad bridges and 4 sets shall be submitted for other structures. After review, between 6 and 12 sets, as requested by the Engineer, shall be submitted to Offices of Structure Design for final approval and for use during construction.
- The working drawings of the prestressing system shall show complete details and substantiating calculations of the method and materials the Contractor proposes to use in the prestressing operations, including any additions or rearrangement of reinforcing steel and any revision in concrete dimensions from that shown on the plans. The details shall outline the method and sequence of stressing and shall include complete specifications and details of the prestressing steel and anchoring devices, working stresses, anchoring stresses, type of ducts and all other data pertaining to the prestressing operation, including the proposed arrangement of the prestressing steel in the members.
- Each working drawing submittal shall consist of plans for a single bridge or portion thereof. For multi-frame bridges, each frame shall require a separate working drawing submittal.
- Working drawings shall be 22" x 34" or 11" x 17" in size and each drawing and calculation sheet shall include the jobsite name of the structure as shown on the contract plans, District-County-Route, bridge number and contract number.
- Working drawings shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the Engineer and correction by the Contractor of the drawings without delaying the work. The time shall be proportional to the complexity of the work, but in no case shall the time be less than 8 weeks for railroad bridges or 6 weeks for other structures after complete drawings and all support data are submitted.

- For railroad bridges, approval by the Engineer of the working drawings will be contingent upon the working drawings being satisfactory to the railroad company involved.
- At the completion of each structure on the contract, one set of reduced prints on 20-pound (minimum) bond paper, 11" x 17" in size, of the corrected original tracings of all working drawings for each structure shall be furnished to the Engineer. Reduced prints of drawings which are common to more than one structure shall be submitted for each structure. An index prepared specifically for the drawings for each structure containing sheet numbers and titles shall be included on the first reduced print in the set for each structure. Reduced prints for each structure shall be arranged in the order of drawing numbers shown in the index.
- The edge of the corrected original tracing image shall be clearly visible and visually parallel with the edges of the page. A clear, legible symbol shall be provided as near to the upper left side of each page as is feasible within the original print to show the amount of reduction, and a horizontal and vertical scale shall be provided on each reduced print to facilitate enlargement to original scale.
- The provisions in this Section 50-1.02 shall not apply to prestressing systems used for concrete piles.

50-1.03 (BLANK)

50-1.04 (BLANK)

50-1.05 PRESTRESSING STEEL

- Prestressing steel shall be high-tensile wire conforming to the requirements in ASTM Designation: A 421, including Supplement I; high-tensile seven-wire strand conforming to the requirements in ASTM Designation: A 416; or uncoated high-strength steel bars conforming to the requirements in ASTM Designation: A 722, including all supplementary requirements. The maximum weight requirement of ASTM Designation: A 722 will not apply.
- In addition to the requirements of ASTM Designation: A 722, for deformed bars, the reduction of area shall be determined from a bar from which the deformations have been removed. The bar shall be machined no more than necessary to remove the deformations over a length of 12 inches, and reduction will be based on the area of the machined portion.
- In addition to the requirements specified herein, epoxy-coated seven-wire prestressing steel strand shall be grit impregnated and filled in conformance with the requirements in ASTM Designation: A 882/A 882M, including Supplement I, and the following:

A. The coating material shall be on the Department's list of approved coating materials for epoxy-coated strand, available from the Transportation Laboratory.
B. The film thickness of the coating after curing shall be 15 mils to 45 mils.
C. Prior to coating the strand, the Contractor shall furnish to the Transportation Laboratory a representative 8 ounces sample from each batch of epoxy coating material to be used. Each sample shall be

packaged in an airtight container identified with the manufacturer's name and batch number.

D. Prior to use of the epoxy-coated strand in the work, written certifications referenced in ASTM Designation: A 882/A 882M, including a representative load-elongation curve for each size and grade of strand to be used and a copy of the quality control tests performed by the manufacturer, shall be furnished to the Engineer.

E. In addition to the requirements in Section 50-1.10, "Samples for Testing," four 5-foot long samples of coated strand and one 5-foot long sample of uncoated strand of each size and reel shall be furnished to the Engineer for testing. These samples, as selected by the Engineer, shall be representative of the material to be used in the work.

F. Epoxy-coated strand shall be cut using an abrasive saw.

G. All visible damage to coatings caused by shipping and handling, or during installation, including cut ends, shall be repaired in conformance with the requirements in ASTM Designation: A 882/A 882M. The patching material shall be furnished by the manufacturer of the epoxy powder and shall be applied in conformance with the manufacturer's written recommendations. The patching material shall be compatible with the original epoxy coating material and shall be inert in concrete.

- All bars in any individual member shall be of the same grade, unless otherwise permitted by the Engineer.
- When bars are to be extended by the use of couplers, the assembled units shall have a tensile strength of not less than the manufacturer's minimum guaranteed ultimate tensile strength of the bars. Failure of any one sample to meet this requirement will be cause for rejection of the heat of bars and lot of couplers. The location of couplers in the member shall be subject to approval by the Engineer.
- Wires shall be straightened if necessary to produce equal stress in all wires or wire groups or parallel lay cables that are to be stressed simultaneously or when necessary to ensure proper positioning in the ducts.
- Where wires are to be button-headed, the buttons shall be cold formed symmetrically about the axes of the wires. The buttons shall develop the minimum guaranteed ultimate tensile strength of the wire. No cold forming process shall be used that causes indentations in the wire. Buttonheads shall not contain wide open splits, more than 2 splits per head, or splits not parallel with the axis of the wire.
- Prestressing steel shall be protected against physical damage and rust or other results of corrosion at all times from manufacture to grouting or encasing in concrete. Prestressing steel that has sustained physical damage at any time shall be rejected. The development of visible rust or other results of corrosion shall be cause for rejection, when ordered by the Engineer.
- Epoxy-coated prestressing steel strand shall be covered with an opaque polyethylene sheeting or other suitable protective material to protect the strand from exposure to sunlight, salt spray, and weather. For stacked coils, the protective covering shall be draped around the perimeter of the stack. The covering shall be adequately secured; however, it should allow for air circulation around the strand to

prevent condensation under the covering. Epoxy-coated strand shall not be stored within 1,000 feet of ocean or tidal water for more than 2 months.

- Prestressing steel shall be packaged in containers or shipping forms for the protection of the steel against physical damage and corrosion during shipping and storage. Except for epoxy-coated strand, a corrosion inhibitor which prevents rust or other results of corrosion, shall be placed in the package or form, or shall be incorporated in a corrosion inhibitor carrier type packaging material, or when permitted by the Engineer, may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.
- The shipping package or form shall be clearly marked with a statement that the package contains high-strength prestressing steel, and the type of corrosion inhibitor used, including the date packaged.
- Prestressing steel for post-tensioning which is installed in members prior to placing and curing of the concrete, and which is not epoxy-coated, shall be continuously protected against rust or other results of corrosion, until grouted, by means of a corrosion inhibitor placed in the ducts or applied to the steel in the duct. The corrosion inhibitor shall conform to the provisions specified herein.
- When steam curing is used, prestressing steel for post-tensioning shall not be installed until the steam curing is completed.
- Water used for flushing ducts shall contain either quick lime (calcium oxide) or slaked lime (calcium hydroxide) in the amount of 0.1-pound per gallon. Compressed air used to blow out ducts shall be oil free.
- When prestressing steel for post-tensioning is installed in the ducts after completion of concrete curing, and if stressing and grouting are completed within 10 days after the installation of the prestressing steel, rust which may form during those 10 days will not be cause for rejection of the steel. Prestressing steel installed, tensioned, and grouted in this manner, all within 10 days, will not require the use of a corrosion inhibitor in the duct following installation of the prestressing steel. Prestressing steel installed as above but not grouted within 10 days shall be subject to all the requirements in this section pertaining to corrosion protection and rejection because of rust. The requirements in this section pertaining to tensioning and grouting within 10 days shall not apply to epoxy-coated prestressing steel strand.
- Any time prestressing steel for pretensioning is placed in the stressing bed and is exposed to the elements for more than 36 hours prior to encasement in concrete, adequate measures shall be taken by the Contractor, as approved by the Engineer, to protect the steel from contamination or corrosion.
- After final fabrication of the seven-wire prestressing steel strand, no electric welding of any form shall be performed on the prestressing steel. Whenever electric welding is performed on or near members containing prestressing steel, the welding ground shall be attached directly to the steel being welded.
- Pretensioned prestressing steel shall be cut off flush with the end of the member. For epoxy-coated prestressing steel, only abrasive saws shall be used to cut the steel. The exposed ends of the prestressing steel and a one-inch strip of

adjoining concrete shall be cleaned and painted. Cleaning shall be by wire brushing or abrasive blast cleaning to remove all dirt and residue on the metal or concrete surfaces. Immediately after cleaning, the surfaces shall be covered with one application of unthinned zinc-rich primer (organic vehicle type) conforming to the provisions in Section 91, "Paint," except that 2 applications shall be applied to surfaces which will not be covered by concrete or mortar. Aerosol cans shall not be used. The paint shall be thoroughly mixed at the time of application and shall be worked into any voids in the prestressing tendons.

50-1.06 ANCHORAGES AND DISTRIBUTION

- Post-tensioned prestressing steel shall be secured at the ends by means of approved permanent type anchoring devices.
- Anchorage devices for post-tensioning shall hold the prestressing steel at a load producing a stress of not less than 95 percent of the specified ultimate tensile strength of the prestressing steel.
- When headed wires are used, the outside edge of any hole for prestressing wire through a stressing washer or through an unthreaded bearing ring or plate shall not be less than 1/4 inch from the root of the thread of the washer or from the edge of the ring or plate.
- The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete. Such approved devices shall conform to the following requirements:

  A. The final unit compressive stress on the concrete directly underneath the plate or assembly shall not exceed 3,300 psi.
  B. Bending stresses in the plates or assemblies induced by the pull of the prestressing steel shall not exceed the yield point of the material or cause visible distortion in the anchorage plate when 95 percent of the specified ultimate tensile strength of the tendons is applied as determined by the Engineer.

- Should the Contractor elect to furnish an anchoring device of a type which is sufficiently large and which is used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stresses to the concrete, the steel distribution plates or assemblies may be omitted.
- If loop tendon anchorages are used, the anchorages shall be enclosed in ducts for their entire length.
- Where the end of a post-tensioned assembly will not be covered by concrete, the anchoring devices shall be recessed so that the ends of the prestressing steel and all parts of the anchoring devices will be at least 2 inches inside of the end surface of the members, unless a greater embedment is shown on the plans. Following post-tensioning, the recesses shall be filled with concrete conforming to the provisions for the structure and finished flush.

50-1.07 DUCTS

- Duct enclosures for prestressing steel shall be rigid ferrous metal, galvanized, mortar tight and accurately placed at the locations shown on the plans or approved by the Engineer.
- Ducts shall be fabricated with either welded or interlocked seams. Galvanizing of the welded seam will not be required. Ducts shall have sufficient strength to maintain their correct alignment during placing of concrete. Joints between sections of duct shall be positive metallic connections which do not result in angle changes at the joints. Waterproof tape shall be used at the connections. Ducts shall be bent without crimping or flattening. Transition couplings connecting the ducts to anchoring devices shall be either ferrous metal or polyethylene. Ferrous metal transition couplings need not be galvanized.
- All ducts or anchorage assemblies shall be provided with pipes or other suitable connections for the injection of grout after prestressing.
- Ducts for prestressing steel when bars are used shall have a minimum inside diameter $^3/_8$ inch larger than the diameter of the bars to be used.
- Ducts for prestressing steel shall be securely fastened in place to prevent movement.
- After installation in the forms, the ends of ducts shall at all times be covered as necessary to prevent the entry of water or debris. If prestressing steel is to be installed after the concrete has been placed, the Contractor shall demonstrate to the satisfaction of the Engineer that the ducts are free of water and debris immediately prior to installation of the steel.
- All ducts with a total length of 400 feet or more shall be vented. Vents shall be placed at not more than 400-foot intervals and shall be located within 6 feet of a high point in the duct profile. Vents shall be $^1/_2$ inch minimum diameter standard pipe or suitable plastic pipe. Connections to ducts shall be made with metallic or plastic structural fasteners. Plastic components, if selected, shall not react with the concrete or enhance corrosion of the prestressing steel, and shall be free of water soluble chlorides. The vents shall be mortar tight, taped as necessary, and shall provide means for injection of grout through the vents and for sealing the vents. Ends of vents shall be removed one inch below the roadway surface after grouting has been completed.

50-1.08 PRESTRESSING

- Prestressing steel shall be tensioned by means of hydraulic jacks so that the force in the prestressing steel shall not be less than the value shown on the plans.
- The maximum temporary tensile stress (jacking stress) in prestressing steel shall not exceed 75 percent of the specified minimum ultimate tensile strength of the prestressing steel. Pretensioned prestressing steel shall be anchored at stresses that will result in the ultimate retention of working forces at not less than those shown on the plans, but in no case shall the stress at anchorages after seating exceed 70 percent for normal relaxation strand, or 75 percent for low relaxation strand, of the specified minimum ultimate tensile strength of the prestressing steel.
- Working force and working stress will be considered as the force and stress remaining in the prestressing steel after all losses, including creep and shrinkage of concrete, elastic compression of concrete, creep of steel, losses in post-tensioned

prestressing steel due to sequence of stressing, friction and take up of anchorages and all other losses peculiar to the method or system of prestressing have taken place or have been provided for.

- The loss in stress in post-tensioned prestressing steel due to creep and shrinkage of concrete, creep of steel and sequence of stressing shall be assumed to be 32,000 psi for normal relaxation wire or strand, 20,000 psi for low relaxation wire or strand and 22,000 psi for bars. If lightweight concrete is used, the loss shall be assumed to be 40,000 psi for normal relaxation wire or strand and 30,000 psi for low relaxation wire or strand.
- The loss in stress in pretensioned prestressing steel due to creep and shrinkage of concrete, creep of steel and elastic compression of concrete shall be assumed to be 45,000 psi for normal relaxation wire or strand and 35,000 psi for low relaxation wire or strand. If lightweight concrete is used, the loss shall be assumed to be 50,000 psi for normal relaxation strand or wire and 40,000 psi for low relaxation strand or wire.
- The following formula and friction coefficients shall be used in calculating friction losses in tendons:

$$T_o = T_x e^{(\mu\alpha + KL)}$$

Where:

T_o = steel stress at jacking end
T_x = steel stress at any point x
e = base of Naperian logarithms
μ = friction curvature coefficient
α = total angular change of prestressing steel profile in radians from jacking end to point x
K = friction wobble coefficient (=0.0002/ft)
L = length of prestressing steel from jacking end to point x

Type of Steel Tendon	Length of Tendon L (feet)	Type of Duct	μ
Wire or Strand	0 to less than 600	Rigid or semi-rigid galvanized sheet metal	0.15
	600 to less than 900		0.20
	900 to less than 1,200		0.25
	Greater than or equal to 1,200		0.25*
Wire or Strand	All	Plastic	0.23
	All	Rigid Steel Pipes	0.25*
High Strength Bar	All	Rigid or semi-rigid galvanized sheet metal	0.30

* With the use of lubrication

Each jack used to stress tendons shall be equipped with either: (1) two pressure gages or (2) one pressure gage and a load cell, at the option of the Contractor. The jack body shall be permanently marked with the ram area. Each pressure gage shall be fully functional and have an accurately reading dial at least 6 inches in diameter. The jack and each gage shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force. The load cell, if used, shall be calibrated and shall be provided with an indicator which may be used to determine the prestressing force in the tendon. The range of the load cell shall be such that the lower 10 percent of the manufacturer's rated capacity will not be used in determining the jacking stress. The jacking equipment calibration procedure shall be as follows:

A. Each jack used to stress tendons, which are permanently anchored at 25 percent or more of the specified minimum ultimate tensile strength of the prestressing steel, shall be calibrated by the Transportation Laboratory within one year prior to use and after each repair, unless otherwise directed. The Contractor shall be responsible for:

1. scheduling the calibration of the jacking equipment with the Transportation Laboratory;
2. verifying that the jack and supporting systems are complete, with proper components, and are in good operating condition;
3. mechanically calibrating the gages with a dead weight tester or other approved means prior to calibration of the jacking equipment by the Transportation Laboratory;
4. providing sufficient labor, equipment and material to install and support the jacking and calibration equipment and to remove the equipment after the calibration is complete; and
5. plotting the calibration results.

B. Each jack used to stress tendons, which are permanently anchored at less than 25 percent of the specified minimum ultimate tensile strength of the prestressing steel, shall be calibrated by a private laboratory approved by the Transportation Laboratory within 6 months prior to use and after each repair, unless otherwise directed.

- The prestressing force may be tested by State forces with either State-furnished load cells or pressure cells, or with State-furnished Vibra-Tension equipment operated in conformance with the requirements in California Test 677. The Contractor shall provide sufficient labor, equipment and material to install and support the testing equipment at the prestressing tendons and to remove the testing equipment after the testing is complete, as ordered by the Engineer.
- Prior to placing forms for closing slabs of box girder cells, the Contractor shall demonstrate to the satisfaction of the Engineer that either the prestressing steel is free and unbonded in the duct or, if prestressing steel has not yet been placed, that all ducts are unobstructed.
- Prior to post-tensioning any member, the Contractor shall demonstrate to the satisfaction of the Engineer that the prestressing steel is free and unbonded in the duct.
- Prestressing forces shall not be applied to cast-in-place concrete until at least 10 days after the last concrete has been placed in the member to be prestressed and until the concrete complies with one of the following requirements:

A. When the concrete is designated by compressive strength, the concrete compressive strength shall have reached the strength shown on the plans at the time of stressing.
B. When the concrete is designated by class or cement content, either the concrete compressive strength shall have reached the strength shown on the plans at the time of stressing, or at least 28 days shall have elapsed since the last concrete to be prestressed has been placed, whichever occurs first.

- Subject to prior approval by the Engineer, a portion of the total prestressing force may be applied to a precast member when the strength of the concrete in the member is less than the value shown on the plans and the member may then be moved. Approval by the Engineer of the partial prestressing and moving shall in no way relieve the Contractor of full responsibility for successfully constructing the members.
- Prestressing steel in pretensioned members shall not be cut or released until the concrete in the member has attained a compressive strength of not less than the value shown on the plans or 4,000 psi, whichever is greater. In addition to these concrete strength requirements, when epoxy-coated prestressing steel strand is used, the steel shall not be cut or released until the temperature of the concrete surrounding the strand is less than 150º F and falling.
- When ordered by the Engineer, prestressing steel strands in pretensioned members, if tensioned individually, shall be checked by the Contractor for loss of

prestress not more than 48 hours prior to placing concrete for the members. The method and equipment for checking the loss of prestress shall be subject to approval by the Engineer. Strands which show a loss of prestress in excess of 3 percent shall be retensioned to the original computed jacking stress.

- When prestressing steel in pretensioned members is tensioned at a temperature appreciably lower than the estimated temperature of the concrete and the prestressing steel at the time of initial set of the concrete, the calculated elongation of the prestressing steel shall be increased to compensate for the loss in stress, but in no case shall the jacking stress exceed 75 percent of the specified minimum ultimate tensile strength of the prestressing steel.
- The cutting and releasing of prestressing steel in pretensioned members shall be performed in such an order that lateral eccentricity of prestress will be a minimum.
- The tensioning process as applied to post-tensioned members shall be so conducted that tension being applied and the elongation of the prestressing steel may be measured at all times.
- Except as provided herein, tendons in continuous post-tensioned members shall be tensioned by jacking at each end of the tendon. Where one-end stressing is shown on the plans, tensioning of such tendons shall be done by jacking from one end or both ends of the tendon at the option of the Contractor.
- Prestressing tendons in simple span post-tensioned members may be tensioned by jacking from one end only.

50-1.09 BONDING AND GROUTING

- Post-tensioned prestressing steel shall be bonded to the concrete by completely filling the entire void space between the duct and the tendon with grout.
- Grout shall consist of portland cement and water, and may contain an admixture if approved by the Engineer.
- Portland cement shall conform to the provisions in Section 90-2.01, "Cement."
- Water shall conform to the provisions in Section 90-2.03, "Water."
- The use of admixtures shall conform to the provisions in Section 90-4, "Admixtures," except that the admixtures shall not contain chloride ions in excess of 0.25-percent by weight of admixture and the admixtures may be dispensed in solid form.
- Water shall be first added to the mixer followed by cement and admixture.
- The grout shall be mixed in mechanical mixing equipment of a type that will produce uniform and thoroughly mixed grout. The water content shall be not more than 5 gallons per 94 pounds of cement. Retempering of grout will not be permitted. Grout shall be continuously agitated until the grout is pumped.
- The quality of the grout shall be determined by the Engineer in conformance with the requirements in California Test 541. The efflux time of a grout sample immediately after mixing shall be not less than 11 seconds.
- Grouting equipment shall be capable of grouting at a pressure of at least 100 psi.
- Grouting equipment shall be furnished with a pressure gage having a full-scale reading of not more than 300 psi.

- When vents are required, standby flushing equipment capable of developing a pumping pressure of 250 psi and of sufficient capacity to flush out any partially grouted ducts shall be provided.
- Ducts shall be clean and free of water and deleterious materials that would impair bonding of the grout or interfere with grouting procedures.
- Grout shall pass through a screen with 0.07-inch maximum clear openings prior to being introduced into the grout pump.
- Grout injection pipes, ejection pipes and vents shall be fitted with positive mechanical shutoff valves. Positive mechanical shutoff valves shall be capable of withstanding the pumping pressures. Valves shall not be removed or opened until the grout has set. Suitable alternatives, when satisfactorily demonstrated to the Engineer, may be substituted for mechanical valves.
- Leakage of grout through the anchorage assembly shall be prevented by positive mechanical means.
- Grout shall be pumped through the duct and continuously wasted at the outlet until no visible slugs or other evidence of water or air are ejected, and the efflux time of ejected grout is not less than 11 seconds. The outlet valve shall then be closed, and the pumping pressure held momentarily. The valve at the inlet shall then be closed while maintaining this pressure.
- When hot weather conditions would contribute to quick stiffening of the grout, the grout shall be cooled by approved methods as necessary to prevent blockages during pumping operations.
- When freezing weather conditions will prevail during and following the placement of grout, the Contractor shall provide adequate means to protect the grout in the ducts from damage by freezing or other causes.
- The surfaces of concrete against which concrete encasement over anchorage assemblies is to be placed shall be abrasive blast cleaned, and clean aggregate exposed after grouting of the ducts has been completed.

50-1.10 SAMPLES FOR TESTING

- Sampling and testing shall conform to the requirements in ASTM Designation: A 416 and ASTM Designation: A 421 and as specified in this Section 50-1.10.
- Samples from each size and each heat of prestressing bars, from each manufactured reel of prestressing steel strand, from each coil of prestressing wire and from each lot of anchorage assemblies and bar couplers to be used shall be furnished for testing. With each sample of prestressing steel wires, bars or strands furnished for testing, a certification shall be submitted stating the manufacturer's minimum guaranteed ultimate tensile strength of the sample furnished.
- Materials for testing shall be furnished by the Contractor at the Contractor's expense. The Contractor shall have no claim for additional compensation in the event the work is delayed awaiting approval of the materials furnished for testing.
- All bars of each size from each mill heat, all wire from each coil, and all strand from each manufactured reel to be shipped to the site shall be assigned an individual lot number and shall be tagged in such a manner that each lot can be accurately identified at the jobsite. Each lot of anchorage assemblies and bar couplers to be installed at the site shall be likewise identified. Unidentified

prestressing steel, anchorage assemblies or bar couplers received at the site will be rejected.

- The following samples of materials and tendons, selected by the Engineer from the prestressing steel at the plant or jobsite, shall be furnished by the Contractor to the Engineer well in advance of anticipated use:

  A. For wire or bars, one 7-foot long sample and for strand, one 5-foot long sample, of each size shall be furnished for each heat or reel.
  B. For epoxy-coated strand, one 5-foot long sample of uncoated strand of each size shall be furnished for each reel.
  C. If the prestressing tendon is a bar, one 7-foot long sample shall be furnished and in addition, if couplers are to be used with the bar, two 4-foot long samples of bar, equipped with one coupler and fabricated to fit the coupler, shall be furnished.

- Approval of new prestressing systems will be contingent on prequalification testing of complete tendon assemblies as proposed for use and the submittal of the written information required by the Prestressing System Prequalification Questionnaire available from the Transportation Laboratory. The prequalification testing shall be performed by the Contractor, at the Contractor's expense, at a location within the State of California and shall be witnessed by the Engineer.
- When prestressing systems have been previously tested and approved for Department of Transportation projects, complete tendon samples need not be tested, provided there is no change whatsoever in the materials, design or details previously approved.
- For prefabricated tendons, the Contractor shall give the Engineer at least 10 days' notice before commencing the installation of end fittings or the heading of wires. The Engineer will inspect end fitting installations and wire headings while such fabrication is in progress at the plant and will arrange for the required testing of the material to be shipped to the site.
- No prefabricated tendon shall be shipped to the site without first having been released by the Engineer, and each tendon shall be tagged before shipment for identification purposes at the site. Unidentified tendons received at the site will be rejected.
- Jobsite or site as referred to herein shall be considered to mean the location where the members are to be manufactured whether at the structure site or a removed casting yard.
- The release of any material by the Engineer shall not preclude subsequent rejection if the material is damaged in transit or later damaged or found to be defective.

50-1.11 PAYMENT

- No separate payment will be made for prestressing precast concrete members. Payment for prestressing precast concrete members shall be considered as included in the contract price paid for furnish precast members as provided for in Section 51, "Concrete Structures."

- The contract lump sum prices paid for prestressing cast-in-place concrete of the types listed in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in furnishing, placing, and tensioning the prestressing steel in cast-in-place concrete structures, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- If a portion or all of the prestressing system is fabricated more than 300 air line miles from both Sacramento and Los Angeles, additional shop inspection expenses will be sustained by the State. Whereas it is and will be impracticable and extremely difficult to ascertain and determine the actual increase in these expenses, it is agreed that payment to the Contractor for prestressing cast-in-place concrete will be reduced $5,000 for each fabrication site located more than 300 air line miles from both Sacramento and Los Angeles and an additional $3,000 ($8,000 total) for each fabrication site located more than 3,000 air line miles from both Sacramento and Los Angeles.
- Full compensation for furnishing and placing additional concrete and deformed bar reinforcing steel required by the particular system used, ducts, anchoring devices, distribution plates or assemblies and incidental parts, for furnishing samples for testing, for calibration of jacking equipment done by a private laboratory, and for pressure grouting ducts shall be considered as included in the contract lump sum price paid for prestressing cast-in-place concrete or in the contract price for furnish precast members, and no additional compensation will be allowed therefor.

SECTION 51: CONCRETE STRUCTURES

51-1.01 DESCRIPTION

- This work shall consist of constructing concrete bridges, grade separations, structure approach slabs, culverts, headwalls, endwalls, drainage inlets, retaining walls and all other types of portland cement concrete structures to the lines and grades established by the Engineer and in conformance with the designs and details shown on the plans and as specified in these specifications and the special provisions.
- This work shall include construction of structures of cast-in-place concrete or of precast concrete members using either unreinforced, reinforced or prestressed concrete or any combination thereof.
- The work involved in precast concrete members shall include the manufacture, transportation and storage of girders, slabs, piling and other structural members of precast concrete and shall also include the placing of all precast concrete members, except piling which shall be placed as provided in Section 49, "Piling." The members shall be furnished complete including all concrete, prestressing steel, bar reinforcing steel and incidental materials in connection therewith.
- Concrete shall conform to the provisions in Section 90, "Portland Cement Concrete," and these specifications.

51-1.02 MINOR STRUCTURES

- Those pipe headwalls, endwalls, drainage inlets and other miscellaneous concrete structures that are identified on the plans or in the special provisions as minor structures shall be constructed of minor concrete or of concrete of the class designated in the contract item.
- Metal frames and covers or frames and grates and other miscellaneous iron and steel for use with minor structures shall conform to the provisions in Section 75-1.02, "Miscellaneous Iron and Steel."
- Minor structures, at the option of the Contractor, may be furnished and installed as precast units, or the units may be combined precast and cast-in-place structures, provided the structures in place substantially conform to cast-in-place construction as specified in these specifications. Precast units for inlets may be round, oval or rectangular in horizontal cross section or any combination of these. Transitions from rectangular grate opening to a round or oval basin shall be made in not less than 8 inches. Means shall be provided for adjustments in the field to meet final grade, paving or surfacing.
- Where new drainage structures are located in areas to be paved or surfaced, no individual structure shall be constructed to final grade until the paving or surfacing has been completed immediately adjacent to the structure.

51-1.03 DEPTH OF FOOTINGS

- The elevations of the bottoms of footings shown on the plans shall be considered as approximate only and the Engineer may order, in writing, such changes in dimensions or elevations of footings as may be necessary to secure a satisfactory foundation. Additional structure excavation and structure backfill

resulting from those changes will be measured and paid for as specified in Section 19-3.07, "Measurement."

- The Contractor shall be responsible for any additional costs incurred should the Contractor elect to fabricate materials or do other work prior to the final determination of footing elevations.

51-1.04 PUMPING

- Pumping from the interior of any foundation enclosure shall be done in such manner as to preclude the possibility of any portion of the concrete materials being carried away. No pumping will be permitted during the placing of concrete, or for a period of at least 24 hours thereafter, unless the pumping be done from a suitable sump separated from the concrete work.

51-1.05 FORMS

- Concrete forms shall be mortartight, true to the dimensions, lines and grades of the structure, and of sufficient strength to prevent appreciable deflection during the placing of the concrete.
- The inside surfaces of forms shall be cleaned of all dirt, mortar and foreign material. Forms which will later be removed shall be thoroughly coated with form oil prior to use. The form oil shall be a commercial quality form oil or other equivalent coating which will permit the ready release of the forms and will not discolor the concrete.
- Concrete shall not be deposited in the forms until all work connected with constructing the forms has been completed, all materials required to be embedded in the concrete have been placed for the unit to be poured, and the Engineer has inspected the forms and materials. This work shall include the removal of all dirt, chips, sawdust, water and other foreign material from the forms.
- The rate of depositing concrete in forms shall be controlled to prevent deflections of the forms or form panels in excess of the deflections permitted by these specifications.
- Forms for all concrete surfaces which will not be completely enclosed or hidden below the permanent ground surface shall conform to the requirements herein for forms for exposed surfaces. Interior surfaces of underground drainage structures shall be considered to be completely enclosed surfaces.
- Prior to the use of each forming system to be used for exposed surfaces and when requested by the Engineer, the Contractor shall furnish form design and materials data to the Engineer for approval in conformance with the provisions in Section 5-1.02, "Plans and Working Drawings."
- Forms for exposed concrete surfaces shall be designed and constructed so that the formed surface of the concrete does not undulate excessively in any direction between studs, joists, form stiffeners, form fasteners or wales. Undulations exceeding either $^{3}/_{32}$ inch or $^{1}/_{270}$ of the center to center distance between studs, joists, form stiffeners, form fasteners or wales will be considered to be excessive. Should any form or forming system, even though previously approved for use, produce a concrete surface with excessive undulations, its use shall be discontinued until modifications satisfactory to the Engineer have been made. Portions of

concrete structures with surface undulations in excess of the limits herein may be rejected by the Engineer.

- All exposed surfaces of each element of a concrete structure shall be formed with the same forming material or with materials which produce similar concrete surface textures, color and appearance.
- Forms for exposed surfaces shall be faced with form panels. A form panel shall be considered to be the continuous section of form facing material, unbroken by joint marks, against which the concrete is placed.
- Form panels for exposed surfaces shall be plywood conforming to or exceeding the requirements of U.S. Product Standard PS 1 for Exterior B-B (Concrete Form) Class I Plywood or any material which will produce a smooth uniform concrete surface substantially equal to that which would result from the use of that plywood. Only form panels in good condition free of defects, such as scars, dents or delaminations, shall be used for exposed surfaces.
- Form panels for exposed surfaces shall be furnished and placed in uniform widths of not less than 3 feet and in uniform lengths of not less than 6 feet, except at the end of continuously formed surfaces where the final panel length required is less than 3 feet. Where the width of the member formed is less than 3 feet the width of the panels shall be not less than the width of the member. Panels shall be arranged in symmetrical patterns conforming to the general lines of the structure. Except when otherwise provided herein or shown on the plans, panels for vertical surfaces shall be placed with the long dimension horizontal and with horizontal joints level and continuous. Form panels for curved surfaces of columns shall be continuous for a minimum of one quarter of the circumference, or 6 feet. For walls with sloping footings which do not abut other walls, panels may be placed with the long dimension parallel to the footing. Form panels on each side of the panel joint shall be precisely aligned, by means of supports or fasteners common to both panels, to result in a continuous unbroken concrete plane surface. When prefabricated soffit panels are used, form filler panels joining prefabricated panels shall have a uniform minimum width of one foot, and shall produce a smooth uniform surface with consistent longitudinal joint lines between the prefabricated panels.
- Forms for exposed surfaces shall be constructed with triangular fillets not less than $^3/_4$" x $^3/_4$" attached so as to prevent mortar runs and to produce smooth straight chamfers at all sharp edges of the concrete.
- Form fasteners consisting of form bolts, clamps or other devices shall be used as necessary to prevent spreading of the forms during concrete placement. The use of ties consisting of twisted wire loops to hold forms in position will not be permitted.
- Anchor devices may be cast into the concrete for later use in supporting forms or for lifting precast members. Driven types of anchorages shall not be used for fastening forms or form supports to concrete, except on interior surfaces of girders in prestressed box girder bridges where the following conditions are met:

A. Girders have more than 2 inches of cover over reinforcing.

B. Anchorages penetrate the girder a maximum of 2 inches and have a minimum spacing of 6 inches.
C. The anchorages are placed 3 inches clear, minimum, from edge of concrete.

- Form fasteners and anchors shall be of those types that can be removed as required for form bolts in Section 51-1.18A, "Ordinary Surface Finish," without chipping, spalling, heating or otherwise damaging the concrete surface.
- All forms shall be removed except as otherwise provided herein. Soffit forms for deck slabs of cast-in-place box girders, forms for the interior voids of precast members, and the forms in hollow abutments or piers may remain in place when no permanent access is available into the cells or voids, when utility facilities are not to be installed in completed cells or voids, or when the only utilities to be installed in completed cells or voids are to be inserted into casings which are placed prior to the completion of the cell or void. When permanent access is available into the cells or voids, or when utility facilities other than those in preplaced casings are to be installed in cells or voids, forms used to support the deck of cast-in-place box girders or to form the void of a precast member shall be removed except that, when the dimensions of the structure or member permit, the forms may remain in place providing the following conditions are met:

A. Any portions of the forms which obstruct access openings or conflict with utility facilities are removed;
B. A longitudinal crawl space not less than 3-feet high and 2-feet wide is provided throughout the length of all such cells or voids;
C. The forming system employed leaves no sharp projections into the cells or voids; and
D. All forms shall be removed between the hinge and 5 feet past the access openings in cells of cast-in-place box girder bridges that have access openings near hinges.

- Prior to the completion of forming for the deck of cast-in-place box girders or for the cells or voids of other members when the forms are to remain in place, or after the removal of the forms or portions of forms, the inside of the cells or voids shall be cleared of all loose material.
- Forms for drainage inlets may be constructed of any suitable material that will produce a structure with the inside dimensions and at least the wall thicknesses shown on the plans. Undulations of finished interior wall surfaces shall not exceed 1/2 inch. Outside forms shall extend at least 5 inches below the top of the inlet. Concrete may be deposited against excavated earth below this depth except that full depth outside forms or other protection shall be used whenever the instability of the earth or the Contractor's operations cause hazardous conditions or contamination of the concrete. Exterior forms shall be removed to not less than 5 inches below final ground surface. Exterior forms below this depth may remain in place if their total thickness does not exceed one inch.

- The removal of forms which do not support the dead load of concrete members, other than railings and barriers, shall not begin until at least 24 hours after the concrete for the member has been placed and until the concrete has sufficient strength to prevent damage to the surface.
- Forms for railings or barriers may be removed at the convenience of the Contractor after the concrete has hardened. The concrete surfaces exposed by removing forms shall be protected from damage.
- Temporary bumpers at the ends of bridges and grade top culverts shall be installed as shown on the plans, prior to backfilling within 3 feet of finished grade, and full compensation therefor shall be considered as included in the contract price paid per cubic yard for the concrete involved.

51-1.06 FALSEWORK

- The Contractor shall be responsible for designing and constructing safe and adequate falsework which provides the necessary rigidity, supports the loads imposed, and produces in the finished structure the lines and grades indicated on the plans.
- Approval by the Engineer of the falsework working drawings or falsework inspection performed by the Engineer will in no way relieve the Contractor of full responsibility for the falsework.

51-1.06A Falsework Design and Drawings

- The Contractor shall submit to the Engineer working drawings and design calculations for falsework proposed for use at bridges. For bridges where the height of any portion of the falsework, as measured from the ground line to the soffit of the superstructure, exceeds 14 feet, or where any individual falsework clear span length exceeds 16 feet, or where provision for vehicular, pedestrian, or railroad traffic through the falsework is made; the drawings shall be signed by an engineer who is registered as a Civil Engineer in the State of California. Six sets of the working drawings and 2 copies of the design calculations shall be furnished. Additional working drawings and design calculations shall be submitted to the Engineer when specified in "Railroad Relations and Insurance" of the special provisions.
- The falsework drawings shall include details of the falsework erection and removal operations showing the methods and sequences of erection and removal and the equipment to be used. The details of the falsework erection and removal operations shall demonstrate the stability of all or any portions of the falsework during all stages of the erection and removal operations.
- Attention is directed to Section 5-1.02, "Plans and Working Drawings."
- For falsework over railroads, approval by the Engineer of the falsework drawings will be contingent upon the drawings being satisfactory to the railroad company involved.
- Except for placement of foundation pads and piles, the construction of any unit of falsework shall not start until the Engineer has reviewed and approved the drawings for that unit.

- Except as otherwise provided in the special provisions, the Contractor shall allow 3 weeks after complete drawings and all support data are submitted for the review of any falsework plan.
- In the event that several falsework plans are submitted simultaneously, or an additional plan is submitted for review before the review of a previously submitted plan has been completed, the Contractor shall designate the sequence in which the plans are to be reviewed. In such event, the time to be provided for the review of any plan in the sequence shall be not less than the review time specified above for that plan, plus 2 weeks for each plan of higher priority which is still under review. A falsework plan submittal shall consist of plans for a single bridge or portion thereof. For multi-frame bridges, each frame shall require a separate falsework plan submittal.
- Should the Engineer fail to complete the review within the time allowance and if, in the opinion of the Engineer, the Contractor's controlling operation is delayed or interfered with by reason of the delay in falsework plan review, the delay will be considered a right of way delay as specified in Section 8-1.09, "Right of Way Delays."
- The Contractor may revise approved falsework drawings provided sufficient time is allowed for the Engineer's review and approval before construction is started on the revised portions. The additional time will not be more than that which was originally allowed.
- The falsework drawings shall include a superstructure placing diagram showing the concrete placing sequence and construction joint locations. When a schedule for placing concrete is shown on the contract plans, no deviation will be permitted.
- The maximum length of falsework spans used to support T-beam girder bridges shall not exceed 14 feet plus 8.5 times the depth of the T-beam girder.
- When footing type foundations are to be used, the Contractor shall determine the bearing value of the soil and shall show the values assumed in the design of the falsework on the falsework drawings.
- When pile type foundations are to be used, the falsework drawings shall show the maximum horizontal distance that the top of a falsework pile may be pulled in order to position the falsework pile under its cap. The falsework plans shall also show the maximum allowed deviation of the top of the pile, in its final position, from a vertical line through the point of fixity of the pile.
- For falsework piles with a calculated loading capacity greater than 100 tons, the falsework piles shall be designed by an engineer who is registered as either a Civil Engineer or a Geotechnical Engineer in the State of California, and the calculations shall be submitted to the Engineer.
- Anticipated total settlements of falsework and forms shall be shown on the falsework drawings. These should include falsework footing settlement and joint take-up. Anticipated settlements shall not exceed one inch. Falsework supporting deck slabs and overhangs on girder bridges shall be designed so that there will be no differential settlement between the girders and the deck forms during placement of deck concrete.

- Falsework footings shall be designed to carry the load imposed upon the footings without exceeding the estimated soil bearing values and anticipated settlements.
- Foundations for individual steel towers where the maximum leg load exceeds 30 kips shall be designed and constructed to provide uniform settlement under all legs of each tower under all loading conditions.
- The support systems for form panels supporting concrete deck slabs and overhangs on girder bridges shall also be considered to be falsework and designed as such.
- Temporary bracing shall be provided, as necessary, to withstand all imposed loads during erection, construction and removal of any falsework. The falsework drawings shall show provisions for the temporary bracing or methods to be used to conform to this requirement during each phase of erection and removal. Wind loads shall be included in the design of the bracing or methods
- The falsework design calculations shall show the stresses and deflections in load supporting members.
- The design of falsework will not be approved unless based on the use of loads and conditions which are no less severe than those described in Section 51-1.06A(1), "Design Loads," and on the use of stresses and deflections which are no greater than those described in Section 51-1.06A(2), "Design Stresses, Loadings, and Deflections." The Contractor is responsible for the proper evaluation of the falsework materials and design of the falsework to safely carry the actual loads imposed.
- If structural composite lumber is proposed for use, the falsework drawings shall clearly identify the structural composite lumber members by grade (E value), species, and type. The Contractor shall provide technical data from the manufacturer showing the tabulated working stress values of the composite lumber. The Contractor shall furnish a certificate of compliance as specified in Section 6-1.07, "Certificates of Compliance," for each delivery of structural composite lumber to the project site.

51-1.06A(1) Design Loads

- The design load for falsework shall consist of the sum of dead and live vertical loads, and an assumed horizontal load. The minimum total design load for any falsework, including members that support walkways, shall be not less than 100 psf for the combined live and dead load regardless of slab thickness.
- Dead loads shall include the loads due to the weight of concrete, reinforcing steel, forms and falsework. The loads due to the weight of concrete, reinforcing steel and forms shall be assumed to be not less than 160 pcf for normal concrete and not less than 130 pcf for lightweight concrete.
- Live loads shall consist of the actual load of any equipment to be supported by falsework applied as concentrated loads at the points of contact and a uniform load of not less than 20 psf applied over the area supported, plus 75 pounds per foot applied at the outside edge of deck overhangs.
- The assumed horizontal load to be resisted by the falsework bracing system shall be the sum of the actual horizontal loads due to equipment, construction sequence or other causes and an allowance for wind, but in no case shall the

assumed horizontal load to be resisted in any direction be less than 2 percent of the total dead load. The falsework shall be designed so that it will have sufficient rigidity to resist the assumed horizontal load without considering the load due to the concrete.

- The minimum horizontal load to be allowed for wind on heavy-duty steel shoring or steel pipe column falsework having a vertical load carrying capacity exceeding 30 kips per leg or column shall be the sum of the products of the wind impact area, shape factor, and applicable wind pressure value for each height zone. The wind impact area is the total projected area of all the elements in the tower face or falsework bent normal to the direction of the applied wind. The shape factor shall be taken as 2.2 for heavy-duty shoring and 1.0 for pipe column falsework. Wind pressure values shall be determined from the following table:

Height Zone (Feet above ground)	Wind Pressure Value	
	Shores or Columns Adjacent to Traffic	At Other Locations
	(psf)	(psf)
0-30	20	15
30-50	25	20
50-100	30	25
Over 100	35	30

- The minimum horizontal load to be allowed for wind on all other types of falsework, including falsework supported on heavy-duty shoring or pipe column falsework, shall be the sum of the products of the wind impact area and applicable wind pressure value for each height zone. The wind impact area is the gross projected area of the falsework and any unrestrained portion of the permanent structure, excluding the areas between falsework bents or towers where diagonal bracing is not used. Wind pressure values shall be determined from the following table:

Height Zone (Feet above ground)	Wind Pressure Value	
	For Members Over and Bents Adjacent to Traffic Opening	At Other Locations
	(psf)	(psf)
0-30	2.0 Q	1.5 Q
30-50	2.5 Q	2.0 Q
50-100	3.0 Q	2.5 Q
Over 100	3.5 Q	3.0 Q

Q = 1 + 0.2 W, but shall not be more than 10
W = width of the falsework system, in feet, measured in the direction of the wind force being considered

- The entire superstructure cross-section, except railing, shall be considered to be placed at one time except as provided herein. Girder stems and connected bottom slabs, if placed more than 5 days prior to the top slab, may be considered to be self supporting between falsework posts at the time the top slab is placed provided that

the distance between falsework posts does not exceed 4 times the depth of the portion of the girder placed in the first pour.

- In addition to the minimum requirements specified in this Section 51-1.06A, falsework for box girder structures with internal falsework bracing systems using flexible members capable of withstanding tensile forces only, shall be designed to include the vertical effects caused by the elongation of the flexible member and the design horizontal load combined with the dead and live loads imposed by concrete placement for the girder stems and connected bottom slabs. Falsework comprised of individual steel towers with bracing systems using flexible members capable of withstanding tensile forces only to resist overturning, shall be exempt from these additional requirements.
- If the concrete is to be prestressed, the falsework shall be designed to support any increased or readjusted loads caused by the prestressing forces.

51-1.06A(2) Design Stresses, Loadings, and Deflections

- The maximum allowable design stresses and loadings listed in this Section 51-1.06A(2) are based on the use of undamaged, high-quality materials and such stresses and loadings shall be reduced by the Contractor if lesser quality materials are to be used.
- The maximum allowable stresses, loadings and deflections used in the design of the falsework shall be as follows:

Timber:

Compression perpendicular to the grain	450 psi
Compression parallel to the grain	$480{,}000 \div (L/d)^2$ psi; not to exceed 1,600 psi
Flexural stress	1,800 psi; not to exceed 1,500 psi for members with a nominal depth of 8 inches or less.
Horizontal shear	140 psi
Axial tension	1,200 psi
Deflection due to concrete loading only	$^1/_{240}$ of the span, irrespective of deflection compensated for by camber strips
Modulus of elasticity (E)	1.6×10^6 psi
Timber piles	45 tons

L = unsupported length
d = least dimension of a square or rectangular column, or the width of a square of equivalent cross-sectional area for round columns

- Timber connections shall be designed in conformance with the procedures, stresses and loads permitted in the Falsework Manual as published by the Department of Transportation.

Steel:

- For identified grades of steel, design stresses, except stresses due to flexural compression, shall not exceed those specified in the Manual of Steel Construction as published by the AISC.

- When the grade of steel cannot be positively identified, design stresses, except stresses due to flexural compression, shall not exceed either those specified in the AISC Manual for ASTM Designation: A 36/A 36M steel or the following:

Tension, axial and flexural	22,000 psi
Compression, axial	$16{,}000-0.38(L/r)^2$ psi; except L/r shall not exceed 120
Shear on gross section of web of rolled shapes	14,500 psi
Web crippling for rolled shapes	27,000 psi

- For all grades of steel, design stresses and deflections shall not exceed the following:

Compression, flexural	$\frac{12{,}000{,}000}{Ld/bt}$ psi* *but not to exceed 22,000 psi for unidentified steel or steel conforming to the requirements in ASTM Designation: A 36/A 36M nor $0.6F_y$ for other identified steel.
Deflection due to concrete loading only	$^1/_{240}$ of the span, irrespective of deflection compensated for by camber strips

- In the foregoing formulas, L is the unsupported length; d is the least dimension of rectangular columns, or the width of a square of equivalent cross-sectional area for round columns, or the depth of beams; b is the width and t is the thickness of the compression flange; and r is the radius of gyration of the member. All dimensions are expressed in inches. F_y is the specified minimum yield stress, psi, for the grade of steel used.
- The modulus of elasticity (E) used for steel shall be 30×10^6 psi.

Manufactured Assemblies:

- The maximum loadings and deflections used on jacks, brackets, columns, joists and other manufactured devices shall not exceed the manufacturer's recommendations except that the dead load deflection of the joists used at locations other than under deck slabs between girders shall not exceed $^1/_{240}$ of their spans. If requested by the Engineer, the Contractor shall furnish engineering data from the manufacturer verifying the manufacturer's recommendations or shall perform tests as necessary to demonstrate the adequacy of the devices proposed for use.

51-1.06A(3) Special Locations

- In addition to the minimum requirements specified in this Section 51-1.06A, falsework over or adjacent to roadways or railroads which are open to traffic shall be designed and constructed so that the falsework will be stable if subjected to impact by vehicles. Falsework posts which support members that cross over a roadway or railroad shall be considered as adjacent to roadways or railroads. Other falsework posts shall be considered as adjacent to roadways or railroads only if they are located in the row of falsework posts nearest to the roadway or railroad and the horizontal distance from the traffic side of the falsework to the edge of pavement, or to a point 10 feet from the centerline of track, is less than the total

height of the falsework and forms. The Contractor shall provide any additional features for the work needed to ensure that falsework will be stable if subjected to impact by vehicles and to comply with the provisions in Section 7-1.09, "Public Safety." The falsework design at these locations shall include, but not be limited to, the following minimum provisions:

A. The vertical load used for the design of falsework posts and towers, but not footings, which support the portion of the falsework over openings, shall be the greater of the following:

   1. 150 percent of the design load calculated in conformance with the provisions for design load previously specified but not including any increased or readjusted loads caused by the prestressing forces, or
   2. the increased or readjusted loads caused by the prestressing forces.

B. Falsework posts adjacent to roadways or railroads shall consist of either steel with a minimum section modulus about each axis of 9.5 inches cubed or sound timbers with a minimum section modulus about each axis of 250 inches cubed.

C. Each falsework post adjacent to roadways or railroads shall be mechanically connected to its supporting footing at its base, or otherwise laterally restrained, so as to withstand a force of not less than 2,000 pounds applied at the base of the post in any direction except toward the roadway or railroad track. The posts also shall be mechanically connected to the falsework cap or stringer. The mechanical connection shall be capable of resisting a load in any horizontal direction of not less than 1,000 pounds.

D. For falsework spans over roadways, all exterior falsework stringers and stringers adjacent to the ends of discontinuous caps, the stringer or stringers over points of minimum vertical clearance and every fifth remaining stringer, shall be mechanically connected to the falsework cap or framing. The mechanical connections shall be capable of resisting a load in any direction, including uplift on the stringer, of not less than 500 pounds. The connections shall be installed before traffic is allowed to pass beneath the span. For falsework spans over railroads, all falsework stringers shall be so connected to caps.

E. When timber members are used to brace falsework bents which are located adjacent to roadways or railroads, all connections for the timber bracing shall be of the bolted type using $^{5}/_{8}$ inch diameter or larger bolts.

F. The falsework shall be located so that falsework footings or piles are at least 3 inches clear of railing posts and barriers and all other falsework members are at least one foot clear of railing members and barriers.

G. Falsework bents within 20 feet of the center line of a railroad track shall be sheathed solid in the area between 3 feet and 17 feet above the track elevation on the side facing the track. Sheathing shall consist of plywood not less than $^{5}/_{8}$ inch thick or lumber not less than $^{3}/_{4}$ inch thick. Bracing

on these bents shall be adequate so that the bent will resist the required assumed horizontal load or 5,000 pounds whichever is greater.

H. The dimensions of the clear openings to be provided through falsework for roadways shall be as specified in "Maintaining Traffic," of the special provisions.

I. The dimensions of clear openings to be provided through the falsework for railroads shall be as specified in "Railroad Relations and Insurance," of the special provisions.

51-1.06B Falsework Construction

- The falsework shall be constructed to substantially conform to the falsework drawings. The materials used in the falsework construction shall be of the quality necessary to sustain the stresses required by the falsework design. When manufactured assemblies are used in falsework, the Contractor shall furnish to the Engineer a letter of certification which certifies that all components of the manufactured assemblies are used in conformance with the manufacturer's recommendations. The workmanship used in falsework construction shall be of the quality that the falsework will support the loads imposed on the falsework without excessive settlement or take-up beyond that shown on the falsework drawings.
- Falsework shall be founded on a solid footing safe against undermining, protected from softening, and capable of supporting the loads imposed on the falsework. When requested by the Engineer, the Contractor shall demonstrate by suitable load tests that the soil bearing values assumed for the design of the falsework do not exceed the supporting capacity of the soil.
- When falsework is supported on piles, the piles shall be driven and the actual nominal resistance assessed in conformance with the provisions in Section 49, "Piling."
- For falsework piles with a calculated nominal resistance greater than 200 tons, the Contractor shall conduct dynamic monitoring of pile driving and generate field acceptance criteria based on a wave equation analysis. These analyses shall be signed by an engineer who is registered as a Civil Engineer in the State of California and submitted to the Engineer prior to completion of falsework erection.
- Prior to the placement of falsework members above the stringers, the final bracing system for the falsework shall be installed.
- When falsework is over or adjacent to roadways or railroads, all details of the falsework system which contribute to horizontal stability and resistance to impact, except for bolts in bracing, shall be installed at the time each element of the falsework is erected and shall remain in place until the falsework is removed.
- Temporary railing (Type K), conforming to the provisions in Section 12-3, "Traffic-Handling Equipment and Devices," shall be installed on both sides of all vehicular openings through falsework and, when ordered by the Engineer, at all other falsework less than 12 feet from the edge of a traffic lane. Temporary railings shall begin approximately 150 feet in advance of the falsework and shall extend past the falsework, in the direction of adjacent traffic flow. For 2-way traffic openings, the temporary railing shall extend at least 60 feet past the falsework, in the direction of adjacent traffic flow. The location and length of railing and the type of flare to be used shall be as ordered by the Engineer. The clear vehicular

opening between temporary railings shall be not less than that specified in the special provisions.

- The installation of temporary railing shall be complete before falsework erection is begun. Temporary railing at falsework shall not be removed until the removal is approved by the Engineer.
- Temporary railing (Type K) installed as specified above will be measured and paid for as provided in Section 12-4, "Measurement and Payment," except that when the Engineer's Estimate does not include a contract item for temporary railing (Type K), full compensation for furnishing, placing, maintaining, repairing, replacing and removing the temporary railing at falsework locations as specified in this Section 51-1.06B shall be considered as included in the contract prices paid for the various items of work requiring falsework and no separate payment will be made therefor.
- Camber strips shall be used where directed by the Engineer to compensate for falsework deflection, vertical alignment and anticipated structure deflection. The Engineer will furnish to the Contractor the amount of camber to be used in constructing the falsework.
- The Contractor shall provide tell-tales attached to the soffit forms and readable from the ground in enough systematically placed locations to determine the total settlement of the entire portion of the structure where concrete is being placed.
- Deck slab forms between girders shall be constructed with no allowance for settlement relative to the girders.
- Dead loads, other than those due to forms and reinforcing steel, shall not be applied to any falsework until authorized by the Engineer.
- Should unanticipated events occur, including settlements that deviate more than $\pm 3/8$ inch from those indicated on the falsework drawings, which in the opinion of the Engineer would prevent obtaining a structure conforming to the requirements of these specifications, the placing of concrete shall be discontinued until corrective measures satisfactory to the Engineer are provided. In the event satisfactory measures are not provided prior to initial set of the concrete in the affected area, the placing of concrete shall be discontinued at a location determined by the Engineer. All unacceptable concrete shall be removed.

51-1.06C Removing Falsework

- The falsework removal operation shall be conducted in such a manner that any portion of the falsework not yet removed remains in a stable condition at all times.
- Falsework supporting any span of a simple span bridge shall not be released before 10 days after the last concrete, excluding concrete above the bridge deck, has been placed. Unless otherwise permitted by the Engineer, falsework supporting any span of a continuous or rigid frame bridge shall not be released before 10 days after the last concrete, excluding concrete above the bridge deck, has been placed in that span and in the adjacent portions of each adjoining span for a length equal to at least one-half the length of the span where falsework is to be released.
- Falsework for cast-in-place prestressed portions of structures shall not be released until after the prestressing steel has been tensioned.
- Falsework supporting any span of a continuous or rigid frame bridge shall not be removed until all required prestressing has been completed in that span and in

the adjacent portions of each adjoining span for a length equal to at least one-half the length of the span where falsework is to be released.

- Falsework for arch bridges shall be removed uniformly and gradually, beginning at the crown and working toward the springing, to permit the arch to take its load slowly and evenly. Falsework for adjacent arch spans shall be struck simultaneously.
- Falsework supporting overhangs, deck slabs between girders and girder stems which slope 45 degrees or more off vertical shall not be released before 7 days after the deck concrete has been placed.
- Falsework supporting the sides of the girder stems which slope less than 45 degrees off vertical may be removed prior to placing deck slab concrete, providing a reshoring system is installed. The reshoring system shall consist of lateral supports which are designed to resist all rotational forces acting on the stem, including those caused by the placement of deck slab concrete. The lateral supports shall be installed immediately after each form panel is removed and prior to the release of supports for the adjacent form panel.
- Falsework for bent caps which will support steel or precast concrete girders shall not be released before 7 days after the cap concrete has been placed. Girders shall not be erected onto the bent caps until the concrete in the cap has attained a compressive strength of 2,600 psi or 80 percent of the specified strength, whichever is higher.
- Unless otherwise specified, removing falsework supporting any span of structural members subject to bending, shall conform to the requirements for removing falsework supporting any span of a simple span bridge.
- In addition to the above requirements, no falsework for bridge spans shall be released until the supported concrete has attained a compressive strength of 2,600 psi or 80 percent of the specified strength, whichever is higher.
- Falsework for box culverts and other structures with decks lower than the roadway pavement and with span lengths of 14 feet or less shall not be released until the last placed concrete has attained a compressive strength of 1,500 psi, provided that curing of the concrete is not interrupted. Falsework removal for other box culverts shall conform to the requirements for release of bridge falsework.
- Falsework for arch culverts shall not be released before 40 hours after the supported concrete has been placed.
- All falsework materials shall be completely removed. Falsework piling shall be removed at least 2 feet below the surface of the original ground or original streambed. When falsework piling is driven within the limits of ditch or channel excavation areas, the falsework piling within those areas shall be removed to at least 2 feet below the bottom and side slopes of the excavated areas.
- All debris and refuse resulting from the work shall be removed and the premises left in a neat and presentable condition.

51-1.07 REINFORCEMENT

- Reinforcement shall conform to the provisions in Section 52, "Reinforcement."

51-1.08 PRESTRESSING

Prestressing shall conform to the provisions in Section 50, "Prestressing Concrete."

51-1.09 PLACING CONCRETE

Concrete shall be placed and consolidated by methods that will not cause segregation of the aggregates and will result in a dense homogeneous concrete which is free of voids and rock pockets. Concrete shall be placed while fresh and before it has taken an initial set. Retempering any partially hardened concrete with additional water will not be permitted.

Forms and subgrade shall be thoroughly moistened with water immediately before placing concrete.

Concrete shall be placed as nearly as possible in its final position and the use of vibrators for extensive shifting of the mass of fresh concrete will not be permitted. Except for concrete used in cast-in-place piles, fresh concrete shall not be permitted to fall from a height greater than 8 feet without the use of adjustable-length pipes, tubes or double belting placed to prevent segregation of the concrete. Double belting shall not be used unless the thickness of the member is less than 16 inches.

With the exception of concrete placed as pipe culvert headwalls and endwalls, slope paving and aprons, and concrete placed under water, concrete shall be consolidated by means of high frequency internal vibrators within 15 minutes after the concrete is deposited in the forms. The vibrators shall not be attached to or held against the forms or the reinforcing steel. The vibrating shall be done with care and in such manner that displacement of reinforcement, ducts and prestressing steel is avoided.

After placing, consolidating and initial screeding of concrete for structure footings, more than 2.5 feet in vertical dimension and with a top layer of reinforcement, the concrete shall be reconsolidated by the use of internal vibrators for a depth of one foot from the top of the footing and finished. Reconsolidation shall be accomplished as late as the concrete will again respond to vibration, but not less than 15 minutes after the initial screeding has been completed.

Vibrators used to consolidate concrete containing epoxy-coated bar reinforcement or epoxy-coated prestressing steel shall have a resilient covering to prevent damage to the epoxy-coating on the reinforcement or prestressing steel.

When concrete is inaccessible for adequate consolidation by other means, external vibrators shall be used and the forms shall be sufficiently rigid to resist displacement or damage.

Concrete for horizontal members or sections shall not be placed until the concrete in the supporting vertical members or sections has been consolidated and settlement due to bleeding has occurred.

Only concrete that is designated as seal course concrete may be placed under water.

51-1.10 CONCRETE DEPOSITED UNDER WATER

If conditions render it impossible or inadvisable in the opinion of the Engineer to dewater excavations before placing concrete, the Contractor shall deposit under

water, by means of a tremie or a concrete pump, a seal course of concrete of sufficient thickness to thoroughly seal the cofferdam. The concrete shall be carefully placed in a compact mass and shall not be disturbed after being deposited. Still water shall be maintained at the point of deposit.

- A tremie shall consist of a watertight tube having a diameter of not less than 10 inches with a hopper at the top. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping the discharge end in the deposited concrete.
- Concrete pump discharge tubes and tremie tubes used to deposit concrete under water shall be equipped with a device that will prevent water from entering the tube while charging the tube with concrete. The tubes shall be supported so as to permit free movement of the discharge end over the entire top surface of the work and to permit rapid lowering, when necessary to retard or stop the flow of concrete. The tubes shall be filled by a method that will prevent washing of the concrete. The discharge end shall be completely submerged in concrete at all times and the tube shall contain sufficient concrete to prevent any water entry. The flow shall be continuous until the work is completed, and the resulting concrete seal shall be monolithic and homogeneous.
- The exact thickness of the seal will depend upon the hydrostatic head, bond and spacing of piles, size of cofferdam, and other related factors, but in no case shall the seal be less than 2 feet in thickness, unless otherwise shown on the plans. Before dewatering, the concrete in the seal shall be allowed to cure for not less than 5 days after placing.
- If a seal which is to withstand hydrostatic pressure is placed in water having a temperature below 45° F, the curing time before dewatering shall be increased. Periods of time during which the temperature of the water has been continuously below 38° F shall not be considered as curing time. After sufficient time has elapsed to ensure adequate strength in the concrete seal, the cofferdam shall be dewatered and the top of the concrete cleaned of all scum, laitance and sediment. Before fresh concrete is deposited, local high spots shall be removed as necessary to provide proper clearance for reinforcing steel.

51-1.11 CONSTRUCTION METHODS

- The concrete in each integral part of the structure shall be placed continuously, and the Contractor will not be allowed to commence work on any integral part unless sufficient material for the concrete is on hand, and the Contractor's forces and equipment are sufficient to complete the part without interruption in the placing of the concrete.
- Joints in the concrete due to stopping work shall be avoided as far as possible, and when necessary, shall be constructed as directed by the Engineer.
- At locations shown on the plans, a bond breaking compound consisting of commercial quality asphalt base roofing emulsion approximately $^1/_{16}$ inch thick shall be applied to joint surfaces, except when a different compound is shown or specified.
- Concrete for girder spans shall be placed in not less than 2 operations, and the last operation shall consist of placing the top deck slab. At least 5 days shall elapse between each operation, unless otherwise permitted by the Engineer.

- Longitudinal construction joints in the bridge decks, if used, shall be located along the lane lines, unless otherwise shown on the plans or permitted by the Engineer.
- Construction methods and equipment employed by the Contractor shall conform to the provisions in Section 7-1.02, "Load Limitations," and the following:

> Loads imposed on existing, new or partially completed structures shall not exceed the load carrying capacity of the structure, or portion of structure, as determined by the Load Factor Design methods of AASHTO using Load Group IB. The compressive strength of concrete (f'_c) to be used in computing the load carrying capacity shall be the actual compressive strength at the time of loading, the value of f'_c shown on the plans for that portion of the structure, or 2.5 times the value of f_c shown on the plans for portions of the structure where no f'_c is given, whichever is smaller.

- Vehicles with a weight in excess of 1,000 pounds will not be allowed on any span until after the concrete in the span has attained a compressive strength of at least 2,400 psi. Vehicles with a weight in excess of 4,000 pounds will not be allowed on any span until after the concrete in the span has attained a compressive strength of at least 3,250 psi or has attained an age of 28 days, whichever occurs first. Vehicles which exceed the weight limitations set forth in Division 15 of the Vehicle Code and which can be allowed to cross bridge decks under the provisions in Section 7-1.02, "Load Limitations," will not be allowed to make repetitive crossings of any span until the concrete in the span has attained an age of 28 days. In addition, for prestressed structures, vehicles whose gross weight exceeds 10,000 pounds will not be allowed on any span until the prestressing steel for that span has been tensioned.
- Elements of structures which are not designated as precast members may be precast if approved by the Engineer. When precasting is proposed and when requested by the Engineer, the Contractor shall submit working drawings in conformance with the provisions in Section 5-1.02, "Plans and Working Drawings," showing construction joint details, foundation bedding, and other information required by the Engineer.
- Where pipes outside the structure join the structure, suitable bell recesses shall be cast in the concrete to receive the pipe, or sections of the pipe shall be cast in the concrete. When bell recesses are used, the end of the pipe shall be mortared into the bell.
- Precast prestressed concrete bridge members may be built by segmental construction in lieu of the full length members as shown on the plans, at the option of the Contractor. Additional details showing the construction joints, the concrete form and casting details, the arrangement of bar reinforcing steel, the arrangement of prestressing tendons and pressure grouting pipes, the materials and methods for making closures, the construction joint keys and surface treatment, and any other information required by the Engineer shall be included on the working drawings specified in Section 50-1.02, "Drawings," and shall be submitted to the Engineer

for approval. For exterior girders, the materials used in the construction joints shall match the color and texture of the adjoining concrete.

- Precast prestressed concrete girders and precast prestressed concrete deck units will be inspected at the fabrication site. The Contractor shall notify the Engineer when materials have been delivered to the fabrication site and shall give the Engineer at least 10 days' notice after delivery before commencing the fabrication of the precast prestressed concrete members. Materials to be used shall be made available to the Engineer so they can be examined. The Engineer shall have free access at all times to any portion of the fabrication site where the material is stored or where work on the material is being performed.
- The slip form method will be permitted for the construction of the pier shafts, provided: (1) the results are equal in all respects to those obtained by conformance with the requirements of these specifications and (2) that adequate arrangements are made and carried out for curing, finishing and protecting the concrete.
- At piers where slip forms are used, the line and grade furnished by the Engineer as provided in Section 5-1.07, "Lines and Grades," will be limited to the establishing of control points and the occasional checking of the position of the slip form. The Contractor shall be wholly responsible for constructing the piers true to line and grade and shall do all work necessary to correctly position the slip form. The Contractor shall provide targets, markers or other suitable devices necessary to enable the Engineer at all times to accurately determine the position of the pier shaft.
- At the option of the Contractor, the warped portions of wingwalls at the ends of culverts, as shown on the plans, may be constructed of shotcrete conforming to the provisions in Section 53, "Shotcrete," in lieu of Class 2 portland cement concrete. For payment, the shotcrete will be considered as cast-in-place Class 2 concrete.

51-1.115 PRECAST MEMBERS

- Precast concrete members shall be placed in the structure in conformance with the plans and special provisions for the structure to be constructed. Extreme care shall be exercised in handling, storing, moving and erecting precast reinforced or prestressed concrete members to avoid twisting, racking or other distortion that would result in cracking or damage to the members. Precast members shall be handled, transported and erected in an upright position and the points of support and directions of the reactions with respect to the member shall be approximately the same as when the member is in its final position.
- Bearing plates, threaded inserts, and other fittings shall conform to the provisions in Section 75-1.03, "Miscellaneous Bridge Metal."
- Precast concrete piling shall be placed in conformance with the provisions for concrete piling in Section 49, "Piling."

51-1.12 EXPANSION AND FIXED JOINTS AND BEARINGS

- Joints shall be constructed in conformance with the details shown on the plans and the following requirements:

51-1.12A Open Joints

Open joints shall be constructed at the locations shown on the plans using a suitable material, which is subsequently removed. When removing the material, care shall be exercised to avoid chipping or breaking the corners of the concrete. The edges of the concrete, at the joints, shall be edger finished. Reinforcement shall not extend across an open joint, unless otherwise shown on the plans.

51-1.12B Filled Joints

When premolded joint filler or expanded polystyrene joint filler is shown on the plans or specified, the filler shall be placed in correct position before concrete is placed against the filler. Holes and joints in the filler shall be filled with mastic to prevent the passage of mortar or concrete from one side of the joint to the other. The edges of the concrete, at the joints, shall be edger finished. When shown on the plans, waterstops shall be placed.

51-1.12C Premolded Expansion Joint Fillers

Unless otherwise provided in the special provisions, premolded joint filler shall conform to the requirements in ASTM Designation: D 1751.

51-1.12D Sheet Packing, Preformed Pads and Board Fillers

Asbestos sheet packing and preformed fabric pads shall conform to the provisions in Section 55-2.05, "Asbestos Sheet Packing," and Section 55-2.04, "Bearing Pads," respectively.

Where asbestos sheet packing is shown on the plans to be placed in joints in the concrete, the bottom layer of the packing shall be firmly attached to the concrete using waterproof cement.

Tempered hardboard shall conform to Federal Specification LLL-B-810, Type II, smooth one side, plain. Hardboard shall be 1/8 inch minimum thickness, unless shown or specified otherwise.

Expanded polystyrene shall be a commercially available polystyrene board. Expanded polystyrene shall have a flexural strength of 35 psi, minimum, determined in conformance with the requirements in ASTM Designation: C 203, and a compressive yield strength of between 16 psi and 40 psi, at 5 percent compression. Surfaces of expanded polystyrene against which concrete is placed shall be faced with hardboard. Hardboard shall be 1/8 inch minimum thickness, conforming to Federal Specification LLL-B-810, any type. Other facing materials may be used provided they furnish equivalent protection. Boards shall be held in place by nails, waterproof adhesive or other means approved by the Engineer.

51-1.12E Expansion Joint Armor

Expansion joint armor shall be fabricated from steel plates, angles or other structural shapes in conformance with the provisions in Section 75, "Miscellaneous Metal," shall be accurately shaped to the section of the concrete deck and shall be match-marked in the shop. Warped sections shall be straightened before placing. Positive methods shall be employed in placing the assemblies to keep them in correct position during the placing of concrete. The opening of the joints at the time of placing shall be that shown on the plans adjusted for temperature. Care shall be taken to avoid impairment of the clearance in any manner.

51-1.12F Sealed Joints

- Where shown on the plans, joints in structures shall be sealed with joint seals, joint seal assemblies, or seismic joints in conformance with the details shown on the plans, the provisions in these specifications, and the special provisions.
- The opening of the joints at the time of placing shall be that shown on the plans adjusted for temperature. Care shall be taken to avoid impairment of the clearance in any manner.
- Type A and AL joint seals shall consist of a groove in the concrete which is filled with field mixed and placed polyurethane or silicone sealant.
- Type B joint seals shall consist of a groove in the concrete which is filled with a preformed elastomeric joint seal.
- Joint seal assemblies and seismic joints shall consist of metal or metal and elastomeric assemblies which are anchored or cast into a recess in the concrete over the joint. Strip seal joint seal assemblies consist of only one joint cell. Modular unit joint seal assemblies consist of more than one joint cell.
- The Movement Rating (MR) shall be measured normal to the longitudinal axis of the joint. The type of seal to be used for the MR shown on the plans shall be as follows:

Movement Rating (MR)	Seal Type
MR ≤ $^1/_2$ inch	Type A or Type B
$^1/_2$ inch < MR ≤ one inch	Type A (silicone only) or Type B
one inch < MR ≤ 2 inches	Type B
2 inches < MR ≤ 4 inches	Joint Seal Assembly (Strip Seal)
MR > 4 inches	Joint Seal Assembly (Modular Unit) or Seismic Joint

- Sealed joints shall comply with the following requirements:

  A. The seal shall be in planned position.
  B. The seal shall satisfactorily resist the intrusion of foreign material and water.
  C. The seal shall provide bump free passage of traffic.

- Joints to be sealed shall be covered or otherwise protected at all times prior to installing joint seals to prevent debris and other foreign material from entering the joint.

51-1.12F(1) Preparation for Type A and B Joint Seals

- Grooves for joint seals shall be saw cut to a uniform width and depth and to the alignment shown on the plans or as ordered by the Engineer. Concrete saws for cutting grooves shall be fitted with diamond blades having a core (disk) thickness of not less than $^3/_{16}$ inch. Both sides of the groove shall be cut simultaneously for a minimum first pass depth of 2 inches. The completed groove shall have a top width within $^1/_8$ inch of the width shown on the plans or ordered by the Engineer,

and the bottom width shall not vary from the top width by more than $^{1}/_{16}$ inch for each 2 inches of depth.

- Saw cutting of grooves shall not be started until joint seal material has been tested, approved and delivered to the jobsite.
- Saw cutting of grooves in existing decks shall include the cutting of conflicting bar reinforcing steel, whether or not the bar reinforcing steel is shown on the plans.
- Saw cutting of grooves will not be required at the following locations:

  A. Joints armored with steel or other metal.
  B. Joints in curbs, sidewalks, barriers and railings, provided that the grooves are formed to uniform dimensions matching the saw cut grooves in the deck.

- Prior to sealing joints, expanded polystyrene, hardboard, concrete spillage and all foreign material shall be removed from the deck joint to the bottom of the saw cut for Type A seals, and to the top of the waterstop or depth of seal plus 3 inches for Type B seals. These materials shall be removed entirely from joints in curbs, sidewalks, barriers, railings and the overhanging portion of deck slabs.
- At least 64 hours prior to installing the joint seal, the Contractor shall repair all spalls, fractures, breaks or voids in the concrete surfaces of the joint groove.
- The lip of the saw cut shall be beveled by grinding as shown on the plans.
- Immediately prior to placing the seal, the joints shall be cleaned by a method that shall include abrasive blast cleaning and then be cleaned with high pressure air jets to remove all residue and foreign material. Waterstops shall be protected from the abrasive blast.
- Joint surfaces shall be surface dry at the time the seal is placed.

51-1.12F(2) Preparation for Type AL Joint Seals

- Prior to sealing joints, expanded polystyrene and all foreign material shall be removed to a depth of the joint seal.
- The lip of the joint shall be ground or edged as shown on the plans.
- Immediately prior to placing the seal, the joints shall be cleaned by a method that shall include abrasive blast cleaning followed by high pressure air jets to remove all foreign material.
- Joint surfaces shall be surface dry at the time the seal is placed.

51-1.12F(3) Materials and Installation

(a) Type A and AL Seal

- The sealant shall consist of a 2 component polyurethane sealant, which will withstand up to ±25 percent movement, or a 2 component silicone sealant, which will withstand up to ±50 percent movement.
- Polyurethane and silicone sealants shall be tested in conformance with the requirements in California Test 435. The sealants shall conform to State Specification 8030-61J-01 and the following requirements:

Specification	Requirement
Modulus at 150 percent elongation	35-520 kPa
Width of sealant after 7 days extension and one hour recovery	17 mm, max.
Condition 24 hours after notching	Notched or loss of bond 6 mm, max.
Condition of water immersed specimen at 7 days	Notched or loss of bond 6 mm, max.
Condition of specimen when tested in conformance with the requirements in ASTM Designation: G 154 using FS 40 UV-B bulbs for a minimum of 25 cycles. The cycle shall be 4 hours UV exposure at 60°C. and 4 hours condensate exposure at 40°C.	No more than slight checking or cracking.
Grease cone penetration	4.5 - 12.0 mm

- State Specifications for polyurethane and silicone sealants may be obtained from the Transportation Laboratory.
- The sealant shall be self-leveling but cure rapidly enough to avoid flow after application on grades up to 15 percent.
- No material shall be used which has skinned over or which has settled in the container to the extent that the material cannot be easily redispersed by hand stirring to form a smooth uniform product.
- Each container shall be clearly labeled or each delivery of material in the tanks of 2-component equipment shall be accompanied with a ticket showing designation (Component A or B), the manufacturer's name, lot or batch number, date of manufacture, date of packaging, date, if any, beyond which the sealant shall not be used without additional testing and approval, and manufacturer's instructions for use.
- Polyethylene foam or rod stock shall be commercial quality, with a continuous, impervious, glazed surface, suitable for retaining the liquid sealant in the joint while hardening.
- A primer, recommended by the manufacturer of the sealant, shall be applied to the sides of the groove and to exposed vertical surfaces in the joint prior to placing the sealant. The primer shall be dry at time of placing the sealant. Contaminated primer shall be removed and replaced.
- The sealant shall be mixed and placed with equipment which accurately proportions and mixes the 2 components and extrudes the mixed material into the joint. The equipment shall be of a type approved by the manufacturer of the sealant and the manufacturer's instructions shall be followed. Unmixed liquid components which have been exposed to the atmosphere for more than 24 hours, shall not be used.
- A Certificate of Compliance, accompanied by a certified test report, shall be furnished for each batch of polyurethane and silicone sealant in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."
- Samples of the 2 components, not less than one quart each, from each batch of sealant shall be submitted to the Transportation Laboratory. In addition, samples of manufacturer required primers, not less than one quart each, shall be submitted.

The samples shall be furnished for testing, with the Certificate of Compliance, 30 days in advance of proposed use.

(b) Type B Seal

- The sealant shall consist of a prefabricated preformed elastomeric joint seal installed in a prepared groove with a combination lubricant-adhesive.
- The preformed elastomeric joint seal shall conform to the requirements in ASTM Designation: D 2628 and the following:

A. The seal shall consist of a multi-channel, nonporous, homogeneous material furnished in a finished extruded form.
B. The minimum depth of the seal, measured at the contact surface, shall be at least 95 percent of the minimum uncompressed width of the seal as designated by the manufacturer.
C. When tested in conformance with the requirements in California Test 673 for Type B seals, joint seals shall provide a Movement Rating (MR) of not less than that shown on the plans.
D. The top and bottom edges of the joint seal shall maintain continuous contact with the sides of the groove over the entire range of joint movement.
E. The seal shall be furnished full length for each joint with no more than one shop splice in any 60-foot length of seal.
F. The Contractor shall demonstrate the adequacy of the procedures to be used in the work before installing seals in the joints.
G. Shop splices and field splices shall have no visible offset of exterior surfaces, and shall show no evidence of bond failure.
H. At all open ends of the seal that would admit water or debris, each cell shall be filled to a depth of 3 inches with commercial quality open cell polyurethane foam, or closed by other means subject to approval by the Engineer.

- The combination lubricant-adhesive shall conform to the requirements in ASTM Designation: D 4070. No material shall be used which has skinned over or which has settled in the container to the extent that it cannot be easily redispersed by hand stirring to form a smooth uniform product.
- Lubricant-adhesive shall be mixed and applied in conformance with directions furnished by the manufacturer.
- The contact surfaces and the top surface area of the seal within $^1/_2$ inch from either edge shall be thoroughly cleaned of all dirt, oil and other deleterious material just prior to applying the lubricant-adhesive.
- The lubricant-adhesive shall be liberally applied to the sides of the seal and vertical surfaces of the groove immediately prior to installation.
- The joint seal shall be installed full length for each joint with equipment which shall not twist or distort the seal, elongate the seal longitudinally, or otherwise cause damage to the seal or to the concrete forming the groove. Field splices shall not be used.
- The top edges of the seal shall be in a plane normal to the sides of the groove.

- A Certificate of Compliance, accompanied by a certified test report, shall be furnished for each lot of preformed elastomeric joint seal and lubricant-adhesive in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."
- The certified test report for the preformed elastomeric joint seal shall include the Movement Rating of the seal, the manufacturer's designated minimum uncompressed width and the test results of the manufacturer or an independent testing agency.
- Samples of the prefabricated joint seals, not less than 39 inches in length, will be taken by the Engineer from each lot of material. Samples of the prefabricated joint seals and the lubricant-adhesive will be selected at random from stock at the jobsite or at a location acceptable to the Engineer and the manufacturer. The samples shall be furnished for testing, with the Certificate of Compliance, 30 days in advance of proposed use.

(c) Joint Seal Assemblies and Seismic Joints

- Joint seal assemblies and seismic joints shall be furnished and installed in joints in bridge decks as shown on the plans and as specified in the special provisions.

51-1.12G Bearing Devices

- Bearing plates, bars, rockers, assemblies and other expansion or fixed devices shall be constructed in conformance with the details shown on the plans and shall be hot-dip galvanized after fabrication. Structural steel, cast steel and galvanizing shall conform to the provisions in Section 75, "Miscellaneous Metal," for those items.
- The bearing plates shall be set level, and the rockers or other expansion devices shall be set to conform to the temperature at the time of erection or to the setting specified.
- When bearing assemblies or masonry plates are shown on the plans to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade and shall be finished by grinding or other approved means to a true level plane which shall not vary perceptibly from a straightedge placed in any direction across the area. The finished plane shall not vary more than $^1/_8$ inch from the elevation shown on the plans.
- When elastomeric bearing pads, preformed fabric pads or asbestos sheet packing are shown on the plans, the concrete surfaces on which pads or packing are to be placed shall be wood float finished to a level plane which shall not vary more than $^1/_{16}$ inch from a straightedge placed in any direction across the area. The area shall extend at least one inch beyond the limits of the pads or packing. The finished plane shall not vary more than $^1/_8$ inch from the elevation shown on the plans.
- Where bearing assemblies or masonry plates are shown on the plans to be placed on mortar pads, they shall be placed in conformance with the provisions in Section 55-3.19, "Bearings and Anchorages."

51-1.12H Elastomeric Bearing Pads

- Elastomeric bearing pads shall conform to the provisions in these specifications and the special provisions.
- Pads 1/2 inch or less in thickness shall conform to the provisions in Section 51-1.12H(1), "Plain and Fabric Reinforced Elastomeric Bearing Pads." At the Contractor's option, pads over 1/2 inch in thickness shall conform to either the provisions in Section 51-1.12H(1) or to the provisions in Section 51-1.12H(2), "Steel Reinforced Elastomeric Bearings."
- Before constructing bearing seats upon which elastomeric bearing pads are to be placed, the Contractor shall notify the Engineer, in writing, of the type of bearing to be used. The elevation of the bearing seats shall correspond to the thickness of the bearings to be used.

51-1.12H(1) Plain and Fabric Reinforced Elastomeric Bearing Pads

- Pads 1/2 inch or less in thickness shall be either laminated or all elastomer. Pads over 1/2 inch in thickness shall be laminated. Stacking of individually laminated pads to attain thicknesses over 1/2 inch, or cold bonding of individual laminated pads will not be permitted.
- Laminated pads shall consist of alternate layers of elastomer and fabric reinforcement bonded together. The top and bottom layers of reinforcement shall be uniformly covered with a maximum of 1/8 inch of elastomer.
- Laminated pads shall have reinforcement every 1/2 inch through the entire thickness. Fabric reinforcement shall be single ply at top and bottom surfaces of the pad and double ply within the pad. The reinforcement shall be parallel to the top and bottom surfaces of the pad. Variations in the location of the reinforcement in excess of 1/8 inch from its theoretical location shall be cause for rejection. The total out to out thickness of a pad shall not be less than the thickness shown on the plans nor more than 1/4 inch greater than that thickness.
- Pads of all elastomer or with fabric reinforcement may be cut from large sheets. Cutting shall be performed in such a manner as to avoid heating of the material and to produce a smooth edge with no tears or other jagged areas and to cause as little damage to the material as possible.
- The peel strength test will be performed after immersing the sample in water for a minimum of 10 days. The bond between elastomer and fabric shall be such that when a sample is tested for separation, the bond shall have a minimum peel strength of 5.3 kN/m when tested in conformance with the requirements in California Test 663.
- Fabric reinforcement shall be woven from 100 percent glass fibers of "E" type yarn with continuous fibers. The minimum thread count in either direction shall be 25 threads per inch. The fabric shall have either a crowfoot or an 8 Harness Satin weave. Each ply of fabric shall have a breaking strength of not less than 140 kN/m of width in each thread direction when 76-mm x 914-mm samples are tested on split drum grips. The bond between double plies shall have a minimum peel strength of 3500 N/m.

- The sole polymer in the elastomeric compound shall be neoprene and shall be not less than 60 percent by volume of the total compound. The elastomer shall be Type CR, Grade 3, and shall have a shear modulus of 110 psi ±10 psi, in conformance with the requirements in ASTM Designation: D 4014.
- The elastomer, as determined from test specimens, shall conform to the following:

Test	ASTM Designation	Requirement
Tensile strength, (psi)	D 412	2,250 Min.
Elongation at break, percent	D 412	350 Min.
Compression set, 22 h at 158° F, percent	D 395 (Method B)	25 Max.
Tear strength, lb/in	D 624 (Die C)	180 Min.
Hardness (Type A)	D 2240 with 2 kg. Wt.	55 ±5
Ozone resistance 20% strain, 100 h at 104° F ±3.6° F	D 1149 (except 100 ±20 parts per 100,000,000)	No cracks
Instantaneous thermal stiffening at -40° F	D 1043	Shall not exceed 4 times the stiffness measured at 73.4° F
Low temperature brittleness at -40° F	D 746 (Procedure B)	Pass

- After accelerated aging in conformance with ASTM Designation: D 573 for 70 hours at 212º F. the elastomer shall not show deterioration changes in excess of the following:

Tensile strength, percent	-15
Elongation at break, percent	-40; but not less than 300% total elongation of the material
Hardness, points	+10

- A Certificate of Compliance conforming to the provisions in Section 6-1.07, "Certificates of Compliance," shall be furnished to the Engineer certifying that the elastomer, and fabric (if used), in the elastomeric bearing pads to be furnished, conforms to the above requirements. The Certificate of Compliance shall be supported by a certified copy of the results of tests performed by the manufacturer upon samples of the elastomer and fabric to be used in the pads.
- A fabric sample not less than 36" x 48" will be taken by the Engineer for testing from each new lot of fabric used in manufacturing bearing pads. A sample pad not less than 8" x 12" in size will be taken by the Engineer for testing from each lot of pads or batch of elastomer to be furnished, whichever results in the greater number of samples. The samples will be selected at random at the point of manufacture or, at the option of the Contractor, at the jobsite. Samples taken at the jobsite shall consist of complete pads as detailed on the plans, and the Contractor shall furnish additional complete pads to replace those taken for testing. Pads shall be available for sampling at least 4 weeks in advance of intended use. All sample pads for testing shall be furnished by the Contractor at the Contractor's expense.

- Specimens tested in conformance with the requirements in California Test 663 shall meet the requirements for the bond between elastomer and fabric reinforcement laminations.
- Test specimens for tensile strength, elongation, tear strength, peel strength and ozone resistance will be taken from production run pads by the Engineer, and will be prepared for testing by cutting and grinding.

51-1.12H(2) Steel Reinforced Elastomeric Bearings

- Steel reinforced elastomeric bearings shall conform to the requirements for steel-laminated elastomeric bearings in ASTM Designation: D 4014 and the following:

A. The bearings shall consist of alternating steel laminates and internal elastomer laminates with top and bottom elastomer covers. Steel laminates shall have a nominal thickness of 1.9 mm (14 gage). Internal elastomer laminates shall have a thickness of 1/2 inch, and top and bottom elastomer covers shall each have a thickness of 1/4 inch. The combined thickness of internal elastomer laminates and top and bottom elastomer covers shall be equal to the bearing pad thickness shown on the plans. The elastomer cover to the steel laminates at the sides of the bearing shall be 1/8 inch. If guide pins or other devices are used to control the side cover over the steel laminates, any exposed portions of the steel laminates shall be sealed by vulcanized patching. The length, width, or diameter of the bearings shall be as shown on the plans.

B. The total thickness of the bearings shall be equal to the thickness of elastomer laminates and covers plus the thickness of the steel laminates.

C. Elastomer for steel reinforced elastomeric bearings shall conform to the provisions for elastomer in Section 51-1.12H(1), "Plain and Fabric Reinforced Elastomeric Bearing Pads."

D. A Certificate of Compliance conforming to the provisions in Section 6-1.07, "Certificates of Compliance," shall be furnished to the Engineer certifying that the bearings to be furnished conform to all of the above provisions. The Certificate of Compliance shall be supported by a certified copy of the results of tests performed by the manufacturer on the bearings.

E. One sample bearing shall be furnished to the Engineer from each lot of bearings to be furnished for the contract. Samples shall be available at least 3 weeks in advance of intended use. The sample bearing shall be one of the following:

Bearing Pad Thickness as Shown on the Plans	Sample Bearing
≤ 2 inches	Smallest complete bearing shown on the plans
> 2 inches	* 2.25 ± 0.125 -inch thick sample not less than 8 inches x 12 inches in plan and cut by the manufacturer from the center of one of the thickest complete bearings

*The sample bearing plus remnant parts of the complete bearing shall be furnished to the Engineer.

F. A test specimen taken from the sample furnished to the Engineer will be tested in conformance with the requirements in California Test 663. Specimens tested shall show no indication of loss of bond between the elastomer and steel laminates.

51-1.13 BONDING

- Construction joints shall be made only where located on the plans or shown in the placing schedule, unless otherwise approved by the Engineer.
- Horizontal construction joints may be made without keys, except when keys are shown on the plans. Surfaces of fresh concrete at horizontal construction joints shall be rough floated sufficiently to thoroughly consolidate the concrete at the surface without completely removing surface irregularities.
- Construction joints shall be cleaned of surface laitance, curing compound and other foreign materials before fresh concrete is placed against the surface of the joint. Abrasive blast methods shall be used to clean horizontal construction joints to the extent that clean aggregate is exposed. Construction joints shall be flushed with water and allowed to dry to a surface dry condition immediately prior to placing concrete.
- When existing structures are to be modified, construction joints between new and existing concrete shall be cleaned and flushed as specified herein for horizontal joints.
- In case of emergency, construction joints shall be made as directed by the Engineer. When it is necessary to make a joint because of an emergency, additional reinforcing steel shall be furnished and placed across the joint as directed by the Engineer. The additional reinforcing steel shall be furnished and placed by the Contractor at the Contractor's expense.
- When new concrete is shown on the plans to be joined to existing concrete by means of bar reinforcing steel dowels grouted into holes drilled in the existing concrete, the holes shall be drilled by methods that will not shatter or damage the concrete adjacent to the holes. Holes in which longitudinal or transverse reinforcement is encountered during drilling before the specified depth is attained shall be rejected. A new hole, which does not strike reinforcement, shall be drilled adjacent to the rejected hole to the depth shown on the plans. With approval of the

Engineer, all holes including rejected holes may be cored through reinforcing steel to the correct depth. The diameters of the drilled holes shall be 1/4 inch larger than the nominal diameter of the dowels unless shown otherwise on the plans. The grout shall be a neat cement paste of portland cement and water. The water content shall be not more than 4 gallons per 94 pounds of cement. Retempering of grout will not be permitted. Immediately prior to placing the dowels, the holes shall be cleaned of dust and other deleterious materials, thoroughly saturated with water, have all free water removed and be dried to a saturated surface dry condition. Sufficient grout shall be placed in the holes so that no voids remain after the dowels are inserted. Grout shall be cured for a period of at least 3 days or until the dowels are encased in concrete, whichever occurs first, by either the curing compound method or by keeping the surface of the grout continuously damp. Any dowels or grout which fail to bond or are damaged before the new concrete is placed shall be removed and replaced.

51-1.135 MORTAR

- Mortar shall be composed of portland cement, sand, and water proportioned and mixed as specified in this Section 51-1.135.
- Mortar shall be furnished and placed in recesses and holes, on surfaces, under structural members, and at other locations specified in these specifications, the special provisions or shown on the plans.
- The proportion of cement to sand, measured by volume, shall be one to 2 unless otherwise specified.
- Materials shall conform to the provisions in Section 90, "Portland Cement Concrete."
- The maximum size of sand shall not be larger than 0.5 of the size of the recess, hole or space where the mortar is to be placed.
- The mortar shall contain only enough water to permit placing and packing.
- Concrete areas to be in contact with the mortar shall be cleaned of all loose or foreign material that would in any way prevent bond between the mortar and the concrete surfaces and shall be flushed with water and allowed to dry to a surface dry condition immediately prior to placing the mortar.
- The mortar shall completely fill and shall be tightly packed into recesses and holes, on surfaces, under structural members, and at other locations specified. After placing, all surfaces of mortar shall be cured by the water method as provided in Section 90-7, "Curing Concrete," for a period of not less than 3 days.
- Keyways, spaces between structural members, holes, spaces under structural members and other locations where mortar could escape shall be mortar-tight before placing mortar.
- No load shall be allowed on mortar that has been in place less than 72 hours, unless otherwise permitted by the Engineer.
- All improperly cured or otherwise defective mortar shall be removed and replaced by the Contractor at the Contractor's expense.

51-1.14 WATERSTOPS

- Waterstops embedded in concrete shall be furnished and installed in conformance with the details shown on the plans, the provisions in these specifications and the special provisions.
- Waterstops shall conform to the cross section and to the minimum dimensions shown on the plans.
- Waterstops shall be manufactured either from neoprene or from polyvinyl chloride (PVC).
- Neoprene shall be manufactured from a vulcanized elastomeric compound containing neoprene as the sole elastomer and shall conform to the following:

Test	ASTM Designation	Requirement
Tensile strength, (psi)	D 412	2,000 Min.
Elongation at break, percent	D 412	300 Min.
Compression set, 22 h at 158° F, percent	D 395 (Method B)	30 Max.
Tear strength, lb/in	D 624 (Die C)	150 Min.
Hardness (Type A)	D 2240	55±5
Ozone resistance 20% strain, 100 h at 100° F ±2.2° F	D 1149 (except 100± 20 parts per 100,000,000)	No cracks
Low temperature brittleness at -40° F	D 746 (Procedure B)	Pass
Flame resistance	C 542	Must not propagate flame
Oil Swell, ASTM Oil #3, 70 h at 212° F, volume change, percent	D 471	80 Max.
Water absorption, immersed 7 days at 158° F, change in weight, percent	D 471	15 Max.

- After accelerated aging in conformance with the requirements in ASTM Designation: D 573 for 70 hours at 212º F the elastomer shall not show deterioration changes in excess of the following:

Tensile strength, percent	-15
Elongation at break, percent	-40
Hardness, points	+10

- Polyvinyl chloride waterstops shall be manufactured from polyvinyl chloride conforming to the Corps of Engineers Specification Number CRD-C 572 and shall conform to the ozone resistance as required for neoprene waterstops. A certificate shall be furnished with the test sample supplied stating that all of the performance requirements specified under paragraph 6 of that specification have been complied with.
- Waterstops shall be furnished full length for each straight portion of the joint, without field splices. Manufacturer's shop splices shall be fully vulcanized.
- The two No. 3 reinforcing bars provided to support the waterstops shown on the plans shall be securely held in position by the use of spacers, supporting wires or other approved devices as provided in Section 52-1.07, "Placing." The two

No. 3 reinforcing bars shall be considered, for payment purposes, as a part of the waterstop.

- If, after placing concrete, waterstops are materially out of position or shape, the surrounding concrete shall be removed, the waterstop reset, and the concrete replaced, all at the Contractor's expense.
- Field splices for neoprene waterstops shall be either vulcanized; mechanical, using stainless steel parts; or made with a splicing union of the same stock as the waterstop, at the option of the Contractor. All finished splices shall have a full size tensile strength of 100 pounds per inch of width.
- Field splices for polyvinyl chloride waterstops shall be performed by heat sealing the adjacent surfaces in conformance with the manufacturer's recommendations. A thermostatically controlled electric source of heat shall be used to make all splices. The heat shall be sufficient to melt but not char the plastic.
- Waterstops when being installed shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distortion of the web or flange.

51-1.145 STRIP WATERSTOPS

- Strip waterstops, consisting of neoprene sheets bonded to surfaces of structures, shall be furnished and installed in conformance with the details shown on the plans, the provisions in these specifications and the special provisions.
- The neoprene sheet shall be fabricated from neoprene conforming to the provisions for "Neoprene" in Section 51-1.14, "Waterstops." The neoprene sheet shall be smooth, free from pin holes or surface blemishes, and shall show no evidence of delamination. The surfaces of the neoprene sheet on which adhesive is to be used shall be cloth finish, or shall be buffed, and shall be dry and free of powder, dust, oil, wax or other deleterious material when adhesive is applied.
- The adhesive used in bonding neoprene to surfaces of the structures or in bonding neoprene to neoprene shall conform to Federal Specification MMM-A-121.
- Protective board shall be $^1/_2$ inch minimum thick wood or fiberboard. Boards shall be not less than 4 feet in length and the width shown on the plans.
- Joints between neoprene sheets shall be made as follows:

  Laps shall be not less than 12 inches in length. A coating of adhesive shall be applied to both faces of the sheets to be joined at the rate recommended by the manufacturer. The adhesive shall be allowed to remain undisturbed until it develops an aggressive tack without transferring to a dry finger touch. The sheets in the joint shall then be brought into contact and rolled in both directions to obtain a tight bond between the sheets.

- Surfaces to receive strip waterstops shall be abrasive blast cleaned to remove all dirt, dust, loose concrete, curing compound and other deleterious materials. Surfaces shall be allowed to air dry for not less than 24 hours before applying adhesive.
- Adhesive shall be applied to both the surface of the structure and the surface of the sheet at the rate recommended by the manufacturer and shall be allowed to

remain undisturbed until it develops an aggressive tack. The neoprene sheet shall then be applied to the surface of the structure and rolled in both directions to obtain a tight bond between the sheet and the surface of the structure.

- After installation, the strip waterstops shall be completely and tightly covered with one layer of protective board. Protective board shall be attached with spots or strips of a commercial quality adhesive of sufficient strength to hold the protective board in place until backfill has been completed.
- The Contractor shall be responsible for protecting the strip waterstops during backfill operations or any other operation which may damage the strip waterstops. The Contractor, at the Contractor's expense, shall repair or replace any unacceptable or damaged strip waterstop.

51-1.15 DRAINS IN WALLS

- Drain holes and weep holes shall be constructed in abutment walls, wingwalls and retaining walls as shown on the plans, and pervious backfill material shall be placed as provided in Section 19-3.065, "Pervious Backfill Material."
- Retaining wall and abutment wall drains shall be covered at the back face of the wall with hardware cloth conforming to the following:

A. Hardware cloth shall be a commercial quality, approximately 1/4 inch mesh wire cloth of aluminum or of galvanized steel wire. The aluminum wire, and steel wire before galvanizing, shall have a diameter of 0.025-inch, minimum. Hardware cloth shall be mounted in the forms prior to placing concrete in such a manner that the wire is firmly bonded to the concrete or may be fastened to the exterior of the concrete surface by masonry nails or other methods approved by the Engineer.

B. Alternative methods of providing screened drain hole openings may be submitted to the Engineer for approval.

- In addition to the drain holes and weep holes specified in the preceding paragraph, holes approximately 3 inches in diameter for relief of hydrostatic pressure shall be provided at the bottom of walls, immediately above the footing, at approximately 15-foot centers.

51-1.16 RAILINGS AND BARRIERS

- Railings and barriers shall conform to the provisions in Section 83, "Railings and Barriers."
- Falsework supporting spans of cast-in-place girders, slab bridges or culverts shall be released prior to constructing or installing railings or barriers on such spans unless permitted otherwise by the Engineer.

51-1.17 FINISHING BRIDGE DECKS

- The completed roadway surfaces of structures, approach slabs and adjoining approach pavement, and the top surfaces of concrete decks which are to be covered with another material, shall be constructed true to the required grade and cross section and to the smoothness, surface texture and surface crack requirements specified herein.

- On structures, the Engineer will set deck elevation control points which shall be used by the Contractor to establish the grade and cross section of the concrete deck surface. The grade established by the deck elevation control points will include all camber allowances. The locations of the elevation control points will not be closer together than approximately 8 feet longitudinally and 24 feet transversely to the centerline of bridge.
- Prior to the start of concrete placement for any section of deck, the Contractor shall set to grade all rails and headers which will be used to support or control the finishing equipment, shall check all the rails and headers as necessary to be satisfied that they conform to the smoothness requirements specified herein for the completed deck, and shall move the finishing equipment over the entire length of the section to be placed in order to check the steel and bulkhead clearances.
- The smoothness of completed roadway surfaces of structures, approach slabs and the adjacent 50 feet of approach pavement, and the top surfaces of concrete decks which are to be covered with another material, will be tested by the Engineer with a bridge profilograph in conformance with the requirements in California Test 547 and the requirements herein. Two profiles will be obtained in each lane approximately 3 feet from the lane lines, and one profile will be obtained in each shoulder approximately 3 feet from the curb or rail face. The surfaces shall have a profile trace showing no high points in excess of 0.25-inch, and the portions of the surfaces within the traveled way shall have a profile count of 13 or less in any 100-foot section. All of the traces shall be made in a direction parallel to traffic. In addition, the roadway surfaces shall not vary more than 0.02-foot from the lower edge of a 12-foot long straightedge placed transversely to traffic.
- It shall be the Contractor's responsibility to schedule profilograph testing operations. The Contractor shall request testing at least 7 days prior to need, and shall ensure that the entire area to be tested has been cleaned and cleared of all obstructions.
- When seal coats are to be placed on concrete surfaces, smoothness testing and any required grinding shall be completed before the seal coat is applied.
- Surfaces which fail to conform to the above smoothness tolerances shall be ground until the above tolerances are met. Grinding shall not reduce the concrete cover on reinforcing steel to less than $1^1/_2$ inches. Portions of decks which cannot be corrected satisfactorily by grinding shall be removed and replaced.
- The surface texture of completed roadway surfaces of structures and approach slabs, except as otherwise provided, shall be uniform and shall have a coefficient of friction of not less than 0.35 at the time the surfaces are opened to public traffic or prior to placing seal coat, whichever occurs first. The coefficient of friction will be measured by California Test 342. Portions of completed concrete surfaces that are found to have a coefficient of friction less than 0.35 shall be ground to produce a coefficient of friction of not less than 0.35, or grooved parallel to the center line.
- When surfaces are ground or grooved as specified herein, the work shall be performed in conformance with the provisions in Section 42, "Groove and Grind Pavement," except that residue from grinding or grooving operations shall be disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13.

- Bridge decks which are to be covered with membrane deck seals shall not be textured and shall be finished to a smooth surface, free of mortar ridges and other projections, before curing compound is applied. The coefficient of friction requirements will not apply to those decks.
- Deck surfaces under the curbs, railings, barriers and sidewalks shall be struck off to the same plane as the roadway and left undisturbed when future widening is shown on the plans.

51-1.18 SURFACE FINISHES

- The following specifications set forth the requirements for the several classes of surface finish, which shall be applied to the various parts of concrete structures.

51-1.18A Ordinary Surface Finish

- Ordinary surface finish shall consist of filling holes or depressions in the surface of the concrete, repairing all rock pockets, removing fins, and removing stains and discolorations visible from traveled ways. Ordinary surface finish shall be applied to all concrete surfaces either as a final finish or preparatory to a higher class finish. On surfaces which are to be buried underground or surfaces which are enclosed, such as the cells of box girders, the removal of fins will not be required. Ordinary surface finish, unless otherwise specified, shall be considered as a final finish on the following surfaces:

A. The undersurfaces of slab spans, box girders, filled spandrel arch spans, and floor slabs between girders of superstructures.
B. The inside vertical surface of T girders of superstructures.
C. Surfaces which are to be buried underground or covered with embankment and surfaces above finished ground of culverts which are not visible from traveled ways.

- Except as provided herein, form bolts and any metal placed for the convenience of the Contractor shall be removed to a depth of at least one inch below the surface of the concrete. All rock pockets and other unsound concrete shall be removed. The resulting holes or depressions shall be cleaned and filled with mortar. Form bolts projecting into the cells of box girders need not be removed unless deck forms are removed from the cells, in which case the bolts shall be removed flush with the surface of the concrete.
- Mortar used to fill bolt holes shall conform to the provisions in Section 51-1.135, "Mortar." Other depressions and pockets shall be filled with either packed mortar or shotcrete as directed by the Engineer and the mortar or shotcrete shall be cured in conformance with the provisions in Section 90-7.03, "Curing Structures."
- For exposed surfaces, white cement shall be added to the mortar or shotcrete in an amount sufficient to result in a patch which, when dry, matches the surrounding concrete.
- If rock pockets, in the opinion of the Engineer, are of such an extent or character as to affect the strength of the structure materially or to endanger the life

of the steel reinforcement, the Engineer may declare the concrete defective and require the removal and replacement of the portions of the structure affected.

51-1.18B Class 1 Surface Finish

- Class 1 surface finish shall consist of finishing the surfaces of the structure as necessary to produce smooth, even surfaces of uniform texture and appearance, free of unsightly bulges, depressions and other imperfections. The degree of care in building forms and character of materials used in form work will be a contributing factor in the amount of additional finishing required to produce smooth even surfaces of uniform texture and appearance, free of unsightly bulges, depressions and other imperfections, and the Engineer shall be the sole judge in this respect. The use of power carborundum stones or disks will be required to remove bulges and other imperfections.
- Class 1 surface finish shall not be applied until a uniform appearance can be obtained.
- After completion of the ordinary surface finish, areas which do not exhibit the required smooth, even surface of uniform texture and appearance shall be sanded with power sanders or other approved abrasive means until smooth, even surfaces of uniform texture and appearance are obtained.
- Class 1 surface finish shall be the final finish for the following surfaces, unless otherwise specified in the special provisions:

A. All surfaces of bridge superstructures, except the undersurfaces between girders, inside vertical surfaces of T girders, and undersurfaces of slab and box girder spans and T girders exclusive of the undersurfaces of deck overhangs.
B. All surfaces of bridge piers, piles, columns and abutments, and retaining walls above finished ground and to at least one foot below finished ground.
C. All surfaces of open spandrel arch rings, spandrel columns and abutment towers.
D. All surfaces of pedestrian undercrossings, except floors and surfaces to be covered with earth.
E. Surfaces above finished ground of culvert headwalls, and endwalls where visible from a traveled way.
F. Surfaces inside of culvert barrels having a height of 4 feet or more for a distance inside the barrel at least equal to the height of the culvert, where visible from a traveled way.
G. All interior surfaces of pump house motor and control rooms and the engine-generator rooms.
H. All surfaces of railings.

51-1.18C Class 2 Surface Finish (Gun Finish)

- Class 2 surface finish (gun finish) shall be applied to the surfaces designated on the plans for gun finish and to surfaces specified in the special provisions.
- When Class 2 surface finish (gun finish) is specified, ordinary surface finish shall first be completed. The concrete surfaces shall then be abrasive blasted to a

rough texture and thoroughly washed down with water. While the washed surfaces are damp, but not wet, a finish coating of machine applied mortar, approximately 1/4 inch thick, shall be applied in not less than 2 passes. The coating shall be pneumatically applied and shall consist of either (1) sand, portland cement and water mechanically mixed previous to its introduction to the nozzle, or (2) premixed sand and portland cement to which water is added previous to its expulsion from the nozzle. The use of additives shall be subject to the approval of the Engineer as provided in Section 90, "Portland Cement Concrete." The proportion of cement to sand shall be not less than one to 4, unless otherwise directed by the Engineer. Sand shall be of a grading suitable for the purpose intended. The machines shall be operated and the coating shall be applied in conformance with standard practice. The coating shall be firmly bonded to the concrete surfaces on which it is applied.

- Areas reserved for bridge name and number, bent number and other designations shall be suitably blocked-out and shall not be coated.
- The surface of the coating shall be uniform without unsightly bulges, depressions and other imperfections and shall be natural finish as left by the nozzle. The coating shall be protected from damage and shall be kept damp for at least 3 days after placing. Loose areas of coating shall be removed and replaced by the Contractor at the Contractor's expense.
- When surfaces to be finished are in pedestrian undercrossings, the sand shall be silica sand and the cement shall be standard white portland cement.

51-1.19 UTILITY FACILITIES

- When shown on the plans, utility facilities will be carried in or on structures at the locations shown on the plans. Hangers, anchor bolt inserts, manhole frames and covers, sleeves and other accessories required for the facilities which must be cast in the concrete will be furnished by the respective owners and shall be installed by the Contractor in conformance with details shown on the plans or as directed by the Engineer. Full compensation for installing these materials shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefor.
- The conductors and their casings for utility facilities in structures will be furnished and installed by the respective owners at such times as the work is ready for the installation and before any construction is in place that would interfere with their installation.
- The Contractor shall notify the Engineer in writing, at least 30 days in advance of the proposed dates, that the work will be ready for installation of accessories or utilities in structures. The Engineer will, in turn, notify the owners of the utilities.

51-1.20 SIDEWALKS, CURBS AND STAIRWAYS ON STRUCTURES

- The concrete shall be finished conforming to the provisions in Section 73-1.06, "Sidewalk, Gutter Depression, Island Paving, Curb Ramp (Wheelchair Ramp), and Driveway Construction," except that surfaces shall not be marked.
- Pedestrian walkways, stair treads and landings shall receive a nonskid abrasive aggregate finish, where shown on the plans, consisting of commercial quality aluminum oxide, silicon carbide or almandite garnet grit particles, sieve size No. 12

to No. 30 or No. 14 to No. 35 applied uniformly at the rate of at least 0.3-psf into the tamped and floated concrete surface while the concrete is plastic. The grit shall be buried about 0.7-diameter of each particle into the concrete.

51-1.21 BRIDGE NAME, NUMBER AND BENT NUMBERS

The bridge name, number and bent numbers when called for on the plans, shall be painted at the locations shown on the plans in neat black letters and figures $2^1/_2$ inches high.

51-1.22 MEASUREMENT

Except as otherwise provided, pay quantities of concrete in structures will be measured by the cubic yard in conformance with the dimensions shown on the plans or such other dimensions as may be ordered in writing by the Engineer. No deduction will be made for the volume occupied by bar reinforcing steel, structural steel, prestressing materials or piles in the concrete.

The estimated quantity of concrete for minor structures designated as final pay in the Engineer's Estimate will not be revised as specified in Section 9-1.015, "Final Pay Items," when the constructed height of the minor structure, including revisions by the Engineer, is within 6 inches of the vertical dimension shown on the plans.

Metal frames and covers or frames and grates for use with minor structures will be measured as provided in Section 75, "Miscellaneous Metal."

Joint seals and joint seal assemblies will be measured by the linear foot from end to end along the centerline of the completed seal including return sections at curb faces. Where individual seals are overlapped or are superimposed, each seal will be measured separately.

The quantity of seal course concrete to be paid for shall include the actual volume of concrete seal course in place, but in no case shall the total volume to be paid for exceed the cubical contents contained between the vertical surfaces one foot outside the neat lines of the seal course as shown on the plans. The thickness of seal course to be paid for shall be the thickness shown on the plans or ordered in writing by the Engineer. If it is found that the seal course is not required, the seal course shall be omitted and the quantity of seal course concrete for payment will be reduced by the amount of the seal course omitted. No adjustment of compensation will be made for any increase or decrease in the quantity of seal course concrete required, regardless of the reason for the increase or decrease. The provisions in Section 4-1.03B, "Increased or Decreased Quantities," shall not apply to the item of seal course concrete.

Precast concrete members, except piling, will be measured by the unit for furnishing precast concrete members of the various types and lengths shown in the Engineer's Estimate and by the unit for erecting the members as shown in the Engineer's Estimate. When various lengths or types of members are grouped together for payment purposes, the basis of the grouping will be shown in the Engineer's Estimate.

Whenever an alternative or option is shown or noted on the plans or permitted by these specifications or the special provisions, the quantities of concrete will be computed on the basis of the dimensions and details shown on the plans, and no

change in the quantities to be paid for will be made because of the use by the Contractor of the alternatives or options.

51-1.23 PAYMENT

- All concrete involved in structures, except concrete in components of the work for which payment is made under separate contract items, will be paid for at the contract prices per cubic yard for the types and classes of concrete shown in the Engineer's Estimate. If concrete involved in bridge work, as listed under "Description of Bridge Work" of the special provisions, is not otherwise designated by type or class, and is not otherwise paid for under separate contract items, the concrete will be paid for at the contract price per cubic yard for structural concrete, bridge.
- The contract prices paid per cubic yard for the various types and classes of concrete in structures and structure approach slabs shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in constructing the concrete work, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer, except as otherwise provided.
- The contract prices paid per cubic yard for minor concrete (minor structure) or for concrete (minor structure) of the class specified in the Engineer's Estimate and for structural concrete, approach slab, shall include full compensation for all structure excavation and structure backfill and for furnishing and placing all bar reinforcing steel and miscellaneous iron and steel (except for metal frames and covers or frames and grates), necessary to construct the minor structures, and approach slabs, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer, and no separate payment will be made for these included items.
- The contract prices paid per cubic yard for concrete in reinforced concrete box and arch culverts, and in headwalls, endwalls and wingwalls for culverts shall also include the payment for the earthwork involved with such structures as provided in Section 19-3.08, "Payment."
- Metal frames and covers or frames and grates for use with minor structures will be paid for as provided in Section 75, "Miscellaneous Metal."
- Members in structures, other than piling, which are designated on the plans or in the special provisions to be precast, will be paid for by a contract unit price for furnishing and a contract unit price for erecting each such member. Piling will be paid for as provided in Section 49, "Piling."
- The contract unit price paid for furnish precast concrete members shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, including reinforcing and prestressing steel as required, and for doing all work involved in constructing and furnishing precast members at the site of the work complete and ready for erection, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- If a portion or all of precast concrete members are fabricated more than 300 air line miles from both Sacramento and Los Angeles, additional shop inspection expenses will be sustained by the State. Whereas it is and will be impracticable and extremely difficult to ascertain and determine the actual increase in these expenses,

it is agreed that payment to the Contractor for furnishing the members will be reduced $5,000 for each fabrication site located more than 300 air line miles from both Sacramento and Los Angeles and an additional $3,000 ($8,000 total) for each fabrication site located more than 3,000 air line miles from both Sacramento and Los Angeles.

- The contract unit price paid for erect precast concrete members shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in erecting precast members in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- Diaphragm dowels or bolts, whether or not embedded in the precast member, will be paid for as bar reinforcing steel.
- Deck shear connector rods, threaded inserts for diaphragm bolts, bearing plates and other items embedded in a precast member, but not including embedded bearing plates which plates are a part of a matching steel bearing assembly incorporated in the cast-in-place concrete construction, shall be considered as a part of the member and full compensation therefor shall be considered as included in the contract unit price paid for furnishing the precast member.
- The contract prices paid per linear foot for joint seals and joint seal assemblies of the types and Movement Ratings listed in the contract items shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in constructing the joint seals and joint seal assemblies, including protecting, repairing, cleaning and saw cutting joints, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Full compensation for waterstops and strip waterstops shall be considered as included in the contract price paid per cubic yard for the various items of concrete work involved and no separate payment will be made therefor.
- Full compensation for drilling holes for dowels and grouting dowels in drilled holes; furnishing and placing mortar for mortaring spaces and recesses in and between precast members; furnishing and placing grit for walkways, stair treads and landings; furnishing and placing expansion joint filler, sheet packing, board fillers, elastomeric bearing pads, sliding joints, sliding bearings and preformed fabric pads; and grinding or grooving, as required, shall be considered as included in the contract prices paid for the various items of concrete work and no additional compensation will be allowed therefor.
- Steel joint armor and steel bearing assemblies for concrete structures will be measured and paid for as provided in Section 75, "Miscellaneous Metal."
- Excavation, backfill, reinforcement, prestressing, miscellaneous iron and steel and such other items as may be involved in the work of constructing concrete structures, will be measured and paid for separately as provided in their respective sections of these specifications and the special provisions, except when full compensation for the foregoing items is specifically included in the contract price paid for the item of concrete structure work involved.

SECTION 52: REINFORCEMENT

52-1.01 DESCRIPTION

This work shall consist of furnishing and placing reinforcement of the shape and dimensions shown on the plans, and as specified in these specifications and the special provisions.

52-1.02 MATERIALS

Bar reinforcement, welded wire fabric and reinforcing wire shall conform to the following requirements:

52-1.02A Bar Reinforcement

Reinforcing bars shall be low-alloy steel deformed bars conforming to the requirements in ASTM Designation: A 706/A 706M, except that deformed or plain billet-steel bars conforming to the requirements in ASTM Designation: A 615/A 615M, Grade 40 or 60, may be used as reinforcement in the following 5 categories:

A. Slope and channel paving,
B. Minor structures,
C. Sign and signal foundations (pile and spread footing types),
D. Roadside rest facilities, and
E. Concrete barrier Type 50 and Type 60 series and temporary railing.

Deformations specified in ASTM Designation: A 706/A 706M will not be required on bars used as spiral or hoop reinforcement in structures and concrete piles.

Reinforcing bars shall be placed in accordance with the size and spacing shown on the plans, regardless of the designation and grade of reinforcing bars selected by the Contractor.

Welded wire fabric may be substituted for reinforcing bars in the following:

A. Slope paving and lined ditches.
B. Retaining walls.
C. Concrete barriers.
D. Sidewalks, curbs and gutters on structures.
E. Nonstructural aesthetic additions.
F. Culvert headwalls, endwalls and wingwalls.
G. Shotcrete.
H. Deck overlays.

Substituted welded wire fabric shall be on an equivalent area basis and shall be placed as directed by the Engineer. Welded wire fabric shall be supplemented with reinforcing bars when the fabric does not provide the required area of steel.

The substitution of welded wire fabric for bar reinforcing steel as provided above shall not apply to epoxy-coated reinforcing bars.

52-1.02B Epoxy-coated Reinforcement

- Bar reinforcement to be epoxy-coated shall conform to the requirements in ASTM Designation and grade required or permitted by Section 52-1.02A, "Bar Reinforcement," for the location or type of structure involved. The epoxy-coated bar reinforcement shall conform to the requirements in ASTM Designation: A 775/A 775M, except as provided herein. Fabrication and jobsite handling of the epoxy-coated bar reinforcement shall conform to the requirements of ASTM Designation: D 3963/D 3963M, except as provided herein.
- Wire reinforcement to be epoxy-coated shall conform to the requirements in ASTM Designation and grade required or permitted by Section 52-1.02D, "Reinforcing Wire," for the location or type of structure involved. The coated wire reinforcement shall conform to the requirements for Class A, Type 1 coating in ASTM Designation: A 884/A 884M, except as provided herein.
- Appendices X1, "Guidelines For Job-Site Practices," of ASTM Designations: A 775/A 775M and A 884/A 884M shall apply except as provided herein. The term "shall" shall replace the term "should" in these appendices. Sections X1.2 shall not apply.
- Coatings shall be light green in color.
- Except for field welding of butt splices, all welding of reinforcement shall be complete prior to epoxy coating the reinforcement.
- When any portion of a reinforcing bar or wire requires epoxy coating, the entire bar or wire shall be coated.
- Within areas where epoxy-coated reinforcement is required, tie wire and bar chairs or other metallic devices used to secure or support the reinforcement shall be plastic-coated or epoxy-coated to prevent corrosion of the devices or damage to the coated reinforcement.
- Prior to coating, the Contractor shall furnish to the Transportation Laboratory a representative 4-ounce sample from each batch of epoxy coating material to be used. Each sample shall be packaged in an airtight container identified with the manufacturer's name and batch number.
- Two 30-inch long samples of coated bar or wire reinforcement from each size and from each load shipped to the jobsite shall be furnished to the Engineer for testing. These samples shall be representative of the material furnished. These samples, as well as any additional random samples taken by the Engineer, may be tested for specification compliance. Additional sampling, and tests performed by the Engineer, may be performed at any location deemed appropriate by the Engineer. Failure of any sample to meet the requirements of the specifications will be cause for rejection.
- If any bar or wire reinforcement tested for coating thickness or for flexibility of coating fails to meet the requirements for coated bars in Section 8 of ASTM Designation: A 775/A 775M or A 884/A 884M, respectively, 2 retests on random samples taken from bars represented by the failed test will be conducted for each failed test. If the results of both retests meet the specified requirements, the coated bars represented by the samples may be certified as meeting the test requirements.
- Epoxy-coated reinforcement shall be covered with an opaque polyethylene sheeting or other suitable protective material to protect the reinforcement from

exposure to sunlight, salt spray and weather. For stacked bundles, the protective covering shall be draped around the perimeter of the stack. The covering shall be adequately secured; however, it should allow for air circulation around the reinforcement to prevent condensation under the covering. Epoxy-coated reinforcement shall not be stored within 1,000 feet of ocean or tidal water for more than 2 months.

- Visible damage to the coatings caused by shipping, handling or installation shall be repaired as required for repairing coating damaged prior to shipment as specified in ASTM Designation: A 775/A 775M for bar reinforcement or ASTM Designation: A 884/A 884M for wire reinforcement. When the extent of coating damage prior to repair exceeds 2 percent of the bar or wire surface area in any one-foot length, repair of the bar or wire will not be allowed and the coated bar or wire will be rejected.
- The patching material and process shall be suitable for field application. The patching material shall be prequalified as required for the coating material and shall be either identified on the container as a material compatible with the bar reinforcement coating, or shall be accompanied by a Certificate of Compliance certifying that the material is compatible with the bar reinforcement coating. Damaged areas shall be patched in accordance with the patching material manufacturer's recommendations. If damage to a bar occurs during field bending, the area shall be patched immediately with the prequalified patching material.
- Except for lap splices, splices for epoxy-coated reinforcement shall be coated with a corrosion protection covering that is on the Department's list of approved products. The covering shall be installed in accordance with the manufacturer's recommendations and as directed by the Engineer. The list is available from the Transportation Laboratory.

52-1.02C Welded Wire Fabric

- Welded wire fabric shall be either plain or deformed conforming to the requirements in ASTM Designation: A 185A/A 185M or ASTM Designation: A 497/A 497M, respectively.

52-1.02D Reinforcing Wire

- Wire used as reinforcement in structures and concrete piles, as shown on the plans, shall be cold drawn steel wire conforming to the requirements in ASTM Designation: A 82/A 82M.

52-1.03 STEEL LISTS

- When requested, 2 copies of a list of all reinforcing steel shall be furnished to the Engineer at the site of the work before the placing of reinforcing steel is begun. Furnishing the lists to the Engineer shall not be construed to mean that the lists will be reviewed for accuracy. The Contractor shall be wholly and completely responsible for the accuracy of the lists and for furnishing and placing all reinforcing steel in accordance with the details shown on the plans and as specified.

52-1.04 INSPECTION

- Except when otherwise ordered by the Engineer, reinforcing steel will be inspected at the fabrication site. The Contractor shall notify the Engineer in

sufficient time to permit this inspection before shipment is made. The inspection of reinforcing steel by the Engineer at the fabrication site shall not preclude the subsequent rejection of the steel if either the materials or fabrication are found defective.

The fabricator shall furnish a Certificate of Compliance to the Engineer in conformance with the provisions in Section 6-1.07, "Certificates of Compliance." The fabricator shall also make available for review, when requested by the Engineer, a copy of the certified mill test report for each heat and size of reinforcing steel, showing physical and chemical analysis.

A Certificate of Compliance conforming to the provisions in Section 6-1.07, "Certificates of Compliance," shall also be furnished for each shipment of epoxy-coated bar reinforcement or wire reinforcement certifying that the coated reinforcement conforms to the requirements in ASTM Designation: A 775/A 775M or A 884/A 884M respectively, and the provisions in Section 52-1.02B, "Epoxy-coated Reinforcement." The Certificate of Compliance shall include all of the certifications specified in ASTM Designation: A 775/A 775M or A 884/A 884M respectively.

52-1.05 CLEANING

Before concrete is placed, the reinforcement to be embedded shall be free of mortar, oil, dirt, excessive mill scale and scabby rust and other coatings of any character that would destroy or reduce the bond.

52-1.06 BENDING

Reinforcement shall conform accurately to the dimensions shown on the plans.

Bars shall not be bent or straightened in a manner that will injure the material. Bars with kinks or improper bends shall not be used.

Hooks and bends shall conform to the provisions of the Building Code Requirements for Structural Concrete of the American Concrete Institute.

52-1.07 PLACING

Reinforcement shall be accurately placed as shown on the plans and shall be firmly and securely held in position by wiring at intersections and splices and by using precast mortar blocks or ferrous metal chairs, spacers, metal hangers, supporting wires, and other approved devices of sufficient strength to resist crushing under applied loads. Wooden, aluminum and plastic supports shall not be used. Placing bars on layers of fresh concrete as the work progresses will not be permitted.

Metal supports shall have a clear coverage of not less than one inch. Protective coatings on metal supports shall not be considered when determining clear coverage. Where the clear coverage to reinforcing steel as shown on the plans or ordered by the Engineer exceeds the minimum coverage specified herein, the clear coverage for metal supports shall be increased accordingly.

The minimum spacing center to center of parallel bars shall be 2.5 times the diameter of the bar. The minimum clear distance between bundles of bars and adjacent bundles or single bars shall be not less than the following:

A. Bundles of 2 bars, 2 times diameter of larger bar.

B. Bundles of 3 bars, 2.5 times diameter of larger bar.

- In no case shall the clear distance between bars or bundles of bars be less than 1.5 times the maximum size of the coarse aggregate.
- Bundle bars shall be tied together at not more than 6-foot centers.
- Reinforcement shall have a clear coverage of 2 inches, except as otherwise shown on the plans or specified in the special provisions. If ordered by the Engineer, additional clear coverage shall be provided. Clear coverage shall be measured from the surface of the concrete to the outside of the reinforcement.
- Reinforcement used in post-tensioned concrete shall be adjusted or relocated during the installation of prestressing ducts or tendons, as required to provide planned clearances to the prestressing tendons, anchorages, jacks and equipment, as approved by the Engineer.
- Each unit of wire spiral reinforcement shall be anchored at both ends by a 135-degree hook with a 6-inch tail hooked around an intersecting longitudinal bar. Discontinuities in spiral reinforcement shall be made only where shown on the plans or where approved by the Engineer. The spiral on each side of a discontinuity shall be considered a separate unit and shall be anchored as specified herein. Where discontinuities in spiral reinforcement are not permitted, individual pieces of spiral reinforcement shall be spliced in conformance with the provisions in Section 52-1.08, "Splicing."
- Welded wire fabric shall be rolled flat before placing concrete, unless otherwise shown on the plans. Welded wire fabric shall be held firmly in place against vertical or transverse movement by means of devices satisfactory to the Engineer.
- Tack welding on reinforcing bars will not be permitted.
- Attention is directed to the provisions in Section 7-1.09, "Public Safety." Whenever a portion of an assemblage of bar reinforcing steel that is not encased in concrete exceeds 20 feet in height, the Contractor shall submit to the Engineer for approval, in accordance with the provisions in Section 5-1.02, "Plans and Working Drawings," working drawings and design calculations for the temporary support system to be used. The working drawings and design calculations shall be signed by an engineer who is registered as a Civil Engineer in the State of California. The temporary support system shall be designed to resist all expected loads and shall be adequate to prevent collapse or overturning of the assemblage. If the installation of forms or other work requires revisions to or temporary release of any portion of the temporary support system, the working drawings shall show the support system to be used during each phase of construction. The minimum horizontal wind load to be applied to the bar reinforcing steel assemblage, or to a combined assemblage of reinforcing steel and forms, shall be the sum of the products of the wind impact area and the applicable wind pressure value for each height zone. The wind impact area is the total projected area of the cage normal to the direction of the applied wind. Wind pressure values shall be determined from the following table:

Height Zone (Feet above ground)	Wind Pressure Value
0-30	20 psi
30-50	25 psi
50-100	30 psi
Over 100	35 psi

52-1.08 SPLICING

- Splices of reinforcing bars shall consist of lap splices, service splices, or ultimate butt splices.
- Splicing of reinforcing bars will not be permitted at a location designated on the plans as a "No-Splice Zone." At the option of the Contractor, reinforcing bars may be continuous at locations where splices are shown on the plans. The location of splices, except where shown on the plans, shall be determined by the Contractor using available commercial lengths where practicable.
- Unless otherwise shown on the plans, splices in adjacent reinforcing bars at any particular section shall be staggered. The minimum distance between staggered lap splices or mechanical lap splices shall be the same as the length required for a lap splice in the largest bar. The minimum distance between staggered butt splices shall be 2 feet, measured between the midpoints of the splices along a line which is centered between the axes of the adjacent bars.

52-1.08A Lap Splicing Requirements

- Splices made by lapping shall consist of placing reinforcing bars in contact and wiring them together, maintaining the alignment of the bars and the minimum clearances. Should the Contractor elect to use a butt welded or mechanical splice at a location not designated on the plans as requiring a service or ultimate butt splice, this splice shall conform to the testing requirements for service splice.
- Reinforcing bars shall not be spliced by lapping at locations where the concrete section is not sufficient to provide a minimum clear distance of 2 inches between the splice and the nearest adjacent bar. The clearance to the surface of the concrete specified in Section 52-1.07, "Placing," shall not be reduced.
- Reinforcing bars Nos. 14 and 18 shall not be spliced by lapping.
- Where ASTM Designations: A 615/A 615M, Grade 60 or A 706/A 706M reinforcing bars are required, the length of lap splices shall be as follows: Reinforcing bars No. 8 or smaller shall be lapped at least 45 diameters of the smaller bar joined; and reinforcing bars Nos. 9, 10, and 11 shall be lapped at least 60 diameters of the smaller bar joined, except when otherwise shown on the plans.
- Where ASTM Designation: A 615/A 615M, Grade 40 reinforcing bars are permitted, the length of lap splices shall be as follows: Reinforcing bars No. 8 or smaller shall be lapped at least 30 diameters of the smaller bar joined; and reinforcing bars Nos. 9, 10, and 11 shall be lapped at least 45 diameters of the smaller bar joined, except when otherwise shown on the plans.
- Splices in bundled bars shall conform to the following:

  A. In bundles of 2 bars, the length of the lap splice shall be the same as the length of a single bar lap splice.

B. In bundles of 3 bars, the length of the lap splice shall be 1.2 times the length of a single bar lap splice.

• Welded wire fabric shall be lapped such that the overlap between the outermost cross wires is not less than the larger of:

A. 6 inches,
B. The spacing of the cross wires plus 2 inches, or
C. The numerical value of the longitudinal wire size (W-Size Number) times 4.3 divided by the spacing of the longitudinal wires in inches.

52-1.08B Service Splicing and Ultimate Butt Splicing Requirements

• Service splices and ultimate butt splices shall be either butt welded or mechanical splices, shall be used at the locations shown on the plans, and shall conform to the requirements of these specifications and the special provisions.

52-1.08B(1) Mechanical Splices

• Mechanical splices to be used in the work shall be on the Department's current prequalified list before use. The prequalified list can be obtained from the Department's internet site listed in the special provisions or by contacting the Transportation Laboratory directly.

• When tested in conformance with the requirements in California Test 670, the total slip shall not exceed the values listed in the following table:

Reinforcing Bar Number	Total Slip
4	0.010-inch
5	0.010-inch
6	0.010-inch
7	0.015-inch
8	0.015-inch
9	0.015-inch
10	0.020-inch
11	0.020-inch
14	0.025-inch
18	0.030-inch

• Slip requirements shall not apply to mechanical lap splices, splices that are welded, or splices that are used on hoops.

• Splicing procedures shall be in conformance with the manufacturer's recommendations, except as modified in this section. Splices shall be made using the manufacturer's standard equipment, jigs, clamps, and other required accessories.

• Splice devices shall have a clear coverage of not less than $1^3/_4$ inches measured from the surface of the concrete to the outside of the splice device. Stirrups, ties, and other reinforcement shall be adjusted or relocated, and additional reinforcement shall be placed, if necessary, to provide the specified clear coverage to reinforcement.

- The Contractor shall furnish the following information for each shipment of splice material in conformance with the provisions in Section 6-1.07, "Certificates of Compliance:"

A. The type or series identification of the splice material including tracking information for traceability.
B. The bar grade and size number to be spliced.
C. A copy of the manufacturer's product literature giving complete data on the splice material and installation procedures.
D. A statement that the splicing systems and materials used in conformance with the manufacturer's installation procedures will develop the required tensile strengths, based on the nominal bar area, and will conform to the total slip requirements and the other requirements in these specifications.
E. A statement that the splice material conforms to the type of mechanical splice in the Department's current prequalified list.

52-1.08B(2) Butt Welded Splices

- Except for resistance butt welds, butt welded splices of reinforcing bars shall be complete joint penetration butt welds conforming to the requirements in AWS D 1.4, and these specifications.
- Welders and welding procedures shall be qualified in conformance with the requirements in AWS D 1.4.
- Only the joint details and dimensions as shown in Figure 3.2, "Direct Butt Joints," of AWS D 1.4, shall be used for making complete joint penetration butt welds of bar reinforcement. Split pipe backing shall not be used.
- Butt welds shall be made with multiple weld passes using a stringer bead without an appreciable weaving motion. The maximum stringer bead width shall be 2.5 times the diameter of the electrode and slagging shall be performed between each weld pass. Weld reinforcement shall not exceed 0.16-inch in convexity.
- Electrodes used for welding shall meet the minimum Charpy V-notch impact requirement of 27°J at -4º F.
- For welding of bars conforming to the requirements of ASTM Designation: A 615/A 615M, Grade 40 or Grade 60, the requirements of Table 5.2, "Minimum Preheat and Interpass Temperatures," of AWS D 1.4 are superseded by the following:

The minimum preheat and interpass temperatures shall be 392º F for Grade 40 bars and 572º F for Grade 60 bars. Immediately after completing the welding, at least 6 inches of the bar on each side of the splice shall be covered by an insulated wrapping to control the rate of cooling. The insulated wrapping shall remain in place until the bar has cooled below 194º F.

- When welding different grades of reinforcing bars, the electrode shall conform to Grade 40 bar requirements and the preheat shall conform to the Grade 60 bar requirements.

- In the event that any of the specified preheat, interpass, and post weld cooling temperatures are not met, all weld and heat affected zone metal shall be removed and the splice rewelded.
- Welding shall be protected from air currents, drafts, and precipitation to prevent loss of heat or loss of arc shielding. The method of protecting the welding area from loss of heat or loss of arc shielding shall be subject to approval by the Engineer.
- Reinforcing bars shall not be direct butt spliced by thermite welding.
- Procedures to be used in making welded splices in reinforcing bars, and welders employed to make splices in reinforcing bars, shall be qualified by tests performed by the Contractor on sample splices of the type to be used, before making splices to be used in the work.

52-1.08B(3) Resistance Butt Welds

- Shop produced resistance butt welds shall be produced by a fabricator who is approved by the Transportation Laboratory. The list of approved fabricators can be obtained from the Department's internet site or by contacting the Transportation Laboratory directly.
- Before manufacturing hoops using resistance butt welding, the Contractor shall submit to the Engineer the manufacturer's Quality Control (QC) manual for the fabrication of hoops. As a minimum, the QC manual shall include the following:

A. The pre-production procedures for the qualification of material and equipment.
B. The methods and frequencies for performing QC procedures during production.
C. The calibration procedures and calibration frequency for all equipment.
D. The welding procedure specification (WPS) for resistance welding.
E. The method for identifying and tracking lots.

52-1.08C Service Splice and Ultimate Butt Splice Testing Requirements

- The Contractor shall designate in writing a splicing Quality Control Manager (QCM). The QCM shall be responsible directly to the Contractor for 1) the quality of all service and ultimate butt splicing including the inspection of materials and workmanship performed by the Contractor and all subcontractors; and 2) submitting, receiving, and approving all correspondence, required submittals, and reports regarding service and ultimate splicing to and from the Engineer.
- The QCM shall not be employed or compensated by any subcontractor, or by other persons or entities hired by subcontractors, who will provide other services or materials for the project. The QCM may be an employee of the Contractor.
- Testing on prequalification and production sample splices shall be performed at the Contractor's expense, at an independent qualified testing laboratory. The laboratory shall not be employed or compensated by any subcontractor, or by other persons or entities hired by subcontractors who will provide other services or materials for the project, and shall have the following:

A. Proper facilities, including a tensile testing machine capable of breaking the largest size of reinforcing bar to be tested with minimum lengths as shown in this section.
B. A device for measuring the total slip of the reinforcing bars across the splice to the nearest 0.001-inch, that, when placed parallel to the longitudinal axis of the bar is able to simultaneously measure movement across the splice at 2 locations 180 degrees apart.
C. Operators who have received formal training for performing the testing requirements of ASTM Designation: A 370 and California Test 670.
D. A record of annual calibration of testing equipment performed by an independent third party that has 1) standards that are traceable to the National Institute of Standards and Technology, and 2) a formal reporting procedure, including published test forms.

- The Contractor shall provide samples for quality assurance testing in conformance with the provisions in these specifications and the special provisions.
- Prequalification and production sample splices shall be 1) a minimum length of 4 feet for reinforcing bars No. 10 and smaller, and 6 feet for reinforcing bars No. 11 and larger, with the splice located at mid-point; and 2) suitably identified before shipment with weatherproof markings that do not interfere with the Engineer's tamper-proof markings or seals. Splices that show signs of tampering will be rejected.
- Shorter length sample splice bars may be furnished if approved in writing by the Engineer.
- The Contractor shall ensure that sample splices are properly secured and transported to the testing laboratory in such a manner that no alterations to the physical conditions occur during transportation. Sample splices shall be tested in the same condition as received. No modifications to the sample splices shall be made before testing.
- Each set or sample splice, as defined herein, shall be identified as representing either a prequalification or production test sample splice.
- For the purpose of production testing, a lot of either service splices or ultimate butt splices is defined as 1) 150, or fraction thereof, of the same type of mechanical splices used for each bar size and each bar deformation pattern that is used in the work, or 2) 150, or fraction thereof, of complete joint penetration butt welded splices or resistance butt welded splices for each bar size used in the work. If different diameters of hoop reinforcement are shown on the plans, separate lots shall be used for each different hoop diameter.
- Whenever a lot of splices is rejected, the rejected lot and subsequent lots of splices shall not be used in the work until 1) the QCM performs a complete review of the Contractor's quality control process for these splices, 2) a written report is submitted to the Engineer describing the cause of failure for the splices in this lot and provisions for preventing similar failures in future lots, and 3) the Engineer has provided the Contractor with written notification that the report is acceptable. The Engineer shall have 3 working days after receipt of the report to provide notification to the Contractor. In the event the Engineer fails to provide notification

within the time allowed, and if, in the opinion of the Engineer, completion of the work is delayed or interfered with by reason of the Engineer's delay in providing notification, the Contractor will be compensated for any resulting loss, and an extension of time will be granted in the same manner as provided for in Section 8-1.09, "Right of Way Delays."

52-1.08C(1) Splice Prequalification Report

- Before using any service splices or ultimate butt splices in the work, the Contractor shall submit a Splice Prequalification Report. The report shall include splice material information, names of the operators who will be performing the splicing, and descriptions of the positions, locations, equipment, and procedures that will be used in the work.
- The Splice Prequalification Report shall also include certifications from the fabricator for prequalifications of operators and procedures based on sample tests performed no more than 2 years before submitting the report. Each operator shall be certified by performing 2 sample splices for each bar size of each splice type that the operator will be performing in the work. For deformation-dependent types of splice devices, each operator shall be certified by performing 2 additional samples for each bar size and deformation pattern that will be used in the work.
- Prequalification sample splices shall be tested by an independent qualified testing laboratory and shall conform to the appropriate production test criteria and slip requirements specified herein. When epoxy-coated reinforcement is required, resistance butt welded sample splices shall have the weld flash removed by the same procedure as will be used in the work, before coating and testing. The Splice Prequalification Report shall include the certified test results for all prequalification sample splices.
- The QCM shall review and approve the Splice Prequalification Report before submitting it to the Engineer for approval. The Contractor shall allow 2 weeks for the review and approval of a complete report before performing any service splicing or ultimate butt splicing in the work. In the event the Engineer fails to complete the review within the time allowed, and in the opinion of the Engineer, completion of the work is delayed or interfered with by reason of the Engineer's delay in completing the review, the Contractor will be compensated for any resulting loss, and an extension of time will be granted, in the same manner as provided for in Section 8-1.09, "Right of Way Delays."

52-1.08C(2) Service Splice Test Criteria

- • Service production and quality assurance sample splices shall be tensile tested in conformance with the requirements in ASTM Designation: A 370 and California Test 670 and shall develop a minimum tensile strength of not less than 80,000 psi.

52-1.08C(2)(a) Production Test Requirements for Service Splices

- Production tests shall be performed by the Contractor's independent laboratory for all service splices used in the work. A production test shall consist of testing 4 sample splices prepared for each lot of completed splices. The samples shall be prepared by the Contractor using the same splice material, position, operators, location, and equipment, and following the same procedure as used in the work.

- At least one week before testing, the Contractor shall notify the Engineer in writing of the date when and the location where the testing of the samples will be performed.
- The 4 samples from each production test shall be securely bundled together and identified with a completed sample identification card before shipment to the independent laboratory. The card will be furnished by the Engineer. Bundles of samples containing fewer than 4 samples of splices shall not be tested.
- Before performing any tensile tests on production test sample splices, one of the 4 samples shall be tested for, and shall conform to, the requirements for total slip. Should this sample not meet the total slip requirements, one retest, in which the 3 remaining samples are tested for total slip, will be allowed. Should any of the 3 remaining samples not conform to the total slip requirements, all splices in the lot represented by this production test will be rejected.
- If 3 or more sample splices from a production test conform to the provisions in this Section 52-1.08C(2),"Service Splice Test Criteria," all splices in the lot represented by this production test will be considered acceptable, provided each of the 4 samples develop a minimum tensile strength of not less than 60,000 psi.
- Should only 2 sample splices from a production test conform to the provisions in this Section 52-1.08C(2), "Service Splice Test Criteria," one additional production test shall be performed on the same lot of splices. This additional production test shall consist of testing 4 samples splices that have been randomly selected by the Engineer and removed by the Contractor from the actual completed lot of splices. Should any of the 4 splices from this additional test fail to conform to these provisions, all splices in the lot represented by these production tests will be rejected.
- If only one sample splice from a production test conforms to the provisions in this Section 52-1.08C(2), "Service Splice Test Criteria," all splices in the lot represented by this production test will be rejected.
- If a production test for a lot fails, the Contractor shall repair or replace all reinforcing bars from which sample splices were removed before the Engineer selects additional splices from this lot for further testing.

52-1.08C(2)(b) Quality Assurance Test Requirements for Service Splices

- For the first production test performed, and for at least one, randomly selected by the Engineer, of every 5 subsequent production tests, or portion thereof, the Contractor shall concurrently prepare 4 additional service quality assurance sample splices. These service quality assurance sample splices shall be prepared in the same manner as specified herein for service production sample splices.
- These 4 additional quality assurance sample splices shall be shipped to the Transportation Laboratory for quality assurance testing. The 4 sample splices shall be securely bundled together and identified by location and contract number with weatherproof markings before shipment. Bundles containing fewer than 4 samples of splices will not be tested. Sample splices not accompanied by the supporting documentation required in Section 52-1.08B(1), "Mechanical Splices," for mechanical splices, or in Section 52-1.08B(3), "Resistance Butt Welds," for resistance butt welds, will not be tested.

- Quality assurance testing will be performed in conformance with the requirements for service production sample splices in Section 52-1.08C(2)(a), "Production Test Requirements for Service Splices."

52-1.08C(3) Ultimate Butt Splice Test Criteria

- Ultimate production and quality assurance sample splices shall be tensile tested in conformance with the requirements described in ASTM Designation: A 370 and California Test 670.
- A minimum of one control bar shall be removed from the same bar as, and adjacent to, all ultimate production, and quality assurance sample splices. Control bars shall be 1) a minimum length of 4 feet for reinforcing bars No. 10 and smaller, and 6 feet for reinforcing bars No. 11 and larger, and 2) suitably identified before shipment with weatherproof markings that do not interfere with the Engineer's tamper-proof markings or seals. The portion of adjacent bar remaining in the work shall also be identified with weatherproof markings that correspond to its adjacent control bar.
- Each sample splice and its associated control bar shall be identified and marked as a set. Each set shall be identified as representing a prequalification, production, or quality assurance sample splice.
- The portion of hoop reinforcing bar, removed to obtain a sample splice and control bar, shall be replaced using a prequalified ultimate mechanical butt splice, or the hoop shall be replaced in kind.
- Reinforcing bars, other than hoops, from which sample splices are removed, shall be repaired using ultimate mechanical butt splices conforming to the provisions in Section 52-1.08C(1), "Splice Prequalification Report," or the bars shall be replaced in kind. These bars shall be repaired or replaced such that no splices are located in any "No Splice Zone" shown on the plans.
- Ultimate production and quality assurance sample splices shall rupture in the reinforcing bar either: 1) outside of the affected zone or 2) within the affected zone, provided that the sample splice has achieved at least 95 percent of the ultimate tensile strength of the control bar associated with the sample splice. In addition, necking of the bar, as defined in California Test 670, shall be evident at rupture regardless of whether the bar breaks inside or outside the affected zone.
- The affected zone is the portion of the reinforcing bar where any properties of the bar, including the physical, metallurgical, or material characteristics, have been altered by fabrication or installation of the splice.
- The ultimate tensile strength shall be determined for all control bars by tensile testing the bars to rupture, regardless of where each sample splice ruptures. If 2 control bars are tested for one sample splice, the bar with the lower ultimate tensile strength shall be considered the control bar.

52-1.08C(3)(a) Production Test Requirements for Ultimate Butt Splices

- Production tests shall be performed for all ultimate butt splices used in the work. A production test shall consist of testing 4 sets of sample splices and control bars removed from each lot of completed splices, except when quality assurance tests are performed.

- After the splices in a lot have been completed, and the bars have been epoxy-coated when required, the QCM shall notify the Engineer in writing that the splices in this lot conform to the specifications and are ready for testing. Except for hoops, sample splices will be selected by the Engineer at the job site. Sample splices for hoops will be selected by the Engineer either at the job site or a fabrication facility.
- After notification has been received, the Engineer will randomly select the 4 sample splices to be removed from the lot and place tamper-proof markings or seals on them. The Contractor shall select the adjacent control bar for each sample splice bar, and the Engineer will place tamper-proof markings or seals on them. These ultimate production sample splices and control bars shall be removed by the Contractor, and tested by an independent qualified testing laboratory.
- At least one week before testing, the Contractor shall notify the Engineer in writing of the date when and the location where the testing of the samples will be performed.
- A sample splice or control bar from any set will be rejected if a tamper-proof marking or seal is disturbed before testing.
- The 4 sets from each production test shall be securely bundled together and identified with a completed sample identification card before shipment to the independent laboratory. The card will be furnished by the Engineer. Bundles of samples containing fewer than 4 sets of splices shall not be tested.
- Before performing any tensile tests on production test sample splices, one of the 4 sample splices shall be tested for, and shall conform to, the requirements for total slip. Should this sample splice not meet these requirements, one retest, in which the 3 remaining sample splices are tested for total slip, will be allowed. Should any of the 3 remaining sample splices not conform to these requirements, all splices in the lot represented by this production test will be rejected.
- If 3 or more sample splices from a production test conform to the provisions in Section 52-1.08C(3), "Ultimate Butt Splice Test Criteria," all splices in the lot represented by this production test will be considered acceptable.
- Should only 2 sample splices from a production test conform to the provisions in Section 52-1.08C(3), "Ultimate Butt Splice Test Criteria," one additional production test shall be performed on the same lot of splices. Should any of the 4 sample splices from this additional test fail to conform to these provisions, all splices in the lot represented by these production tests will be rejected.
- If only one sample splice from a production test conforms to the provisions in Section 52-1.08C(3), "Ultimate Butt Splice Test Criteria," all splices in the lot represented by this production test will be rejected.
- If a production test for a lot fails, the Contractor shall repair or replace all reinforcing bars from which sample splices were removed, complete in place, before the Engineer selects additional splices from this lot for further testing.
- Production tests will not be required on repaired splices from a lot, regardless of the type of prequalified ultimate mechanical butt splice used to make the repair. However, should an additional production test be required, the Engineer may select any repaired splice for the additional production test.

52-1.08C(3)(b) Quality Assurance Test Requirements for Ultimate Butt Splices

- For the first production test performed, and for at least one, randomly selected by the Engineer, of every 5 subsequent production tests, or portion thereof, the Contractor shall concurrently prepare 4 additional ultimate quality assurance sample splices along with associated control bars.
- Each time 4 additional ultimate quality assurance sample splices are prepared, 2 of these quality assurance sample splice and associated control bar sets and 2 of the production sample splice and associated control bar sets, together, shall conform to the requirements for ultimate production sample splices in Section 52-1.08C(3)(a),"Production Test Requirements for Ultimate Butt Splices."
- The 2 remaining quality assurance sample splice and associated control bar sets, along with the 2 remaining production sample splice and associated control bar sets shall be shipped to the Transportation Laboratory for quality assurance testing. The 4 sets shall be securely bundled together and identified by location and contract number with weatherproof markings before shipment. Bundles containing fewer than 4 sets will not be tested.
- Quality assurance testing will be performed in conformance with the requirements for ultimate production sample splices in Section 52-1.08C(3)(a), "Production Test Requirements for Ultimate Butt Splices."

52-1.08C(3)(c) Nondestructive Splice Tests

- When the specifications allow for welded sample splices to be taken from other than the completed lot of splices, the Contractor shall meet the following additional requirements.
- Except for resistance butt welded splices, radiographic examinations shall be performed on 25 percent of all complete joint penetration butt welded splices from a production lot. The size of a production lot will be a maximum of 150 splices. The Engineer will select the splices which will compose the production lot and also the splices within each production lot to be radiographically examined.
- All required radiographic examinations of complete joint penetration butt welded splices shall be performed by the Contractor in conformance with the requirements in AWS D 1.4 and these specifications.
- Before radiographic examination, welds shall conform to the requirements in Section 4.4, "Quality of Welds," of AWS D 1.4.
- Should more than 12 percent of the splices which have been radiographically examined in any production lot be defective, an additional 25 percent of the splices, selected by the Engineer from the same production lot, shall be radiographically examined. Should more than 12 percent of the cumulative total of splices tested from the same production lot be defective, all remaining splices in the lot shall be radiographically examined.
- Additional radiographic examinations performed due to the identification of defective splices shall be at the Contractor's expense.
- All defects shall be repaired in conformance with the requirements in AWS D 1.4.
- The Contractor shall notify the Engineer in writing 48 hours before performing any radiographic examinations.

- The radiographic procedure used shall conform to the requirements in AWS D1.1, AWS D1.4, and the following:

A. Two exposures shall be made for each complete joint penetration butt welded splice. For each of the 2 exposures, the radiation source shall be centered on each bar to be radiographed. The first exposure shall be made with the radiation source placed at zero degrees from the top of the weld and perpendicular to the weld root and identified with a station mark of "0." The second exposure shall be at 90 degrees to the "0" station mark and shall be identified with a station mark of "90." When obstructions prevent a 90 degree placement of the radiation source for the second exposure, and when approved in writing by the Engineer, the source may be rotated, around the centerline of the reinforcing bar, a maximum of 25 degrees.

B. For field produced complete joint penetration butt welds, no more than one weld shall be radiographed during one exposure. For shop produced complete joint penetration butt welds, if more than one weld is to be radiographed during one exposure, the angle between the root line of each weld and the direction to the radiation source shall be not less than 65 degrees.

C. Radiographs shall be made by either X-ray or gamma ray. Radiographs made by X-ray or gamma rays shall have densities of not less than 2.3 nor more than 3.5 in the area of interest. A tolerance of 0.05 in density is allowed for densitometer variations. Gamma rays shall be from the iridium 192 isotope and the emitting specimen shall not exceed 0.18 inch in the greatest diagonal dimension.

D. The radiographic film shall be placed perpendicular to the radiation source at all times; parallel to the root line of the weld unless source placement determines that the film must be turned; and as close to the root of the weld as possible.

E. The minimum source to film distance shall be maintained so as to ensure that all radiographs maintain a maximum geometric unsharpness of 0.020 at all times, regardless of the size of the reinforcing bars.

F. Penetrameters shall be placed on the source side of the bar and perpendicular to the radiation source at all times. One penetrameter shall be placed in the center of each bar to be radiographed, perpendicular to the weld root, and adjacent to the weld. Penetrameter images shall not appear in the weld area.

G. When radiography of more than one weld is being performed per exposure, each exposure shall have a minimum of one penetrameter per bar, or 3 penetrameters per exposure. When 3 penetrameters per exposure are used, one penetrameter shall be placed on each of the 2 outermost bars of the exposure, and the remaining penetrameter shall be placed on a centrally located bar.

H. An allowable weld buildup of 0.16 inch may be added to the total material thickness when determining the proper penetrameter selection. No image

quality indicator equivalency will be accepted. Wire penetrameters or penetrameter blocks shall not be used.

I. Penetrameters shall be sufficiently shimmed using a radiographically identical material. Penetrameter image densities shall be a minimum of 2.0 and a maximum of 3.6.

J. Radiographic film shall be Class 1, regardless of the size of reinforcing bars.

K. Radiographs shall be free of film artifacts and processing defects, including, but not limited to, streaks, scratches, pressure marks or marks made for the purpose of identifying film or welding indications.

L. Each splice shall be clearly identified on each radiograph and the radiograph identification and marking system shall be established between the Contractor and the Engineer before radiographic inspection begins. Film shall be identified by lead numbers only; etching, flashing or writing in identifications of any type will not be permitted. Each piece of film identification information shall be legible and shall include, as a minimum, the following information: Contractor's name, date, name of nondestructive testing firm, initials of radiographer, contract number, part number and weld number. The letter "R" and repair number shall be placed directly after the weld number to designate a radiograph of a repaired weld.

M. Radiographic film shall be developed within a time range of one minute less to one minute more than the film manufacturer's recommended maximum development time. Sight development will not be allowed.

N. Processing chemistry shall be done with a consistent mixture and quality, and processing rinses and tanks shall be clean to ensure proper results. Records of all developing processes and any chemical changes to the developing processes shall be kept and furnished to the Engineer upon request. The Engineer may request, at any time, that a sheet of unexposed film be processed in the presence of the Engineer to verify processing chemical and rinse quality.

O. The results of all radiographic interpretations shall be recorded on a signed certification and a copy kept with the film packet.

P. Technique sheets prepared in conformance with the requirements in ASME Boiler and Pressure Vessels Code, Section V, Article 2 Section T-291 shall also contain the developer temperature, developing time, fixing duration and all rinse times.

52-1.08D Reporting Test Results

A Production Test Report for all testing performed on each lot shall be prepared by the independent testing laboratory performing the testing and submitted to the QCM for review and approval. The report shall be signed by an engineer who represents the laboratory and is registered as a Civil Engineer in the State of California. The report shall include, as a minimum, the following information for each test: contract number, bridge number, lot number and location, bar size, type of splice, length of mechanical splice, length of test specimen, physical condition of test sample splice and any associated control bar,

any notable defects, total measured slip, ultimate tensile strength of each splice, and for ultimate butt splices, limits of affected zone, location of visible necking area, ultimate tensile strength and 95 percent of this ultimate tensile strength for each control bar, and a comparison between 95 percent of the ultimate tensile strength of each control bar and the ultimate tensile strength of its associated splice.

- The QCM must review, approve, and forward each Production Test Report to the Engineer for review before the splices represented by the report are encased in concrete. The Engineer will have 3 working days to review each Production Test Report and respond in writing after a complete report has been received. Should the Contractor elect to encase any splices before receiving notification from the Engineer, it is expressly understood that the Contractor will not be relieved of the responsibility for incorporating material in the work that conforms to the requirements of the plans and specifications. Material not conforming to these requirements will be subject to rejection. Should the Contractor elect to wait to encase splices pending notification by the Engineer, and in the event the Engineer fails to complete the review and provide notification within the time allowed, and if, in the opinion of the Engineer, the work is delayed or interfered with by reason of the Engineer's delay in completing the review, the Contractor will be compensated for any resulting loss, and an extension of time will be granted, in the same manner as provided for in Section 8-1.09, "Right of Way Delays."
- Quality assurance test results for each bundle of 4 sets or 4 samples of splices will be reported in writing to the Contractor within 3 working days after receipt of the bundle by the Transportation Laboratory. In the event that more than one bundle is received on the same day, 2 additional working days shall be allowed for providing test results for each additional bundle received. A test report will be made for each bundle received. Should the Contractor elect to encase splices before receiving notification from the Engineer, it is expressly understood that the Contractor will not be relieved of the responsibility for incorporating material in the work that conforms to the requirements of the plans and specifications. Material not conforming to these requirements will be subject to rejection. Should the Contractor elect to wait to encase splices pending notification by the Engineer, and in the event the Engineer fails to complete the review within the time allowed, and in the opinion of the Engineer, completion of the work is delayed or interfered with by reason of the Engineer's delay in completing the review, the Contractor will be compensated for any resulting loss, and an extension of time will be granted, in the same manner as provided for in Section 8-1.09, "Right of Way Delays."

52-1.09 (BLANK)

52-1.10 MEASUREMENT

- Quantities of bar reinforcing steel and reinforcing wire placed as reinforcement as shown on the plans or directed by the Engineer will be determined from computations based upon the calculated weight of the reinforcing steel and wire placed in accordance with these specifications.
- No allowance will be made for the weight of epoxy coating in computing the weight of epoxy-coated bar reinforcing steel to be paid for.

- The lap of bars for all splices, including splices shown on the plans where a continuous bar is used, will be measured for payment. The weight calculated shall be based upon the following table:

Bar Reinforcing Steel

Deformed Bar Designation Number	Weight (Pounds Per Linear Foot)	Nominal Diameter (Inches)
3	0.376	0.375
4	0.668	0.500
5	1.043	0.625
6	1.502	0.750
7	2.044	0.875
8	2.670	1.000
9	3.400	1.128
10	4.303	1.270
11	5.313	1.410
14	7.650	1.693
18	13.600	2.257

Bar numbers approximate the number of eighths of an inch included in the nominal diameter of the bars. The nominal diameter of a deformed bar is equivalent to the diameter of a plain round bar having the same weight per linear foot as the deformed bar.

- The cross sectional area of reinforcing wire, in hundredths of square inches, will be assumed to be equal to its W-Size Number and the density of reinforcing wire will be assumed to be 0.2833-pound per cubic inch.
- Quantities of welded wire fabric placed as shown on the plans or directed by the Engineer will be determined from measurements taken of the area covered by the welded wire fabric, with no allowance for laps.
- The exercise of the splicing options by the Contractor as provided in Section 52-1.08, "Splicing," will not be considered as a change in the dimensions of the work.
- Whenever alternative bridge deck reinforcement placement details are shown on the plans, the quantities of bar reinforcing steel will be computed on the basis of the dimensions and details of placement detail 5-10, and no change in the quantities to be paid for will be made because of the use by the Contractor of the alternative details.
- Whenever any other alternative or option is shown or noted on the plans, or permitted by these specifications or the special provisions, the quantities of bar reinforcing steel and welded wire fabric will be computed on the basis of the dimensions, details and type of reinforcement shown on the plans, and no change in the quantities to be paid for will be made because of the use by the Contractor of the alternatives or options.

52-1.11 PAYMENT

- Unless otherwise provided, bar reinforcing steel placed as shown on the plans or directed by the Engineer, will be paid for at the contract price per pound for bar reinforcing steel. Reinforcing wire used as reinforcing steel will be paid for as bar reinforcing steel.

- The contract price paid per pound for the types and classes of bar reinforcing steel shown on the plans shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in furnishing and placing the bar reinforcing steel and reinforcing wire, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- Unless otherwise provided, welded wire fabric placed as shown on the plans or directed by the Engineer will be paid for at the contract price per square yard for welded wire fabric, with no allowance for laps, which price shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in furnishing and placing the welded wire fabric, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- When the contract does not include a contract pay item for welded wire fabric, welded wire fabric will be paid for as bar reinforcing steel except when full compensation for the welded wire fabric is specifically included in the contract prices paid for shotcrete or concrete work involved.
- Full compensation for furnishing all tie wires, blocks, chairs and other supporting devices shall be considered as included in the contract prices paid for reinforcement and no separate payment will be made therefor.
- Full compensation for furnishing and testing sample splices, for radiographic examinations performed by the Contractor, and for furnishing access facilities for inspection and nondestructive testing by the Engineer shall be considered as included in the contract price paid per pound for the bar reinforcing steel involved and no additional compensation will be allowed therefor.
- Full compensation for coating epoxy-coated bar reinforcing steel as specified shall be considered as included in the contract price paid per pound for the epoxy-coated reinforcing steel involved and no additional compensation will be allowed therefor.
- If a portion or all of the reinforcing steel is epoxy-coated more than 300 air line miles from both Sacramento and Los Angeles, additional shop inspection expenses will be sustained by the State. Whereas it is and will be impracticable and extremely difficult to ascertain and determine the actual increase in these expenses, it is agreed that payment to the Contractor for furnishing the epoxy-coated reinforcement will be reduced $5,000 for each epoxy-coating facility located more than 300 air line miles from both Sacramento and Los Angeles and an additional $3,000 ($8,000 total) for each epoxy-coating facility located more than 3,000 air line miles from both Sacramento and Los Angeles.
- The quantities of bar reinforcing steel required in concrete piling, including the length extending into caps or footings, will not be paid for as a separate item and full compensation therefor will be considered as included in the contract price paid per linear foot for concrete piling, unless otherwise specified in the special provisions.
- The quantities of bar reinforcing steel required in precast concrete members, including the length extending beyond the limits of concrete in the members, will

not be paid for as a separate item and full compensation therefor will be considered as included in the contract price paid for furnishing the members.

- The quantities of bar reinforcing steel required for minor structures as provided in Section 51-1.02, "Minor Structures," will not be paid for as a separate item and full compensation therefor will be considered as included in the contract price paid per cubic yard for minor concrete (minor structure) or for concrete (minor structure) of the class specified in the Engineer's Estimate.
- The quantities of bar reinforcing steel required for structure approach slabs will not be paid for as a separate item and full compensation therefor will be considered as included in the contract price paid per cubic yard for structural concrete, approach slab.
- The quantities of bar reinforcing steel required in concrete barriers, including the length extending into decks, walls or footings, will not be paid for as a separate item and full compensation therefor will be considered as included in the contract price paid per linear foot for concrete barrier of the type or types specified in the Engineer's Estimate.
- Bar reinforcing steel involved in the bridge work, as listed under "Description of Bridge Work" of the special provisions, except bar reinforcing steel involved in components of the work for which payment is made under separate contract items, and where that payment expressly includes the reinforcing steel involved, will be paid for at the contract price per pound for bar reinforcing steel (bridge) or per pound for bar reinforcing steel (epoxy-coated) (bridge).

SECTION 53: SHOTCRETE

53-1.01 DESCRIPTION

- This work shall consist of lining ditches and channels, paving slopes, and constructing warped sections and other similar features with shotcrete in accordance with the details and dimensions shown on the plans and as specified in these specifications and the special provisions.
- Shotcrete shall consist of concrete or mortar pneumatically applied onto a surface. Shotcrete shall be applied by either the dry-mix process or the wet-mix process, at the option of the Contractor.
- The dry-mix process shall consist of delivering dry mixed aggregate and cement pneumatically or mechanically to the nozzle body, and adding water and mixing the materials in the nozzle body. The wet-mix process shall consist of delivering mixed aggregate, cement and water pneumatically to the nozzle, and adding any admixture at the nozzle.

53-1.02 MATERIALS

- Portland cement, fine aggregate and mixing water shall conform to the provisions in Section 90, "Portland Cement Concrete."
- Shotcrete to be mixed and applied by the dry-mix process shall consist of one part portland cement to not more than 4.5 parts fine aggregate, thoroughly mixed in a dry state before being charged into the machine. Measurement may be either by volume or by weight. The fine aggregate shall contain not more than 6 percent moisture by weight.
- Shotcrete to be mixed and applied by the wet-mix process shall consist of cement, fine aggregate and water, and shall contain not less than 632 pounds of portland cement per cubic yard. A maximum of 30 percent pea gravel may be substituted for fine aggregate. The maximum size of pea gravel shall be such that 100 percent passes the $^{1}/_{2}$ inch screen and at least 90 percent passes the $^{3}/_{8}$ inch screen.
- Admixtures may be added to shotcrete mixed and applied by the wet-mix process, as provided in Section 90-4, "Admixtures."
- When required by the plans or the special provisions, shotcrete shall be colored by mixing a fine ground, synthetic mineral oxide, specifically manufactured for coloring concrete, into the shotcrete. The coloring agent shall be uniformly and homogeneously mixed with the shotcrete. The color of the completed shotcrete, after curing and when air dry, shall conform closely to Color No. 30450 of Federal Standard No. 595B or to such other color specified in the special provisions or shown on the plans.
- Reinforcement, if required, shall conform to the provisions in Section 52, "Reinforcement."

53-1.03 PREPARATION OF FOUNDATION

- The foundation for areas to receive shotcrete shall be evenly graded before the shotcrete is applied and no point on the graded slope shall be above the slope plane shown on the plans or directed by the Engineer.

- The areas shall be thoroughly compacted, with sufficient moisture to provide a firm foundation and to prevent absorption of water from the shotcrete, but shall not contain free surface water.
- When shown on the plans, joints, side forms and shooting strips shall be provided for backing or paneling. Ground or gaging wires shall be used where necessary to establish thicknesses, surface planes and finish lines.

53-1.04 PLACING SHOTCRETE

- The nozzle shall be directed in such a manner as to result in minimum rebound of the shotcrete.
- The velocity of the material as it leaves the nozzle shall be maintained uniform and at a rate determined for the given job conditions.
- Placing dry-mix shotcrete shall conform to the following:

  A. A constant pressure of not less than 45 psi shall be maintained in the placing machine where the hose length is 100 feet or less, and the pressure shall be increased at least 5 psi for each additional 50 feet of hose or fraction thereof.
  B. Water at the nozzle shall be maintained at a uniform pressure, which shall not be less than 15 psi greater than the air pressure at the machine.
  C. Aggregate and cement that have been mixed for more than 45 minutes shall not be used, unless otherwise permitted by the Engineer.

- Transporting and placing wet-mix shotcrete shall conform to the following:

  A. Transporting wet-mixed shotcrete shall conform to the provisions for transporting concrete in Section 90-6.03, "Transporting Mixed Concrete."
  B. The placing shall be limited to 8-foot lifts measured along the slopes, and gaging wires shall be placed at approximately 7-foot centers.
  C. Materials that have been mixed for more than 90 minutes shall not be used unless otherwise permitted by the Engineer.

53-1.05 REBOUND

- Rebound, consisting of shotcrete material that has ricocheted off the receiving surface, which is recovered and which is clean and free of foreign material, may be reused as fine aggregate in quantities not to exceed 20 percent of the total fine aggregate requirements.

53-1.06 FINISHING

- After the shotcrete has been placed as nearly as practicable to the required depth, the surface shall be checked with a straightedge, and any low spots or depressions shall be brought to grade by placing additional shotcrete in such a manner that the finished surface will be reasonably smooth and uniform for the type of work involved.
- Loose areas of shotcrete shall be removed and replaced by the Contractor at the Contractor's expense.
- Shotcrete shall be cured as provided in Section 90-7, "Curing Concrete," and shall be protected as provided in Section 90-8, "Protecting Concrete."

- If a coloring agent is added and the Contractor elects to use the curing compound method for curing shotcrete, the curing compound shall be curing compound (6) specified in Section 90-7.

53-1.07 MEASUREMENT

- Quantities of shotcrete in lining ditches and channels, paving slopes, and constructing warped sections and other similar features will be measured by the cubic yard computed from measurements, along the slope, of actual areas placed and the theoretical thickness shown on the plans. Shotcrete placed outside the dimensions shown on the plans or to fill low foundation will not be paid for.

53-1.08 PAYMENT

- The contract price paid per cubic yard for shotcrete shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in placing shotcrete, including preparing the foundation, reinforcement, structure backfill, joint filling material and if required by the plans, drains with sacked pervious backfill material, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 54: WATERPROOFING

54-1.01 DESCRIPTION

- This work shall consist of furnishing and applying asphalt membrane waterproofing or dampproofing to the surface of the concrete as shown on the plans and as specified in these specifications and the special provisions. Asphalt membrane waterproofing consists of a coating of primer and a firmly bonded membrane composed of 2 layers of saturated glass fabric and 3 moppings of waterproofing asphalt. Dampproofing consists of a coating of primer and 2 moppings of waterproofing asphalt.

54-1.02 MATERIALS

- Waterproofing asphalt shall conform to the requirements in ASTM Designation: D 312, Type I for below ground and Type II for above ground.
- Primer for use with asphalt in waterproofing below and above ground level shall conform to the requirements in ASTM Designation: D 41.
- Treated glass fabric shall conform to the requirements in ASTM Designation: D 1668 for woven glass fabric treated with asphalt.

54-1.03 APPLICATION

- Concrete surfaces which are to be waterproofed shall be reasonably smooth and free from holes and projections which might puncture the membrane. The surface to be waterproofed or dampproofed shall be dry and shall be thoroughly cleaned of dust and loose materials.
- No primer or asphalt shall be applied in wet weather, nor when the temperature is below 65º F, without authorization in writing from the Engineer.
- The primer shall be applied to the surface and allowed to dry before the first coat of asphalt is applied.
- The waterproofing asphalt shall be applied at a temperature of not less than 300º F, nor more than 350º F.

54-1.03A Asphalt Membrane Waterproofing

- Asphalt membrane waterproofing shall not be applied to any surface until the Contractor is prepared to follow its application with the placing of the backfill within a sufficiently short time that the waterproofing will not be damaged as a result of exposure. Any waterproofing membrane which loses its bond with the concrete shall be removed and replaced with new membrane waterproofing by the Contractor at the Contractor's expense.
- Beginning at the low point of the surface to be waterproofed, the waterproofing asphalt shall be thoroughly mopped onto the primed surface. A strip of fabric of half the width of the roll shall be rolled onto the hot asphalt immediately and pressed into place so as to eliminate all air bubbles and obtain close conformity with the surface. This strip and an adjacent section of the surface of a width equal to slightly more than one-half the width of the fabric being used, shall then be mopped with hot asphalt and a full width of the fabric shall be rolled into this, completely covering the first strip, and shall be pressed into place as before. This second strip and an adjacent section of the concrete surface shall then be mopped with hot asphalt and the third strip of fabric shingled on so as to lap the first strip by

not less than 2 inches. This process shall be continued until the entire surface is covered, each strip of fabric lapping at least 2 inches over the last strip. The entire surface shall then be mopped with hot asphalt. Special care shall be taken at all laps to see that the laps are thoroughly sealed down.

- The work shall be so regulated that at the close of the day's work the final mopping of asphalt shall have been applied to all the fabric in place.

54-1.03B Dampproofing

- The surface to be dampproofed shall be primed and then thoroughly mopped with waterproofing asphalt. When the first mopping of asphalt has set sufficiently, the entire surface shall then be mopped with the second coating of hot asphalt. Special care shall be taken to see that there are no skips in the coatings and that all surfaces are thoroughly covered.

54-1.04 MEASUREMENT

- Quantities of asphalt membrane waterproofing or dampproofing placed as shown on the plans or directed by the Engineer will be measured by the square foot as determined from measurement of the area covered by the membrane waterproofing or dampproofing.

54-1.05 PAYMENT

- The contract price paid per square foot for asphalt membrane waterproofing or dampproofing shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in applying the waterproofing membrane or dampproofing, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 55: STEEL STRUCTURES

55-1 GENERAL

55-1.01 DESCRIPTION

- This work shall consist of constructing steel structures in conformance with the details shown on the plans and as specified in these specifications and the special provisions.
- The Contractor shall furnish, fabricate and erect the structural steel or metalwork, construct and remove the temporary construction and do all work required to complete the bridge or bridges.
- Details of connections for highway bridges selected for use by the Contractor shall conform to the AASHTO LRFD Bridge Design Specifications with Caltrans Amendments.
- Details of design selected by the Contractor, fabrication and workmanship, for steel railway bridges shall conform to the requirements of the Specifications for Steel Railway Bridges, for Fixed Spans Not Exceeding 400 Feet in Length of the AREMA, as set forth in the special provisions.

55-1.02 DRAWINGS

- The Contractor shall submit working drawings for structural steel to the Offices of Structure Design for approval in conformance with the provisions in Section 5-1.02, "Plans and Working Drawings." For initial review, 6 sets of the drawings shall be submitted for highway bridges and 10 sets shall be submitted for railroad bridges. After review, between 6 and 12 sets, as requested by the Engineer, shall be submitted to Offices of Structure Design for final approval and for use during construction.
- The working drawings shall show details of any permitted options proposed in the work, details for connections not dimensioned on the plans, the direction of rolling of plates where specific orientation is required, the sequence of shop and field assembly and erection, welding sequences and procedures, the location of all butt welded splices on a layout drawing of the entire structure, the location of any temporary supports that are to be used and the vertical alignment of the girder at each stage of the erection. Substantiating camber calculations shall be submitted with the working drawings.
- The working drawings shall be supplemented by a written quality control program listing methods and personnel to satisfy the requirements of AASHTO/AWS D1.5.
- Working drawings shall be 22" x 34" or 11" x 17" in size and each drawing and calculation sheet shall include the jobsite name of the structure as shown on the contract plans, District-County-Route, bridge number and contract number.
- Working drawings shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the Engineer and correction by the Contractor of the drawings without delaying the work. The time shall be proportional to the complexity of the work, but in no case shall the time be less than 6 weeks for highway bridges or 8 weeks for railroad bridges.

- For railroad bridges, approval by the Engineer of the working drawings will be contingent upon the working drawings being satisfactory to the railroad company involved.
- At the completion of each structure on the contract, one set of reduced prints on 20-pound (minimum) bond paper, 11" x 17" in size, of the corrected original tracings of all working drawings for each structure shall be furnished to the Engineer. Reduced prints that are common to more than one structure shall be submitted for each structure. An index prepared specifically for the drawings for each structure containing sheet numbers and titles shall be included on the first reduced print in the set for each structure. Reduced prints for each structure shall be arranged in the order of drawing numbers shown in the index.
- The edge of the corrected original tracing image shall be clearly visible and visually parallel with the edges of the page. A clear, legible symbol shall be provided on the upper left side of each page to show the amount of reduction and a horizontal and vertical scale shall be provided on each reduced print to facilitate enlargement to original scale.
- For railroad bridges, in addition to the reduced prints of the working drawings, the Contractor shall furnish to the Engineer one set of working drawings consisting of either ink tracings on cloth, ink tracings on polyester base drafting film, silver sensitized cloth duplicate tracings or silver sensitized polyester based reproduction films with matte surface on both sides.

55-1.03 INSPECTION

- Structural steel will be inspected at the fabrication site. The Contractor shall notify the Engineer when materials have been delivered to the fabrication site and shall give the Engineer at least 10 days notice after delivery before commencing the fabrication of any structural steel.
- The Contractor shall furnish to the Engineer a copy of all mill orders, certified mill test reports and Certificates of Compliance for all fabricated structural steel to be used in the work other than steel which is to be used under the provisions in Section 55-2.07, "Unidentified Stock Material," and other reports or certificates required by the specifications. Certified mill test reports for steels with specified impact values shall include, in addition to other test results, the results of Charpy V-notch impact tests. When fine grain steel is specified, the test report shall include the grain size. Copies of mill orders shall be furnished at the time orders are placed with the manufacturer. Certified mill test reports shall be furnished prior to the start of fabrication. The Certificate of Compliance shall be submitted in conformance with the provisions in Section 6-1.07, "Certificates of Compliance," shall be signed by the fabricator and shall certify to the State of California the specifications to which the material has been fabricated and tested, and that the material is in conformance with those specifications and test requirements.
- Material to be used shall be made available to the Engineer so that each piece can be examined. The Engineer shall have free access at all times to any portion of the fabrication site where the material is stored or where work on the material is being performed.

55-1.04 SHIPPING, HANDLING AND STORING MATERIALS

- Members weighing more than 3 tons shall have the weight marked thereon.
- In handling and shipping of the steel work, every care shall be taken to avoid bending, scraping or overstressing the pieces. All pieces bent or otherwise injured will be rejected.
- The loading, transporting and unloading of structural material shall be so conducted that the metal will be kept clean. Material to be stored shall be placed above the ground upon platforms, skids or other supports and shall be kept free from dirt, grease and other foreign material and properly drained and protected from corrosion. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent damage from deflection.

55-1.05 FALSEWORK

- Falsework used for the erection of structural steel shall conform to the provisions in Section 51-1.06, "Falsework," except that dead loads shall consist of the weight of the structural steel and any other portions of the structure which are supported by the falsework.
- Falsework and forms supporting the concrete work on steel structures shall be constructed so that any loads applied to girder webs shall be applied within 6 inches of a flange or stiffener and shall be distributed in a manner that will not produce local distortion of the web. Temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girder flanges and to prevent appreciable relative vertical movement between the edge of deck form and the adjacent steel girder.
- Construction methods and equipment employed by the Contractor shall conform to the provisions in Section 7-1.02, "Load Limitations." Loads imposed on existing, new or partially completed structures shall not exceed the load carrying capacity of the structure, or portion of structure, as determined by the AASHTO LRFD Bridge Design Specifications with Caltrans Amendments.

55-1.06 CONTINUOUS MEMBERS

- Unless otherwise noted on the plans, structural steel girders have been designed for continuity in supporting girder dead load. The Contractor may, as an option, erect the girders in such a manner that the girder continuity for dead load is or is not as assumed in design. Furnishing and erecting the girders shall be subject to the requirements in this section.
- If erection procedures are to be used which will provide the designed girder continuity for dead load, the Contractor shall furnish to the Engineer for review a statement of intended steel erection procedures with calculations in sufficient detail to substantiate that the girder geometry will be correct.
- If erection procedures are to be used which will provide the designed girder continuity for dead load, members with field joints shall be preassembled in a no-load condition in a horizontal or an upright position.
- If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the Contractor shall furnish to the Engineer for review a statement of steel erection procedures with

calculations, in sufficient detail to substantiate that girder capacity and geometry will be correct.

- If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the structure shall, after erection, have a load carrying capacity at least equal to the designed structure shown on the plans. The Contractor may increase the cross-sectional area or change the grades of steel to provide the specified load carrying capacity, subject to approval by the Engineer. Any additional steel or higher strength steels required to accommodate the method of erection selected shall be considered to be for the convenience of the Contractor and no additional payment will be made therefor.

55-2 MATERIALS

55-2.01 DESCRIPTION

- The various materials shall conform to the requirements in ASTM as listed in the table entitled "Structural Steel Materials" at the end of this Section 55-2.01.
- Coiled steel plate shall not be used for the fabrication of flanges, eyebars and hanger plates nor for splice plates for flanges and eyebars.
- All structural steel precut prior to arrival at the fabrication site shall be cut so that the plate orientation conforms to the provisions in Section 55-3.03, "Orientation of Plates."
- All structural steel plate used for the fabrication of tension members, tension flanges, eyebars and hanger plates and for splice plates of tension members, tension flanges and eyebars shall meet the longitudinal Charpy V-notch impact value requirements specified herein. Sampling procedures shall conform to the requirements in ASTM Designation: A 673. The H (Heat) frequency of testing shall be used for structural steels conforming to the requirements in ASTM Designations: A 709/A 709M, Grades 36, 50, 50W, and HPS 50W. The P (Piece) frequency of testing shall be used for structural steel conforming to the requirements in ASTM Designation: A 709/A 709M, Grades HPS 70W, 100, and 100W. Charpy V-notch impact values shall be determined in conformance with the requirements in ASTM Designation: E 23.

- Charpy V-notch (CVN) impact values shall conform to the following minimum values for non fracture critical members:

Material Conforming to ASTM Designation: A 709/A 709M	CVN Impact Value (Ft. Lbs at Temp.)
Grade 36	15 at 40º F
Grade 50* (2 inches and under in thickness)	15 at 40º F
Grade 50W* (2 inches and under in thickness)	15 at 40º F
Grade 50* (Over 2 inches to 4 inches in thickness)	20 at 40º F
Grade 50W* (Over 2 inches to 4 inches in thickness)	20 at 40º F
Grade HPS 50W* (4 inches and under in thickness)	20 at -10º F
Grade HPS 70W* (4 inches and under in thickness)	25 at -10º F
Grade 100 ($2^1/_2$ inches and under in thickness)	25 at 0º F
Grade 100W (Over $2^1/_2$ inches to 4 inches in thickness)	35 at 0º F

* If the yield point of the material exceeds 65,000 psi, the temperature for the CVN impact value for acceptability shall be reduced 15º F for each increment of 10,000 psi above 65,000 psi

Structural Steel Materials

Material	Specification
Structural steel:	
Carbon steel	ASTM: A 709/A 709M, Grade 36 or {A 36/A 36M}[a]
High strength low alloy columbium vanadium steel	ASTM: A 709/A 709M, Grade 50 or {A 572/A 572M, Grade 50}[a]
High strength low alloy structural steel	ASTM: A 709/A 709M, Grade 50W, Grade HPS 50W, or {A 588/A 588M}[a]
High strength low alloy structural steel plate	ASTM: A 709/A 709M, Grade HPS 70W
High-yield strength, quenched and tempered alloy steel plate suitable for welding	ASTM: A 709/A 709M, Grade 100 and Grade 100W, or {A 514/A 514M}[a]
Steel fastener components for general applications:	
Bolts and studs	ASTM: A 307
Headed anchor bolts	ASTM: A 307, Grade B, including S1 supplementary requirements
Nonheaded anchor bolts	ASTM: A 307, Grade C, including S1 supplementary requirements and S1.6 of AASHTO: M 314 supplementary requirements or AASHTO: M 314, Grade 36 or 55, including S1 supplementary requirements
High-strength bolts and studs	ASTM: A 449, Type 1
High-strength threaded rods	ASTM: A 449, Type 1
High-strength nonheaded anchor bolts	ASTM: A 449, Type 1
Nuts	ASTM: A 563, including Appendix X1[b]
Washers	ASTM: F 844
Components of high-strength steel fastener assemblies for use in structural steel joints:	
Bolts	ASTM: A 325, Type 1
Tension control bolts	ASTM: F 1852, Type 1
Nuts	ASTM: A 563, including Appendix X1[b]
Hardened washers	ASTM : F 436, Type 1, Circular, including S1 supplementary requirements
Direct tension indicators	ASTM: F 959, Type 325, zinc-coated
Carbon steel for forgings, pins and rollers	ASTM: A 668/A 668M, Class D
Alloy steel for forgings	ASTM: A 668/A 668M, Class G
Pin nuts	ASTM: A 36/A 36M
Carbon-steel castings	ASTM: A 27/A 27M, Grade 65-35, Class 1
Malleable iron castings	ASTM: A 47, Grade 32510 or A 47M, Grade 22010
Gray iron castings	ASTM: A 48, Class 30B
Carbon steel structural tubing	ASTM: A 500, Grade B or A 501
Steel pipe (Hydrostatic testing will not apply)	ASTM: A 53, Type E or S, Grade B; A 106, Grade B; or A 139, Grade B
Stud connectors	ASTM: A 108 and AASHTO/AWS D1.5

a Grades that may be substituted for the equivalent ASTM Designation: A 709 steel, at the Contractor's option, subject to the modifications and additions specified and to the requirements of A 709.

b Zinc-coated nuts that will be tightened beyond snug or wrench tight shall be furnished with a dry lubricant conforming to Supplementary Requirement S2 in ASTM Designation: A 563.

55-2.02 STRUCTURAL STEEL

- Unless otherwise specified or shown on the plans, all structural steel plates, shapes and bars shall conform to ASTM Designation: A 709/A 709M, Grade 50. At the option of the Contractor, girder flange plates shown on the plans may be increased in thickness, and may be increased in length provided that the change does not involve a decrease in detailed thickness of any portion of the plates. For continuous girders, increases in length of girder flange plates which involve changes in locations of butt welds between different thicknesses of flange plates shall be approved in writing by the Engineer prior to fabrication.
- When stud type shear connectors longer than 8 inches are to be used, the connectors may consist of 2 or more shorter studs of the type shown on the plans connected together with full penetration welds.
- Rolled shapes may be substituted for the welded sections, and welded sections may be substituted for the rolled shapes shown on the plans, provided that the shapes and sections to be substituted comply with the following provisions:

A. The depth, width and average thicknesses shall be at least equal to those for the shape or section shown on the plans.
B. For welded sections, the flanges shall be welded to the web with continuous fillet welds on each side of the web, and the welding shall conform to the provisions in Section 55-3.17, "Welding."
C. The strength classification of the material shall not be reduced.

55-2.03 CASTINGS

- Steel, gray iron and malleable iron castings shall be provided with adequate continuous fillets cast in place in all re-entrant angles. The radius of curvature of the exposed surface of a fillet shall define the size of the fillet. The size of fillets shall not be less than one-half of the thickness of the thinnest adjoined member nor less than $^1/_2$ inch.
- The dimensions of the finished casting shall not be less than the specified dimensions. Castings shall not be more than 7.5 percent overweight. Large castings shall be suspended and hammered over their entire area. No cracks, flaws or other defects shall appear after the hammering.

55-2.04 BEARING PADS

- Preformed fabric pads shall be composed of multiple layers of cotton duck impregnated and bound with rubber, compressed into resilient pads of uniform thickness conforming to Military Specification MIL-C-882. The number of plies shall be such as to produce the specified thickness after compression and vulcanizing. The finished pads shall withstand compression loads perpendicular to the plane of the laminations of not less than 10,000 psi without detrimental extrusion or reduction in thickness.
- Elastomeric bearing pads shall conform to the provisions in Section 51-1.12H, "Elastomeric Bearing Pads."

55-2.05 ASBESTOS SHEET PACKING

- Asbestos sheet packing shall be approximately 1/16 inch, unless otherwise shown on the plans, and shall be composed essentially of compressed white chrysotile asbestos fibers bound together with a synthetic rubber binder and fillers.
- The deformation of the sheet packing under a load of 5,000 psi shall be not more than 15 percent. When tested between planed steel plates under a load of 800 psi, the sheet packing shall show a static coefficient of friction less than 0.4 after one hundred 1/2-inch movements.

55-2.06 (BLANK)

55-2.07 UNIDENTIFIED STOCK MATERIAL

- Unidentified stock material, consisting of material which cannot be identified with certified mill test reports, may be used on non-fracture critical members subject to the provisions in this section.
- When unidentified stock material is proposed for use the Engineer may select random test specimens from each piece. The selection and number of test specimens shall be entirely at the discretion of the Engineer. Test specimens shall be cut and machined in conformance with ASTM requirements. Test specimens from unidentified stock material, including those required for retest, shall be furnished, machined and tested by the Contractor at the Contractor's expense.
- Fabrication shall not commence until the materials involved have been approved by the Engineer.
- Not more than 30,000 pounds of unidentified stock material may be used on one contract.
- Unidentified stock material shall be segregated from all other material to be used in the work.

55-3 FABRICATION

55-3.00 GENERAL

- The provisions in this Section 55-3, "Fabrication," shall supersede the requirements for fabrication in AASHTO/AWS D1.5.

55-3.01 QUALITY OF WORKMANSHIP

- Workmanship and finish shall be equal to the best general practice in modern bridge shops.

55-3.02 STRAIGHTENING MATERIAL

- Rolled material before being laid out or worked shall be straight. Subassemblies and completed members shall be straight before being incorporated into the work. If straightening is necessary, it shall be done by methods acceptable to the Engineer. Details for methods proposed for straightening shall be submitted in writing to the Engineer prior to their use. After straightening, evidence of fracture or other damage will be cause for rejection of the material.

55-3.03 ORIENTATION OF PLATES

Steel plates for flanges, eyebars, hanger plates and splice plates for flanges and eyebars shall be cut and fabricated so that the primary direction of rolling is parallel to the direction of the main tensile stress or main compressive stress in the member.

55-3.04 MECHANICAL CUTTING

Edges cut by mechanical methods shall be clean cut, without torn or ragged edges.

55-3.05 FLATNESS OF FAYING AND BEARING SURFACES

Surfaces of bearing and base plates and other metal surfaces that are to come in contact with each other or with ground concrete surfaces or with asbestos sheet packing shall be flat to within $^1/_{32}$ inch tolerance in 12 inches and to within $^1/_{16}$ inch tolerance overall. Surfaces of bearing and base plates and other metal bearing surfaces that are to come in contact with preformed fabric pads, elastomeric bearing pads or portland cement mortar shall be flat to within $^1/_8$ inch tolerance in 12 inches and to within $^3/_{16}$ inch tolerance overall.

Steel slabs where not in contact with other metal bearing surfaces may be heat straightened in lieu of machining at the option of the Contractor, provided the above tolerances are met.

55-3.06 FIT OF STIFFENERS

Girder stiffeners designated on the plans as bearing stiffeners shall be welded in conformance with details shown on the plans. Where the end of a stiffener is shown as "Tight-fit" on the plans, the end of the plate shall be so fitted that it bears on the girder flange with at least point bearing. Local clearances between the end of the stiffener and the girder flange shall not exceed $^1/_{16}$ inch. Except where stiffeners are cut back, local clearances between the end of the stiffener and the girder flange which are too great to be sealed by the paint film shall be caulked prior to painting.

55-3.07 BENT PLATES

Cold-bent load-carrying rolled steel plates shall conform to the following:

A. The plates shall be so taken from the stock plates that the direction of bending will be at right angles to the direction of rolling.
B. The radius of bend, measured to the concave face of the metal, shall be as specified in the Manual of Steel Construction published by the AISC.
C. Before bending, the corners of the plate shall be rounded to a radius of $^1/_{16}$ inch throughout that portion of the plate at which the bending is to occur.

If a shorter radius is essential, the plates shall be bent hot. Hot-bent plates shall conform to A, above.

55-3.08 END CONNECTION ANGLES

Floor beams, stringers and girders having end connection angles shall be built to exact length back to back of connection angles. If end connections are faced, the

finished thickness of the angle shall not be less than that shown on the detail drawings.

55-3.09 FINISHED MEMBERS

- Finished members shall be true to line and free from twists, bends and open joints.

55-3.10 FASTENER THREADS

- Fastener threads for general applications shall conform to the following:

A. External threads, prior to zinc coating, shall conform to the Unified Coarse Thread Series requirements in ANSI Standard: B1.1 with Class 2A tolerances.
B. Internal threads shall conform to the requirements in ASTM Designation: A 563 or A 563M.

- Threads for pin ends and pin nuts, $1^1/_2$ inch and greater in diameter, shall conform to the following:

A. External threads shall be Unified Inch Screw Threads, UN Series with 6 threads per one inch conforming to the requirements in ANSI Standard: B1.1 with Class 2A tolerances.
B. Internal threads shall be Unified Inch Screw Threads, UN Series with 6 threads per one inch conforming to the requirements in ANSI Standard: B1.1 with Class 2B tolerances.

55-3.11 MATCH-MARKING

- Connecting parts pre-assembled for the purpose of setting up for welding or for drilling or reaming holes for field connections shall be match-marked, and a diagram showing the marks shall be furnished on the working drawings.

55-3.12 FINISH

- Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting and chipping shall be done carefully and accurately. All sharp corners and edges, and edges that are marred, cut or roughened in handling or erection, shall be slightly rounded by grinding or other suitable means.

55-3.13 PAINTING

- All iron and steel surfaces shall be cleaned and painted in conformance with the provisions in Section 59, "Painting."

55-3.14 BOLTED CONNECTIONS

- Bolted connections in structural steel joints, unless otherwise shown on the plans or specified in the special provisions, shall be made with high-strength steel fastener assemblies. Fastener assemblies shall consist of either 1) a high-strength steel bolt, nut and hardened washer or 2) a tension control bolt, nut and hardened washer. A direct tension indicator may be used with the high-strength bolt, nut and hardened washer fastener assembly.

- Bolted connections using fastener assemblies shall conform to the requirements in "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" (RCSC Specification) approved by the Research Council on Structural Connections of the Engineering Foundation, and these specifications.
- When reference is made to the RCSC Specification, the "Allowable Stress Design" version shall be used when allowable stress design is shown on the plans and the "Load and Resistance Factor Design" version shall be used when load factor design or load and resistance factor design is shown on the plans.
- All connections made with fastener assemblies shall be tensioned as a slip critical connection, whether classified as a slip critical or bearing type connection, unless otherwise designated on the plans.
- The hardened washer shall be installed under the nut or bolt head, whichever element is turned in tightening. Nuts shall be located, wherever practicable, on the side of the member that will not be visible from the traveled way. Nuts for bolts that will be partially embedded in concrete shall be located on the side of the member that will be encased in concrete.
- When the bolt head is used as the turned element, all tension testing and tension verification, including determining job inspecting torque, shall be performed by turning the bolt head.
- Each length and diameter of fastener assemblies used in any one joint of a high-strength bolted connection shall be from the same rotational capacity lot. The Contractor shall keep a record of which rotational capacity lots are used in each joint.
- The Contractor shall provide, calibrate and maintain the equipment and tools necessary for the preliminary testing, installation and inspection of all fasteners.
- Bolt tension measuring devices and calibrated wrenches shall be calibrated within one year prior to first being used on the job, and a minimum of once each year thereafter. This calibration shall be done by a qualified independent laboratory or authorized warranty repair and calibration center recognized by the tool manufacturer. Bolt tension measuring devices shall be calibrated, to within one percent of the actual tension value, with a minimum of 4 verification readings evenly spaced over a range of 20 to 80 percent of full scale. Calibrated wrenches shall be calibrated to within 2 percent of the actual torque value, with a minimum of 4 verification readings evenly spaced over a range of 20 to 100 percent of full scale. Test equipment used for certification and calibration standards shall be traceable to the National Institute of Standards and Technology.
- If a torque multiplier is used in conjunction with a calibrated wrench as a method for tightening fastener assemblies to the required tension, both the multiplier and the wrench shall be calibrated together as a system. The same length input and output sockets and extensions that will be used in the work shall also be included in the calibration of the system. The manufacturer's torque multiplication ratio shall be adjusted during calibration of the system, such that when this adjusted ratio is multiplied by the actual input calibrated wrench reading, the product is a calculated output torque that is within 2 percent of the true output torque. When this system is used in the work to perform any installation tension testing, rotational

capacity testing, fastener tightening, or tension verification, it shall be used, intact as calibrated.

- Prior to the use of bolt tension measuring devices or calibrated wrenches, the Contractor shall furnish to the Engineer certificates of calibration with plots of verification readings for each device or wrench.
- In addition to the submittals required in Section 55-1.03, "Inspection," the Contractor shall furnish certified test reports of tests on fastener components and fastener assemblies performed prior to shipment to the jobsite. Certified test reports for fastener components and fastener assemblies shall be furnished to the Engineer prior to use of the fastener assembly. The certified test reports shall include the rotational capacity lot numbers for fastener assemblies supplied and the test reports specified in the "Certification," "Report," "Number of Tests and Retests," and "Certification and Test Report" sections in the appropriate ASTM requirements for the fastener components. For ASTM Designation: A 307, Grade B or Grade C anchor bolts, the chemical composition and calculated carbon equivalent of each heat of steel shall be furnished.
- The surfaces of all bolted connections shall be prepared before assembly in conformance with the requirements in the special provisions.

55-3.14A Bolt Holes

- Bolt holes shall be either punched full size, drilled full size, sub-punched and reamed, or sub-drilled and reamed.
- Attention is directed to the provisions in Section 55-3.16, "Assembly," the special provisions, and details shown on the plans for connections where drilling or reaming is required after the joint is assembled.
- The finished holes shall be cylindrical, perpendicular to the plane of the connection and shall be not more than $^1/_{16}$ inch larger than the nominal diameter of the bolt. Holes shall be clean cut, without torn or ragged edges. All burrs, fins, sharp edges and hole irregularities which would prevent solid seating of the parts shall be removed.
- All holes punched full size, sub-punched or sub-drilled shall be located with sufficient accuracy so that after assembling (before any reaming is done) a cylindrical pin $^1/_8$ inch smaller in diameter than the nominal size of the punched, sub-punched or sub-drilled hole may be passed through the hole without drifting, in at least 75 percent of the holes for each connection. All holes shall pass a pin $^3/_{16}$ inch smaller in diameter than the nominal size of the hole.
- Mispunched or misdrilled holes shall not be corrected by welding, unless approved by the Engineer.
- Punching, drilling and reaming shall conform to the following:

55-3.14A(1) Punching

- Punching or sub-punching of structural steel conforming to the requirements in ASTM Designation: A 36/A 36M where the material is thicker than $^7/_8$ inch will not be permitted. Punching or sub-punching of high-strength structural steel where the material is thicker than $^3/_4$ inch will not be permitted.

- The diameter of the die for punching shall not exceed that of the punch by more than $^{3}/_{32}$ inch.
- Holes sub-punched for reaming shall be sub-punched $^{1}/_{4}$ inch less in diameter than that of the finished hole.

55-3.14A(2) Drilling

- Drilling full size shall be done with the parts assembled or to a steel template with hardened bushings or may be performed with gang drill equipment if approved by the Engineer. The Engineer may require a proof assembly to check the fit of major field connections.
- Where bolt holes are sub-drilled for reaming, they shall be sub-drilled $^{1}/_{4}$ inch less in diameter than that of the finished hole.
- Drilling through templates shall be performed only after the templates have been accurately placed and firmly clamped or bolted.
- If members are drilled while assembled, the parts shall be held securely together while drilling is being done.
- Stack drilling of plate parts with precision gang drills will be permitted if all parts are firmly clamped during drilling and if the drill bits remain perpendicular to the work during drilling operations.

55-3.14A(3) Reaming

- Reaming shall be done after the pieces forming a built-up member are assembled and are firmly bolted together so that the surfaces are in close contact or after templates are securely located over the member. The pieces shall be taken apart before bolting, if necessary, and shavings removed. If it is necessary to take the members apart for shipping or handling, the pieces reamed together shall be so marked in order that they may be reassembled in the same position. Reamed parts shall not be interchanged.
- Reaming templates shall have hardened steel bushings and holes accurately dimensioned. Templates shall have reference lines which will permit accurate location of the template on the member or members to be reamed. Templates used for reaming shall be properly located on the material and shall be firmly clamped or bolted in position. Templates used for the reaming of matching members, or the opposite faces of one member, shall be exact duplicates.
- Holes through assembled material that are to be reamed shall not consist of both sub-punched or sub-drilled holes and holes punched or drilled full size.

55-3.14B Installation

- If any components of fastener assemblies are furnished with water soluble lubricants, fastener installation will not be permitted when surface moisture is present at a high-strength bolted connection. If fastener assemblies are furnished with other than water soluble lubricants, the Engineer may require the Contractor to perform additional fastener testing if any fastener work or testing is performed when surface moisture is present.
- Manual torque wrenches shall have either a dial gage or digital read out. Any electric, pneumatic or hydraulic calibrated wrench used to tension fasteners shall

have an adjustable control unit that can be set to positively shut off at the desired torque.

- Wrenches used for snugging tension control bolts in a connection prior to final tensioning shall not apply torsion to the splined end of the bolt.
- For all bolts, the threaded end projecting past the outer face of the nut (thread stickout), where first full formed thread is present, shall be at least flush with, but not more than 1/4 inch beyond, the outer face of the nut. In addition, a minimum of 3 full threads shall be located within the grip of the connection. A maximum of one hardened washer, in addition to the single washer required under the turned element, may be installed under the non-turning element.
- The thread stickout of studs, rods and anchor bolts shall be at least flush with, but not more than one inch beyond, the outer face of the nut, unless otherwise approved in writing by the Engineer.
- Larger bolts, having diameters up to 1/4 inch greater than the diameter of the bolt shown on the plans, may be used if approved by the Engineer, provided that spacing and edge distance requirements for the larger bolt are met and the net section is adequate.
- When direct tension indicators are used, one direct tension indicator shall be installed under each bolt head with the direct tension indicator protrusions contacting the bearing surface of the bolt head. To tension the bolt, the bolt head shall be held stationary and the nut turned. Unless otherwise specified, manufacturer's installation procedures shall be followed. Each bolt shall be tensioned in at least 2 tightening stages until at least 50 percent of the gaps on each direct tension indicator are greater than zero and less than 0.005-inch. Complete crushing of all direct tension indicator protrusions (0 gaps) on any given direct tension indicator will be cause for rejection.
- The same head orientation shall be used within any one high-strength bolted connection.

55-3.14C Rotational Capacity Testing Prior to Shipment to Jobsite

- Rotational capacity tests on fastener assemblies shall be performed as specified in the special provisions.

55-3.14D Installation Tension Testing and Rotational Capacity Testing After Arrival to Jobsite

- Installation tension tests and rotational capacity tests on fastener assemblies shall be performed as specified in the special provisions.

55-3.14E Tension Verification of Fastener Assemblies

- Minimum fastener tension in all completed high-strength bolted connections shall be verified.
- For each type of fastener assembly, at least 10 percent, but no fewer than 2 assemblies used in each high-strength bolted connection shall be checked for minimum tension, by the Contractor, in conformance with the procedure described in Section 9(b), "Arbitration Inspection," of the RCSC Specification. For determining the job inspecting torque for short bolts, the procedure described in steps 1 through 9 of the "Arbitration of Disputes, Inspection Torque Method-Short Bolts," section of the "Structural Bolting Handbook," published by the Steel

Structures Technology Center, Incorporated shall replace Section 9(b)(2) of the RCSC Specification. A separate inspecting torque shall be determined and used for each different rotational capacity lot of fasteners.

- The verification for minimum tension shall be performed 1) no longer than 48 hours after all fasteners in the connection have been tensioned, 2) on fastener assemblies selected by the Engineer, 3) in the presence of the Engineer, and 4) in such a manner that the Engineer can read the torque wrench gage or access the direct tension indicator gaps during inspection.

55-3.15 PIN CONNECTIONS

- Pins shall be accurately turned to the dimensions shown on the plans and shall be straight, smooth and free from flaws. The final surface shall be produced by a finishing cut.
- Pins and rollers shall be forged and heat treated in conformance with the designation shown on the plans or as specified in the special provisions.
- In pins larger than 9 inches in diameter, a hole not less than $1^{7}/_{8}$ inches in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling, and before being annealed.
- Holes for pins shall be bored true to the specified diameter, smooth and straight, at right angles to the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.
- Machined surfaces for pins and holes shall be coated with a rust inhibitor that can be easily removed.
- The distance outside-to-outside of holes in tension members and inside-to-inside of holes in compression members shall not vary from that shown on the plans by more than $^{1}/_{32}$ inch.
- The diameter of the holes for pins shall not exceed that of the pin by more than $^{1}/_{50}$ inch for pins 5 inches or less in diameter, or $^{1}/_{32}$ inch for larger pins.
- Holes for pins in built-up members shall be bored after assembly of the member, or may be bored prior to assembly, provided procedures approved in advance by the Engineer are followed which result in the holes being positioned to the same degree of accuracy as would be obtained if the holes were bored after assembly.
- Pin-connected hanger plates shall be bored in pairs or in stacks firmly bolted or clamped together so that each pair of hanger plates is matched. Pilot and driving nuts shall be used in driving pins. Pins shall be so driven that the members will take full bearing on them. In field assembling, the pin nuts on pin connections shall be tightened and secured with a positive locking device.

55-3.16 ASSEMBLY

- Attention is directed to the provisions in Section 55-1.06, "Continuous Members."
- Contact surfaces of high strength bolted connections shall be cleaned and painted in conformance with the provisions in Section 55-3.14, "Bolted Connections," and the special provisions. All other surfaces of metal in contact

shall be thoroughly cleaned of rust, mill scale, dirt, grease, paint or other material foreign to the metal before assembly.

- Completed subassemblies for structures or units of structures shall be preassembled prior to erection as necessary to verify the geometry of the complete structure or unit and to verify or prepare field connections as specified herein.
- Bolted trusses, skew portals, skew connections, rigid frames, bents and towers shall be completely preassembled and accurately adjusted to line and camber and prepared for welding or checked for fit of bolts prior to erection.
- Long span truss work shall be preassembled in lengths of not less than 3 abutting panels, the members adjusted for line and camber after which joints shall be prepared for welding or holes for field connections shall be drilled or reamed while assembled or checked for fit of bolts if previously drilled full size.
- Bolted splice joints for plate girders shall be preassembled with the abutting sections adjusted for line and camber and holes for field connections shall be drilled or finish reamed while the sections are assembled.
- Splice joints for welded girders shall be preassembled with abutting members adjusted for line and camber and prepared for welding.
- All preassembly methods shall be compatible with the erection methods to be used, unless otherwise permitted in writing by the Engineer.
- All machinery shall be completely preassembled. All bearings shall be fitted to the specified clearances and alignments. Gear reductions and all line gears shall have gear center distances set and the gears properly match-marked.
- The parts shall be accurately assembled in their final position, as shown on the plans, and all match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged. Hammering which will injure or distort the members will not be permitted.
- Drifting done during assembly shall be only such as to bring the parts into position, and not sufficient to enlarge bolt holes or distort the metal.

55-3.17 WELDING

- Welding, welder qualification and inspection of welding shall conform to the requirements in these specifications, AASHTO/AWS D1.5 and the special provisions.
- The minimum size of all fillet welds, except those to reinforce groove welds, shall be as shown in the following table:

Base Metal Thickness of the Thicker Part Joined (Inches)	*Minimum Size of Fillet Weld (Inches)
To $^3/_4$ inclusive	$^1/_4$
Over $^3/_4$	$^5/_{16}$

* Except that the weld size need not exceed the thickness of the thinner part joined.

- The flat side of all butt welded joints shall not deviate from flatness by more than 0.20-inch in a length of 2 feet centered over the weld joint.
- In addition to the nondestructive testing requirements in AASHTO/AWS D1.5, 25 percent of all main member tension groove welds, in material in excess of $^1/_2$ inch thickness, shall be ultrasonically tested.

- The location of all nondestructive testing shall be determined by the Engineer.
- All weld surfaces shall be ground smooth and flush when nondestructive testing is required.
- Brackets, clips, shipping devices or other material not required by the project plans or special provisions shall not be welded or tacked to any part of the girders, unless shown on the working drawings specified in Section 55-1.02, "Drawings," and approved by the Engineer.

55-3.18 GALVANIZING

- Where portions of structural steel are shown on the plans or specified in the special provisions to be galvanized, galvanizing shall conform to the provisions in Section 75-1.05, "Galvanizing."

55-3.19 BEARINGS AND ANCHORAGES

- All bearing assemblies shall be set level. Adjustments in the horizontal positions of bearing assemblies shall be made for temperature as directed by the Engineer. Full bearing on the concrete shall be obtained under bearing assemblies regardless of tolerances otherwise permitted.
- In conformance with the details shown on the plans, masonry plates and the bearing plates of bearing assemblies shall be set on ground concrete surfaces, on preformed fabric pads, on elastomeric bearing pads or on mortar pads.
- Immediately before setting bearing assemblies or masonry plates directly on ground concrete surfaces, the Contractor shall thoroughly clean the surfaces of the concrete and the metal to be in contact and shall apply a coating of non-sag polysulfide or polyurethane caulking conforming to the requirements in Federal Specification TT-S-230, Type II, to contact areas to provide full bedding.
- Nonmetallic bearing pads shall be protected from damage due to welding heat by means subject to approval by the Engineer.
- Mortar to be placed below masonry plates or bearing plates of the bearing assemblies and in anchor bolt sleeves or canisters shall conform to the provisions in Section 51-1.135, "Mortar," except that the proportion of cement to sand shall be one to 3.
- The embedded end of anchor bolts shall be either headed or with a nut and washer. Anchor bolts shall be installed with or without either pipe sleeves or corrugated metal canisters as detailed on the plans. The anchor bolts shall be carefully installed to permit true positioning of the bearing assemblies.
- When anchor bolts are installed in pipe sleeves or metal canisters, the pipes or canisters shall be completely filled with mortar. Mortaring and the construction of mortar pads under masonry plates, if required, shall be done after erection of girders and before placing deck concrete.

55-4 MEASUREMENT AND PAYMENT

55-4.01 MEASUREMENT

- Pay quantities of each type of steel and iron will be measured by the pound computed from the dimensions shown on the plans by the Engineer using the following rules and assumptions:

A. The density of structural and cast steel will be assumed at 0.2833-pound per cubic inch. The density of cast iron will be assumed at 0.26-pound per cubic inch.
B. The weight of rolled shapes and of structural plates will be computed on the basis of their nominal weight and dimensions, without deductions for copes, cuts and holes.
C. The weight of shop and field fillet welds will be assumed as follows:

Size of Fillet Weld (Inches)	Weight (Pounds per Linear Foot)
3/16	0.08
1/4	0.14
5/16	0.22
3/8	0.30
1/2	0.55
5/8	0.80
3/4	1.10
7/8	1.50
1	2.00

D. To determine the pay quantities of galvanized metal, the weight to be added to the calculated weight of the base metal for the galvanizing will be determined from the table of weights of zinc coatings specified in ASTM Designation: A 153.
E. The computed weight of the completed members will be obtained by adding to the above weight the weight of all bolts, nuts and washers. The additional weight of oversize bolts and nuts will not be included in the computed weight.
F. The weight of bolts, cap screws, anchor bolts, nuts, washers and anchor pipe sleeves remaining in the finished structure will be computed on the basis of their nominal weight and dimensions.
G. No allowance will be made for the weight of paint in computing the weight of metal to be paid for.

• Whenever an alternative or option is shown or noted on the plans or permitted by these specifications or the special provisions, the quantity of structural steel to be paid for will be computed on the basis of the dimensions, details and types of structural steel shown on the plans and no increase or decrease in the quantity to be paid for will be made for any variation because of the use by the Contractor of the alternatives or options.

55-4.02 PAYMENT

• Structural steel for use in bridge structures will be paid for at the contract price per pound for furnish structural steel (bridge) and the contract price per pound for erect structural steel (bridge).

- The contract price paid per pound for furnish structural steel (bridge) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in furnishing, fabricating and delivering structural steel to the job site, ready for erection, including furnishing all bolts, nuts and washers, stud connectors, welding materials, asbestos sheet packing, preformed fabric pads and elastomeric bearing pads, or other materials required for the erection and connection or splicing of the structural steel; galvanizing the structural steel when galvanizing is required by the specifications or plans; and conforming to the qualification and testing requirements associated with member fabrication; as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract price paid per pound for erect structural steel (bridge) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in erecting the structural steel, complete in place, including connecting and splicing the structural steel; installing stud connectors; placing asbestos sheet packing, preformed fabric pads and elastomeric bearing pads; furnishing and applying caulk; furnishing and placing mortar for masonry or bearing plates and anchor bolts; checking bolt tension; and conforming to qualification and testing requirements associated with member erection, connection or splicing; as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- The furnishing of all structural steel involved in bridge work, except steel described as separate items and for which payment is otherwise provided elsewhere in these specifications or in the special provisions, will be paid for at the contract price per pound for furnish structural steel (bridge).
- The erecting of all structural steel involved in bridge work, except steel described as separate items and for which payment is otherwise provided elsewhere in these specifications or in the special provisions, will be paid for at the contract price per pound for erect structural steel (bridge).
- If a portion or all of the structural steel is fabricated more than 300 air line miles from both Sacramento and Los Angeles, additional shop inspection expenses will be sustained by the State. Whereas it is and will be impracticable and extremely difficult to ascertain and determine the actual increase in these expenses, it is agreed that payment to the Contractor for furnishing the structural steel from each fabrication site located more than 300 air line miles from both Sacramento and Los Angeles will be reduced $5,000 or by an amount computed at $0.020 per pound of structural steel fabricated, whichever is greater, or in the case of each fabrication site located more than 3,000 air line miles from both Sacramento and Los Angeles, payment will be reduced $8,000 or by $0.036 per pound of structural steel fabricated, whichever is greater.
- The contract prices paid per pound for cast steel and cast iron shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and placing the materials, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

- Where the specifications or plans require metal to be galvanized, the contract price paid per pound for the metal, including the weight of zinc coating, shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing the galvanized metal, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- Cleaning and painting structural steel will be paid for as provided in Section 59, "Painting."

SECTION 56 : SIGNS

56-1 OVERHEAD SIGN STRUCTURES

56-1.01 DESCRIPTION

- This work shall consist of furnishing and installing sign structures in conformance with these specifications and the special provisions, and in conformance with the details shown on the plans or directed by the Engineer.
- Sign structures shall be of the following types: truss, box beam-closed truss, tubular, lightweight and bridge mounted. The type of sign structure to be installed at each location will be shown on the plans.

56-1.02 MATERIALS

- The various materials and fabrication thereof shall conform to the following requirements:

56-1.02A Bars, Plates, Shapes, and Structural Tubing

- Bars, plates, and shapes shall be structural steel conforming to the requirements in ASTM Designation: A 36/A 36M, except, at the option of the Contractor, the light fixture mounting channel shall be continuous-slot steel channel conforming to the requirements in ASTM Designation: A 1011/A 1011M, Designation SS, Grade 33, or aluminum Alloy 6063-T6 extruded aluminum conforming to the requirements in ASTM Designation: B 221 or B 221M.
- Structural tubing shall be structural steel conforming to the requirements in ASTM Designation: A 500, Grade B.
- Removable sign panel frames shall be constructed of structural steel conforming to the requirements in ASTM Designation: A 36/A 36M.

56-1.02B Sheets

- Sheets shall be carbon-steel sheets conforming to the requirements in ASTM Designation: A 1011/A 1011M, Designation SS, Grade 33.
- Ribbed sheet metal for box beam-closed truss sign structures shall be fabricated from galvanized sheet steel conforming to the requirements in ASTM Designation: A 653/A 653M, Designation SS, Grade 33. Sheet metal panels shall be G 165 coating designation in conformance with the requirements in ASTM Designation: A 653/A 653M.

56-1.02C Bolts, Nuts and Washers

- Bolts, nuts and washers for use in sign structures shall conform to the provisions in Section 55-2, "Materials."

56-1.02D Anchorages

- Anchorages for bridge mounted sign structures shall conform to the provisions for concrete anchorage devices in Section 75-1.03, "Miscellaneous Bridge Metal."

56-1.02E Pipe Posts

- Pipe posts shall be welded or seamless steel pipe conforming to the requirements in ASTM Designation: A 53/A 53M, Grade B; ASTM Designation: A 106/A 106M, Grade B; API Specification 5L Grade B or Grade X42. At the

option of the Contractor, posts may be fabricated from structural steel conforming to the requirements in ASTM Designation: A 36/A 36M.

56-1.02F Steel Walkway Gratings

Steel walkway gratings shall be furnished and installed in conformance with the details shown on the plans and the following provisions:

A. Gratings shall be the standard product of an established grating manufacturer.
B. Material for gratings shall be structural steel conforming to the requirements in ASTM Designation: A 1011/A 1011M, Designation CS, Type B.
C. For welded type gratings, each joint shall be full resistance welded under pressure, to provide a sound, completely beaded joint.
D. For mechanically locked gratings, the method of fabrication and interlocking of the members shall be approved by the Engineer, and the fabricated grating shall be equal in strength to the welded type.
E. Gratings shall be accurately fabricated and free from warps, twists, or other defects affecting their appearance or serviceability. Ends of all rectangular panels shall be square. The tops of the bearing bars and cross members shall be in the same plane. Gratings distorted by the galvanizing process shall be straightened.

56-1.02G Elastomeric Bearing Pads

Elastomeric bearing pads shall conform to the provisions in Section 51-1.12H, "Elastomeric Bearing Pads."

56-1.03 FABRICATION

Fabrication shall be equal to the best general practice in modern shops.

Structural steel for sign structures will be inspected at the fabrication site. The Contractor shall notify the Engineer when materials have been delivered to the fabrication site and shall give the Engineer at least 10 days' notice after delivery before commencing the fabrication of the structural steel. Materials to be used shall be made available to the Engineer so they can be examined. The Engineer shall have free access at all times to any portion of the fabrication site where the material is stored or where work on the material is being performed.

Sign structures shall be constructed true to dimensions; shall be free from kinks, twists or bends; and shall be uniform in appearance. The completed sections shall be assembled in the shop and shall be checked for straightness, alignment and dimension. Any variations shall be corrected to the satisfaction of the Engineer.

Posts for tubular sign structures shall be formed to the radii shown on the plans by heat treatment or by fabrication to those radii by methods which will not crimp or buckle the interior radius of the pipe bend, and which will not change the physical characteristics of the material.

Clips, eyes or removable brackets shall be affixed to all signs and all posts, and shall be used to secure the sign during shipping, and for lifting and moving during erection as necessary to prevent damage to the finished galvanized or painted surfaces. Brackets on tubular sign structures shall be removed after erection.

Details of the devices shall be shown on the erection plans to be submitted as required in Section 56-1.01, "Description."

- High-strength bolted connections, where shown on the plans, shall conform to the provisions in Section 55-3.14, "Bolted Connections," except that only fastener assemblies consisting of a high-strength bolt, nut, hardened washer, and direct tension indicator shall be used.
- High-strength fastener assemblies, and any other bolts, nuts, and washers attached to sign structures shall be zinc-coated by the mechanical deposition process.
- Nuts for high-strength bolts designated as snug-tight shall not be lubricated.
- An alternating snugging and tensioning pattern for anchor bolts and high-strength bolted splices shall be used. Once tensioned, high-strength fastener components and direct tension indicators shall not be reused.
- For bolt diameters less than $^{3}/_{8}$ inch the diameter of the bolt hole shall be not more than $^{1}/_{32}$ inch larger than the nominal bolt diameter. For bolt diameters greater than or equal to $^{3}/_{8}$ inch the diameter of the bolt hole shall be not more than $^{1}/_{16}$ inch larger than the nominal bolt diameter.
- Sign structures shall be fabricated into the largest practical sections prior to galvanizing.
- Ribbed sheet metal panels for box beam closed truss sign structures shall be fastened to the truss members by cap screws or bolts as shown on the plans, or by $^{3}/_{16}$ inch stainless steel blind rivets conforming to Industrial Fasteners Institute, Standard IFI-114, Grade 51. The outside diameter of the large flange rivet head shall be not less than $^{5}/_{8}$ inch in diameter. Web splices in ribbed sheet metal panels may be made with similar type blind rivets of a size suitable for the thickness of material being connected.
- Spalling or chipping of concrete structures shall be repaired by the Contractor at the Contractor's expense.
- Overhead sign supports shall have an aluminum identification plate permanently attached near the base, adjacent to the traffic side on one of the vertical posts, using either stainless steel rivets or stainless steel screws. As a minimum, the information on the plate shall include the name of the manufacturer, the date of manufacture and the contract number.

56-1.04 WELDING

- Welding, nondestructive testing of welds, and acceptance and repair criteria for nondestructive testing of welds on steel overhead sign structure members shall conform to the requirements of AWS D1.1 and the special provisions.

56-1.05 SURFACE FINISH

- Excepting tubular and box beam-closed truss types, all ferrous metal parts of sign structures shall be galvanized and not painted, unless otherwise specified in the special provisions.
- Except as herein provided, all exterior surfaces including those areas to be covered by sign panels of tubular and box beam-closed truss types of sign structures shall be cleaned and painted as provided in Section 59-5, "Painting Sign

Structures," and as provided in the special provisions. All ferrous metal truss parts for box beam-closed truss type sign structures shall be galvanized after fabrication and prior to painting. There shall be no chemical treatment of galvanized surfaces prior to cleaning and painting. Walkway gratings, walkway brackets, gutters, safety railings, steel mountings for light fixtures, and all nuts, bolts, and washers for sign structures shall be galvanized after fabrication and shall not be painted.

- Galvanizing shall conform to the provisions in Section 75-1.05, "Galvanizing," except that when permission is granted by the Engineer, surfaces may be coated with zinc by the metalizing process. Metalizing shall be performed in conformance with the AWS requirements and the thickness of the sprayed zinc coat shall be not less than 5 mils.

56-1.06 SIGN PANELS AND FASTENING HARDWARE

- Sign panels will be furnished by the State as provided under "Materials" of the special provisions. Sign panels shall be installed by the Contractor. Any chipping or bending of sign panels shall be considered as sufficient cause to require replacement of panels at the Contractor's expense.
- Laminated sign panels shall be installed on sign structures using fastening hardware of the type and sizes shown on the plans. Closure inserts, aluminum bolts and nuts, and steel beveled washers for mounting laminated sign panels will be furnished by the State as provided under "Materials" of the special provisions. All other fastening hardware shall be furnished by the Contractor, including 1/4" x 2" x 2" galvanized plate washers when shown on the plans. The washers shall be of commercial quality.
- Sign panels for overhead formed panels shall be installed as shown on the plans. Aluminum bolts, nuts and washers for mounting the formed sign panels will be furnished by the State as provided under "Materials" of the special provisions. The State-furnished bolts, nuts and washers shall be installed in conformance with the manufacturer's instructions. The instructions will be furnished with the bolts, nuts and washers.
- At sign panel joints, the Contractor shall mount any overlapping letters and borders on the face of the sign with blind, self-plugging type rivets. Blind rivets for mounting overlapping legend will be furnished by the State as provided under "Materials" of the special provisions.
- The exposed portion of fastening hardware on the face of the sign panels shall match closely the face color in appearance and durability with either a factory or a field applied finish.

56-1.07 FOUNDATIONS

- Reinforced concrete spread footing foundations and cast-in-drilled-hole concrete pile foundations for sign structures and the anchorages for bridge mounted sign structures shall conform to the details shown on the plans.
- Anchorage assemblies shall be considered as part of the sign structures.
- Cast-in-drilled-hole concrete pile foundations shall be completed at least 7 days before sign structures are erected thereon.
- After placing, the exposed surfaces of the foundations shall be cured as provided in Section 90-7, "Curing Concrete."

- Structure excavation and structure backfill, cast-in-drilled-hole concrete piles, concrete, and reinforcement shall conform to the provisions in Sections 19, "Earthwork," 49, "Piling," 51, "Concrete Structures," and 52, "Reinforcement," respectively.

56-1.08 ELECTRICAL INSTALLATIONS

- Electrical installations shall conform to the provisions in Section 86, "Signals, Lighting and Electrical Systems."

56-1.09 MEASUREMENT

- Sign structures of the type or types designated in the Engineer's Estimate will be measured by the pound for furnish sign structure and by the pound for install sign structure. The pay quantities will be determined as provided in Section 55-4.01, "Measurement." The weight of removable sign panel frames and anchorage assemblies will be included as part of the sign structures. The weight of State-furnished hardware and sign panels will not be included as part of the sign structures.
- Extruded aluminum used in lieu of steel slot channel for the light fixture mounting channel will be measured and paid for on the basis of the computed weight of the steel channel shown on the plans.
- Electrical installations and concrete spread footing foundation work will be measured as separate items as provided in their respective sections of these specifications.
- Quantities of cast-in-drilled-hole concrete piles (sign foundation) will be measured by the linear foot as shown on the plans.

56-1.10 PAYMENT

- Sign structures of the type or types designated in the Engineer's Estimate will be paid for by the pound for furnish sign structure and by the pound for install sign structure.
- The contract price paid per pound for furnish sign structure of the type or types designated in the Engineer's Estimate shall include full compensation for furnishing all labor, materials (except State-furnished materials), tools, equipment and incidentals, and for doing all the work involved in furnishing and delivering anchor bolt assemblies, removable sign panel frames, hardware for installing the sign structure (other than State-furnished hardware), and fabricated sign structures at the site of the work, ready for installation, including welding and surface finishing as required, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- If a portion or all of the structural steel for sign structures is fabricated more than 300 air line miles from both Sacramento and Los Angeles, additional shop inspection expenses will be sustained by the State. Whereas it is and will be impracticable and extremely difficult to ascertain and determine the actual increase in these expenses, it is agreed that payment to the Contractor for furnishing that structural steel will be reduced $5,000 for each fabrication site located more than 300 air line miles from both Sacramento and Los Angeles and an additional $3,000 ($8,000 total) for each fabrication site located more than 3,000 air line miles from both Sacramento and Los Angeles.

- The contract price paid per pound for install sign structure of the type or types designated in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in installing sign structures, complete in place, including installing anchor bolt assemblies, removable sign panel frames, and State-furnished sign panels and performing any welding, painting or galvanizing required during installation, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Electrical installations will be paid for as provided in Section 86, "Signals, Lighting and Electrical Systems."
- Spread footing foundation work will be paid for as separate items as provided in their respective sections of these specifications.
- Cast-in-drilled-hole concrete pile foundations will be paid for at the contract price per linear foot for cast-in-drilled-hole concrete pile (sign foundation), for each size included in the Engineer's Estimate, which prices shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in constructing the cast-in-drilled-hole concrete pile and pedestal, complete in place, including reinforcement and any necessary excavation and disposing of excess excavated material, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

56-2 ROADSIDE SIGNS

56-2.01 DESCRIPTION

- This work shall consist of furnishing and installing roadside signs in conformance with these specifications and the special provisions, and in conformance with the details shown on the plans or directed by the Engineer.

56-2.02 MATERIALS

- The various materials and fabrication thereof shall conform to the following requirements:

56-2.02A Metal Posts

- Mountings for roadside signs to be installed on barriers or railings shall be fabricated from welded or seamless steel pipe conforming to the requirements in ASTM Designation: A 53, Grade B and structural steel conforming to the requirements in ASTM Designation: A 36/A 36M. Bolted connections and anchorages shall conform to the provisions in Section 56-1.02C, "Bolts, Nuts and Washers," and the provisions for concrete anchorage devices in Section 75-1.03, "Miscellaneous Bridge Metal."
- Mountings for ground-mounted roadside signs shall be wide flange metal posts fabricated from structural steel conforming to the requirements in ASTM Designation: A 36/A 36M. Bolts, nuts and washers for the breakaway connections of wide flange steel posts shall conform to the requirements in ASTM Designation: A 325 or A 325M.

- All metal parts of roadside sign mountings shall be galvanized after fabrication. Galvanizing shall conform to the provisions in Section 75-1.05, "Galvanizing."

56-2.02B Wood Posts

- Wood posts shall be of the following grades and species. The grades and species allowed for wood posts, 4" x 4" nominal size, are select heart redwood; No. 1 heart structural redwood (1050f); No. 2 heart structural redwood (900f); No. 1 structural light framing Douglas fir, free of heart center; No. 1 structural light framing Hem-Fir, free of heart center; and No. 1 structural light framing Southern yellow pine, free of heart center. The grades and species allowed for wood posts, 4" x 6" nominal size, are select heart grade redwood; select heart structural grade redwood (1100f); No. 1 heart structural redwood (950f); No. 2 structural joists and planks, Douglas fir, free of heart center; No. 1 structural joists and planks Hem-Fir, free of heart center; and No. 2 structural joists and planks Southern yellow pine. The grades and species allowed for wood posts larger than 4" x 6" nominal size are select heart redwood; No. 1 heart structural redwood (950f); No. 1 posts and timbers (also known as No. 1 structural) Douglas fir, free of heart center; select structural posts and timbers Hem-Fir, free of heart center; and No. 1 timbers Southern yellow pine, free of heart center. The sizes shown are minimum, dressed dry sizes.
- Posts shall be graded in conformance with the provisions in Section 57-2, "Structural Timber." Sweep shall not exceed 0.08-foot in 10 feet.
- Before preservative treatment, the moisture content of Douglas fir, Hem-Fir, and Southern yellow pine posts shall be not more than 25 percent as measured at the midpoint of the post in the outer inch, using an approved type of moisture meter, in conformance with the requirements of ASTM Designation: D 4444.
- At the time of delivery to the jobsite, treated posts shall have a moisture content of not more than 25 percent when tested as described above. The posts shall conform in all respects to the specified grading requirements at the time of delivery to the job site.
- Douglas fir and Hem-Fir posts shall be treated in conformance with the provisions in Section 58, "Preservative Treatment of Lumber, Timber and Piling," and in conformance with AWPA Use Category System: UC4A, Commodity Specification A. Posts shall be incised and the minimum retention of preservative shall be as specified in AWPA Standards.
- The cutting of the ends of wood posts in the field will be permitted. Where field cutting or boring of wood posts is performed after treatment, all cuts and holes shall be thoroughly swabbed, sprayed or brushed with 2 applications of the same type of preservative as initially used or copper naphthenate. Application of preservative in the field shall conform to the provisions in the last paragraph in Section 58-1.04, "Wood Preservative for Manual Treatment."
- Wood block spacers, inserted between the post and the sign panel on single post installations as shown on the plans, shall be treated with preservative in the same manner as specified for wood posts.
- Unless specified in the special provisions or shown on the plans, wood posts and blocks shall not be painted.

56-2.02C Laminated Wood Box Posts

- Laminated wood box posts with attached metal caps at the top of each post will be furnished by the State as provided under "Materials" of the special provisions.
- If the laminated wood box posts are not immediately used, the posts shall be neatly stacked on dunnage. The posts shall be handled in a manner that will avoid injury or damage to the posts.

56-2.02D Sign Panel Fastening Hardware

- Frame assemblies for multiple sign installations shall be fabricated of structural steel conforming to the requirements in ASTM Designation: A 36/A 36M, or of aluminum alloy as shown on the plans. Frames fabricated of structural steel shall be hot-dip galvanized after fabrication.
- Back braces for signs shall be commercial quality, mild steel, hot-dip galvanized after fabrication.
- Straps and saddle brackets for mounting sign panels on electroliers, sign structure posts and traffic signal standards or where shown on the plans shall be stainless steel conforming to the requirements in ASTM Designation: A 167, Type 302 or 304. Theft-proof bolts shown on the plans shall be stainless steel with a chromium content of at least 16 percent and a nickel content of at least 8 percent.
- Lag screws, bolts (except theft-proof bolts), metal washers and nuts shall be commercial quality steel, hot-dip galvanized after fabrication. Fiber washers shall be of commercial quality.
- Galvanizing shall conform to the provisions in Section 75-l.05, "Galvanizing."

56-2.03 CONSTRUCTION

- Posts shall be placed in holes excavated in the ground.
- Holes shall be excavated to the required depth for the bottom of the posts as shown on the plans.
- The space around the wood posts shall be backfilled to finished ground surface with selected earth or sand, free of rocks or other deleterious material. The space around laminated wood box posts shall be backfilled to finished ground surface with a granular material. The backfill material shall be placed in layers approximately 0.33-foot thick, and each layer shall be moistened and thoroughly compacted.
- Backfill material for metal posts shall consist of minor concrete conforming to the provisions in Section 90-10, "Minor Concrete," or, at the option of the Contractor, backfill material may consist of portland cement concrete produced from commercial quality aggregates and cement, containing not less than 463 pounds of cement per cubic yard.
- Surplus excavated material shall be disposed of in a uniform manner along the adjacent roadway as directed by the Engineer.
- The line between the center of the top of a post and the center of a post at the ground line shall be plumb within a tolerance of not to exceed 0.02-foot in 10 feet.
- The breakaway saw cuts and holes for the saw cuts in the laminated wood box posts shall be made after installation of the posts. Posts shall not be spliced, and one trim cut at the bottom of the post will be allowed.

- Bolted connections shall conform to the provisions in Section 56-1.03, "Fabrication."
- Holes for bolts, threaded rods or expansion anchorage devices drilled in existing concrete shall be drilled by a method that will not shatter the concrete adjacent to the holes.
- Any spalling or chipping of concrete structures shall be repaired by the Contractor at the Contractor's expense.
- Standard commercial polyvinyl chloride tape, polyethylene tape or other approved corrosion-resistant barrier shall be applied to the areas on metal sign surfaces or hardware that will be in contact with treated wood. Before the bolts are inserted, all bolt holes shall be filled with a grease, recommended by the manufacturer for corrosion protection, which will not melt or run at a temperature of 150º F. The tape, or other corrosion-resistant barrier, and grease shall be furnished by the Contractor. Corrosion-resistant barrier and grease will not be required when wood posts and blocks are treated with pentachlorophenol in hydrocarbon solvent.

56-2.04 SIGN PANEL INSTALLATION

- Sign panels shall be installed by the Contractor in conformance with the details shown on the plans or as directed by the Engineer. Any chipping or bending of sign panels shall be considered as sufficient cause to require replacement of panels at the Contractor's expense.
- Closure inserts shall be installed into the openings at the edges of adjacent sign panel sections. Adjacent edges of sign panels shall be in contact their full length. At sign panel joints, the Contractor shall mount any overlapping letters and borders on the face of the sign with blind, self-plugging type rivets.
- Sign panels shall be attached to metal and wood posts, laminated wood box posts, electroliers, sign structure posts and traffic signal standards and mast arms with fastening hardware of the types and sizes shown on the plans.
- Lag screws shall be installed by turning the lag screw into pilot holes by use of a wrench. The pilot holes shall be bored with a bit diameter equal to the root diameter of the lag screw thread.
- Sign panels, blind rivets and closure inserts will be furnished by the State as provided under "Materials" of the special provisions.
- All fastening hardware shall be furnished by the Contractor.

56-2.05 MEASUREMENT

- Roadside signs on wood posts will be measured by the unit from actual count. One or more sign panels mounted on a single post installation will be counted as a roadside sign-one post, and one or more sign panels mounted on a two post installation will be counted as a roadside sign-two post.
- The installing of roadside signs on laminated wood box posts will be measured as units determined from actual count. A unit shall consist of installing 2 posts with sign panels, fastening hardware and metal caps complete in place.
- Roadside signs mounted on barriers or railings will be measured by the pound as metal (rail mounted sign) for the quantity of steel (including pipe posts, base plates, anchorage assemblies and other metal parts, except sign panels and sign

panel fastening hardware). The pay quantities will be determined as provided in Section 55-4.01, "Measurement."

- The wide flange metal posts and parts shown on the plans for supporting roadside signs will be measured by the pound for the steel posts. The pay quantities will be determined as provided in Section 55-4.01, "Measurement."
- The installing of roadside signs by the strap and saddle bracket method on electroliers, sign structure posts and traffic signal standards, and by the mast arm hanger method on traffic signal mast arms will be measured as units determined from actual count of the sign panels in place.

56-2.06 PAYMENT

- Items of work, measured as specified in Section 56-2.05, "Measurement," will be paid for at the contract prices per pound for metal (roadside sign), per pound for metal (rail mounted sign), per unit for roadside sign-one post and roadside sign-two post, per unit for install roadside sign (laminated wood box post), per unit for install sign (strap and saddle bracket method), and per unit for install sign (mast arm hanger method).
- The above prices and payments shall include full compensation for furnishing all labor, materials (except State-furnished materials), tools, equipment, and incidentals, and for doing all the work involved in furnishing and installing roadside signs, complete in place, including the installation of sign panels, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- Frame assemblies for multiple sign installations, back braces, straps and saddle brackets, lag screws, bolts, washers and nuts as specified in Section 56-2.02D, "Sign Panel Fastening Hardware," shall be considered as sign panel fastening hardware. Full compensation for furnishing and installing sign panel fastening hardware shall be considered as included in the contract prices paid for the roadside signs requiring the hardware and no separate payment will be made therefor.

SECTION 57: TIMBER STRUCTURES

57-1 GENERAL

57-1.01 DESCRIPTION

This work shall consist of constructing timber structures at the locations specified, in the position, to the elevations, and conforming to the design shown on the plans and in accordance with the requirements specified in these specifications and the special provisions.

57-1.02 MATERIALS

The materials required for timber construction shall conform to the following requirements:

57-1.02A Structural Timber and Lumber

Structural timber and lumber shall be of the following species: Douglas fir, Hem-Fir, redwood or Southern yellow pine, as shown on the plans or as specified in the specifications.

When preservative treatment of timber and lumber is required, the treatment shall conform to the provisions in Section 58, "Preservative Treatment of Lumber, Timber and Piling," and AWPA's Use Category 4B. The type of treatment to be used will be shown on the plans or specified in the special provisions.

Structural timber and lumber shall be inspected and grade marked and shall be accompanied by a certified grading report in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."

Treated timber and lumber shall also be accompanied by a certified treating report in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."

57-1.02B Structural Metal

Structural metal shall consist of structural shapes, eye-bars, castings, rods with necessary nuts and washers, metal shoes and plates, but shall not include hardware as described in Section 57-1.02C, "Hardware."

Structural metals used in timber structures shall conform to the provisions in Section 75-1.03, "Miscellaneous Bridge Metal."

57-1.02C Hardware

Hardware shall consist of bolts with the necessary nuts and washers, timber connectors, drift pins, dowels, nails, screws, spikes, wire rope for wrapping, and other metal fastenings.

Bolts and nuts shall conform to the requirements in ASTM Designation: A 307. Machine bolt heads and nuts shall be Regular Square Series, and threads shall be Coarse Thread Series, Class 2 tolerance, all conforming to ANSI Standard.

Washers shall be cast iron Ogee, malleable iron, plate or cut washers, as specified.

Timber connectors and other metal fastenings shall be of the type and size shown on the plans or specified.

Nails shall be common wire nails.

- Wire rope shall be commercial quality galvanized steel wire rope. Splices and end connections of wire rope shall be made with metal clips.

57-1.03 GALVANIZING

- Structural metal, unless otherwise specified or shown on the plans, and all hardware shall be hot-dip galvanized, in conformance with the provisions in Section 75-1.05, "Galvanizing."

57-2 STRUCTURAL TIMBER

57-2.01 DESCRIPTION

- Douglas fir timber shall be the species "Pseudotsuga menziesii"; redwood shall be the species "Sequoia sempervirens"; Hem-Fir shall be one of the species "Abies magnifica," "Abies grandis," "Abies procera," "Abies amabillis," "Abies concolor," or "Tsuga heterophylla"; and Southern yellow pine shall be one of the several species recognized by the Southern Pine Inspection Bureau.

57-2.02 GRADING RULES AND REQUIREMENTS

- Lumber and timber shall be of the stress grade shown on the plans or as specified in these specifications, or in the special provisions.
- Douglas fir and Hem-Fir shall be graded in conformance with the requirements of the current standard grading and dressing rules of the West Coast Lumber Inspection Bureau, or the current standard grading rules of the Western Wood Products Association.
- Redwood shall be graded in conformance with the current standard specifications for structural grades of California redwood approved by the Board of Review, American Lumber Standards Committee and published by the Redwood Inspection Service.
- Southern yellow pine shall be graded in conformance with the current grading rules adopted by the Southern Pine Inspection Bureau.
- The following general provisions apply to all stress-grades:

A. All material shall be well manufactured. Only pieces consisting of sound wood, free from decay, will be accepted.
B. All sizes shown on the plans or specified in the special provisions applying to lumber and timber refer to nominal sizes, and the American Lumber Standards rough and dressed sizes will be accepted as conforming thereto.
C. Green timber shall be adequately protected from uneven seasoning during transit. Stress-grades of Douglas fir shall be end coated with a protective coating at the time of manufacture to retard checking.

57-3 CONSTRUCTION

57-3.01 DESCRIPTION

- The various kinds and grades of timber used in the structure shall be as shown on the plans or as specified in these specifications, or in the special provisions.

- When shown on the plans and in addition to the items specified in Section 57-1.02B, "Structural Metal," structural members fabricated from steel, concrete, or other materials shall be incorporated into the structure.
- Lumber and timber shall be stored in piles at the site unless the lumber and timber are to be immediately placed in the structure. Structural timber shall be neatly stacked on dunnage above ground and shall be protected from the sun when necessary to prevent warping.
- Lumber and timber shall be stacked on dunnage so that it may be readily inspected and shall be handled in a manner that will avoid injury or breakage. Treated timber shall be handled with rope slings. Cant hooks, peaveys or other sharp instruments shall not be used in handling treated timber. Undue injury in handling will be cause for rejection.

57-3.02 FRAMING

- The framing shall conform to the following requirements:

57-3.02A Workmanship

- Workmanship shall be first class throughout.
- Lumber and timber shall be accurately cut and framed to a close fit and shall have even bearing over the entire contact surfaces. No shimming will be permitted in making joints.
- Holes for drift pins and dowels in untreated timber shall be bored at least $^{1}/_{16}$ inch less in diameter than the pin or dowel. Holes for drift pins and dowels in treated timber shall be bored the same diameter as the pin or dowel. Holes for bolts shall be bored not more than $^{1}/_{16}$ inch larger than the diameter of the bolt. Holes for lag screws shall be bored with a bit diameter not larger than the root diameter of the lag screw thread. Holes in small timbers for boat or wire spikes shall be bored with a bit of the same diameter or smallest dimension of the spike, when necessary to prevent splitting.
- All bolts $^{5}/_{8}$ inch and less in diameter shall be fitted with cut washers, and all bolts and lag screws over $^{5}/_{8}$ inch in diameter shall be fitted with cast or malleable iron washers unless otherwise shown on the plans.

57-3.02B Framed Bents

- Mud sills shall be firmly and evenly bedded in solid material.
- Sills shall have full, even bearing on the pedestals, mud sills or piles.
- Posts shall be framed true and shall have full bearing on pedestals, sills and caps.

57-3.02C Bracing

- Bents shall be properly aligned before bracing is placed. All bracing shall be of sufficient length to provide a minimum distance of 8 inches between the outside bolt and the end of the brace.

57-3.02D Stringers

- In placing stringers for bridge decks the better edge shall be placed down. The tops of the stringers after placing shall not vary from a plane more than will permit bearing of the floor on all the stringers.

57-3.02E Wheel Guards and Railings

- Wheel guards and railings shall be accurately framed and aligned.

57-3.03 SURFACE TREATMENT OF TIMBER

- Rails, rail posts (except portions embedded in earth or concrete), wheel guards or timber curbs (except the bottom faces over an earth surface), and the exposed faces of posts shall be painted with one application of Wood Primer, Latex-Base, Section 91-3.01, and 2 applications of white, Paint, Latex-Base for Exterior Wood, White and Tints, Section 91-3.02, all applied in conformance with the provisions in Section 59, "Painting." Such other parts of the structure as are specified in the special provisions shall be painted.
- Portions of rail posts which are to be embedded in earth or concrete and the faces of timber bulkheads, except those of treated Douglas fir, which are to be in contact with earth, shall be treated with 2 applications of wood preservative conforming to the provisions in Section 58-1.04, "Wood Preservative for Manual Treatment."
- When any framing, cutting or boring of treated timber is performed after treatment, all cuts, daps and holes shall be thoroughly swabbed with 2 applications of the same preservative specified for the treatment of the timber or copper naphthenate.

57-4 MEASUREMENT AND PAYMENT

57-4.01 MEASUREMENT

- Timber and lumber will be measured by the thousand foot board measure. The quantity to be paid for shall be determined from nominal widths and thicknesses and the actual lengths of the pieces in the finished structure, with the exception that in the case of laminated timber flooring, the number of laminations to be paid for shall be the required number of the size specified after dressing and the length of each lamination shall be considered as equal to the full width or length of the floor.
- Structural metal will be measured by the pound as determined from scale weighing.
- Scale weighings will not be required when structural metal is designated as a final pay item in the Engineer's Estimate.

57-4.02 PAYMENT

- The contract prices paid per thousand foot board measure for treated or untreated lumber and timber shall include full compensation for furnishing all labor, materials (including hardware, paint and wood preservative), tools, equipment, and incidentals, and for doing all the work involved in the production of a finished timber structure, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract price paid per pound for structural metal shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and installing structural metal, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer. When there is no

contract item for structural metal, full compensation for furnishing and placing structural metal shall be considered as included in the contract price paid for lumber and timber and no separate payment will be made therefor.

SECTION 58: PRESERVATIVE TREATMENT OF LUMBER, TIMBER AND PILING

58-1.01 DESCRIPTION

- This work shall consist of treating lumber, timber and piling. Lumber, timber and piling to be treated shall conform to the requirements of the various sections of these specifications specifying the lumber, timber or piling.
- The various types of treatments are specified under several sections of these specifications and shall conform to the requirements specified in these specifications and the special provisions and as shown on the plans.

58-1.02 TREATMENT AND RETENTION

- Timber, lumber, and piling shall be pressure treated after millwork is completed. Preservatives, treatment, and results of treatment shall conform to the requirements in AWPA Standards U1 and T1. Treatment of lumber and timber shall conform to the specified AWPA Use Category cited in the special provisions, on the plans, or elsewhere in these specifications.
- Handling and care of pressure treated wood products shall conform to the requirements of AWPA Standard M4.
- The treating plant shall imprint legible symbols in the end of all lumber and timber treated indicating the name of the treating company and the type and year of treatment in accordance with AWPA Standards M1 and M6.
- When kiln drying prior to treatment is specified in the special provisions or elsewhere in these specifications, the moisture content after drying and immediately prior to treating shall not exceed 25 percent as measured at the midpoint of the piece in the outer one inch, using an approved type of moisture meter in accordance with ASTM Designation: D 4444. Unless otherwise specified in the special provisions or elsewhere in these specifications, lumber and timber treated with waterborne preservatives shall be dried after treatment and shall have a moisture content of not more than 25 percent at the time of shipment to the job site.

58-1.03 INSPECTION

- Lumber, timber and piling to be treated shall be inspected and marked as specified in the various sections of these specifications for those materials.
- Treated lumber, timber and piling shall be subject to inspection by the Engineer after arrival at the site or after being placed in the completed structure, and no previous inspection at the plant shall bar rejection in the completed structure.
- Lumber and timber, whether treated or untreated, shall conform in all respects to the specified grading requirements at the time of delivery to the job site. Certified treating reports shall be furnished for all treated timber to be shipped. A Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance," shall be furnished stating the species of the material to be shipped and that the material conforms to the specified grading rules.

58-1.04 WOOD PRESERVATIVE FOR MANUAL TREATMENT

The preservative to be applied manually to lumber, timber and piling where specified, shall be creosote or copper naphthenate as specified in AWPA Standard M4.

At the time of applying the wood preservative the moisture content of the wood shall not exceed 25 percent, and no free moisture shall be on the surface. The preservative shall not be applied in wet or damp weather, except when the wood on which it is to be applied is adequately protected. Wood preservative shall be applied to exposed surfaces with suitable brushes, to holes with swabs, or by other means that will result in adequate coverage.

58-1.05 PAYMENT

Full compensation for treatment of lumber, timber and piling as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer shall be considered as included in the contract prices paid for furnishing treated lumber, timber or piling and no separate payment will be made therefor.

SECTION 59: PAINTING

59-1 GENERAL

59-1.01 DESCRIPTION

This work shall consist of painting new installations and repainting existing installations in conformance with the provisions of the various sections of these specifications.

Painting shall conform to the provisions specified in these specifications and the special provisions, and as shown on the plans or directed by the Engineer.

59-1.02 WEATHER CONDITIONS

Paint shall be applied only on thoroughly dry surfaces and during periods of favorable weather. Blast cleaning or application of solvent-borne paint will not be permitted when the atmospheric or surface temperature is at or below 35° F or above 100° F, or when the relative humidity exceeds 85 percent at the site of the work. Application of water-borne paint will not be permitted when the atmospheric or surface temperature is at or below 50° F, or above 100° F, or when the relative humidity exceeds 75 percent at the site of the work. Application of paint will not be permitted when the steel surface temperature is less than 5° F above the dew point, or when freshly painted surfaces may become damaged by rain, fog or condensation, or when it can be anticipated that the atmospheric temperature or relative humidity will not remain within the specified application conditions during the drying period, except as provided in the following paragraph for enclosures. If uncured paint is damaged by the elements, it shall be replaced or repaired by the Contractor at the Contractor's expense.

Subject to approval by the Engineer in writing, the Contractor may provide suitable enclosures to permit painting during inclement weather. Provisions shall be made to control atmospheric conditions artificially inside the enclosures within limits suitable for painting throughout the painting operation and drying period. Full compensation for providing and maintaining the enclosures shall be considered as included in the prices paid for the various contract items of work requiring paint and no additional compensation will be allowed therefor.

59-1.03 APPLICATION

The Contractor shall notify the Engineer, in writing, at least one week in advance of the date cleaning and painting operations are to begin.

Attention is directed to Section 91-1.02, "Sampling and Testing."

Painting shall be done in a neat and workmanlike manner. Unless otherwise specified, paint shall be applied by brush, or spray, or roller, or any combination of these methods. Airless spray methods shall not be used.

Each application of paint shall be thoroughly cured and any skips, holidays, thin areas or other deficiencies corrected before the succeeding application. The surface of the paint being covered shall be free from moisture, dust, grease or any other deleterious material which would prevent the bond of the succeeding applications. In spot painting, old paint which lifts after the first application, shall be removed by scraping and the area repainted before the next application.

- Unless otherwise specified, should 7 days elapse between paint applications, the painted surface shall be water rinsed prior to the next paint application. Water rinsing is defined as a pressurized water rinse with a minimum nozzle pressure of 1,160 psi. During rinsing, the tip of the pressure nozzle shall be placed between 12 inches and 18 inches from the surface to be rinsed. The nozzle shall have a maximum fan tip angle of 30°.
- Brushes, when used, shall have sufficient body and length of bristle to spread the paint in a uniform film. Paint shall be evenly spread and thoroughly brushed out.
- On all surfaces which are inaccessible for painting by regular means, the paint shall be applied by sheepskin daubers, bottle brushes or by any other means approved by the Engineer.
- Rollers, when used, shall be of a type which do not leave a stippled texture in the paint film.
- Runs, sags, thin and excessively thick areas in the paint film, skips and holidays, or areas of non-uniform appearance shall be considered as evidence that the work is unsatisfactory, and the Contractor may be required to blast clean the areas and reapply the paint.
- A water trap acceptable to the Engineer shall be furnished and installed at each spray pot.
- Mechanical mixers shall be used to mix paint. Prior to applying, the paint shall be mixed a sufficient length of time to thoroughly mix the pigment and vehicle together.
- Precautions in the handling and the application of paints shall be in conformance with all applicable occupational safety and health standards, rules, regulations and orders established by the State of California.

59-1.04 THINNING PAINT

- Paints specified are formulated ready for application, and no thinning will be allowed unless otherwise provided in the specifications or permitted by the Engineer.

59-1.05 PROTECTION AGAINST DAMAGE

- Attention is directed to Section 7-1.11, "Preservation of Property," and to Section 7-1.12, "Idemnification and Insurance." The Contractor shall provide protective devices, such as tarps, screens or covers, as necessary to prevent damage to the work and to other property or persons from all cleaning and painting operations.
- Paint or paint stains on surfaces not designated to be painted shall be removed by the Contractor at the Contractor's expense and to the satisfaction of the Engineer.
- If traffic causes an objectionable amount of dust, the Contractor, when directed by the Engineer, shall sprinkle the adjacent roadbed and shoulders with water or dust palliative for a sufficient distance on each side of the location where painting is being done, and the application will be paid for as provided in Section 10, "Dust Control."

- All painted surfaces that are marred or damaged as a result of operations of the Contractor shall be repaired by the Contractor, at the Contractor's expense, with materials and to a condition equal to that of the coating specified herein.
- Upon completion of all painting operations and of any other work that would cause dust, grease or other foreign materials to be deposited upon the painted surfaces, the painted surfaces shall be thoroughly cleaned.

59-1.06 SPECIAL STENCILING

- The date (month and year) of painting shall be stenciled at 2 locations on all bridge structures in block letters $2^1/_2$ inches high. The exact locations will be determined by the Engineer. The paint used shall form a distinct contrast with the background.

59-2 PAINTING STRUCTURAL STEEL

59-2.01 GENERAL

- Cleaning and painting of structural steel shall conform to the provisions in Section 59-1, "General," and this Section 59-2.
- Unless otherwise specified, no painting Contractors or subcontractors will be permitted to perform work without having the following current "SSPC: The Society for Protective Coatings" (formerly the Steel Structures Painting Council) certifications in good standing throughout the duration of the contract:

A. For cleaning and painting structural steel in the field, certification in conformance with the requirements in Qualification Procedure No. 1, "Standard Procedure For Evaluating Painting Contractors (Field Application to Complex Industrial Structures)" (SSPC-QP 1).
B. For removing paint from structural steel, certification in conformance with the requirements in Qualification Procedure No. 2, "Standard Procedure for the Qualification of Painting Contractors (Field Removal of Hazardous Coatings from Complex Structures)" (SSPC-QP 2).
C. For cleaning and painting structural steel in a permanent painting facility, certification in conformance with the requirements in Qualification Procedure No. 3, "Standard Procedure For Evaluating Qualifications of Shop Painting Applicators" (SSPC-QP 3). All cleaning and painting of structural steel shall be performed in a Category I Enclosure. The AISC's Sophisticated Paint Endorsement (SPE) quality program, Certification P-1 Enclosed, will be considered equivalent to SSPC-QP 3.

- Unless otherwise specified, all exposed surfaces of structural steel and other metals, except galvanized or metalized surfaces, shall be cleaned and painted.

59-2.02 SURFACE PREPARATION

- All surfaces of new structural steel or other metals which are to be painted shall be blast cleaned unless otherwise specified in the special provisions, or approved in writing by the Engineer.
- In repainting existing steel structures the method of cleaning will be specified in the special provisions. Any damage to sound paint, on areas not designated for

treatment, resulting from the Contractor's operations shall be repaired by the Contractor at the Contractor's expense to the satisfaction of the Engineer.

59-2.03 BLAST CLEANING

- Abrasives used for blast cleaning shall be either clean dry sand, mineral grit, steel shot or steel grit, at the option of the Contractor, and shall be of a grading suitable to produce satisfactory results. The use of abrasives other than those specified in this Section 59-2.03 will not be permitted unless authorized in writing by the Engineer.
- Unwashed beach sand containing salt or excessive amounts of silt will not be allowed.
- Exposed steel or other metal surfaces to be blast cleaned shall be cleaned in conformance with the requirements in SSPC-SP 6, "Commercial Blast Cleaning," of the "SSPC: The Society for Protective Coatings." Blast cleaning shall leave all surfaces with a dense, uniform, angular anchor pattern of not less than 1.5 mil as measured in conformance with the requirements in ASTM Designation: D 4417.
- Attention is directed to the regulations for abrasive blasting operations adopted by the State Air Resources Board, Subchapter 6 in Chapter 1, of Part III of Title 17, California Code of Regulations.
- When blast cleaning is being performed near machinery, all journals, bearings, motors and moving parts shall be sealed against entry of abrasive dust before blast cleaning begins.
- Blast cleaned surfaces shall be primed or treated the same day blast cleaning is done, unless otherwise authorized by the Engineer. If cleaned surfaces rust or are contaminated with foreign material before painting is accomplished, the surfaces shall be recleaned by the Contractor at the Contractor's expense.

59-2.04 (BLANK)

59-2.05 STEAM CLEANING

- All dirt, grease, loose chalky paint or other foreign material which has accumulated on the previously painted or galvanized surfaces shall be removed with a steam cleaning apparatus which shall precede all other phases of cleaning. The temperature of the steam produced by the steam cleaning apparatus shall be between 266° F and 374° F at the nozzle. Gloss on the existing paint shall be removed without removing sound paint. Areas of gloss on the existing paint that are not removable by steam cleaning and rinsing shall be lightly roughened by sanding with 100- to 200-grit sandpaper. Any paint which becomes loose, curled or lifted or loses its bond with the preceding coat or coats after steam cleaning, shall be removed to sound paint or metal surface by the Contractor at the Contractor's expense.
- A biodegradable detergent shall be either added to the feed water of the steam generator or applied to the surface to be cleaned. The detergent shall be of such composition and shall be added or applied in such quantity that the cleaning as provided in the above paragraph is accomplished.
- Steam cleaned surfaces shall be rinsed clean with fresh water to remove any residue, detergent or other foreign material.

- Steam cleaning shall not be performed more than 2 weeks prior to painting or other phases of cleaning.
- Subsequent painting shall not be performed until the cleaned surfaces are thoroughly dry and in no case in less than 24 hours after cleaning.

59-2.06 HAND CLEANING

- Dirt, loose rust, and mill scale, or paint which is not firmly bonded to the surfaces shall be removed in conformance with the requirements in SSPC-SP 2, "Hand Tool Cleaning," of the "SSPC: The Society for Protective Coatings." Edges of old remaining paint shall be feathered.
- Pneumatic chipping hammers shall not be used unless authorized in writing by the Engineer.

59-2.07 (BLANK)

59-2.08 (BLANK)

59-2.09 (BLANK)

59-2.10 (BLANK)

59-2.11 PAINT

- The paint systems for new or existing structural steel or other metal surfaces shall be as specified in the special provisions or as shown on the plans.

59-2.12 PAINTING

- Painting of new structural steel shall be done at the following stages of construction unless otherwise specified in these specifications or in the special provisions or approved in writing by the Engineer:

A. Structures, other than sign structures, shall be blast cleaned and painted with the total thickness of undercoats before erection. Finish coats and final coats shall be applied after erection. If concrete deck is to be placed on a steel member to be painted, finish coats and final coats shall be applied after concrete deck placement. After erection and deck placement, but before applying subsequent paint, areas where paint has been damaged or has deteriorated and exposed unpainted surfaces shall be thoroughly cleaned, including removal of foreign substances, and surfaces shall be spot painted with undercoats to the specified thickness. Damaged areas of undercoat paint shall be blast cleaned and painted as specified in the special provisions.

B. When sign structures are to be painted as specified in Section 59-5, "Painting Sign Structures," cleaning and painting may be performed prior to erection or after erection, at the option of the Contractor. After erection, any damaged paint shall be repaired to the satisfaction of the Engineer.

C. Surfaces exposed to the atmosphere and which would be inaccessible for painting after erection shall be painted the full number of applications prior to erection.

- Blast cleaning, except that performed within closed buildings, and all painting shall be performed during daylight hours unless the terms of the contract prohibit work being performed during daylight hours.
- Contact surfaces of stiffeners, railings, built up members or open seam exceeding 6 mils in width that would retain moisture, shall be caulked with non-silicone type sealing compound conforming to the requirements in Federal Specification TT-S-230, Type II, or other approved material. The sealing compound shall be applied no sooner than 72 hours after the last application of undercoat, unless otherwise revised in writing by the Engineer. The sealing compound shall cure as recommended by the manufacturer prior to the water rinsing and application of the first finish coat. When no finish coats are applied, the sealing compound shall be gray in color.
- The dry film thickness of the paint will be measured in place with a calibrated Type 2 magnetic film thickness gage in conformance with the requirements in SSPC-PA 2, "Measurement of Dry Coating Thickness with Magnetic Gages," of the "SSPC: The Society for Protective Coatings."
- The thickness of each application shall be limited to that which will result in uniform drying throughout the paint film.
- Succeeding applications of paint shall be of such shade as to slightly contrast with the paint being covered.
- Except for anchor bolt assemblies, metal surfaces embedded in concrete need not be painted. Ungalvanized anchor bolt assemblies shall be painted prior to installation with 2 applications of unthinned zinc-rich primer (organic vehicle type) conforming to the provisions in Section 91, "Paint." Aerosol cans shall not be used.
- The bottom surfaces of masonry plates and surfaces of structural steel to be in contact with elastomeric bearing pads or preformed fabric pads shall be cleaned and painted with the full number of applications prior to erection.

59-2.13 APPLICATION OF ZINC-RICH PRIMER

- Painting with zinc-rich primer shall conform to the provisions in Section 59-2.12, "Painting," and this Section 59-2.13.
- Zinc-rich primer shall be applied by spray methods. On areas inaccessible to spray application, limited applications may be made by brush, daubers or rollers.
- Mechanical mixers shall be used in mixing the primer. After mixing, the zinc-rich primer shall be strained through a 30-60 mesh screen or a double layer of cheesecloth immediately prior to or during pouring into the spray pot.
- An agitating spray pot shall be used in all spray application of zinc-rich primer. The agitator or stirring rod shall reach to within 2 inches of the bottom of the spray pot and shall be in motion at all times during primer application. The motion shall be sufficient to keep the primer well mixed.
- Cured zinc-rich primer shall be free from dust, dirt, salt or other deleterious deposits and thoroughly cured before applying subsequent coats.

59-2.14 MACHINE FINISHED SURFACES

- With the exception of abutting chord and column splices and column and truss shoe bases, machine finished surfaces shall be coated with a rust inhibitor which

can be easily removed. Surfaces of iron and steel castings which have been machine finished shall be painted with a coat of shop paint.

59-2.15 MACHINERY

Prior to installation, all surfaces of machinery exposed to the atmosphere shall be painted with 2 applications of unthinned zinc-rich primer (organic vehicle type) conforming to the provisions in Section 91, "Paint." Unless otherwise specified in the special provisions, the exposed surfaces shall be painted after installation with 2 finish applications of commercial quality gray gloss enamel. Aerosol cans shall not be used.

59-2.16 PAYMENT

Cleaning and painting structural steel will be paid for on the basis of lump sum prices, unless otherwise specified in the special provisions.

The lump sum prices paid for clean structural steel and for paint structural steel or the lump sum price paid for clean and paint structural steel shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in cleaning and painting structural steel as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

59-3 PAINTING GALVANIZED SURFACES

59-3.01 GENERAL

When galvanized surfaces are required to be painted, the surfaces shall be cleaned and painted in conformance with the provisions in Sections 59-1, "General," 59-2, "Painting Structural Steel," and this Section 59-3.

59-3.02 SURFACE PREPARATION

Galvanized surfaces shall be steam cleaned.

After steam cleaning, all areas shall be roughened by abrasive blasting using an abrasive that is no larger than 30 mesh. Galvanizing shall not be removed by this operation.

59-3.03 PAINTING

Galvanized surfaces shall be covered with 2 separate applications of finish coats as specified in the special provisions. Paint for the first application shall be tinted by the manufacturer to slightly contrast with the color of the second application.

59-3.04 PAYMENT

No separate payment will be made for preparing and painting galvanized surfaces and full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in preparing and painting galvanized surfaces as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer will be considered as included in the prices paid for the various contract items of work involving the galvanized surfaces.

59-4 PAINTING TIMBER

59-4.01 GENERAL

- Timber surfaces which are required to be painted shall be prepared and painted in conformance with the provisions in Section 59-1, "General," and this Section 59-4.
- The paint used for various applications will be shown on the plans or specified in these specifications or the special provisions and if not so shown or specified, the paint to be used will be selected by the Engineer.

59-4.02 PREPARATION OF SURFACES

- Cracked or peeled paint, loose chalky paint, dirt and other foreign material shall be removed by wire brushing, scraping or other means immediately prior to painting. The moisture content of the timber shall not be more than 20 percent at the time of the first application.

59-4.03 PAINTING

- When permitted in writing by the Engineer, the first application of paint may be applied prior to erection.
- Unless otherwise shown on the plans or specified in the special provisions, new timber requiring painting shall be painted with 3 applications of paint consisting of one application of primer and 2 finish coats.
- Unless otherwise shown on the plans or specified in the special provisions, timber previously painted shall be coated with 2 applications of finish coats. Bare wood shall be primed with one application of primer specified in Section 91-3.01, "Wood Primer, Latex-Base."
- After the timber is in place, cracks, checks, nail holes or other depressions shall be puttied flush with the surface and allowed to dry before application of the first finish coat of paint.

59-4.04 PAYMENT

- No separate payment will be made for preparing surfaces and for painting timber and full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in preparing surfaces and painting timber as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer will be considered as included in the prices paid for the various contract items of work involving timber.

59-5 PAINTING SIGN STRUCTURES

59-5.01 GENERAL

- Tubular and box beam-closed truss sign structures shall be cleaned and painted in conformance with the provisions in Section 59-1, "General," and this Section 59-5. Sign structures, other than tubular and box beam-closed truss sign structures, shall not be painted unless otherwise specified in the special provisions.

59-5.02 CLEANING AND PAINTING

- Galvanized surfaces shall be cleaned and painted in conformance with the provisions in Section 59-3, "Painting Galvanized Surfaces."

- Ungalvanized steel surfaces, except the interior of tubular posts and mast arms, shall be cleaned and painted in conformance with the provisions in Section 59-2, "Painting Structural Steel," this Section 59-5.02, and as provided in the special provisions.

59-5.03 PAYMENT

- No separate payment will be made for cleaning and painting sign structures and full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in cleaning and painting sign structures as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer will be considered as included in the price or prices paid for sign structures.

59-6 PAINTING CONCRETE

59-6.01 GENERAL

- When painting is specified in the special provisions, cleaning and painting of concrete surfaces shall conform to the provisions in Section 59-1, "General," and this Section 59-6.

59-6.02 SURFACE PREPARATION

- Prior to painting concrete surfaces, laitance and curing compounds shall be removed from the surface by abrasive blast cleaning in conformance with the requirements in ASTM Designation: D 4259. The cleaned surface shall have a roughened, textured appearance as designated in the special provisions.
- Concrete surfaces shall be thoroughly dry and free of dust at the time the paint is to be applied.
- Any artificial drying procedures and methods shall be subject to approval by the Engineer.

59-6.03 PAINT

- Paints to be applied to concrete surfaces shall be Acrylic Emulsion, Exterior White and Light and Medium Tints, Section 91-4.05, or other paints as specified in the special provisions.
- All paints shall be white, unless otherwise specified in the special provisions.

59-6.04 APPLICATION OF ACRYLIC EMULSION PAINT

- Acrylic emulsion paint shall be applied in not less than 2 applications to produce a uniform appearance.

59-6.05 (BLANK)

59-6.06 MEASUREMENT

- Preparing and painting concrete will be measured by the square foot. Measurement will be determined along the surface of the actual area painted.

59-6.07 PAYMENT

- The contract price paid per square foot for prepare and paint concrete shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in preparing the concrete and

applying the paint to concrete surfaces, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 60: (BLANK)

DRAINAGE FACILITIES

SECTION 61: CULVERT AND DRAINAGE PIPE JOINTS

61-1.01 DESCRIPTION

Joint systems or couplers for culvert or drainage pipes to be installed will be designated by classification on the plans, elsewhere in these specifications, or in the special provisions. The classification of joint systems or couplers will be designated as "Standard", "Positive" or "Downdrain".

At the option of the Contractor, joint systems or couplers to be installed shall conform to the details shown on the plans for the classification designated and the provisions in Sections 64, "Plastic Pipe," 65, "Reinforced Concrete Pipe," 66, "Corrugated Metal Pipe," and 69, "Overside Drains," for the kind of pipe to be installed, or the joint systems or couplers to be installed shall conform to the provisions in Section 61-1.02, "Performance Requirements for Culvert and Drainage Pipe Joints."

61-1.02 PERFORMANCE REQUIREMENTS FOR CULVERT AND DRAINAGE PIPE JOINTS

The values for joint properties shall be determined by mathematical analysis or a suitable, approved test. The analysis or test results performed on representative joints proposed to be used shall be submitted to the Engineer. Joint components, subject to bending forces, shall not be stressed beyond the minimum specified yield strength of the material, as determined by using the plastic section modulus. The required joint properties are defined as:

A. Shear Strength.— The shear strength required of the joint is expressed as a percent of the calculated shear strength of the pipe at a transverse section remote from the joint. All joints, including any connection, shall be capable of transferring the required shear across the joint.
B. Moment Strength.— The moment strength required of the joint is expressed as a percent of the calculated moment capacity of the pipe on a transverse section remote from the joint.
C. Tensile Strength.— The tensile strength is that which resists the longitudinal force which tends to separate (disjoint) adjacent pipe sections.
D. Integral Joint Overlap.— The joint overlap is the amount of projection of one culvert barrel into the adjacent culvert barrel. When pipe sections are installed on straight alignment, the pipe sections shall be joined to provide maximum joint overlap. When pipe sections are installed on curved alignment, the pipe sections shall be joined to provide maximum joint overlap on one side of the outside perimeter of the pipe with not less than $^{1}/_{4}$ inch overlap on the opposite side. Joints not meeting the above requirements will be considered disjointed, and the disjointed pipe sections shall be replaced with specially manufactured pipe sections which will meet the above requirements.
E. Sleeve Joint Overlap.— The joint overlap is the minimum sleeve width required to engage both culvert barrels which are abutted to each other.

F. Watertightness.— Watertightness is the ability of a joint to hold water under pressure without leaking. Watertightness shall be attained by the use of approved durable, high quality, resilient joint materials designed to perform the intended function. These materials shall be neoprene expanded rubber or sheet rubber gaskets, "O" ring rubber gaskets, butyl rubber base joint sealant or other approved resilient materials. When watertight joints are shown on the plans or specified in these specifications or the special provisions, the assembled joint shall pass the following performance test without leakage at the joint:

1. A hydrostatic pressure test on a joint shall be made on an assembly of 2 sections of pipe, properly connected in accordance with the joint design. At the option of the Contractor, suitable bulkheads shall be provided within the pipe adjacent to and on either side of the joint, or the outer ends of the joined pipe sections shall be bulkheaded. No mortar or concrete coatings, fillings or packings, in addition to that normally required for the joint shall be placed prior to watertightness tests. After the pipe sections are fitted together with the gasket or gaskets in place, the assembly shall be subjected to a pressure resulting from a head of 10 feet of water above the crown of the pipe for 10 minutes. Moisture or beads of water appearing on the surface of the joint will not be considered as leakage. The tests on individual joints may be performed at the fabricator's facility or at the job site.
2. The joint watertightness test shall be performed on pipe sections in straight alignment and on pipe sections deflected from straight alignment. When testing pipe sections not on straight alignment, the pipe sections shall be positioned to create a gap on one side of the outside perimeter of the pipe that is $^1/_2$ inch wider than the gap for pipe sections in straight alignment. When coupling bands are used to test pipe sections not on straight alignment and the maximum gap on one side of the outside perimeter of the pipe is less than $^1/_2$ inch wider than that for pipe sections in straight alignment, the coupling band pipe sections shall be positioned to provide maximum gap.

• If the Contractor elects to furnish and install joint systems or couplers for culvert and drainage pipes in conformance with the provisions in this Section 61-1.02, the joint systems or couplers shall be approved by the Engineer prior to their intended use. The joint systems or couplers shall perform the intended function, possess durability equivalent to that of the pipe and comply with the joint property requirements set forth below for the classification of joint system or coupler designated.

Joint Property Requirements	Joint Classification		
	Standard	Positive[a]	Downdrain[b]
Shear Strength	2%	5%	5%
Moment Strength	0%	15%	15%
Tensile Strength			
6" through 42" diam.[c]	0	0	5,000 lbs
45" through 84" diam.[c]	0	0	10,000 lbs
Joint Overlap[d]			
Integral			
12" and smaller diam.[e]	1/4" Min	1/2" Min	—
15" through 33" diam.[e]	1/2" Min	3/4" Min	—
36" and larger diam.[e]	3/4" Min	1" Min	—
Sleeve min. width	10 1/2"	10 1/2"	10 1/2"
Watertightness	When specified	When specified	Required

a Positive joints shall meet either (a) the shear strength, moment strength and joint overlap-sleeve requirements, or (b) the shear strength and joint overlap-integral requirements.

b Joints for downdrains shall meet the specified joint property requirements when tested with the joint sealed as proposed to meet the watertightness requirement.

c The limits for corrugated metal pipe arch will depend upon the equivalent diameter of circular pipe as shown in AASHTO Designations: M 36 for corrugated steel pipe and M 196 for corrugated aluminum pipe.

d Joints designed to meet the required joint properties by means other than joint overlap as defined herein may be used upon prior approval by the Engineer.

e The inside diameter of circular pipes or the inside horizontal dimension of oval or arch pipes.

- The Contractor shall furnish to the Engineer a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance," that the material being furnished conforms to the joint property requirements as described above. Field tests may be required by the Engineer whenever there is a question regarding compliance with these requirements.

SECTION 62: ALTERNATIVE CULVERTS

62-1.01 DESCRIPTION

This work shall consist of furnishing and installing or constructing alternative culverts as shown on the plans or as directed by the Engineer and as specified in these specifications and the special provisions.

The allowable kinds of culvert to be used for installation or construction of alternative culverts will be shown on the plans for each nominal size of alternative culvert. The kind of culvert to be installed or constructed shall be selected by the Contractor from the allowable kinds of culverts shown on the plans. The kind of culvert selected shall conform to the provisions in Section 62-1.02, "Alternatives."

Alternative culverts of the same nominal size shown with different combinations of allowable culverts will be designated on the plans and in the Engineer's Estimate as Type A, Type B or as other types for each combination of allowable culverts.

62-1.02 ALTERNATIVES

The kinds of culverts for alternative culverts shall conform to the following provisions:

62-1.02A Reinforced Concrete Pipe and Pipe Arch

Reinforced concrete pipe and pipe arch shall conform to the provisions in Section 65, "Reinforced Concrete Pipe."

62-1.02B Corrugated Steel Pipe and Pipe Arch

Corrugated steel pipe and pipe arch shall conform to the provisions in Section 66, "Corrugated Metal Pipe."

62-1.02C Corrugated Aluminum Pipe and Pipe Arch

Corrugated aluminum pipe and pipe arch shall conform to the provisions in Section 66, "Corrugated Metal Pipe."

62-1.02D Plastic Pipe

Plastic pipe culverts shall conform to the provisions in Section 64, "Plastic Pipe."

62-1.02E Cast-In-Place Concrete Pipe

Cast-in-place concrete pipe shall conform to the provisions in Section 63, "Cast-In-Place Concrete Pipe."

62-1.02F Structural Steel Plate Pipe, Arch and Pipe Arch

Structural steel plate pipe, arch, and pipe arch shall conform to the provisions in Section 67, "Structural Metal Plate Pipe."

62-1.02G Structural Aluminum Plate Pipe, Arch and Pipe Arch

Structural aluminum plate pipe, arch, and pipe arch shall conform to the provisions in Section 67, "Structural Metal Plate Pipe."

62-1.02H Reinforced Concrete Box Culverts and Arch Culverts

Reinforced concrete box culverts and arch culverts shall conform to the provisions in Section 51, "Concrete Structures."

62-1.03 MEASUREMENT

- The provisions for measurement as provided in Sections 63, "Cast-In-Place Concrete Pipe," 64, "Plastic Pipe," 65, "Reinforced Concrete Pipe," 66, "Corrugated Metal Pipe," and 67, "Structural Metal Plate Pipe," shall apply to alternative culverts for the kind of pipe or pipe arch selected for installation.
- Reinforced concrete box culverts and arch culverts, if selected, will be measured by the linear foot as alternative culvert. The length to be paid for will be the slope length designated by the Engineer.

62-1.04 PAYMENT

- The contract price or prices paid per linear foot for the different sizes or sizes and types of alternative pipe or pipe arch culverts, or alternative culverts, shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and installing or constructing alternative culverts, complete in place, including structure excavation and structure backfill, and connecting new pipe to existing or new facilities including concrete collars or concrete tees and reinforcement, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 63: CAST-IN-PLACE CONCRETE PIPE

63-1.01 DESCRIPTION

- Cast-in-place concrete pipe shall consist of portland cement concrete placed monolithically in a prepared trench at the locations shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

63-1.02 MATERIALS

- The pipe shall be constructed of Class 2 portland cement concrete conforming to the provisions in Section 90, "Portland Cement Concrete."
- The combined aggregates for concrete shall conform to the grading limits for the one inch, maximum size specified in Section 90-3.04, "Combined Aggregate Gradings."
- Penetration shall not exceed $1^1/_2$ inches when determined by California Test 533.
- The minimum wall thickness for the various sizes of pipe shall conform to the following table:

Minimum Internal Diameter (inches)	Minimum Wall Thickness (inches)
36	$3^1/_2$
42	4
48	5
54	$5^1/_2$
60	6
66	$6^1/_2$
72	7
78	$7^1/_2$
84	8

63-1.03 PIPE MAKING EQUIPMENT

- The pipe shall be constructed with equipment specially designed for constructing cast-in-place monolithic concrete pipe in one operation. The equipment shall be acceptable to the Engineer and the Contractor may be required to furnish evidence of successful operation on other work of the equipment the Contractor proposes to use. Equipment not suitable to produce the quality of work required for the pipeline will not be permitted to operate on the work.

63-1.04 EARTHWORK

- Excavation, backfill and shaped bedding shall conform to the provisions in Section 19-3, "Structure Excavation and Backfill," except that slurry cement backfill shall not be used.
- The trench shall be excavated to the lines and grades established by the Engineer. The trench width shall not exceed the outside diameter of the pipe plus 2 inches to a height of one foot above the top of the pipe. The bottom of the trench shall be shaped to the external diameter of the pipe and shall be graded and

prepared to provide a firm and uniform bearing throughout the entire length of the pipe.

- The grade of the bottom of the trench shall not vary from the grade established by the Engineer by more than 0.10-foot, nor shall the rate of any variance from grade exceed 0.10-foot per 10 feet. The horizontal alignment of the trench shall not vary from the lines established by the Engineer by more than 0.40-foot, nor shall the rate of any variance from line exceed 0.20-foot per 10 feet.
- The trench shall be free of rocks, mud, sloughed material, debris and standing or running water. Voids shall be backfilled or filled with concrete as part of the pipe placement, as approved by the Engineer.

63-1.05 CONSTRUCTION

- Surfaces against which concrete is to be placed shall be thoroughly moistened with water, if necessary, so that moisture will not be drawn from the freshly placed concrete.
- Concrete shall not be placed when the temperature of the soil of the trench walls is at or below 32º F.
- The concrete shall be placed around the full circumference of the pipe in one operation by means of fixed forms and traveling forms. Traveling forms shall be of sufficient strength to withstand vibrating or tamping the concrete. Fixed forms shall be of sufficient strength to withstand consolidation of the concrete. Inflatable internal forms will not be allowed.
- The traveling forms shall be equipped with internal vibrators and tampers. Portable vibrators will be allowed in addition to the internal vibrators, but shall not be the primary means used to consolidate and distribute the concrete.
- The concrete shall be vibrated, tamped or worked until the concrete has been consolidated to the maximum practicable density, free of rock pockets. The concrete shall bond to the bottom and walls of the trench and close snugly against all surfaces of forms.
- When placing operations cease for more than 30 minutes, or in any case prior to initial set of the concrete, a construction joint shall be formed. The ends of the pipeline shall be covered with suitable material, to maintain a humid condition within the pipe.
- Construction joints shall consist of embedding reinforcing bars into the ends of the pipe wall, a maximum of 12 inches on center around the circumference for pipes 42 inches in diameter and smaller, and 18 inches on center for pipes larger than 42 inches in diameter. The reinforcing bars shall conform to the provisions in Section 52, "Reinforcement," and to the requirements in ASTM Designation: A 615/A 615M, Grade 40 or 60. The bars shall be No. 4, a minimum of 24 inches long, and shall be embedded a minimum of 12 inches into the ends of the pipe wall. The concrete at the ends of the pipe wall shall be left rough.
- Construction joints shall be cleaned immediately prior to completing the construction joint and continuing pipe construction. Cleaning construction joints shall consist of removing laitance, loose or defective concrete, coatings and any other deleterious materials.
- The flow line grade of the finished pipe shall not vary more than 0.10-foot from the grade line established by the Engineer.

- Fixed forms shall be removed not less than 6 hours and not more than 24 hours after placement of the concrete.
- After the removal of forms, any required repairs shall be made. Offsets and indentations, greater than 1/4 inch for pipes with internal diameters of 42 inches or less, 3/8 inch for pipes with internal diameters larger than 42 inches and less than 72 inches, and 1/2 inch for pipes with internal diameters 72 inches and larger, shall be repaired as directed by the Engineer. Rock pockets, blisters, voids, fractures, porous concrete or similar defects not extending through the pipe wall and less than 2 square feet in area shall be removed and repaired with concrete or other materials, as directed by the Engineer. Holes cut in the pipe for inspection or to facilitate removing the forms shall be repaired by filling with concrete or dry patching mortar, as directed by the Engineer.
- After completion of backfill and compaction, cracks shall be repaired as directed by the Engineer. Cracks less than 0.01-inch in width, and cracks exceeding 0.01-inch in width and less than 12 inches in length, shall be repaired with mortar or other materials approved by the Engineer. Longitudinal cracks exceeding 0.01-inch in width and 12 inches in length shall be repaired with pressurized epoxy grout as directed by the Engineer, provided the total length of such cracks is less than 25 percent of the length of the reach. A reach is any length between 2 structures. Circumferential cracks exceeding 0.01-inch in width shall be repaired as directed by the Engineer.
- Any of the following conditions may be cause for rejection of pipe:

  A. Rock pockets, blisters, voids, fractures, porous concrete or similar defects extend through the pipe wall or exceed 2 square feet in area. Pipe may be rejected for one foot on each side beyond the limits of the defect.
  B. The total length of longitudinal cracks exceeding 0.01-inch in width and 12 inches in length exceeds 25 percent of the length of any reach. The entire reach of pipe may be rejected.
  C. The pipe is damaged during construction.
  D. Failure to repair other cracks and defects as directed by the Engineer.
  E. The pipe is not in conformance with the provisions for thickness, grade or alignment, or was not constructed in conformance with the provisions in this Section 63.

- Rejected pipe shall be removed and replaced as directed by the Engineer.
- The finished surface of the concrete pipe shall be the equivalent of wood float surface, substantially free of fractures, cracks and roughness.

63-1.06 CURING AND PROTECTING CONCRETE

- Immediately after casting, the pipe shall be cured either by covering with polyethylene film or by application of a waterproof membrane or pigmented curing compound. Polyethylene film shall be a minimum of 0.0015-inch thick and shall be placed to cover the exposed surface of the pipe. After initial set of the concrete, moist, loose backfill material shall be placed over the film to a depth of between 3 inches and 6 inches. Waterproof membrane and curing compound shall conform

to the provisions in Section 90-7, "Curing Compound." Hand spraying of the compound will be permitted. During the period following the placement of the concrete, the ends of the pipeline shall be covered with suitable material to maintain a humid condition within the pipe for a minimum of 7 days.

- The concrete pipe shall be protected as provided in Section 90-8, "Protecting Concrete."
- Except as otherwise provided, backfill shall not be placed or compacted until the concrete has developed a compressive strength of not less than 2,500 psi.

63-1.07 (BLANK)

63-1.08 MEASUREMENT

- The length of cast-in-place concrete pipe to be paid for will be the slope length designated by the Engineer. Pipe placed in excess of the length designated will not be paid for.

63-1.09 PAYMENT

- The contract price paid per linear foot for cast-in-place concrete pipe shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing the pipeline, complete in place, including structure excavation, backfill, and reinforcement bars for construction joints, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 64: PLASTIC PIPE

64-1.01 DESCRIPTION

- This work shall consist of furnishing and installing corrugated or ribbed plastic pipe for culverts, drains and conduits, with all necessary fittings and coupling systems, as shown on the plans or as directed by the Engineer and as specified in these specifications and the special provisions.
- Plastic pipe shall be either Type C, Type D or Type S corrugated polyethylene pipe, ribbed profile wall polyethylene pipe, or ribbed polyvinyl chloride drain pipe.
- Where designated on the plans as corrugated interior wall type, plastic pipe shall be Type C corrugated polyethylene pipe.
- Where designated on the plans as smooth interior wall type, plastic pipe shall be, at the option of the Contractor, either Type D or Type S corrugated polyethylene pipe, ribbed profile wall polyethylene pipe or ribbed polyvinyl chloride drain pipe.
- Where the type of plastic pipe is not designated on the plans, plastic pipe shall be, at the option of the Contractor, either corrugated or smooth interior wall.

64-1.02 MATERIALS

- Type C, Type D and Type S corrugated polyethylene pipe shall conform to the requirements in AASHTO Designation: M 294, except as otherwise specified. Corrugated polyethylene pipe shall be manufactured from high density polyethylene (HDPE) virgin compounds.
- Ribbed profile wall polyethylene pipe shall be manufactured from high density polyethylene (HDPE) virgin compounds and shall conform to the requirements in ASTM Designation: F 894, except as otherwise specified in these specifications.
- Ribbed polyvinyl chloride drain pipe shall be manufactured from polyvinyl chloride (PVC) virgin compounds and shall conform to the requirements in AASHTO Designation: M 304, except as otherwise specified in these specifications.
- PVC compounds used in the manufacture of plastic pipe culverts shall conform to the following Cell Classifications specified in ASTM Designation: D 1784:

Property	Cell Classification
Base resin	1
Impact strength (Izod)	2 through 6
Tensile strength	3 or 4
Modulus of elasticity	5 or 6
Deflection temperature	4 or 5
Chemical resistance	A, B or C

• HDPE compounds used in the manufacture of plastic pipe culverts shall conform to the following Cell Classifications specified in ASTM Designation: D 3350:

Property	Cell Classification
Density	3
Melt index	2[a], 3 or 4
Flexural modulus	4, 5 or 6
Tensile strength	4, 5 or 6
Environmental stress crack resistance	1, 2 or 3
Hydrostatic design basis	0, 1, 2, 3 or 4
Ultraviolet stabilizer	C[b]

a The Melt Index for Cell Classification 2 material used to manufacture pipe shall not be greater than 0.6. Rotationally molded couplings and end fittings may be produced from material compounds having a Melt Index Cell classification of 1.

b HDPE resin shall contain not less than 2 ±0.5 percent carbon black ultraviolet stabilizer.

• The residue from ignition of the HDPE and PVC compounds shall not exceed 30 percent as determined by ASTM Designation: D 2584, except that the muffle furnace temperature shall be 840° ±45° F.

• In conformance with the provisions in Section 6-1.07, "Certificates of Compliance," a Certificate of Compliance shall be furnished to the Engineer for each type of plastic pipe furnished. The certificate shall also certify that the plastic pipe complies with the requirements of the specifications, and shall include the resin material Cell Classification, unit weight of pipe, average pipe stiffness and date of manufacture.

64-1.03 PIPE THICKNESS, STIFFNESS AND UNIT WEIGHT

• Wall thickness of Type C corrugated polyethylene pipe shall be measured at the inside valley of the corrugation. Wall thickness of Type D corrugated polyethylene pipe shall be measured as the thickness of the inner liner. Wall thickness of Type S corrugated polyethylene pipe shall be the thickness of the inner liner measured between corrugation valleys. Wall thickness of ribbed profile wall polyethylene pipe shall be measured in the gap between ribs. The wall thickness of the various types of polyethylene pipe, measured as specified above, shall equal or exceed the minimum wall thickness values in Table 1. The wall thickness of ribbed profile wall PVC pipe measured in the gap between ribs shall equal or exceed the minimum wall thickness values in Table 3.

• The pipe stiffness shall be determined in conformance with the requirements in ASTM Designation: D 2412 at 5 percent deflection. Average pipe stiffness shall be determined for each manufactured run from 3 test specimens. The length of each test specimen shall equal the nominal pipe diameter, except that the specimen length shall not exceed 36 inches for pipe larger than 36 inches in nominal diameter. The average pipe stiffness shall equal or exceed the minimum pipe stiffness value for each individual kind and size of plastic pipe listed in Tables 1 and 3.

- The pipe unit weight shall be computed as the average weight per foot of length determined from 3 test specimens, taken from each manufactured run. Each test specimen for pipes 24 inches in diameter and less shall be a minimum length of 2 diameters. The length of each test specimen for pipes larger than 24 inches in diameter shall be one diameter or a maximum of 36 inches, whichever is less. The weight of pipe specimens shall be determined with any suitable weighing device accurate to 0.10-pound. The pipe unit weight for each individual kind and size of plastic pipe shall equal or exceed the minimum unit weight value for each individual kind and size of plastic pipe listed in Tables 2 and 3.

TABLE 1
HDPE Pipe

Nominal Diameter (inches)	Minimum Wall Thickness (inches)	Minimum Pipe Stiffness (psi)
12	0.035	50
15	0.035	42
18	0.050	40
21	0.050	38
24	0.050	34
27	0.050	31
30	0.050	28
33	0.050	25
36	0.050	22
42	0.070	20
48	0.070	18

TABLE 2
HDPE Pipe

Nominal Diameter (inches)	Minimum Unit Weight			
	Type C Corrugated (Pounds per linear foot)	Type D Corrugated (Pounds per linear foot)	Type S Corrugated (Pounds per linear foot)	Ribbed (Pounds per linear foot)
12	2.8	na	2.7	na
15	4.0	na	4.0	na
18	5.8	na	6.0	9.6
21	na	na	na	13.2
24	9.6	na	10.2	17.6
27	na	na	na	na
30	na	na	15.0	na
33	na	na	na	na
36	na	na	18.1	na
42	na	22.2	22.2	na
48	na	31.9	26.9	na

Note: "na" in the above table indicates that the pipe size of that type of pipe either is not available from manufacturers or has not been approved for use.

TABLE 3
Ribbed PVC Pipe

Nominal Diameter (inches)	Minimum Wall Thickness (inches)	Minimum Pipe Stiffness (psi)	Minimum Pipe Unit Weight (pounds per linear foot)
18	0.095	32	8.0
21	0.105	28	11.0
24	0.115	24	13.0
27	0.125	22	17.0
30	0.135	19	20.0
36	0.155	16	27.0
42	0.170	14	38.0
48	0.190	12	52.0

64-1.04 JOINTS

- Plastic pipe culvert joints shall conform to either standard or positive joint provisions in Section 61-1.02, "Performance Requirements for Culvert and Drainage Pipe Joints," except that where sleeve joint connections are utilized, the sleeve minimum width shall be $7^3/_4$ inches, and at least 2 corrugations from each pipe to be joined are engaged by the sleeve.
- Where watertight joints are not specified, Type S corrugated polyethylene pipe shall incorporate, on each side of the joint, a closed-cell expanded rubber gasket conforming to the requirements in ASTM Designation: D 1056, Grade 2A2. Type D corrugated polyethylene pipe shall incorporate a rubber gasket in a groove on the spigot end of the pipe. The gasket for Type D polyethylene pipe shall conform to the requirements in ASTM Designation: F 477 or D 1056, Grade 2A2. The gaskets described in this paragraph shall be installed by the pipe manufacturer. Pipe shall be stored in a manner that protects the gaskets from weather. Cracks or splits occurring on gaskets will be cause for rejection.
- Corrugated polyethylene pipe joints manufactured to conform to the integral joint provisions in Section 61-1.02, "Performance Requirements for Culvert and Drainage Pipe Joints," shall be laid to line and grade with the sections jointed closely. Corrugated polyethylene pipe to be joined by sleeve joints shall be laid to line and grade with the separate sections not more than $1^1/_2$ inches apart and then joined together firmly with at least 2 corrugations from each pipe section engaged in the coupler.
- Joints for pipe designated on the plans as watertight, shall be watertight under pressure and all conditions of expansion, contraction and settlement, and shall conform to the provisions for watertightness in Section 61-1.02, "Performance Requirements for Culvert and Drainage Pipe Joints."

64-1.05 EARTHWORK

- Excavation, backfill and shaped bedding shall conform to the provisions in Section 19-3, "Structure Excavation and Backfill," except at locations where pipe is to be backfilled with concrete, the backfill shall conform to the provisions in Section 64-1.06, "Concrete Backfill."

- Plastic pipe shall be laid in a trench excavated to the lines and grades established by the Engineer. The bottom of the trench shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of the pipe.

64-1.06 CONCRETE BACKFILL

- At locations where pipe is to be backfilled with concrete as shown on the plans, the concrete backfill shall be constructed of minor concrete or Class 4 concrete conforming to the provisions in Section 90, "Portland Cement Concrete," except that minor concrete shall contain not less than 380 pounds of cement per cubic yard. The concrete to be used will be designated in the contract item or shown on the plans.
- The concrete backfill shall be placed in the trench against undisturbed material at the sides and bottom of the trench and in a manner that will prevent floating or shifting of the pipe, and voids in, or segregation of, the concrete. Foreign material which falls into the trench, prior to or during placing of the concrete, shall be immediately removed. Where necessary, earth plugs shall be constructed and compacted at the ends of the planned concrete backfill to contain the concrete within the trench.
- The surface of the concrete backfill shall be broomed with a heavy broom to produce a uniform rough surface if asphalt concrete is to be placed directly thereon.
- No material shall be placed on top of the concrete backfill until 8 hours after placing the concrete backfill.

64-1.07 LAYING PIPE

- Plastic pipe shall be laid and jointed in accordance with generally accepted practice and the following provisions in order to be suitable for the purpose intended.
- Necessary facilities shall be provided for lowering and properly placing the sections of pipe in the trench.
- The pipe shall be laid to line and grade with the sections closely jointed.
- Every precaution shall be taken to prevent flooding the pipe trench before backfilling operations.
- New plastic pipe shall be connected to existing or new drainage facilities as shown on the plans. When concrete collars or tee connections are required to connect new plastic pipe to existing or new pipe, the concrete collars or tee connections shall be constructed of minor concrete conforming to the provisions in Section 90-10, "Minor Concrete." Reinforcement for the concrete collars or tees shall conform to the provisions in Section 52, "Reinforcement."

64-1.08 MEASUREMENT

- The pipe work to be performed under these specifications will be listed in the contract item by size, type or whatever information is necessary for identification.
- The length of pipe to be paid for will be the slope length designated by the Engineer. Pipe placed in excess of the length designated will not be paid for, unless pipes are cut to fit a structure or slope. When pipes are cut to fit a structure or slope, the quantity to be paid for will be the length of pipe necessary to be placed before cutting, measured in 2-foot increments.

- Plastic pipe elbows, wyes, tees and other branches will be measured by the linear foot for the size of pipe involved. Elbows will be measured along centerlines. Wyes, tees and other branches will be measured along centerlines to the point of intersection of the centerlines.
- The quantity of concrete in concrete backfill to be paid for by the cubic yard will be determined from the dimensions shown on the plans or other dimensions as may be ordered in writing by the Engineer. Concrete placed outside the limits shown on the plans or ordered by the Engineer will not be measured nor paid for.

64-1.09 PAYMENT

- Items of work, measured as specified in Section 64-1.08, "Measurement," will be paid for at the contract price per linear foot for the different sizes or types of plastic pipe, and the contract price per cubic yard for Class 4 concrete or minor concrete (backfill) as designated in the contract item.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in installing the different sizes, or types of plastic pipe, complete in place, including structure excavation and structure backfill and connecting new pipe to existing or new facilities, including concrete collars or concrete tees and reinforcement, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 65: REINFORCED CONCRETE PIPE

65-1.01 DESCRIPTION

This work shall consist of furnishing and installing circular or oval shaped reinforced concrete pipe or reinforced concrete pipe arch for culverts, siphons, drains and conduits as shown on the plans or as directed by the Engineer and as specified in these specifications and the special provisions.

65-1.02 MATERIALS

Portland cement and aggregate shall conform to the provisions in Section 90-2, "Materials," except that mortar strengths relative to Ottawa sand and grading requirements shall not apply to the aggregate.

The materials for reinforced concrete pipe products shall also conform to the following:

65-1.02A Circular Reinforced Concrete Pipe

Circular reinforced concrete pipe shown by Class on the project plans and designated by Class in the Engineer's Estimate shall conform to the provisions in Section 65-1.02A(1), "Circular Reinforced Concrete Pipe (Designated or Selected by Class)," for the Class shown or designated.

Circular reinforced concrete pipe less than 24 inches in diameter and not shown or designated by Class shall conform to the provisions in Section 65-1.02A(1) for the Class selected by the Contractor.

All other circular reinforced concrete pipe shall, at the option of the Contractor, conform to the provisions in Section 65-1.02A(1), "Circular Reinforced Concrete Pipe (Designated or Selected by Class)," for the Class selected by the Contractor, or to the provisions in Section 65-1.02A(2), "Circular Reinforced Concrete Pipe (Direct Design Method)," for the wall thickness and reinforcement details selected by the Contractor.

65-1.02A(1) Circular Reinforced Concrete Pipe (Designated or Selected by Class)

Circular reinforced concrete pipe designated or selected by Class shall conform to the requirements in AASHTO Designation: M 170 for the Class designated or selected except as provided in this Section 65-1.02A(1).

When the Class of circular reinforced concrete pipe is not shown or designated, the Class of pipe and the corresponding method of backfill shall be selected by the Contractor in accordance with the details shown on the plans.

When the Class of circular reinforced concrete pipe is shown or designated, the method of backfill shall be selected by the Contractor in accordance with the details shown on the plans.

The D-load to produce a 0.01-inch crack shall be not less than the D-load specified.

The wall thickness and steel area for the classes of pipes which are of a size not set forth in AASHTO Designation: M 170, but within the minimum and maximum size limits set forth in AASHTO Designation: M 170, shall be determined by interpolation from data given in the tables for pipes of the next smaller size and pipes of the next larger size.

- For classes of pipes, except Class I, which are of a size less than the minimum size for the particular class set forth in AASHTO Designation: M 170, the minimum wall thickness shall be not less than $1^3/_4$ inches and the steel area shall be not less than 0.06-square inch per linear foot of pipe barrel.
- Prior approval required under AASHTO Designation: M 170 will be granted to extrapolate minimum wall thicknesses and steel areas beyond the limits for Walls A or B in Table 4 and for Wall B in Table 5 in AASHTO Designation: M 170, providing the pipe designs are submitted to the Engineer in advance and the pipe meets all specified tests and performance requirements.
- The basis for acceptance of reinforced concrete pipe over 24 inches in diameter shall be determined by the results of the 3-edge bearing test for the load to produce a 0.01-inch crack, and testing to the ultimate load will not be required, except as necessary to obtain samples for making the absorption test.
- Pipe 24 inches in diameter and smaller need not be tested to the load to produce a 0.01-inch crack provided the pipe is subjected to a load equivalent to the ultimate test load and meets all other requirements in this Section 65-1.02. In lieu of broken pieces of pipe obtained as above provided, 4-inch diameter cores from pipe sections selected by the Engineer may be furnished for performing the absorption test. Sections of pipe which have been tested to the actual 0.01-inch crack will not be further load-tested, and those sections which meet or exceed the required strength and workmanship standards may be accepted for use in the work.
- Pipe shall be marked in conformance with the requirements in AASHTO Designation: M 170, except that sections of circular pipe with elliptical reinforcing shall have the location of the minor axis of the reinforcing indicated by 3-inch wide, waterproof, painted stripes on the inside and outside of the pipe at the top and bottom, at least 12 inches long at each end of the pipe section, or at the option of the Contractor, a lift hole or lift holes may be provided at the top of the pipe along the minor axis of the reinforcement. If one lift hole is provided, the lift hole shall be located at the balance point; if 2 lift holes are provided, the lift holes shall be spaced equidistant each side of the balance point. Lift holes shall not interfere with the reinforcement. After placing, open lift holes shall be filled with cement mortar or concrete plugs before backfilling.
- Non-reinforced concrete pipe may be substituted for reinforced concrete pipe for sizes 36 inches in diameter and smaller and shall conform to the following provisions:

a. The minimum 3-edge bearing strength shall be the D-load to produce the ultimate load for the class of equivalent reinforced concrete pipe as specified in AASHTO Designation: M 170.
b. The pipe shall conform to the requirements in AASHTO Designation: M 86M/M 86, Class 1, 2 or 3 as required to comply with the specified D-load requirements.

   The Contractor may request approval of modified or special designs as provided in AASHTO Designation: M 86M/M 86. The Contractor shall submit proof of the adequacy of the proposed modified or special design. The proof shall consist of 3-edge bearing tests certified by an

independent testing laboratory or by manufacturer's tests attended by State representatives. Tests shall demonstrate the adequacy of the proposed design. A minimum of 3 proof tests will be required for each size and class to be supplied.

c. Portland cement and aggregate for non-reinforced concrete pipe shall conform to the provisions in Section 65-1.02, "Materials."

65-1.02A(2) Circular Reinforced Concrete Pipe (Direct Design Method)

- Direct design method circular reinforced concrete pipe shall conform to the requirements in AASHTO Designation: M 170 except as provided in this Section 65-1.02A(2).
- Direct design method circular reinforced concrete pipe shall be of the wall thickness and reinforcement selected by the Contractor in conformance with the details shown on the plans and the provisions in this Section 65-1.02A(2). The method of backfill shall be as designated on the plans for the particular pipe design selected by the Contractor.
- The 3-edge bearing test shall not apply to direct design method pipe.
- The wall thickness of "Wall X" circular reinforced concrete pipe shall not vary more than $^1/_4$ inch from the wall thickness shown on the plans.
- Shop plans shall conform to the provisions in Section 5-1.02, "Plans and Working Drawings," and shall be submitted to the Engineer for approval. For initial review, 3 sets shall be submitted to the Office of Structure Design. After review, 6 sets shall be submitted to that Office for final approval and for use during construction.
- Shop plans shall include the wall thickness; type, size, location, and configuration of the reinforcement; and a list of station locations for the pipes, including the size, wall type, maximum height of cover, and method of excavation, bedding and backfill for each location.
- The Contractor shall determine the mix proportions for the concrete to be used in direct design method pipe. Before using concrete or in advance of revising approved mix proportions the Contractor shall submit, in writing, a copy of the concrete mix design to the Engineer for approval.
- Concrete shall be designated by compressive strength in conformance with the provisions in Section 90-1, "General," and shall be prequalified in conformance with the provisions in Section 90-9, "Compressive Strength."
- Concrete shall be sampled and tested for compressive strength by the Contractor, at the Contractor's expense, at least once every production shift, but not less often than once daily.
- The circumferential reinforcement for circular reinforced concrete pipe shown on the plans shall be smooth or deformed reinforcement with a specified minimum yield strength of 65,000 psi with longitudinal reinforcement welded thereto at not more than 8 inches maximum spacing.
- Splices of circumferential reinforcement shall develop at least a strength equal to $A_{wr} \times F_y$, where A_{wr} = required area of reinforcement shown on the plans and F_y = specified yield strength of reinforcement.
- Spacers or stirrups may be welded to the longitudinal reinforcement. Welding of spacers or stirrups will be allowed on not more than 10 percent of the

circumferential reinforcement at not less than 24-inch spacing along the pipe length. Where spacers or stirrups are welded to circumferential reinforcement in excess of the above requirements or where longitudinals are welded to circumferential reinforcement, the strength of the circumferential reinforcement across the finished welds shall be not less than 1.1 x A_{wr} x F_y.

- Additional reinforcement required for handling and installation stresses shall be determined, furnished and placed by the Contractor at the Contractor's expense.
- Markings for direct design method circular reinforced concrete pipe shall conform to the requirements in AASHTO Designation: M 170 except that marking for class of pipe will not be required for the pipe. The markings specified in AASHTO Designation: M 170 shall be supplemented by the following: contract number, maximum height of cover, method of backfill for the pipe.
- The Contractor shall furnish to the Engineer a Certificate of Compliance from the manufacturer in conformance with the provisions in Section 6-1.07, "Certificates of Compliance," for each pipe shipment. The certificate shall be signed by the manufacturer's quality control representative and shall state that all materials and workmanship comply with the specifications and approved shop plans.
- Modified designs are the designs which differ from the direct designs shown on the plans with respect to the reinforcement only. Special designs are the designs which differ in any respect from those shown on the plans. Modified or special designs for direct design method pipe shall be submitted to the Engineer for approval in conformance with the provisions in Section 5-1.02, "Plans and Working Drawings."
- Modified or special designs shall be designed according to the California Department of Transportation Bridge Design Specifications.
- The Contractor shall submit proof of the adequacy of the proposed modified or special design. The adequacy of modified or special designs, based upon conformance with crack requirements and structural design parameters, will be as determined by the Engineer.
- Modified designs shall not change the clear coverage from the surface of the concrete to the outside of the reinforcement nor the thickness of the pipe barrel wall shown on the plans.
- The Department will not be liable to the Contractor for failure to accept any modified or special design submitted by the Contractor.

65-1.02B Oval Shaped Reinforced Concrete Pipe

- Oval shaped pipe, within the meaning of this section, shall be pipe having major and minor internal axial dimensions as designated in the contract item. The length of the minor axis shall be between 60 percent and 65 percent of the length of the major axis. The first dimension designated will represent the rise and second dimension will represent the span.
- Oval shaped reinforced concrete pipe shall be of the class shown on the plans or designated in the contract item.
- Oval shaped reinforced concrete pipe shall conform to the requirements in AASHTO Designation: M 207, except as provided herein.

- Prior approval required under AASHTO Designation: M 207 will be granted to extrapolate minimum wall thicknesses and steel areas beyond the limits in Table 1 and Table 2 in AASHTO Designation: M 207, providing the pipe designs are submitted to the Engineer in advance and the pipe meets all specified tests and performance requirements.
- The basis for acceptance of oval shaped reinforced concrete pipe larger in size than equivalent 24-inch diameter round pipe shall be determined by the results of the 3-edge bearing test for the load to produce a 0.01-inch crack, and testing to the ultimate load will not be required, except as necessary to obtain samples for making the absorption test.
- Oval shaped reinforced concrete pipe, equivalent in size or smaller than 24-inch diameter round pipe, need not be tested to the load to produce a 0.01-inch crack provided the pipe is subjected to a load equivalent to the ultimate test load and meets all other requirements in this section. In lieu of broken pieces of pipe obtained as above provided, 4-inch diameter cores from pipe sections selected by the Engineer may be furnished for performing the absorption test. Sections of pipe which have been tested to the actual 0.01-inch crack will not be further load-tested, and those sections which meet or exceed the required strength and workmanship standards may be accepted for use in the work.

65-1.02C Reinforced Concrete Pipe Arch

- Reinforced concrete pipe arch shall conform to the requirements in AASHTO Designation: M 206 and these specifications.
- Reinforced concrete pipe arch shall be of the class shown on the plans or designated in the contract item.
- The basis for acceptance of reinforced concrete pipe arch shall be determined by the results of the 3-edge bearing test for the load to produce a 0.01 inch crack, and testing to the ultimate load will not be required, except as necessary to obtain samples for making the absorption test.

65-1.03 EARTHWORK

- Excavation, backfill and culvert beddings shall conform to the provisions in Section 19-3, "Structure Excavation and Backfill," except at locations where pipe is to be backfilled with concrete, the backfill shall conform to the provisions in Section 65-1.035, "Concrete Backfill."
- If non-reinforced concrete pipe is substituted for reinforced concrete pipe, excavation and backfill for the non-reinforced concrete pipe shall conform to the details shown on the plans for reinforced concrete pipe.
- The pipe shall be laid in a trench excavated to the lines and grades established by the Engineer. The bottom of the trench shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of the pipe.
- Backfill of culvert pipe trenches may be partially completed or completed while the joint mortar is still plastic. Should the joint mortar become set before the backfill is placed, backfilling of the pipe trenches shall not be commenced within 16 hours of jointing the pipe sections.

65-1.035 CONCRETE BACKFILL

- At locations where pipe is to be backfilled with concrete as shown on the plans, the concrete backfill shall be constructed of minor concrete or Class 4 concrete in conformance with the provisions in Section 90, "Portland Cement Concrete," except that minor concrete shall contain not less than 380 pounds of cement per cubic yard. The concrete to be used will be designated in the contract item.
- The concrete backfill shall be placed in the trench against undisturbed material at the sides and bottom of the trench and in a manner that will prevent floating or shifting of the pipe, and voids in, or segregation of, the concrete. Foreign material which falls into the trench, prior to or during placing of the concrete, shall be immediately removed. Where necessary, earth plugs shall be constructed and compacted at the ends of the planned concrete backfill to contain the concrete within the trench.
- The surface of the concrete backfill shall be broomed with a heavy broom to produce a uniform rough surface if asphalt concrete is to be placed directly thereon.
- No material shall be placed on top of the concrete backfill until 8 hours after placing the concrete backfill.

65-1.04 STRUCTURES

- Where shown on the plans, inlet and outlet structures shall be constructed or installed in connection with reinforced concrete pipes. Where such structures are constructed or installed, the ends of pipes shall be placed flush or cut off flush with the structure face, unless otherwise directed by the Engineer.

65-1.05 JACKING PIPE

- At locations shown on the plans, or specified, reinforced concrete pipe shall be jacked into place between the limits shown, or specified, in accordance with these specifications.
- The strength of pipe designated in the contract item will be determined for vertical load only. Additional reinforcement or strength of pipe required to withstand jacking pressure shall be determined and furnished by the Contractor at the Contractor's expense.
- Variations from theoretical alignment and grade at the time of completion of jacking shall not exceed one percent of the distance from the jacking point.
- The diameter of the excavated hole shall not be more than 0.1-foot greater than the outside limits of the pipe. Sluicing or jetting with water will not be permitted. When material tends to cave in from outside these limits, a shield shall be used ahead of the first section of pipe or the face of excavation shall not extend beyond the end of pipe more than $1^1/_2$ feet, unless permitted by the Engineer.
- Areas resulting from caving or excavating outside the above limits shall be backfilled with sand or mortar by a method which will fill the voids.
- The annular space in the inside joints of the pipe shall be filled with jointing material and finished smooth. The space shall be finished as each section of pipe is installed for pipe 24 inches in diameter and smaller, and after the entire installation is completed for larger pipe.

65-1.06 JOINTS

- Reinforced concrete pipe joints shall conform to the provisions in this Section 65-1.06 and, at the option of the Contractor, to the details shown on the plans or the provisions in Section 61-1.02, "Performance Requirements for Culvert and Drainage Pipe Joints."
- Each joint shall be sealed to prevent leakage and infiltration. Unless otherwise shown on the plans or specified in the special provisions, sealing materials shall conform to one or more of the following:

Cement Mortar.— Mortar shall be composed of one part portland cement and 2 parts sand by volume.

Sand shall be well graded and of such size that all will pass a No. 8 sieve.

The materials shall be mixed to a consistency suitable for the purpose intended. Mortar shall be used within 30 minutes after the mixing water has been added.

Admixtures of hydrated lime, fire clay, diatomaceous earth or other approved inert material may be used in the mortar to facilitate workability if the Contractor elects. The amount of admixture to be added shall be the quantity permitted by the Engineer.

Rubber Gasketed Joints.— Rubber gasketed joints shall conform to the requirements of ASTM Designation: C 443 and shall be flexible and able to withstand expansion, contraction, and settlement.

All rubber gaskets shall be stored in as cool a place as practicable, preferably at 70º F or less, and in no case shall the rubber gaskets be exposed to the direct rays of the sun for more than 72 hours.

Rubber gaskets, of the type requiring lubrication, shall be lubricated with the lubricant recommended and supplied by the manufacturer of the pipe.

Resilient Materials.— Resilient joint materials shall be submitted for testing in advance of their use and shall consist of polyvinyl chloride, or fiber glass impregnated with epoxy resin, or other approved resilient materials.

- Other joint sealant materials which will prevent leakage and infiltration may be used, if approved by the Engineer.
- Joints for siphons and pressure pipe, and joints for pipes designated as watertight on the plans, shall be watertight under pressure and all conditions of expansion, contraction and settlement, and shall conform to the provisions for watertightness in Section 61-1.02, "Performance Requirements for Culvert and Drainage Pipe Joints."

65-1.07 LAYING PIPE

- Reinforced concrete pipe used for drainage purposes and dry conduits shall be laid and jointed in accordance with generally accepted practice and the following provisions in order to be suitable for the purpose intended.
- New reinforced concrete pipe shall be connected to existing or new drainage facilities as shown on the plans. When concrete collars or tee connections are

required to connect new reinforced concrete pipe to existing or new pipe, the concrete collars or tee connections shall be constructed of minor concrete in conformance with the provisions in Section 90-10, "Minor Concrete." Reinforcement for the concrete collars or tees shall conform to the provisions in Section 52, "Reinforcement."

- Necessary facilities shall be provided for lowering and properly placing the sections of pipe in the trench.
- Circular pipe with elliptical reinforcement shall be placed with the minor axis of the reinforcement in a vertical position.
- The pipe shall be laid to the lines and grades with the sections closely jointed. The pipe shall be laid upgrade, unless otherwise permitted by the Engineer.
- Joints shall be cleaned and then sealed with the type of materials necessary to make a tight joint.
- Voids occurring in the outer and inner annular sealing material shall be filled with the same type of sealing material and the inside of the joint finished smooth.
- Jointing materials shall be sufficiently protected from the air and sun to prevent drying or deterioration.
- Liquid types of sealing materials shall be retained by molds or runners. Liquid materials shall be poured or pumped into the joint space in a continuous operation and agitated until the joint is completely filled.
- Every precaution shall be taken to prevent flooding the pipe trench before backfilling operations. Free water shall not be allowed to come in contact with the pipe line until portland cement sealing materials have set at least 24 hours.

65-1.08 LAYING SIPHON AND PRESSURE PIPE

- Reinforced concrete pipe used for siphons, low head (internal hydrostatic heads not exceeding 50 feet conduits and drains shall be laid in conformance with the provisions in Section 65-1.07, "Laying Pipe," and in addition, the joints shall be watertight under pressure and all conditions of expansion, contraction and settlement.
- After the pipe has been laid and backfill has been placed and compacted to a minimum of 2 feet above the pipe, the pipe line shall be filled with water to a hydrostatic head of 10 feet above the highest point in the line.
- A hydrostatic test shall be conducted for a period of not less than 24 hours, during which time an accurate measure of the water required to maintain the test pressure shall be made. Any leakage developed by the test shall not exceed the allowable leakage computed by the following formula:

$$E = 0.00002H^{1/2}LD$$

Where:

E = the allowable leakage in GPM.

H = the difference in elevation in feet between the water surface at 10 feet above the highest point in the line and the invert elevation of the pipe at its lowest point.

L = the length of culvert or drainage pipe in feet.

D = the internal diameter of the pipe in inches.

- The Contractor shall, at the Contractor's expense, furnish all water, materials and labor for making the required test. All tests shall be made in the presence of the Engineer. Any leakage in excess of the allowable leakage shall be stopped in a manner satisfactory to the Engineer, and the test repeated until the total leakage does not exceed the allowable leakage. All obvious leaks shall be stopped in a manner satisfactory to the Engineer, whether or not the leakage from the line exceeds that permitted herein.
- The Contractor may, at the Contractor's option, maintain the pipe line full of water for not more than 8 hours prior to commencing the test period.

65-1.09 MEASUREMENT

- The pipe work to be performed under these specifications will be listed in the contract items by size, or size and class, and whatever other information is necessary for identification.
- The length of pipe to be paid for will be the slope length designated by the Engineer. Pipe placed in excess of the length designated will not be paid for, unless pipes are cut to fit a structure or slope. When pipes are cut to fit a structure or slope, the quantity to be paid for will be the length of pipe necessary to be placed before cutting, measured in 2-foot increments.
- Concrete pipe bends, wyes, tees and other branches will be measured and paid for by the linear foot for the sizes, or sizes and classes, of pipes involved. Bends will be measured along center lines. Wyes, tees and other branches will be measured along center lines to the point of intersection of the center lines.
- The quantity of concrete in concrete backfill to be paid for by the cubic yard will be determined from the dimensions shown on the plans or other dimensions as may be ordered in writing, by the Engineer. Concrete placed outside the limits shown on the plans or ordered by the Engineer will not be measured nor paid for.
- Except as otherwise provided in Section 65-1.10, "Payment," portland cement concrete and reinforcement required for headwalls, endwalls, structures and other items of work required by the plans, special provisions and in Section 65, "Reinforced Concrete Pipe," to complete the work, will be measured and paid for as separate items as provided for under their respective sections of these specifications, or the special provisions.
- When the Contractor elects to construct a cast-in-place connection as shown on the plans in lieu of cutting off the pipe to fit the structure, the quantity to be paid for shall be considered as pipe measured along the center line to the inside face of the structure.

65-1.10 PAYMENT

- Items of work, measured as specified in Section 65-1.09, "Measurement," will be paid for at the contract price per linear foot for the different sizes, or the different sizes and classes, of jacked reinforced concrete pipe, reinforced concrete pipe, reinforced concrete pipe siphons, oval shaped reinforced concrete pipe or reinforced concrete pipe arch, and the contract price per cubic yard for Class 4 concrete or minor concrete (backfill) as designated in the contract item.

- The contract price paid per linear foot for jacked reinforced concrete pipe shall include full compensation for furnishing the pipe, excavating, jacking, furnishing and placing backfill material, constructing jacking pits and backfilling pits after the pipe is jacked, and all incidentals necessary to jacking the pipe, complete in place, as specified.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in installing pipe, complete in place, including structure excavation and structure backfill, and connecting new pipe to existing or new facilities, including concrete collars or concrete tees and reinforcement, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 66: CORRUGATED METAL PIPE

66-1 GENERAL

66-1.01 DESCRIPTION

- This work shall consist of furnishing and installing corrugated metal pipe and pipe arches for culverts, siphons, drains, slotted pipe and conduits, all with necessary fittings, as shown on the plans or as directed by the Engineer and as specified in these specifications and the special provisions.
- Corrugated metal pipe shall be either corrugated aluminum pipe or corrugated steel pipe as shown on the plans or designated in the Engineer's Estimate.
- Whenever pipe arches are to be installed, the specifications contained in Section 66, "Corrugated Metal Pipe," for pipe shall also apply to pipe arches.

66-1.02 DIMENSIONS AND THICKNESS

- Dimensions and thicknesses shown are nominal and shall conform to the requirements in AASHTO Designation: M 36 for corrugated steel pipe and AASHTO Designation: M 196 for corrugated aluminum pipe, except as modified herein.
- The nominal thickness of sheets for corrugated metal pipe shall be equal to or greater than that designated in the contract item.
- The lapped longitudinal seams of riveted or resistance spot welded pipe arches shall be placed in the top arch and shall be staggered so as to alternate on each side of the center of the top arch not less than 3 inches.

66-1.03 PROTECTIVE COATINGS, LININGS AND PAVINGS

- When required by the special provisions or designated in the Engineer's Estimate, pipes shall be protected with bituminous coating, bituminous lining or have the invert paved with bituminous material or coated with polymerized asphalt. Moisture, dirt, oil, unbonded or incompatible paint, grease, alkalies or other foreign matter shall be removed from the surface to be coated before the coating material is applied.
- Bituminous coatings shall be applied to the inside and outside of pipes to a minimum thickness of 0.05-inch as provided in AASHTO Designation: M 190, Type A, except as specified in this Section 66-1.03.
- Coupling bands and connecting hardware for coated pipes shall have a protective coating. Coupling bands to be protected by coatings in conformance with the requirements in AASHTO Designation: M 190 may be single-dipped with the coating thickness requirement waived.
- Bituminous linings, if required, shall be applied over bituminous coatings, to the inside of the pipe as provided in this Section 66-1.03.
- Bituminous pavings, if required, shall be applied over bituminous coatings, to the inside bottom portion of pipe as provided in AASHTO Designation: M 190, Type C.
- When linings and pavings are not required, an asphalt mastic coating may be substituted for the bituminous coating on corrugated steel pipe or a polymeric sheet coating may be substituted for bituminous coating on corrugated steel pipe. The asphalt mastic or polymeric sheet coating shall be placed on the outside surface of

the pipe, and the insides need not be coated unless otherwise provided in the special provisions.

- Asphalt mastic coating shall conform to the requirements in AASHTO Designation: M 243 except that asbestos fibers will not be required. The asphalt mastic material shall be applied uniformly to the surface with a minimum thickness of 0.05-inch at any point. Asphalt mastic coating shall be applied at the fabrication plant. Any pinholes, blisters, cracks or lack of bond shall be cause for rejection.
- Polymeric sheet coating shall conform to the requirements in AASHTO Designation: M 246. The polymeric sheet coating shall be applied to the galvanized sheet prior to corrugating and, unless otherwise specified in the plans or special provisions, the thickness shall be not less than 0.010-inch. Any pinholes, blisters, cracks or lack of bond shall be cause for rejection.
- Polymerized asphalt invert coating shall be applied in conformance with the requirements in ASTM Designation: A 849 for "Invert Paved Type with Polymer Material (Class P)," except that polymerized asphalt coatings shall be applied by immersion to a minimum thickness of 0.050-inch above the crests and troughs of the corrugations of the interior and exterior invert including pipe ends. Polymerized asphalt material shall conform to the "Requirements for Polymer Coating" contained in ASTM Designation: A 742/A 742M, and the following:

  Polymerized asphalt shall be hot-applied thermoplastic material containing a minimum of 7.0 percent styrene-butadiene-styrene block copolymer.

  There shall be not more than 1/4 inch undercutting or delamination from the scribe when a minimum 12-inch by 12-inch coupon cut from the coated pipe is exposed for 1000 hours in conformance with the requirements in ASTM Designation: B 117. Cut edges shall be sealed by dipping in a sample of the polymerized asphalt coating heated to the manufacturer's recommended application temperature. There shall be no corrosion or delamination from the sealed edges following exposure as specified.

- When corrugated metal pipes are to be bituminous lined, the fabrication requirements specified in Section 66, "Corrugated Metal Pipe," shall be altered so that the rivet heads inside the pipe will be in the valley of the corrugation. During the fabricating process, provisions shall be made at the ends of pipes to retain the bituminous material. Both the inside and outside surfaces shall be bituminous coated as specified in AASHTO Designation: M 190, Type A. In addition to this coating the valleys on the inside periphery shall be filled by the centrifugal process with the same type of bituminous material to the extent that the thickness on the crests of the corrugations will not be less than 1/8 inch. The lining shall be smooth and uniform, and its surface shall be parallel to a line projected along the crests of the corrugations.
- When protective coatings are applied to pipes, each section of pipe and fittings shall have the thickness of the metal clearly identified on the inner surface with paint or other means approved by the Engineer.
- Damaged protective coatings, linings and invert paving shall be repaired by the Contractor at the Contractor's expense. Bituminous material conforming to the

requirements in AASHTO Designation: M 190 or other materials approved by the Engineer shall be used to repair damaged bituminous coatings; asphalt mastic material conforming to the requirements in AASHTO Designation: M 243 shall be used to repair damaged asphalt mastic coatings; and tar base material conforming to the requirements in AASHTO Designation: M 243 shall be used to repair damaged polymeric sheet coatings. The repair of damaged polymerized asphalt coatings shall conform to the requirements in ASTM Designation: A 762/A 762M, Section 11, "Repair of Damaged Coatings."

66-1.04 EARTHWORK

- Excavation, backfill and shaped bedding shall conform to the provisions in Section 19-3, "Structure Excavation and Backfill," except at locations where pipe is to be backfilled with concrete, the backfill shall conform to the provisions in Section 66-1.045, "Concrete Backfill."
- The pipe shall be laid in a trench excavated to the lines and grades established by the Engineer. The bottom of the trench shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of the pipe.

66-1.045 CONCRETE BACKFILL

- At locations where pipe is to be backfilled with concrete as shown on the plans, the concrete backfill shall be constructed of minor concrete or Class 4 concrete conforming to the provisions in Section 90, "Portland Cement Concrete," except that minor concrete shall contain not less than 380 pounds of cement per cubic yard. The concrete to be used will be designated in the contract item or shown on the plans.
- The concrete backfill shall be placed in the trench against undisturbed material at the sides and bottom of the trench and in a manner that will prevent floating or shifting of the pipe, and voids in, or segregation of, the concrete. Foreign material which falls into the trench, prior to or during placing of the concrete, shall be immediately removed. Where necessary, earth plugs shall be constructed and compacted at the ends of the planned concrete backfill to contain the concrete within the trench.
- The surface of the concrete backfill shall be broomed with a heavy broom to produce a uniform rough surface if asphalt concrete is to be placed directly thereon.
- No material shall be placed on top of the concrete backfill until 8 hours after placing the concrete backfill.

66-1.05 LAYING PIPE

- Corrugated metal products shall be shipped, handled and laid in such a manner as to prevent bruising, scaling or breaking of the galvanized surface or protective coating.
- Annular corrugated pipe shall be laid in the trench with the outside laps of circumferential joints upgrade, with the longitudinal laps positioned other than in the invert, with the separate sections spaced not more than $1^1/_2$ inch apart and then firmly joined together. Helical corrugated pipe shall be laid in the trench with the separate sections spaced not more than $1^1/_2$ inch apart and then firmly jointed together with the corrugations in alignment. Corrugations or projections on the

coupler shall properly engage the corrugations of the pipe section before bolts are tightened.

- New corrugated metal pipe shall be connected to existing or new drainage facilities as shown on the plans. When concrete collars or tee connections are required to connect new corrugated metal pipe to existing or new pipe, the concrete collars or tee connections shall be constructed of minor concrete conforming to the provisions in Section 90-10, "Minor Concrete." Reinforcement for the concrete collars or tees shall conform to the provisions in Section 52, "Reinforcement."

66-1.06 STRUCTURES

- Where shown on the plans, inlet and outlet structures shall be constructed or installed in connection with corrugated metal pipes. Where the structures are constructed or installed, the ends of pipes shall be placed flush or cut off flush with the structure face, unless otherwise directed by the Engineer.

66-1.07 COUPLING BANDS

- At the option of the Contractor, coupling bands for corrugated metal pipe shall conform to the provisions in this Section 66-1.07, or to the provisions in Section 61-1.02, "Performance Requirements for Culvert and Drainage Pipe Joints."
- The provisions and details for corrugated metal pipe coupling bands conforming to this Section 66-1.07 are shown on the plans. The type of coupling band used will be at the Contractor's option and shall conform to the provisions and details shown on the plans. The metal of the bands shall be corrugated, dimpled, or otherwise formed in a manner that will effectively engage the corrugations of the pipe ends.
- Coupling bands for corrugated steel pipe shall conform to the requirements in AASHTO Designation: M 36. Coupling bands for corrugated aluminum pipe shall conform to the requirements in AASHTO Designation: M 196.
- When channel or wing channel coupling bands are used, the interior bend radii of the pipe flange and the channel shall be not less than the thickness of the metal of which they are formed.
- Aluminum and steel materials shall not be mixed in any installation except for coupling band fastening hardware.
- Joints for siphons shall consist of connections made with coupling bands as shown on the plans for positive joints. The universal coupling band shall not be used.
- Joints for siphons, and joints for pipe designated on the plans as watertight, shall be watertight under pressure and all conditions of expansion, contraction and settlement, and shall conform to the provisions for watertightness in Section 61-1.02, "Performance Requirements for Culvert and Drainage Pipe Joints."

66-2 CORRUGATED ALUMINUM PIPE

66-2.01 DESCRIPTION

- Corrugated aluminum pipe shall conform to the provisions for corrugated metal pipe in Section 66-1, "General," for corrugated aluminum pipe in this Section 66-2, and Section 66-4, "Measurement and Payment."

66-2.02 MATERIALS

- The materials for corrugated aluminum products shall conform to the requirements in AASHTO Designation: M 196 and M 197.
- The manufacturer of aluminum pipe and pipe arch shall furnish to the Engineer a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."

66-2.03 FABRICATION

- Corrugated aluminum pipe shall be fabricated by riveting or with a continuous helical lock seam paralleling the corrugations. Annular or helically corrugated pipe shall be fabricated from sheets having $2^2/_3$" x $^1/_2$" or 3" x 1" corrugations.

66-2.03A Fabrication by Riveting

- Pipe fabricated by riveting shall be lap joint construction with annular corrugations. Fabrication shall conform to the requirements in AASHTO Designation: M 196.

66-2.03B Fabrication by Continuous Helical Lock Seam

- Pipe fabricated with a continuous helical lock seam extending from end to end of each length may be used for full circle and equivalent pipe arch sizes. Fabrication shall conform to the requirements in AASHTO Designation: M 196 except that the profile of the sheet on at least one side of the lock seam and adjacent to the 180° fold shall have a minimum retaining offset of one-half the sheet thickness as defined in California Test 662.
- Sampling and testing for continuous lock seam quality control shall conform to the requirements in California Test 662.

66-2.04 END FINISH

- The ends of helically corrugated pipe may be rerolled to form annular corrugations extending at least 2 corrugations from the pipe end. The diameter of reformed ends shall not exceed that of the pipe barrel by more than the depth of the corrugation. All types of pipe ends, whether rerolled or not, shall be matched in a joint such that the maximum difference in the diameter of abutting pipe ends is $^1/_2$ inch.
- Where the ends of helically corrugated aluminum lock seam pipe have been rerolled, the lock seam in the rerolled end shall not contain any visible cracks in the base metal, and the tensile strength of the lock seam shall be not less than 60 percent of that required for the remainder of the pipe. The rerolled ends of the pipe shall exhibit good workmanship and shall not have open lock seams.
- Pipe shall be fabricated in such a manner that it can effectively be joined with standard coupling bands that are described in these specifications or shown on the plans.

66-3 CORRUGATED STEEL PIPE

66-3.01 DESCRIPTION

- Corrugated steel pipe shall conform to the provisions for corrugated metal pipe in Section 66-1, "General," for corrugated steel pipe in this Section 66-3 and Section 66-4, "Measurement and Payment."

66-3.02 MATERIALS

- Corrugated steel products shall conform to the requirements in AASHTO Designation: M 36 and shall be fabricated from either zinc-coated steel sheet or aluminum-coated steel sheet except when fabrication from zinc-coated steel sheet is required by the special provisions.
- Zinc-coated steel sheet shall conform to the requirements in AASHTO Designation: M 218, except that California Test 652 will be used to determine the weight of coating.
- Aluminum-coated steel sheet shall conform to the requirements in AASHTO Designation: M 274.
- The manufacturer of corrugated steel products shall furnish to the Engineer a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."

66-3.03 FABRICATION

- Corrugated steel pipe shall be fabricated either by riveting, resistance spot welding or using a helically corrugated steel pipe with a continuous helical lock seam or continuous helical welded seam paralleling the corrugation. Pipe fabricated from 0.050-inch thick sheets shall be helically corrugated steel pipe with a continuous helical lock seam or a continuous helical welded seam.
- Annular corrugated steel pipe shall be fabricated from sheets having either $2^2/_3$" x $^1/_2$" or 3" x 1" corrugations.

66-3.03A Fabrication by Riveting

- Pipe fabricated by riveting shall conform to the requirements in AASHTO Designation: M 36.

66-3.03B Fabrication by Spot Welding

- Pipe fabricated by resistance spot welding shall conform to the requirements in AASHTO Designation: M 36.

66-3.03C Fabrication by Continuous Helical Seam

- Helically corrugated steel pipe shall conform to the requirements in AASHTO Designation: M 36, and as specified in this section.
- Helically corrugated pipe shall be fabricated using corrugation profiles and continuous helical seam pitches as shown in the following table:

Corrugation Profile

Diameter (Inches)	Nominal Pitch [a] (Inches)	Max. Pitch [a] (Inches)	Nominal Depth (Inches)	Seam Pitch [a] (Inches)
6 through 18	$1^1/_2$	$1^7/_8$	$^1/_4$	12
12 through 84	$2^2/_3$	$2^3/_4$	1/2	24
48 through 120	3	$3^1/_4$	1	21
48 through 120	5	$5^3/_{16}$	1	$29^1/_2$

a Pitch shall be measured at right angles to the direction of the corrugations. A tolerance of plus or minus $^1/_2$ inch on seam pitch is allowable.

66-3.03C(1) Fabrication by Continuous Lock Seam

- Pipe fabricated with a continuous helical lock seam extending from end to end of each length may be used for full circle and equivalent pipe arch sizes. Fabrication shall conform to the requirements in AASHTO Designation: M 36, except that the profile of the sheet on at least one side of the lock seam and adjacent to the 180° fold shall have a minimum retaining offset of one-half the sheet thickness as defined in California Test 662.
- Sampling and testing for continuous lock seam quality control shall conform to the requirements in California Test 662.

66-3.03C(2) Fabrication by Continuous Welded Seam

- Pipe fabricated with a continuous helical welded seam parallel to the corrugations may be used for full circle and equivalent pipe arch sizes. The welding process shall be so controlled that the combined width of the weld and adjacent spelter or aluminum coating burned by the welding does not exceed 3 times the thickness of the metal. If spelter is damaged by the welding outside the above specified area, the weld and damaged spelter adjacent to the weld shall be repaired as specified in Section 75-1.05, "Galvanizing." A coating of aluminum shall be applied to the welded area of aluminum-coated pipe using the metalizing process in conformance with the requirements in AWS C2.2, except that surface cleaning will not be required when the metalizing is applied immediately in a continuous operation following the resistance welding. Testing for welded seam quality control shall conform to the requirements in California Test 665.

66-3.04 END FINISH

- The ends of helically corrugated steel pipe may be rerolled to form annular corrugations extending at least 2 corrugations from the pipe end, or to form an upturned flange with or without reformed annular corrugations. The diameter of reformed ends shall not exceed that of the pipe barrel by more than the depth of the corrugation. All types of pipe ends, whether rerolled or not, shall be matched in a joint such that the maximum difference in the diameter of abutting pipe ends is $^1/_2$ inch.
- Where the ends of helically corrugated steel lock seam pipe have been rerolled, the lock seam in the rerolled end shall not contain any visible cracks in the base metal and the tensile strength of the lock seam shall be not less than 60 percent of that required for the remainder of the pipe. This requirement shall not apply to the lock seam located within a flange formed in rerolling. The rerolled ends of the pipe and flanges shall exhibit good workmanship and shall not have open-lock seams.
- When corrugated steel pipe is rerolled for coupling with a wing channel coupling or a channel coupling band, the maximum distance from any point on the end of the pipe to the plane, normal to the pipe axis and passing through the outermost portion of the pipe end, shall not exceed one-half the width of the channel minus the thickness of the pipe metal. The difference between the minimum and maximum flange diameter shall not exceed $^1/_2$ inch.
- Pipe shall be fabricated in such a manner that it can effectively be joined with standard coupling bands that are described in these specifications or shown on the plans.

66-3.05 DAMAGED GALVANIZING

- In lieu of the requirements in AASHTO Designation: M 36, damaged galvanized surfaces shall be repaired as provided in Section 75-1.05, "Galvanizing."
- When the galvanized surface has been burned by welding, all surfaces of the welded connections shall be thoroughly cleaned by wire brushing and all traces of the welding flux and loose or cracked galvanizing removed, after which the areas shall be repaired as provided in Section 75-1.05, "Galvanizing."

66-3.06 DAMAGED ALUMINUM COATINGS

- In lieu of the requirements in M 36/M 36M, damaged aluminum coatings shall be repaired as provided for damaged galvanizing in Section 75-1.05, "Galvanizing," or Section 66-3.05, "Damaged Galvanizing."

66-3.07 SIPHONS

- Siphons shall be of the thickness shown on the plans or designated in the Engineer's Estimate. When required by the plans, special provisions or the Engineer's Estimate pipe shall be coated as provided in Section 66-1.03, "Protective Coatings, Linings and Pavings."
- The pipe for siphons shall be ordered in such lengths that the number of field connections will be held to a minimum.
- When soldered pipe is specified, the outside seams of pipe fabricated by riveting, spot welding or continuous helical lock seam shall be soldered in a workmanlike manner, the solder being sweated into the joints. If the pipe is fabricated by riveting or spot welding, rivets and spot welds on the circumferential seams shall be spaced at approximately $2^1/_2$ inch centers with maximum spacing of 3 inches. If the pipe is fabricated by a continuous helical welded seam, soldering will not be required.
- After the pipe has been laid and backfill has been placed and compacted to a minimum of 2 feet above the pipe, the pipe line shall be filled with water to a hydrostatic head of 10 feet above the highest point in the line.
- A hydrostatic test shall be conducted for a period of not less than 24 hours, during which time an accurate measure of the water required to maintain the test pressure shall be made. Any leakage developed by the test shall not exceed the allowable leakage computed by the following formula:

$$E = 0.00002H^{1/2}\ LD$$

Where:

E = the allowable leakage in GPM.
H = the difference in elevation in feet between the water surface at 10 feet above the highest point in the line and the invert elevation of the pipe at its lowest point.
L = the length of culvert or drainage pipe in feet.
D = the internal diameter of the pipe in inches.

- The Contractor shall, at the Contractor's expense, furnish all water, materials and labor for making the required test. All tests shall be made in the presence of the Engineer. Any leakage in excess of the allowable leakage shall be stopped in a manner satisfactory to the Engineer, and the test repeated until the total leakage does not exceed the allowable leakage. Obvious leaks shall be stopped in a manner satisfactory to the Engineer, whether or not the leakage from the line exceeds that permitted herein.

66-3.08 NESTABLE PIPE

- Nestable corrugated steel pipe shall meet the requirements for steel pipe in Section 66, "Corrugated Metal Pipe," except the method of fabrication.
- Nestable pipe shall be fabricated in 2 separate half-circle sections and the sections shall be firmly joined together, all in accordance with Military Specification MIL-P-236. At the option of the Contractor, the longitudinal joint of the nestable pipe sections may either be Type I, flanged, or Type II, notched, as specified in Military Specification MIL-P-236.

66-3.09 SLOTTED PIPE

- Slotted pipe shall be grate slot type as shown on the plans.
- Slotted corrugated steel pipe shall be joined with the coupling bands shown on the plans and shall be made watertight.
- If the channel coupling band is used, a $^{3}/_{8}$ inch thick closed cell sponge neoprene gasket or butyl rubber joint sealant shall be placed in the channel interior for its full width. If the modified hugger band is used, a butyl rubber joint sealant shall be placed between the coupling band and the periphery of the pipe as shown on the plans. The butyl rubber joint sealant material shall:

A. Be an extruded strip or bead compounded from a non-drying, non-toxic, synthetic resin base with butyl rubber and inorganic extenders and be 100 percent solid material with no shrinkage.
B. Be furnished in $^{5}/_{8}$" x 1" strips or one inch diameter beads on one inch wide release paper and wound into rolls.
C. Have sufficient adhesion so the strip or bead will adhere to galvanized steel and be soft enough to allow cold flow when compressed during connection of the pipe sections.
D. Not flow or sag at temperatures up to 180º F, nor become brittle, crack or lose adhesion at temperatures down to -30º F.
E. Contain no migrating components that could leach out nor produce any chemical reaction with galvanized steel.

- An alternative joint sealant or sealing method that will provide a watertight joint may be used provided the alternative sealant or method is approved, in writing, by the Engineer.
- Grate assemblies shall conform to the provisions in Section 75-1.02, "Miscellaneous Iron and Steel," but may be fabricated from any of the materials specified in Section 75-1.02 for steel bars, plates and shapes. Any damage to the galvanized surface of the pipe at the toe of the grate assembly fillet weld

connection to the pipe shall be repaired as specified in Section 75-1.05, "Galvanizing."

- Installation of the slotted corrugated steel pipe shall not be started until after paving of the traffic lanes adjacent to the pipe has been completed at the locations where the pipe is to be placed.
- The pipe slot shall be covered with a heavy duty tape or other approved covering during backfilling and paving operations to prevent infiltration of material into the pipe.
- Structure backfill (cement treated) for slotted corrugated steel pipe shall be placed in accordance with the details shown on the plans and shall conform to the provisions for soil cement bedding in Section 19-3.025C, except that the completed structure backfill (cement treated) shall be covered with a curing seal of asphaltic emulsion, Grade SS1 or CSS1, conforming to the provisions in Section 94, "Asphaltic Emulsions."
- Loads shall not be placed on structure backfill (cement treated) sooner than 16 hours after placement.

66-3.10 JACKING PIPES

- At locations shown on the plans, or specified, corrugated steel pipe shall be jacked in place between the limits shown, or specified, in conformance with these specifications.
- The thickness of pipe designated in the contract item will be the minimum thickness permitted. Any heavier thickness of pipe or other facilities required to withstand jacking pressure shall be determined and furnished by the Contractor at the Contractor's expense.
- Pipe lengths may be joined by field welding in conformance with the provisions in Section 49-5.02, "Splicing," or by field riveting.
- Variation from theoretical alignment and grade at the time of completion of jacking shall not exceed one percent of the distance from the jacking point.
- The diameter of the excavated hole shall not be more than 0.10-foot greater than the outside diameter of the pipe. Sluicing or jetting with water will not be permitted. When material tends to cave in from outside these limits a shield shall be used ahead of the first section of pipe or the face of excavation shall not extend beyond the end of the pipe more than $1^1/_2$ feet, unless otherwise permitted by the Engineer.
- Areas resulting from caving or excavating outside the above limits shall be backfilled with sand or mortar by a method which will fill the voids.

66-4 MEASUREMENT AND PAYMENT

66-4.01 MEASUREMENT

- The pipe work to be performed under these specifications will be listed in the contract item by size, type, thickness or whatever information is necessary for identification.
- The length of pipe to be paid for will be the slope length designated by the Engineer. Pipe placed in excess of the length designated will not be paid for, unless pipes are cut to fit a structure or slope. When pipes are cut to fit a structure

or slope, the quantity to be paid for will be the length of pipe necessary to be placed before cutting, measured in 2-foot increments.

- Corrugated aluminum or steel pipe elbows, wyes, tees and other branches will be measured by the linear foot for the size of pipe involved. Elbows will be measured along centerlines. Wyes, tees, and other branches will be measured along centerlines to the point of intersection of the centerlines.
- The quantity of concrete in concrete backfill to be paid for by the cubic yard will be determined from the dimensions shown on the plans or such other dimensions as may be ordered in writing by the Engineer. Concrete placed outside the limits shown on the plans or ordered by the Engineer will not be measured nor paid for.
- Except as otherwise provided in Section 66-4.02, "Payment," structures constructed or installed in connection with placing corrugated aluminum or steel pipe will be measured and paid for in the manner prescribed for the various items involved.

66-4.02 PAYMENT

- Items of work, measured as specified in Section 66-4.01, "Measurement," will be paid for at the contract price per linear foot for the different sizes, types, thickness, coatings, linings and pavings of corrugated aluminum or steel pipe or pipe arch, and the contract price per cubic yard for Class 4 concrete or minor concrete (backfill) as designated in the contract item.
- When any of the various sizes, types, thickness, coatings, linings and pavings of pipe specified in the above paragraph are installed by the jacking method, the contract price paid per linear foot for jacked pipe shall include full compensation for furnishing the pipe, excavating, jacking, furnishing and placing backfill material, constructing jacking pits and backfilling all pits after the pipe is jacked, and all incidentals, and for doing all the work involved in jacking the pipe, complete in place, as specified.
- Pipe with asphalt mastic or polymeric coatings substituted for bituminous coated pipe will be paid for at the contract price per linear foot for the item of bituminous coated pipe listed in the Engineer's Estimate.
- Full compensation for furnishing pipe with end finish will be considered as included in the price paid per linear foot for the pipe involved and no additional compensation will be allowed therefor.
- Full compensation for structure excavation and structure backfill (cement treated) and curing seal, and furnishing and placing concrete plugs or metal caps at the ends of the pipes, as shown on the plans, shall be considered as included in the contract price paid per linear foot for slotted corrugated steel pipe, and no separate payment will be made therefor.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in installing the different sizes, types, thicknesses, coatings, linings and pavings of pipe, complete in place, including structure excavation and structure backfill and connecting new pipe to existing or new facilities, including concrete collars or concrete tees and reinforcement, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 67: STRUCTURAL METAL PLATE PIPE

67-1.01 DESCRIPTION

- This work shall consist of furnishing and installing structural metal plate pipe, arches and pipe arches of the sizes, thickness and dimensions designated on the plans or in the special provisions and as specified in these specifications.
- Structural metal plate pipe, arches and pipe arches shall be made from structural steel plates or structural aluminum plates. The kind of metal, steel or aluminum, to be used will be shown on the plans or designated in the contract item.

67-1.02 MATERIALS

- Structural plates, and nuts and bolts for structural steel plate pipe, arches, and pipe arches shall conform to the requirements in AASHTO Designation: M 167M/M 167.
- Structural plates, and nuts and bolts for structural aluminum plate pipe, arches and pipe arches shall conform to the requirements in AASHTO Designation: M 219, except that the nuts and bolts shall be zinc coated steel conforming to the requirements in ASTM Designation: A 449 and A 563, Grade C, respectively.
- Aluminum and steel materials shall not be mixed in any installation except as provided for steel bolts and nuts on structural aluminum plate pipe.
- The manufacturer of structural metal plate pipe, arches and pipe arches shall furnish to the Engineer a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."
- California Test 652 will be used to determine the thickness of galvanizing of structural steel plates.
- Galvanized surfaces which are damaged shall be repaired in conformance with the provisions in Section 75-1.05, "Galvanizing."
- Where the number of plates around the circumference of the structural metal plate pipe and pipe arch is designated on the plans or in the Engineer's Estimate, the Contractor may, as an option, construct the pipe and pipe arch with fewer plates than the number designated.
- Welding of steel, if required, shall conform to the requirements in AWS D1.1, "Structural Welding Code." Welding of steel plates, other than fittings, shall be performed prior to galvanizing. The Engineer may perform nondestructive testing of the welds, at the Engineer's discretion.
- Welding of aluminum, if required, shall conform to the requirements in AWS D1.2, "Structural Welding Code."
- Concrete and reinforcement, if required, shall conform to the provisions in Sections 51, "Concrete Structures," and 52, "Reinforcement," respectively.

67-1.025 PROTECTIVE COATING

- When required by the special provisions or designated in the Engineer's Estimate, structural steel plate pipes, arches and pipe arches shall be protected with bituminous coating. Coating shall conform to the provisions of Section 66-1.03, "Protective Coatings, Linings and Pavings," except that polymeric sheet coatings will not be permitted and that asphalt mastic may be field applied.

- When protective coating is applied to plates for structural steel plate pipe, arches and pipe arches, each plate shall have the nominal metal thickness painted on the inner surface so that the plate thickness can be readily identified.
- The portion of nuts and bolts, used for assembly of coated structural steel plate pipe, arches and pipe arches projecting outside the pipe shall be coated after installation. The portions of the nuts and bolts projecting inside the pipe need not be coated.
- When asphalt mastic is used for protective coating, the surface at the joints of the pipe need not be coated prior to assembly. Joints shall be thoroughly sealed after assembly with the asphalt mastic on the outside of the pipe.
- Damaged coatings shall be repaired by the Contractor at the Contractor's expense as provided in Section 66-1.03, "Protective Coatings, Linings and Pavings."

67-1.03 IDENTIFICATION

- When plates of 2 dissimilar thicknesses are involved in one cross section of an installation, the thickness of structural plates will be identified on the plans, or in the contract item in accordance with the following:

Each installation will be designated not only by size, but also by a symbol indicating the number and thickness of plates required. Thus, (4.109-1.168) will be used to designate an installation for one plate length composed of four 0.109-inch thickness steel plates and one 0.168-inch thickness steel plate, the heavier thickness to be centered on the invert. This designation does not prevent the Contractor from using fewer plates provided that the minimum thickness requirements are met.

67-1.04 LONGITUDINAL SEAMS

- Structural metal plate pipes, arches and pipe arches shall have the longitudinal seams, other than seams at radius changes, staggered a minimum of 6 inches.

67-1.05 PLACING

- Structural plates shall be assembled in accordance with the manufacturer's instructions. A copy of the manufacturer's assembly instructions shall be furnished to the Engineer prior to assembling the structural plates.
- Prior to backfilling, plate section bolts shall be tightened within the following ranges:

$^{3}/_{4}$ inch diameter bolts: 100 foot-pounds, min.; 300 foot-pounds, max.
$^{7}/_{8}$ inch diameter bolts: 150 foot-pounds, min.; 350 foot-pounds, max.

- Excavation, backfill and shaped bedding shall conform to the provisions in Section 19-3, "Structure Excavation and Backfill."
- Struts shall be placed, as shown on the plans, during construction of pipes, arches and pipe arches. The struts shall remain in place until the backfill has been placed to grading plane elevation or 5 feet over the crown, whichever is less. Unless otherwise permitted by the Engineer, the struts shall be removed prior to the construction of structures at the ends of pipes, arches and pipe arches.

67-1.06 STRUCTURES AND FOOTINGS

- Where shown on the plans, inlet and outlet structures shall be constructed in connection with structural metal plate installations. When the structures are constructed, the ends of plates shall be placed flush or cut off flush with the structure face, unless otherwise directed by the Engineer.
- Each side of the arch shall rest on a galvanized metal angle or channel bearing, securely anchored to the footing and capable of resisting the arch thrust without damage to the angle or channel.

67-1.07 MEASUREMENT

- The work to be performed under these specifications will be listed in the contract items by size, type, thickness, or whatever information is necessary for identification.
- The length of structural metal plate installations to be paid for will be the slope length designated by the Engineer. Installations placed in excess of the length designated will not be paid for, unless installations are cut to fit a structure or slope.
- Bends and elbows will be measured along the centerline of the pipe and will be paid for by the linear foot as structural metal plate pipe of the size and thickness involved.
- When structural metal plate installations are cut to fit a structure or slope, the quantity to be paid for will be the length of structural metal plate installation necessary to be placed before cutting, measured in 4-foot increments.
- The quantities of concrete and reinforcement included in the completed work will be measured and paid for as contract items, except that if there is no contract item, the work will be considered as incidental to performing the work covered by Section 67, "Structural Metal Plate Pipe," and no separate payment will be made therefor.

67-1.08 PAYMENT

- Items of work, measured as specified in Section 67-1.07, "Measurement," will be paid for at the contract price per linear foot for the different sizes, thicknesses, coatings and pavings of structural steel or aluminum plate pipe, arch or pipe arch.
- The above contract prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in installing the different sizes, thicknesses, coatings and pavings of structural metal plate pipe, arches and pipe arches, complete in place, including structure excavation, structure backfill and shaped bedding, and installation and removal of struts if used, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 68: SUBSURFACE DRAINS

68-1 UNDERDRAINS

68-1.01 DESCRIPTION

- This work shall consist of furnishing and installing alternative pipe, perforated steel pipe, perforated concrete pipe, perforated aluminum pipe and perforated plastic pipe or tubing underdrains, and furnishing and placing permeable material and filter fabric as shown on the plans or as directed by the Engineer, and as specified in these specifications and the special provisions.
- When more than one kind of pipe is allowed to be installed at underdrain installations, the underdrain will be designated as alternative pipe underdrain on the plans and in the Engineer's Estimate. The allowable kinds of pipe to be used will be shown on the plans. The kind of pipe to be installed shall be selected by the Contractor from the allowable kinds of pipe shown on the plans. The kind of pipe selected shall conform to the requirements in Section 68-1.02, "Materials."

68-1.02 MATERIALS

- Pipe materials shall be manufactured in accordance with the following requirements:

68-1.02A (Blank)

68-1.02B (Blank)

68-1.02C (Blank)

68-1.02D (Blank)

68-1.02E (Blank)

68-1.02F Perforated Steel Pipe

- Perforated steel pipe and coupling bands shall conform to the requirements in AASHTO Designations: M 36 and M 218, with the following modifications. The pipe shall conform to any one of the full circle types specified in AASHTO Designation: M 36 and perforations in the pipe shall be either drilled or punched. The perforations shall be located either in the inside crests or in the flat tangent portion of all corrugations but not in both locations in a given length of pipe.
- The manufacturer of perforated steel pipe shall furnish to the Engineer a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."
- California Test 652 will be used to determine the weight of galvanizing.
- At the option of the Contractor, sleeve type couplings may be substituted for the band couplers required by AASHTO Designation: M 36. The couplings shall be either plastic or galvanized steel, suitable for holding the pipe firmly in alignment without the use of sealing compound or gaskets. The mechanical properties of the couplings shall be such that they will not be distorted under normal conditions of use.
- Damaged galvanized surfaces shall be repaired in conformance with the provisions in Section 75-1.05, "Galvanizing."

68-1.02G (Blank)

68-1.02H (Blank)

68-1.02I Protective Coating

- When required by the special provisions or designated in the Engineer's Estimate, subsurface drains shall be protected with a coating conforming to the provisions in Section 66-1.03, "Protective Coatings, Linings and Pavings."
- Damaged coatings shall be repaired by the Contractor at the Contractor's expense as provided in Section 66-1.03, "Protective Coatings, Linings and Pavings."

68-1.02J Perforated Aluminum Pipe

- Aluminum underdrain pipe and fittings shall conform to the requirements in AASHTO Designation: M 196 and the following modifications. The pipe shall conform to Type III in AASHTO Designation: M 196. Perforations in the pipe shall be either drilled or punched. The minimum thickness of sheet shall be 0.060-inch.
- Sleeve type couplings may be substituted for the band couplers required by AASHTO Designation: M 196.
- The couplings shall be either plastic or aluminum, suitable for holding the pipe firmly in alignment without the use of sealing compound or gaskets. The mechanical properties of the couplings shall be such that they will not be distorted under normal conditions of use.
- The manufacturer of aluminum underdrain pipe and fittings shall furnish to the Engineer a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."

68-1.02K Perforated Plastic Pipe

- Perforated plastic pipe shall be either smooth-wall polyvinyl chloride plastic pipe, corrugated polyvinyl chloride plastic pipe with a smooth interior surface, or corrugated polyethylene plastic tubing.
- Smooth-wall polyvinyl chloride plastic pipe shall conform to the requirements in AASHTO Designation: M 278.
- Corrugated polyvinyl chloride plastic pipe with a smooth interior surface shall conform to the material and structural requirements in AASHTO Designation: M 278. The pipe shall have perforations located in the bottom half of the pipe, and the perforations shall consist of slots meeting the size and opening area requirements in AASHTO Designation: M 252. The inside diameter and diameter tolerances shall conform to the requirements of either AASHTO Designation: M 252 or M 278.
- Corrugated polyethylene plastic tubing shall conform to the requirements in AASHTO Designation: M 252 or M 294.
- Polyvinyl chloride pipe shall be connected with belled ends, or with sleeve-type or stop-type couplings conforming to the requirements in AASHTO Designation: M 278. Polyethylene tubing shall be connected with snap-on, screw-on, or wrap-around fittings and couplings conforming to the requirements of

AASHTO Designation: M 252 or M 294. Solvent cementing of joints will not be required.

The manufacturer of the polyvinyl chloride pipe or the polyethylene tubing shall furnish to the Engineer a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."

68-1.023 UNDERDRAIN OUTLETS AND RISERS

Underdrain outlets and underdrain terminal risers, vertical risers and 45-degree risers, consisting of covers, pipe, band couplers, pipe elbows, tees and wyes shall be furnished and installed in accordance with the details shown on the plans and as specified in these specifications.

Underdrain outlets and risers shall be fabricated of the same material as the underdrain pipe or of corrugated metal pipe. Except for covers and coupling band fastening hardware, aluminum and steel shall not be mixed in any installation. Outlet and riser pipe and fittings shall not be perforated.

The welded metal cover for risers shall conform to the details shown on the plans. Welded steel covers shall be galvanized after fabrication, in conformance with the provisions in Section 75-1.05, "Galvanizing."

Welding workmanship and technique shall be equal to the best practice in modern commercial shops.

Covers shall be fitted and bolted into the riser pipe or elbow. The covers shall seat uniformly and shall not be subject to rocking.

68-1.025 PERMEABLE MATERIAL

Permeable material for use in backfilling trenches, under, around and over underdrains, shall consist of hard, durable, clean sand, gravel or crushed stone, and shall be free from organic material, clay balls or other deleterious substances.

The class or kind of permeable material to be used will be specified in the special provisions. Class 1 and Class 2 permeable material shall conform to the requirements in these specifications. Class 3 permeable material shall conform to the requirements in the special provisions. When permeable material is required and the class or kind is not specified, Class 1 permeable material shall be used.

The alternative gradings within Class 1 permeable material are identified by types. The Contractor will be permitted to furnish and place any one of the types provided for this class.

The percentage composition by weight of permeable material in place shall conform to the following gradings:

CLASS 1

Sieve Sizes	Percentage Passing	
	Type A	Type B
2"	—	100
$1^1/_2$"	—	95-100
$^3/_4$"	100	50-100
$^1/_2$"	95-100	—
$^3/_8$"	70-100	15-55
No.-4	0-55	0-25
No.-8	0-10	0-5
No. -200	0-3	0-3

CLASS 2

Sieve Sizes	Percentage Passing
1"	100
$^3/_4$"	90-100
$^3/_8$"	40-100
No.-4	25-40
No.-8	18-33
No.-30	5-15
No.-50	0-7
No.-200	0-3

- Class 1 and Class 2 permeable material shall have a Durability Index of not less than 40.
- Class 2 permeable material shall have a Sand Equivalent value of not less than 75.

68-1.028 FILTER FABRIC

- Filter fabric for use with underdrains shall conform to the provisions in Section 88, "Engineering Fabrics." Filter fabric shall be placed in underdrain trenches in accordance with the details shown on the plans and as specified in Section 68-1.03, "Installing Underdrains."

68-1.03 INSTALLING UNDERDRAINS

- Trenches for underdrains shall be excavated, the filter fabric placed, the pipe installed and the trench backfilled with permeable material according to the dimensions and details shown on the plans. When underdrains are installed in trenches outside the subgrade area, the top 6 inches of the trench shall be backfilled as shown on the plans, with structure backfill conforming to the provisions in Section 19-3, "Structure Excavation and Backfill."
- Surfaces to receive filter fabric, immediately prior to placing, shall be free of loose or extraneous material and sharp objects that may damage the filter fabric during installation.
- Adjacent rolls of the fabric shall be overlapped a minimum of 18 inches. The preceding roll shall overlap the following roll in the direction the material is being spread.

- Should the fabric be damaged during placing, the torn or punctured section shall be either completely replaced or shall be repaired by placing a piece of fabric that is large enough to cover the damaged area and to meet the overlap requirement.
- Damage to the fabric resulting from the Contractor's vehicles, equipment or operations shall be replaced or repaired by the Contractor at the Contractor's expense.
- Lengths of perforated steel pipe and perforated aluminum pipe shall be joined by couplers.
- Perforated pipes shall be laid with the perforations down.
- Perforated polyethylene tubing shall be placed to line and grade in a close fitting semicircular bedding groove formed in the bottom of the trench.

68-1.04 MEASUREMENT

- Underdrain pipe will be listed in the contract item by size and type, or whatever information is necessary for identification.
- The length of pipe to be paid for will be the slope length designated by the Engineer. Pipe placed in excess of the length designated by the Engineer will not be paid for.
- Elbows, wyes, tees, risers, outlets and other branches will be measured by the linear foot for the size and type of underdrain pipe they are connected to. Elbows, outlets and risers will be measured along center lines. Wyes, tees and other branches will be measured along center lines to the point of intersection.

68-1.05 PAYMENT

- Pipe underdrains, measured as specified in Section 68-1.04, "Measurement," will be paid for at the contract price per linear foot for the various sizes, types, thicknesses and coatings of pipe underdrains as designated in the Engineer's Estimate.
- The contract price paid per linear foot for pipe underdrains shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in installing pipe underdrains complete in place, including excavation, filter fabric, permeable material, welded metal covers, and structure backfill if required, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

68-2 HORIZONTAL DRAINS

68-2.01 DESCRIPTION

- This work shall consist of furnishing and installing horizontal drains as shown on the plans or directed by the Engineer and as specified in these specifications and the special provisions.

68-2.02 MATERIALS

- Horizontal drains shall consist of nominal $1^1/_2$ inch, Schedule 80 polyvinyl chloride (PVC) plastic pipe conforming to the requirements of ASTM Designation: D 1785. At the option of the Contractor, the type, grade, and design stress designation of the pipe shall be either 1120, 1220, 2110, 2112, 2116 or 2120 as specified in ASTM Designation: D 1785. The plastic pipe shall conform to the

requirements of the National Sanitation Foundation Standard No. 14 when used to conduct water for human consumption.

- Slotted pipe shall have 2 rows of slots. The rows shall be in the longitudinal direction of the pipe and the slots shall be cut in the circumferential direction of the pipe. The rows shall be centered on 2 of the third points (120 degrees apart) of the pipe circumference. Each row of slots shall conform to one of the following configurations. The configuration to be used will be determined by the Engineer.

Number of Slots (one per linear foot)	Width of Slot (inch)	Minimum Opening per linear foot (square inches)
22	0.050	1.00
23	0.020	0.46
46	0.010	0.46

- Slots shall be spaced uniformly along the pipe. The minimum opening will be measured on the inner surface of the pipe.
- Perforated pipe shall have 3 rows of perforations with one row on each side of the pipe and the third row in the top. The perforations shall be $^3/_8$ inch in diameter spaced at 3-inch centers with the top perforations staggered in relation with the holes on either side.
- Fittings for the PVC plastic pipe shall be Schedule 80 Type II PVC solvent weld type fittings conforming to the requirements in ASTM Designation: D 2467. Machined male and female ends may be used in lieu of couplings.
- Unslotted or unperforated PVC plastic pipe, approximately 3 feet to 30 feet in length, shall be provided at the outlet of the drain. The exact length will be determined by the Engineer.

68-2.03 INSTALLING HORIZONTAL DRAINS

- The drains shall be installed as shown on the plans. The locations of horizontal drains shown on the plans are approximate only and the exact location and sequence of placing horizontal drains shall be as directed by the Engineer. Exploratory work required by the Engineer will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."
- Horizontal drains installed at benches in excavation slopes shall be completed before any excavation is made more than 40 feet below the elevation of the bench where the drains are to be installed.
- The horizontal holes shall be drilled with rotary equipment capable of drilling 3-inch to 6-inch diameter holes up to 600 feet in length to designated lines and grades through soil and rock formations.
- Plastic pipe shall be installed by pushing the pipe into the hole with slots or perforations on top or, at the Contractor's option, shall be installed by inserting the pipe inside the drill rod and then retracting the drill rod so that the drilled hole is cased for the full depth. The entrance end of the plastic pipe shall be tightly plugged with a rounded or pointed extension which shall not extend more than 0.5-foot beyond the end of the pipe.

- The casing operation of the drilled hole with plastic pipe shall be done in such a manner that the plastic casing will be cemented together where necessary to form a continuous tube and will not be telescoped or damaged to the extent that its drainage efficiency will be impaired when completed.
- Each drain shall be identified by attaching securely to the outlet end of the non-perforated pipe a brass plate with a number assigned by the Engineer, or by some other permanent marking designated by the Engineer.
- The space between the drilled hole and the pipe shall be tightly plugged with earth for a length of at least 2 feet at the outlet end of the hole.
- The outlet ends of drains shall be equipped with a tee, plug, street ell, and a length of commercial quality galvanized steel pipe or plastic pipe. The length of the pipe shall be varied to connect with the collector system. The exact length will be determined by the Engineer.
- During the drilling operations, the Contractor shall determine the elevation of the drilled hole at 100-foot intervals and also the elevation at the upper end of the completed drain hole. The measurements may be made by inserting tubes or pipes and measuring liquid levels or shall be by other means satisfactory to the Engineer. The Contractor shall furnish all labor, materials, tools, equipment, and incidentals necessary for determining the elevations.
- Water used for drilling and water developed during drilling operations shall be disposed of by the Contractor in such a manner that no damage will result to the project or the environment.

68-2.04 MEASUREMENT

- Horizontal drains will be measured by the linear foot for furnishing and installing drain pipe and by the linear foot for drilling holes.
- The quantity of furnishing and installing drain pipe shall be the length of pipe installed regardless of whether perforated or slotted pipe or non-perforated pipe is used, and also the length of pipe at the outlet end required to connect to the collector system.
- The quantity of drilling holes to be paid for shall be the length of hole drilled, except that any hole drilled in which the drain pipe cannot be installed for the full length of the drilled hole will not be measured and paid for.

68-2.05 PAYMENT

- Horizontal drains will be paid for at the contract price per linear foot for furnish and install drain pipe (horizontal drain) and per linear foot for drill hole (horizontal drain), measured as provided in Section 68-2.04, "Measurement," which payments shall include furnishing all water required for drilling holes and necessary tees, plugs and street ells required for connecting to the collector system.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in installing horizontal drains, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

- Unless otherwise provided in the special provisions, furnishing and installing a collector system will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."

68-3 EDGE DRAINS

68-3.01 DESCRIPTION

- This work shall consist of furnishing and installing plastic pipe edge drains and edge drain outlets, vents and cleanouts, and furnishing and placing treated permeable material, filter fabric and miscellaneous appurtenances as shown on the plans and as specified in these specifications and the special provisions.
- Cross drain interceptors at structure approaches, at end anchors or pressure relief joints, and at pavement terminals joining existing pavements as shown on the plans will be considered as edge drains and shall be furnished and installed in conformance with the provisions for edge drains in this Section 68-3.

68-3.02 MATERIALS

- The materials for edge drains shall conform to the following:

68-3.02A Pipe and Pipe Fittings

- Pipe and pipe fittings for edge drains and edge drain outlets, vents, and cleanouts shall be of the size or sizes shown on the plans or designated in the Engineer's Estimate.
- Pipe installed in trenches to be backfilled with asphalt treated permeable material shall be polyvinyl chloride (PVC) 90°C electric plastic conduit, EPC-40 or EPC-80, conforming to the requirements of NEMA Specification TC-2.
- All other pipe for edge drains and edge drain outlets, vents and cleanouts shall, at the Contractor's option, be either:

1. PVC 90°C electric plastic conduit, EPC-40 or EPC-80, conforming to the requirements of NEMA Specification TC-2, or
2. PVC plastic pipe, Schedule 40 or Schedule 80, conforming to the requirements of ASTM Designation: D 1785. The type, grade and design stress designation of the pipe shall be, at the Contractor's option, either 1120, 1220, 2120, 2116, 2112, or 2110 as specified in ASTM Designation: D 1785.

- Pipe shall be straight end or bell end. Bell end sockets shall conform to the requirements in ASTM Designation: D 2672 except for marking.
- In addition, pipe designated as slotted on the plans shall have 3 rows of slots in the pipe. The rows shall be in the longitudinal direction of the pipe and the slots shall be cut in the circumferential direction of the pipe. The 3 rows shall be spaced equally around the circumference of the pipe. Each row shall have 22(±1) uniformly spaced slots per linear foot of pipe. The slots shall be 0.045-inch to 0.065-inch wide and of such length as to provide a minimum of 2.00 square inches of slot opening per linear foot of pipe. Other suitable configurations of slots which provide drainage equal to or better than the above slot requirements may be used if approved in writing by the Engineer.

- Except as otherwise provided for "Y" fittings, fittings for PVC 90°C electric plastic conduit shall conform to the requirements of NEMA Specification TC-3, and fittings for PVC plastic pipe shall be socket-type fittings conforming to the requirements of ASTM Designation: D 2467 for Schedule 80 pipe and ASTM Designation: D 2466 for Schedule 40 pipe. "Y" fittings shall be shop fabricated from pipe conforming to the requirements for the kind of edge drain pipe installed. The fitting shall provide an unobstructed passageway through both legs of the "Y".

68-3.02B Treated Permeable Material

- Permeable material for edge drains shall be asphalt treated permeable material or cement treated permeable material conforming to the provisions for treated permeable bases in Section 29-1.02, "Materials." The type of treatment (asphalt or cement) for the treated permeable material for edge drains shall be at the Contractor's option.
- Treated permeable material shall be stored, proportioned and mixed in conformance with the provisions for storing, proportioning, and mixing treated permeable bases in Section 29-1.04, "Storing, Proportioning, and Mixing."

68-3.02C Filter Fabric

- Filter fabric shall conform to the provisions in Section 88, "Engineering Fabrics."

68-3.02D Miscellaneous

- Concrete for splash pads shall be produced from commercial quality aggregates and cement and shall contain not less than 470 pounds of cement per cubic yard.
- Mortar placed where edge drain outlets and vents connect to drainage pipes and existing drainage inlets shall conform to the provisions in Section 51-1.135, "Mortar," except that the sand and cement shall be commercial quality.
- Expansion type pressure plugs for cleanouts shall seat firmly against the lip of the pipe and shall conform to one of the following:

Expandable plugs manufactured from neoprene conforming to the requirements for neoprene in Section 51-1.14, "Waterstops," with commercial quality stainless steel bolts and 2 hex nuts.

Commercial quality expandable duct plugs consisting of reinforced polypropylene rigid threaded plug with a commercial quality thermoplastic rubber sealing ring.

68-3.03 INSTALLATION

- Edge drains, edge drain outlets, vents and cleanouts, treated permeable material and filter fabric shall be installed in conformance with the details shown on the plans and as specified in this section.
- Prior to excavating trenches for the installation of edge drains and edge drain outlets, vents and cleanouts in existing paved areas, the outline of the paved areas to be removed shall be cut to a neat line to a minimum depth of 2 inches with a power-driven saw or a wheel type rock cutting excavator. Cuts along the joint

between existing asphalt concrete and existing portland cement concrete pavement will not be required.

- Surfaces to receive filter fabric, immediately prior to placing, shall be free of loose or extraneous material and sharp objects that may damage the filter fabric during installation.
- The fabric shall be aligned and placed in a wrinkle-free manner.
- Adjacent rolls of the fabric shall be overlapped from 12 inches to 18 inches. The preceding roll shall overlap the following roll in the direction the material is being spread.
- Should the fabric be damaged during placing, the torn or punctured section shall be either completely replaced or shall be repaired by placing a piece of fabric that is large enough to cover the damaged area and to meet the overlap requirement.
- Damage to the fabric resulting from the Contractor's vehicles, equipment or operations shall be replaced or repaired by the Contractor at the Contractor's expense.
- Pipe and fittings shall be joined by solvent cementing with commercial quality solvent cement and primer specifically manufactured for use with rigid PVC plastic pipe and fittings. The solvent cement and primer used shall be made by the same manufacturer. The color of the primer shall contrast with the color of the pipe and fittings. The solvent cement and primer shall be used in accordance with the manufacturer's printed instructions.
- Treated permeable material shall be spread only when the atmospheric temperature is above 40° F and may be spread in one or more layers.
- When edge drains are to be installed adjacent to a treated permeable base, the treated permeable material (except for the lower 6 inches of asphalt treated permeable material) may be spread with the treated permeable base. The lower 6 inches of asphalt treated permeable material shall be spread in a separate operation if the upper portion of the asphalt treated permeable material is spread with the asphalt treated permeable base.
- Asphalt treated permeable material shall be placed at a temperature of not less than 180º F nor more than 230º F, except that the temperature of asphalt treated permeable material spread with asphalt treated permeable base shall conform to the temperature provisions for spreading asphalt treated permeable base in Section 29, "Treated Permeable Bases."
- Treated permeable material spread with adjacent treated permeable base shall be compacted with the adjacent base and in the same manner as specified for compacting the base in Section 29, "Treated Permeable Bases." All other layers of treated permeable material shall be compacted with a vibrating shoe-type compactor connected to the spreading device. The vibrating shoe-type compactor shall be in operation when the material is being spread in the trench and shall be turned off when the material is not being spread.
- Cement treated permeable material, which is not covered with asphalt concrete within 12 hours after compaction of the permeable material, shall be cured by either sprinkling the material with a fine spray of water every 4 hours during daylight hours or covering the material with a white polyethylene sheet, not less than 6 mils thick. The above curing requirements shall begin at 7:00 a.m. on the morning

following compaction of the cement treated permeable material and continue for the next 72 hours or until the material is covered with asphalt concrete, whichever is less. The cement treated permeable material shall not be sprayed with water during the first 12 hours after compacting, but may be covered with the polyethylene sheet during the first 12 hours or prior to the beginning of the cure period.

- Trenches in existing embankment areas shall be backfilled with native material and compacted as directed by the Engineer.
- Aggregate base for backfilling trenches in existing paved areas shall be produced from commercial quality aggregates consisting of broken stone; crushed gravel; natural, clean, rough-surfaced gravel or sand; or a combination thereof. The aggregate shall be free from organic material and other deleterious substances and shall conform to the 3/4-inch maximum grading specified in Section 26-1.02A, "Class 2 Aggregate Base."
- Aggregate base backfill shall be spread and compacted by methods that will produce a uniform base, firmly compacted and free from pockets of coarse or fine material.
- Asphalt concrete for backfilling trenches in existing paved areas shall be produced from commercial quality aggregates and asphalt and mixed at a central mixing plant. The aggregate shall conform to the 3/4-inch maximum coarse or medium grading, or the 1/2-inch maximum coarse or medium grading specified in Section 39-2.02, "Aggregate." The amount of asphalt binder to be mixed with the aggregate shall be between 4 percent and 7 percent by weight of the dry aggregate, as determined by the Engineer.
- Asphalt concrete backfill shall be spread and compacted in approximately 2 equal layers by methods that will produce an asphalt concrete surfacing of uniform smoothness, texture and density. Each layer shall be compacted before the temperature of the mixture drops below 250º F. Prior to placing the asphalt concrete backfill, a paint binder (tack coat) of asphaltic emulsion conforming to the provisions in Section 94, "Asphaltic Emulsions," shall be applied to the vertical edges of existing pavement at an approximate rate of 0.05-gallon per square yard.
- Surplus excavated material shall become the property of the Contractor and shall be disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."
- Type A pavement markers conforming to the details shown on the plans and the provisions in Section 85, "Pavement Markers," shall be placed on paved shoulders or dikes at outlet, vent and cleanout locations as directed by the Engineer. The waiting period for placing pavement markers on new asphalt concrete surfacing will not apply.
- The edge drain outlet, vent and cleanout pipes shall be clean at the time of installation and shall be free of obstructions after installation. The Contractor shall use a high pressure, flexible hose with a nominal one inch diameter nozzle containing flushing and propelling jets. The hose shall be inserted into each edge drain outlet, vent and cleanout pipe and pushed through the pipe with a minimum 1,000 psig water pressure so that the entire edge drain system will be penetrated by

the flushing nozzle. Pipes that are found to be plugged shall be replaced by the Contractor at the Contractor's expense, including replacement of treated permeable material, surfacing and backfill materials.

- Outlet and vent covers consisting of commercial quality galvanized metal screens or grates approximately 1/2 inch mesh with polyvinyl chloride slip joint nut fittings shall be installed at the end of each outlet pipe and vent pipe.

68-3.04 MEASUREMENT

- The various sizes of edge drains and edge drain outlets, vents and cleanouts will be measured by the linear foot along the line of the pipe. The length to be paid for will be the slope length of the pipe designated by the Engineer. Pipe placed in excess of the length designated by the Engineer will not be paid for. Outlet pipe, vent pipe and cleanout pipe will be measured and paid for as plastic pipe (edge drain outlet).
- No deduction in the length of plastic pipe (edge drain) will be made for gaps in edge drain pipe at locations of dual outlet, dual vent or dual outlet and vent connections to the edge drain.
- The "Y" fitting at cleanout pipes and at intermediate outlet connections will be measured and paid for as plastic pipe (edge drain outlet) between the couplings at each end of the curved section of the "Y" fitting, and as plastic pipe (edge drain) between the couplings at each end of the straight section of the "Y" fitting.
- Cross drain interceptors at structure approaches, at end anchors or pressure relief joints, and at pavement terminals joining existing pavements as shown on the plans will be measured and paid for as plastic pipe (edge drain).

68-3.05 PAYMENT

- The contract price paid per linear foot for plastic pipe (edge drain) of the size or sizes shown in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in installing edge drains complete in place, including excavation (and removal of any concrete deposits that may occur along the lower edge of the concrete pavement in Type 1 installations) and asphalt concrete backfill for Type 1 edge drain installation, asphaltic emulsion for paint binder (tack coat), filter fabric, and treated permeable material, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract price paid per linear foot for plastic pipe (edge drain outlet) of the size or sizes shown in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in installing edge drain outlets, vents and cleanouts complete in place, including outlet and vent covers, expansion plugs, pavement markers, concrete splash pads, connecting outlets and vents to drainage facilities, and excavation and backfill [aggregate base, asphalt concrete, asphaltic emulsion for paint binder (tack coat), and native material] for outlets, vents, and cleanouts to be installed in embankments and existing shoulders, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 69: OVERSIDE DRAINS

69-1.01 DESCRIPTION

- This work shall consist of furnishing and installing entrance tapers, pipe downdrains, tapered inlets, flume downdrains, anchor assemblies, reducers, slip joints and asphalt concrete overside drains to collect and carry surface drainage down the roadway slopes as shown on the plans or as directed by the Engineer and as specified in these specifications and the special provisions.
- When aluminum or steel pipe downdrains are allowed to be installed at downdrain installations, the downdrain will be designated as alternative pipe downdrain on the plans and in the Engineer's Estimate. The kind of pipe (aluminum or steel) to be installed shall be selected by the Contractor. The kind of pipe selected shall conform to the provisions in Section 69-1.02, "Materials."

69-1.02 MATERIALS

- Overside drain materials shall conform to the following:

69-1.02A Steel Entrance Tapers, Pipe Downdrains, Reducers, Coupling Bands and Slip Joints

- Steel entrance tapers, pipe downdrains, reducers, coupling bands and slip joints shall be constructed of galvanized steel sheets and shall conform to the requirements in AASHTO Designation: M 36, and to the provisions in Section 66, "Corrugated Metal Pipe." The pipe shall conform to Type I pipe specified in AASHTO Designation: M 36. The nominal minimum thickness of sheet shall be 0.064-inch.
- Coupling bands for steel pipe shall conform to the details shown on the plans. The type of coupling band will be at the Contractor's option consistent with the requirements shown on the plans.
- The manufacturer of the steel products shall furnish to the Engineer a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."
- California Test 652 will be used to determine the weight of galvanizing.
- At the option of the Contractor, coupling bands for corrugated steel pipe shall conform to the provisions in this Section 69-1.02A or to the provisions for "Downdrain" pipes in Section 61-1.02, "Performance Requirements for Culvert and Drainage Pipe Joints."

69-1.02B Steel Tapered Inlets and Flume Downdrains

- Steel tapered inlets and flume downdrains shall be fabricated from steel sheets conforming to the provisions in Section 69-1.02A, "Steel Entrance Tapers, Pipe Downdrains, Reducers, Coupling Bands and Slip Joints."

69-1.02C Anchor Assemblies

- Steel parts for anchor assemblies may be obtained from commercial sources.
- Pipe stakes, plates, bars, clip brackets, and hardware shall be hot-dip galvanized, after fabrication, in conformance with the provisions in Section 75-1.05, "Galvanizing."

- Coupling bands shall conform to the provisions in Section 69-1.02A, "Steel Entrance Tapers, Pipe Downdrains, Reducers, Coupling Bands and Slip Joints."

69-1.02D Asphalt Concrete

- Asphalt concrete for overside drains shall conform to the provisions in Section 39-7.01, "Miscellaneous Areas."

69-1.02E Protective Coating

- When required by the special provisions or designated in the Engineer's Estimate, overside drains shall be protected with a coating conforming to the provisions of Section 66-1.03, "Protective Coatings, Linings and Pavings."
- When a protective coating is applied to overside drains, each section of downdrain pipe and each accessory shall have the nominal thickness of the metal clearly identified on the inner surface with paint or other means approved by the Engineer.
- Damaged coatings shall be repaired by the Contractor at the Contractor's expense as provided in Section 66-1.03, "Protective Coatings, Linings and Pavings."

69-1.02F Aluminum Entrance Tapers, Pipe Downdrains, Reducers, Coupling Bands and Slip Joints

- Aluminum entrance tapers, pipe downdrains, reducers, coupling bands and slip joints shall be constructed of aluminum sheets and shall conform to the requirements in AASHTO Designation: M 196, and the provisions in Section 66, "Corrugated Metal Pipe." The pipe shall conform to Type I pipe specified in AASHTO Designation: M 196. The nominal minimum thickness of sheet shall be 0.060-inch.
- Coupling bands for aluminum pipe shall conform to the details shown on the plans. The type of coupling band will be at the Contractor's option consistent with the requirements on the plans.
- The manufacturer of the aluminum products shall furnish to the Engineer a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."
- At the option of the Contractor, coupling bands for corrugated aluminum pipe shall conform to the provisions in this Section 69-1.02F or to the provisions for "Downdrain" pipes in Section 61-1.02, "Performance Requirements for Culvert and Drainage Pipe Joints."

69-1.02G Aluminum Tapered Inlets and Flume Downdrains

- Aluminum tapered inlets and flume downdrains shall be fabricated of aluminum sheet conforming to the requirements in AASHTO Designation: M 197 with a minimum thickness of 0.060-inch.

69-1.02H General Material Requirements

- Overside drain metal products shall be fabricated in accordance with the details and dimensions shown on the plans, except that minor variations may be accepted at the discretion of the Engineer to permit the use of manufacturer's standard jigs and templates in the fabrication. Metal shall be not less than the thickness shown on the plans or as specified in Section 69-1.02A, "Steel Entrance Tapers, Pipe

Downdrains, Reducers, Coupling Bands and Slip Joints," or Section 69-1.02F, "Aluminum Entrance Tapers, Pipe Downdrains, Reducers, Coupling Bands and Slip Joints." Bulkheads and outlet pipes or flume pieces shall be welded or riveted to the inlet chamber to form watertight connections as shown on the plans.

- Each separate overside drain installation shall be assembled from one material only. Ferrous metal and aluminum shall not be used in the same installation, except that the anchor assemblies as shown on the plans may be used with an aluminum installation provided the anchor assemblies are electrically insulated.
- Welding workmanship and technique shall be equal to the best practice in modern commercial shops.
- The entrance taper shall be connected to a downdrain pipe of the dimensions shown on the plans by means of a band coupler or a slip joint.
- The weight of galvanizing for overside drain metal products will be determined by California Test 652.
- Galvanized surfaces on overside drain metal products which are damaged shall be repaired in conformance with the provisions in Section 75-1.05, "Galvanizing."
- When required by the special provisions, or designated in the Engineer's Estimate, overside drain metal products, except anchor assemblies, shall be coated as provided in Section 66-1.03, "Protective Coatings, Linings and Pavings."
- Joints for metal overside drains shall be made watertight with sealant as shown on the plans and shall conform to the provisions for watertightness test in Section 61-1.02, "Performance Requirements for Culvert and Drainage Pipe Joints."

69-1.03 INSTALLATION

- Entrance tapers and tapered inlets shall be installed in such a manner as to function properly and efficiently and shall be so placed as to retain the material in the dike and prevent water from percolating under or around them. The seal between an entrance chamber and the surrounding material shall be watertight.
- When a downdrain is not to be placed in a trench and if directed by the Engineer or specified, the downdrain shall be securely anchored to the slope of the ground with an anchor assembly as directed by the Engineer.

69-1.04 ASPHALT CONCRETE OVERSIDE DRAINS

- Asphalt concrete overside drains shall be constructed as shown on the plans or as directed by the Engineer. The asphalt concrete shall be placed in conformance with the provisions in Section 39-7.01, "Miscellaneous Areas."

69-1.05 MEASUREMENT

- Entrance tapers, tapered inlets, reducers, slip joints and anchor assemblies will be measured as units.
- An entrance taper shall include the length of the tapered section and the length of tail pipe shown on the plans, and the length of tail pipe will not be measured as downdrain pipe.
- A tapered inlet shall include the length of tapered section and flume stub as shown on the plans. The flume stub will not be measured as flume downdrain.
- An anchor assembly shall consist of pipe stakes, bars or coupling bands, and hardware for fastening downdrain pipe or flume downdrain as shown on the plans.

For payment purposes, a downdrain anchor assembly shall include 2 pipe stakes with necessary hardware.

- Alternative pipe downdrains and corrugated aluminum or steel pipe downdrains will be measured by the linear foot for the actual length ordered by the Engineer and placed, exclusive of the length of a slip joint if installed, and exclusive of the length of tail pipe attached to the entrance taper as provided above for entrance tapers. Pipe placed in excess of the length designated will not be paid for, unless pipes are cut to fit a structure or slope. When pipes are cut to fit a structure or slope, the quantity to be paid for will be the length of pipe necessary to be placed before cutting, measured in 2-foot increments.
- Elbows, wyes, tees and other branches will be measured by the linear foot for the size and type of pipe involved. Elbows will be measured along center lines. Wyes, tees and other branches will be measured along center lines to the point of intersection.
- Corrugated aluminum or steel flume downdrain will be measured by the linear foot for the actual length ordered by the Engineer and placed.

69-1.06 PAYMENT

- The quantities of overside drains, measured as specified in Section 69-1.05, "Measurement," will be paid for by the linear foot for the various sizes, types, thicknesses, coatings and pavings of downdrains, and by units for entrance tapers, tapered inlets, reducers, and downdrain slip joints; aluminum entrance tapers, tapered inlets, reducers, and downdrain slip joints; and anchor assemblies for the type of work involved.
- Quantities of asphalt concrete placed for overside drains will be paid for as provided in Section 39-8, "Measurement and Payment," for asphalt concrete placed in miscellaneous areas.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing and installing the different sizes, types, thicknesses, coatings and pavings of overside drains, complete in place, including any necessary excavation and backfill as shown on the plans, and as specified in these specifications, and the special provisions, and as directed by the Engineer.

SECTION 70: MISCELLANEOUS FACILITIES

70-1.01 DESCRIPTION

This work shall consist of furnishing and installing concrete, plastic or metal flared end sections; concrete or metal pipe energy dissipators, pipe inlets, pipe manholes, pipe risers and pipe reducers; drainage gates; and welded steel pipe required for drainage and transmission facilities; all as shown on the plans or as directed by the Engineer and as specified in these specifications and the special provisions.

70-1.02 MATERIALS

Materials shall conform to the following requirements:

70-1.02A Corrugated Metal Products

Corrugated aluminum or steel pipe energy dissipators, pipe inlets, pipe manholes, pipe risers and pipe reducers, all with necessary connections, shall conform to the material requirements in Section 66, "Corrugated Metal Pipe," and shall be of the thickness of metal, dimensions and with the protective coating designated on the plans, in the Engineer's Estimate or specified in the special provisions.

70-1.02B Welded Steel Pipe

Welded steel pipe shall conform to the requirements in AWWA Designation: C 200; ASTM Designation: A 53/A 53M, Grade B; or API Specification 5L, Grade B or Grade X42.

Steel used for the manufacture of the pipe shall be made by either the open-hearth or electric-furnace process.

Field welding shall be performed in conformance with the requirements in AWWA Designation: C 206.

After the pipe has been fabricated and welded into lengths, it shall be thoroughly cleaned of dirt, oil, grease, loose scale and other foreign material.

Unless otherwise provided in the special provisions, the pipe shall be treated in accordance with the following requirements, prior to shipping. Interior and exterior surfaces of welded steel pipe shall be cleaned, primed and coated with coal tar enamel, and the exterior wrapped with a bonded felt wrapper in conformance with the requirements in AWWA Designation: C 203, together with Section A1.2 of the Appendix of that specification.

The outside of coated pipe exposed to the weather shall be painted with one application of Primer, polyvinyl acetate paint, Federal Specification TT-P-55B, White, and, after drying for 24 hours, one finish coat of Federal Specification TT-P-38D, Aluminum Paint.

Welded steel pipe shall be installed in such a manner that it is not electrically connected to, or in direct physical contact with other metal pipe. When welded steel pipe is mechanically connected to public utility lines or to another metal pipe line, electrically insulated connections shall be used. If the other pipe is non-metallic, electrically insulated connections will not be required. Electrically insulated connections shall be placed in welded steel pipe within 5 feet of its ingress into or egress from any building or structure.

- Prior to backfilling at the welded joints, the pipe shall be placed under operating head for a period of 2 hours. Any leaks or other defects shall be corrected by the Contractor. Full compensation for furnishing and disposing of water used for testing will be considered as included in the contract price paid per linear foot for welded steel pipe and no additional compensation will be allowed therefor.
- When backfill material contains rock or highly expansive clay soils, a sand shield shall be provided in conformance with the requirements in AWWA Designation: C 203, Section A1.3 of the Appendix of the specification.

70-1.02C Flared End Sections

- Flared end sections shall be constructed in accordance with the details and dimensions shown on the plans, except that minor variations may be accepted to permit the use of the manufacturer's standard methods of fabrication.
- Precast concrete flared end sections shall conform to the requirements for Class III Reinforced Concrete Pipe in AASHTO Designation: M 170. Portland cement and aggregate shall conform to the provisions in Section 90-2, "Materials," except that mortar strengths relative to Ottawa sand and grading requirements shall not apply to the aggregate. The area of steel reinforcement per linear foot of flared end section shall be at least equal to the minimum steel requirements for circular reinforcement in circular pipe for the internal diameter of the circular portion of the flared end section. The basis of acceptance of the precast concrete flared end section shall conform to the requirements of Section 5.1.2 of AASHTO Designation: M 170.
- Plastic flared end sections shall conform to the requirements in ASTM Designation: D 1248.
- Prefabricated steel flared end sections shall conform to the requirements in AASHTO Designations: M 36 and M 218. Prefabricated aluminum flared end sections shall conform to the requirements in AASHTO Designations: M 196 and M 197. Metal flared end sections may be used in place of precast concrete flared end sections or plastic flared end sections. Metal flared end sections used on concrete pipe 36 inches in diameter or smaller, shall be equipped with toe plates.
- Alternative flared end sections shall conform to the material provisions in Section 62, "Alternative Culverts," for the type of alternative pipe or pipe arch culvert installed except that metal flared end sections may be used with precast concrete pipe or plastic pipe.
- Mortar used to connect metal flared end sections to precast concrete pipe shall conform to the provisions in Section 51-1.135, "Mortar." Welded wire fabric shall be commercial quality.

70-1.02D Drainage Gates

- Automatic drainage gates and slide headgates shall be of the type and size shown on the plans or specified in the special provisions.

70-1.02E Miscellaneous Iron and Steel

- Miscellaneous iron and steel items shall conform to the provisions in Section 75-1.02.

70-1.02F Reinforcement

- Reinforcement shall conform to the provisions in Section 52, "Reinforcement."

70-1.02G Concrete

- Concrete shall conform to the provisions in Sections 51, "Concrete Structures," and 90, "Portland Cement Concrete."

70-1.02H Precast Concrete Structures

- Precast concrete pipe risers and pipe reducers, and precast concrete pipe sections, adjustment rings and tapered sections for pipe energy dissipators, pipe inlets and pipe manholes shall conform to the requirements in AASHTO Designation: M 199M/M 199, except that the portland cement and aggregate shall conform to the provisions in Section 90-2, "Materials," except that mortar strengths relative to Ottawa sand and grading requirements shall not apply to the aggregate.
- Mortar joints shall be constructed in conformance with the provisions in Section 65, "Reinforced Concrete Pipe."
- Reinforced concrete pipe drainage inlets may be formed in place in lieu of using precast pipe and cutting the side openings.

70-1.02I Redwood Covers

- Boards for redwood covers shall be No. 1 heart structural grade, S4S redwood.

70-1.02J Protective Coating

- When required by the special provisions or designated in the Engineer's Estimate, drainage gates, pipes and pipe appurtenances shall be coated as provided in Section 66-1.03, "Protective Coatings, Linings and Pavings."
- Damaged coatings shall be repaired by the Contractor at the Contractor's expense as provided in Section 66-1.03, "Protective Coatings, Linings and Pavings."

70-1.02K (Blank)

70-1.02L Excavation and Backfill

- Excavation and backfill shall conform to the provisions in Section 19-3, "Structure Excavation and Backfill."

70-1.03 INSTALLATION

- Items of work covered by Section 70, "Miscellaneous Facilities," shall be installed as shown on the plans and in accordance with similar work of these specifications.
- Cutoff walls for precast concrete flared end sections shall be constructed of minor concrete with a minimum of 470 pounds of portland cement per cubic yard.
- Drainage gates shall be installed in accordance with the manufacturer's recommendations. The height of guide and control frame for slide headgates shall be as shown on the plans or specified in the special provisions.
- Portland cement concrete structures, or portions of structures shall be constructed in conformance with the provisions in Section 51, "Concrete Structures."
- Mortar and concrete shall be cured as provided in Section 90-7, "Curing Concrete."

- When steps or ladders are required they shall conform to the details shown on the plans and shall be steel when installed in steel or concrete structures, or aluminum when installed in aluminum structures.
- Where new pipe manholes or pipe inlets are located in areas to be paved or surfaced, no individual structure shall be constructed to final grade until the paving or surfacing has been completed immediately adjacent to the structure.

70-1.04 MEASUREMENT

- Miscellaneous facilities to be constructed or installed under Section 70, "Miscellaneous Facilities," will be designated in the contract item by size, type, thickness, or whatever information is necessary for identification.
- The length of welded steel pipe (either plain or coated and wrapped) to be paid for by the linear foot will be the slope length designated by the Engineer.
- Pipe placed in excess of the length designated will not be paid for.
- Quantities of corrugated aluminum or steel or precast concrete pipe energy dissipators, pipe inlets, pipe manholes and pipe risers will be measured by the linear foot to the nearest 0.1-foot of pipe.
- Corrugated aluminum or steel pipe inlets and manholes shall include pipe stubs as shown on the plans and the lengths of pipe stubs will not be measured as pipe.
- Pipe reducers and flared end sections will be measured as units. The limits of payment for flared end sections shall be as shown on the plans. Metal toe plates, when required, and concrete cutoff walls will be considered as part of the flared end section and no separate payment will be made therefor. Metal flared end sections substituted for precast concrete flared end sections or plastic flared end sections will be measured and paid for as the types of flared end sections designated.
- Automatic drainage gates and slide headgates, complete with fastenings, will be measured as complete units.
- Concrete foundations, bases, basin floors or other concrete structures in connection with miscellaneous facilities will be measured by the cubic yard for the quantity of concrete placed or by the cubic yard of concrete (minor structure), if such structures are identified on the plans or in the special provisions as minor structures, all as provided in Section 51, "Concrete Structures."
- Reinforcement will be measured by the pound as provided in Section 52, "Reinforcement," except when structures are identified on the plans or in the special provisions as minor structures, as provided in Section 51-1.02, "Minor Structures."
- Structure excavation and structure backfill will be measured as provided in Section 19-3, "Structure Excavation and Backfill," except as provided in Section 70-1.05, "Payment."
- Metal frames, covers, grates, trash racks and debris rack cages will be measured as provided in Section 75, "Miscellaneous Metal."

70-1.05 PAYMENT

- Unless otherwise provided in this Section 70-1.05, items of work, measured as provided in Section 70-1.04, "Measurement," will be paid for at the contract price or prices per linear foot for the various sizes and wall thicknesses of welded steel pipe or coated and wrapped or lined welded steel pipe; per linear foot for the

various sizes, types and coatings of corrugated aluminum or steel or precast concrete pipe energy dissipators, pipe inlets, pipe manholes, and pipe risers; the contract unit price or prices for pipe reducers and flared end sections for the various sizes, types, coatings or pavings of pipes; the contract unit price or prices for the various sizes, types and coatings of automatic drainage gates or slide headgates; the contract price per pound for bar reinforcing steel; the contract price per cubic yard for the various classes of concrete (minor structure) or concrete (structure); the contract prices per cubic yard for structure excavation and structure backfill; and the contract price paid per pound for miscellaneous iron and steel or the contract unit price paid for frames and covers or frames and grates.

- Full compensation for structure excavation and structure backfill involved in installing flared end sections, pipe energy dissipators, pipe inlets, pipe manholes, pipe risers and pipe reducers will be considered as included in the contract unit prices paid for pipe reducers and flared end sections and per linear foot for pipe energy dissipators, pipe inlets, pipe manholes and pipe risers and no separate payment will be made therefor.
- Full compensation for miscellaneous iron and steel (except frames, covers, grates, trash racks, and debris rack cages) required for pipe energy dissipators, pipe inlets, pipe risers, and pipe manholes will be considered as included in the contract prices paid per linear foot for pipe energy dissipators, pipe inlets, pipe risers and pipe manholes and no additional compensation will be allowed therefor.
- Full compensation for pipe stubs will be considered as included in the contract prices paid per linear foot for corrugated aluminum or steel pipe inlets and manholes and no separate payment will be made therefor.
- Full compensation for making pipe riser connections and constructing bar reinforcing steel riser safety cages will be considered as included in the contract price paid per linear foot for the pipe riser involved and no additional compensation will be allowed therefor.
- When concrete foundations, bases, basin floors or other concrete structures in connection with miscellaneous facilities are identified on the plans or in the special provisions as minor structures, and those structures are paid for at the contract price per cubic yard for concrete (minor structure), full compensation for bar reinforcing steel, steps, structure excavation, and structure backfill will be considered as included in the contract price paid per cubic yard for concrete (minor structure) and no separate payment will be made therefor.
- Redwood covers will be considered as part of the structure upon which they are to be placed and no separate payment will be made therefor.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing or installing the different sizes, thicknesses, coatings, linings, pavings and wrappings of the miscellaneous facilities, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 71: (BLANK)

SECTION 72: SLOPE PROTECTION

72-1 GENERAL

72-1.01 DESCRIPTION

Slope protection consists of rock, concrete, concreted-rock or slope paving. The type of slope protection to be used will be designated in the Engineer's Estimate, the special provisions or shown on the plans. The slope protection shall be placed in conformance with these specifications, the special provisions, and the details and dimensions shown on the plans or directed by the Engineer.

72-2 ROCK SLOPE PROTECTION

72-2.01 DESCRIPTION

This work shall consist of placing revetment type rock courses on the slopes.

The size of the individual pieces of rock in each class shall be as indicated in the table in Section 72-2.02, "Materials," or as specified in the special provisions. The classes of rock slope protection will be designated in the Engineer's Estimate as 8T, 4T, 2T, 1T, $^1/_2$T, $^1/_4$T, Light, Facing, and No. 1, No. 2 or No. 3 Backing.

72-2.02 MATERIALS

The individual classes of rocks used in rock slope protection shall conform to the following, unless otherwise specified in the special provisions, or as shown on the plans.

GRADING OF ROCK SLOPE PROTECTION					
Method A Placement, Percentage Larger Than*					
	Classes				
Rock Sizes	8T	4T	2T	1T	$^1/_2$T
16 Ton	0-5	—	—	—	—
8 Ton	50-100	0-5	—	—	—
4 Ton	95-100	50-100	0-5	—	—
2 Ton	—	95-100	50-100	0-5	—
1 Ton	—	—	95-100	50-100	0-5
$^1/_2$ Ton	—	—	—	95-100	50-100
$^1/_4$ Ton	—	—	—	—	95-100

* The amount of material smaller than the smallest rock size listed in the above tables for any class of rock slope protection shall not exceed the percentage limit listed in the above tables determined on a weight basis. Compliance with the percentage limit shown in the above tables for all other rock sizes of the individual pieces of any class of rock slope protection shall be determined by the ratio of the number of individual pieces larger than the specified rock size compared to the total number of individual pieces larger than the smallest rock size listed in the above tables for that class.

GRADING OF ROCK SLOPE PROTECTION

Method B Placement, Percentage Larger Than*								
	Classes							
Rock Size	1T	1/2T	1/4T	Light	Facing	No. 1	No. 2	No. 3
2 Ton	0-5	—	—	—	—	—	—	—
1 Ton	50-100	0-5	—	—	—	—	—	—
1/2 Ton	—	50-100	0-5	—	—	—	—	—
1/4 Ton	95-100	—	50-100	0-5	—	—	—	—
200 lb	—	95-100	—	50-100	0-5	0-5	—	—
75 lb	—	—	95-100	—	50-100	50-100	0-5	—
25 lb	—	—	—	95-100	90-100	90-100	25-75	0-5
5 lb	—	—	—	—	—	—	90-100	25-75
1 lb	—	—	—	—	—	—	—	90-100

* The amount of material smaller than the smallest rock size listed in the above tables for any class of rock slope protection shall not exceed the percentage limit listed in the above tables determined on a weight basis. Compliance with the percentage limit shown in the above tables for all other rock sizes of the individual pieces of any class of rock slope protection shall be determined by the ratio of the number of individual pieces larger than the specified rock size compared to the total number of individual pieces larger than the smallest rock size listed in the above tables for that class.

- The material shall also conform to the following quality requirements:

Test	California Test	Requirement
Apparent Specific Gravity	206	2.5 min.
Absorption	206	4.2% max.*
Durability Index	229	52 min.*

* Based on the formula listed below, absorption may exceed 4.2 percent if DAR is greater than 10. Durability Index may be less than 52 if DAR is greater than 24.

$$\frac{\text{Coarse Durability Index}}{\text{\% Absorption} + 1} = \text{Durability Absorption Ratio (DAR)}$$

- Rocks, when conforming to the provisions in this Section 72-2.02, may be obtained from rock excavation of the roadway prism or other excavation being performed under the provisions of the contract, in conformance with the provisions in Section 4-1.05, "Use of Materials Found on the Work."
- Rocks shall be of such shape as to form a stable protection structure of the required section. Rounded boulders or cobbles shall not be used on prepared ground surfaces having slopes steeper than 2:1 (horizontal:vertical). Angular shapes may be used on any planned slope. Flat or needle shapes will not be accepted unless the thickness of the individual pieces is greater than 0.33 times the length.

72-2.025 ROCK SLOPE PROTECTION FABRIC

- Rock slope protection fabric shall be placed prior to placing rock slope protection, when the fabric is shown on the plans, or specified in the special provisions, or ordered by the Engineer.
- Rock slope protection fabric shall conform to the provisions in Section 88, "Engineering Fabrics," and shall be placed in conformance with the details shown on the plans and as specified in these specifications.
- Prior to placing rock slope protection fabric, the surfaces upon or against which rock slope protection fabric is to be placed, shall be free of loose or extraneous material and sharp objects that may damage the fabric during installation.
- Rock slope protection fabric shall be handled and placed in conformance with the manufacturer's recommendations and as directed by the Engineer. Rock slope protection fabric shall be placed loosely upon or against the surface to receive the fabric so that the fabric conforms to the surface without damage when the cover material is placed.
- Rock slope protection fabrics shall be joined, at the option of the Contractor, either with overlapped joints or stitched seams.
- When fabric is joined with overlapped joints, adjacent borders of the fabric shall be overlapped not less than 24 inches. The fabric shall be placed such that the fabric being placed shall overlap the adjacent section of fabric in the direction the cover material is being placed.
- When the fabric is joined by stitched seams, the fabric shall be stitched with yarn of a contrasting color. The size and composition of the yarn shall be as recommended by the fabric manufacturer. The number of stitches per inch of seam shall be approximately 5 to 7. The strength of stitched seams shall be the same as specified for the fabric, except when stitched seams are oriented up and down a slope, the strength shall be a minimum of 80 percent of that specified for the fabric.
- Equipment or vehicles shall not be operated or driven directly on the rock slope protection fabric.
- Rock slope protection fabric damaged during placement shall be replaced or repaired, as directed by the Engineer, by the Contractor at the Contractor's expense. Fabric damaged beyond repair, as determined by the Engineer, shall be replaced. Repairing damaged fabric shall consist of placing new fabric over the damaged area. The minimum fabric overlap from the edge of the damaged area shall be 3 feet for overlap joints. If the new fabric joints at the damaged areas are joined by stitching, the stitched joints shall conform to the requirements specified herein.

72-2.03 PLACING

- Rock slope protection shall be placed in conformance with one of the following methods as designated in the Engineer's Estimate.
- At the completion of slope protection work, the footing trench shall be filled with excavated material and compaction will not be required.

Method A Placement

- A footing trench shall be excavated along the toe of slope as shown on the plans.

- The larger rocks shall be placed in the footing trench.
- Rocks shall be placed with their longitudinal axis normal to the embankment face and arranged so that each rock above the foundation course has a 3-point bearing on the underlying rocks. Foundation course is the course placed on the slope in contact with the ground surface. Bearing on smaller rocks which may be used for chinking voids will not be acceptable. Placing of rocks by dumping will not be permitted.
- Local surface irregularities of the slope protection shall not vary from the planned slope by more than one foot measured at right angles to the slope.

Method B Placement

- A footing trench shall be excavated along the toe of the slope as shown on the plans.
- Rocks shall be so placed as to provide a minimum of voids, and the larger rocks shall be placed in the toe course and on the outside surface of the slope protection. The rock may be placed by dumping and may be spread in layers by bulldozers or other suitable equipment.
- Local surface irregularities of the slope protection shall not vary from the planned slopes by more than one foot measured at right angles to the slope.

72-2.04 MEASUREMENT

- Rock slope protection will be measured by the ton or cubic yard as designated in the Engineer's Estimate.
- Quantities of rock slope protection to be paid for by the cubic yard will be determined from the dimensions shown on the plans or the dimensions directed by the Engineer and rock slope protection placed in excess of these dimensions will not be paid for.
- Quantities of rock slope protection to be paid for by the ton will be weighed in conformance with the provisions in Section 9-1.01, "Measurement of Quantities."
- Rock slope protection fabric will be measured by the square yard. The quantity to be paid for will be the actual area covered not including additional fabric required for overlaps.

72-2.05 PAYMENT

- The contract price paid per cubic yard or per ton for rock slope protection (the class of rock and method of placement to be designated in the Engineer's Estimate) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing the rock slope protection, complete in place, including excavation, and backfilling footing trenches, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract price paid per square yard for rock slope protection fabric shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and placing rock slope protection fabric, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

72-3 (BLANK)

72-4 CONCRETE SLOPE PROTECTION, GUTTER LINING, DITCH LINING, AND CHANNEL LINING

72-4.01 DESCRIPTION

This work shall consist of constructing concrete slope protection, and concrete gutter, ditch and channel lining. At the option of the Contractor, the slope protection and linings, including footings, support walls, cut-off stubs, cut-off walls and aprons, shall be constructed of either portland cement concrete or shotcrete.

72-4.02 FOUNDATION PREPARATION

The foundation, which includes all surfaces upon which concrete or shotcrete is to be placed, shall be evenly graded such that no point on the graded surface shall be above the designated plane. If unsuitable material is encountered at the elevation of the foundation, the material shall be removed and disposed of as directed by the Engineer. The resulting space shall be filled with material suitable for the foundation. The foundation areas shall be thoroughly compacted, with moisture sufficient to allow a firm foundation and to prevent absorption of water from the concrete or shotcrete, but shall not contain free surface water.

72-4.03 MATERIALS

Portland cement concrete shall conform to the provisions in Section 90, "Portland Cement Concrete," and shall be either Class 3 concrete or minor concrete at the Contractor's option.

Shotcrete shall conform to the provisions in Section 53, "Shotcrete."

Expansion joint filler shall conform to the provisions in Section 51-1.12C, "Premolded Expansion Joint Fillers."

Pervious backfill material shall conform to the provisions in Section 19-3.065, "Pervious Backfill Material."

Reinforcement shall conform to the provisions in Section 52, "Reinforcement."

72-4.04 CONSTRUCTION

Concrete shall be mixed and placed in conformance with the provisions in Section 51, "Concrete Structures," and shall be spread and tamped until the concrete is thoroughly compacted and mortar flushes to the surface. If the slope is too steep to permit the use of concrete sufficiently wet to flush with tamping, the concrete shall be tamped until consolidated, and a mortar surface, 1/4 inch thick, shall be troweled on immediately. The mortar shall consist of one part portland cement and 3 parts of fine aggregate.

After striking off to grade, the concrete shall be hand floated with wooden floats not less than 4 inches in width and not less than 30 inches in length. The entire surface shall be broomed with a fine texture hair push broom to produce a uniform surface. Brooming shall be done when the surface is sufficiently set to prevent deep scarring and shall be accomplished by drawing the broom down the slope leaving the marks parallel to the edges of the panel. If directed by the Engineer, a fine spray of water shall be applied to the surface immediately in

advance of brooming. Edges and joints shall be edged with a 1/4 inch radius edger prior to the brooming.

- Shotcrete shall be placed and finished in conformance with the provisions in Section 53, "Shotcrete ."
- Expansion joints shall be installed transversely at intervals of 20 feet. Longitudinal expansion joints shall be installed if shown on the plans. Expansion joints shall be filled with expansion joint filler 1/2 inch thick.
- Concrete and shotcrete shall be cured as provided in Section 90-7, "Curing Concrete."
- Pervious backfill material, if required by the plans, shall be placed as shown. A securely tied sack containing one cubic foot of pervious backfill material shall be placed at each weep hole and drain hole. The sack material shall conform to the requirements in Section 88-1.03, "Filter Fabric".
- At the completion of the work, footing trenches shall be filled with excavated material and compaction will not be required.

72-4.05 MEASUREMENT

- Quantities of concrete or shotcrete will be measured by the cubic yard computed from measurements, along the slope, of the actual areas constructed and the theoretical thickness shown on the plans. No additional compensation will be allowed for additional concrete or shotcrete placed by reason of low foundation.

72-4.06 PAYMENT

- Quantities of concrete or shotcrete measured as specified in Section 72-4.05, "Measurement," will be paid for at the contract price per cubic yard as concrete (slope protection, gutter lining, ditch lining and channel lining, as individual items, or combinations thereof).
- The above price and payment shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in shaping slopes and preparing the foundation, constructing weep holes and drain holes, furnishing and placing expansion joint filler, mortar, reinforcement, structure excavation and structure backfill, and pervious backfill material, and constructing the finished slope protection, lined gutters, ditches and channels, including support walls, cut-off stubs, cut-off walls, footings and aprons, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Except for structure excavation, excavation within the limits of payment shown on the plans will be paid for as provided in Section 19, "Earthwork." Removal and disposal of unsuitable material will be paid for at the contract price for the class of excavation designated on the plans or in the special provisions for removal of the material above the foundation elevation. The material used to replace unsuitable material will be paid for as provided in Section 19-7, "Borrow Excavation."

72-5 CONCRETED-ROCK SLOPE PROTECTION

72-5.01 DESCRIPTION

- This work shall consist of placing revetment type concreted-rock courses on the slopes.

- The rock slope protection shall be concreted as shown on the plans and as specified in these specifications and the special provisions.
- The size of the individual pieces of rock in each class shall be as indicated in the table in Section 72-5.02, "Materials," or as specified in the special provisions. The classes of concreted-rock slope protection will be designated in the Engineer's Estimate as 1/2T, 1/4T, Light, Facing and Cobble.

72-5.02 MATERIALS

- The individual classes of rocks used in concreted-rock slope protection shall conform to the following, unless otherwise specified in the special provisions or shown on the plans.

GRADING OF CONCRETED-ROCK SLOPE PROTECTION

Rock Sizes	Percentage Larger Than*				
	Classes				
	1/2T	1/4T	Light	Facing	Cobble
1 Ton	0–5	—	—	—	—
1/2 Ton	50–100	0–5	—	—	—
1/4 Ton	—	50–100	0–5	—	—
200 lb	90–100	—	50–100	0–5	—
75 lb	—	90–100	90–100	50–100	0–5
25 lb	—	—	—	90–100	95–100
Minimum Penetration of Concrete (inches)	18	14	10	8	6

* The amount of material smaller than the smallest rock size listed in the table for any class of concreted-rock slope protection shall not exceed the percentage limit listed in the table determined on a weight basis. Compliance with the percentage limit shown in the table for all other rock sizes of the individual pieces of any class of concreted-rock slope protection shall be determined by the ratio of the number of individual pieces larger than the specified rock size compared to the total number of individual pieces larger than the smallest rock size listed in the table for that class.

- The material shall also conform to the following quality requirements:

Test	California Test	Requirement
Apparent Specific Gravity	206	2.5 min.
Absorption	206	4.2% max.*
Durability Index	229	52 min.*

* Based on the formula listed below, absorption may exceed 4.2 percent if DAR is greater than 10. Durability Index may be less than 52 if DAR is greater than 24.

$$\frac{\text{Coarse Durability Index}}{\text{\% Absorption} + 1} = \text{Durability Absorption Ratio (DAR)}$$

- Rocks, when conforming to the provisions in this Section 72-5.02, may be obtained from rock excavation of the roadway prism or other excavation being

performed under the provisions of the contract, in conformance with the provisions in Section 4-1.05, "Use of Materials Found on the Work."

- Rocks shall be of such shape as to form a stable protection structure of the required section. Flat or needle shapes will not be accepted unless the thickness of the individual pieces is greater than 0.33-times the length.
- Concrete shall be Class 3 concrete or minor concrete conforming to the provisions in Section 90, "Portland Cement Concrete," one-inch combined aggregate and mixed as provided for structures. The water content of the concrete shall be such as to permit gravity flow into the interstices with limited spading and brooming. The amount of water used shall be that designated by the Engineer.

72-5.03 PLACING ROCK

- Rock for concreted-rock slope protection shall be placed in conformance with one of the following methods as designated in the Engineer's Estimate.
- At the completion of slope protection work, the footing trench shall be filled with excavated material and compaction will not be required.

Method A Placement

- A footing trench shall be excavated along the toe of slope as shown on the plans.
- The larger rocks shall be placed in the footing trench.
- Rocks shall be placed with their longitudinal axis normal to the embankment face and arranged so that each rock above the foundation course has a 3-point bearing on the underlying rocks. Foundation course is the course placed on the slope in contact with the ground surface. Bearing on smaller rocks which may be used for chinking voids will not be acceptable. Placing of rocks by dumping will not be permitted.
- Local surface irregularities of the slope protection shall not vary from the planned slope by more than one foot measured at right angles to the slope.

Method B Placement

- A footing trench shall be excavated along the toe of the slope as shown on the plans.
- Rocks shall be so placed as to provide a minimum of voids and the larger rocks shall be placed in the toe course and on the outside surface of the slope protection. The rock may be placed by dumping and may be spread in layers by bulldozers or other suitable equipment.
- Local surface irregularities of the slope protection shall not vary from the planned slopes by more than one foot measured at right angles to the slope.

72-5.04 PLACING CONCRETE

- The surfaces of the rock to be concreted shall be cleaned of adhering dirt and clay and then moistened. The concrete shall be placed in a continuous operation for any day's run at any one location. Concrete shall be brought to the place of final deposit by use of chutes, tubes or buckets, or may be placed by means of pneumatic equipment or other mechanical methods. In no case shall concrete be permitted to flow on the slope protection a distance in excess of 10 feet.

- Immediately after depositing, the concrete shall be spaded and rodded into place with suitable spades, trowels or other approved means until the minimum penetration is that shown in the table entitled "Grading of Concreted-Rock Slope Protection" in Section 72-5.02, "Materials."
- After the concrete has been placed, the rocks shall be thoroughly brushed so that their top surfaces are exposed. The outer rocks shall project 0.33 to 0.25 times their diameter above the concrete surface. After completion of any 10-foot strip, no workman or load shall be permitted on the surface for a period of at least 24 hours, and longer if so ordered by the Engineer.
- Concreted-rock slope protection shall be cured as provided in Section 90-7, "Curing Concrete."

72-5.05 MEASUREMENT

- Concreted-rock slope protection will be measured by the ton or cubic yard for the rock as designated in the Engineer's Estimate and by the cubic yard for the concrete.
- Quantities of rock to be paid for by the cubic yard will be determined from the dimensions shown on the plans or the dimensions directed by the Engineer, and rock placed in excess of these dimensions will not be paid for.
- Quantities of rock to be paid for by the ton will be weighed in conformance with the provisions in Section 9-1.01, "Measurement of Quantities."
- Quantities of concrete to be paid for by the cubic yard will be measured at the mixer as provided in Section 90-11, "Measurement and Payment."

72-5.06 PAYMENT

- The contract price paid per cubic yard or per ton for concreted-rock slope protection (the class of rock and method of placement to be designated in the Engineer's Estimate) and per cubic yard for concrete (concreted-rock slope protection) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing the concreted-rock slope protection, complete in place, including excavation and backfilling footing trenches, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

72-6 SLOPE PAVING

72-6.01 DESCRIPTION

- This work shall consist of constructing slope paving under the ends of bridges and in other locations. At the option of the Contractor, slope paving shall be constructed of either shotcrete or portland cement concrete.

72-6.02 FOUNDATION PREPARATION

- The foundation, which includes surfaces upon which slope paving is to be constructed, shall be evenly graded such that no point on the graded surface shall be above the designated slope plane. The foundation areas shall be thoroughly compacted, with moisture sufficient to allow a firm foundation and to prevent absorption of water from the concrete or mortar, but shall not contain free surface water.

72-6.03 MATERIALS

- Portland cement concrete shall conform to the provisions in Section 90, "Portland Cement Concrete," and shall be either Class 3 concrete or minor concrete at the Contractor's option. The one-inch maximum combined grading shall be used for Class 3 concrete, and the maximum size of aggregate for minor concrete shall be not larger than one-inch nor smaller than 3/4-inch.
- Shotcrete shall conform to the provisions in Section 53, "Shotcrete."
- When required by the plans or special provisions, slope paving shall be colored by mixing a fine ground, synthetic mineral oxide, specifically manufactured for coloring concrete, into the concrete or mortar mix. The coloring agent shall be uniformly and homogeneously mixed with the concrete or mortar. The color of the completed slope paving after curing and when air dry shall be tan conforming closely to Color No. 30450 of Federal Standard No. 595B.
- Reinforcement shall conform to the provisions in Section 52, "Reinforcement."
- Timber spacers shall be construction heart redwood or better, graded in conformance with the provisions in Section 57-2.02, "Grading Rules and Requirements." Nails used to fasten the timber spacers shall be hot-dip galvanized.

72-6.04 CONSTRUCTION

- Concrete slope paving shall be constructed and finished in conformance with the provisions in the first 2 paragraphs in Section 72-4.04, "Construction."
- Shotcrete slope paving shall be constructed and finished in conformance with the provisions in Section 53, "Shotcrete." After the shotcrete has been placed as nearly as practicable to the required depth, the surface shall be checked with a straightedge, and any low spots or depressions shall be brought up to proper grade by placing additional mortar. The finish of the shotcrete slope paving shall be uniform without humps or hollows of more than 1/2 inch in 10 feet.
- Timber spacers shall be furnished and installed as shown on the plans. The timber spacers shall be securely held in place by anchor bars consisting of commercial quality bar reinforcing steel.
- Concrete curbs shall be constructed in conformance with the provisions in Section 73, "Concrete Curbs and Sidewalks," and shall be constructed prior to constructing sidewalks or constructing the slope paving.
- Slope paving shall be cured by the curing compound method using curing compound (6) as provided in Section 90-7.01B, "Curing Compound Method."
- The construction of the slope paving shall be scheduled so that the work, including placing, finishing and application of curing compound, is completed in any section bordered by timber spacers on the same day that the work is started in that section. There shall be no construction joints between timber spacers.
- Earthwork for slope paving, including excavation for drain trenches, shall conform to the provisions in Section 19, "Earthwork."

72-6.05 MEASUREMENT

- The quantity of concrete or shotcrete used in slope paving (concrete) will be computed from measurements, along the slope, of the actual areas constructed and the theoretical thickness shown on the plans. No additional compensation will be

allowed for additional shotcrete or concrete placed by reason of low foundation. No deduction will be made for timber spacers.

72-6.06 PAYMENT

- The contract price paid per cubic yard for slope paving (concrete) shall include full compensation for furnishing all labor, materials (including bar reinforcing steel, reinforcing steel anchors, welded wire fabric and timber spacers), tools, equipment and incidentals, and for doing all the work involved in constructing the slope paving, complete in place (including excavation, backfill and installing timber spacers), as shown on the plans, as specified in the special provisions and these specifications, and as directed by the Engineer.
- Curbs, drain inlets, downdrains and underdrains used in connection with slope paving will be paid for as specified in the special provisions.

SECTION 73: CONCRETE CURBS AND SIDEWALKS

73-1.01 DESCRIPTION

This work shall consist of constructing concrete curbs, sidewalks, gutter depressions, island paving, curb ramps (wheelchair ramps) and driveways of the form and dimensions shown on the plans, and as specified in these specifications and the special provisions.

This work shall be constructed of minor concrete conforming to the provisions in Section 90-10, "Minor Concrete," except as follows:

1. The maximum size of aggregate used for extruded or slip-formed curb construction shall be at the option of the Contractor, but in no case shall the maximum size be larger than one inch nor smaller than $^{3}/_{8}$-inch
2. The cement content of the minor concrete shall be not less than 463 pounds per cubic yard, except that when extruded or slip-formed curbs are constructed using $^{3}/_{8}$-inch maximum size aggregate, the cement content shall be not less than 548 pounds per cubic yard.

Curbs, sidewalks, gutter depressions, island paving, curb ramps and driveways shall be constructed by using fixed forms, except that curbs, not on structures, may be constructed by using an extrusion machine or a slip-form paver, and sidewalks, not on structures, may be constructed by using a slip-form paver.

73-1.02 SUBGRADE PREPARATION

The subgrade shall be constructed true to grade and cross section, as shown on the plans or directed by the Engineer. It shall be watered and thoroughly compacted before placing the concrete. Where concrete is to be placed on basement material, soft or spongy material shall be removed to a depth of not less than 0.5-foot below subgrade elevation for curbs, gutter depressions, island paving and driveways and 0.25-foot below for sidewalks and curb ramps, and the resulting space filled with earth, sand or gravel of a quality that when moistened and compacted will form a stable foundation.

The completed subgrade shall be tested for grade and cross section by means of a template supported on the side forms and shall not project into the planned concrete cross section at any point. When concrete is to be extruded or slip-formed, the subgrade shall be checked from the offset guide line or survey marks. The subgrade and forms shall be wet immediately in advance of placing concrete.

73-1.03 EXISTING CURBS AND SIDEWALKS

Where the plans provide for the reconstruction of a portion of an existing curb and sidewalk, the existing section shall be cut to a minimum depth of $1^{1}/_{2}$ inches with an abrasive type saw at the first scoring line at or beyond the planned joint and the entire section to be reconstructed shall be removed. The new curb and sidewalk or curb ramp shall join the old work at this line.

73-1.04 FIXED FORMS

- Forms shall be smooth on the side placed next to the concrete, and shall have a straight upper edge and shall be rigid enough to withstand the pressure of fresh concrete without distortion.
- Forms shall be cleaned thoroughly and coated with form oil to prevent the concrete from adhering to them. Form oil shall be a commercial quality form oil or other equivalent coating which will permit the ready release of the forms and will not discolor the concrete.
- The depth of forms for back of curbs shall be equal to the full depth of the curb. The depth of face forms for concrete curbs shall be equal to the full face height of the curb.
- Benders or thin plank forms may be used on curves, grade changes or for curb returns. Back forms for curb returns may be made of 1/2 inch thick benders cleated together for the full depth of the curb.

73-1.05 CURB CONSTRUCTION

- In constructing curbs, entrances shall be provided for driveways. The entrances shall be of the dimensions shown on the plans or designated by the Engineer.
- Transverse weakened plane and expansion joints shall be constructed in concrete curbs as provided in this section. Joints shall be constructed at right angles to the line of curbs.
- Weakened plane joints shall be constructed at 20-foot intervals, except that when portland cement concrete pavement is adjacent thereto, or to be constructed adjacent thereto, the joints shall coincide with the weakened plane joints in the adjacent pavement. The joints shall be constructed to a minimum depth of one inch by scoring with a tool which will leave the corners rounded and ensure a free movement of the concrete at the joint, or by sawing the hardened concrete and covering the exposed area with curing compound.
- Expansion joints shall be constructed at each side of structures and at ends of curb returns, except that expansion joints shall not be constructed within 20 feet of an island nose. Expansion joints shall be filled with 1/4 inch thick premolded joint filler conforming to the provisions in Section 51-1.12C, "Premolded Expansion Joint Fillers." The joint filler shall be shaped to the cross section of the curb.
- The top and face of the finished curb shall be true and straight, and the top surface of curbs shall be of uniform width, free from humps, sags or other irregularities. When a straightedge 10 feet long is laid on the top or face of the curb or on the surface of gutters, the surface shall not vary more than 0.01-foot from the edge of the straightedge, except at grade changes or curves.
- Curbs shall be cured as provided in Section 90-7, "Curing Concrete."
- The Contractor shall clean at the Contractor's expense all discolored concrete. The concrete may be cleaned by abrasive blast cleaning or other methods approved by the Engineer.
- Repairs shall be made by removing and replacing the entire unit between joints.

73-1.05A Fixed-Form Curb Construction

- Forms shall be carefully set to alignment and grade and shall conform to the required dimensions. Forms shall be held rigidly in place by stakes. Clamps, spreaders and braces shall be used where required to ensure rigidity in the form.
- Concrete curbs to be constructed over an existing pavement shall be anchored to the pavement by means of steel dowels and reinforcing steel as shown on the plans. The steel dowels shall be firmly mortared with 1:1 portland cement and sand mortar in holes drilled in the pavement. Dowels and reinforcing steel shall conform to the provisions for bar reinforcing steel in Section 52, "Reinforcement." Approved anchor bolts may be used in lieu of dowels at the option of the Contractor.
- The premolded joint filler at expansion joints shall be placed in correct position before concrete is placed against the filler.
- Concrete shall be placed and compacted in forms without segregation.
- Prior to the removal of the forms, the surface shall be finished true to grade by means of a straightedge float, not less than 10 feet in length, operated longitudinally over the surface of the concrete. Form clamps shall be so constructed as not to interfere with the operation of the float.
- The form on the front of curbs shall not be removed in less than one hour nor more than 6 hours after the concrete has been placed. In no event shall forms be removed while the concrete is sufficiently plastic to slump.
- Immediately, after removing the front curb forms, the face of the curb shall be troweled smooth to a depth of not less than 0.17-foot below the flow line or to the flow line of integral curb and gutter, and then finished with a steel trowel. The top shall be finished and the front and back edges rounded as shown on the plans.
- After the face of the curb has been troweled smooth, it shall be given a final fine brush finish with brush strokes parallel to the line of the curb.

73-1.05B Extruded or Slip-Formed Curb Construction

- Any curb, except on structures, may be placed by using an extrusion machine or slip-form paver, provided the finished curb is true to line and grade, and the concrete is dense and of the required surface texture.
- The concrete shall conform to the provisions in Section 73-1.01, "Description," except that the aggregate grading limits proposed by the Contractor shall be further restricted if necessary to produce concrete that has well defined web marks of water on the surface and is free from surface pits larger than $^{3}/_{16}$ inch in diameter.
- The concrete shall be of such consistency that the concrete will maintain the shape of the curb section without support. The concrete shall contain the maximum amount of water that will permit this result.
- At the Contractor's option, concrete curbs to be constructed over an existing pavement shall be anchored to existing pavement either by placing steel dowels and reinforcing steel, as provided in Section 73-1.05A, "Fixed-Form Curb Construction," or by using an adhesive. If an adhesive is used, in advance of extruding or slip-forming the curbs on the existing pavement, the surface of the pavement shall be thoroughly cleaned and the adhesive shall be applied. The pavement shall be cleaned either by wire brushing or by blast cleaning, except that

blast cleaning shall be used if directed by the Engineer. The cleaned surface shall be free from dust, loose material or oil.

- The adhesive shall consist of 2 components which shall be mixed together at the site of the work and shall conform to the provisions in Section 95-2.03, "Epoxy Resin Adhesive for Bonding New Concrete to Old Concrete."
- The grade for the top of extruded curb shall be indicated by an offset guide line set by the Contractor from survey marks established by the Engineer. The forming tube portion of the extrusion machine shall be readily adjustable vertically during the forward motion of the machine to provide, when necessary, a variable height of curb conforming to the predetermined curb grade. A grade line gage or pointer shall be attached to the machine in such a manner that a continual comparison can be made between the curb being placed and the established curb grade as indicated by the offset guide line.
- In lieu of the above method for maintaining the curb grade, the extrusion machine may be operated on rails or forms set at uniform depth below the predetermined finished top of the curb grade.
- Concrete shall be fed to the extrusion machine at a uniform rate. The machine shall be operated under sufficient uniform restraint to forward motion to produce a well compacted mass of concrete free from surface pits larger than $^{3}/_{16}$ inch in diameter and requiring no further finishing, other than light brushing with a brush filled with water only. Finishing with a brush application of grout will not be permitted.
- Equipment for slip-forming curbs shall be controlled automatically for alignment, grade and cross slope by sensing from preset string lines, or by string line control of alignment and grade and automatic cross-slope control. Equipment for slip-forming curbs shall have traveling forms of dimension, shape and strength necessary to produce the required cross section of the curb. The equipment shall spread, consolidate and finish the concrete so that a minimum of handwork will be required to produce a dense, homogeneous concrete true to grade and cross section. Concrete shall be consolidated effectively by internal vibrators, or by other means approved by the Engineer.
- Expansion joints shall be constructed as specified in Section 73-1.05A, "Fixed-Form Curb Construction," or shall be constructed by sawing through the curb section to its full depth. The width of the cut shall be such as to admit the joint filler with a snug fit. Premolded joint filler for sawed joints shall be inserted and mortared in place.
- If sawing is performed before the concrete has hardened, the adjacent portions of the curb shall be supported firmly with close fitting shields. The operations of sawing and inserting the joint filler shall be completed before curing the concrete.
- If sawing is performed after the concrete has hardened, the joint filler shall be mortared in place with heavy trowel pressure. After sawing is performed, exposed portions of the curb in the vicinity of the joint shall be covered with another application of curing compound.
- At the conclusion of the curing period, the filler in each sawed joint shall be checked for tightness of fit. The loose filler in any sawed joint shall again be mortared in place and cured.

73-1.06 SIDEWALK, GUTTER DEPRESSION, ISLAND PAVING, CURB RAMP (WHEELCHAIR RAMP) AND DRIVEWAY CONSTRUCTION

- When gutter depressions, island paving, curb ramps (wheelchair ramp) or driveways are to be constructed, or when sidewalks are to be constructed by using fixed forms, forms shall be carefully set to alignment and grade and shall conform to the required dimensions. Forms shall be held rigidly in place by stakes. Clamps, spreaders and braces shall be used where required to ensure rigidity in the forms.
- In fixed-form construction, fresh concrete shall be struck off and compacted until a layer of mortar has been brought to the surface. The surface shall be finished to grade and cross section with a float and troweled smooth. Concrete adjacent to expansion joints shall be finished with an edger tool.
- Equipment for slip-forming sidewalks shall be controlled automatically for alignment, grade, and cross slope by sensing from preset string lines, or by string line control of alignment and grade and automatic cross-slope control.
- Equipment for slip-forming sidewalks shall have traveling forms of dimension, shape and strength necessary to produce the required cross section of the sidewalk. The equipment shall spread, consolidate and finish the concrete so that a minimum of handwork will be required to produce a dense, homogeneous concrete true to grade and cross section. Concrete shall be consolidated effectively by internal vibrators or by other means approved by the Engineer.
- Expansion joints shall be constructed at all returns and opposite expansion joints in adjacent curb. Where curb is not adjacent, expansion joints shall be constructed at intervals of 60 feet. Expansion joints shall be filled with 1/4 inch thick premolded joint filler conforming to the provisions in Section 51-1.12C, "Premolded Expansion Joint Fillers." Expansion joint filler shall be shaped to fit the concrete that is being placed.
- The premolded joint filler in fixed-form construction shall be placed in correct position before concrete is placed against the filler.
- Expansion joints in slip-formed sidewalk construction shall be constructed as specified above for fixed-form construction, or shall be constructed by sawing through the concrete to its full depth after the concrete has hardened. The width of the cut shall be such as to admit the joint filler with a snug fit. The premolded joint filler for sawed joints shall be inserted and mortared in place with heavy trowel pressure. After sawing is performed, exposed portions of the sidewalk in the vicinity of the joint shall be covered with an application of curing compound. At the end of the curing period, the filler in each sawed joint shall be checked for tightness of fit. Loose filler in any sawed joint shall again be mortared in place and cured.
- Surfaces shall be broom finished. Surfaces to be used by pedestrian traffic shall be broomed transversely to the line of traffic. If water is necessary, the water shall be applied to the surface immediately in advance of brooming.
- The surface of sidewalks shall be marked into rectangles of not less than 12 square feet nor more than 20 square feet with a scoring tool which will leave the edges rounded.

- Fixed forms for sidewalks, gutter depressions, island paving, curb ramps and driveways shall not be removed in less than 12 hours after the finishing has been completed.
- The surface shall not vary more than 0.02-foot from a 10-foot straightedge, except at grade changes, and the finished surface shall be free from blemishes.
- Concrete sidewalks, gutter depressions, island paving, curb ramps and driveways shall be cured as provided in Section 90-7, "Curing Concrete."
- The Contractor shall clean at the Contractor's expense all discolored concrete. The concrete may be cleaned by abrasive blast cleaning or other methods approved by the Engineer.
- Repairs shall be made by removing and replacing the entire unit between scoring lines or joints.
- Where asphalt concrete or portland cement concrete pavements are to be placed around or adjacent to manholes, pipe inlets or other miscellaneous structures in sidewalk, gutter depression, island paving, curb ramps or driveway areas, the structures shall not be constructed to final grade until after the pavements have been constructed for a reasonable distance on each side of the structures.

73-1.07 MEASUREMENT

- Quantities of concrete in curbs, sidewalks, island paving, gutter depressions, curb ramps or driveway areas, to be paid for by the cubic yard, will be determined from the dimensions shown on the plans or such other dimensions as may be ordered in writing by the Engineer, and concrete placed in excess of these dimensions will not be paid for; or concrete curbs may be measured by the linear foot.

73-1.08 PAYMENT

- Quantities of minor concrete shown in the Engineer's Estimate, in curbs, sidewalks, gutter depressions, island paving, curb ramps and driveways will be paid for at the contract price per cubic yard for minor concrete (curb, sidewalk, gutter depression, island paving, curb ramps and driveway, as individual items or combinations thereof), or as a combined item of minor concrete (miscellaneous construction), or curbs may be paid for at the contract price per linear foot for minor concrete (curb).
- The above prices and payments shall include full compensation for furnishing all labor, materials (including adhesive, or reinforcing steel and dowels for anchoring curbs to existing pavement), tools, equipment, and incidentals, and for doing all the work involved in constructing curbs, sidewalks, gutter depressions, island paving, curb ramps and driveways, complete in place, including subgrade preparation, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 74: PUMPING PLANT EQUIPMENT

74-1 GENERAL

74-1.01 DESCRIPTION

This work consists of furnishing and installing pumping plant equipment, consisting of drainage pumping equipment and pumping plant electrical equipment, as shown on the plans and as specified in these specifications and the special provisions. The Contractor shall be responsible for the compatibility and adjustment of all components as necessary for the successful operation of the completed pumping plant. Any incidental material or equipment not mentioned in these specifications or the special provisions or shown on the plans which may be necessary for completion and successful operation of the pumping plant shall be furnished and installed as though shown or provided for.

74-1.02 REGULATIONS AND CODE

Electrical equipment shall conform to the standards of the NEMA and shall be listed by a recognized independent testing laboratory. In addition to the requirements of the plans, these specifications and the special provisions, materials and workmanship shall conform to the requirements of the National Electrical Code; National Fire Code, Flammable Liquids and Gases; California Code of Regulations, Title 8, Division 1, Chapter 4, Subchapter 5, "Electrical Safety Orders," and Subchapter 7, "General Industry Safety Orders"; California Code of Regulations, Title 19, Chapter 1, "Public Safety," Regulations of State Fire Marshal; California Code of Regulations, Title 24, Part 3, "California Electrical Code"; Rules for Overhead Electrical Line Construction, General Order No. 95, of the Public Utilities Commission; and any local ordinances which may apply.

Wherever reference is made to any of the standards mentioned above, the reference shall be construed to mean the code, order or standard that is in effect on the day the Notice to Contractors for the work is dated.

74-1.03 PLANS

The general arrangement and location of the pumping plant equipment is shown on the plans. Installation shall be in accordance with the plans, except for changes which may be necessary due to interference with other work, such as building construction and other mechanical or electrical work. Changes required to install this work with all other work shall be made by the Contractor at the Contractor's expense.

74-1.04 DATA TO BE FURNISHED

Unless otherwise permitted in writing by the Engineer, the Contractor shall within 60 days after approval of the contract, submit to the Offices of Structure Design, lists of material which the Contractor proposes to install, complete working drawings showing fully the work the Contractor proposes to do, and other data as specified in this Section 74-1.04, all in conformance with the provisions in Section 5-1.02, "Plans and Working Drawings."

- Each submission of data shall consist of at least 5 copies. Two copies will be returned to the Contractor either approved for use or returned for correction and resubmittal.
- When the submitted data is approved, the Contractor shall furnish the Engineer with 6 additional copies for use during construction.
- Data submitted shall bear a descriptive title, the name of the project, District, County, and Route, the contract number and the name and number of the pumping plant in which the data will be used. Plans and detail drawings shall be either 22" x 34" or 11" x 17".
- Installation of equipment will not be permitted until the material lists have been reviewed by the Engineer. The State will not be responsible for any equipment purchased or labor performed prior to the review and will not be responsible for any delay to the Contractor pending review of submissions made after the 60 day period.
- The material lists shall be complete as to name of manufacturer, catalog number, size, capacity, finish, all pertinent ratings including horsepower, kva, kw, power factor, starting and running current, voltage, thermal and magnetic trip settings, starter overload current setting and identification symbol used on the plans and in the special provisions for each unit. The list shall be supplemented by such other data as may be required. Motor nameplate data shall be submitted and shall include full load speed, full load current, voltage and locked rotor kva per rated horsepower, or code letter. It is not intended that this list shall include miscellaneous material such as conduit and wire. The Contractor shall, if requested to do so, submit for review sample articles of the material proposed to be used.
- Directions for maintenance and adjustment of the pumps and lubricators shall be submitted for approval. When approved, one set of the directions shall be mounted in the pump house in a galvanized sheet metal frame behind a sheet of clear plastic of 0.030-inch minimum thickness as directed by the Engineer.
- Parts lists and service instructions packaged with or accompanying the drainage pumping equipment and pump house electrical equipment installed in the work shall be delivered to the Engineer.

74-1.05 CARE AND CLEANING

- Pumping plant equipment, except for embedded equipment, shall not be installed until as much of the pump house construction has been completed as is practicable. Equipment shall be protected from damage. Dirty condition of any equipment will be grounds for rejection of the equipment. Broken, damaged or otherwise defective parts shall be repaired or replaced by the Contractor at the Contractor's expense.
- Debris shall be removed from the pump house and pump house storage box and premises before acceptance of the contract.

74-1.055 USE OF PUMPS BY CONTRACTOR PRIOR TO ACCEPTANCE OF WORK

- The Contractor may use the pumps prior to acceptance of the work, subject to the following requirements:

A. The storage box, screens, pump sump and pumping plant equipment shall be completely operable.
B. Safeguards against damage to the pumps during usage shall be taken.
C. The Contractor shall furnish to the Engineer, for the Engineer's approval, plans for the safeguards prior to using the pumps.
D. Safeguards shall include, but shall not be limited to, stilling ponds or checks and weirs to intercept drainage water from contributory surfaces which shall effectively stop non-suspended solids such as soil, sand and gravel and deliver the settled water directly to paved surfaces, pipes or other non-erodible channels leading to the pump sump.
E. A bulkhead composed of burlap sacks filled with a pervious material shall be constructed in the inlet just ahead of the pump sump.
F. The temporary stilling basins so developed shall be maintained so that the basins shall continue to function as intended.
G. When no longer required, safeguards shall become the property of the Contractor and shall be disposed of in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."
H. After use of the pumps by the Contractor, and prior to performance tests, the Contractor shall disassemble the pumps for detailed inspection by the Engineer. Worn, damaged or otherwise unsatisfactory parts, as determined by the Engineer, shall be replaced.

- Performance tests shall be made in conformance with the provisions in Section 74-1.07, "Tests," after use of the pumps by the Contractor even though the tests may have been performed previously.
- Use of the pumps without approval by the Engineer shall be considered cause for rejection of pumps so used.
- Nothing in this section will be construed as relieving the Contractor of full responsibility for making good any defective work or materials found at any time before the acceptance of the work.
- Electrical energy for operation of the pumps for the convenience of the Contractor shall be furnished by the Contractor at the Contractor's expense.
- Full compensation for conforming to the requirements of this section, not otherwise provided for, shall be considered as included in the prices paid for the various contract items of work involved and no additional compensation will be allowed therefor.

74-1.06 PAINTING

- Painting of pumping and electrical equipment and metal work within the pump house shall be performed as specified in this Section 74-1.06.
- Equipment, enclosures, metal surfaces (except galvanized or non-corrodible metal surfaces) and wood surfaces shall be cleaned and painted.
- Metal work shall be painted after installation. The wood panel board shall be painted on all surfaces prior to installation of any electrical equipment or mounting the panel in the control room.

- In preparation for painting, the equipment shall be thoroughly cleaned of all dirt, grease, oil, rust or other foreign material.
- Uncoated or primed only drainage pumping equipment and uncoated metal and damaged surfaces of coated metal shall be painted with 2 applications of unthinned zinc-rich primer (organic vehicle type) conforming to the provisions in Section 91, "Paint," and 2 finish applications of industrial quality gray gloss enamel. Aerosol can application of primer and finish paint will not be allowed.
- Electrical equipment and enclosures shall be supplied with a factory painted finish or shall be cleaned, lightly sanded, and painted after installation with 2 applications of gray gloss industrial quality enamel which is compatible with the factory applied paint and matches the surrounding pumping equipment color.
- Exposed ungalvanized threads and abrasions in galvanizing shall be repaired in conformance with the provisions for repair of galvanized surfaces in Section 75-1.05, "Galvanizing."
- The number of each pump, as shown on the plans, shall be painted with 2 applications of white enamel at least $1\frac{1}{2}$ inches high on the motor. An arrow at least 6 inches long with $\frac{1}{4}$ inch wide line shall be painted showing the proper direction of pump rotation.
- Brass surfaces, nameplates, push buttons, operating handles, locks, plastic parts, cover plates on duplex plug outlets and any other item which would be impaired in legibility, life expectancy or function shall not be painted.
- Wood surfaces shall be cleaned and painted in conformance with the provisions in Section 59-4, "Painting Timber." Undercoat paint for wood shall conform to Section 91-3.01, "Wood Primer, Latex-Base," and finishing coat paint shall be gray commercial quality gloss enamel.
- Paint shall be applied as recommended by the manufacturer, and each application shall be completely dried and inspected by the Engineer before the next application is applied. Surfaces to be painted which may become inaccessible by assembly operations shall be painted prior to those operations.
- After installation, areas where the paint has been damaged shall be repaired to provide the paint applications specified herein.

74-1.07 TESTS

- Equipment installed shall be tested by the Contractor in the presence of the Engineer. Defective material, equipment or workmanship shall be replaced by the Contractor at the Contractor's expense.
- The drainage pumping equipment shall be tested to demonstrate satisfactory operation throughout the full pumping range of the installed pumping equipment. Testing shall be volumetric or other approved method and shall show that the installed pumping equipment delivers a minimum of 97 percent of the factory certified performance curve for a corresponding head and flow rate without overloading the motor (when supplied with the rated nameplate voltage) to more than the actual full load nameplate amperage, regardless of head. To determine compliance with this requirement, the maximum motor current will be calculated by converting the current measured at the test horsepower to the current that would be drawn (at the same terminal voltage) at the maximum horsepower certified for

this range of heads, and converting this current to the current that would be drawn at the rated nameplate voltage.

- For the purpose of making the test, pipes discharging into the storage box shall be blocked at their entrance to the storage box. Debris shall be removed from within the pump plant, storage box, debris sump and pump sump before testing. The blocking of these pipes shall be removed after testing.
- The pump sump and storage chamber shall be filled with the quantity of water shown on the plans or ordered by the Engineer.
- In the event initial tests are unsatisfactory or insufficient storage is available to test all pumps, the sump and storage chamber shall be refilled as many times as necessary to demonstrate the satisfactory operation of the pumps.
- Water and electrical energy for testing shall be furnished by the Contractor at the Contractor's expense.

74-1.08 PAYMENT

- Full compensation for conforming to the provisions in Section 74-1, "General," shall be considered as included in the contract lump sum prices paid for drainage pumping equipment and pumping plant electrical equipment and no additional compensation will be allowed therefor.

74-2 DRAINAGE PUMPING EQUIPMENT

74-2.01 DESCRIPTION

- Drainage pumping equipment shall consist of pumps, pumping apparatus, motors, pipe, joints and fittings, bracing, hardware, storage cabinet, supply fan, duct work, pump house door and tools.

74-2.02 PUMPS, PUMPING APPARATUS AND MOTORS

- Pumps, pumping apparatus and motors shall be as specified in the special provisions.

74-2.03 PUMP HOUSE DOOR, SUPPLY FAN AND DUCT WORK

- Pump house door, supply fan and duct work shall be as specified in the special provisions.

74-2.04 PIPE, JOINTS AND FITTINGS

- Pump suction and discharge piping and fittings shall be of the size and type shown on the plans.
- Galvanized steel pipe shall conform to the requirements in ASTM Designation: A 53/A 53M. All Nominal Pipe Size (NPS) designations shall be Standard Weight. Threaded fittings shall be galvanized malleable iron or steel.
- Welded steel pipe shall be of the thickness shown on the plans, coated and wrapped, and shall conform to the provisions in Section 70-1.02B, "Welded Steel Pipe," except that electrically insulated connections will not be required.
- Steel pipe shall be furnished with flanged joints. Flanges shall be either threaded or welded to the piping. Threaded flanges shall be ductile iron conforming to the requirements in ANSI/AWWA Standard: C115/A21.15. Flanges for welding shall be slip-on type steel hub flanges conforming to the requirements

in ANSI/AWWA Standard: C207, Class D. If steel flanges are welded to pipe, the completed assembly shall be hot-dip galvanized after fabrication.

- Flanged joints shall be made up with minimum 1/8-inch thick gaskets of rubber or equal. Gaskets shall be one piece without seam or joint.
- All flange bolts and nuts shall be non-magnetic stainless steel.
- Ductile iron pipe shall conform to the requirements in ANSI/AWWA Standard: C151/A21.51. The pipe and fittings shall be of the size shown on the plans. Each length of pipe shall be marked with "DI" or "Ductile" and the Class.
- Ductile iron pipe shall be furnished with mechanical joints conforming to the requirements in ANSI/AWWA Standard: C111/A21.11.
- Fittings shall be ductile iron and shall conform to the requirements in ANSI/AWWA Standard: C110/A21.10, or to the requirements in ANSI Standard: B16.1, Class 125, and shall be of the size shown on the plans.
- A standard bituminous coating shall be applied to the inside and outside of pipes and fittings.
- Mechanical couplings in piping designated on the plans as flexible expansion couplings shall be gasketed short sleeve type couplings consisting of a mild steel middle ring with pipe stop, 2 rubber-compounded wedge-section ring gaskets, 2 mild steel follower rings and sufficient mild steel bolts to compress the gaskets. Ferrous parts of the couplings shall be hot-dip galvanized after fabrication. The couplings shall be assembled in such a manner as to ensure a permanent watertight joint.

74-2.05 BRACING AND HARDWARE

- Pumps and other equipment shall be braced and secured in a substantial manner to prevent working loose during operation. Anchorages shall conform to the provisions for concrete anchorage devices in Section 75-1.03, "Miscellaneous Bridge Metal."
- Bolt holes in the bracing and clips shall be slotted a total of 2 bolt diameters parallel to the axis of the member to provide adjustment during erection. U-bolt holes shall be similarly slotted parallel to the axis of the member. Cut washers shall be installed under both head and nut of all bolts or threaded studs in slotted holes.
- All anchorages, braces, frames, and other ferrous hardware shall be hot-dip galvanized after fabrication or stainless steel.
- Galvanizing shall conform to the provisions in Section 75-1.05, "Galvanizing."
- Pumping plant metal work shall conform to the provisions in Section 75-1.04, "Pumping Plant Metal Work."

74-2.06 STORAGE CABINET

- An all steel wall storage cabinet, with bolted or welded construction, 2 doors with single locking handle or magnet catch and padlock staples, 2 adjustable shelves, dimensions of approximately 24 inches to 28 inches wide, 10 inches to 12 inches deep and 30 inches to 33 inches high overall, shall be installed as shown on the plans. The cabinet shall be supplied factory painted.

74-2.07 TOOLS

- Special tools which may be necessary for assembly or adjustment of the pumping equipment shall be provided and secured in a neat manner on the walls of the motor room or placed in the wall cabinet.

74-2.08 PAYMENT

- The contract lump sum price paid for drainage pumping equipment shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in furnishing and installing drainage pumping equipment, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

74-3 PUMPING PLANT ELECTRICAL EQUIPMENT

74-3.01 DESCRIPTION

- Pumping plant electrical equipment consists of control, power, and metering equipment, conduit, insulated wire and cable, lights, indicating lights and floor covering but does not include pump motors.

74-3.02 CONTROL, POWER, AND METERING EQUIPMENT AND LIGHTS

- Control, power, and metering equipment and lights shall be as shown on the plans and as specified in the special provisions.

74-3.03 PUMP CONTROL

- The method of controlling the pumps shall be as specified in the special provisions.

74-3.04 CONDUIT

- Conduit and fittings shall conform to the provisions in Section 86-2.05, "Conduit," except that rigid metallic conduit shall have interior and exterior surfaces zinc-coated by hot-dip galvanizing.
- Short loops of polyvinyl chloride covered flexible conduit shall be used for connecting the motors of the pumps. Flexible conduit shall be no longer than is absolutely necessary for the purpose of looping from the rigid conduit to the motor connection box.
- For equipment grounding, flexible conduits and their fittings shall be considered a discontinuity and shall be shunted by bonding jumpers within the flexible conduit separate and not integral with the flexible conduit.

74-3.05 CONDUCTORS AND CABLE

- Conductors shall conform to the provisions for traffic signal conductors in Section 86-2.08, "Conductors."
- Standard stock items of a manufacturer which are on the material list submitted by the Contractor need not be rewired.
- Single conductors and cables shall have clear, distinctive and permanent markings on the outer surface throughout the entire length showing the manufacturer's name or trademark, insulation type letter designation, conductor size, voltage rating and the number of conductors if a cable.

74-3.06 INSTALLATION OF CONDUCTORS AND CABLE

- Pulling of conductors shall be done with special care to avoid injury to sheath or insulation. An inert lubricant listed by a recognized independent testing laboratory shall be used.
- Conductors and cables entering fixtures and boxes shall have definite drip loops arranged to prevent the carrying of water to current-carrying parts or to other conduits.
- Insulation shall be removed without nicking or otherwise damaging the conductor.

74-3.07 SPLICES

- Splices shall be avoided wherever possible and those required shall occur only in fixtures, junction boxes or gutters.
- Splices shall be made by soldering or by the use of pressure connectors listed by a recognized independent testing laboratory. Soldering of joints, where necessary, shall be by the use of hot irons. Open flame soldering will not be permitted.
- Splices shall be insulated with 2 half-lapped layers of self-fusing, oil and flame-resistant, synthetic rubber tape followed by the application of 2 half-lapped layers of pressure-sensitive, adhesive, 0.007-inch minimum thickness polyvinyl chloride electrical tape. After the final layer of polyvinyl chloride tape has been applied, an electrical insulating coating shall be applied to the tape. The coating shall be fast drying; resistant to oil, acids, alkalies and corrosive atmospheric conditions; and compatible with the tape.

74-3.08 (BLANK)

74-3.09 IDENTIFICATION OF UNITS AND CONDUCTORS

- Each unit of equipment shall be identified by nameplates with inscription engraved in 2-color bakelite material. The plates shall show white letters $^1/_4$ inch high against a black field and shall be secured to the units or adjacent thereto with screws or rivets, without the use of adhesives of any kind.
- Each control switch which is intended for external operation and is a part of a major unit shall be marked with nameplate as above provided, except that the letters shall have an overall height of not less than $^1/_8$ inch designating the functions performed or the equipment served by that switch.
- The inscriptions on the nameplates shall be as described in the special provisions.
- All conductors shall be marked at each termination by (1) adhesive backed paper or cloth wrap-around markers with clear, heat shrinkable tubing sealed over either type of markers, or (2) close fitting machine imprinted plastic sleeves.

74-3.10 ENCLOSURES

- Enclosures shall be NEMA Type 1, except as otherwise specified.

74-3.11 FLOOR COVERING

- Floor covering in front of the electrical panelboard shall be the size shown on the plans with a minimum thickness of $^1/_4$ inch and shall be rated for a minimum

dielectric strength of 20,000 volts in conformance with the requirements in ASTM Designations: D 149 and D 178.

74-3.12 PAYMENT

The contract lump sum price paid for pumping plant electrical equipment shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in furnishing and installing pumping plant electrical equipment, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 75: MISCELLANEOUS METAL

75-1.01 DESCRIPTION

- This work shall consist of furnishing and installing miscellaneous iron and steel, miscellaneous metal (bridge), miscellaneous metal (restrainer), and pumping plant metal work, all as shown on the plans or as directed by the Engineer, and as specified in these specifications and the special provisions.
- Miscellaneous iron and steel, miscellaneous metal (bridge), and miscellaneous metal (restrainer) will be inspected at the fabrication site. The Contractor shall notify the Engineer when materials have been delivered to the fabrication site and shall give the Engineer at least 10 days' notice after delivery before commencing the fabrication of the miscellaneous metal. Materials to be used shall be made available to the Engineer so they can be examined. The Engineer shall have free access at all times to any portion of the fabrication site where the material is stored or where work on the material is being performed.

75-1.02 MISCELLANEOUS IRON AND STEEL

- Miscellaneous iron and steel items shall conform to the dimensions and details shown on the plans and as specified in these specifications and the special provisions.
- At the option of the Contractor, grates shall be fabricated from either structural steel conforming to the requirements in ASTM Designations: A 36/A 36M or A 576 Grades 1021, 1022, 1026, 1029 or 1030, ductile iron castings, or carbon-steel castings.
- Welding shall conform to the requirements in AWS D1.1.
- Fabrication shall be performed in a workmanlike manner in conformance with the practice in modern commercial shops. Burrs, rough and sharp edges, and other flaws shall be removed. Warped pieces shall be straightened after all fabrication and galvanizing.
- Raised pattern plates shall be of commercial quality.
- Manhole frames and covers shall be fabricated from gray cast iron.
- Unless otherwise specified all steel items and cast iron lightweight sidewalk frames and covers shall be galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing." Galvanizing shall be performed after fabrication and before assembling component parts. All other cast iron items shall be painted with or dipped in commercial quality asphaltum.
- Drainage inlet frames and grates, except those which are to be on bridges, need not be galvanized or coated with asphalt paint.
- Frames and grates, or frames and covers shall be matchmarked in pairs before delivery to the work and the grates and covers shall fit into their frames without rocking.

- Unless otherwise specified, materials shall conform to the following specifications:

Material	Specification
Steel bars, plates and shapes	ASTM Designation: A 36/A 36M or A 575, A 576 (AISI or M Grades 1016 through 1030)
Steel fastener components for general applications:	
Bolts and studs	ASTM Designation: A 307
Headed anchor bolts	ASTM Designation: A 307, Grade B, including S1 supplementary requirements
Nonheaded anchor bolts	ASTM Designation: A 307, Grade C, including S1 supplementary requirements and S1.6 of AASHTO Designation: M 314 supplementary requirements or AASHTO Designation: M 314, Grade 36 or 55, including S1 supplementary requirements
High-strength bolts and studs, threaded rods, and nonheaded anchor bolts	ASTM Designation: A 449, Type 1
Nuts	ASTM Designation: A 563, including Appendix X1*
Washers	ASTM Designation: F 844
Components of high-strength steel fastener assemblies for use in structural steel joints:	
Bolts	ASTM Designation: A 325, Type 1
Tension control bolts	ASTM Designation: F 1852, Type 1
Nuts	ASTM Designation: A 563, including Appendix X1*
Hardened washers	ASTM Designation: F 436, Type 1, Circular, including S1 supplementary requirements
Direct tension indicators	ASTM Designation: F 959, Type 325, zinc-coated
Stainless steel fasteners (Alloys 304 & 316) for general applications:	
Bolts, screws, studs, threaded rods, and nonheaded anchor bolts	ASTM Designation: F 593 or F 738M
Nuts	ASTM Designation: F 594 or F 836M
Washers	ASTM Designation: A 240/A 240M and ANSI B 18.22M
Carbon-steel castings	ASTM Designation: A 27/A 27M, Grade 65-35, Class 1
Malleable iron castings	ASTM Designation: A 47, Grade 32510 or A 47M, Grade 22010
Gray iron castings	ASTM Designation: A 48, Class 30B
Ductile iron castings	ASTM Designation: A 536, Grade 65-45-12
Cast iron pipe	Commercial quality
Steel pipe	Commercial quality, welded or extruded
Other parts for general applications	Commercial quality

* Zinc-coated nuts that will be tightened beyond snug or wrench tight shall be furnished with a dyed dry lubricant conforming to Supplementary Requirement S2 in ASTM Designation: A 563.

75-1.03 MISCELLANEOUS BRIDGE METAL

Miscellaneous bridge metal shall conform to the provisions in Section 75-1.02, "Miscellaneous Iron and Steel," and the provisions in this section. Miscellaneous metal used in constructing bridges and other structures described as bridge work in the special provisions, excepting miscellaneous metal in pumping plants and miscellaneous metal identified on the plans or in these specifications for which payment is made under separate contract items, shall conform to the details shown on the plans and as specified in these specifications and the special provisions.

Miscellaneous bridge metal shall consist of the following, except as further provided in Section 51-1.19, "Utility Facilities," and in the special provisions:

A. Bearing assemblies, equalizing bolts and expansion joint armor in concrete structures.
B. Expansion joint armor in steel structures.
C. Manhole frames and covers, frames and grates, ladder rungs, guard posts and access door assemblies.
D. Deck drains, area drains, retaining wall drains, and drainage piping, except drainage items identified as "Bridge Deck Drainage System" in the special provisions.

Bearing assemblies shall be fabricated from structural steel conforming to the requirements in ASTM Designation: A 36/A 36M.

High-strength bolted connections shall conform to the provisions for high-strength steel fasteners and bolted connections in Section 55, "Steel Structures."

Equalizing bolts shall consist of bolts or threaded bars. Threaded bars identified as prestressing steel on the plans shall conform to the requirements for plain bars in ASTM Designation: A 722/A 722M, including Supplementary Requirements. Nuts shall conform to the provisions in the first and second paragraphs in Section 50-1.06, "Anchorages and Distribution." When noted on the plans, nuts, bolts, threaded bars and plate washers shall be cleaned as specified in Section 59-2.03, "Blast Cleaning," or Section 59-2.06, "Hand Cleaning," at the option of the Contractor. All surfaces, except the portion of threads engaged by nuts, shall be painted with 2 applications of unthinned zinc-rich primer (organic vehicle type) conforming to the provisions in Section 91, "Paint." Aerosol cans shall not be used. The second application shall be applied to nuts and threads after installation.

An approved thread locking system, consisting of a cleaner, primer and anaerobic adhesive, shall be applied where shown on the plans. Lubricants and foreign materials shall be removed from the threaded areas of both parts using the cleaner and small wire brush. The primer shall be applied to cover the threaded areas of both parts. The anaerobic adhesive shall be applied to fill the male threads in the area of the final position of the nut. The nut shall be installed at the location or to the torque shown on the plans, and an additional fillet of anaerobic adhesive shall be applied completely around the exposed junctions of the nut and male part.

Access opening covers shall be fabricated from commercial quality sheet steel.

- Sheet steel for access doors shall be galvanized sheet conforming to the requirements in ASTM Designation: A 653/A 653M, Coating Designation Z600 {G210}.
- Springs for deck drain grating latches shall be made from commercial quality stainless steel spring wire containing a nominal composition of 18 percent chromium and 8 percent nickel. Spring latches and other mechanical devices shall be tested before delivery to the work and shall operate smoothly and properly.
- Cast steel and cast iron shall conform to the provisions in Section 55, "Steel Structures."
- Pipe bends shall be commercial quality tube bends or fabricated bends of substantially equal smoothness. Miter-joint bends will not be accepted.
- Transition fittings between pipes of different diameters shall be smooth, uniform, without sags, projections or offsets, and shall be at least 4 inches in length for each one inch reduction in pipe diameter.
- Concrete anchorage devices shall be mechanical expansion or resin capsule types installed in drilled holes or cast-in-place insert types. The anchorage devices shall be a complete system, including threaded studs, hex nuts and cut washers. Thread dimensions for externally threaded concrete anchorage devices prior to zinc coating, shall conform to the requirements in ANSI Standard: B1.1 having Class 2A tolerances or ANSI Standard: B 1.13M having Grade 6g tolerances. Thread dimensions for internally threaded concrete anchorage devices shall conform to the requirements in ASTM Designation: A 563 or A 563M.
- Mechanical expansion anchors shall be the integral stud type or the shell type with internal threads and an independent stud. Self-drilling mechanical expansion anchors shall not be used.
- Cast-in-place inserts shall be ferrule loop or cast iron type.
- All metal parts of anchorage devices shall be fabricated from steel or stainless steel, except iron castings for cast-in-place inserts shall be malleable iron or ductile iron.
- All metal parts of anchorage devices, except stainless steel mechanical expansion anchors and iron castings for cast-in-place inserts, shall be hot-dip or mechanically galvanized. Mechanical expansion anchors may be hot-dip or mechanically galvanized, made from stainless steel, or coated with electrodeposited zinc conforming to the requirements in ASTM Designation: B 633. Iron castings shall be mechanically galvanized.

- Mechanical expansion and resin capsule anchors shall, when installed in accordance with the manufacturer's instructions and these specifications and tested in conformance with the requirements in California Test 681, withstand the application of a sustained tension test load of at least the following values for a period of at least 48 hours with a movement not greater than 0.035-inch:

Stud Diameter (inches)	Sustained Tension Test Load (pounds)
$1^1/_4$	31,000
1	17,900
$^7/_8$	14,400
*$^3/_4$	5,000
$^5/_8$	4,100
$^1/_2$	3,200
$^3/_8$	2,100
$^1/_4$	1,000

* Maximum stud diameter permitted for mechanical expansion anchors.

- Cast-in-place inserts shall, when installed in conformance with the manufacturer's instructions and these specifications, and tested in conformance with the requirements in California Test 682, withstand the following minimum ultimate tensile loads:

Stud Diameter (inches)	Ultimate Tensile Load (pounds)
$1^1/_4$	25,200
$1^1/_8$	19,800
1	16,000
$^7/_8$	11,600
$^3/_4$	7,200
$^5/_8$	6,600
$^1/_2$	4,200

- Concrete anchorage devices shall be subject to the approval of the Engineer. Approval of anchorage device types and sizes shall be contingent upon the Contractor submitting to the Engineer one sample of each type of concrete anchorage device, manufacturer's installation instructions and certified results of tests, either by a private testing laboratory or the manufacturer, indicating compliance with the above requirements. Anchorage devices previously tested and found to be in compliance with the above requirements and approved by the Engineer need not be retested.

- Concrete anchorage devices shall be installed in the concrete as shown on the plans, as recommended by the manufacturer of the devices, and as specified herein, so that the attached equipment or fixtures will bear firmly against the concrete. Shell type mechanical expansion anchors shall be installed so that the top surface of the anchor body remains 1/2 inch to one inch below the surface of the concrete after expansion. After installation of shell type mechanical expansion anchors, and prior to mounting any equipment or fixture, the Contractor shall demonstrate in the presence of the Engineer that the expansion anchor is firmly seated within the above tolerances.
- If the manufacturer's instructions do not include specific torque requirements, nuts used to attach equipment or fixtures to anchorage devices shall be tightened to the following installation torque values in foot-pounds:

Installation Torque Values, (foot-pounds)

Stud Diameter (inches)	Shell Type Mechanical Expansion Anchors	Integral Stud Type Mechanical Expansion Anchors	Resin Capsule Anchors and Cast-in-Place Inserts
1 1/4	—	—	400
1	—	—	230
7/8	—	—	175
3/4	80	175	150
5/8	35	90	75
1/2	22	50	30
3/8	11	25	18
1/4	4	7	-

- Joints in drain pipe shall be watertight, and shall be smooth and free from projections or offsets in excess of 1/16 inch on the inside. Mechanical couplings in piping shall be gasketed short sleeve type couplings consisting of a mild steel middle ring with pipe stop, 2 rubber-compounded wedge-section ring gaskets, 2 mild steel follower rings and sufficient mild steel bolts to compress the gaskets.
- Sealing compound, for caulking and adhesive sealing, shall be a non-sag polysulfide or polyurethane material conforming to the requirements in Federal Specification TT-S-230, Type II.
- Galvanizing of miscellaneous bridge metal will not be required for portions of plates, shapes or other items embedded more than 2 inches in concrete; embedded steel pipe terminating at or below the surface of encasing concrete; and items shown on the plans to receive other finish.
- Where local conditions require that pipes under walkways and other improved areas be of smaller diameter than the downdrain pipes, a transition section shall be provided.
- During construction operations, deck drain grates and other grating openings shall be securely covered to prevent intrusion of debris until after final cleanup of the deck and other drainage areas.

After the cleanup of the deck and other drainage areas, each drain pipe and facility, except short free fall pipes, shall be tested in the presence of the Engineer by discharging approximately 100 gallons of water into the drain to demonstrate the proper operation of the drain pipe and facility. If evidence of obstructions in the pipe is observed, the pipe shall be cleared and the test repeated until the drain pipe and facility are unobstructed.

75-1.035 BRIDGE JOINT RESTRAINER UNITS

Bridge joint restrainer units, of the type or types shown on the plans, consisting of cables or cable assemblies and associated materials or components, shall conform to the details shown on the plans and the requirements of these specifications and the special provisions.

The associated materials or components required for each restrainer unit type shall be as shown on the plans or as specified in the special provisions and include various combinations of the following: structural steel components, bolts, bearing plates, cable drum units, pipe sleeves, polyvinyl chloride pipe, elastomeric pads, expansion joint filler, expanded neoprene, expanded polystyrene, sheet neoprene, hardboard and incidentals.

Cables shall be 3/4 inch preformed, 6 x 19, wire strand core or independent wire rope core (IWRC), galvanized, and in conformance with the requirements in Federal Specification RR-W-410D, right regular lay, manufactured of improved plow steel with a minimum breaking strength of 23 tons. Two certified copies of mill test reports of each manufactured length of cable used shall be furnished to the Engineer.

Cable assemblies shall consist of cables, swaged fittings, studs, nuts, cable yield indicators, disk springs and when shown on the plans, turnbuckles and shall conform to the following requirements:

A. The swaged fitting shall be machined from hot-rolled bars of steel conforming to the requirements in AISI Designation: C1035, and shall be annealed, suitable for cold swaging. A lock pin hole to accommodate a 1/4 inch plated spring steel pin shall be drilled through the head of the swaged fitting to retain the stud in proper position. The manufacturer's identifying mark shall be stamped on the body of the swaged fitting.
B. The one inch diameter stud shall conform to the requirements in ASTM Designation: A 449 after galvanizing. Prior to galvanizing, a 3/8 inch slot for the locking pin shall be milled in the stud end.
C. Nuts shall conform to the requirements in ASTM Designation: A 563 or A 563M including Appendix X1, except lubrication is not required.
D. The cable yield indicator shall be machined from hot-rolled bars of steel conforming to the requirements in AISI Designation: C 1035 and shall be annealed, suitable for cold swaging. The heat number and manufacturer's identifying mark shall be stamped on the end surface of each cable yield indicator. The wall thickness of the reduced section of the cable yield indicator shall be machined by the Contractor so that the indicator yields at a load between 36,000 pounds and 38,000 pounds when tested in

compression along the major axis at a test speed not to exceed 1/2 inch per minute. Two certified copies of the mill test and heat treating reports of each heat of bars used for cable yield indicators shall be furnished to the Engineer.

E. The disc springs shall be made from steel conforming to the requirements in ASTM Designation: A 684/A 684M, Grade 1075. Galvanizing of the disc springs will not be required. The disc springs shall be cleaned and painted with a paint recommended by the manufacturer and color coded as shown on the plans.
F. Turnbuckles shall be the steel pipe type. Pulls for the turnbuckles shall consist of a swaged fitting and stud assembly.
G. The swaged fittings, turnbuckles, stud and nut assembly shall develop the specified breaking strength of the cable.
H. The cable assemblies shall be shipped as a complete unit including cable yield indicator, disk springs, stud and nut and, when required, turnbuckle.
I. The Contractor shall be responsible for determining the required lengths of the cable assemblies.
J. The Contractor shall notify the Engineer, in writing, at least 2 days prior to tightening and setting of cable restrainer units.

- The following materials shall be furnished to the Engineer at the manufacturer's plant:

A. One sample cable assembly, consisting of a cable properly fitted with a swaged fitting and right hand thread stud at both ends, 3 feet in total length, for each 200 cable assemblies or fraction thereof produced.
B. One turnbuckle fitted with a 8-inch stud at each end for each 200 turnbuckles or fraction thereof produced.
C. One percent of the cable yield indicators, but not fewer than 8, produced from each mill heat.
D. Two disc springs of each size produced from each mill heat.

- Free ends of cable for restrainer units shall be securely wrapped at each end to prevent separation.
- Bolts, thread locking system and concrete anchorage devices shall conform to the provisions in Section 75-1.03, "Miscellaneous Bridge Metal."
- Unless otherwise specified, steel parts shall conform to the requirements in ASTM Designation: A 36/A 36M. Steel for bearing bars or pins shall conform to the requirements in ASTM Designation: A 36/A 36M or A 576 Grade 1030 (AISI 1030) and shall be other than rimmed or capped steel.
- Pipe sleeves shall be commercial quality welded steel pipe.
- Steel parts shall be galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing." Holes may be drilled after galvanizing provided all holes are repaired as provided in Section 75-1.05.

- Fabrication and welding shall conform to the provisions in Section 75-1.03, "Miscellaneous Bridge Metal." The minimum size of fillet welds shall conform to the requirements in AWS D1.1 except as modified below:

Base Metal Thickness of Thicker Part Joined (inches)	Minimum Size of Fillet Weld (inches)
Over $^3/_4$ to $1^1/_2$	$^5/_{16}$
Over $1^1/_2$ to $2^1/_4$	$^3/_8$
Over $2^1/_4$ to 6	$^1/_2$
Over 6	$^5/_8$

- Concrete for filling cable drum units shall conform to the provisions in Section 90-10, "Minor Concrete," or shall be a commercial grade pea gravel mix with not less than 674 pounds of cement per cubic yard.
- Existing structural steel paint areas damaged by the Contractor's operations and holes drilled through existing steel members shall be repaired in conformance with the provisions for repair of galvanized surfaces in Section 75-1.05, "Galvanizing," at the Contractor's expense.
- Elastomeric pads shown with restrainer units shall conform to the provisions in Section 51-1.12H, "Elastomeric Bearing Pads," except that the pads may consist of elastomer only regardless of thickness. Laminated reinforcement will not be required.
- Polyvinyl chloride (PVC) pipe shall be commercial quality.
- When shown on the plans, bond breaker on PVC pipe shall consist of a mortar-tight wrapping of plastic sheet or rubber sheet, 0.010-inch minimum thickness, or equal.
- Expanded polystyrene and hardboard shall conform to the provisions in Section 51-1.12D, "Sheet Packing, Preformed Pads and Board Fillers."
- Expansion joint filler shall conform to the provisions in Section 51-1.12C, "Premolded Expansion Joint Fillers."
- Neoprene sheets shown with restrainer units shall conform to the requirements for neoprene in Section 51-1.14, "Waterstops." The neoprene sheets shall be smooth, free from pin holes or surface blemishes, and shall show no evidence of delamination.
- Closed cell expanded neoprene material shall be of commercial quality conforming to the stiffness requirements for Class SC Grade 43E material or firmer as set forth in ASTM Designation: D 1056.
- Each restrainer unit shall consist of the number of cable units shown on the plans.
- Where shown on the plans, the cable shall be covered with a piece of $^3/_4$-inch inside diameter neoprene tubing having a wall thickness of not less than $^1/_8$ inch. Neoprene tubing shall be held in place with stainless steel hose clamps. Neoprene tubing and hose clamps shall be of commercial quality. Cadmium plated screws furnished with stainless steel clamps will be acceptable.

75-1.04 PUMPING PLANT METAL WORK

- Pumping plant metal work shall conform to the provisions in Section 75-1.02, "Miscellaneous Iron and Steel," and the provisions in this section. Pumping plant metal work consisting of fabricated and cast metal parts involved in the construction of pumping plants, including metal parts in the pumphouse, outside stairway, storage box and discharge box and the roadway type inlet frames and grates at the pumping plant site; but excluding bar reinforcing steel, metal parts furnished and installed as provided in Section 74, "Pumping Plant Equipment," and excluding roadway type inlet frames and grates listed and paid for under the contract item of miscellaneous iron and steel, shall be furnished and installed in accordance with the details shown on the plans and as required in these specifications.
- Pipe handrailing shall conform to the provisions in Section 83-1.02A, "Pipe Handrailing."
- Anchorage devices for attaching pumping plant metal work to concrete shall be hot-dip or mechanically galvanized or fabricated from stainless steel, and shall conform to the provisions for concrete anchorage devices in Section 74-2.05, "Bracing and Hardware."
- Cast iron manhole covers and frames and cast iron grates and frames (except in walkway areas) and other items as shown on the plans shall be dipped in commercial quality asphaltum.
- Manhole covers and frames for pumping plant discharge boxes shall be watertight and certified by the manufacturer to be rated to the pressure shown on the plans. Modifications to the manhole cover and frame by the Contractor to achieve pressure rating will not be allowed.

75-1.05 GALVANIZING

- Galvanizing of products fabricated from rolled, pressed and forged steel shapes, plates, bars and strip 1/8 inch thick or thicker, shall conform to the requirements in ASTM Designation: A 123/A 123M, except that complete seal welding of tightly contacting surfaces of these products prior to galvanizing is required only where seal welding is shown on the plans or specified in the special provisions. Except for pregalvanized standard pipe, galvanizing of material 1/8 inch thick or thicker shall be performed after fabrication into the largest practical sections.
- At the option of the Contractor, material thinner than 1/8 inch shall be galvanized either before fabrication in conformance with the requirements of ASTM Designation: A 653/A 653M, Coating Designation Z600, or after fabrication in conformance with the requirements of ASTM Designation: A 123/A 123M, except that the weight of zinc coating shall average not less than 1.2 ounce per square foot of actual surface area with no individual specimen having a coating weight of less than 1.0 ounce per square foot.
- Galvanizing of standard pipe shall conform to the requirements of ASTM Designation: A 53/A 53M, except that the zinc coating for pipe used in fence work as provided in Section 80, "Fences," shall average not less than 1.2 ounces per square foot of actual surface area with no individual specimen having less than

1.0 ounce per square foot of actual surface area. The zinc coating for any structural shape used in fence work, except for metal line posts for barbed wire and wire mesh fence, shall conform to the above requirement for pipe used in fence work. Galvanizing will not be required for stainless steel, monel metal and similar corrosion resistant parts.

- Fabrication shall include all operations such as shearing, cutting, punching, forming, drilling, milling, bending, welding and riveting.
- Welded areas shall be thoroughly cleaned prior to galvanizing to remove slag or other material that would interfere with the adherence of the zinc. When it is necessary to straighten any sections after galvanizing, the work shall be performed without damage to the zinc coating.
- Galvanizing of iron and steel hardware and nuts and bolts, when specified or shown on the plans, shall conform to the requirements in ASTM Designation: A 153/A 153M, except whenever threaded studs, bolts, nuts, and washers are specified to conform to the requirements in ASTM Designation: A 307, A 325, A 325M, A 449, A 563, A 563M, or F 436 and zinc coating is required, they shall be hot-dip zinc coated or mechanically zinc coated in conformance with the requirements in the ASTM Designations. Unless otherwise specified, galvanizing shall be performed after fabrication.
- Components of bolted assemblies shall be galvanized separately before assembly.
- Tapping of nuts or other internally threaded parts to be used with zinc coated bolts, anchor bars or studs shall be done after galvanizing and shall conform to the requirements for thread dimensions and overtapping allowances in ASTM Designation: A 563 or A 563M.
- When specified, painting of zinc coated surfaces shall be in conformance with the provisions in Section 59-3, "Painting Galvanized Surfaces."
- Galvanized surfaces that are abraded or damaged at any time after the application of the zinc coating shall be repaired by thoroughly wire brushing the damaged areas and removing loose and cracked coating, after which the cleaned areas shall be painted with 2 applications of unthinned zinc-rich primer (organic vehicle type) conforming to the provisions in Section 91, "Paint." Aerosol cans shall not be used.

75-1.06 MEASUREMENT

- Miscellaneous iron and steel, miscellaneous bridge metal, miscellaneous metal (restrainer) and pumping plant metal work will be measured by the pound as determined from scale weighings. The weight of non-metallic materials involved in constructing restrainer units will not be included in the weight of miscellaneous metal (restrainer).
- Scale weighings will not be required when miscellaneous iron and steel, miscellaneous bridge metal, miscellaneous metal (restrainer), or pumping plant metal work are designated as final pay items in the Engineer's Estimate.
- Metal frames, covers, and grates and other metal required by the plans, except as provided in Sections 51-1.23, "Payment," 70-1.05, "Payment," 75-1.03, "Miscellaneous Bridge Metal," 75-1.035, "Bridge Joint Restrainer Units," and 75-1.04, "Pumping Plant Metal Work," will be measured by the pound as

miscellaneous iron and steel, except when grates, frames and grates or frames and covers are measured and paid for as units. A frame and cover or frame and grate together will be considered as a single unit.

75-1.07 PAYMENT

- The contract prices paid per pound, for miscellaneous iron and steel, miscellaneous metal (bridge) miscellaneous metal (restrainer) of the types shown in the Engineer's Estimate, or pumping plant metal work, or the contract unit price paid for grate, for frame and grate, or for frame and cover shall include full compensation for furnishing all labor, materials (including non-metallic materials for restrainer units), tools, equipment and incidentals, and for doing all the work involved in furnishing and installing the miscellaneous metal, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- If a portion or all of the miscellaneous iron and steel, miscellaneous metal (bridge) and miscellaneous metal (restrainer) are fabricated more than 300 air line miles from both Sacramento and Los Angeles, additional shop inspection expenses will be sustained by the State. Whereas it is and will be impracticable and extremely difficult to ascertain and determine the actual increase in these expenses, it is agreed that payment to the Contractor for the miscellaneous metal items of work will be reduced $5,000 for each fabrication site located more than 300 air line miles from both Sacramento and Los Angeles and an additional $3,000 ($8,000 total) for each fabrication site located more than 3,000 air line miles from both Sacramento and Los Angeles.

SECTIONS 76 THROUGH 79: (BLANK)

RIGHT OF WAY AND TRAFFIC CONTROL FACILITIES

SECTION 80: FENCES

80-1 GENERAL

80-1.01 DESCRIPTION

- This work shall consist of constructing barbed wire fence, wire mesh fence and chain link fence in accordance with the details and at the locations shown on the plans. Fences shall be of the type designated on the plans or in the special provisions and shall be constructed as specified in these specifications and the special provisions.
- Barbed wire and wire mesh fences shall be designated as Type BW and Type WM fences, respectively. Type BW shall consist of 5 lines of barbed wire and Type WM shall consist of wire mesh and 3 lines of barbed wire. Both types shall be fastened to metal posts, or treated or untreated wood posts. The type of posts will be specified in the special provisions.
- Chain link fence shall be designated as "Type CL-" followed by a number specifying the width, in feet, of the fence fabric. The type of chain link fence to be constructed will be designated in the contract item and specified in the special provisions.
- When specified in the special provisions, chain link fence posts shall be equipped with extension arms upon which shall be strung the specified number of lines of barbed wire.
- Fences on freeways shall be constructed within the highway right of way and fences on all other highways shall be constructed on private property as shown on the plans.
- Fence construction operations shall be conducted so as to prevent the escape of livestock.

80-1.02 EXISTING FENCES

- Attention is directed to Sections 7-1.11, "Preservation of Property," and 7-1.12, "Indemnification and Insurance." Fences that are to remain in place and which have been damaged by the Contractor shall be replaced by the Contractor at the Contractor's expense.

80-1.03 CLEARING

- Earth, trees, brush and other obstructions which interfere with the proper construction of fences shall be removed and disposed of, unless the Engineer orders certain trees to remain in place. This work will be considered as part of fence construction and no measurement nor payment will be made for this work.

80-1.04 CONNECTIONS

- Existing cross fences shall be connected to the new fences. Corner posts with braces for every direction of strain shall be placed at the junction with existing fences. The wire in the new and existing fences shall be fastened to the posts. At structures, if directed by the Engineer, the new fence shall be connected to the structure in such a manner as to permit the free passage of stock through or under the structure, or else an end post shall be installed and the fence connected thereto.

80-2 (BLANK)

80-3 TYPES BW AND WM FENCE

80-3.01 MATERIALS

- Materials for Type BW and Type WM fences shall conform to the following:

80-3.01A Metal Posts and Braces

- Line posts shall conform to the requirements in ASTM Designation: A 702, except that packaging of posts will not be required. Posts shall be Class B steel and not less than 7 feet long. The anchor plate may be omitted provided the post is set in a portland cement concrete footing with a minimum cross sectional dimension of 6 inches and a depth equal to full penetration of the post.
- End, latch, pull and corner posts shall have a minimum resisting section modulus of 0.32 cubic inch in any direction. The posts shall be not less than 7 feet long and shall be not less than 3.1 pounds per foot. Braces and brace posts shall be not less than 7 feet long and shall be not less than 1.93 pounds per foot. Gate posts shall conform to the details shown on the plans.

80-3.01B Wood Posts and Braces

- Wood posts and braces shall be treated unless otherwise provided in the special provisions.

80-3.01B(1) Untreated Wood Posts and Braces

- Untreated wood posts and braces shall be redwood, cedar, Douglas fir or Southern Yellow Pine, shall be cut from sound timber, and shall be straight and free from loose or unsound knots, shakes in excess of one third the thickness of the post, splits longer than the thickness of the post, or other defects which would render them unfit structurally for the purpose intended. Knots in posts shall be sound, tight, well spaced, and shall not exceed 2 inches in size on any face. Sweep shall not exceed 0.08 foot in 6 feet.
- Untreated wood line posts and braces may be split material and shall not be less than 7 feet long with a perimeter of not less than 16 inches and no dimension less than 4 inches.
- Untreated wood end, corner and brace posts shall be sawed or hewed and shall be not less than 8 feet long and not less than 6" x 6" nominal size.

80-3.01B(2) Treated Wood Posts and Braces

- Treated wood posts and braces shall be sawed rectangular, free of heart center, Douglas fir, Hem-Fir, Southern yellow pine, round fir or pine. Sawed Douglas fir, Hem-Fir and Southern yellow pine posts and braces shall be graded in conformance with the provisions in Section 57-2, "Structural Timber." The minimum grades and species allowed for sawed 4" x 4" nominal size treated posts and braces shall be construction light framing Douglas fir, No. 1 structural light framing Hem-Fir or No. 2 structural light framing Southern yellow pine. The minimum grades and species allowed for sawed 6" x 6" nominal size or larger treated posts and braces shall be select structural posts and timbers No. 1 (also known as No. 1 structural) Douglas fir, select structural posts and timbers Hem-Fir or No. 1 timbers Southern yellow pine. The timber for round posts shall be sound and free from decay, shakes

exceeding one third the diameter of the post, splits longer than the thickness or diameter of the post, loose or unsound knots, multiple crooks, or any other defects which would weaken the posts and braces or otherwise cause them to be structurally unsuitable for the purpose intended. Sweep in all posts shall not exceed 0.08-foot in 6 feet.

- Posts and braces to be treated shall be pressure treated in conformance with the provisions in Section 58, "Preservative Treatment of Lumber, Timber and Piling," and AWPA Use Category System: UC4A, Commodity Specification A or B.
- In lieu of the marking requirement in Section 58-1.02, "Treatment and Retention," the treating plant may hammer stamp either end of treated wood posts and braces with the symbol or name of the company performing the treatment.
- Round posts and braces shall be peeled to remove all outer bark and all inner cambium bark, except that occasional strips of inner bark may remain if not over $^1/_2$ inch wide or over 3 inches long. Knots shall be trimmed flush with the sides, spurs and splinters removed, and ends cut square.
- Line posts and braces shall be 7 feet long and all other posts including brace posts shall be 8 feet long. The maximum permissible variations from these lengths shall be minus one inch and plus 2 inches.
- The small end of round line posts and braces shall be between $3^1/_2$ inches and 5 inches in cross sectional dimension; the small end of all other round posts including brace posts shall be between $5^1/_2$ inches and 7 inches in cross sectional dimension. The allowable taper from end to end of round posts and braces shall not exceed $1^1/_2$ inches. Sawed rectangular line posts shall be not less than 4" x 4" nominal size; all other sawed rectangular posts including brace posts shall be not less than 6" x 6" nominal size.

80-3.01C Barbed Wire

- Barbed wire shall conform to the requirements in ASTM Designation: A 121 and shall be either $12^1/_2$-gage Class 1, $13^1/_2$-gage Class 3, or $15^1/_2$-gage Class 3. The barbed wire shall consist of 2 strands of wire, twisted with 2 point barbs.

80-3.01D Wire Mesh

- Wire mesh shall be fabric conforming to the requirements in ASTM Designation: A 116, Class 1. It shall be 32 inches wide, consisting of 8 horizontal wires with vertical stays spaced 6 inches apart. The top and bottom wires shall be 10-gage and the intermediate wires and vertical stays shall be $12^1/_2$-gage.

80-3.01E Gates

- Gates shall conform to the provisions in Section 80-4.01D, "Gates." Fabric for the gates shall conform to the provisions in Section 80-4.01B, "Fabric." Drive gates shall not be over 58 inches nor less than 48 inches high.

80-3.01F Miscellaneous

- Galvanized bolts and nuts for attaching braces and straps to metal posts and the suitable galvanized devices for holding barbed wire and wire mesh firmly in position shall be of commercial quality and design.

- Staples used to fasten barbed wire and wire mesh fabric to wood posts shall be not less than $1^3/_4$ inches long and shall be fabricated from 9-gage galvanized wire.
- Wire used to fasten barbed wire and wire mesh to metal posts shall be galvanized and 11-gage or heavier. Clips and hog rings shall be 9-gage or heavier.
- Portland cement concrete for metal post and brace footings and for deadmen shall be produced from commercial quality aggregates and cement and shall contain not less than 470 pounds of cement per cubic yard.

80-3.02 CONSTRUCTION

- Fence posts for Type BW and Type WM fences shall be spaced at the intervals and set to the depths shown on the plans.
- In general, in determining the post spacing, measurements shall be made parallel to the ground slope, and all posts shall be placed in a vertical position, except in unusual locations where directed by the Engineer the posts shall be set perpendicular to the ground surface.
- Any high points which interfere with the placing of wire mesh shall be excavated to provide the clearance shown on the plans.
- Posts shall be braced as shown on the plans.
- Changes in line where the angle of deflection exceeds 5 degrees for steel post fence or 15 degrees for wood post fence shall be considered as corners and corner posts shall be installed. Changes in line where the angle of deflection does not exceed 5 degrees for steel post fence or 15 degrees for wood post fence shall be considered as alignment angles. The adjacent line posts at alignment angles shall be made fast to the angle post by means of diagonal tension wires, or, if that method is considered impractical in the opinion of the Engineer, the posts shall be braced as provided for bracing corner posts.
- Pull post assemblies shall be installed as shown on the plans. Metal diagonal braces and metal corner, end, latch, gate and pull posts shall be set in a portland cement concrete footing crowned at the top to shed water.
- Metal line posts may be driven in place provided driving does not injure the posts.
- At the option of the Contractor, wood line posts may be driven into place, provided the method of driving does not damage the post; or they may be installed in drilled holes of the same dimension as the post and the post made firm in place; or they may be installed in larger drilled or dug holes and backfilled and compacted. In any event the posts shall be set solid and any space left around the posts shall be backfilled and compacted. All other wood posts shall be installed in drilled or dug holes and backfilled and compacted until solid. Round posts installed in drilled holes shall have the butt end down. Line posts which are to be driven shall have the small end machine pointed at the plant before being treated.
- Diagonal tension wires shall consist of two 8-gage galvanized wires securely fastened to wood posts. An extra loop shall be made around each post at each point of attachment and the wire stapled to the posts.
- Wood braces shall be connected to adjacent posts with $^3/_8$" x 4" steel dowels and the tension wires twisted until the installation is rigid.
- Barbed wire and wire mesh fabric shall be stretched and fastened to each wood post by means of galvanized fence staples and to metal posts by means of suitable

fasteners. The barbed wire and mesh fabric shall be attached to the private property side of the posts and at the spacings shown on the plans. On Type WM fence, the lower line of the barbed wire shall be tied to the top wire of the wire mesh with 12-gage galvanized wire at 4 foot intervals between posts. The wire mesh fabric shall be attached to each post by fastening the top and bottom wires and alternate longitudinal wires using a minimum of 5 fasteners.

- At all grade depressions where stresses tend to pull the posts from the ground, the fencing shall be snubbed or guyed at the critical point by means of a double 8-gage or 9-gage galvanized wire connected to each horizontal line of barbed wire or to the top and bottom wire of wire mesh fabric, and to a deadman weighing approximately 100 pounds and buried in the ground not less than 2 feet.. The fencing shall be stretched and fastened before being snubbed or guyed.
- When fence construction utilizes wood line posts, the fence fabric and fence wires shall be grounded. The grounding device shall consist of a metal fence post which shall be substituted for a regular fence post at intervals not to exceed 500 feet with not less than one metal post in any length of fence over 200 feet between openings. Each line of barbed wire and alternate longitudinal wires of the fence fabric shall be tightly fastened to the metal post with 11-gage, or heavier, galvanized steel wire.
- At each location where an electric transmission, distribution or secondary line crosses fences with wood posts, the fence shall be grounded with a galvanized or copper coated steel ground rod 8 feet long having a minimum diameter of $^1/_2$ inch installed directly below the point of crossing. The rod shall be driven vertically until the top is 6 inches below the ground surface. A No. 6 solid copper conductor or equivalent shall be used to connect each fence element to the grounding rod. The connections shall be either brazed or fastened with approved noncorrosive clamps.
- When a powerline runs parallel or nearly parallel to and within 100 feet of the wood post fence, the fence shall be grounded with a ground rod at each end post or at intervals not to exceed 1,500 feet.
- When the specified vertical penetration of the ground rod cannot be obtained, an equivalent horizontal grounding system approved by the Engineer, shall be installed.
- After the fencing has been attached to untreated wood posts, long posts which cause a non-uniform appearing fence shall be cut off. Surplus excavated material remaining after the fence has been constructed shall be disposed of in a uniform manner along the adjacent roadway as directed by the Engineer.

80-3.03 MEASUREMENT

- Quantities of fence to be paid for will be determined by the linear foot or mile from actual measurements of the completed fence, the measurements to be made parallel to the ground slope along the line of completed runs of fence, deducting the widths of openings.
- Quantities of gates will be determined from actual count. When more than one gate is placed in an opening, each single unit placed will be counted as a gate. A gate unit complete in place shall include one gate with all necessary fittings, hardware and gate posts with braces.

80-3.04 PAYMENT

- Quantities of barbed wire and wire mesh fence, measured as specified in Section 80-3.03, "Measurement," will be paid for at the contract price per linear foot, or per mile, for fence (Type BW or WM, wood or metal posts), and the contract unit price per wire mesh gate, of the size or sizes required.
- Full compensation for clearing the line of the fence and disposing of the resulting material, excavating high points in the existing ground, excavating and backfilling holes, disposing of surplus excavated material, and furnishing and placing concrete footings and deadmen, and connecting new fences to structures and existing cross fences, and constructing temporary fences for the protection of stock, shall be considered as included in the contract price paid per linear foot or per mile for the fence and no additional compensation will be allowed therefor.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing fences, complete in place, as shown on the plans and as specified in these specifications and the special provisions, and as directed by the Engineer.

80-4 CHAIN LINK FENCE

80-4.01 MATERIALS

- All ferrous materials shall be protected by galvanizing or other specified coatings. Imperfectly galvanized or coated material or material with serious abrasions shall not be used.

80-4.01A Posts and Braces

- The base metal for the manufacture of posts and braces shall be commercial quality, or better, weldable steel.
- Posts and braces shall be galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing," or, if the Contractor elects, tubular posts and braces shall have protective coating conforming to the following:

Exterior surfaces of tubular posts and braces shall have a combination coating consisting of a hot-dip galvanized primer followed by a chromate conversion coating, followed by a finish coat of clear, cross-linked organic coating. The thickness of the zinc coating shall be a minimum of 0.9 mil as determined from the average results of 2 or more specimens and not less than 0.8 mil on an individual specimen. The chromate conversion coating shall be a minimum of 15 micrograms per square inch. The total thickness of the combination coating shall be a minimum of 1.7 mils. The exterior clear coated surface of the pipe shall have a demonstrated ability to resist 1000 hours of exposure to salt fog with a maximum of 5 percent red rust when tested in conformance with the requirements in ASTM Designation: B 117. The clear finish coat shall not have any film cracking after 500 hours of exposure in an artificial weathering device in conformance with the requirements in ASTM Designation: G 152, cycles 1 or 3 Carbon Arc artificial weathering device, or G 155, cycles 1 or 2 Xenon Arc artificial weathering device. The clear finish coat shall not have any blistering or cracking after 500 hours of exposure to

100 percent relative humidity in conformance with the requirements in ASTM Designation: D 2247. Interior surfaces shall have a zinc coating or a cross-linked organic coating containing a corrosion inhibitor. The minimum coating thickness shall be 0.3 mil. The interior coated surface shall have a demonstrated ability to resist 300 hours of exposure to salt fog with a maximum of 5 percent red rust when tested in conformance with the requirements in ASTM Designation: B 117.

The protective coating system to be used shall be approved by the Engineer prior to the intended use of the posts and braces. Any change of a coating system once approved will be considered a new system and will be subject to reapproval.

The manufacturer shall supply a certification that the protective coatings comply with the above requirements. The certification shall be in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."

- Line, end, latch, and corner posts shall have not less than the following Minimum Resisting Moments:

	Minimum Resisting Moments (foot-pounds)*		
	Line Posts		End, Latch, and Corner posts
	Perpendicular to Fence Line	Parallel to Fence Line	Any Direction
Fence height 6 ft and less	800	400	1,400
Fence height over 6 ft (but not to exceed 10 ft)	1,400	700	2,400

* Resisting moment is defined as the product of the member's Section Modulus about the designated axis and its yield strength.

- Braces shall have a Minimum Resisting Moment of not less than 400 foot-pounds about the major axis and not less than 300 foot-pounds about the minor axis.
- End, latch and corner posts shall have a midpoint deflection about either axis not greater than 0.25-inch and posts and braces shall have a permanent set about either axis not greater than 0.01-inch when tested in conformance with the requirements in California Test 674.
- One post from each lot of 1500 posts or less and one brace from each lot of 500 braces or less shall be tested in conformance with the requirements in California Test 674. If that post or brace fails, then 2 additional posts or braces from the same lot shall be sampled and tested. The entire lot of posts or braces will be rejected if either one of the additional sampled posts or braces fails.
- The material of which posts and braces are fabricated shall have a nominal thickness, before galvanizing, of not less than 0.105-inch for posts and 0.075-inch for braces.
- If the line posts being used have a resisting moment about the weaker axis which is less than 75 percent of the required minimum resisting moment

perpendicular to the fence line, the posts shall not be used at angle points in the fence line where the deflection angle exceeds 10 degrees. If the line posts being used have a resisting moment about the weaker axis which is not less than 75 percent of the required minimum resisting moment perpendicular to the fence line, the posts may be used at angle points in the fence line up to a deflection angle of 30 degrees. Changes in line where the angle of deflection exceeds 30 degrees shall be considered as corners and corner posts shall be installed.

- Gate posts shall be fabricated from pipe conforming to the requirements shown on the plans.
- The length of posts, exclusive of fitted top fixtures or other methods of supporting the top tension wire which are integral with the post, shall not be less than the depth of the concrete footings shown on the plans plus the height of the fabric as shown on the plans or specified in the special provisions, less 4 inches.
- Posts shall have provisions to securely hold the top tension wire in position and allow for removal and replacement of a post without damaging the top tension wire. Tubular posts shall be fitted with rainproof tops.
- Post tops, extension arms, stretcher bars and other required fittings and hardware shall be steel or malleable iron or wrought iron and shall be galvanized after fabrication in conformance with the provisions for posts and braces in Section 75-1.05, "Galvanizing." All required fittings and hardware shall be fastened to the posts in the proper manner.

80-4.01B Fabric

- Chain link fabric shall conform to the requirements in AASHTO Designation: M 181 for Type I zinc coated fabric with a Class C coating. The wire used in the manufacture of the fabric shall be 11-gage for fence 84 inches or less in height and shall be 9-gage for fence over 84 inches in height.
- Chain link fence fabric shall be woven into approximately 2-inch mesh such that there shall be at least 7 meshes in a vertical dimension of 23 inches along the diagonals of the openings. Chain link fence fabric shall have knuckled finish on top and bottom edges.

80-4.01C Miscellaneous

- Between posts, chain link fabric shall be fastened to a top and bottom tension wire. The tension wire shall be at least 7-gage (0.177-inch dia.) coil spring steel of good commercial quality and shall be galvanized in conformance with the requirements in ASTM Designation: A 116, Coating Class 3.
- Tie wires and hog rings shall be at least 9-gage (0.148-inch dia.) steel and post clips shall be at least 6-gage (0.192-inch dia.) steel; all tie wires, hog rings and post clips shall be galvanized in conformance with the requirements in ASTM Designation: A 116, Coating Class 3.
- Turnbuckles and truss tighteners shall be fabricated of commercial quality steel, malleable iron or wrought iron and shall be galvanized as provided in Section 75-1.05, "Galvanizing." The truss tighteners shall have a strap thickness of not less than $^1/_4$ inch.

- Portland cement concrete for metal post footings and for deadmen shall be produced from commercial quality aggregates and cement and shall contain not less than 470 pounds of cement per cubic cubic yard.

80-4.01D Gates

- Drive gates shall be of the widths designated in the contract item. Walk gates shall be 4 feet wide.
- Gates greater than 8 feet in length shall have interior vertical members installed so that no panel exceeds 8 feet in length. Gate frames shall be constructed of not less than $1^1/_2$-inch pipe. Interior vertical members shall be constructed of not less than one inch pipe. Pipe shall conform to the provisions for posts and braces in Section 80-4.01A, "Posts and Braces."
- Gate frame panels shall be cross trussed with adjustable truss rods having diameters of not less than $^3/_8$ inch. The corners of the gate frames shall be fastened together and reinforced with a malleable iron or a pressed steel fitting designed for the purpose, or by welding. Pressed steel fittings shall have a nominal thickness, before galvanizing, of not less than 0.135-inch and shall be fastened suitably to develop the strength of the connected members. Welding shall conform to the best commercial practice; welds shall be sound and shall develop the strength of the connected member. Welds shall be smooth.
- Fittings, latches, rods and other gate hardware shall be galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing."
- Chain link fence fabric specified for the fence shall be attached to the gate frame by the use of stretcher bars and tie wires as specified for fence construction, and suitable tension connectors shall be spaced at approximately one foot intervals.
- The gates shall be hung by at least 2 steel or malleable iron hinges not less than 3 inches in width, so designed as to securely clamp to the gate post and permit the gate to be swung back against the fence. The bottom hinge shall have a socket to take the ball end of the gate frame.
- Gates shall be provided with a combination steel or malleable iron catch and locking attachment of approved design which will not rotate around the latch post. Stops to hold gates open and a center rest with catch shall be provided where required.

80-4.02 CONSTRUCTION

- Line posts shall be spaced at not more than 10-foot intervals, measured from center to center of posts. In general, in determining the post spacing, measurement will be made parallel to the slope of the natural ground, and posts shall be placed in a vertical position, except in unusual locations where directed by the Engineer the posts shall be set perpendicular to the ground surface.
- Posts shall be set in concrete footings conforming to the details shown on the plans and crowned at the top to shed water.
- End, latch and corner posts shall be braced to the nearest line post. At the Contractor's option bracing shall be accomplished either with diagonal braces used as compression members or with horizontal braces used as compression members and steel truss rods having minimum diameters of $^3/_8$ inch used as tension members. Gate posts shall be braced to the nearest line post with a horizontal brace

used as a compression member and steel truss rods having minimum diameters of 3/8 inch as tension members. Each steel truss rod shall be equipped with a turnbuckle or truss tightener with tensile strength equal to the truss rod. Line posts shall be braced horizontally and trussed in both directions at intervals not to exceed 1,000 feet, except that this bracing and trussing may be omitted when the fabric is installed by stretching with equipment.

- Chain link fabric shall be fastened on the side of the posts designated by the Engineer.
- The fabric shall be stretched and securely fastened to the posts, and between posts the top and bottom edges of the fabric shall be fastened to the tension wires. Tension wires shall be stretched tight. The bottom tension wire shall be installed on a straight grade between posts by excavating the high points of ground and in no case will filling of depressions be permitted.
- The fabric shall be fastened to end, latch, corner and gate posts with stretcher bars having dimensions of not less than 1/4" x 3/4" and stretcher bar bands having dimensions of not less than 1/8" x 3/4" spaced at one foot intervals. The fabric shall be fastened to line posts with tie wires or post clips and to tension wires with tie wires or hog rings. The fasteners shall be spaced at approximately 14 inches on line posts and at approximately 18 inches on tension wires. Wire ties shall be given at least one complete turn. Hog rings shall be closed with ends overlapping. The tension wires shall be wrapped around terminal posts. The distance from the top of the fabric to the top tension wire shall be 2 inches maximum.
- In lieu of using stretcher bars and bar bands, the fabric may be fastened to the end and corner posts by threading through loops formed on the posts.
- Surplus excavated material remaining after the fence has been constructed shall be disposed of in a uniform manner along the adjacent roadway as directed by the Engineer.

80-4.03 MEASUREMENT

- Quantities of chain link fence to be paid for will be determined by the linear foot or mile from actual measurements, the measurements to be made parallel to the ground slope along the line of the completed fence, deducting the widths of openings.
- Quantities of gates will be determined from actual count. When more than one gate is placed in an opening, each single unit placed will be counted as a gate. A gate unit complete in place shall include one gate with all necessary fittings, hardware, and gate and latch posts with braces.

80-4.04 PAYMENT

- Items of work, measured as specified in Section 80-4.03, "Measurement," will be paid for at the contract price per linear foot, or per mile, for chain link fence of the type designated in the Engineer's Estimate and the contract unit price per chain link gate, if gates are required. The size and type of gate will be designated in the contract item or special provisions.
- Full compensation for clearing the line of the fence and disposing of the resulting material, excavating high points in the existing ground between posts, excavating holes, disposing of surplus excavated material, and furnishing and

placing portland cement concrete footings, and connecting new fences to structures and existing cross fences, and constructing temporary fences for the protection of stock, shall be considered as included in the price paid for the fence and no additional compensation will be allowed therefor.

- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing chain link fences and gates, complete in place, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 81: MONUMENTS

81-1.01 DESCRIPTION

- This work shall consist of constructing cast-in-place portland cement concrete survey monuments at the locations shown on the plans or directed by the Engineer and as specified in these specifications and the special provisions.
- Monuments shall conform to the dimensions and details shown on the plans.

81-1.02 MATERIALS

- The concrete portion of monuments shall be constructed in conformance with the provisions in Sections 51, "Concrete Structures," and 90, "Portland Cement Concrete."
- Concrete shall be Class 3 or minor concrete at the option of the Contractor. A one inch maximum aggregate shall be used.
- Concrete shall be thoroughly compacted and shall be cured in conformance with the provisions in Section 90-7.01A, "Water Method."
- Survey marker disks for survey monuments will be furnished by the State at the site of the project.
- At the option of the Contractor, the frame and cover for Type B and Type D survey monuments shall be fabricated from either cast steel or gray cast iron. The covers shall fit into the frames without rocking.
- The cast steel and gray cast iron frames and covers shall conform to the provisions in Section 55-2, "Materials."
- Granular material for Type B and Type D survey monuments shall be gravel, crushed gravel, crushed rock or any combination thereof. Granular material shall not exceed $1^1/_2$ inches in greatest dimension.

81-1.03 CONSTRUCTION

- Survey monuments may be cast-in-place in neat holes without the use of forms, except where forms are shown on the plans.
- State-furnished survey marker disks shall be placed in survey monuments before the concrete has acquired its initial set and shall be firmly bedded in the concrete. The concrete monument shall be so located that when the disk is placed in the center of the monument, the point being referenced will fall within a one inch circle in the center of the disk.
- After the monuments have been constructed as specified, any resultant space around them shall be filled with earth, free from rock, or with base and surfacing material as shown on the plans. Earthy material shall be watered and tamped into place.
- Surplus excavated material remaining after the monuments have been constructed shall be disposed of in a uniform manner along the adjacent roadway as directed by the Engineer.

81-1.04 (BLANK)

81-1.05 MEASUREMENT

- The quantities of each type of monument will be paid for as units determined from actual count.

81-1.06 PAYMENT

The contract unit prices paid for survey monuments shall include full compensation for furnishing all labor, materials (except disks for survey monuments), tools, equipment, and incidentals, and for doing all the work involved in constructing the monuments, complete in place, including frames and covers, granular material, excavating and backfilling holes, and disposing of surplus excavated material, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 82: MARKERS AND DELINEATORS

82-1.01 DESCRIPTION

- This work shall consist of furnishing and installing markers and delineators at the locations shown on the plans or where directed by the Engineer.
- The markers and delineators shall conform to the details shown on the plans and as specified in these specifications and the special provisions.

82-1.02 MATERIAL

- The markers and delineators shall conform to the following material requirements:

82-1.02A Wood Posts

- Wood posts shall conform to the provisions in Section 56-2.02B, "Wood Posts and Braces."

82-1.02B Metal Posts

- Steel for metal posts shall conform to the requirements in ASTM Designation: A 36/A 36M. The posts shall be galvanized in conformance with the requirements in Section 75-1.05, "Galvanizing."
- Completed posts shall be free from injurious defects and shall have a workmanlike finish.
- Galvanized surfaces which are damaged shall be cleaned and repaired as provided in Section 75-1.05, "Galvanizing."

82-1.02C Flexible Posts

- Flexible posts shall conform to the provisions in the special provisions.

82-1.02D Target Plates

- Target plates for highway post markers and Type L object markers installed on a metal post, shall be manufactured from zinc-coated steel sheet or aluminum sheet.
- Target plates for Type K object markers shall be of the same color and material as the flexible post.
- The zinc-coated steel sheet shall conform to the requirements in ASTM Designation: A 653/A 653M, Classification: Commercial Steel (CS Types A, B and C). The steel sheets shall be galvanized in conformance with the requirements in Section 75-1.05, "Galvanizing." The zinc-coated surface shall be prepared for painting in a manner designed to produce optimum paint adherence. The surface preparation shall be accomplished without damaging or removing the zinc coating. Any evidence of damage or removal of the zinc coating shall be cause for rejection of the entire lot.
- Aluminum target plates shall be fabricated of Alloy 3003-H14. Other alloys having equivalent properties may be used provided prior approval is obtained.
- The aluminum sheet shall be prepared for painting by suitable cleaning to remove contaminants and by the uniform application of an acid-chromate-fluoride, acid-chromate-fluoride phosphate or equivalent chemical conversion coating.
- The minimum nominal thickness of zinc-coated steel sheet shall be 0.038-inch, and the minimum nominal thickness of aluminum sheet shall be 0.050-inch.

- Fabrication of all metal parts shall be accomplished in a uniform and workmanlike manner. Target plates shall be cut to size and shape and the holes punched for mounting bolts and reflectors in conformance with the details shown on the plans. Surfaces and edges of the target plates shall be free from fabrication defects. If the one-coat paint system is to be used, all fabrication of zinc-coated steel target plates, including shearing, cutting and punching shall be done prior to enameling.
- The pretreated metal target plates shall be coated an opaque white on both sides in conformance with either of the following paint systems:

1. One-Coat System.—The dry film when tested in conformance with the requirements in California Test 671 shall be uniform and have a minimum average thickness of 0.75-mil with no individual measurement less than 0.65-mil.
2. Two-Coat System.—The dry film when tested in conformance with the requirements in California Test 671 shall be uniform and conform to the following thicknesses:

    a. Primer, 0.10-mil to 0.20-mil.
    b. Primer plus top coat, 0.75-mil minimum average thickness with no individual measurement less than 0.65-mil.

- At the option of the manufacturer, the spray, dip, roller or continuous roller coating methods may be used for application of the enamel. Other methods may be used provided prior approval is obtained.
- All coatings shall be commercially smooth, substantially free of flow lines, paint washout, streaks, blisters and other defects that would impair serviceability or detract from general appearance.
- When tested in conformance with the requirements in California Test 671, the painted metal target plates shall, in general, have satisfactory resistance to weathering, humidity, salt spray and chemicals; the enamel coating shall have satisfactory adherence and impact resistance, a pencil lead hardness of HB minimum, 60° specular gloss of 80 percent minimum, an excitation purity of 3 percent maximum as received and after 1,000 hours in an artificial weathering device in conformance with the requirements in ASTM Designation: G 155, Table X3.1, Cycle 1, and a daylight luminous directional reflectance ("Y" value) of 70 minimum.
- The completed metal target plates shall be free of dents and defects and the maximum edge to edge surface deviation from a horizontal plane shall not exceed $^1/_8$ inch.
- Samples of metal target plates may be selected at one or all of the following stages of production:

1. Finished Target Plates.—Target plates selected at random shall constitute a representative sample for each lot. The number of target plates to be selected is dependent upon the lot size as follows:

Lot Size	Number of Specimens
Less than 5,000	5
5,000 - 10,000	10
The maximum lot size shall not exceed 10,000 target plates.	

2. Flat Sheet Stock.—Five 12" x 24" specimens selected at random shall constitute a representative sample for each lot. The lot size shall not exceed 10,000 square feet. The flat sheet material must be identifiable with the parent coil stock.
3. Coil Stock.—Two 12" x 12" specimens or one 12" x 24" specimen shall constitute a representative sample for each coil. The coil weight shall not exceed 5,000 pounds.

- The failure of any specimen to comply with all specified requirements will be cause for rejection of the entire lot. At the discretion of the State, a resample may be permitted and will consist of twice the number of test specimens originally sampled.
- A Certificate of Compliance covering the metal target plates and enamel shall be furnished to the Engineer in conformance with the provisions in 6-1.07, "Certificates of Compliance."

82-1.02E Marker Panels

- Marker panels for Type N, Type P and Type R object markers will be furnished by the State as provided in "Materials" of the special provisions.

82-1.02F Reflectors

- Standard reflex reflectors conforming to the Department of Transportation current specifications for reflex reflectors for traffic signs, delineators and warning devices shall be attached directly to metal target plates on Type K and Type L object markers, and to the back of Class 2 delineator posts with Type E or Type I reflectorization. Copies of the current specifications are available at the Transportation Laboratory. The reflectors shall be of the type, size and color designated on the plans.
- Reflectors for flexible target plates on Type K object markers and target plates on Class 2 delineators, and reflectors for Class 1 delineators shall be made from impact resistant retroreflective sheeting as specified in the special provisions. The color of the retroreflective sheeting shall conform to the color designated on the plans and the Chromaticity Coordinates specified in ASTM Designation: D 4956, or the PR color number specified by the Federal Highway Administration's Color Tolerance Chart.
- Reflex reflectors or retroreflective sheeting may be used for object markers and delineators with rigid posts. Retroreflective sheeting shall be used for object markers and delineators with flexible posts.

- The instrumental method of determining color shall conform to the requirements specified in ASTM Designation: D 4956. In the event of any dispute concerning the test results of instrumental testing, the visual test shall prevail.
- A significant difference between day and night reflective color shall be grounds for rejection.

82-1.02G Hardware

- Hardware for attaching the target plates shall consist of $^{1}/_{4}$ inch galvanized steel or aluminum nuts and bolts or $^{3}/_{16}$ inch blind aluminum rivets and washers. Hardware for attaching marker panels to posts shall consist of $^{5}/_{16}$ inch galvanized steel bolts, nuts and washers. Commercial quality hardware will be acceptable.

82-1.03 INSTALLATION

- Posts may be driven in place where soil conditions permit, provided the method of driving does not damage the posts. If ground conditions are such that the posts cannot be driven without damaging the posts, pilot holes will be required. Target plates and marker panels shall be installed after the posts have been set in place.
- Posts shall be placed in the ground to the depth shown on the plans. After the posts have been set in position, any space around them shall be filled with earth free from rock. The filling material shall be thoroughly watered and tamped into place in such a manner as to hold the post securely in position.
- Surplus excavated material remaining after the posts have been installed shall be disposed of in a uniform manner along the adjacent roadway as directed by the Engineer.
- Before the completion of the contract, all areas where the paint has been damaged shall be given a spot application of paint and all exposed areas that have become soiled shall be cleaned.

82-1.04 MARKER INFORMATION

- Stenciled information for highway post markers shown on the plans or directed by the Engineer shall be painted or at the Contractor's option, the information may be applied with black cutout letters and numerals.
- The black cutout letters and numerals shall be die-cut from material conforming to the Department of Transportation current specifications for retroreflective sheeting for use on aluminum signs, except that the material shall be black and opaque. Copies of the current specifications are available at the Transportation Laboratory, Sacramento, California.
- Paint for stenciled information shall be commercial quality exterior black paint.

82-1.05 MEASUREMENT

- Quantities of markers and delineators to be paid for will be determined as units from actual count in place.
- A delineator post equipped with 2 target plates will be considered a single delineator.

82-1.06 PAYMENT

- Items of work, measured as specified in Section 82-1.05, "Measurement," will be paid for at the contract unit price for highway post markers and object markers of the type designated in the contract item, or at the single contract unit price for object markers or markers; and the contract unit price for delineators of the class designated in the contract item.
- The above prices and payments shall include full compensation for furnishing all labor, materials (except State-furnished marker panels), tools, equipment and incidentals, and for doing all the work involved in installing markers and delineators, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 83: RAILINGS AND BARRIERS

83-1 RAILINGS

83-1.01 DESCRIPTION

- This work shall consist of constructing pipe handrailing, metal beam guard railing, steel bridge railing, cable railing, concrete railing, metal railing or chain link railing at the locations and in conformance with the details shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- The type of railing to be constructed will be specified in the special provisions or shown on the plans.

83-1.02 MATERIALS AND CONSTRUCTION

- Materials and construction for the various types of railings shall conform to the provisions in this Section 83-1.02.
- At locations where public traffic is adjacent to metal beam guard railing work, all materials required to complete the guard railing construction at any one location shall be available before beginning the guard railing work at that location.
- Welding shall conform to the requirements in AWS D1.1. Welds on exposed surfaces shall be ground flush with the adjacent surfaces.
- All completed steel components and hardware for railings shall be galvanized in conformance with the requirements in AASHTO Designation: M 180 and Section 75-1.05, "Galvanizing."
- After galvanizing, all elements of the railing shall be free of fins, abrasions, rough or sharp edges and other surface defects and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done by methods approved by the Engineer. Kinks, twists or bends in railing elements may be cause for rejection of the railing elements.
- Abraded or damaged galvanized surfaces of steel railing and posts, and ends of steel railing cut after galvanizing, shall be cleaned and regalvanized as specified for galvanizing, except if permitted by the Engineer, repairs to the surfaces may be made in conformance with the provisions in Section 75-1.05, "Galvanizing."
- Mortar shall conform to the provisions in Section 51-1.135, "Mortar," and shall consist of one part portland cement and 3 parts sand.
- Mortar shall be cured by either the water method or the curing compound method using curing compound (6) as provided in Section 90-7, "Curing Concrete."

83-1.02A Pipe Handrailing

- Pipe handrailing shall consist of handrailing elements supported by metal brackets (wall type) or handrailing elements supported by tubular steel posts (post type).
- Handrailing elements shall be either structural tubing as specified herein for tubular steel posts or commercial quality standard steel pipe. Tubular steel posts shall be round, seamless or welded structural tubing conforming to the requirements in ASTM Designation: A 501 and shall have a wall thickness not less than that of standard steel pipe of the same nominal size.

- Brackets, bolts, threaded studs, nuts, washers and other fittings shall be commercial quality structural steel, except that standard steel pipe fittings may be used where shown on the plans.
- Mechanical expansion anchors for attaching the railing to supporting concrete members shall conform to the provisions for concrete anchorage devices in Section 75-1.03, "Miscellaneous Bridge Metal."
- The railing shall be carefully erected true to line and grade. Posts shall be vertical within a tolerance not to exceed 0.02-foot in 10 feet. Posts shall be set in sockets or on mortar pads as shown on the plans.

83-1.02B Metal Beam Guard Railing

- The rail elements, backup plates, terminal sections, end and return caps, bolts, nuts and other fittings shall conform to the requirements in AASHTO Designation: M 180, except as modified in this Section 83-1.02B and as specified in Section 83-1.02. The rail elements, backup plates, terminal sections, end and return caps shall conform to Class A, Type 1 W-Beam guard railing as shown in AASHTO Designation: M 180. The edges and center of the rail element shall contact each post block. Rail element joints shall be lapped not less than $12^1/_2$ inches and bolted. The rail metal, in addition to conforming to the requirements in AASHTO Designation: M 180, shall withstand a cold bend, without cracking, of 180 degrees around a mandrel of a diameter equal to 2.5 times the thickness of the plate.
- Workmanship shall be equivalent to good commercial practice and all edges, bolt holes and surfaces shall be free of torn metal, burrs, sharp edges and protrusions.
- Two certified copies of mill test reports of each heat from which the rail element is formed shall be furnished to the Engineer.
- Bolts shall have shoulders of such shape that will prevent the bolts from turning. Holes in rail elements shall be of similar shape as the bolt shoulder.
- Rail elements shall be spliced at intervals not to exceed 12.5 feet and the splices shall be made at posts, unless otherwise shown on the plans.
- The rail elements at joints shall have full bearing. When the radius of curvature is 150 feet or less, the rail elements shall be shaped in the shop. The radius of curvature shall be stenciled on the back of each section of rail elements in numerals $2^1/_2$ inches in height.
- At the option of the Contractor, metal beam guard railing shall be constructed using either steel posts or wood posts, both with wood blocks, for line posts. Only one type of line post shall be used for any one continuous length of guard railing.
- Steel posts shall be fabricated from steel conforming to the requirements in ASTM Designation: A 36/A 36M, unless otherwise specified. Two certified copies of mill test reports of each heat of steel from which steel posts are formed or fabricated shall be furnished to the Engineer.
- The grades and species of wood posts and blocks shall be No. 1 timbers (also known as No. 1 structural) Douglas fir or No. 1 timbers Southern yellow pine. Wood posts and blocks shall be graded in conformance with the provisions in Section 57-2, "Structural Timber," of the Standard Specifications, except allowances for shrinkage after mill cutting shall in no case exceed 5 percent of the American Lumber Standards minimum sizes, at the time of installation.

- Wood posts and blocks shall be rough or S4S, at the option of the Contractor. Only one type of post and block shall be used for any one continuous length of guard railing. The size tolerance of rough sawn blocks in the direction of the bolt holes shall be not more than $\pm 1/4$ inch.
- After fabrication, wood posts and blocks shall be pressure treated in conformance with Section 58, "Preservative Treatment of Lumber, Timber and Piling," and AWPA Use Category System: UC4A, Commodity Specification A.
- If copper naphthenate, ammoniacal copper arsenate, chromated copper arsenate, ammoniacal copper zinc arsenate, ammoniacal copper quat or copper azole is used to treat the wood posts and blocks, the bolt holes shall be treated as follows:

  A. Before the bolts are inserted, bolt holes shall be filled with a grease, recommended by the manufacturer for corrosion protection, which will not melt or run at a temperature of 149° F.

- Breakaway wood guard rail terminal posts may be field bored to provide the $2^3/_8$-inch diameter hole as shown on the plans.
- Where field cutting or boring is performed after treatment, all cuts and holes shall be thoroughly swabbed, sprayed or brushed with 2 applications of the same type of preservative as initially used, or treated with copper naphthenate as specified in AWPA Standard M4. Application of preservative in the field shall conform to the provisions in the last paragraph in Section 58-1.04, "Wood Preservative for Manual Treatment."
- Wood posts shall be driven, with or without pilot holes, or shall be placed in drilled holes, at the option of the Contractor. Any space around wood posts shall be backfilled with selected earth, free of rock, placed in layers approximately 0.33-foot thick and each layer shall be moistened and thoroughly compacted.
- Steel posts shall be driven. If ground conditions are such that pilot holes are necessary to prevent damage to posts during driving, any space around steel posts after driving shall be filled with dry sand or pea gravel.
- At the Contractor's option, steel foundation tubes with soil plates attached, shall be either driven, with or without pilot holes, or placed in drilled holes. Any space around the steel foundation tubes shall be backfilled with selected earth, free of rock, placed in layers approximately 4 inches thick and each layer shall be moistened and thoroughly compacted. Wood terminal posts shall be inserted into the steel foundation tubes by hand. Before the wood terminal posts are inserted, the inside surfaces of the steel foundation tubes to receive the wood posts shall be coated with a grease which will not melt or run at a temperature of 149° F or less. The edges of the wood terminal posts may be slightly rounded to facilitate insertion of the post into the steel foundation tubes.
- Posts shall be placed at equal intervals, as shown on the plans, except that the end posts may be spaced closer to adjacent posts if directed by the Engineer.
- The bolted connection of the rail element to the post shall withstand a 5,000-pound pull at right angles to the line of the railing.

- All metal work shall be fabricated in the shop, and no punching, cutting or welding will be permitted in the field. Rail elements shall be lapped so that the exposed ends will not face approaching traffic.
- Terminal sections shall be installed in conformance with the manufacturer's recommendations.
- Components built up from structural steel plates welded together may be substituted for the rolled steel components shown on the plans provided that the depth, width and average thicknesses are at least equal to those of the rolled section; and further provided that, for the welded section, the steel plates conform to the requirements in ASTM Designation: A 36/A 36M, and the flanges are welded to the web with continuous fillet welds on each side of the web.
- Metal beam guard railing shall be connected to bridge railings, barriers, retaining walls, abutments and other flat concrete surfaces in conformance with the details shown on the plans and the following provisions:

Metal rail posts, box spacers and plate washers shall be fabricated of steel conforming to the requirements in ASTM Designation: A 36/A 36M.

The metal box spacer shall be either fabricated from separate plates and welded or press-formed and welded.

High strength bolts shall conform to the requirements in ASTM Designations: A 325, A 325M or A 449, or the bolts may be fabricated from steel rod conforming to the requirements in ASTM Designation: A 449. The bolts or rods shall conform to the mechanical requirements in ASTM Designation: A 325 or A 325M after galvanizing. Nuts and washers shall conform to the requirements in ASTM Designation: A 325 or A 325M.

For the connection of guard railing to new bridge railing or barriers, anchor bolt holes shall be formed in the concrete parapet by the use of metal sleeves.

For the connection of guard railing to existing bridge railing or barriers, anchor bolt holes shall be drilled in the concrete parapet as shown on the plans. Areas around the holes spalled or otherwise damaged during drilling, as determined by the Engineer, shall be repaired with a mixture of commercial quality epoxy adhesive and sand. The proportions of epoxy adhesive to sand shall be from 1:4 to 1:6, the exact proportion to be determined by the Engineer. The cementing agent shall consist of a 2-component epoxy adhesive manufactured especially for the making of epoxy-sand mortar. The 2 components and the epoxy-sand mixture shall be mixed in conformance with the manufacturer's instructions.

Footings for railing posts shall be constructed of Class 3 or minor concrete conforming to the provisions in Section 90, "Portland Cement Concrete." Reinforcement shall conform to the provisions in Section 52, "Reinforcement."

Concrete shall be placed against undisturbed material of the excavated holes for footings.

- End anchor assemblies and rail tensioning assemblies for metal beam guard railing shall be constructed as shown on the plans and shall conform to the following provisions:

An end anchor assembly (Type SFT) for metal beam guard railing shall consist of an anchor cable, an anchor plate, a wood post, a steel foundation tube, a steel soil plate and hardware.

An end anchor assembly (Type CA) for metal beam guard railing shall consist of an anchor cable, an anchor plate, a single anchor rod or double anchor rods, hardware and one concrete anchor.

A rail tensioning assembly for metal beam guard railing shall consist of an anchor cable, an anchor plate, and hardware.

The anchor plate, metal plates, steel foundation tubes and steel soil plate shall be fabricated of steel conforming to the requirements in ASTM Designation: A 36/A 36M.

The anchor rods shall be fabricated of steel conforming to the requirements in ASTM Designation: A 36/A 36M, A 441 or A 572, or ASTM Designation: A 576, Grades 1018, 1019, 1021 or 1026. The eyes shall be hot forged or formed with full penetration welds. After fabrication, anchor rods with eyes that have been formed with any part of the eye below 1,600° F during the forming operation or with eyes that have been closed by welding shall be thermally stress relieved prior to galvanizing. The completed anchor rod, after galvanizing, shall develop a strength of 50,000 pounds.

In lieu of built-up fabrication of anchor plates as shown on the plans, anchor plates may be press-formed from steel plate, with or without welded seams.

All bolts and nuts shall conform to the requirements in ASTM Designation: A 307, unless otherwise specified in the special provisions or shown on the plans.

Anchor cable shall be $^{3}/_{4}$ inch preformed, 6 x 19, wire strand core or independent wire rope core (IWRC), galvanized in conformance with the requirements in Federal Specification RR-W-410D, right regular lay, manufactured of improved plow steel with a minimum breaking strength of 23 tons. Two certified copies of mill test reports of each manufactured length of cable used shall be furnished to the Engineer. The overall length of each cable anchor assembly shall be as shown on the plans, but shall be a minimum of 6.5 feet.

Where shown on the plans, cable clips and a cable thimble shall be used to attach cable to the anchor rod. Thimbles shall be commercial quality, galvanized steel. Cable clips shall be commercial quality drop forged galvanized steel.

The swaged fitting shall be machined from hot-rolled bars of steel conforming to AISI Designation: C 1035, and shall be annealed suitable for cold swaging. The swaged fitting shall be galvanized before swaging. A lock pin hole to accommodate a $^{1}/_{4}$-inch, plated, spring steel pin shall be drilled through the head of the swage fitting to retain the stud in proper position. The

manufacturer's identifying mark shall be stamped on the body of the swage fitting.

The one-inch nominal diameter stud shall conform to the requirements in ASTM Designation: A 449 after galvanizing. Prior to galvanizing, a 3/8-inch slot for the locking pin shall be milled in the stud end.

The swaged fittings, stud and nut assembly shall develop the specified breaking strength of the cable.

The cable assemblies shall be shipped as a complete unit including stud and nut.

Clevises shall be drop forged galvanized steel and shall develop the specified breaking strength of the cable.

One sample of cable properly fitted with swaged fitting and right hand thread stud at both ends as specified above, including a clevis when shown on the plans, 39 inches in total length, shall be furnished the Engineer for testing.

The portion of the anchor rod to be buried in earth shall be coated with a minimum 20-mil thickness of coal tar enamel conforming to AWWA Standard: C203 or a coal tar epoxy conforming to the requirements in Steel Structures Painting Council Paint Specification No. 16, Coal-Tar Epoxy-Polymide Black Paint or Corps of Engineers Specification, Formula C-200a, Coal-Tar Epoxy Paint.

Metal components of the anchor assembly shall be fabricated in conformance with good shop practice and shall be hot-dip galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing."

Anchor cables shall be tightened after the concrete anchor has cured for at least 5 days.

Concrete used to construct anchors for end anchor assemblies shall be Class 3 or minor concrete conforming to the provisions in Section 90, "Portland Cement Concrete."

Concrete shall be placed against undisturbed material of the excavated holes for end anchors. The top 12 inches of holes shall be formed, if required by the Engineer.

Reinforcing steel in concrete anchors for end anchor assemblies shall conform to the provisions in Section 52, "Reinforcement."

- Anchor bolts shown on the plans to be set with epoxy shall be placed in holes filled with the 2-component epoxy mixture specified in Section 95-2.01, "Binder (Adhesive), Epoxy Resin Base."
- Surplus excavated material remaining after the guard railing has been constructed shall be disposed of in a uniform manner along the adjacent roadway as directed by the Engineer.
- Railing parts furnished under these specifications shall be interchangeable with similar parts regardless of source.

83-1.02C (Blank)

83-1.02D Steel Bridge Railing

- Steel bridge railing shall include steel railing fabricated from structural shapes, pipe, formed sections, tubing, plates and bars and shall be of the type shown on the plans.
- Structural shapes, tubing, plates, bars, bolts, nuts, and washers shall be structural steel conforming to the provisions in Section 55-2, "Materials." Other fittings shall be commercial quality.
- Pipe sections shall be standard steel pipe.
- Formed sections shall be formed from mild steel and shall be true to dimensions, free from kinks, twists or bends, and uniform in appearance. Closed sections shall be made of one-piece tubing or of 2 bent plates welded together at the longitudinal joints, at the option of the Contractor. Seams in the posts, if any, shall be in the faces of the posts normal to the plane of the railing.
- Mechanical expansion anchors for attaching the railing to supporting concrete members shall conform to the provisions for concrete anchorage devices in Section 75-1.03, "Miscellaneous Bridge Metal."
- The railing shall conform closely to the horizontal and vertical lines shown on the plans or ordered by the Engineer. Railings shall conform to the curvature by means of a series of short chords, from center to center of rail posts, except that railing noted on the plans or specified in the special provisions shall be shop bent to fit the curvature. Joints shall be matchmarked. The railing shall present a smooth, uniform appearance in its final position.
- The railings shall be carefully erected true to line and grade. Posts and balusters shall be vertical within a tolerance not to exceed 0.02-foot in 10 feet. Adjacent railing panels shall align with each other within $^{1}/_{16}$ inch.
- Posts shall be either mortared in sockets, set on mortar pads, or set on steel or concrete supporting members as shown on the plans.

83-1.02E Cable Railing

- Cable railing shall consist of cables supported by pipe posts set in either concrete footings or post pockets in the tops of retaining walls or other structures, as shown on the plans.
- Pipe for posts and braces shall be standard steel pipe or pipe that conforms to the provisions in Section 80-4.01A, "Posts and Braces."
- Truss rods, post tops, cable clamps, eye bolts, thimbles and other required fittings shall be commercial quality steel, malleable iron or wrought iron. All post tops shall be watertight. The eye of the eye bolts shall be either drop forged or formed with a full penetration weld, at the Contractor's option. The eye shall develop 100 percent of the bolt strength.
- Turnbuckles shall be commercial quality, and shall have jaw or eye ends as shown on the plans. Turnbuckles shall have 2,700 pounds minimum, breaking strength. At the option of the Contractor, turnbuckles shall be steel pipe type or drop forged steel.
- Crimped sleeve clamps and stop sleeve clamps shall be nonferrous metal, shall develop the strength of the cable and shall be the color of the cable.

- Cable shall be wire strand or rope with a minimum diameter of 1/4 inch, and a minimum breaking strength of at least 1,800 pounds. Cable shall be galvanized in conformance with the requirements in Federal Specification RR-W-410D.
- The cables shall be tensioned to provide taut railings between posts.
- Post footings shall be constructed of Class 3 or minor concrete conforming to the provisions in Section 90, "Portland Cement Concrete."

83-1.02F Concrete Railing

- Concrete railing shall consist of either an all reinforced concrete section or the reinforced concrete portion of composite railing sections, with end and intermediate posts, as shown on the plans, and shall conform to the provisions in Section 51, "Concrete Structures," and Section 52, "Reinforcement."
- Concrete railings shall present a smooth uniform appearance in their final position, conforming closely to the horizontal and vertical lines shown on the plans or ordered by the Engineer.
- When ordered by the Engineer, the height of the concrete railings shall be adjusted to compensate for the camber and dead load deflection of the superstructure. The amount of adjustment will be determined by the Engineer and will be ordered before the concrete is placed.

83-1.02G Metal Railing

- Metal railing shall consist of metal elements mounted on concrete members as shown on the plans.

83-1.02G(1) (Blank)

83-1.02G(2) Metal Railing (Tubular)

- Metal railing (tubular), and tubular hand railing or such other types as are designated on the plans, shall consist of tubular metal rails supported by metal posts, together with anchor bolts, hardware and fittings, as shown on the plans.
- Materials for tubular rails, posts, rods, bolts and nuts shall conform to the following requirements:

Material	ASTM Designation
Tubular steel rails, and tubular handrailing	A 500, Grade B
Steel posts, rolled bars and plate washers	A 36/A 36M
Steel sleeves for tubular rails	A 36/A 36M
High strength bolts	A325 or A 325M or A 449
High strength threaded rods	A 449
Nuts and washers for high strength bolts and rods	A 325 or A 325M

- Stud bolts shall conform to the provisions for stud connectors in Section 55-2, "Materials."
- High strength bolts or threaded rods furnished in conformance with the requirements in ASTM Designation: A 449 shall comply with the mechanical requirements in ASTM Designation: A 449 after galvanizing.

- Posts for metal railing to which chain link railing will be attached shall be of such type that will fit the mounting brackets, pipe sleeves and other connection fittings.
- Metal railing shall conform closely to the horizontal and vertical lines shown on the plans or ordered by the Engineer. The railing shall present a smooth, uniform appearance in its final position.
- Shims shall be installed at posts and railings, where necessary, to provide uniform bearing and conformance with the horizontal lines and vertical grade lines. Shims at steel posts shall be commercial quality galvanized sheet steel.
- When the horizontal radius of the railing is 30 feet or less, that portion of the tubular railing may be either shop bent or built up from structural steel plates, $^{1}/_{4}$ inch thick, conforming to the requirements in ASTM Designation: A 36/A 36M, at the option of the Contractor. Built up tubular railing shall match the seamless tubing in appearance.
- The difference between out-to-out rail sleeve dimensions and the clear inside dimensions of the tubular steel rails shall not exceed $^{3}/_{16}$ inch after galvanizing.
- The Contractor shall submit 2 sets of anchor bolt layouts to the Engineer at the jobsite, prior to placing parapet or other structural support reinforcement.
- Materials shall be carefully handled so that no parts will be bent, broken, abraded or otherwise damaged. Fabrication, handling or installation methods which will injure or distort the members or damage the galvanizing shall not be used.
- Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the railing parts are assembled. The bases of posts shall be true and flat to provide uniform bearing on the concrete portions of the railing.
- The vertical position of the metal railing shall be adjusted to compensate for camber and dead load deflection of the superstructure. The amount of adjustment will be determined by the Engineer before the metal railing is installed.

83-1.02H (Blank)

83-1.02I Chain Link Railing

- Chain link railing shall consist of a metal frame covered with chain link fabric, including posts, horizontal members, post anchorages, stretcher bars, truss rods, tension wires and other required hardware and fittings, as shown on the plans.
- Posts and horizontal members shall be standard steel pipe, structural steel tubing or structural shapes as shown on the plans, except where metal conduit is specified in this Section 83-1.02I. Structural tubing steel shall conform to the requirements in ASTM Designations: A 500 or A 501.
- Structural shapes, plates, bars and bolts shall be structural steel conforming to the provisions in Section 55-2, "Materials."
- Stretcher bars, truss rods, post tops and other required fittings and hardware shall be steel, malleable iron or wrought iron. All post tops and other closures shall be watertight. All required fittings and hardware shall fasten to the posts and other members in proper manner.
- Where shown on the plans, cables used in the frame shall be $^{5}/_{16}$ inch in diameter, wire rope, with a minimum breaking strength of 5,000 pounds, and shall

be galvanized in conformance with the requirements in Federal Specification RR-W-410D.

- Crimped sleeve clamps and stud socket assemblies shall be ferrous or nonferrous metal, shall develop the strength of the cable and shall be the color of the cable.
- All frame members carrying electrical conductors shall be rigid metal conduit manufactured of mild steel, conforming to the requirements in UL Publication UL 6 for Rigid Metallic Conduits. The rigid metallic conduit shall have interior and exterior surfaces zinc-coated by hot-dip galvanizing.
- Tension wires shall be at least 7-gage coil spring steel.
- Post clips shall be at least 9-gage steel.
- Wire ties or hog rings shall be 9-gage commercial quality steel wire. Wire ties shall be given at least one complete turn.
- Tension wires, post clips, wire ties and hog rings shall be galvanized in conformance with the requirements in ASTM Designation: A 116, Coating Class 3.
- Six-gage (0.1920-inch minimum diameter) aluminum wire ties, conforming to the requirements in ASTM Designation: B 211 or B 211M, Alloy 1100-H18, or 6-gage (0.1920-inch minimum diameter) aluminum hog rings, conforming to the requirements in ASTM Designation: B 211 or B 211M, Alloy 6061-T94 or Alloy 5052-H38 may be substituted for steel wire ties or hog rings.
- Ends of wire ties shall be bent away from pedestrian traffic.
- Chain link fabric shall be either 11-gage Type I zinc coated fabric conforming to the requirements in AASHTO Designation: M 181 or 11-gage Type IV polyvinyl chloride (PVC) coated fabric conforming to the requirements in Federal Specification RR-F-191/1D.
- The color of vinyl coated chain link fabric shall be either medium green or dark green unless otherwise specified in the special provisions. The railings pertaining to any structure shall all be of the same color.
- All chain link fabric shall be woven into approximately one inch mesh.
- Truss rods and cables shall be tightened with turnbuckles or other fittings.
- The fabric shall be stretched and securely fastened to the posts, other members and tension wires. Tension wires shall be stretched tight.
- Where necessary to conform to curvature, either horizontal or vertical, the fabric shall be reworked and fitted so as to present a smooth, neat and workmanlike appearance.
- Where required by the other facilities, openings in the fabric shall be provided. The openings shall be reinforced with not less than one turn of 6-gage wire.
- Where shown on the plans, pipe handrailing shall be attached to the chain link railing. The handrailing shall conform to the provisions in Section 83-1.02A, "Pipe Handrailing."

83-1.03 MEASUREMENT

- Concrete railing will be measured by the cubic yard of concrete as provided in Section 51, "Concrete Structures."
- Except for metal beam guard railing within the pay limits of a terminal system end treatment or transition railing (Type WB), metal beam guard railing will be

measured by the linear foot along the face of the rail element from end post to end post of the completed railing at each installation. The point of measurement at each end post will be the center of the bolt attaching the rail element to the end post.

- All other railing will be measured by the linear foot from end to end along the face of the railing, including end and intermediate posts, and with no deductions for gaps in railing for lighting and sign supports.
- When metal beam guard railing is connected to structures, barriers, walls or abutments, the structure, barrier, wall or abutment will be considered the end post and the point used for measuring the rail length shall be the midpoint between the 2 bolts attaching the rail element to the structure, barrier, wall or abutment.
- The measurement shall be made along the face of the rail elements without allowance for overlap at rail splices.
- The quantity of the various types of terminal systems end treatments for metal beam guard railing will be measured as units determined from actual count in place in the completed work.
- The quantities of end anchor assemblies (Type SFT or Type CA) and rail tensioning assemblies will be measured as units determined from actual count. An end anchor assembly (Type CA) with 2 cables attached to one concrete anchor will be counted as one terminal anchor assembly (Type CA) for measurement and payment.
- The quantities of return and end caps and the various types of terminal sections for metal beam guard railing will be determined as units from actual count.

83-1.04 PAYMENT

- The contract prices paid per linear foot for railings of the types shown in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing the railings, complete in place, including, but not limited to, excavation, backfill and disposal of surplus material, concrete and reinforcing steel, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract unit price paid for the various types of terminal system end treatments for metal beam guard railing shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all work involved in furnishing and installing terminal system end treatments, complete in place, including excavation, backfill and disposal of surplus material and connecting the terminal system to new or existing metal beam guard railing, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract unit prices paid for end anchor assembly (Type SFT), end anchor assembly (Type CA), and rail tensioning assembly shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in constructing the end anchor assemblies, complete in place, including drilling anchor plate bolt holes in rail elements, driving steel foundation tubes, excavating for concrete anchor holes and disposing of surplus material, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

- The contract unit prices paid for return caps, end caps, and the various types of terminal sections for metal beam guard railing shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in installing terminal sections, return and end caps, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Concrete in concrete railing will be paid for as provided in Section 51, "Concrete Structures." Bar reinforcing steel in concrete railing will be paid for as provided in Section 52, "Reinforcement."
- Full compensation for connecting metal beam guard railing to bridge sidewalks and curbs, bridge railing, barriers, retaining walls, abutments and other flat concrete surfaces, and constructing guard rail layout flares (including special size and spacing of posts) shall be considered as included in the prices paid for the various items of metal beam guard railing work and no additional compensation will be allowed therefor.
- Full compensation for furnishing connections on metal railing for steel picket railing, chain link railing and other classes of metal railing designated on the plans, drilling anchor bolt holes and anchoring bolts for railings shall be considered as included in the prices paid for the various items of railing work involved and no additional compensation will be allowed therefor.
- Full compensation for buried post anchors shall be considered as included in the contract price paid per linear foot for metal beam guard railing and no separate payment will be made therefor.

83-2 BARRIERS

83-2.01 DESCRIPTION

- This work shall consist of constructing single and double thrie beam barrier and concrete barrier at the locations and in conformance with the details shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- The type of barrier to be constructed will be specified in the special provisions or shown on the plans.
- If there is an existing median barrier, the existing barrier shall not be removed more than 500 feet in advance of the new barrier being constructed.
- At the end of each day's operation, the existing median barrier removed shall be reinstalled without mesh or glare screen and anchored as approved by the Engineer, such that no gap will be left between the reinstalled barrier and the barrier being installed. At the option of the Contractor, temporary railing (Type K) conforming to the provisions in Section 12-3.08, "Temporary Railing (Type K)," may be placed instead of reinstalling the existing barrier.

83-2.02 MATERIALS AND CONSTRUCTION

- Materials and construction for the various types of barriers shall conform to the following requirements:

83-2.02A (Blank)

83-2.02B Thrie Beam Barrier

- Thrie beam barrier shall conform to the provisions for metal beam guard railing in Section 83-1.02B, "Metal Beam Guard Railing," except as otherwise provided in this Section 83-2.02B.
- Rail elements, backup plates, terminal connectors, terminal sections, and return caps shall conform to Class A, Type 1 thrie beam guard railing as shown in AASHTO Designation: M 180.
- Posts for thrie beam barrier on bridges shall be steel. Posts for approach barrier transitions to connect to concrete structures, and posts set in steel foundation tubes at trailing end anchors, shall be wood. At all other locations, posts for thrie beam barrier shall be wood or steel at the Contractor's option, however, only one kind of post shall be selected in any one continuous length of barrier.
- Wood blocks shall be used with wood posts and with steel posts.
- Toenailing of wood blocks to wood posts will not be required.
- Unless otherwise specified, anchor bolts and threaded rods shall conform to the requirements in ASTM Designation: A 307.
- Plates shall be structural steel conforming to the provisions in Section 55, "Steel Structures."
- When the barrier is to be installed on existing structures, the posts shall be anchored to the deck as shown on the plans.
- When cored or drilled holes for anchor bolts must be offset to avoid existing main reinforcing steel, the corresponding base plate anchor bolt holes may be slotted to adjust to the new anchor bolt locations. Slotting shall not reduce the edge distance of the hole to less than $^{7}/_{8}$ inch.
- Mortar under base plates shall conform to the provisions in Section 83-1.02, "Materials and Construction."
- Drilling of anchor bolt holes and grouting of the bolts shall conform to the provisions for grouting dowels in Section 51-1.13, "Bonding."
- Posts shall be placed at equal intervals, as shown on the plans, except that the end posts may be spaced closer to adjacent posts if directed by the Engineer.
- When the spacing between the posts must be varied from standard spacing because of construction or other controls, the metal railing may be modified in the field, subject to approval by the Engineer. Damaged galvanizing shall be repaired as specified in Section 75-1.05, "Galvanizing."
- All metal work shall be fabricated in the shop, and no punching, cutting or welding will be permitted in the field. Rail elements shall be lapped so that the exposed ends will not face approaching traffic. Terminal sections and return caps shall be installed in conformance with the manufacturer's recommendation.

83-2.02C (Blank)

83-2.02D Concrete Barrier

- This work shall consist of constructing concrete barriers at the locations and in conformance with the details shown on the plans and in conformance with the provisions in Sections 51, "Concrete Structures," 52, "Reinforcement," and these specifications.

83-2.02D(l) General

- If it is necessary, during construction on highways open to public traffic, to leave a gap in concrete barriers due to the equipment chosen or due to special drainage features, the gaps shall be closed by temporary or permanent means at all times when work is not actively in progress at the location of the gap.
- Concrete barriers shall present a smooth, uniform appearance in their final position, conforming to the horizontal and vertical lines shown on the plans or ordered by the Engineer, and shall be free of lumps, sags or other irregularities. The top and exposed faces of the barrier shall conform to the following requirements when tested with a 10-foot straightedge laid on the surfaces:

  a. For concrete barriers Type 50 and 60 series, the top shall not vary more than 0.02-foot from the edge of the straightedge and the faces shall not vary more than 0.04-foot from the edge of the straightedge.
  b. For concrete barriers other than Type 50 and 60 series, both the top and faces shall not vary more than 0.02-foot from the edge of the straightedge.

- When concrete barriers are to be constructed on recently completed bridges, the height of the barriers shall be adjusted to compensate for the camber and dead load deflection of the superstructure. The amount of adjustment will be determined by the Engineer and will be ordered before the concrete is placed. The barriers shall be placed after falsework has been released and as long after superstructure construction as the progress of the work will permit, unless otherwise ordered by the Engineer.
- When concrete barriers are to be constructed on existing pavement or existing structures, the height of the barriers shall be adjusted to compensate for irregularities in the existing grade. The amount of the adjustment will be determined by the Engineer and will be ordered before the concrete is placed.
- When concrete barriers are to be constructed on existing structures, the dowels shall be bonded in holes drilled in the existing concrete. Drilling of holes and bonding of dowels shall conform to the following:

The bonding materials shall be magnesium phosphate concrete, either single component (water activated) or dual component (with a prepackaged liquid activator), as approved by the Engineer. Magnesium phosphate concrete shall conform to the following requirements:

Property	Test Method	Requirements
Compressive Strength		
at 3 hours, MPa	California Test 551	21 min.
at 24 hours, MPa	California Test 551	35 min.
Flexure Strength		
at 24 hours, MPa	California Test 551	3.5 min.
Bond Strength: at 24 hours		
SSD Concrete, MPa	California Test 551	2.1 min.
Dry Concrete, MPa	California Test 551	2.8 min.
Water Absorption, %	California Test 551	10 max.
Abrasion Resistance		
at 24 hours, grams	California Test 550	25 max.
Drying Shrinkage at 4 days, %	ASTM Designation: C 596	0.13 max.
Soluble Chlorides by weight, %	California Test 442	0.05 max.
Water Soluble Sulfates by weight, %	California Test 417	0.25 max.

Magnesium phosphate concrete shall be formulated for minimum initial set time of 15 minutes and minimum final set time of 25 minutes at 70° F. The materials, prior to use, shall be stored in a cool, dry environment.

Mix water used with water activated material shall conform to the provisions in Section 90-2.03, "Water."

The quantity of water for single component type or liquid activator (for dual component type) to be blended with the dry component, shall be within the limits recommended by the manufacturer and shall be the least amount required to produce a pourable batter.

Addition of retarders, when required and approved by the Engineer, shall be in conformance with the manufacturer's recommendations.

Before using concrete material that has not been previously approved, a minimum of 45 pounds shall be submitted to the Engineer for testing. The Contractor shall allow 45 days for the testing. Each shipment of concrete material that has been previously approved shall be accompanied by a Certificate of Compliance as provided in Section 6-1.07, "Certificates of Compliance."

Magnesium phosphate concrete shall not be mixed in containers or worked with tools containing zinc, cadmium, aluminum or copper metals.

The surface of any dowel coated with zinc or cadmium shall be coated with a colored lacquer before installation of the dowel. The lacquer shall be allowed to dry thoroughly before embedment of the dowels.

The holes shall be drilled by methods that will not shatter or damage the concrete adjacent to the hole. The diameter of the drilled hole shall be $^1/_2$ inch larger than the nominal diameter of the dowels.

The drilled holes shall be clean and dry at the time of placing the bonding material and the steel dowels. Bonding material and dowel shall completely fill the drilled hole. The surface temperature shall be 40° F or above when the magnesium phosphate concrete is placed.

After bonding, dowels shall remain undisturbed for a minimum of 3 hours or until the magnesium phosphate concrete has reached a strength sufficient to support the dowels. Dowels that are improperly bonded, as determined by the Engineer, shall be removed. The holes shall be cleaned or new holes shall be drilled and the dowels replaced and securely bonded to the concrete. Removing, redrilling and replacing improperly bonded dowels shall be performed at the Contractor's expense.

- Excavation and backfill shall conform to the provisions in Section 19-3, "Structure Excavation and Backfill," and as provided herein.
- The portion of barrier below finished grade may be placed to the neat lines of the excavation.
- Granular material for backfill between the 2 walls of concrete barrier (Types 50E, 60E, 60GE and 60SE), as shown on the plans, shall be placed without compaction.
- At connections to structures, a uniform film of grease shall be applied to the upper surface of the neoprene strip prior to placing the sheet metal.

83-2.02D(2) Materials

- Type 50 and 60 series concrete barriers shall be constructed of minor concrete conforming to the provisions in Section 90-10, "Minor Concrete," except as follows:

  a. The maximum size of aggregate used for extruded or slip-formed concrete barriers shall be at the option of the Contractor, but in no case shall the maximum size be larger than $1^1/_2$ inch or smaller than $^3/_8$ inch.

  b. If the $^3/_8$-inch maximum size aggregate grading is used to construct extruded or slip-formed concrete barriers, the cementitious material content of the minor concrete shall be not less than 674 pounds per cubic yard.

- Concrete barriers other than Type 50 and 60 series shall be constructed of Class 2 concrete conforming to the provisions in Section 90, "Portland Cement Concrete."
- The concrete paving between the tops of the 2 walls of concrete barrier (Types 50E, 60E, 60GE, and 60SE) and the optional concrete slab at the base between the 2 walls of concrete barrier (Types 50E, 60E, 60GE, and 60SE) shall be constructed of minor concrete conforming to the provisions of Section 90-10, "Minor Concrete," except that the minor concrete shall contain not less than 506 pounds of cementitious material per cubic yard.
- Reinforcing bars shall conform to the provisions in Section 52-1.02A, "Bar Reinforcement."

- Structural steel plates and hardware required to join concrete barrier at gaps caused by foundations of overhead signs, electroliers, drainage structures and at other locations shown on the plans shall conform to the details shown on the plans and to the provisions for materials, fabrication and galvanizing in Sections 75-1.03, "Miscellaneous Bridge Metal," and 75-1.05, "Galvanizing."
- Polystyrene shown on the plans at connections to structures and at transitions to bridge columns shall conform to the provisions in Section 51-1.12D, "Sheet Packing, Preformed Pads and Board Fillers."
- The sheet metal, neoprene strip and grease required at connections to structures shall conform to the following:

  a. Sheet metal shall be commercial quality galvanized sheet steel, smooth and free of kinks, bends or burrs. Joints in the sheet metal shall be butt joints sealed with plastic duct sealing tape.
  b. Neoprene strip shall conform to the provisions in Section 51-1.14, "Waterstops."
  c. Grease shall conform to the requirements in Military Specification MIL-S-8660.

- Granular material for backfill between the 2 walls of concrete barrier (Types 50E, 60E, 60GE and 60SE) shall be earthy material suitable for the purpose intended, having no rocks, lumps or clods exceeding $1^1/_2$ inches in greatest dimension.

83-2.02D(3) Construction Methods

- Type 50 and Type 60 series concrete barriers shall be constructed by either the "cast-in-place with fixed forms" method or the "extrusion or slip form" method or a combination thereof, at the Contractor's option.
- Concrete barriers other than Type 50 and Type 60 series shall be constructed by the "cast-in-place with fixed forms" method.

83-2.02D(3a) Cast-In-Place with Fixed Forms

- Concrete barriers constructed by casting-in-place with fixed forms shall conform to the provisions in Section 51, "Concrete Structures," and the details shown on the plans.
- Precast mortar blocks shall not be used to support the reinforcing steel on the traffic side of barriers.

83-2.02D(3b) Extrusion or Slip Form

- Concrete barriers constructed by using an extrusion or slip form machine or other similar type equipment shall be of well compacted, dense concrete, and the exposed surfaces shall conform to the provisions in Section 51, "Concrete Structures," and this Section 83-2.02D(3b). The Contractor may be required to furnish evidence of successful operation of the extrusion or slip form machine or other equipment.
- The combined aggregate grading for the minor concrete shall be as necessary to produce concrete of the shape and surface texture conforming to the provisions in this Section 83-2.02D(3b).

- At the option of the Contractor, concrete may be made with the materials continuously batched by volume and mixed in a continuous mixer in conformance with the batching and mixing requirements in ASTM Designation: C 685.
- Concrete shall be fed to the extrusion or slip form machine at a uniform rate. The machine shall be operated under sufficient uniform restraint to forward motion to produce a well compacted mass of concrete free from surface pits larger than one inch in diameter and requiring no further finishing, other than that conforming to the provisions in Section 83-2.02D(4), "Finishing."
- The concrete shall be of such consistency that, after extrusion or slip forming, it will maintain the shape of the barrier without support.
- The grade for the top of the concrete barrier shall be indicated by an offset guide line set by the Contractor from survey marks established by the Engineer. The forming portion of the extrusion or slip form machine shall be readily adjustable vertically during the forward motion of the machine to conform to the predetermined grade line. A grade line gage or pointer shall be attached to the machine in such a manner that a continual comparison can be made between the barrier being placed and the established grade line as indicated by the offset guide line.
- Instead of the above method for maintaining the barrier grade, the extrusion or slip form machine may be operated on rails or forms set at uniform depth below the predetermined finished top of the barrier grade, or on existing pavement or bridge decks.
- Expansion joints of the width shown on the plans may be constructed by sawing through the barrier section to its full depth. Insertion of joint filler will not be required.
- When expansion joints are not constructed by sawing, the expansion joints shall be constructed in conformance with the provisions in Section 51, "Concrete Structures."
- If sawing or forming joints is performed before the concrete has hardened, the adjacent portions of the barrier shall be supported firmly with close fitting shields.
- When sawing or forming joints is performed after the application of curing compound, the exposed faces of the barrier in the vicinity of the joint shall be treated with curing compound after sawing or forming the joints.
- If extrusion or slip forming methods of placement are used, the horizontal reinforcing bars shall be placed continuously.

83-2.02D(4) Finishing

- The surface finish of concrete barriers Type 50 and Type 60 series, prior to the application of the curing compound, shall be free from surface pits larger than one inch in diameter and shall be given a final soft brush finish with strokes parallel to the line of the barriers. Finishing with a brush application of grout will not be permitted.
- To facilitate finishing, fixed forms for cast-in-place concrete barriers Type 50 and Type 60 series, shall be removed as soon as possible after the concrete has set enough to maintain the shape of the barrier without support.

- Not less than 7 days after placing, exposed surfaces of concrete barriers, Type 50 and Type 60 series, shall receive a light abrasive blast finish so that a uniform appearance is achieved.
- The final surface finish of concrete barriers other than Type 50 and Type 60 series shall be Class 1 Surface Finish conforming to the provisions in Section 51-1.18B, "Class 1 Surface Finish." Alternative final surface finish methods proposed by the Contractor shall be submitted in writing and shall not be used unless approved by the Engineer.

83-2.02D(5) Curing

- Exposed surfaces of concrete barriers shall be cured with the non-pigmented curing compound (6) conforming to the provisions in Section 90-7.01B, "Curing Compound Method." At the Contractor's option, the formed surfaces of concrete barriers, which are on bridges or walls but which do not support soundwalls, may be cured as provided in Section 90-7.01D, "Forms-In-Place Method," except the forms shall be retained in place for a minimum period of 12 hours after the concrete has been placed. When curing Type 50 and Type 60 series concrete barrier, curing compound shall be applied by a mechanical sprayer capable of applying the curing compound to at least one entire side and the top of the concrete barrier in one application at a uniform rate of coverage. The spray shall be adequately protected against wind.

83-2.03 MEASUREMENT

- Except for single thrie beam barrier within the pay limits of transition railing (Type STB), single thrie beam barrier will be measured by the linear foot from end post to end post along the face of the rail element of the installed barrier. Single thrie beam barriers constructed on each side of piers under structures or other obstructions will be measured for payment along each line of the installed barrier.
- Except for double thrie beam barrier within the pay limits of transition railing (Type DTB), double thrie beam barrier will be measured by the linear foot from end post to end post along the center line of the installed barrier.
- The point of measurement at end posts of single and double thrie beam barriers will be the center of the bolt or rod attaching the rail element or elements to the end post. At locations where single barriers are constructed on each side of median obstructions and the single barriers merge into double barrier, the post with 2 blocks attached thereto shall be considered an end post for measuring the length of single and double barrier.
- Transition sections will be measured and paid for by the linear foot as single thrie beam barrier.
- The quantity of return caps, terminal connectors and the various types of terminal sections for single and double thrie beam barriers will be determined as units from actual count.
- The quantity of end anchor assemblies will be paid for as units determined from actual count.
- Concrete barriers will be measured by the linear foot.
- Concrete barriers, except Type 50E, Type 60E, Type 60GE, and Type 60SE will be measured along the top of the barrier.

- Concrete barriers Type 50E, Type 60E, Type 60GE, and Type 60SE will be measured once along the centerline between the 2 walls of the barrier.

83-2.04 PAYMENT

- The various types of thrie beam barrier, measured as specified in Section 83-2.03, "Measurement," will be paid for at the contract price per linear foot for single or double thrie beam barrier, whichever applies, and the contract unit price or prices for end anchor assemblies, return caps, terminal connectors and the various types of terminal sections.
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in constructing the barrier, complete in place, including drilling holes for wood posts, driving posts, backfilling the space around posts, excavating and backfilling end anchor assembly holes, connecting thrie beam barrier to concrete surfaces and disposing of surplus excavated material, and for furnishing, placing, removing and disposing of the temporary railing for closing the gap between existing barrier and the barrier being constructed as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract prices paid per linear foot for concrete barrier of the type or types listed in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in constructing the concrete barriers, complete in place, including bar reinforcing steel, steel dowels and drilling and bonding dowels in structures, hardware for steel plate barrier, miscellaneous metal, excavation, backfill (including concrete paving for, and granular material or concrete slab used as backfill in Type 50E, Type 60E, Type 60GE, and Type 60SE concrete barrier), and disposing of surplus material and for furnishing, placing, removing and disposing of the temporary railing for closing the gap between existing barrier and the concrete barrier being constructed, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Steel plate barrier attached to concrete barrier at overhead sign foundations, electroliers, drainage structures, and other locations shown on the plans will be measured and paid for as the type of concrete barrier attached thereto.

SECTION 84: TRAFFIC STRIPES AND PAVEMENT MARKINGS

84-1 GENERAL

84-1.01 DESCRIPTION

- This work shall consist of applying painted and thermoplastic traffic stripes (traffic lines) and pavement markings at the locations and in conformance with the details shown on the plans or designated by the Engineer, and as specified in these specifications and the special provisions.
- The kind of material, paint or thermoplastic, to be applied will be designated in the contract item, specified in the special provisions, or shown on the plans.
- For the purposes of this Section 84, "Traffic Stripes and Pavement Markings," traffic stripes (traffic lines) are defined as longitudinal centerlines and lanelines which separate traffic lanes in the same or opposing direction of travel, and longitudinal edgelines which mark the edge of the traveled way or the edge of the lanes at gore areas separating traffic at exit and entrance ramps. Pavement markings are defined as transverse markings which include, but are not limited to, word and symbol markings, limit lines (stoplines), crosswalk lines, shoulder markings parking stall markings and railroad grade crossing markings.

84-1.02 CONTROL OF ALIGNMENT AND LAYOUT

- All work necessary to establish satisfactory alignment for stripes and all layout work required for pavement markings shall be performed by the Contractor with any device or method that will not damage the pavement nor conflict with other traffic control devices.

84-1.03 TOLERANCES AND APPEARANCE

- Traffic stripes and pavement markings shall conform to the dimensions and details shown on the plans.
- Completed traffic stripes shall have clean and well-defined edges without running or deformation, shall be uniform, shall be straight on tangent alignment and shall be on a true arc on curved alignment. The widths of completed traffic stripes shall not deviate more than $^1/_4$ inch on tangent nor more than $^1/_2$ inch on curves from the widths shown on the plans. Broken traffic stripes shall also conform to the following requirements:

A. The lengths of the gaps and individual stripes that form broken traffic stripes shall not deviate more than 2 inches from the lengths shown on the plans.
B. The lengths of the gaps and individual stripes shall be of such uniformity throughout the entire length of each broken traffic stripe that a normal striping machine will be able to repeat the pattern and superimpose additional stripes upon the traffic stripe being applied.

- The completed pavement markings shall have clean and well-defined edges without running or deformation and shall conform to the dimensions shown on the plans, except that minor variations may be accepted by the Engineer.

- Drips, overspray, improper markings and paint and thermoplastic material tracked by traffic shall be immediately removed from the pavement surface by methods approved by the Engineer. All this removal work shall be at the Contractor's expense.

84-1.04 PROTECTION FROM DAMAGE

- The Contractor shall take special care to protect existing reflective pavement markers and shall, at the Contractor's expense, replace all coated markers.
- Newly placed traffic stripes and pavement markings shall be protected from damage by public traffic or other causes until the paint is thoroughly dry or the thermoplastic material has sufficiently hardened.

84-2 THERMOPLASTIC TRAFFIC STRIPES AND PAVEMENT MARKINGS

84-2.01 DESCRIPTION

- This work shall consist of furnishing and applying thermoplastic traffic stripes and pavement markings, including glass beads.

84-2.02 MATERIALS

- The thermoplastic material shall conform to State Specification PTH-02SPRAY, PTH-02HYDRO or PTH-02ALKYD. Glass beads to be applied to the surface of the molten thermoplastic material shall conform to the requirements of State Specification 8010-004 (Type II).
- State Specifications for thermoplastic material and glass beads may be obtained from the Transportation Laboratory.

84-2.03 (BLANK)

84-2.04 APPLICATION

- Existing surfacing which is to receive the thermoplastic material shall be mechanically wire brushed to remove all dirt and contaminants. Surfaces of new portland cement concrete pavement to receive the thermoplastic material shall be mechanically wire brushed or abrasive blast cleaned to remove all laitance and curing compound.
- Existing pavement markers which are damaged by blast cleaning or wire brushing shall be removed and replaced by the Contractor at the Contractor's expense.
- Thermoplastic material shall be applied only to dry pavement surfaces and only when the pavement surface temperature is above 50° F.
- A primer, of the type recommended by the manufacturer of the thermoplastic material, shall be applied to all asphaltic surfaces over 6 months old and to all portland cement concrete surfaces. The primer shall be applied immediately in advance of, but concurrent with, the application of thermoplastic material. The primer shall be applied at the application rate recommended by the manufacturer and shall not be thinned.
- Preheaters with mixers having 360 degree rotation shall be used to preheat material.

- The thermoplastic material shall be applied to the pavement at a temperature between 400° F and 425° F, unless a different temperature is recommended by the manufacturer.
- The thermoplastic material shall be applied by either spray or extrusion methods in a single uniform layer.
- Stencils shall be used when applying thermoplastic material for pavement markings.
- The pavement surface to which thermoplastic material is applied shall be completely coated by the material and the voids of the pavement surface shall be filled.
- Unless otherwise specified in the special provisions, the thermoplastic material for traffic stripes shall be applied at a minimum thickness of 0.060-inch. Thermoplastic material for pavement markings shall be applied at a thickness of 0.100-inch to 0.150-inch. Glass beads shall be applied immediately to the surface of the molten thermoplastic material at a rate of not less than 8 pounds per 100 square feet. The amount of glass beads applied shall be measured by stabbing the glass bead tank with a calibrated rod.

84-2.05 MEASUREMENT

- Thermoplastic traffic stripes will be measured by the linear foot along the line of the traffic stripes, without deductions for gaps in broken traffic stripes. A double traffic stripe, consisting of two 4-inch wide yellow stripes, will be measured as 2 traffic stripes.
- Thermoplastic pavement markings will be measured by the square foot for the actual area covered.

84-2.06 PAYMENT

- The contract prices paid per linear foot for thermoplastic traffic stripes of the widths and patterns designated in the Engineer's Estimate and per square foot for thermoplastic pavement markings shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in applying thermoplastic traffic stripes and pavement markings, complete in place, including establishing alignment for stripes and layout work, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

84-3 PAINTED TRAFFIC STRIPES AND PAVEMENT MARKINGS

84-3.01 DESCRIPTION

- This work shall consist of painting traffic stripes and pavement markings, including applying glass beads.

84-3.02 MATERIALS

- Paint for traffic stripes and pavement markings shall conform to the following State Specifications:

Paint Type	Color	State Specification No.
Waterborne Traffic Line	White, Yellow and Black	PTWB-01
Acetone-Based	White, Yellow and Black	PT-150VOC(A)
Waterborne Traffic Line for disabled persons' parking, and other curb markings	Blue, Red and Green	Federal Specification No. TT-P-1952D

- Glass beads shall conform to State Specification No. 8010-004 (Type II).
- Copies of State specifications for traffic paint and glass beads may be obtained from the Transportation Laboratory.
- The kind of paint to be used (waterborne or acetone-based) shall be determined by the Contractor based on the time of year the paint is applied and local air pollution control regulations.
- Thinning of paint will not be allowed.
- Paint shall be tested prior to use or the manufacturer shall provide the Engineer with a Certificate of Compliance in conformance with the provisions of Section 6-1.07, "Certificates of Compliance." The certificate shall certify that the paint complies with the specifications and that paint manufactured to the same formulation and process has previously passed State testing. A list of manufacturers that have produced paint meeting State specifications is available from the Transportation Laboratory. (Material supplied by manufacturers other than those that have manufactured approved paint will require complete testing.)

84-3.03 MIXING

- Mechanical mixers shall be used to mix paint. Prior to applying, the paint shall be mixed a sufficient length of time to thoroughly mix the pigment and vehicle together, and shall be kept thoroughly agitated during its application.

84-3.04 APPLICATION EQUIPMENT

- Mechanical means shall be used to paint traffic stripes and pavement markings and to apply the glass beads for traffic stripes.
- Equipment used in the application of traffic stripes and pavement markings shall produce stripes and pavement markings of uniform quality that conform to the specified requirements.
- Stencils and hand spray equipment shall be used to paint pavement markings. Stencils shall conform to the dimensions shown on the plans.
- The striping machine shall be capable of accurately superimposing succeeding coats of traffic paint upon the first coat and upon existing stripes at a speed of at least 5 miles per hour.
- The striping machine shall consist of a rubber-tired vehicle that is maneuverable to the extent that straight lines can be followed and normal curves can be made in true arcs. It shall be capable of applying traffic paints and glass beads at the rates specified. The striping machine shall be equipped with the

following: (a) a pointer or sighting device not less than 5 feet long and extending from the front of the machine; (b) a pointer or sighting device extending from the side of the machine to gauge the distance from the centerline for painting shoulder stripes; (c) a positive acting cutoff device to prevent depositing paint in gaps of broken stripes; (d) shields or an adjustable air curtain for line control; (e) pressure regulators and gages (if pneumatically operated) that are in full view of the operator; (f) a paint strainer in the paint supply line; (g) a paint storage tank with a mechanical agitator that operates continuously during painting operations; (h) a glass bead dispenser located behind the paint applicator nozzle and which is controlled simultaneously with the paint applicator nozzle; and (i) calibrated rods for measuring the volumes of paint and glass beads in the paint and glass bead tanks.

- Spray equipment shall be of a proper type and of adequate capacity for the work. Air atomized spray equipment shall be equipped with oil and water extractors and pressure regulators and shall have adequate air volume and compressor recovery capacity. Spray gun tip needle assemblies and orifices shall be of the proper sizes.
- Attention is directed to Section 5-1.11, "Alternative Equipment," of these specifications.
- Where the configuration or location of a traffic stripe is such that the use of a striping machine is unsuitable, traffic paint and glass beads may be applied by other methods and equipment approved by the Engineer. The Engineer will determine if the striping machine is unsuitable for a particular use.

84-3.05 APPLICATION

- Traffic stripes and pavement markings shall be applied only on dry surfaces and only during periods of favorable weather. Painting shall not be performed when the atmospheric temperature is below 40° F when using acetone-based paint or below 50° F when using waterborne paint; when freshly painted surfaces may become damaged by rain, fog, or condensation; nor when it can be anticipated that the atmospheric temperature will drop below the aforementioned 40° F or 50° F temperatures during the drying period.
- Surfaces which are to receive traffic stripes and pavement markings shall be cleaned of all dirt and loose material.
- A one-coat 3-inch wide black stripe shall be painted between the two 4-inch wide yellow stripes of a double traffic stripe. If the two 4-inch wide yellow stripes are to be applied in 2 coats, the black stripe shall be applied concurrently with the second coat of yellow stripes.
- On new surfacing, pavement markings and traffic stripes (except the black stripe between the yellow stripes of a double traffic stripe) shall be applied in 2 coats unless otherwise shown on the plans. The first coat of paint shall be dry before application of the second coat.
- On 2-lane highways, when the first coat of the centerline stripe is applied in the same direction as the post miles increase, the right-hand spray gun of the 3 spray guns used to apply double yellow stripe shall be used to apply a single yellow stripe. When the first coat of the centerline stripe is applied in the same direction as the post miles decrease, the left-hand spray gun of the 3 spray guns used to apply

double yellow stripe shall be used to apply a single yellow stripe. The second coat of centerline striping shall be applied in the opposite direction that the first coat was applied.

- On existing surfacing, pavement markings and traffic stripes shall be applied in one coat.
- Each coat of paint for any traffic stripe, including glass beads where required, shall be applied in one pass of the striping machine, regardless of the number, widths and patterns of individual stripes involved.
- Paint to be applied in one coat shall be applied at an approximate rate of one gallon per 107 square feet.
- Paint to be applied in 2 coats shall be applied approximately as follows:

Paint Type	Square Foot Coverage Per Gallon	
	First Coat	Second Coat
Waterborne Paint	215	215
Acetone-Based Paint	360	150

- The exact rate of paint to be applied will be determined by the Engineer. The volume of paint applied shall be measured by stabbing the paint tank with a calibrated rod. At the option of the Engineer, if the striping machine is provided with paint gages, the volume of paint may be determined by using the gages.
- Unless otherwise directed by the Engineer, glass beads shall be uniformly incorporated in all coats of paint concurrently with the application of the paint, except that glass beads shall not be applied to black paint. Beads shall be embedded in the coat of traffic paint being applied to a depth of one-half their diameters.
- Glass beads shall be applied at an approximate rate of 5 pounds per gallon of paint. The exact rate will be determined by the Engineer. The amount of glass beads applied shall be measured by stabbing the glass bead tank with a calibrated rod.

84-3.06 MEASUREMENT

- Painting traffic stripes will be measured by the linear foot along the line of the traffic stripes, without deductions for gaps in broken traffic stripes. A double traffic stripe, consisting of two 4-inch wide yellow stripes separated by a 3-inch wide black stripe, will be measured as one traffic stripe. Painted pavement markings will be measured by the square foot for the actual area painted.

84-3.07 PAYMENT

- The contract prices paid per linear foot for paint traffic stripe and per square foot for paint pavement marking, of the number of coats designated in the Engineer's Estimate, shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in painting traffic stripes (regardless of the number, widths and patterns of individual stripes involved in each traffic stripe) and pavement markings including establishing alignment for stripes and layout work, complete in place, as shown on

the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 85: PAVEMENT MARKERS

85-1.01 DESCRIPTION

- This work shall consist of furnishing and placing pavement markers and constructing pavement recesses at the locations shown on the plans or where directed by the Engineer.
- The markers shall conform to the shape, dimensions and tolerances shown on the plans.
- Pavement markers shall be of the type and color shown on the plans or specified in these specifications and the special provisions.
- Pavement recesses shall be Type 1 or Type 2 as required by the plans and shall be constructed to the shape and dimensions shown on the plans.

85-1.02 TYPE OF MARKERS

- Pavement markers shall conform to one or more of the following types:

Type A— Non-Reflective White Markers
Type AY— Non-Reflective Yellow Markers
Type C— Red-Clear Retroreflective Markers
Type D— 2-Way Yellow Retroreflective Markers
Type G— One-Way Clear Retroreflective Markers
Type H— One-Way Yellow Retroreflective Markers

- Certificates of compliance shall be furnished for pavement markers as specified in the special provisions.

85-1.03 SAMPLING, TOLERANCES AND PACKAGING

- Pavement markers shall conform to the following sampling, tolerances and packaging requirements:

Sampling

- Twenty markers selected at random will constitute a representative sample for each lot of markers.
- The lot size shall not exceed 25,000 markers.

Tolerances

- Three test specimens will be randomly selected from the sample for each test and tested in conformance with these specifications. Should any one of the 3 specimens fail to conform with the requirements in these specifications, 6 additional specimens will be tested. The failure of any one of these 6 specimens shall be cause for rejection of the entire lot or shipment represented by the sample.
- The entire sample of retroreflective pavement markers will be tested for reflectance. The failure of 10 percent or more of the original sampling shall be cause for rejection.

Packaging

- Shipments shall be made in containers which are acceptable to common carriers and packaged in such a manner as to ensure delivery in perfect condition. Any damaged shipments shall be replaced by the Contractor. Each package shall

be clearly marked as to the name of the manufacturer, type, color, quantity enclosed, lot number and date of manufacture.

85-1.035 STORAGE

- Markers shall be stored indoors and shall be protected from any source of moisture both during shipment to the jobsite and at the jobsite. The markers shall be maintained at a high enough temperature as to preclude moisture condensation, and, at the time of placement, both the markers and their containers shall be dry.

85-1.04 NON-REFLECTIVE PAVEMENT MARKERS

- Non-reflective pavement markers (Types A and AY) shall be, at the option of the Contractor, either ceramic or plastic conforming to these specifications.
- The top surface of the marker shall be convex with a gradual change in curvature. The top, bottom and sides shall be free of objectionable marks or discoloration that will affect adhesion or appearance.
- The bottom of markers shall have areas of integrally formed protrusions or indentations, which will increase the effective bonding surface area of adhesive. The bottom surface of the marker shall not deviate more than 0.05-inch from a flat surface. The areas of protrusion shall have faces parallel to the bottom of the marker and shall project approximately 0.04-inch from the bottom.

85-1.04A Non-Reflective Pavement Markers (Ceramic)

- Ceramic non-reflective pavement markers Types A and AY shall consist of a heat-fired, vitreous, ceramic base and a heat-fired, opaque, glazed surface to produce the properties required in these specifications. The markers shall be produced from any suitable combination of intimately mixed clays, shales, talcs, flints, feldspars or other inorganic material which will meet the properties herein required. The markers shall be thoroughly and evenly matured and free from defects which affect appearance or serviceability.

Testing

- Tests shall be performed in conformance with the requirements in California Test 669.

Test	Test Description	Requirement
a	Bond strength	700 psi, min.
b	Glaze thickness	0.007", min.
c	Hardness	6 Moh, min.
d	Luminance factor, Type A, white markers only, glazed surface	75, min.
e	Yellowness index, Type A, white markers only, glazed surface	7, max.
f	Color-yellow, Type AY, yellow markers only. The chromaticity coordinates shall be within a color box defined in CTM 669	Pass
g	Compressive strength	1500 lbs, min.
h	Water absorption	2.0 %, max.
i	Artificial weathering, 500 hours exposure, yellowness index	20, max.

85-1.04B Non-Reflective Pavement Markers (Plastic)

- Plastic non-reflective pavement markers Types A and AY shall be, at the option of the Contractor, either polypropylene or acrylonitrile-butadiene-styrene (ABS) plastic type.
- Plastic markers shall conform to the testing requirements specified in Section 85-1.04A, "Non-Reflective Pavement Markers (Ceramic)," except that Tests a, b, c, and h shall not apply. The plastic markers shall not be coated with substances that interfere with the ability of the adhesive to bond to the marker.

85-1.05 RETROREFLECTIVE PAVEMENT MARKERS

- The exterior surface of the shell shall be smooth and contain one or 2 retroreflective faces of the color specified.
- The infrared curves of the plastic resins shall match approved curves on file in the Transportation Laboratory.
- The base of the marker shall be flat (the deviation from a flat surface shall not exceed 0.05-inch), rough textured and free from gloss or substances which may reduce its bond to the adhesive.
- Retroreflective pavement markers shall conform to the following color and testing requirements:

Color

- The color of the reflectors, when illuminated by the white light from a sealed-beam automobile headlight as defined in the Society of Automotive Engineers (SAE) Standard J 578, shall be an approved clear, yellow or red color as designated. Off-color reflection shall constitute grounds for rejection. The daylight color of the marker body shall be compatible with the color of the primary lens, and shall be subject to approval by the Engineer.

Testing

- Tests shall be performed in conformance with the requirements in California Test 669.

Test Description	Requirement		
Bond strength[a]	500 psi, min.		
Compressive strength[b]	2000 lbs, min.		
Abrasion resistance, marker must meet the respective specific intensity minimum requirements after abrasion.	Pass		
Water Soak Resistance	No delamination of the body or lens system of the marker nor loss of reflectance		
	Specific Intensity		
Reflectance	Clear	Yellow	Red
0° Incidence Angle, min.	3.0	1.5	0.75
20° Incidence Angle, min.	1.2	0.60	0.30
After one year field evaluation	0.30	0.15	0.08

aFailure of the marker body or filler material prior to reaching 500 psi shall constitute a failing bond strength test.

bDeformation of the marker of more than 0.125-inch at a load of less than 2000 lb or delamination of the shell and the filler material of more than 0.125-inch regardless of the load required to break the marker shall be cause for rejection of the markers as specified in Section 85-1.03, "Sampling, Tolerances and Packaging."

- Pavement markers to be placed in pavement recesses shall conform to the above requirements for retroreflective pavement markers except that the minimum compressive strength requirement shall be 1200 pounds.

85-1.055 ADHESIVES

- Rapid set type epoxy adhesive shall conform to the provisions in Section 95-2.04, "Rapid Set Epoxy Adhesive for Pavement Markers."
- Hot melt bituminous adhesive shall conform to the following:

Specification	ASTM Designation	Requirement
Flash Point, COC, °F	D 92	550 Min.
Softening Point, °F	D 36	200 Min.
Brookfield Thermosel Viscosity, Centipoise, No. 27 Spindle, 20 RPM, 400° F	D 4402	3,000 - 6,000
Penetration, dmm, 100 g, 5 seconds, 77° F	D 5	10 - 20
Filler Content, percent by weight (Insoluble in 1,1,1 Trichloroethane)	D 2371	65 - 75

- Filler material used in bituminous adhesive shall be Type PC, Grade III, calcium carbonate conforming to the requirements in ASTM Designation: D 1199, and shall conform to the following fineness:

Sieve Sizes	Percentage Passing
No. 100	100
No. 200	95
No. 325	75

85-1.06 PLACEMENT

- Except as otherwise provided in this Section 85-1.06, pavement markers shall be cemented to the pavement with hot melt bituminous adhesive or rapid set type epoxy adhesive in conformance with the manufacturer's instructions.
- In areas of new construction where the markers are protected from all traffic, including the Contractor's vehicles, standard set type adhesive conforming the provisions in Section 95-2.05, "Standard Set Epoxy Adhesive for Pavement Markers," may be used. The protection from all traffic shall be for at least 3 hours after marker placement when the pavement surface temperature is 55° F or above, at least 24 hours when the temperature is between 40° F and 55° F, and at least 48 hours when the temperature is 40° F or below.
- The Engineer shall be the judge as to when adhesive has set sufficiently to bear traffic.
- All work necessary to establish satisfactory alignment for placing pavement markers shall be performed by the Contractor. Reflective markers shall be placed in such manner that the reflective face of the marker is perpendicular to a line parallel to the roadway centerline.
- No pavement markers shall be placed over longitudinal or transverse joints of the pavement surface.
- Pavement markers shall not be placed on new asphalt concrete surfacing or seal coat until the surfacing or seal coat has been opened to public traffic for a period of not less than 7 days when hot melt bituminous adhesive is used, and not less than 14 days when epoxy adhesive is used.
- Pavement markers shall not be placed using hot melt bituminous adhesive when the pavement or air temperature is 50° F or less. Pavement markers shall not be placed using epoxy adhesives when either the pavement or the air temperature is 32° F or less. Regardless of the type of adhesive used, markers shall not be placed when the pavement is not surface dry.
- Epoxy adhesive shall not be used to apply non-reflective plastic pavement markers.
- Hot melt bituminous adhesive shall be heated indirectly in an applicator with continuous agitation or recirculation. Bituminous adhesive shall not be heated above the maximum safe heating temperature recommended by the manufacturer and shall not be applied at temperatures greater than 425° F nor less than 375° F.

Epoxy adhesive requires that the mixing operation and placing of the markers be done rapidly. When hand mixing the standard set type epoxy adhesive, not more

than one quart shall be mixed at one time, and the markers shall be aligned and pressed into place within 5 minutes after mixing operations are started. Any mixed batch of epoxy adhesive which becomes so viscous that the adhesive cannot be readily extruded from under the marker on application of slight pressure shall not be used. Rapid set type epoxy adhesive shall not be mixed by hand.

- The rapid set type epoxy adhesive shall be mixed by a 2-component type automatic mixing and extrusion apparatus. When machine mixing the standard set type epoxy adhesive or the rapid set type epoxy adhesive, the markers shall be placed within 60 seconds after the epoxy adhesive has been mixed and extruded and no further movement of the marker will be allowed. In addition, no more than 90 seconds shall be permitted between the time the epoxy adhesive is pumped into the mixing head and the time this adhesive is in place on the roadway and not subject to further movement. The mixed epoxy adhesive shall not remain in the mixing head for more than 45 seconds. Epoxy adhesive remaining in the mixing head longer than this period shall be wasted before resuming the operation.
- Automatic mixing equipment for the epoxy adhesive shall use positive displacement pumps and shall properly meter the 2 components in the specified ratio, ±5 percent by volume of either component. At the beginning of each day and at any other time ordered by the Engineer, the ratio of the 2 components of the epoxy adhesive shall be checked by the Contractor in the presence of the Engineer. This check shall be made by disconnecting the mixing heads, or using suitable bypass valves, and filling 2 suitable containers with the unmixed components. The mixing head shall properly mix the 2 components so that there is no trace of black or white streaks in the mixed material.
- Voids in a cured, undisturbed sample of the mixed epoxy adhesive obtained from the extrusion nozzle, shall not exceed 4 percent.
- The portion of the highway surface to which the marker is to be bonded shall be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint and any other material which would adversely affect the bond of the adhesive. Cleaning shall be done by blast cleaning on all surfaces regardless of age or type, except that blast cleaning of clean, new asphalt concrete and clean, new seal coat surfaces will not be required when hot melt bituminous adhesive is used. Adhesive shall be placed uniformly on the pavement surface or on the bottom of the marker in a quantity sufficient to result in complete coverage of the area of contact of the marker with no voids present and with a slight excess after the marker has been pressed in place. The marker shall be placed in position and pressure applied until firm contact is made with the pavement. When hot melt bituminous adhesive is used, the markers shall be placed immediately after application of the adhesive. Excess adhesive around the edge of the marker, excess adhesive on the pavement, and adhesive on the exposed surfaces of the markers shall be immediately removed. Soft rags moistened with mineral spirits conforming to Army Mil-PRF-680A(1) or kerosene may be used, if necessary, to remove adhesive from exposed faces of pavement markers. No other solvent shall be used. The marker shall be protected against impact until the adhesive has hardened to the degree designated by the Engineer.

85-1.07 PAVEMENT RECESSES

- Pavement recesses shall be located along the line or lines of new or existing stripes.
- Pavement recesses shall be constructed in new or existing pavement. The method of recess construction shall be selected by the Contractor. Equipment for recess construction shall be power-operated, mechanical and capable of removing the pavement to the dimensions shown on the plans.
- Residue shall be removed from the roadbed by use of vacuum equipment. Residue from removal operations shall not be permitted to flow across the pavement nor to flow into gutters or other drainage facilities. Residue shall be removed from pavement surfaces before the residue is blown by action of traffic or wind.
- All removed material shall be disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way."
- Recesses shall not be constructed on existing structures.

85-1.08 MEASUREMENT

- The quantity of retroreflective and non-reflective pavement markers will be measured as units determined from actual count in place.
- Retroreflective pavement markers placed in pavement recesses will be measured and paid for as pavement marker (reflective-recessed).

85-1.09 PAYMENT

- The contract unit prices paid for pavement marker (retroreflective) and pavement marker (non-reflective) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and placing pavement markers, complete in place, including adhesives, and establishing alignment for pavement markers, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract unit price paid for pavement marker (retroreflective-recessed) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and placing retroreflective pavement markers in pavement recesses, complete in place, including adhesives, constructing the recesses regardless of the type of recess required, and removing and disposing of residue from recess construction, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

SECTION 86: SIGNALS, LIGHTING AND ELECTRICAL SYSTEMS

86-1 GENERAL

86-1.01 DESCRIPTION

- Electrical work shall consist of furnishing and installing, modifying or removing one or more traffic signals, traffic signal master controller assemblies and interconnection facilities, ramp metering systems, flashing beacon systems, lighting systems, sign illumination systems, traffic monitoring stations, communication systems, electrical equipment in structures, falsework lighting, provisions for future systems or combinations thereof, all as shown on the plans, and as specified in these specifications and the special provisions.
- The locations of signals, beacons, standards, lighting fixtures, signs, controls, services and appurtenances shown on the plans are approximate and the exact locations will be approved by the Engineer in the field.
- All systems shall be complete and in operating condition at the time of acceptance of the contract.

86-1.015 DEFINITIONS

- The following definitions pertain only to Section 86, "Signals, Lighting and Electrical Systems."

Actuation

- The operation of any type of detector.

Channel

- A discrete information path.

Controller Assembly

- The complete assembly for controlling the operation of a traffic signal or other system, consisting of a controller unit and all auxiliary equipment housed in a rainproof cabinet.

Controller Unit

- That part of the controller assembly which performs the basic timing and logic functions.

Detector

- A device for indicating the passage or presence of vehicles or pedestrians.

Magnetic Vehicle Detector

- A detector capable of being actuated by the induced voltage caused by the passage of a vehicle through the earth's magnetic field.

Magnetometer Vehicle Detector

- A detector capable of being actuated by the magnetic disturbance caused by the passage or presence of a vehicle.

Inductive Loop Vehicle Detector

- A detector capable of being actuated by the change of inductance caused by a vehicle passing over or standing over the loop.

Pedestrian Detector

- A detector, usually of the push button type, capable of being operated by hand.

Pressure-Sensitive Vehicle Detector

- A detector capable of being actuated by the pressure of a vehicle passing over its surface.

Electrolier

- The complete assembly of lighting standard, luminaire, ballast and lamp.

Flasher

- A device used to open and close signal circuits at a repetitive rate.

Flashing Beacon Control Assembly

- A complete electrical mechanism for operating a warning beacon or intersection control beacon.

Luminaire

- The assembly which houses the light source and controls the light emitted from the light source.

Lighting Standard

- The pole and mast arm which support the luminaire.

Major Street

- The roadway approach or approaches at an intersection normally carrying the major volume of vehicular traffic.

Minor Street

- The roadway approach or approaches at an intersection normally carrying the minor volume of vehicular traffic.

Pre-timed Controller Assembly

- A controller assembly for operating traffic signals in conformance with a predetermined cycle length.

Signal Face

- That part of a signal head provided for controlling traffic in a single direction and consisting of one or more signal sections.

Signal Head

- An assembly containing one or more signal faces.

Signal Indication

- The illumination of a signal section or other device, or of a combination of sections or other devices at the same time.

Signal Section

- A complete unit for providing a signal indication consisting of a housing, lens, reflector, lamp receptacle and lamp.

Traffic-Actuated Controller Assembly

- A controller assembly for operating traffic signals in conformance with the varying demands of traffic as registered with the controller unit by detectors.

Traffic Phase

- The right of way, change and clearance intervals assigned to a traffic movement or combination of movements.

Vehicle

- Any motor vehicle normally licensed for highway use.

86-1.02 REGULATIONS AND CODE

- All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA), the Underwriters' Laboratories Inc. (UL), the Electrical Testing Laboratories (ETL), the National Electrical Testing Association, Inc. (NETA) or the Electronic Industries Association (EIA), wherever applicable. In addition to the provisions of the plans, these specifications and the special provisions, all materials and workmanship shall conform to the requirements in the National Electrical Code, hereinafter referred to as the Code; California Code of Regulations, Title 8, Chapter 4, Subchapter 5, Electrical Safety Orders; Rules for Overhead Electrical Line Construction, General Order No. 95 of the Public Utilities Commission; Standards of the American Society for Testing and Materials (ASTM); American National Standards Institute (ANSI) and any local ordinances which may apply.
- Wherever reference is made to any of the standards mentioned above, the reference shall be construed to mean the code, order or standard that is in effect on the day the Notice to Contractors for the work is dated.

86-1.03 COST BREAK-DOWN

- The Contractor shall determine the quantities required to complete the work shown on the plans. The quantities and values shall be included in the cost break-down submitted to the Engineer for approval. The Contractor shall be responsible for the accuracy of the quantities and values used in the cost break-down submitted for approval.
- No adjustment in compensation will be made in the contract lump sum prices paid for the various electrical work items due to differences between the quantities shown in the cost break-down furnished by the Contractor and the quantities required to complete the work as shown on the plans and as specified in these specifications and the special provisions.
- The sum of the amounts for the units of work listed in the cost break-down for electrical work shall be equal to the contract lump sum price bid for the work. Overhead, profit, bond premium, temporary construction facilities and plant shall be included in each individual unit listed in the cost break-down, except that for projects with a bid item for mobilization, bond premium, temporary construction facilities and plant will not be paid for under the various electrical work items and shall be included in the mobilization bid item for the entire project. Costs for traffic control system shall not be included in the cost break-down.

- At the Engineer's discretion, the approved cost break-down may be used to determine partial payments during the progress of the work and as the basis of calculating the adjustment in compensation for the item or items of electrical work due to changes ordered by the Engineer. When an ordered change increases or decreases the quantities of an approved cost break-down, the adjustment in compensation may be determined, at the Engineer's discretion, in the same manner specified for increases and decreases in the quantity of a contract item of work in Section 4-1.03B, "Increased or Decreased Quantities."
- The cost breakdown shall, as a minimum, include the following items:

foundations - each type
standards and poles - list by each type
conduit - list by each size and installation method
pull boxes - each type
conductors - each size and type
service equipment enclosures
telephone demarcation box
signal heads and hardware - each type
pedestrian signal heads and hardware - each type
pedestrian push buttons
loop detectors - each type
luminaires - each type

86-1.04 EQUIPMENT LIST AND DRAWINGS

- Unless otherwise permitted in writing by the Engineer, the Contractor shall, within 15 days following approval of the contract, submit to the Engineer for review a list of equipment and materials which the Contractor proposes to install in conformance with the provisions in Section 5-1.02, "Plans and Working Drawings." The list shall be complete as to name of manufacturer, size and identifying number of each item. The list shall be supplemented by such other data as may be required, including schematic wiring diagrams and scale drawings of cabinets showing location and spacing of shelves, terminal blocks and equipment, including dimensioning. The above data shall be submitted, in duplicate, for review. Where electrical equipment is constructed as detailed on the plans, the submission of detailed drawings and diagrams will not be required.
- The Contractor shall furnish 5 sets of controller cabinet schematic wiring diagrams made by (1) wet blueprint, white background process using iron-sensitized paper, (2) the offset lithograph process or (3) the electrostatic process. The diagrams shall show the location of the installation and shall list the equipment installed in each controller cabinet. In addition, for each signal installation, the Contractor shall furnish an intersection sketch showing poles, detectors, field wire connection terminals and phasing as shown on the plans. One copy of the controller cabinet diagram and the intersection and phase diagram, as reviewed by the Engineer, shall be placed in a heavy duty plastic envelope and attached to the inside of the door of each controller cabinet.
- All schematic wiring diagrams of the controller units and auxiliary equipment, all cabinet diagrams and all operation manuals shall be submitted at the time the

controller assemblies are delivered for testing. The diagrams shall show in detail all circuits and parts. All parts shown thereon shall be identified by name or number and in such manner as to be readily interpreted.

- All diagrams, plans and drawings shall be prepared using graphic symbols shown in ANSI publication Y32.2, entitled "IEEE Standard and American National Standard Graphic Symbols for Electrical and Electronic Diagrams."

86-1.05 WARRANTIES, GUARANTIES AND INSTRUCTION SHEETS

- Manufacturers' warranties and guaranties furnished for materials used in the work, and instruction sheets and parts lists supplied with materials, shall be delivered to the Engineer prior to acceptance of the project.

86-1.06 MAINTAINING EXISTING AND TEMPORARY ELECTRICAL SYSTEMS

- Existing electrical systems (traffic signal, ramp metering, highway and street lighting, flashing beacon, traffic monitoring, sign illumination and other facilities), or approved temporary replacements thereof, shall be kept in effective operation for the benefit of the traveling public during the progress of the work, except when shutdown is permitted to allow for alterations or final removal of the systems. The traffic signal shutdowns shall be limited to normal working hours, or shall be as specified in the special provisions. Lighting system shutdowns shall not interfere with the regular lighting schedule, unless otherwise permitted by the Engineer. The Contractor shall notify the Engineer prior to performing any work on existing systems.
- The Contractor shall notify the local traffic enforcement agency prior to any operational shutdown of a traffic signal.
- Where an existing system or temporary system is being modified, work not shown on the plans or specified in the special provisions and which is considered by the Engineer as necessary to keep all or any part of the system in effective operation will be paid for as extra work as provided in Section 4-1.03D.
- The State or local agency will:

  A. Continue the operation and maintenance of existing electrical facilities.
  B. Continue to provide for electrical energy for the operation of existing electrical facilities.
  C. Repair or replace existing facilities damaged by public traffic.
  D. Pay the cost of electrical energy for the operation of existing or new facilities that are undergoing the functional tests described in Section 86-2.14C, "Functional Testing."

- The Contractor shall ascertain the exact location and depth of existing detectors, conduits, pull boxes and other electrical facilities before using any tools or equipment that may damage those facilities or interfere with any electrical system.
- Where damage is caused by the Contractor's operations, the Contractor shall, at the Contractor's expense, repair or replace damaged facilities promptly in conformance with these specifications. If any existing loop conductor, including

the portion leading to the detector handhole or termination pull box, is damaged by the Contractor's operations, the Contractor shall immediately notify the Engineer. The affected detectors shall be replaced at the Contractor's expense and as directed by the Engineer within 24 hours. If the Contractor fails to complete the repairs within this period, the repairs will be made by State forces at the Contractor's expense.

- Should the Contractor fail to perform the required repairs or replacements, the cost of performing the repairs or replacements will be deducted from any moneys due or to become due the Contractor.
- Where roadways are to remain open to traffic and existing lighting systems are to be modified, the lighting systems shall remain in operation and the final connection to the modified circuit shall be made so that the modified circuit will be in operation by nightfall of the same day.
- Temporary electrical installations shall be kept in effective operation until the temporary installations are no longer required for the traveling public. Removal of temporary installations shall conform to the provisions in Section 86-7, "Removing, Reinstalling or Salvaging Electrical Equipment."
- These provisions will not relieve the Contractor in any manner of the Contractor's responsibilities as provided in Sections 7-1.12, "Indemnification and Insurance," and 7-1.16, "Contractor's Responsibility for the Work and Materials."
- During traffic signal system shutdown the Contractor shall place "STOP AHEAD" and "STOP" signs to direct vehicle and pedestrian traffic through the intersection. All signal faces shall be covered when the system is shut down overnight. Temporary "STOP AHEAD" and "STOP" signs shall be either covered or removed when the system is turned on.
- "STOP AHEAD" and "STOP" signs shall be furnished by the Contractor and shall conform to the provisions in Section 12-3.06, "Construction Area Signs." Minimum size of "STOP" signs shall be 30 inches.
- One "STOP AHEAD" sign and one "STOP" sign shall be placed for each direction of traffic. For two-lane approaches, 2 "STOP" signs shall be placed. Location of the signs shall be as directed by the Engineer.

86-1.07 SCHEDULING OF WORK

- No above ground work, except service equipment, shall be performed until the Contractor has all materials on hand to complete that particular signal location or lighting circuit. Work shall be so scheduled that each traffic signal, lighting and sign illumination system shall be completed and ready for operation prior to opening the corresponding section of the roadway to traffic.
- Traffic signals shall not be placed in operation for use by public traffic without the energizing of street lighting at the intersection to be controlled if street lighting exists or is being installed in conjunction with the traffic signals.
- Traffic signals shall not be placed in operation until the roadways to be controlled are open to public traffic, unless otherwise directed by the Engineer.
- Lighting and traffic signals shall not be placed in operation, including flashing operation, prior to commencement of the functional test period specified in Section 86-2.14, "Testing," unless ordered otherwise by the Engineer.

- Conductors shall not be pulled into conduit until pull boxes are set to grade, crushed rock sumps installed, mortar placed around conduit, concrete bottom of pull boxes placed, and metallic conduit bonded.
- In vehicular undercrossings, soffit lights shall be placed in operation as soon as practicable after falsework has been removed from the structure. Lighting for pedestrian structures shall be placed in operation prior to opening the structure to pedestrian traffic.
- If the Engineer orders soffit lights or lighting for pedestrian structures placed in operation before permanent power service is available, the cost of installing and removing temporary power service will be paid for as extra work as provided in Section 4-1.03D.
- The initial turn-on shall be made between 9:00 a.m. and 2:00 p.m. unless specified otherwise in the special provisions. Prior to turn-on, all equipment as shown on the plans shall be installed and operable including pedestrian signals, pedestrian push buttons, vehicle detectors, lighting, signs and pavement delineation. All louvers, visors and signal faces shall be directed to provide maximum visibility.
- Functional tests shall start on any working day except Friday or the day preceding a legal holiday.

86-1.08 SAFETY PRECAUTIONS

- Attention is directed to Section 7-1.06, "Safety and Health Provisions." Before starting work on existing series lighting circuits, the Contractor shall obtain daily a safety circuit clearance from the serving utility. Bypass switch plugs shall be pulled and "Men at Work" signs posted at switch boxes before any work is done.

86-2 MATERIALS AND INSTALLATION

86-2.01 EXCAVATING AND BACKFILLING

- The excavations required for the installation of conduit, foundations and other appurtenances shall be performed in such a manner as to avoid any unnecessary damage to streets, sidewalks, landscaping and other improvements. The trenches shall not be excavated wider than necessary for the proper installation of the electrical appurtenances and foundations. Excavation shall not be performed until immediately before installation of conduit and other appurtenances. The material from the excavation shall be placed in a position that will not cause damage or obstruction to vehicular and pedestrian traffic nor interfere with surface drainage.
- Unless otherwise permitted in writing by the Engineer, surplus excavated material shall be removed and disposed of, within 48 hours, outside the highway right of way in conformance with the provisions in Section 7-1.13.
- The excavations shall be backfilled in conformance with the provisions in Section 19-3, "Structure Excavation and Backfill." Backfill placed in conduit trenches which are to be outside of slope lines and not under pavement shall be compacted to a relative compaction of not less than 90 percent. Backfill on slopes and in areas where pavement is to be constructed shall be compacted to a relative compaction of not less than 95 percent.
- Excavations after backfilling shall be kept well filled and maintained in a smooth and well-drained condition until permanent repairs are made.

- All excavations shall be filled, and sidewalks, pavement and landscaping restored at each intersection prior to excavating at any other intersection, unless otherwise permitted by the Engineer.
- Excavations in the street or highway shall be performed in such a manner that not more than one traffic lane is restricted at any time, unless otherwise provided in the special provisions.

86-2.02 REMOVING AND REPLACING IMPROVEMENTS

- Improvements such as sidewalks, curbs, gutters, portland cement concrete and asphalt concrete pavement, underlying material, lawns and plants and any other improvements removed, broken or damaged by the Contractor's operations, shall be replaced or reconstructed with the same kind of material as found on the work or with materials of equal quality. The new work shall be left in a serviceable condition.
- Whenever a part of a square or slab of existing concrete sidewalk, curb, gutter or driveway is broken or damaged, the entire square, section or slab shall be removed and the concrete reconstructed as above specified.
- The outline of all areas to be removed in portland cement concrete sidewalks and driveways and in pavements shall be cut to a minimum depth of 0.17-foot with an abrasive type saw prior to removing the sidewalk, driveways and pavement material. Cuts shall be neat and true along score lines, with no shatter outside the removal area.

86-2.03 FOUNDATIONS

- Except for concrete for cast-in-drilled-hole concrete pile foundations, portland cement concrete shall conform to Section 90-10, "Minor Concrete."
- Concrete foundations shall rest on firm ground.
- Except when located on structures, foundations for posts, standards and pedestals shall be placed "in the solid" and monolithic except for the top 2 inches which shall be placed after the post, standard or pedestal is in proper position.
- After each post, standard and pedestal on structures is in proper position, mortar shall be placed under the base plate as shown on the plans. The exposed portions shall be formed to present a neat appearance. Mortar shall consist of one part by volume of portland cement and 3 parts of clean sand, shall contain only sufficient moisture to permit packing and shall be cured by keeping it damp for 3 days.
- Reinforced cast-in-drilled-hole concrete pile foundations for traffic signal and lighting standards shall conform to the provisions in Section 49, "Piling," with the following exceptions: 1) material resulting from drilling holes shall be disposed of in conformance with the provisions in Section 86-2.01, "Excavating and Backfilling," and 2) concrete filling for cast-in-drilled-hole concrete piles will not be considered as designated by compressive strength.
- The exposed portions of the foundation shall be formed to present a neat appearance.
- Forms shall be true to line and grade. Tops of foundations for posts and standards, except special foundations, shall be finished to curb or sidewalk grade or as directed by the Engineer. Forms shall be rigid and securely braced in place.

Conduit ends and anchor bolts shall be placed in proper position and to proper height, and anchor bolts shall be held in place by means of rigid top and bottom templates. The bottom template shall be made of steel. The bottom template shall provide proper spacing and alignment of the anchor bolts near their bottom embedded end. The bottom template shall be installed before placing footing concrete. Anchor bolts shall not be installed more than 1:40 from vertical.

- All steel parts shall be galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing."
- The upper threaded portion of all anchor bolts shall be provided with 2 nuts and 2 washers each. Anchor bars or studs shall be provided with 3 nuts and washers each as shown on the plans.
- Welding shall not be performed on any portion of the body of high-strength anchor bolts, anchor bars or studs.
- Plumbing of the standards shall be accomplished by adjusting the leveling nuts before placing the mortar or before the foundation is finished to final grade. Shims or other similar devices shall not be used for plumbing or raking of posts, standards, or pedestals. After final adjustments of both top nuts and leveling nuts on anchorage assemblies have been made, firm contact shall exist between all bearing surfaces of the anchor bolt nuts, washers, and the base plates.
- Both forms and ground which will be in contact with the concrete shall be thoroughly moistened before placing concrete. Forms shall not be removed until the concrete has thoroughly set.
- Ordinary surface finish, as specified in Section 51-1.18A, "Ordinary Surface Finish," shall be applied to exposed surfaces of concrete.
- Where obstructions prevent the construction of a planned foundation, the Contractor shall construct an effective foundation as directed by the Engineer.
- The foundations shown on the plans shall be extended if conditions require additional depth, and the additional work, if ordered by the Engineer, will be paid for as extra work as provided in Section 4-1.03D.
- Unless otherwise shown on the plans, standards to be relocated shall be provided with new foundations and anchor bolts of the proper type and size.
- Posts, poles, standards, pedestals and cabinets shall not be erected until the foundation has set at least 7 days, and shall be plumbed or raked as directed by the Engineer.
- In unpaved areas, a raised pad of portland cement concrete of the size shown on the plans shall be placed in front of each controller cabinet.
- Unless otherwise specified or shown on the plans, foundations not to be reused shall be removed.
- When a foundation is to be abandoned, the top of foundation, anchor bolts and conduits shall be removed to a depth of not less than 0.5-foot below surface of sidewalk or unimproved ground. The resulting hole shall be backfilled with material equivalent to the surrounding material.

86-2.04 STANDARDS, STEEL PEDESTALS AND POSTS

- Bolts, nuts and washers, and anchor bolts for use in signal and lighting support structures shall conform to the provisions in Section 55-2, "Materials." Except when bearing-type connections or slipbases are specified, high-strength bolted

connections shall conform to the provisions in Section 55-3.14, "Bolted Connections." Welding, nondestructive testing (NDT) of welds, and acceptance and repair criteria for NDT of steel members shall conform to the requirements of AWS D1.1 and the special provisions.

- On each lighting standard except Type 1, one rectangular corrosion resistant metal identification tag shall be permanently attached above the hand hole, near the base of the standard, using stainless steel rivets. On each signal pole support, two corrosion resistant metal identification tags shall be attached, one above the hand hole near the base of the vertical standard and one on the underside of the signal mast arm near the arm plate. As a minimum, the information on each identification tag shall include the name of the manufacturer, the date of manufacture, the identification number as shown on the plans, the contract number, and a unique identification code assigned by the fabricator. This number shall be traceable to a particular contract and the welds on that component, and shall be readable after the support structure is coated and installed. The lettering shall be a minimum of 1/4 inch high. The information may be either depressed or raised, and shall be legible.
- Type 1 standards and steel pedestals for controller cabinets shall be constructed of 0.120-inch or thicker galvanized steel, or 4-inch standard weight galvanized steel pipe or 4-inch, Type 1 conduit, with the top designed for post-top slip-fitter. Standard weight galvanized steel pipe shall conform to the specifications of ASTM Designation: A 53.
- Ferrous metal parts of standards, with shaft length of 15 feet and longer, shall conform to the details shown on the plans, the provisions in Section 55-2, "Materials," except as otherwise noted, and the following requirements:

A. Except as otherwise specified, standards shall be fabricated from sheet steel of weldable grade having a minimum yield strength, after fabrication, of 40,000 psi.
B. Certified test reports which verify conformance to the minimum yield strength requirements shall be submitted to the Engineer. The test reports may be the mill test reports for the as-received steel or, when the as-received steel has a lower yield strength than required, the Contractor shall provide supportive test data which provides assurance that the Contractor's method of cold forming will consistently increase the tensile properties of the steel to meet the specified minimum yield strength. The supportive test data shall include tensile properties of the steel after cold forming for specific heats and thicknesses.
C. When a single-ply, 5/16-inch thick pole is specified, a 2-ply pole with equivalent section modulus may be substituted.
D. Standards may be fabricated of full-length sheets or shorter sections. Each section shall be fabricated from not more than 2 pieces of sheet steel. Where 2 pieces are used, the longitudinal welded seams shall be directly opposite one another. When the sections are butt-welded together, the longitudinal welded seams on adjacent sections shall be placed to form continuous straight seams from base to top of standard.

E. Butt-welded circumferential joints of tubular sections requiring CJP groove welds shall be made using a metal sleeve backing ring inside each joint. The sleeve shall be 1/8 inch nominal thickness, or thicker, and manufactured from steel having the same chemical composition as the steel in the tubular sections to be joined. When the sections to be joined have different specified minimum yield strengths, the steel in the sleeve shall have the same chemical composition as the tubular section having the higher minimum yield strength. The width of the metal sleeve shall be consistent with the type of NDT chosen and shall be a minimum width of one inch. The sleeve shall be centered at the joint and be in contact with the tubular section at the point of the weld at time of fit-up.

F. Welds shall be continuous.

G. The weld metal at the transverse joint shall extend to the sleeve, making the sleeve an integral part of the joint.

H. During fabrication, longitudinal seams on vertical tubular members of cantilevered support structures shall be centered on and along the side of the pole that the pole plate is located. Longitudinal seams on horizontal tubular members, including signal and luminaire arms, shall be within ±45 degrees of the bottom of the arm.

I. The longitudinal seam welds in steel tubular sections may be made by the electric resistance welding process.

J. Longitudinal seam welds shall have 60 percent minimum penetration, except that within 6 inches of circumferential welds, longitudinal seam welds shall be CJP groove welds. In addition, longitudinal seam welds on lighting support structures having telescopic pole segment splices shall be CJP groove welds on the female end for a length on each end equal to the designated slip fit splice length plus 6 inches.

K. Exposed circumferential welds, except fillet and fatigue-resistant welds, shall be ground flush (-0, +0.080-inch) with the base metal prior to galvanizing or painting.

L. Circumferential welds and base plate-to-pole welds may be repaired only one time without written permission from the Engineer.

M. Exposed edges of the plates that make up the base assembly shall be finished smooth and exposed corners of the plates shall be broken unless otherwise shown on the plans. Shafts shall be provided with slip-fitter shaft caps.

N. Flatness of surfaces of 1) base plates that are to come in contact with concrete, grout, or washers and leveling nuts; 2) plates in high-strength bolted connections; 3) plates in joints where cap screws are used to secure luminaire and signal arms; and 4) plates used for breakaway slip base assemblies shall conform to the requirements in ASTM A6.

O. Standards shall be straight, with a permissive variation not to exceed one inch measured at the midpoint of a 30-foot or 35-foot standard and not to exceed 3/4 inch measured at the midpoint of a 17-foot through 20-foot standard. Variation shall not exceed one inch at a point 15 feet above the base plate for Type 35 and Type 36 standards.

P. Zinc-coated nuts used on fastener assemblies having a specified preload (obtained by specifying a prescribed tension, torque value, or degree of turn) shall be provided with a colored lubricant that is clean and dry to the touch. The color of the lubricant shall be in contrast to the zinc coating on the nut so that the presence of the lubricant is visually obvious. In addition, either the lubricant shall be insoluble in water, or fastener components shall be shipped to the job site in a sealed container.

Q. No holes shall be made in structural members unless the holes are shown on the plans or are approved in writing by the Engineer.

R. Standards with an outside diameter of 12 inches or less shall be round. Standards with an outside diameter greater than 12 inches shall be round or multisided. Multisided standards shall have a minimum of 12 sides which shall be convex and shall have a minimum bend radius of 4 inches.

S. Mast arms for standards shall be fabricated from material as specified for standards, and shall conform to the dimensions shown on the plans.

T. The cast steel option for slip bases shall be fabricated from material conforming to the requirements in ASTM Designation: A 27/A 27M, Grade 70-40. Other comparable material may be used if written permission is given by the Engineer. The casting tolerances shall be in conformance with the Steel Founder's Society of America recommendations (green sand molding).

U. One casting from each lot of 50 castings or less shall be subject to radiographic inspection, in conformance with the requirements in ASTM Designation: E 94. The castings shall comply with the acceptance criteria severity level 3 or better for the types and categories of discontinuities in conformance with the requirements in ASTM Designations: E 186 and E 446. If the one casting fails to pass the inspection, 2 additional castings shall be radiographed. Both of these castings shall pass the inspection, or the entire lot of 50 will be rejected.

V. Material certifications, consisting of physical and chemical properties, and radiographic films of the castings shall be filed at the manufacturer's office. These certifications and films shall be available for inspection upon request.

W. High-strength bolts, nuts, and flat washers used to connect slip base plates shall conform to the requirements in ASTM Designation: A 325 or A 325M and shall be galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing."

X. Plate washers shall be fabricated by saw cutting and drilling steel plate conforming to the requirements in AISI Designation: 1018, and be galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing." Prior to galvanizing, burrs and sharp edges shall be removed and holes shall be chamfered sufficiently on each side to allow the bolt head to make full contact with the washer without tension on the bolt.

Y. High-strength cap screws shown on the plans for attaching arms to standards shall conform to the requirements in ASTM Designation:

A 325, A 325M, or A 449, and shall comply with the mechanical requirements in ASTM Designation: A 325 or A 325M after galvanizing. The cap screws shall be galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing." The threads of the cap screws shall be coated with a colored lubricant that is clean and dry to the touch. The color of the lubricant shall be in contrast to the color of the zinc coating on the cap screw so that presence of the lubricant is visually obvious. In addition, either the lubricant shall be insoluble in water, or fastener components shall be shipped to the job site in a sealed container.

Z. Unless otherwise specified, bolted connections attaching signal or luminaire arms to poles shall be considered slip critical. Galvanized faying surfaces on plates on luminaire and signal arms and matching plate surfaces on poles shall be roughened by hand using a wire brush prior to assembly and shall conform to the requirements for Class C surface conditions for slip-critical connections in "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts," a specification approved by the Research Council on Structural Connections (RCSC) of the Engineering Foundation. For faying surfaces required to be painted, the paint shall be an approved type, brand, and thickness that has been tested and approved according to the RCSC Specification as a Class B coating.

AA. Samples of fastener components will be randomly taken from each production lot by the Engineer and submitted, along with test reports required by appropriate ASTM fastener specifications, for QA testing and evaluation. Sample sizes for each fastener component shall be as determined by the Engineer.

- Handholes in the base of standards shall conform to the details shown on the plans. Handholes shall be provided with covers.
- Changes in configuration of mast arms will be permitted, provided the mounting height and stability are maintained.
- To avoid interference of arm plate-to-tube welds with cap screw heads, and to ensure cap screw heads can be turned using conventional installation tools, fabricators shall make necessary adjustments to details prior to fabrication and properly locate the position of arm tubes on arm plates during fabrication.
- Mast arms shall be bent to the approximate configuration shown on the plans. A smooth, curving arm is required.
- Pedestrian push button posts shall be constructed of $2^1/_2$-inch standard pipe conforming to the dimensions shown on the plans.
- Guard posts shall be constructed of 4-inch galvanized standard pipe 5.5 feet long. Posts shall be set 3 feet in a block of portland cement concrete, as shown on the plans, and the pipe shall be filled with portland cement concrete.
- Push button posts and guard posts shall be pipe conforming to the specifications of ASTM Designation: A 53.
- Slip bases shall be assembled and tightened when the pole is on the ground prior to erection. The threads of the heavy hex nuts for the slip base bolts shall be coated with an additional lubricant which is clean and dry to the touch. Each high

strength slip base bolt shall be tightened to within 10 foot-pounds, plus or minus, of the following value:

Standard Type	Torque (foot-pounds)
15-SB	150
30	150
31	200
36-20A	165

- Holes left in the shafts of existing standards, due to removal of equipment or mast arms, shall be repaired by welding in a suitable disk, grinding smooth and painting as provided for repairing damaged galvanized surfaces in Section 75-1.05, "Galvanizing."
- When directed by the Engineer, existing standards to be relocated or reused in place shall be repaired. Large dents shall be removed, shafts shall be straightened and portions which are in poor condition, due to corrosion or damage, shall be replaced. Extent of repairs or replacements will be determined by the Engineer, and the repairs or replacements ordered by the Engineer will be paid for as extra work as provided in Section 4-1.03D.
- Anchor bolts or bars and nuts required for relocating existing standards shall be furnished by the Contractor.
- When a standard or mast arm is relocated, or when a used standard or mast arm is State-furnished, new nuts, bolts, cap screws and washers shall be provided and, if the standard has a slip base, a new keeper plate shall be provided. New hardware shall conform to the requirements for hardware used with new standards.
- New standards, mast arms, posts and other ferrous materials shall be galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing."

86-2.05 CONDUIT

- Conductors shall be run in conduit, except overhead and temporary installations, and where conductors are run inside poles.
- Conduit shall be of the sizes shown on the plans, or as specified in this Section 86-2.05 or in the special provisions. In addition, the Contractor may, as an option at the Contractor's expense, use conduit of a larger size than that shown or specified, provided the larger size is used for the entire length of the run from outlet to outlet. Reducing couplings will not be permitted.
- New conduit shall not pass through foundations for standards.

86-2.05A Material

- Conduit and conduit fittings shall be UL or ETL listed and shall conform to the following:

A. Type 1. Hot-dip galvanized rigid steel conduit conforming to the requirements in UL Publication UL 6 for Rigid Metallic Conduit. The zinc coating will be tested in conformance with the requirements in ASTM Designation: A 239.

B. Type 2. Hot-dip galvanized rigid steel conduit conforming to Type 1 above and coated with polyvinyl chloride or polyethylene. The exterior thermoplastic coating shall have a minimum thickness of 35 mils.
C. Type 3. Rigid non-metallic conduit conforming to the requirements in the UL Standard for Rigid Non-Metallic Conduit (Publication UL 651). Type 3 conduit shall be installed at underground locations only.
D. Type 4. Liquidtight flexible metal conduit shall consist of conduit with a liquidtight, non-metallic, sunlight-resistant jacket over an inner flexible metal core. Type 4 conduit shall be UL listed for use as the grounding conductor.
E. Type 5. Intermediate steel conduit (IMC) conforming to the requirements in UL Publication 1242 for Intermediate Metallic Conduit. Type 5 conduit shall only be used when specified.

- Bonding bushings to be installed on metal conduit shall be insulated and shall be the galvanized or zinc alloy type.

86-2.05B Use

- Conduit to be installed on the surface of poles or structures, other exposed locations or in concrete structures shall be Type 1. Exposed conduit installed on a painted structure shall be painted the same color as the structure. The conduit run between a structure and the nearest pull box shall be Type 1.
- Where existing metal conduit runs are to be modified or extended, conduit of the same material only shall be installed. A pull box shall be installed whenever an underground conduit changes from the metallic type to Type 3.
- Unless otherwise indicated, the minimum trade size of conduit:

A. From an electrolier to the adjacent pull box shall be $1^1/_2$-inch.
B. From a pedestrian push button post to the adjacent pull box shall be one inch.
C. From a signal standard to the adjacent pull box shall be 2-inch.
D. From a controller cabinet to the adjacent pull box shall be 3-inch.
E. For detector runs shall be $1^1/_2$-inch.
F. From an overhead sign to the adjacent pull box shall be 2-inch.
G. Not otherwise specified shall be $1^1/_2$-inch.

- Conduit from a No. 9 or 9A pull box to soffit, wall or other lights or fixtures below the grade of the pull box shall be installed in the end of the pull box with the center line of the conduit terminus a minimum of 5 inches above the bottom of the pull box.

86-2.05C Installation

- Conduit shall be installed in conformance with the codes and regulations listed in Section 86-1.02, "Regulations and Code."
- Conduit runs shown on the plans may be changed to avoid underground obstructions with written approval by the Engineer.

- The ends of all conduits, whether shop or field cut, shall be reamed to remove burrs and rough edges. Cuts shall be made square and true. Slip joints or running threads will not be permitted for coupling conduit. When a standard coupling cannot be used for coupling metal type conduit, a UL or ETL listed threaded union coupling shall be used. All couplings for metal type conduit shall be tightened to provide a good electrical connection throughout the entire length of the conduit run. Type 3 conduit shall be cut with a hacksaw or other tool that will not deform the conduit. Type 3 conduit connections shall be of the solvent weld type.
- Type 2 conduit shall be cut only with pipe cutters. Hacksaws shall not be used to cut Type 2 conduit. Coated conduit shall be threaded with standard conduit threading dies. Conduit shall be tightened into couplings or fittings using strap wrenches or approved groove joint pliers.
- Conduit threads and damaged surfaces on metal conduit shall be painted with 2 applications of approved unthinned zinc-rich primer (organic vehicle type) conforming to the provisions in Section 91, "Paint." Aerosol cans shall not be used.
- Type 2 conduit couplings and conduit damaged by wrenches, groove joint pliers, threading machine chucks or otherwise shall be wrapped with at least one layer of 2-inch wide, 20-mil, minimum thickness, polyvinyl chloride tape, conforming to the requirements in ASTM Designation: D 1000, with a minimum tape overlap of $^1/_2$ inch. Before applying the tape, conduit or fittings shall be cleaned and painted with one coat of rubber-resin based adhesive as recommended by the tape manufacturer. Damaged spots in the plastic coating may be repaired by painting over with a brushing type compound as supplied by the conduit manufacturer, in lieu of the tape wrap.
- The ends of Types 1, 2 or 5 conduit shall be threaded and shall be capped with standard pipe caps or "pennies" to protect the raceway against dirt and concrete until wiring is started. The ends of Types 3 and 4 conduit shall be capped until wiring is started. When caps or "pennies" are removed, the ends of conduit and conduit fittings shall be provided with conduit bushings. Metal conduits terminating in pull boxes or foundations shall be provided with insulated bonding bushings. Bell or end bushings for Type 3 conduit shall be the non-metallic type.
- Conduit bends, except factory bends, shall have a radius of not less than 6 times the inside diameter of the conduit. Where factory bends are not used, conduit shall be bent, without crimping or flattening, using the longest radius practicable.
- Type 2 conduit shall be bent with a standard bending tool designed for use on plastic coated conduit, and shall be free of burrs and pits.
- Bending of Type 3 conduit shall be by methods recommended by the conduit manufacturer, and with equipment approved for the purpose. Equipment shall not expose conduit to direct flame.
- A No. 12 copper pull wire or a pull rope shall be installed in conduits which are to receive future conductors. The pull rope shall consist of a flat, woven, lubricated, soft-fiber polyester tape with a minimum tensile strength of 1,800 pounds and shall have printed sequential measurement markings at least every 3 feet. At least 2 feet of pull wire or rope shall be doubled back into the conduit at each termination.

- Existing underground conduit to be incorporated into a new system shall be cleaned with a mandrel or cylindrical wire brush and blown out with compressed air.
- Conduit shall be laid to a depth of not less than 18 inches below grade in portland cement concrete sidewalk areas and curbed paved median areas, and not less than 30 inches below finished grade in all other areas. Conduit may be laid on top of the existing pavement within new curbed medians being constructed on top of the existing pavement.
- Conduit couplings shall be located at least 6 inches from face of foundation.
- Prior to placing Type 2 or Type 3 conduit, a bed of fine soil or sand, a minimum of 2 inches thick, shall be placed in the trench. A minimum of 4 inches of the same type material shall be placed over the conduit before additional backfill material is placed.
- Unless "Trenching In Pavement Method" is specifically allowed or required in the special provisions, conduit shall be placed under existing pavement by jacking or drilling methods. Pavement shall not be disturbed without permission from the Engineer. In the event obstructions are encountered, upon approval of the Engineer, small holes may be cut in the pavement to locate or remove obstructions. Jacking or drilling pits shall be kept 2 feet clear of the edge of any type of pavement wherever possible. Excessive use of water, such that pavement might be undermined or subgrade softened, will not be permitted.
- Conduit to be placed as part of the completed work shall not be used for drilling or jacking. Type 2 and Type 3 conduit may be installed under existing pavement if a hole larger than the conduit is pre-drilled and the conduit installed by hand.
- When "Trenching in Pavement Method" is specifically allowed or required in the special provisions, installation of conduit under pavement, not on freeway lanes nor freeway to freeway connector ramps, shall conform to the following:

A. Conduit shall be Type 3. Conduit shall be placed under existing pavement in a trench approximately 2 inches wider than the outside diameter of the conduit to be installed. Trench shall not exceed 6 inches in width. Trench depth shall not exceed 12 inches or conduit trade size plus 10 inches, whichever is greater, except that at pull boxes the trench may be hand dug to required depth. The top of the installed conduit shall be a minimum of 9 inches below finished grade.
B. In areas where additional pavement is to be placed, trenching installation shall be completed prior to placing the final pavement layer.
C. The outline of areas of pavement to be removed shall be cut to a minimum depth of 3 inches with a rock cutting excavator specifically designed for this purpose. Cuts shall be neat and true with no shatter outside the removal area.
D. The conduit shall be placed in the bottom of the trench, and the trench shall be backfilled with commercial quality concrete containing not less than 590 pounds of cement per cubic yard. Concrete backfill shall be placed to the pavement surface except, when the trench is in asphalt

concrete pavement and additional pavement is not being placed, the top 0.10-foot of the trench shall be backfilled with asphalt concrete produced from commercial quality paving asphalt and aggregates.

E. Prior to spreading asphalt concrete, paint binder (tack coat) shall be applied in conformance with the provisions in Section 39-4.02, "Prime Coat and Paint Binder (Tack Coat)." Spreading and compacting of asphalt concrete shall be performed by any method which will produce an asphalt concrete surfacing of uniform smoothness, texture and density.

F. All excavated areas in the pavement shall be backfilled, except for the top 0.10-foot, by the end of each work period. The top 0.10-foot shall be placed within 3 calendar days after trenching.

- Conduit to be placed beneath railroad tracks shall comply with the following:

  The conduit shall be either Type 1 or 2, $1^1/_2$ inch minimum, and shall be placed to a minimum depth of 3 feet below bottom of tie. The near side of each conduit jacking pit shall be constructed not less than 13 feet from the centerline of track. When the jacking pit is to be left overnight, the pit shall be covered with substantial planking.

- Conduit terminating in standards or pedestals shall extend not more than 3 inches vertically above the foundation and shall be sloped toward the handhole opening. Conduit entering through the side of non-metallic pull boxes shall terminate not more than 2 inches inside the box wall and 2 inches above the bottom, and shall be sloped toward top of box to facilitate pulling of conductors. Conduit entering through the bottom of a pull box shall terminate 2 inches above the bottom and shall be located near the end walls to leave the major portion of the box clear. At all outlets, conduits shall enter from the direction of the run.
- Conduit runs from underground, including under sidewalks, which are adjacent to gasoline service stations or other installations of underground gasoline or diesel storage, piping or pumps, and which lead to a controller cabinet, circuit breaker panel, service or any enclosure where an arc may occur during normal operations, shall be sealed if the conduit is within the limits specified in the National Electrical Code for Class 1, Division 1, Hazardous Locations. Type 1 or Type 2 conduit shall be used for these runs.
- Conduit for future use in structures shall be threaded and capped. Conduit leading to soffit, wall or other lights or fixtures below the grade of the pull box shall be sealed by means of a sealing fitting and sealing compound, except that sealing fitting and sealing compound will not be required where conduit terminates in a No. 9 or No. 9A pull box.
- Conduits in or on walls or bridge superstructures shall be supported as shown on the plans and in conformance with the following:

A. Steel hangers, steel brackets and other fittings shall conform to the provisions in Section 75-1.03, "Miscellaneous Bridge Metal."

B. Cast-in-place metal inserts for hangers or brackets shall be capable of developing 20,000 psi in tension on the net section of the bolt or threaded rod.

C. Precast concrete conduit cradles shall conform to the dimensions shown on the plans and shall be constructed of commercial quality concrete containing not less than 590 pounds of portland cement per cubic yard and commercial quality welded wire fabric. The cradles shall be moist cured for not less than 3 days.

D. Precast concrete cradles shall be bonded to the structure with epoxy adhesive conforming to the provisions in Section 95-2.03, "Epoxy Resin Adhesive for Bonding New Concrete to Old Concrete," Section 95-2.05, "Standard Set Epoxy Adhesive for Pavement Markers," or Section 95-2.04, "Rapid Set Epoxy Adhesive for Pavement Markers."

E. Openings for conduits through bridge superstructure concrete shall be formed or may consist of pipe sleeves.

F. Where conduits pass through the abutment concrete, the conduits shall be wrapped with 2 layers of asphalt-felt building paper, securely taped or wired in place.

G. The space around conduits through bridge abutment walls shall be filled with portland cement mortar conforming to the provisions in Section 51-1.135, "Mortar," except that the proportion of cement to sand shall be one to 3.

H. When the bridge superstructure is to be prestressed, the space around conduits through abutments shall not be filled until the prestressing has been completed.

I. Conduit which is surface mounted shall be run straight and true, horizontal or vertical on the walls and parallel to walls on ceilings or other similar surfaces. Conduit shall be supported at intervals of not more than 5 feet, and closer where necessary to prevent vibration or unsightly deflection. The supports shall consist of galvanized malleable iron conduit clamps and clamp backs secured with expansion anchorage devices conforming to the provisions for concrete anchorage devices in Section 75-1.03, "Miscellaneous Bridge Metal." Threaded studs shall be galvanized and shall be of the largest diameter that will pass through the mounting hole in conduit clamp.

J. Attention is directed to Section 86-2.10, "Bonding and Grounding." Where pull boxes are placed in conduit runs, the conduit shall be fitted with threaded bushings and bonded.

K. The location of ends of all conduits in structures, or terminating at curbs, shall be marked by a "Y" at least 3 inches high cut into the face of curb, gutter or wall, directly above the conduit and above grade line.

86-2.05D Expansion Fittings

Expansion fittings shall be installed where the conduit crosses any expansion joint in the structure. Each expansion fitting for metal conduit shall be provided with a copper bonding jumper having the ampacity required by the Code.

- Each expansion-deflection fitting for expansion joints of $1^1/_2$-inch movement rating shall be watertight and shall consist of a molded neoprene sleeve, a bonding jumper and 2 silicon bronze or zinc-plated iron hubs. Each fitting shall permit a minimum of $^3/_4$ inch expansion and contraction and a minimum of $^3/_4$ inch lateral deflection.
- Details of expansion-deflection fittings for joints of movement rating of more than $1^1/_2$ inches shall be as shown on the plans and specified in the special provisions.

86-2.06 PULL BOXES

- Pull boxes shall be installed at the locations shown on the plans or as specified. The Contractor may, as an option, at the Contractor's expense, use pull boxes of a larger standard size than that shown or specified.

86-2.06A Materials

- Pull boxes, covers and extensions for installation in the ground or in sidewalk areas shall be of the sizes and details shown on the plans and shall be precast of reinforced portland cement concrete (PCC) or of non-PCC material. Non-PCC material shall be fire resistant and shall not burn at a rate greater than 0.3-inch per minute per 0.1-inch of thickness when tested in conformance with the requirements in ASTM Designation: D 635. The non-PCC material shall show no appreciable change in physical properties with exposure to the weather. Non-PCC material shall be dense and free of voids or porosity, and shall be a gray or brown color.
- Top dimensions of non-PCC pull boxes shall not exceed the bottom dimensions by more than one inch. Extensions for non-PCC pull boxes shall be of the same material as the pull boxes, and shall be attached to the pull boxes in a manner that will maintain the minimum combined depths shown on the plans.
- Non-PCC pull boxes shall be of sufficient rigidity that when a designated concentrated force is applied perpendicularly to the midpoint of one of the long sides at the top while the opposite long side is supported by a rigid surface, it shall be possible to remove the cover without the use of tools. The designated concentrated force shall be 150 pounds for a No. $3^1/_2$ pull box and shall be 100 pounds for a No. 5 or No. 6 pull box.
- When a vertical force of 1,500 pounds is applied, through a $^1/_2$" x 3" x 6" steel plate, to a non-PCC cover in place on a pull box, the cover shall not fail and shall not deflect more than $^1/_4$ inch. The steel plate shall be centered on the cover with its longitudinal axis coinciding with the longitudinal axis of the cover.
- Where a ballast or transformer or other device is to be placed in a non-metallic pull box, the box shall be provided with recesses for a hanger.
- Pull boxes and covers for installation in structures shall be of the sizes and details shown on the plans.
- Each No. 7 ceiling pull box located near a flush soffit fixture and to be used to house the ballast for the fixture shall be provided with mounting brackets for the ballast and any required capacitors.
- Covers, except covers for ceiling pull boxes, shall be secured with $^3/_8$ inch bolts, cap screws or studs, and nuts which shall be of brass, stainless steel or other

non-corroding metal material. Stainless steel holddown bolts, cap screws or studs, and nuts and washers shall have a chromium content of not less than 18 percent and a nickel content of not less than 8 percent.

- All ferrous metal parts shall be galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing."

86-2.06B Cover Marking

- Covers for pull boxes, except covers for ceiling pull boxes, shall be marked as shown on the plans.
- Marking shall be clearly defined and uniform in depth and may be placed parallel to either the long or short sides of the cover.
- Marking letters shall be between one inch and 3 inches high.
- Marking shall be applied to each steel or cast iron cover prior to galvanizing by one of the following methods:

A. Cast iron strips, at least 1/4 inch thick, with the letters raised a minimum of 1/16 inch. Strips shall be fastened to covers with 1/4 inch flathead stainless steel machine bolts and nuts. Bolts shall be peened after tightening.
B. Sheet steel strips at least 0.027-inch with the letters raised a minimum of 1/16 inch above the surrounding surface of the strips. Strips shall be fastened to covers by spot welding, tack welding or brazing, with 1/4 inch stainless steel rivets, or with 1/4 inch roundhead stainless steel machine bolts and nuts. Bolts shall be peened after tightening.
C. Bead welding the letters on the covers. The letters shall be raised at least 3/32 inch.

86-2.06C Installation and Use

- Pull boxes shall be installed at the locations shown on the plans and shall be spaced at no more than 200-foot intervals. The Contractor may, at the Contractor's expense, install additional pull boxes to facilitate the work.
- The bottoms of pull boxes installed in the ground or in sidewalk areas, shall be bedded in crushed rock as shown on the plans and shall be grouted prior to the installation of conductors. The grout shall be between 0.5-inch and one inch thick and shall be sloped toward the drain hole. A layer of roofing paper shall be placed between the grout and the crushed rock sump. A one inch drain hole shall be provided in the center of the pull box through the grout and the roofing paper. Grout shall be placed in between the pull box and pull box extension as shown on the plans.
- Where the sump of an existing pull box is disturbed by the Contractor's operations, the sump shall be reconstructed and, if the sump was grouted, the old grout shall be removed and new grout placed.

86-2.07 TRAFFIC PULL BOXES

- Attention is directed to Section 86-2.06B, "Cover Marking," and Section 86-2.06C, "Installation and Use." In addition, traffic pull boxes and covers shall have a vertical proof-load strength of 25,000 pounds. The 25,000 pound load shall be distributed through a 9" x 9" x 2" steel plate according to Federal Specification

RR-F-621e. This load shall be placed anywhere on the box and cover for a period of one minute without causing any cracks or permanent deformations.

- The No. 3 1/2(T) and No. 5(T) pull boxes shall be reinforced with a galvanized Z-bar welded frame and cover similar to that shown on the plans for No. 6(T) pull boxes. Frames shall be anchored to the boxes by means of $^1/_4$" x $2^1/_4$" long concrete anchors. Four concrete anchors shall be provided for the No. 3 1/2(T) pull box, one placed in each corner. Six concrete anchors shall be provided for each No. 5(T) and No. 6(T) pull box, one placed in each corner and one placed near the middle of each of the longer sides.
- Hold down screws shall be $^3/_8$ inch hex flange cap screws of Type 316 stainless steel. The nut shall be zinc plated carbon steel and shall be made vibration resistant with a wedge ramp at the root of the thread. The nut shall be spot welded to the underside of, or fabricated with, the galvanized Z-bar pull box frame.
- Steel covers shall be countersunk approximately $^1/_4$ inch to accommodate the bolt head. The bolt head shall not extend more than $^1/_8$ inch above the top of the cover when tightened down. A $^1/_4$ inch tapped hole and brass bonding screw shall be provided.
- Concrete placed around and under traffic pull boxes as shown on the plans shall contain a minimum of 550 pounds of portland cement per cubic yard.
- After the installation of traffic pull boxes, the steel covers shall be installed and kept bolted down during periods when work is not actively in progress at the pull box. When placing the steel cover for the final time, the cover and the Z-bar frame shall be cleaned of all debris and securely tightened down.

86-2.08 CONDUCTORS

- Conductors shall be copper of the gage shown on the plans, unless specified otherwise.
- Copper wire shall conform to the requirements in ASTM Designations: B 3 and B 8.
- Wire sizes, other than conductors used in loop detector lead-in cable, shall be based on American Wire Gage (AWG), except that conductor diameter shall be not less than 98 percent of the specified American Wire Gage diameter. Conductors used in loop detector lead-in cable shall conform to the requirements in ASTM Designation: B 286.
- A Certificate of Compliance conforming to the provisions in Section 6-1.07, "Certificates of Compliance," shall be submitted by the manufacturer with each type of cable to be used on a project.

86-2.08A Conductor Identification

Circuit	Signal Phase or Function	Identification: Insulation Colors[k] Base	Identification: Insulation Colors[k] Stripe[a]	Identification: Band Symbols[f]	Size
Vehicle Signals[d]	2,6	Red, Yel, Brn	Blk	2,6	14
	4,8	Red, Yel, Brn	Ora	4,8	14
	1,5	Red, Yel, Brn	None	1,5	14
	3,7	Red, Yel, Brn	Pur	3,7	14
	Ramp Meter 1	Red, Yel, Brn	None	NBR	14
	Ramp Meter 2	Red, Yel, Brn	Blk	NBR	14
Pedestrian Signals[d]	2p,6p	Red, Brn	Blk	2p,6p	14
	4p,8p	Red, Brn	Ora	4p,8p	14
	1p,5p	Red, Brn	None	1p,5p	14
	3p,7p	Red, Brn	Pur	3p,7p	14
Pedestrian Push Buttons[d]	2p,6p	Blu	Blk	P-2,P-6	14
	4p,8p	Blu	Ora	P-4,P-8	14
	1p,5p	Blu	None	P-1,P-5	14
	3p,7p	Blu	Pur	P-3,P-7	14
Traffic Signal Controller Cabinet	Ungrounded between Service	Blk	None	CON-1	6
	Grounded Circuit Conductor	White	None	CON-2	6
Highway Lighting Pull Box to Luminaire[i]	Ungrounded-Line 1	Blk	None	NBR	14
	Ungrounded-Line 2	Red	None	NBR	14
	Grounded	Wht	None	NBR	14
Multiple Highway Lighting	Ungrounded-Line 1	Blk	None	ML1	10
	Ungrounded-Line 2	Red	None	ML2	10
Lighting Control	Ungrounded to PEU	Blk	None	C1	14
	Switching leg from PEU unit or SM transformer	Red	None	C2	14
Multiple Service	Ungrounded-Line 1 (Signals)	Blk	None	NBR[e]	6
	Ungrounded-Line 2 (Lighting)	Red[j]	None	NBR[e]	8
Sign Lighting[h]	Ungrounded-Line 1	Blk	None	SL-1	10
	Ungrounded-Line 2	Red	None	SL-2	10
Flashing Beacons[g]	Ungrounded between Flasher and Beacons	Red or Yel	None	F-Loc.[c]	14
Grounded and Common	Pedestrian Push Buttons	Wht	Blk	NBR	14
	Signals and Multiple Lighting	Wht	None	NBR	10
	Flashing Beacons and Sign Lighting	Wht	None	NBR	12
	Lighting Control	Wht	None	C-3	14
	Multiple Service	Wht	None	NBR	14
Railroad Preemption		Blk	None	R	14
Spares		Blk	None	NBR	14

NBR = No Band Required PEU=Photoelectric unit

a On overlaps, insulation is striped for first phase in designation. e.g., phase (2+3) conductor is striped as for phase 2.
b Band for overlap and special phases as required.
c Flashing beacons having separate service do not require banding.
d These requirements do not apply to signal cable.
e "S" if circuit is switched on line side of service equipment by utility.
f Band conductors in each pull box and near ends of termination points. On signal light circuits, a single band may be placed around 2 or 3 ungrounded conductors comprising a phase.
g Ungrounded conductors between service switch and flasher mechanism shall be black and banded.
h Conductors between ballasts and sign lighting lamps shall be No. 16 and color shall correspond to the ballast leads.
i Both conductors between external high intensity discharge (H.I.D.) ballast and lamp socket shall be black.
j Black acceptable for size No. 2 and larger. Tape ends for 20 inches with indicated color.
k Color Code: Yel-Yellow, Brn-Brown, Blu-Blue, Blk-Black, Wht-White, Ora-Orange, Pur-Purple.

- All single conductors and cables, except detector lead-in cables, shall have clear, distinctive and permanent markings on the outer surface throughout the entire length showing the manufacturer's name or trademark, insulation type letter designation, conductor size, voltage rating and the number of conductors if a cable.
- Conductor insulation shall be of a solid color or of basic colors with a permanent colored stripe as detailed in the above table unless otherwise specified. Solid or basic colors shall be homogeneous through the full depth of insulation. Identification stripes shall be continuous over the entire length of the conductor. For conductor sizes No. 2 and larger, the insulation may be black and the ends of the conductors shall be taped with electrical insulating tape of the required color for a minimum of 20 inches.

86-2.08B Multiple Circuit Conductors

- Conductors for multiple circuits shall be UL or ETL listed and rated for 600-V operation. The insulation for No. 14 through No. 4 conductors shall be one of the following:

A. Type TW polyvinyl chloride conforming to the requirements in ASTM Designation: D 2219.
B. Type THW polyvinyl chloride.
C. Type USE, Type RHH or Type RHW cross-linked polyethylene.

- At any point, the minimum insulation thickness of any Type USE, RHH, or RHW insulation shall be 39 mils for conductor sizes No. 14 to No. 10, inclusive; and 51 mils for No. 8 to No. 2, inclusive.
- At any point, the minimum insulation thickness of any Type THW or TW wires shall be 27 mils for conductor sizes No. 14 to No. 10, inclusive; 40 mils for No. 8; and 54 mils for No. 6 to No. 2, inclusive.
- The insulation for No. 2 and larger conductors shall be one of the types listed above or shall be Type THWN.
- Conductors for wiring wall luminaires and soffits shall be stranded copper, with insulation rated for use at temperatures up to 125°C.
- Overhead lighting conductors shall be No. 8, or larger, medium hard drawn copper with weatherproof covering.

86-2.08C Series Circuit Conductors

- Conductors for series circuits shall be No. 8, shall be rated for 5000-V operation and shall be insulated with 148 mils minimum thickness polyvinyl chloride compound conforming to the requirements in ASTM Designation: D 2219, or polyethylene conforming to the requirements in ASTM Designation: D 1351.

86-2.08D Signal Cable

- Where shown on the plans, signal cable shall be installed in lieu of individual conductors. Signal cable shall not be spliced, except for the 28-conductor signal cable when it is shown on the plans to be spliced.
- Each signal cable, except 28-conductor, shall be marked, in each pull box, showing the signal standard to which it is connected.

- Signal cable shall conform to the following:

A. The cable jacket shall be black polyethylene with an inner polyester binder sheath, and shall be rated for 600 V and 75°C. All cables shall have clear, distinctive and permanent markings on the outer surface throughout the entire length of the cable showing the manufacturer's name or trademark, insulation designation, number of conductors, conductor sizes and the voltage rating of the jacket. Filler material, if used, shall be polyethylene material.

B. Individual conductors in the cable shall be solid copper with Type THWN insulation, and shall conform to the requirements in Section 86-2.08, "Conductors," and ASTM Designation: B 286. The minimum thickness of Type THWN insulation, at any point, shall be 12 mils for conductor sizes No. 14 and No. 12, and 16 mils for conductor size No. 10. The minimum thickness of the nylon jacket shall be 4 mils at any point.

Three-Conductor Cable (3CSC)

- The 3-conductor signal cable shall consist of three No. 14 conductors. The cable jacket shall have a minimum average thickness of 44 mils and a minimum thickness at any point of 36 mils. The nominal outside diameter of the cable shall not exceed 0.40-inch. The color code of the conductors shall be blue/black stripe, blue/orange stripe and white/black stripe.
- The 3 conductor cable shall be used for pedestrian push buttons and a spare.

Five-Conductor Cable (5CSC)

- The 5-conductor signal cable shall consist of five No. 14 conductors. The cable jacket shall have a minimum average thickness of 44 mils and shall have a minimum thickness at any point of 36 mils. The nominal outside diameter of the cable shall not exceed 0.50-inch. The color code of the conductors shall be red, yellow, brown, black and white.

Nine-Conductor Cable (9CSC)

- The 9-conductor cable shall consist of eight No. 14 conductors and one No. 12 conductor. The cable jacket shall have a minimum average thickness of 60 mils and shall have a minimum thickness at any point of 48 mils. The nominal outside diameter of the cable shall not exceed 0.65-inch. The color code for the No. 12 conductor shall be white. The color code for the No. 14 conductors shall be as follows:

red	yellow/black stripe
yellow	brown/black stripe
brown	black
red/black stripe	white/black stripe

Twelve-Conductor Cable (12CSC)

- The 12-conductor signal cable shall consist of eleven No. 14 conductors and one No. 12 conductor. The cable jacket shall have a minimum average thickness of 60 mils and shall have a minimum thickness at any point of 48 mils. The nominal outside diameter of the cable shall not exceed 0.80-inch. The color code for the

No. 12 conductor shall be white. The color code and functional connections for the No. 14 conductors shall be as follows, unless otherwise approved by the Engineer:

Color Code	Termination	Phase
red	vehicle signal red	2, 4, 6, or 8
yellow	vehicle signal yellow	2, 4, 6, or 8
brown	vehicle signal green	2, 4, 6, or 8
red/black stripe	vehicle signal red	1, 3, 5, or 7
yellow/black stripe	vehicle signal yellow	1, 3, 5, or 7
brown/black stripe	vehicle signal green	1, 3, 5, or 7
black/red stripe	spare, or use as required for red or DONT WALK	
black/white stripe	spare, or use as required for yellow	
black	spare, or use as required for green or WALK	
red/white stripe	ped signal DONT WALK	
brown/white stripe	ped signal WALK	

- The 12-conductor cable shall be used for vehicle signals, pedestrian signals, spares and the signal common.

Twenty Eight-Conductor Cable (28CSC)

- The 28-conductor signal cable shall consist of 27 No. 14 conductors and one No. 10 conductor. The cable jacket shall have a minimum average thickness of 80 mils and shall have a minimum thickness at any point of 64 mils. The nominal outside diameter of the cable shall not exceed 0.90-inch.
- The signal commons in each 28-conductor cable shall be kept separate except at the signal controller.
- Each 28-conductor cable shall be labeled in each pull box, "C1" or "C2."
- The cable identified "C1" shall be used for signal Phases 1, 2, 3 and 4. The cable identified "C2" shall be used for signal Phases 5, 6, 7 and 8.

- The color code for the No. 10 conductor shall be white. The color code and functional connections for the No. 14 conductors shall be as follows:

Color Code	Termination	Phase
red/black stripe	vehicle signal red	2 or 6
yellow/black stripe	vehicle signal yellow	2 or 6
brown/black stripe	vehicle signal green	2 or 6
red/orange stripe	vehicle signal red	4 or 8
yellow/orange stripe	vehicle signal yellow	4 or 8
brown/orange stripe	vehicle signal green	4 or 8
red/silver stripe	vehicle signal red	1 or 5
yellow/silver stripe	vehicle signal yellow	1 or 5
brown/silver stripe	vehicle signal green	1 or 5
red/purple stripe	vehicle signal red	3 or 7
yellow/purple stripe	vehicle signal yellow	3 or 7
brown/purple stripe	vehicle signal green	3 or 7
red/2 black stripes	ped signal DONT WALK	2 or 6
brown/2 black stripes	ped signal WALK	2 or 6
red/2 orange stripes	ped signal DONT WALK	4 or 8
brown/2 orange stripes	ped signal WALK	4 or 8
red/2 silver stripes	overlap A, C red	OLA, OLC
brown/2 silver stripes	overlap A, C green	OLA, OLC
red/2 purple stripes	overlap B, D red	OLB, OLD
brown/2 purple stripes	overlap B, D green	OLB, OLD
blue/black stripe	ped push button	2 or 6
blue/orange stripe	ped push button	4 or 8
blue/silver stripe	overlap A, C yellow	OLA(y), OLC(y)
blue/purple stripe	overlap B, D yellow	OLB(y), OLD(y)
white/black stripe	ped push button common	
black/red stripe	railroad preemption	
black	spare	

86-2.08E Signal Interconnect Cable (SIC)

- Signal interconnect cable shall consist of six or twelve No. 20, minimum, stranded tinned copper conductors as shown on the plans or required in the special provisions. Each conductor shall be insulated with 13 mils, minimum nominal thickness, color coded, polypropylene material. Conductors shall be in twisted pairs. Color coding shall distinguish each pair. Each pair shall be wrapped with an aluminum polyester shield and shall have a No. 22 or larger, stranded, tinned copper drain wire inside the shielded pair.
- The cable jacket shall be black, high density polyethylene, rated for a minimum of 300 V and 60°C, and shall have a nominal wall thickness of 40 mils, minimum. The cable jacket or the moisture-resistant tape directly under the outer jacket shall be marked with the manufacturer's name, insulation type designation, number of conductors and conductor size, and voltage and temperature ratings.
- Splices shall be made only where shown on the plans or in controller cabinets. A minimum of 3 feet of slack shall be provided at each splice and 6 feet at each controller cabinet.

- Splices of conductors shall be insulated with heat-shrink tubing of the appropriate size and shall overlap the conductor insulation at least 0.6-inch. The overall cable splice shall be covered with heat-shrink tubing, with at least $1^1/_2$-inch of overlap of the cable jacket.

86-2.09 WIRING

- Conductors shall be run in conduit, except overhead and temporary installations and where conductors are run inside poles. Wiring shall be done in conformance with the regulations and code listed in Section 86-1.02, "Regulations and Code," and the following additional requirements:

86-2.09A Circuitry

- Sufficient traffic signal light conductors shall be provided to perform the functional operation of the signal and, in addition thereto, 3 spare conductors shall be provided in all conduits containing traffic signal light conductors, unless shown otherwise on the plans.
- Traffic signal indication conductors shall not run to a terminal block on a standard unless they are to be connected to a signal head that is mounted thereon.
- Connection to each terminal of a pedestrian push button shall be by a single conductor.
- The common for pedestrian push button circuits shall be separate from the traffic signal light circuit grounded conductors.
- Where ballasts or transformers are used, series conductors shall be run from ballast to ballast, transformer to transformer and from ballast or transformer to service.

86-2.09B Installation

- A UL or ETL listed inert lubricant shall be used in placing conductors in conduit.
- Conductors shall be pulled into conduit by hand, and the use of winches or other power actuated pulling equipment will not be permitted.
- When new conductors are to be added or existing conductors are to be removed from existing conduit, all conductors shall be removed; the conduit shall be cleaned as provided in Section 86-2.05C, "Installation"; and both old and new conductors, as shown on the plans, shall be pulled into the conduit as a unit.
- Where traffic signal light conductors are run in lighting standards containing street lighting conductors from a different service point, either the traffic signal light conductors or the lighting conductors shall be encased in flexible or rigid metal conduit, to a point where the 2 types of conductors are no longer in the same raceway.
- Temporary conductors less than 10 feet above grade shall be enclosed in flexible or rigid metal conduit.
- At least one foot of slack shall be left for each conductor at each signal or lighting standard, or combined standard, and at least 3 feet of slack at each pull box.
- At least 3 feet of slack shall be left for each conductor at each splice.
- Ends of spare conductors or conductors terminated in pull boxes shall be taped to provide a watertight seal.

- Conductors within fixtures or service cabinets shall be neatly arranged and shall be cabled together with self-clinching nylon cable ties, or other method approved by the Engineer. Traffic signal light conductors, interconnect conductors, service conductors, detector conductors and cables in controller cabinets and flashing beacon cabinets shall be neatly arranged, and shall be cabled together with self-clinching nylon cable ties or enclosed in plastic tubing or raceway.
- Conductor identification shall be provided under the following conditions:

A. Where signal phase or circuit is not clearly indicated by conductor insulation color and stripe as detailed in the conductor table in Section 86-2.08, "Conductors," or when identification stripes are not available, marking shall be as detailed in the conductor table for special and overlap phases.
B. Where metered and unmetered conductors occupy the same pull box, the unmetered circuit conductors shall be identified, "UNMETERED-STREET LTG," "UNMETERED-COUNT STATION," or as appropriate to describe the unmetered circuit.

- Conductors shall be permanently identified as to function. Identification shall be placed on each conductor, or each group of conductors comprising a signal phase, in each pull box and near the end of terminated conductors.
- Identification shall be by direct labeling, tags or bands fastened to the conductors in such a manner that they will not move along the conductors. Labeling shall be by mechanical methods.

86-2.09C Connectors and Terminals

- Conductors shall be joined by the use of UL or ETL listed crimp type connectors as shown on the plans. Connectors and terminals shall be applied with the proper type tool as recommended by the manufacturer of the connector or terminal being used. Finished connections and terminals shall comply with the requirements of Military Specification MIL-T-7928.
- Stranded conductors smaller than No. 14 shall be terminated in crimp style terminal lugs.
- Connectors and terminal lugs for conductor sizes No. 8 and smaller shall be soldered by the hot iron, pouring or dipping method. Open flame soldering will not be permitted.

86-2.09D Splicing and Terminations

- Unless specified otherwise or permitted by the Engineer, splices shall conform to the details shown on the plans and will be permitted only in the following types of circuits at the following locations:

A. Grounded conductors in pull boxes.
B. Pedestrian push button conductors in pull boxes.
C. Multiple or series lighting conductors in the pull box adjacent to each electrolier or luminaire location or in the bases of Type 21 standards.

Where electroliers are more than 400 feet apart, splices will be permitted in pull boxes at 400 feet, or greater, intervals.

D. When traffic signals are being modified, ungrounded traffic signal light conductors may be spliced in pull boxes at locations shown on the plans.

E. Ungrounded traffic signal indication conductors to a terminal compartment or signal head on a standard may be spliced to through conductors of the same phase in the pull box adjacent to the standard.

- All splices and terminal lugs for conductor sizes No. 8 and smaller shall be soldered by the hot iron, pouring or dipping method. Open flame soldering will not be permitted.

86-2.09E Splice Insulation

- All splices shall be capable of satisfactory operation under continuous submersion in water.
- Multi-conductor cables shall be spliced and insulated to provide a watertight joint and to prevent absorption of moisture by the cable.
- Where more than one conductor enters the sleeve of a ballast installed in a pull box, the insulation and taping shall be applied between the conductors in such a manner as to provide a watertight joint.
- Splice insulation shall conform to the details shown on the plans.
- Low-voltage tape shall be UL or ETL listed and shall be the following types:

A. Self-fusing, oil and flame-resistant, synthetic rubber.

B. Pressure-sensitive, adhesive, polyvinyl chloride, 6 mils minimum thickness.

- Tape for insulating splices in high-voltage (over 600 V) circuits shall be designed for use on 5-kV circuits and shall be resistant to ozone, corona and water.
- Insulating pad shall be composed of a laminate of 80 mils thickness of electrical grade polyvinyl chloride and a 120 mils thickness of butyl splicing compound with removable liner.
- Heat-shrink tubing shall be medium or heavy wall thickness, irradiated polyolefin tubing containing an adhesive mastic inner wall. Minimum wall thickness prior to contraction shall be 40 mils. When heated, the inner wall shall melt and fill all crevices and interstices of the object being covered while the outer wall shrinks to form a waterproof insulation. Each end of the heat-shrink tube or the open end of the end cap of heat-shrink tubing shall, after contraction, overlap the conductor insulation at least $1^1/_2$ inches. Heat-shrink tubing shall conform to the requirements in UL Standard 468D and ANSI C119.1, for extruded insulated tubing at 600 V.

- Heat-shrink tubing shall also meet the following requirements:

Shrinkage Ratio	33 percent, maximum, of supplied diameter when heated to 125°C and allowed to cool to 25°C.
Dielectric Strength	350 kV per inch minimum.
Resistivity	25^{13} ohms per inch minimum.
Tensile Strength	2,000 psi minimum.
Operating Temperature	-40°C to 90°C (135°C Emergency).
Water Absorption	0.5 percent, maximum.

A. When 3 or more conductors are to be enclosed within a single splice using heat-shrink tubing, mastic shall be placed around each conductor prior to being placed inside the heat-shrink tubing. The mastic shall be the type recommended by the manufacturer of the heat-shrink tubing.
B. After contraction, the ends and seams of heat-shrink tubing shall be painted with electrical insulating coating.
C. Heat-shrink tubing shall not be heated with an open flame. A heating device designed for the purpose is required.

- The Contractor may, at the Contractor's option, use either of the following splice insulation methods:

A. "Method B" as shown on the plans. A minimum of 2 thicknesses of electrical insulating pad shall be used. Pads shall be applied to the splice in conformance with the manufacturer's recommendations.
B. Heat-shrink tubing as provided above.

86-2.095 FUSED SPLICE CONNECTORS

- In the pull box adjacent to each luminaire a fused disconnect splice connector shall be installed in each ungrounded conductor between the line and the ballast. The connector shall be readily accessible in the pull box regardless of whether the ballast is remote or is integral with the luminaire.
- For 240-V and 480-V circuits, each connector shall be designed so that both ungrounded conductors are disconnected simultaneously. The connector shall have no exposed metal parts, except the head of a stainless steel assembly screw may be exposed. The head of the metal assembly screw shall be recessed a minimum of $^{1}/_{32}$ inch below the top of a plastic boss which surrounds the head.
- The splice connector shall completely enclose the fuse and shall protect the fuse against damage from water and weather. The contact between the fuse and fuseholder shall be by spring pressure. The terminals of the splice connector shall be rigidly crimped, using a tool of the type recommended by the manufacturer of the fused splice connector, onto the line conductors and the conductors to the ballasts and shall be insulated and made waterproof in conformance with the splice connector manufacturer's recommendations.
- Fused splice connectors shall not be used in series circuits.
- Fuses shall be standard midget, ferrule type, with "Non-Time-Delay" feature, and shall be $^{13}/_{32}$" x $1^{1}/_{2}$".

86-2.10 BONDING AND GROUNDING

- Metallic cable sheaths, metal pull box covers, metal conduit, equipment grounding conductors, ballast and transformer cases, service equipment, sign switches and metal poles and pedestals shall be made mechanically and electrically secure to form a continuous system, and shall be effectively grounded. Bonding jumpers shall be copper wire or copper braid of the same cross sectional area as No. 6 for series lighting systems and No. 8 or larger for all other systems. The jumper size shall be increased to match the load or the circuit breaker size, or shall be as shown on the plans. Equipment grounding conductors shall be color coded to Code requirements or shall be bare.
- The bonding jumper in standards with handholes and traffic pull box lid cover shall be attached by a $^{3}/_{16}$-inch or larger brass bolt and shall be run to the conduit or bonding wire in the adjacent pull box. Standards without handholes shall be bonded by a jumper attached to all anchor bolts, and shall be run to the conduit or bonding wire in the adjacent pull box. The grounding jumper shall be visible after the cap has been placed on foundation.
- Where slip base standards or slip base inserts are installed, the bonding jumper shall not intrude into the slip plane. Bonding shall be accomplished by a bonding strap to all anchor bolts or a $^{3}/_{16}$-inch or larger brass bolt installed in the bottom slip base plate.
- One side of the secondary circuit of series-multiple and step-down transformers shall be grounded.
- Grounding of metal conduit, service equipment and the grounded conductor at service point shall be accomplished as required by the Code and the serving utility, except that grounding electrode conductor shall be No. 6, or larger.
- For equipment grounding purposes in Type 3 conduit, a No. 6 copper wire shall be run continuously in circuits used for series lighting, and a No. 8, minimum, copper wire shall be run continuously in all other circuits. The bonding wire size shall be increased to match the circuit breaker size, or shall be as shown on the plans. Where Type 3 conduit is to be installed for future conductors, the copper wire may be omitted. Equipment bonding and grounding conductors are not required in conduits which contain only loop lead-in cable or signal interconnect cable or both.
- At each multiple service disconnect location, a ground electrode shall be furnished and installed.
- Ground electrodes shall be one-piece, 10-foot, minimum, lengths of galvanized steel rod or pipe not less than $^{3}/_{4}$ inch in diameter, or of copper clad steel rod not less than $^{5}/_{8}$ inch in diameter. Ground electrodes shall be installed in conformance with the provisions of the Code. The service equipment shall be bonded to the ground electrode by use of a ground clamp or exothermic weld and No. 6 or larger copper wire enclosed in a $^{1}/_{2}$ inch or larger diameter conduit.
- Ground clamp for service grounding, and for grounding of equipment, on wood poles shall be $^{1}/_{2}$ inch galvanized, malleable iron conduit hub with swivel feature.

- On wood poles, all metallic equipment mounted less than 8 feet above ground surface shall be grounded.
- Bonding of metallic conduit in non-metallic pull boxes shall be by means of bonding bushings and bonding jumpers.
- Bonding of metallic conduit in metal pull boxes shall be by means of locknuts, one inside and one outside of the box.

86-2.11 SERVICE

- Electrical service installation and materials shall conform to the requirements of the serving utility.
- When the service equipment is to be installed on a utility-owned pole, the Contractor shall furnish and install conduit, conductors and other necessary material to complete the installation of the service. The position of the riser and equipment will be determined by the utility.
- Service conduit shall conform to the requirements of the serving utility and shall be not less than $1^1/_2$ inches.
- Where a kilowatt-hour meter is required, a meter socket with sealing ring, as approved by the serving utility, shall be furnished and installed. Where a meter socket is installed, the meter enclosure shall be provided with factory installed test bypass facilities as required by the serving utility.
- Service equipment shall be installed as soon as possible to enable the utility to schedule its work well in advance of the completion of the project.
- Each service shall be provided with a circuit breaker which shall simultaneously disconnect all ungrounded service entrance conductors.
- Circuit breakers shall be quick-break on either automatic or manual operation. The operating mechanism shall be enclosed and shall be trip-free from the operating handle on overload. Circuit breakers shall be trip-indicating, shall have frame size plainly marked and shall have trip rating clearly indicated on the operating handle. Overload tripping of breakers shall not be influenced by an ambient temperature range of from -18°C to 50°C. Multiple-pole breakers shall be the internal trip type. All circuit breakers shall be listed by UL or ETL. Current rating of breakers shall be as shown on the plans. Circuit breakers used as service disconnect equipment shall have a minimum interrupting capacity of 10,000 A, rms. Circuit breakers shall be enclosed in a NEMA raintight enclosure with dead-front panel and hasp with a $^7/_{16}$-inch hole for a padlock. The padlock will be furnished by others.
- A barrier type terminal block rated for 40 A, minimum, shall be provided in each service equipment enclosure. The terminal block shall have a minimum of 12 positions with terminals rated at Size No. 8 or larger, to accept the field wires indicated on the plans. Field wires shall be terminated using crimped, insulated loop connectors.
- Service equipment enclosures, except Types II and III, shall be galvanized or, at the option of the Contractor, the enclosures may be provided with a factory applied rust resistant prime coat and finish coat, instead of galvanizing.
- Types II and III service equipment enclosures shall be fabricated from galvanized sheet steel, or fabricated from sheet steel and zinc or cadmium plated after fabrication, or shall be fabricated from aluminum. Fabrication of service

equipment enclosures shall conform to the provisions in Section 86-3.04A, "Cabinet Construction." Steel enclosures shall be painted in conformance with the provisions in Section 86-2.16, "Painting." Overlapping exterior seams and doors shall meet the requirements for Type 3R enclosures specified in the NEMA Enclosure Standards.

- If an alternative design is proposed for Type II or III service equipment enclosure, plans of that design shall be submitted to the Engineer for approval.
- Except for falsework lighting and power for the Contractor's operations, upon written request by the Contractor, the Engineer will arrange with the serving utility to complete service connections for both temporary and permanent installations and the State will pay all costs and fees required by the utility. The request shall be submitted not less than 15 days before service connections are required.
- Except for falsework lighting and power for the Contractor's operations, upon written request by the Contractor, the Engineer will arrange for furnishing electrical energy. Energy used prior to completion of the contract will be charged to the Contractor, except that the cost of energy used for public benefit, when an operation is ordered by the Engineer, will be at the expense of the State or local authorities.
- Full compensation for furnishing and installing State-owned or permanent service poles, service equipment, conduit, conductors and pull boxes (including equipment, conduit and conductors placed on utility-owned poles) shall be considered as included in the contract item of electrical work involved and no additional compensation will be allowed therefor.
- Where the service point is indeterminate and is shown on the plans as an "approximate location" or "service point not yet established," the labor and materials required for making the connection between the service point, when established, and the nearest pull box shown on the plans will be paid for as extra work as provided in Section 4-1.03D.

86-2.12 WOOD POLES

- Wood poles for service or temporary installations shall be ANSI Class 5, or larger.
- Poles shall not have more than 180 degrees twist in grain over the full length. Sweep shall be no more than 4 inches. Tops of poles shall be beveled. Poles shall be placed in the ground to a depth of at least 6 feet. The lengths of poles shall be 25 feet for service poles and 35 feet for other poles, unless otherwise specified.
- After each wood pole is set in the ground, the space around the pole shall be backfilled with selected earth or sand, free of rocks and other deleterious material, placed in layers approximately 4 inches thick. Each layer shall be moistened and thoroughly compacted.
- Mast arms for wood pole installations shall be fabricated from standard pipe, free from burrs. Each mast arm shall be provided with an insulated wire inlet and wood pole mounting brackets for mast arm and tie-rod cross arm. Tie rods shall be of structural steel and pipe.
- Mast arms for luminaires shall be mounted to provide a mounting height of 30 feet. Mast arms for traffic signals and flashing beacons shall provide a minimum vertical clearance of 17 feet from bottom of equipment to the pavement.

- After fabrication, wood poles shall be pressure treated in conformance with the provisions in Section 58, "Preservative Treatment of Lumber, Timber and Piling," and AWPA Use Category System: UC4B, Commodity Specification D.
- Wood poles, when specified in the special provisions to be painted, shall be treated with waterborne wood preservatives.

86-2.13 SIGN CONTROL

- Each sign illumination installation shall be provided with a disconnect circuit breaker mounted on the sign standard or structure, as shown on the plans. Where the sign lighting is served from a series lighting circuit through a series-multiple transformer, the circuit breaker shall be installed in the secondary circuit. Where the sign lighting is served through a multiple-multiple transformer, the circuit breaker shall be installed in the primary circuit. Circuit breakers shall meet the requirements for circuit breakers in Section 86-2.11, "Service."
- Enclosure for the circuit breaker shall be NEMA Type 3R, shall be galvanized or shall be cadmium plated, and shall be provided with dead front panel and a hasp with a $^{7}/_{16}$-inch diameter hole for a padlock. Padlocks will be furnished by others.
- When the sign structure is to be painted, the circuit breaker or sign switch enclosure shall be painted the same color as the sign structure on which it is mounted.

86-2.14 TESTING

- Attention is directed to Section 6-3, "Testing." Testing shall conform to the following:

86-2.14A Materials Testing

- Material and equipment to be tested shall be delivered to either the Transportation Laboratory or a testing location designated by the Engineer. Acceptance testing will be performed by the State.
- The Contractor shall allow 30 calendar days for State testing from the time the material or equipment is delivered to the State test site. All shipping, handling, and related transportation costs associated with testing shall be borne by the Contractor. When equipment being tested has been rejected for failure to comply with the specifications, the Contractor shall allow 30 calendar days for State retesting. The retesting period shall begin when the corrected equipment is made available at the test site.
- In the event equipment submitted for testing does not comply with specifications, the Contractor shall remove the equipment within 5 working days after notification that the equipment is rejected. In the event the equipment is not removed within that period, it may be shipped to the Contractor at the Contractor's expense.
- All testing subsequent to rejection of the equipment for failure to comply with specification requirements will be at the expense of the Contractor. Deductions to cover the cost of that testing will be made from any moneys due or which may become due the Contractor under the contract.
- The Contractor will be notified when testing of the equipment has been completed and it shall be the Contractor's responsibility to pick-up the equipment at the test site and deliver the equipment to the site of the work.

- Testing and quality control procedures for Model 170 and Model 2070 controller assemblies shall conform to the requirements in "Transportation Electrical Equipment Specifications," and "Traffic Signal Control Equipment Specifications," issued by the Department, and to all addenda thereto current at the time of project advertising.
- Testing and quality control procedures for all other traffic signal controller assemblies shall conform to the requirements in the NEMA TS Standards for Traffic Control Systems.

86-2.14B Field Testing

- Prior to start of functional testing, the Contractor shall perform the following tests on all circuits, in the presence of the Engineer.

86-2.14B(1) Continuity

- Each circuit shall be tested for continuity.

86-2.14B(2) Ground

- Each circuit shall be tested for grounds.

86-2.14B(3) Insulation Resistance

- An insulation resistance test at 500 V (dc) shall be made on each circuit between the circuit and a ground. The insulation resistance shall not be less than 10 MΩ on all circuits, except for inductive loop detector circuits which shall have an insulation resistance value of not less than 100 MΩ.
- The insulation resistance test shall not be performed on magnetometer sensing elements. Splices in the pull box adjacent to the magnetometer sensing elements shall not be made prior to performing the test on the lead-in conductors between the pull box and the controller cabinet field terminals.

86-2.14C Functional Testing

- Attention is directed to Section 86-1.07, "Scheduling of Work," regarding requirements for test periods.
- Acceptance of new or modified traffic signals shall be made only after all traffic signal circuits have been thoroughly tested.
- A functional test shall be made in which it is demonstrated that each and every part of the system functions as specified.
- The functional test for each new or modified system shall consist of not less than 5 days of continuous, satisfactory operation. If unsatisfactory performance of the system develops, the condition shall be corrected and the test shall be repeated until the 5 days of continuous, satisfactory operation is obtained.
- Except for new or modified portions of existing lighting circuits and sign illumination systems, the State or local agency will maintain the system or systems during the test period and will pay the cost of electrical energy for the operation of all of the facilities that are undergoing testing. The cost of any necessary maintenance performed by the State or local agency on new circuits or on the portions of existing circuits modified under the contract, except electrical energy, shall be at the Contractor's expense and will be deducted from any moneys due, or to become due, the Contractor.

- A shutdown of the electrical system resulting from damage caused by public traffic, from a power interruption or from unsatisfactory performance of State-furnished materials shall not constitute discontinuity of the functional test.

86-2.15 GALVANIZING

- Galvanizing shall be in conformance with the provisions in Section 75-1.05, "Galvanizing," except that cabinets may be constructed of material galvanized prior to fabrication in conformance with the requirements in ASTM Designation: A 653/653M, Coating Designation G 90, in which case all cut or damaged edges shall be painted with at least 2 applications of approved unthinned zinc-rich primer (organic vehicle type) conforming to the provisions in Section 91, "Paint." Aerosol cans shall not be used. Other types of protective coating must be approved by the Engineer prior to installation.
- Iron or steel pipe standards and pipe mast arms shall be hot-dip galvanized after fabrication in conformance with the requirements in ASTM Designation: A 53. Galvanized surfaces shall have spurs removed.
- Tie-rods, bolts, nuts, washers, clamps and other miscellaneous ferrous parts shall be hot-dip galvanized after fabrication in conformance with the provisions in Section 75-1.05, "Galvanizing."
- Not less than 10 inches of the upper end of the anchor bolts, anchor bars or studs, and all nuts and washers shall be galvanized in conformance with the provisions in Section 75-1.05, "Galvanizing."
- After galvanizing, the bolt threads shall accept galvanized standard nuts without requiring tools or causing removal of protective coatings.
- Galvanizing of existing materials in an electrical installation will not be required.

86-2.16 PAINTING

- Painting of electrical equipment and materials shall conform to the provisions in Section 59, "Painting," with the following additions and modifications.
- Paint materials for electrical installations, unless otherwise specified, shall conform to the provisions in Section 91, "Paint."
- Factory or shop cleaning methods for metals will be acceptable if equal to the methods specified herein.
- In lieu of the temperature and seasonal restrictions for painting as provided in Section 59, "Painting," paint may be applied to equipment and materials for electrical installations at any time permitted by the Engineer.
- Ungalvanized ferrous surfaces to be painted shall be cleaned prior to applying the prime coat. Blast cleaning will not be required.
- If an approved prime coat has been applied by the manufacturer, and it is in good condition, the first primer application by the Contractor will not be required.
- Existing equipment to be painted in the field, including State-furnished equipment, shall be washed with a stiff bristle brush using a solution of water containing 2 tablespoons of heavy duty detergent powder per gallon. After rinsing, all surfaces shall be wire brushed with a coarse, cup shaped, power-driven brush to remove all poorly bonded paint, rust, scale, corrosion, grease or dirt. Any dust or residue remaining after wire brushing shall also be removed prior to priming.

- Galvanized equipment and wood poles for traffic signal or flashing beacon installations shall not be painted unless specified in the special provisions or shown on the plans.
- New galvanized metal surfaces to be painted in the field shall be cleaned as specified for existing equipment before applying the prime coats specified. Wire brushing of new galvanized surfaces will not be required.
- After erection, all exterior surfaces shall be examined for damaged primer and the damaged surfaces shall be cleaned and spot coated with primer.
- Galvanized metal guard posts shall not be painted.
- Painting of State-furnished controller cabinets will not be required.
- Types II and III steel service equipment enclosures shall be painted with a polymeric or an enamel coating system conforming to Color No. 14672 (light green) of Federal Standard 595B. All coatings shall be commercially smooth, substantially free of flow lines, paint washout, streaks, blisters and other defects that would impair serviceability or detract from general appearance. The coatings shall comply with the following requirements:

  A. Coating Hardness - The finish shall have a pencil lead hardness of HB minimum using an Eagle Turquoise pencil.
  B. Salt Spray Resistance - The undercutting of the film of the coating system shall not exceed $^1/_8$ inch average, from lines scored diagonally and deep enough to expose the base metal, after 336 hours exposure in a salt spray cabinet in conformance with the requirements in ASTM Designation: B 117.
  C. Adherence - There shall be no coating loss when tested in conformance with the requirements in California Test 645. Compliance of the coating system to the above requirements may be determined by the application of the coating to 4" x 8" x 0.024" test specimens of the same material as the cabinets, in the same manner as applied to the cabinets.

- A Certificate of Compliance shall be furnished in conformance with the provisions in Section 6-1.07, "Certificates of Compliance," certifying that the coating system furnished complies in all respects with these requirements.
- Interior of metal signal visors, louvers and front faces of back plates shall be finished with 2 applications of lusterless black exterior grade latex paint formulated for application to properly prepared metal surfaces, except that factory finish in good condition will be acceptable.
- Metal signal sections, signal head mountings, brackets and fittings, outside of visors, pedestrian push button housings, pedestrian signal sections and visors, and back faces of back plates shall be finished with 2 applications of lusterless black or dark olive green exterior grade latex paint formulated for application to properly prepared metal surfaces. Dark olive green color shall match Color Chip No. 68 on file at the Transportation Laboratory.
- Conduit and conduit fittings above ground shall be prepared and finished in the same manner as the adjacent standard or post.

- Relocated, reset or modified equipment previously finished as provided in this Section 86-2.16, except for galvanized standards previously finished with traffic signal yellow enamel, shall be given a spot finishing application on newly primed areas, followed by one finishing application over the entire surface. If any signal faces or mounting brackets are required to be painted under this Section 86-2.16, all signal faces and mounting brackets on the same mounting shall be repainted.
- Small rusted or repaired areas of relocated or reset galvanized equipment shall be cleaned and painted in conformance with the provisions in Section 75-1.05, "Galvanizing," for repairing damaged galvanized surfaces.
- Equipment number shall be neatly stenciled on the standard or adjacent structure. The number designation will be determined by the Engineer.
- Paint shall be applied either by hand brushing or by spraying machines in the hands of skilled operators. The work shall be done in a neat and workmanlike manner. The Engineer reserves the right to require the use of brushes for the application of paint, should the work done by the paint spraying machine prove unsatisfactory or objectionable, as determined by the Engineer.

86-3 CONTROLLER ASSEMBLIES

86-3.01 CONTROLLER ASSEMBLIES

- A controller assembly shall consist of a complete mechanism for controlling the operation of traffic signals or other systems, including the controller unit and all necessary auxiliary equipment, mounted in a cabinet. All equipment required to provide the operation shown on the plans and as specified shall be provided.
- Field conductors No. 12 and smaller shall terminate with spade type terminals. Field conductors No. 10 and larger shall terminate in spade type or ring type terminals.

86-3.02 TYPE 90 CONTROLLER ASSEMBLIES

- Each Type 90 controller assembly shall consist of a complete traffic signal controller assembly which conforms to the requirements in the NEMA TS Standards for Traffic Control Systems.
- The provisions in Sections 86-3.03, "Model 170 and Model 2070 Controller Assemblies," 86-3.04, "Controller Cabinets," 86-3.05, "Cabinet Accessories," and 86-3.06, "Components," shall not apply to Type 90 controller assemblies.

86-3.03 MODEL 170 AND MODEL 2070 CONTROLLER ASSEMBLIES

- Model 170 and Model 2070 (Model 170/2070) controller assemblies shall consist of a Model 170, 170E or 2070 controller unit, a wired cabinet and all auxiliary equipment required to control the system as shown on the plans, and as specified in these specifications and in the special provisions.
- Model 170/2070 controller assemblies shall conform to the requirements in "Transportation Electrical Equipment Specifications," (TEES) and "Traffic Signal Control Equipment Specifications" (TSCES), issued by the Department, and to all addenda thereto current at the time of project advertising.
- Unless otherwise specified or shown on the plans, controller assembly cabinets (housing) shall be Type 1 as shown in the TSCES.

- The provisions in Sections 86-3.04, "Controller Cabinets," 86-3.05, "Cabinet Accessories," and 86-3.06, "Components," shall not apply to Model 170/2070 controller assemblies.

86-3.04 CONTROLLER CABINETS

- Unless otherwise specified, controller cabinets for other than Type 90 and Model 170/2070 controllers shall conform to the following:

86-3.04A Cabinet Construction

- The cabinet shall be a rainproof cabinet with dimensions as shown on the plans. The cabinet top shall be crowned 1/2 inch or slanted to the rear to prevent standing water.
- The cabinet and doors shall be fabricated of either 0.073-inch minimum thickness cold rolled steel, 0.073-inch minimum thickness stainless steel or 0.125-inch minimum thickness aluminum. All exterior seams for cold rolled steel and aluminum cabinets and doors shall be continuously welded. All overlapping exterior seams for stainless steel cabinets and doors shall meet the requirements for Type 4 enclosures in the NEMA Enclosure Standards.
- Exterior welds shall be ground smooth. Edges shall be filed to a radius of 0.03-inch, minimum.
- Cabinets fabricated from cold rolled steel shall be finished with a polymeric or an enamel coating system conforming to Color No. 14672 of Federal Standard 595B. All coatings shall be commercially smooth, substantially free of flow lines, paint washout, streaks, blisters and other defects that would impair serviceability or detract from general appearance. The coatings shall conform to the following requirements:

A. Coating Hardness— The finish shall have a pencil lead hardness of HB minimum using an Eagle Turquoise pencil.
B. Salt Spray Resistance— The undercutting of the film of the coating system shall not exceed 1/8 inch average, from lines scored diagonally and deep enough to expose the base metal, after 336 hours exposure in a salt spray cabinet in conformance with the requirements in ASTM Designation: B 117.
C. The cabinet shall suffer no coating loss when subjected to the following: Two test specimens, 4" x 8", of the same material and coating as the cabinet supplied, shall be furnished for the tests. Two 9-inch diagonal scratches exposing bare metal will be made on a specimen. It will be soaked in demineralized water for 192 hours. A one inch wide strip of masking tape shall be tightly affixed to this surface and removed with one quick motion; evidence of blistering, softening, or peeling of the paint or coating from the base metal shall be cause for rejection. Testing will be in conformance with California Test 645, except that conformance to the 180 Degree Bend Test will not be required.
D. Metal preparation shall be the 3-step iron phosphate conversion coating bonderizing technique.

E. The inside walls, doors and ceiling of the housing shall be finished the same as the outside finish.

- Cabinets fabricated from stainless steel shall conform to the following:

A. Annealed or quarter hard stainless steel sheet shall be used and shall conform to the requirements in ASTM Designation: A 666 for Type 304, Grades A or B, stainless steel sheet.
B. Welding on stainless steel cabinets shall be by the gas tungsten arc welding (GTAW) process using bare stainless steel welding electrodes. Electrodes shall conform to the requirements in American Welding Society (AWS) A5.9 for ER308 chromium-nickel bare arc welding electrodes.
C. Procedures, welders and welding operators for welding on stainless steel shall conform to the requirements and practices recommended in AWS C5.5.
D. The exposed, exterior surfaces of stainless steel cabinets shall be ground or brushed to a 25 to 50-microinch finish using iron-free abrasives or stainless steel brushes.
E. The stainless steel cabinet, after grinding or brushing, shall not show any rust discoloration when subjected to the following:

1. Forty-eight hours of exposure in a salt spray cabinet in conformance with the requirements in ASTM Designation: B 117; and
2. Twenty-four hours of exposure in a tap water spray cabinet with the water temperature between 38°C and 45°C.

F. Any cabinet which shows rust discoloration anywhere on its surface after the test will be rejected.
G. Stainless steel cabinets that have been rejected because of surface discoloration may be cleaned, passivated and resubmitted for testing.

- Cabinets fabricated from aluminum sheet shall conform to the requirements in ASTM Designation: B 209 or B 209M for 5052-H32 aluminum sheet.

A. Welding on aluminum cabinets shall be done by the gas metal arc welding (GMAW) process using bare aluminum welding electrodes. Electrodes shall conform to the requirements in American Welding Society (AWS) A5.10 for ER5356 aluminum alloy bare welding electrodes.
B. Procedures, welders and welding operators for welding on aluminum shall be qualified in conformance with the requirements in AWS B3.0, "Welding Procedure and Performance Qualification," and to the practices recommended in AWS C5.6.
C. The surfaces of each aluminum cabinet shall be finished to conform to the requirements in Military Specification MIL-A-8625C "Anodic Coatings for Aluminum and Aluminum Alloys" for a Type II, Class I coating,

except that the anodic coating shall have a minimum thickness of 0.0007-inch and a minimum coating weight of 0.001-ounce per square inch. The anodic coating shall be sealed in a 5 percent aqueous solution of nickel acetate (pH 5.0 to 6.5) for 15 minutes at 97°C. Prior to applying the anodic coating, the cabinets shall be cleaned and etched as follows:

1. Clean by immersion in inhibited alkaline cleaner such as Oakite 61A or Diversey 909, or equivalent, 6 ounces to 8 ounces per gallon, 71°C for 5 minutes.
2. Rinse in cold water.
3. Etch in a solution of $1^1/_2$ ounce of sodium fluoride, plus 4 ounces to 6 ounces of sodium hydroxide per gallon of distilled water at 60°C to 65°C for 5 minutes.
4. Rinse in cold water.
5. Desmut in a 50 percent by volume nitric acid solution at room temperature for 2 minutes.
6. Rinse in cold water.

- The cabinet shall have a single front door equipped with a lock. The door width shall not exceed 44 inches. When the door is closed and latched, the door shall be locked. The handle shall have provision for padlocking in the closed position. The handle shall have a minimum length of 7 inches and shall be provided with a $^5/_8$ inch, minimum, steel shank. The handle shall be fabricated of cast aluminum or of zinc-plated or cadmium-plated steel. The cabinet door frame shall be designed so that the latching mechanism will hold tension on and form a firm seal between door gasketing and door frame. Cabinet locks shall be the solid brass, 6-pin tumbler rim type. The lock shall have rectangular, spring-loaded bolts. The locks shall be left hand, and rigidly mounted with stainless steel machine screws approximately 2 inches apart. Keys shall be removable in the locked and unlocked positions, and 2 keys furnished with each cabinet. The front position of the lock shall extend $^1/_8$ inch to $^3/_8$ inch beyond the outside surface of the door.
- The latching mechanism shall be a 3-point cabinet latch with nylon rollers. The center catch and pushrods shall be zinc-plated or cadmium-plated steel. Pushrods shall be turned edgewise at the outer supports and shall be $^1/_4$" x $^3/_4$", minimum. The nylon rollers shall have a minimum diameter of $^3/_4$ inch and shall be equipped with ball bearings.
- All cadmium plating shall conform to the requirements in Military Specification MIL-QQ-416b. All zinc plating shall conform to the requirements in Military Specification MIL-QQ-325b.
- The door's hinging shall be three-bolt butt hinges. Each hinge shall have a fixed pin. Doors larger than 22 inches in width or 6 square feet in area shall be provided with catches to hold the door open at both 90 degrees and 180 degrees, plus or minus 10 degrees. The catches shall be $^3/_8$ inch diameter, minimum, plated steel rods. The catches shall be capable of holding the door open at 90 degrees in a 60 mph wind at an angle perpendicular to the plane of the door.

- The police panel shall be mounted on the door as shown on the plans, and equipped with a lock keyed for a master police key. Two keys shall be furnished with each cabinet for the police lock. Each police key shall have a shaft at least $1^3/_4$ inch in length. Police panels shall not be furnished for controller assemblies that do not control traffic signals.
- Door hinges, pins and bolts shall be made of stainless steel. Hinges on aluminum cabinets may be aluminum with a stainless steel hinge pin. The hinges shall be bolted to the cabinet. The hinge pins and bolts shall not be accessible when the door is closed.
- Gasketing shall be provided on all door openings and shall be dust-tight. Gaskets shall be permanently bonded to the metal. The mating surface of the gasketing shall be covered with a silicone lubricant to prevent sticking to the mating surface.
- Details of alternative designs shall be submitted for review and approval prior to the fabrication of the cabinets.
- Substantial metal shelves or brackets shall be provided to support controller unit and auxiliary equipment.
- Machine screws and bolts shall not protrude beyond the outside wall of the cabinet.
- Conduit shall enter the controller cabinet at the front unless shown otherwise on the plans.
- A pliable seal, composed of caulking compound or mastic, shall be placed between each controller cabinet and the concrete foundation to prevent water, dust and dirt from entering the cabinet.

86-3.04B Cabinet Ventilation

- Each controller cabinet shall be provided with 8 screened, raintight vent holes, $^1/_2$ inch in diameter or larger, in the lower side or bottom of the cabinet, or at the option of the Contractor, louvered vents with a permanent metal mesh or 4-ply woven polypropylene air filter held firmly in place, which will permit the fan to pass the volume of air specified, may be substituted.
- Each controller cabinet shall be equipped with an electric fan with ball or roller bearings and a capacity of at least 100 cubic feet per min.
- The fan shall be thermostatically controlled and shall be manually adjustable to turn on between 32°C and 65°C with a differential of not more than 6°C between automatic turn on and turn off. The cabinet fan circuit shall be fused at 125 percent of the ampacity of the fan motor installed.
- The fan and cabinet vent holes shall be located with respect to each other so as to direct the bulk of the air flow over the controller unit or through the ventilating holes of the controller unit where those holes exist.

86-3.04C Cabinet Wiring

- Conductors used in controller cabinet wiring shall be No. 22, or larger, with a minimum of 19 strands. Conductors shall conform to Military Specification MIL-W-16878D, Type B or better. The insulation shall have a minimum thickness of 10 mil and shall be nylon jacketed polyvinyl chloride or shall be irradiated

cross-link polyvinyl chloride, polyhalocarbon or polychloro-alkene, except that, at the Contractor's option, conductors No. 14 and larger may be UL Type THHN.

- At the Contractor's option, flat cable may be used in lieu of individual conductors. Cable shall be constructed of No. 28, or larger, conductors. Conductor insulation shall be rated at 300 V and shall be rated for use at 105°C. Cables shall be provided with strain relief.
- Wiring within controller cabinets shall be neatly arranged and laced, or enclosed in plastic tubing or raceway.
- Conductors used in controller cabinet wiring shall conform to the following color-code requirements:

A. The grounded conductor of a circuit shall be identified by a continuous white or natural gray color.
B. The equipment grounding conductor shall be identified by a continuous green color or by a continuous green color with one or more yellow stripes.
C. The ungrounded conductors shall be identified by any color not specified in A or B above.

- Conductors used in cabinet wiring shall terminate with properly sized captive or spring spade type terminals or shall be soldered to a through-panel solder lug on the rear side of the terminal block. Crimp-style connectors shall be applied with a proper tool which prevents opening of the handles until the crimp is completed.
- An equipment grounding conductor bus shall be provided in each controller cabinet. The bus shall be grounded to the cabinet and shall be connected to the metal conduit system or other approved ground with a No. 8, or larger, grounding conductor.
- With all the cabinet equipment in place and connected, the resistance between the grounded conductor terminal bus and the equipment grounding conductor bus shall be 50 MΩ, minimum, when measured with an applied voltage of 150 V (dc).
- If direct current (dc-) is to be grounded, it shall be connected to equipment ground only.
- Two or more terminal blocks shall be provided for field connections. Field terminals shall be installed within 22 inches of the face of the cabinet and shall be oriented for screwdriver operation from the door opening. All terminals shall be a minimum of 5 inches above the foundation.
- No more than 3 conductors shall be brought to any one terminal. Two flat metal jumpers, straight or U shaped, may also be placed under a terminal screw. At least 2 full threads of all terminal screws shall be fully engaged when the screw is tightened. No live parts shall extend beyond the barrier.
- Attention is directed to Section 86-1.04, "Equipment List and Drawings," regarding wiring diagrams.

86-3.05 CABINET ACCESSORIES

- The following accessories shall be furnished with each cabinet assembly for other than Type 90 and Model 170/2070 controllers:

86-3.05A Labels

- A permanent printed, engraved or silk screened label shall be provided for the following equipment and for all other removable items of equipment:

  A. Receptacles for relays and switching devices.
  B. Switches, fuses and circuit breakers.

- Labels shall conform to the designations on the cabinet wiring diagram. Labels for all shelf-mounted equipment shall be on the face of the shelf below the item. Labels for wall-mounted equipment shall be below the item.

86-3.05B Convenience Receptacle

- A convenience receptacle shall be mounted in a readily accessible location inside the cabinet.
- Convenience receptacle shall be a duplex, 3-prong, NEMA Type 5-15R grounding type outlet and shall conform to the requirements in UL Standard 943.

86-3.05C Lighting Fixture

- Each cabinet shall be provided with a fluorescent lighting fixture mounted on the inside top of the cabinet near the front edge. Fixture shall be provided with an F15T8, cool white lamp operated from a normal power factor UL or ETL listed ballast.
- The "On-Off" switch for the lighting fixture shall be either of the following:

  A. A toggle switch mounted on the inside door panel.
  B. A door-actuated switch that turns the light on when the door is open, and off when the door is closed.

86-3.05D Surge Arrestor

- The surge arrestor shall reduce the effects of power line voltage transients and shall have ratings as follows:

Recurrent peak voltage	184 V
Energy rating, maximum	20 J
Power dissipation, average	0.85-W
Peak current for pulses less than 7 µs	1,250 A

- Standby current shall be one milliampere or less for 60 Hz sinusoidal input.

86-3.05E Terminal Blocks

- Terminal blocks shall be rated 600 V (ac), minimum, and shall be provided with nickel, silver or cadmium plated brass binder head screw terminals.
- Heavy duty terminal blocks shall be rated at 20 A and shall be provided with 12 poles with No. 10 x $^{5}/_{16}$ inch nickel plated brass binder head screws and nickel plated brass inserts. Each pole position shall be provided with 2 terminal positions. The terminal blocks shall be the barrier type, with shorting bars in each of the 12 positions, and shall be provided with integral type marking strips.

- Light duty terminal blocks shall be rated at 5 A and shall be provided with 12 poles with No. 6 x 1/8 inch binder head screws. Each pole position shall be provided with one terminal position.

86-3.06 COMPONENTS

- Components used in the construction of control equipment for other than Type 90 and Model 170/2070 controllers shall conform to the following:

86-3.06A Toggle Switches

- Toggle switches shall have poles as required and shall be rated at 200 percent of circuit current for circuits of 10 A or less and 125 percent of circuit current for circuits over 10 A.
- Circuit breakers used as toggle switches shall be UL or ETL listed for switching operation.

86-3.06B Cartridge Fuses

- Cartridge fuses shall be installed in panel mounted fuseholders. Fuse type and rating shall be as recommended by the fuse manufacturer for the type of load being protected.

86-3.06C Circuit Breakers

- Circuit breakers shall conform to the provisions for circuit breakers in Section 86-2.11, "Service," except that the breakers shall have a minimum interrupting capacity of 5000 A, rms.

86-3.06D Connectors

- Connectors used for interconnecting various portions of circuits together shall be designed and constructed for the application involved. Connectors shall be designed to provide positive connection of all circuits, and easy insertion and removal of mating contacts. Connectors shall be permanently keyed to prevent improper connection of circuits.
- Connectors, or devices plugging into connectors, shall be provided with positive means to prevent any individual circuit from being broken due to vibration, pull on connecting cable or similar disruptive force.

86-3.07 ACCESSORIES

- Accessories shall be provided in the controller assemblies when shown on the plans or specified in the special provisions and shall conform to the following:

86-3.07A Telephone Bridge

- The telephone bridge shall meet the following requirements:

86-3.07A(1) General Description

- The dual 5-way active data bridge shall provide a 4-wire transmission interconnection between a dedicated common port and a number of multiple ports. The bridge shall provide four multiple ports. The bridge shall incorporate a splitter channel and a combiner channel. Multiple inputs shall be connected to a common output in the combiner channel and, in the splitter channel, a common input shall be connected to multiple outputs. Splitter and combiner shall be separate and independent, allowing operation in full-duplex data transmission applications.

- The active bridge shall provide front - panel - accessible potentiometers with continuous adjustment of cross - bridge gain or loss within two switch - selectable loss/gain ranges suitable for most data applications: -30 to -10 dB and -10 to +10 dB. Either range shall be independently selectable for each channel. The level to which each channel is adjusted shall be common to all cross-bridge port combinations in that channel (that is, if the splitter-channel potentiometer is set for +3 dB gain, all common-to-multiple-port paths in the splitter channel shall receive a +3 dB level increase).
- All ports of the bridge, both common and multiple, shall be characterized by a balanced 600 Ω terminating impedance. The module's active circuit shall allow unused multiple ports to be left unterminated without affecting the transmission response of the ports in use.
- Input, output and line monitor jacks on the front panel of the bridge shall allow isolated - module, isolated - facility, and cross - bridge measurement of transmission parameters in both the splitter and combiner channels.
- The bridge shall be powered from input voltage of -22 V to -56 V (dc) at a maximum current of 60 mA.
- Each dual 5-way active bridge unit shall be individually packaged in a housing. All circuitry shall be solid state, constructed on removable industry standard circuit boards with plug in edge connectors. All test jacks, edge connectors and external plug connectors shall be of a type and material suitable for use in the above stated environment without deterioration of electrical connection for the useful life of the equipment. The physical size of the case shall not exceed 225 cubic inches (approximately 7" x 8" x 4") and shall be suitable for mounting to the frame of a field cabinet. Mounting holes shall be provided for attaching the unit to one side of the frame of a relay rack.
- Input and output ports shall be provided for five full duplex telephone circuits with input and output ports labeled as to function. Level control, or switches and level adjustment potentiometers, along with the input and output level test jacks shall provide external adjustments without removal of the housing.

86-3.07A(2) Application

- The dual 5-way active data bridge shall be used to interconnect several 4-wire data modems to a common data channel or data link. The common data link is terminated at the distant end into a central processor unit (CPU) or computer that may time - sequentially poll various outlying or remote data terminals. A bridge shall be used to provide the central transmission arrangement, or "hubbing" network, that extends data transmission to the outlying terminals.
- Tandem bridge arrangements to expand the number of multiple ports of a 4-wire data hubbing network shall be effected by direct connection of one multiple port in each channel of the first bridge to the common port of the same channel of a second bridge to provide a 4-wire data bridge with one common and 7 multiple ports.

86-3.07A(3) Circuit Description

- The combiner channel of the dual 5-way active data bridge shall consist of a variable-gain integrated-circuit operational amplifier with an input summing

circuit. The summing circuit shall add the transmission energy from all multiple input ports at a low-impedance summing point to provide input port isolation. The output of the amplifier shall be connected to a transformer for balanced connection to the facility.

- The splitter channel shall consist of a transformer - input, variable - gain, integrated - circuit operational amplifier and a power amplifier. The output of the power transformer shall be a very low impedance and shall drive eight 300 Ω resistors to derive proper impedance at the multiple output circuits and provide isolation between output circuits.
- The multiple ports in the splitter and combiner channels of the bridge shall be isolated and balanced via an output transformer and matched precision resistors in each channel.

86-3.07A(3) Electrical Requirements

- Electrical requirements are as follows:

Splitter channel loss/gain	-30 to +10 dB usable range.
Combiner channel loss/gain	-30 to +10 dB usable range.
Maximum output level (overload point)	Splitter: +5 dBm. Combiner: +12 dBm.
Level change with loading	1 dB maximum, one port to all ports loaded.
Input port impedance	Splitter (multiple ports): 600 Ω balanced. Combiner (common port): 600 Ω balanced.
Output port impedance	Splitter (multiple ports): 600 Ω balanced. Combiner (common port): 600 Ω balanced.
Harmonic distortion	Splitter: less than one percent at +3 dBm. Combiner: less than one percent at +8 dBm.
Noise	20 dBm maximum.
Frequency response	±1dB re 1,000 Hz level, 300 to 5,000 Hz.
Delay distortion	Less than 75 µs, 400 to 3,000 Hz.
Cross-port coupling loss (crosstalk)	Greater than 55 dB.
Input power	-22 to -56 VDC, 60 mA maximum.
Operating environment	-7°C to 54°C, humidity to 95% (no condensation).
Mounting	One position.

86-3.07A(4) Testing and Troubleshooting

- Complete testing and troubleshooting instructions, circuit diagrams and pictorial component location and identification guides shall be provided with each unit.

86-4 TRAFFIC SIGNAL FACES AND FITTINGS

86-4.01 VEHICLE SIGNAL FACES

- Each vehicle signal face shall be of the adjustable type conforming to the requirements in Institute of Transportation Engineers (ITE) Publication: ST-017B, "Vehicle Traffic Control Signal Heads."
- Metal signal sections shall conform to the requirements of California Test 666. Any fracture within the housing assembly or a deflection of more than one-half the

lens diameter of the signal section during the wind load test will be considered structural failure.

- Plastic signal sections shall conform to the requirements of California Test 605. Any fracture within the housing assembly, or a deflection of more than 10 degrees in either the vertical or horizontal plane after the wind load has been removed from the front of the signal face, or a deflection of more than 6 degrees in either the vertical or horizontal plane after the wind load has been removed from the back of the signal face will be considered structural failure.
- Vehicle signal faces, except arrow and "X" faces, shall conform to the requirements of California Test 604.
- Adjustment shall permit rotation of 360 degrees about a vertical axis. The number and type of sections shall be as specified herein or as shown on the plans. Each vehicle signal face shall be installed at the location and mounted in the manner shown on the plans.
- Unless otherwise shown on the plans, all vehicle signal faces shall contain 3 sections arranged vertically; red-top, yellow-center, green-bottom.
- All new vehicle signal faces, except programmed visibility type, installed at any one intersection shall be of the same manufacture and of the same material.
- Top openings of signal faces shall be sealed with neoprene gaskets.

86-4.01A Optical Units

- Each optical unit for yellow and green sections shall consist of a lens, a reflector or reflector assembly, a lamp receptacle and a clear traffic signal lamp, conforming to the following:

A. Lenses, reflectors, reflector assemblies, lamp receptacles, lamps, wiring and light distribution shall conform to the requirements in ITE Publication: ST-017B.
B. Each lens shall be of best quality glass, true to color and free of imperfections.
C. All reflectors shall conform to the requirements in ITE Publication: ST-017B except that reflectors shall be made of silvered glass or of specular aluminum with an anodic coating. Reflector ring holder shall be made of cast aluminum.
D. A single piece formed metal reflector ring holder may be used.

- Each optical unit for red sections shall conform to the provisions in Section 86-4.02, "Light Emitting Diode Signal Module."

86-4.01B Signal Sections

- Each signal section housing shall be either die-cast or permanent mold-cast aluminum conforming to ITE Publication: ST-017B or, when specified in the special provisions, shall be structural plastic.
- Signal sections shall conform to the following:

A. Maximum height of a signal section shall be $10^1/_4$ inches for each 8-inch section and $14^3/_4$ inches for each 12-inch section.

B. The housing of each signal section shall be provided with a one-piece, hinged, square-shaped door designed to permit access to the section for relamping without the use of tools. The door shall be secured by a method that will hold the door closed during the loading tests specified in this section. The lens shall be mounted in the door in a watertight manner.

C. All exposed hardware, such as hinge pins and door latching devices, shall be Type 304 or 305 stainless steel. Interior screws and fittings shall be stainless steel or steel with a corrosion resistant plating or coating.

D. An opening shall be provided in the top and bottom of each signal section to receive $1^1/_2$-inch pipe. The 8-inch and 12-inch signal sections of an individual manufacturer shall be capable of joining to form a signal face in any combination. This interchangeability is not required between metal and plastic signal sections.

E. All gaskets, including those for the door, lens, reflector and lampholder, shall be made of a material that is not affected when installed in a signal section with a metal or plastic housing that is operated continuously for 336 hours.

86-4.01B(1) Metal Signal Sections

- Each metal signal section shall be provided with a metal visor. Metal signal faces which require backplates shall be provided with metal backplates.

86-4.01B(2) Plastic Signal Sections

- Housings shall be either molded in one piece or shall be fabricated from 2 or more pieces joined into a single piece. The plastic shall have ultraviolet stability, shall be unaffected by the heat of the lamp used and shall be self-extinguishing. Housings and doors shall be colored throughout and shall be black matching Color No. 17038, 27038 or 37038 of Federal Standard 595B.
- Each section in a face shall be joined to the adjacent section by one of the following methods:

A. A minimum of 3 machine screws for 8-inch sections and 4 machine screws for 12-inch sections, installed through holes near the front and rear of the housings. Machine screws shall be No. 10 and each shall be provided with a nut, flat washer and lock washer.

B. Two machine screws (each with a nut, flat washer and lock washer) installed through holes near the front of the housings, plus a fastening through the $1^1/_2$-inch pipe openings. The fastening shall consist of 2 large flat washers to distribute the load around the pipe opening and three carriage bolts, each with a nut and lock washer. Minimum size of the machine screws shall be No. 10. Minimum size of the carriage bolts shall be $^1/_4$ inch.

- The supporting section of each signal face supported solely at the top or bottom shall be provided with reinforcement.
- Reinforcement plates shall be either sheet aluminum, galvanized steel or cast aluminum. Each plate shall be not less than 0.110-inch thick and shall have a hole

concentric with the $1^1/_2$ inch pipe mounting hole in the housing. Sheet aluminum reinforcement plates shall be placed both inside and outside the housing; galvanized steel reinforcement plates shall be placed inside only; and cast aluminum reinforcement plates shall be placed outside only. Reinforcement plates placed outside of the housing shall be finished to match the color of the signal housing and shall be designed to permit the proper serrated coupling between signal face and mounting hardware. A minimum of three No. 10 machine screws shall be installed through holes in the plates and matching holes in the housing. Each screw shall have a round or binder head and shall be provided with a nut and lock washer.

- Where a signal face is to be supported by a Type MAS side attachment slip-fitter inserted between 2 sections, a spacer or spacers shall be placed between the 2 sections. The vertical dimension of spacers shall permit proper seating of the serrations between the slip-fitter and the 2 sections. Holes in spacers shall align with the front holes in the section housings. In addition to the fastening through the large openings in the housings, the 2 sections shall be joined with at least 2 machine screws through holes near the front of the housings and the spacers, and through matching holes in a reinforcing plate installed in each housing. Machine screws shall be No. 10 minimum size. Spacers shall be made of the same material as the signal housings. Reinforcing plates and machine screws shall be as specified above.
- Reinforcing plates will not be required where the housing is provided with reinforcing webs connecting the rear of the housing with the top, bottom and sides.
- Holes for machine screws shall be either cast or drilled during fabrication of the signal section. Each hole shall be surrounded by a $^1/_8$ inch minimum width boss to permit contact between signal sections about the axis of the hole.
- Each plastic signal face shall be provided with plastic or metal visors. Plastic signal faces which require backplates shall be provided with plastic backplates.
- A serrated nylon washer shall be inserted between each plastic signal section and a metal mounting assembly. Each washer shall be not less than $^3/_{16}$-inch nor more than $^1/_4$-inch thick. Serrations shall match those on the signal section and the mounting assembly.

86-4.01C Electrical Components

- Lamp receptacles and wiring shall conform to ITE Publication: ST-017B. The metal portion of the medium base lamp socket shall be brass, copper or phosphor bronze.
- Each lamp receptacle shall be wired with a conductor, connected to the shell of the receptacle, with white insulation, and a conductor, to the bottom or end terminal of the receptacle, with black insulation or with insulation color-coded.
- These conductors shall, in turn, be connected to a terminal block mounted inside at the back of the housing. The terminal block shall have sufficient screw type terminals or NEMA type tab connectors to terminate all field conductors and lamp conductors independently. The terminals to which field conductors are attached shall be permanently identified or conductors shall be color coded to facilitate field wiring.

- Lamp receptacle conductors shall be No. 18, or larger, 600-V, appliance wiring material (AWM), with 30-mil thickness insulation rated 105°C or with insulation that conforms to the requirements in Military Specification MIL-W-16878 D, Type B, with vinyl nylon jacket rated 115°C. The manufacturer's name or trademark, conductor size, insulation type letter designation and temperature rating shall be marked on the insulation or a Certificate of Compliance conforming to the provisions in Section 6-1.07, "Certificates of Compliance," shall be submitted by the manufacturer with each shipment of traffic signal faces.

86-4.01D Visors

- Each signal section shall be provided with a removable visor conforming to the requirements in ITE Publication: ST-017B. Visors are classified, on the basis of lens enclosure, as full circle, tunnel (bottom open), or cap (bottom and lower sides open). Unless otherwise specified, visors shall be the tunnel type.
- The visor shall be a minimum of $9^1/_2$ inches in length for nominal 12-inch round lenses and 7 inches in length for nominal 8-inch round lenses, with a downward tilt between 3 degrees and 7 degrees.
- Metal visors shall be made from 0.050-inch, minimum thickness, aluminum alloy sheets.
- Plastic visors shall conform to the following:

A. Visors shall be either formed from sheet plastic or assembled from one or more injection, rotational or blow molded plastic sections.
B. Sections shall be joined using thermal, chemical or ultrasonic bonding or with aluminum rivets and washers permanently colored to match the visor.
C. Visors shall be of black homogeneous colored material with a lusterless finish.

- Each visor shall be secured to its door in a manner that will prevent its removal or permanent deformation when the wind load specified in California Test 605 for plastic visors or 666 for metal visors is applied to the side of the visor for 24 hours.

86-4.02 LIGHT EMITTING DIODE SIGNAL MODULE

- The 12-inch red sections, the 8-inch red sections and the red arrow sections traffic signal faces shall utilize light emitting diode signal modules. Each light emitting diode signal module shall consist of an assembly that utilizes light emitting diodes as the light source. Each light emitting diode signal module shall be designed to be installed in the door frame of a standard traffic signal housing.
- Light emitting diode signal modules shall be from the same manufacturer and each size shall be the same model.
- Light emitting diode signal modules shall be sealed units with 2 conductors for connecting to power, a printed circuit board, a power supply, a red lens and gasket, and shall be weatherproof after installation and connection. The circuit board and power supply shall be contained inside the light emitting diode signal module. Circuit boards shall conform to Chapter 1, Section 6, of the "Transportation Electrical Equipment Specifications" published by the Department.

- Conductors for light emitting diode signal modules shall be 3 feet in length, with terminals attached, and shall conform to the provisions in Section 86-4.01C, "Electrical Components."
- Connections shall be to the terminal block in the signal face or shall utilize an adapter that screws into the medium base lamp socket. Contacts shall be brass. Splices will not be allowed.
- The lens of the light emitting diode signal module shall be integral to the unit, shall be convex with a smooth outer surface and shall be made of ultraviolet stabilized plastic or glass. The lens shall be capable of withstanding ultraviolet (UV) (direct sunlight) exposure for a minimum period of 48 months without exhibiting evidence of deterioration.
- The light emitting diode signal module shall be sealed in the door frame with a one-piece ethylene propylene rubber (EPDM) gasket.
- The light emitting diodes shall utilize Aluminum Indium Gallium Phosphate (AlInGap) technology and shall be the ultra bright type or equivalent rated for 100,000 hours of continuous operation from -40°C to +74°C.
- The individual light emitting diodes shall be wired such that physical damage or the failure of one light emitting diode will result in the loss of not more than 5 percent of the light emitting diode signal module light output.
- Maximum power consumption requirements for light emitting diode signal modules shall be as follows:

LED Signal Module	Power Consumption	
	25°C	74°C
12-inch Circular	25.0 W	30.0 W
8-inch Circular	15.0 W	18.0 W
12-inch Arrow	15.0 W	18.0 W

- Light emitting diode signal modules shall be rated for a minimum useful life of 48 months.

86-4.02A Physical and Mechanical Requirements

- Light emitting diode signal modules shall be designed as retrofit replacements for optical units of standard traffic signal sections and shall not require special tools for installation. Light emitting diode signal modules shall fit into existing traffic signal section housings built in conformance with the requirements in the Institute of Transportation Engineers (ITE) publication ST-017B, "Vehicle Traffic Control Signal Heads (VTCSH)" without modification to the housing.
- Installation of light emitting diode signal modules shall not require the removal of material in the traffic signal section except the optical unit components, that is, lens, gaskets, lamp, lamp socket and reflector. Installed light emitting diode signal modules shall fit securely in the door frame and shall be weathertight.
- Light emitting diode signal modules shall have a maximum weight of 4.4 pounds.
- The lens may be tinted or may use transparent film or materials with similar characteristics to enhance "ON/OFF" contrasts. The use of tinting or other

materials to enhance "ON/OFF" contrasts shall not affect chromaticity and shall be uniform across the face of the lens.

- If a polymeric lens is used, a surface coating or chemical surface treatment shall be used to provide front surface abrasion resistance.
- Light emitting diode signal modules shall be rated for use in the operating temperature range of -40°C to +74°C.
- Light emitting diode signal modules shall be protected against dust and moisture intrusion in conformance with the requirements in NEMA Standard 250 for Type 4 enclosures to protect the internal components.
- Light emitting diode signal modules shall be single, self-contained devices, not requiring on-site assembly for installation into existing traffic signal housing. The power supply for the light emitting diode signal module shall be integral to the unit.
- The light emitting diode signal module assembly shall be manufactured to withstand mechanical shock and vibration from high winds and other sources.
- Enclosures containing either the power supply or electronic components of light emitting diode signal modules shall be made of UL94VO flame retardant materials. The lens of the light emitting diode signal module is excluded from this specification.
- Each light emitting diode signal module shall have the manufacturer's name, trademark, model number, serial number, lot number and the month and year of manufacture permanently marked on the back of the light emitting diode signal module.
- The following operating characteristics shall be identified: rated voltage, power consumption and volt-ampere (VA).
- Each light emitting diode signal module shall have prominent and permanent vertical markings for correct indexing and orientation within a signal housing. The markings shall consist of an "UP" arrow, or the word "UP" or "TOP."

86-4.02B Photometric Requirements

- The minimum initial luminous intensity values for light emitting diode signal modules shall conform to the requirements in Section 11.04 of the Institute of Transportation Engineers (ITE) publication ST-017B, "Vehicle Traffic Control Signal Heads (VTCSH)" at 25°C.
- Light emitting diode signal modules shall meet or exceed 85 percent of the standard light output values specified in the VTCSH, after 48 months of continuous use over the temperature range of -40°C to +74°C in a traffic signal operation.
- The measured chromaticity coordinates of light emitting diode signal modules shall conform to the requirements for chromaticity in Section 8.04 and Figure 1 of the VTCSH over the temperature range of -40°C to +74°C.
- In addition to the specifications for circular light emitting diode signal modules, light emitting diode red arrow signal modules shall conform to the following:

The light emitting diode red arrow signal module indication shall conform to the requirements in Section 9.01 of the VTCSH for arrow lenses. The light emitting diodes shall be spread evenly across the illuminated portion of the arrow area. Each light emitting diode signal section indication shall provide an

average luminous intensity of 1,600 foot-lamberts. Measurements shall be performed at rated operating voltage of 120 V (ac).

86-4.02C Electrical

- Light emitting diode signal modules shall operate over a voltage range from 95 V (ac) to 135 V (ac) at a frequency of 60 Hz ±3 Hz. The light emitting diode circuitry shall prevent perceptible flicker over the specified voltage range. The fluctuations of line voltage shall have no visible effect on the luminous intensity of the indications. Rated voltage for the measurements shall be 120 V.
- Wiring and terminal blocks shall conform to the requirements in Section 13.02 of the VTCSH. Two secured, color coded, 600 V, 20 AWG minimum, jacketed wires, conforming to the National Electric Code, rated for service at or greater than 105°C, are to be provided for electrical connection for each light emitting diode signal module.
- The light emitting diode signal module on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients as specified in Section 2.1.6 of NEMA Standard TS2.
- Light emitting diode signal modules shall be operationally compatible with currently used controller assemblies (solid state load switches, flashers and conflict monitors).
- Light emitting diode signal modules and associated on-board circuitry shall meet Federal Communications Commission (FCC) Title 47, SubPart B, Section 15 regulations concerning the emission of electronic noise.
- Light emitting diode signal modules shall provide a power factor of 0.90 or greater while operating throughout the temperature range of -40°C to +74°C.
- Total harmonic distortion (current and voltage) induced into an AC power line by a light emitting diode signal module shall not exceed 20 percent while operating throughout the temperature range of -40°C to +74°C.

86-4.02D Testing

- The light emitting diode signal modules tested or submitted for testing shall be representative of typical average production units. Circular light emitting diode signal modules shall be tested in conformance with the requirements in California Test 604. Optical testing shall be performed with the light emitting diode signal module mounted in a standard traffic signal section but without a visor or hood attached to the signal section.

86-4.02D(1) Design Qualification Testing

- Design Qualification Testing shall be performed by the manufacturer on new light emitting diode signal module designs, and on an existing design when a major design change has been implemented.
- A quantity of 2 units for each design shall be submitted for Design Qualification Testing. Test units shall be submitted to the Transportation Laboratory, after the manufacturer's testing is complete.
- Manufacturer's test data shall be submitted with test units for Transportation Laboratory verification of Design Qualification Testing data.
- The sample light emitting diode signal modules shall be energized for a minimum of 24 hours, at 100 percent on-time duty cycle, at or greater than 74°C

before performing Design Qualification Testing. For Design Qualification Testing, parameters measured shall include but not be limited to:

A. The luminous intensity measurements shall be taken over the temperature range of -40°C to +74°C.
B. Color requirements shall be measured while operating throughout the temperature range of -40°C to +74°C.
C. Specified parameters shall be measured and used for quality comparison of Production Quality Assurance current measurement on production light emitting diode signal modules.
D. Light emitting diode signal modules shall be tested for compatibility with the controller unit, conflict monitor and load switch. Each light emitting diode signal module shall be connected to the output of a standard load switch connected to a voltage supply between the values of 95 V (ac) and 135 V (ac) with the input to the load switch in the "OFF" position. The voltage developed across each light emitting diode signal module so connected shall not exceed 10 V rms as the input AC voltage is varied from 95 V (ac) rms to 135 V (ac) rms.
E. Mechanical vibration testing shall conform to the requirements in Military Specification MIL-STD-883, Test Method 2007, using 3 four-minute cycles along each x, y and z axis, at a force of 2.5 Gs, with a frequency sweep from 2 Hz to 120 Hz. The loosening of the lens, of internal components or other physical damage shall be cause for rejection.
F. Temperature cycling shall be performed in conformance with the requirements in Military Specification MIL-STD-883, Test Method 1010. The temperature range shall be according to "Environmental Requirements." A minimum of 20 cycles shall be performed with a 30 minute transfer time between temperature extremes and a 30 minute dwell time at each temperature. Light emitting diode signal modules shall be tested under operating conditions. Failure of an light emitting diode signal module to function properly or evidence of cracking of the light emitting diode signal module lens or housing after temperature cycling shall be cause for rejection.
G. Moisture resistance testing shall be performed on light emitting diode signal modules in conformance with the requirements in NEMA Standard 250 for Type 4 enclosures. Evidence of internal moisture after testing shall be cause for rejection.

86-4.02D(2) Production Quality Control Testing

The following Production Quality Control tests shall be performed on each new light emitting diode signal module prior to shipment:

A. A single point measurement with a correlation to the intensity requirements of Section 1.04 of the VTCSH may be used.
The ambient temperature for this measurement shall be greater than 25°C.
B. Each light emitting diode signal module not meeting minimum luminous intensity requirements according to Table 1 of VTCSH for circular

indications, or 1,600 foot-lamberts for arrow indications shall be rejected. The manufacturer shall retain test results for 7 years.

- For the burn-in period, each light emitting diode signal module shall be energized at rated voltage for a 30 minute stabilization period before the measurement is made.
- Each light emitting diode signal module shall be tested for rated initial intensity after burn-in.
- Each light emitting diode signal module shall be tested for required power factor after burn-in.
- Each light emitting diode signal module shall be measured for current flow in amperes after burn-in. The measured current values shall be compared against rated values resulting from design qualification measurements under "Design Qualification Testing." The current flow shall not exceed the rated value. The measured ampere values with rated voltage shall be recorded as volt-ampere (VA) on the product labels.
- Each light emitting diode signal module shall be visually inspected for exterior physical damage or assembly anomalies. Careful attention shall be paid to the surface of the lens to ensure that no scratches, abrasions, cracks, chips, discoloration or other defects are apparent. Defects shall be cause for rejection.

86-4.02D(3) Production Quality Assurance Testing

- Production Quality Assurance Tests may be performed on each new light emitting diode signal module. The number of units tested (sample size) shall be determined by the quantity of each model in the shipment. The sample size shall conform to the requirements of American National Standard Institute/Acceptance Sampling in Quality Control, ANSI/ASQC Z1.4.
- The State will determine the sampling parameters to be used for the random sample testing.
- Specified parameters may be tested on the sample.
- Acceptance or rejection of the shipment shall conform to the requirements in ANSI/ASQC Z1.4 for shipments which are sampled randomly.
- Upon rejection of the shipment, the vendor shall arrange for pick-up of the shipment at no cost to the State.

86-4.02D(4) Certificate of Compliance

- The Contractor shall provide the Engineer with a Certificate of Compliance from the manufacturer in conformance with the provisions in Section 6-1.07, "Certificates of Compliance." The certificate shall certify that the light emitting diode signal modules comply with the requirements in these specifications. The certificate shall also include a copy of applicable test reports on the light emitting diode signal modules.

86-4.03 DIRECTIONAL LOUVERS

- Where shown on the plans, directional louvers shall be furnished and installed in signal visors. Directional louvers shall be so constructed as to have a snug fit in the signal visors. The outside cylinder shall be constructed of 0.030-inch nominal thickness, or thicker, sheet steel and the vanes shall be constructed of 0.016-inch

nominal thickness, or thicker, sheet steel or the cylinder and vanes shall be constructed of 5052-H32 aluminum alloy of equivalent thickness. Dimensions of louvers and arrangements of vanes shall be as shown on the plans.

86-4.04 BACKPLATES

- Where shown on the plans, backplates shall be furnished and installed on signal faces. Dimensions, materials and installation details shall be as shown on the plans.
- No background light shall show between the backplate and the signal face or between sections.
- Plastic backplates shall be either formed from sheet plastic or assembled from extruded, molded or cast sections. Sections shall be factory joined using (1) an appropriate solvent cement, (2) aluminum rivets and washers painted or permanently colored to match the backplate, or (3) No. 10 machine screws with washer, lock washer and nut, painted to match the backplate. Backplates shall be of black homogeneous colored material with a lusterless finish. Each plastic backplate shall be secured to the plastic signal face in a manner that will prevent its removal or permanent deformation when the wind-load test is applied to either the front or the rear of the signal face. The permanent deformation of any portion of the backplate shall not exceed 5 degrees forward or backward after the wind loading has been applied for 24 hours.
- When a plastic backplate requires field assembly, it shall be joined with at least four No. 10 machine screws at each field assembled joint. Each machine screw shall be provided with an integral or captive flat washer, a hexagonal head slotted for a standard screwdriver, and either (1) a locking nut with an integral or captive flat washer, or (2) a nut, flat washer and lockwasher. Machine screws, nuts and washers shall be stainless steel or steel with a zinc or black oxide finish.
- Where a metal backplate consists of 2 or more sections, the sections shall be fastened with rivets or with aluminum bolts peened after assembly to prevent loosening.
- In lieu of the screws shown on the plans, plastic backplates may be fastened to the plastic signal face using self-threading No. 10 steel screws. The screws shall have an integral or captive flat washer and a hexagon head slotted for a standard screwdriver, and shall be stainless steel or steel with a zinc or black oxide finish.

86-4.05 PROGRAMMED VISIBILITY VEHICLE SIGNAL FACES

- Each programmed visibility signal face and the installation thereof shall conform to the provisions in Sections 86-4.01, "Vehicle Signal Faces," 86-4.04, "Backplates," and 86-4.08, "Signal Mounting Assemblies," except that the provisions in Section 86-4.01A, "Optical Units," shall not apply.
- Each programmed visibility signal section shall provide a nominal 12-inch diameter circular or arrow indication. Color and arrow configuration shall conform to the requirements in ITE Publication: ST-017B.
- Each section shall be provided with a cap visor.
- Each signal section shall be provided with an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal while maintaining a common vertical axis through couplers and mountings.

Terminal connection shall permit external adjustment about the mounting axis in 5 degree increments.

- The signal shall be mountable with ordinary tools and capable of being serviced without tools. Adjustment shall be preset at 4 degrees below the horizontal, unless otherwise specified.
- The visibility of each programmed visibility signal face shall be capable of adjustment or programming within the face. When programmed, each signal face's indication shall be visible only in those areas or lanes to be controlled, except that during dusk and darkness a faint glow to each side will be permissible.
- Prior to programming, each signal section with a yellow indication shall provide a minimum luminous intensity of 2,500 cd on the optical axis, and a maximum intensity of 100 cd at 15 degrees horizontal from the axis. Each signal section with a yellow indication shall be capable of having its visibility programmed to achieve the following luminous intensities: a minimum of 2,500 cd on the optical axis, a maximum of 100 cd at from 0.5 to 2 degrees horizontal from the axis and a maximum of 10 cd at from 2 to 15 degrees horizontal from the axis. Under the same conditions, the intensities of the red indication and the green indication shall be at least 19 and 38 percent, respectively, of the yellow indication.
- Each signal face or each signal section shall include integral means for regulating its luminous intensity between limits in proportion to the individual background luminance. Lamp intensity shall not be less than 97 percent of uncontrolled intensity at 1,000 foot-candles, and shall reduce to 15 ±2 percent of maximum intensity at less than one foot-candle. The dimming device shall operate over an applied voltage range of 95 to 130 V, 60 Hz and a temperature range of -40°C to 74°C.
- The Contractor shall program the head as recommended by the manufacturer and as directed by the Engineer.

86-4.06 PEDESTRIAN SIGNAL FACES

- Message symbols for pedestrian signal faces_shall be white WALKING PERSON and Portland orange UPRAISED HAND conforming to the requirements in the Institute of Transportation Engineers Standards: "Pedestrian Traffic Control Signal Indications," "Manual on Uniform Traffic Control Devices," and "MUTCD California Supplement." The height of each symbol shall be not less than 10 inches and the width of each symbol shall be not less than $6^1/_2$ inches.
- The luminance of the UPRAISED HAND symbol shall be 1,100 foot-lamberts, minimum, and the luminance of the WALKING PERSON symbol shall be 1,550 foot-lamberts, minimum, when tested in conformance with the requirements in California Test 606.
- The uniformity ratio of an illuminated symbol shall not exceed 4 to 1 between the highest luminance area and the lowest luminance area.
- The luminance difference between a nonilluminated symbol and the background around the symbol shall be less than 30 percent when viewed with the visor and front screen in place and at a low sun angle.
- Brightness measurements for signals designed for an incandescent lamp will be made when the signal is equipped with an A-21 traffic signal lamp operated at a voltage to produce 665 lm.

- Each housing, including the front screen, shall have maximum overall dimensions of $18^1/_2$ inches width, 19 inches height, and $11^1/_2$ inches depth.
- All new pedestrian signal faces installed at any one intersection shall be the same make and type.
- Each pedestrian signal face shall be installed at the location and mounted in the manner shown on the plans.

86-4.06A Types

- Pedestrian signal faces shall be Type A unless otherwise specified and shall conform to the following:

A. Each Type A signal shall consist of a housing, two-color message plate, a reflector assembly, one incandescent lamp and one Light Emitting Diode Module conforming to the provisions in Section 86-4.07, "Light Emitting Diode Pedestrian Signal Face 'Upraised Hand' Module," with sockets and a front screen.

B. Each message plate shall be one piece and shall be made of $^1/_8$ inch minimum thickness, ultraviolet stabilized polycarbonate plastic or $^3/_{16}$ inch tempered glass. The symbols shall be applied to the inside smooth surface of the message plate.

C. Each reflector assembly shall consist of a double reflector or 2 single reflectors. Each reflector shall be made of either aluminum or plastic. Reflectors shall conform to the requirements in Institute of Transportation Engineers Publication: ST-017B, "Vehicle Traffic Control Signal Heads." Plastic reflectors shall consist of molded or vacuum-formed plastic with a vacuum-deposited aluminum reflecting surface. The plastic material shall not distort when the reflector is used with the lamp of the wattage normally furnished with the signal. In addition, the UL nonmechanical loading temperature of the material shall exceed, by at least 10°C, the maximum temperature in the signal section with the lamp "ON" and measured in an ambient air temperature of 25°C in conformance with the requirements in UL Publication UL 746B. Each completed reflector shall, when operated with the appropriate lamp and lens, provide the message brightness specified.

86-4.06B Front Screen

- One of the following types of front screen shall be provided on each Type A signal:

A. An aluminum honeycomb screen with 0.2-inch cells, $^3/_8$ inch thick or a plastic screen of $^3/_8$ inch squares, $^1/_2$ inch thick with wall thickness of $^1/_{16}$ inch shall be installed tilting downward, at an angle of 15 ±2 degrees out from the top. The screen shall completely cover the message plate. The screen shall have a clear front cover of $^1/_8$ inch minimum thickness acrylic plastic sheet or $^1/_{16}$ inch minimum thickness polycarbonate plastic.

Screen and cover shall be held firmly in place by the use of stainless steel or aluminum clips or stainless steel metal screws.

B. A $1^1/_2$-inch deep eggcrate or Z-crate type screen of $^1/_{32}$-inch nominal thickness polycarbonate. The screening shall be mounted in a frame constructed of 0.040-inch minimum thickness aluminum alloy or polycarbonate. The screen shall be installed parallel to the face of the message plate and shall be held in place by the use of stainless steel screws. The visor described in Section 86-4.06D, "Visors," is not required with this type screen.

- The front screen shall not fracture, separate at the welds or compress more than $^1/_8$ inch when a 3-inch diameter, 4-pound steel ball is dropped onto the screen from a height of 4 feet above the screen. The screen will be lying in a horizontal position and supported on its edges for this test. The message plate will be removed from the pedestrian signal housing, when the pedestrian housing is used to support the front screen during the test, so there will be no back support for the screen.
- The screen and frame shall be fabricated from aluminum anodized flat black, or finished with lusterless black exterior grade latex paint formulated for application to properly prepared metal surfaces, or shall be fabricated from flat black plastic.
- Alternate methods of screening may be substituted for the above screens provided that the results are at least equal to those obtained with the above specified screens as determined by the Engineer.

86-4.06C Housing

- Pedestrian signal housings shall conform to the provisions in Section 86-4.01B, "Signal Sections."

86-4.06D Visors

- The visor shall be of a material similar to the housing. The top of the visor shall extend a minimum length of 6 inches at the top and 5 inches at the bottom when measured from the front surface of the line. The front shall be normal to the top.

86-4.06E Finish

- The exterior of each housing and visor and the interior of visors shall be painted in conformance with the provisions in Section 86-2.16, "Painting."

86-4.06F Control

- All pedestrian signals shall be capable of being controlled by the solid-state switching devices specified for traffic signal controller assemblies.

86-4.06G Terminal Blocks

- Each pedestrian signal face shall be provided with a light duty terminal block conforming to the provisions in Section 86-4.01C, "Electrical Components."
- All field wiring shall connect to this terminal block.

86-4.07 LIGHT EMITTING DIODE PEDESTRIAN SIGNAL FACE "UPRAISED HAND" MODULE

- The pedestrian signal face "Upraised Hand" section shall utilize a light emitting diode (LED) module.
- Each light emitting diode pedestrian signal module shall consist of an assembly that utilizes light emitting diodes as the light source for pedestrian signal faces in lieu of an incandescent lamp.
- Light emitting diode pedestrian signal modules shall be designed to mount in the standard lamp socket of an existing Type A pedestrian signal housing. The installation of a light emitting diode pedestrian signal module shall not require modification to the standard lamp socket or reflector.
- Light emitting diode pedestrian signal modules shall be from the same manufacturer.
- The circuit board and power supply shall be integral to the unit. Printed circuit boards shall conform to Chapter 1, Section 6 of the "Transportation Electrical Equipment Specifications" published by the State of California, Department of Transportation.
- Light emitting diode pedestrian signal modules shall not require a specific mounting orientation or have a variance in light output, pattern or visibility for any mounting orientation.
- The light emitting diodes shall utilize Aluminum Indium Gallium Phosphate (AlInGAP) technology and shall be the ultra bright type or equivalent rated for 100,000 hours of continuous operation from -40°C to +74°C.
- The individual light emitting diodes shall be wired such that physical damage or the failure of one light emitting diode will result in the loss of not more than 5 percent of the pedestrian signal modules light output.
- Maximum power consumption requirements for light emitting diode pedestrian signal modules shall be 15.0 W at 25°C and 18.0 W at 74°C.
- The luminance of the "UPRAISED HAND" symbol shall be 1,100 foot-lamberts minimum. The color of "UPRAISED HAND" shall be Portland orange conforming to the requirements of the Institute of Transportation Engineers Standards: "Pedestrian Traffic Control Signal Indications," "Manual on Uniform Traffic Control Devices," and "MUTCD California Supplement." The height of each symbol shall be not less than 10 inches and the width of each symbol shall be not less than $6^1/_2$ inches.
- The uniformity ratio of an illuminated symbol shall not exceed 4 to 1 between the highest luminance area and the lowest luminance area.
- Light emitting diode pedestrian signal modules shall be rated for a minimum useful life of 48 months.

86-4.07A Physical and Mechanical Requirements

- Light emitting diode pedestrian signal modules shall be designed as retrofit replacements for existing optical units and shall not require special tools for installation. Light emitting diode pedestrian signal modules shall fit into existing pedestrian signal face housings built according to the specifications of "Vehicle Traffic Control Signal Heads (VTCSH)" without modification to the housing.

- Installation of light emitting diode pedestrian signal modules shall only require removal of the lamp.
- Light emitting diode pedestrian signal modules shall be rated for use in the operating temperature range of -40°C to +74°C.
- Light emitting diode pedestrian signal modules shall be single, self-contained devices, not requiring on-site assembly for installation into an existing Type A Housing. The power supply for light emitting diode pedestrian signal modules shall be integral to the unit.
- Light emitting diode pedestrian signal modules shall be manufactured to withstand mechanical shock and vibration from high winds and other sources.
- Enclosures containing either the power supply or electronic components of light emitting diode pedestrian signal modules shall be made of UL94VO flame retardant materials.
- Each light emitting diode pedestrian signal module shall have the manufacturer's name, trademark, model number, serial number, lot number and the month and year of manufacture permanently marked on the back of the module.
- The following operating characteristics shall be identified: rated voltage, power consumption and volt-ampere (VA).

86-4.07B Photometric Requirements

- The minimum initial luminous intensity values for light emitting diode pedestrian signal modules shall be 1,100 foot-lamberts.
- Light emitting diode pedestrian signal modules shall meet or exceed 85 percent of 1,100 foot-lamberts after 48 months of continuous use over the temperature range of -40°C to +74°C in a traffic signal operation.
- The measured chromaticity coordinates of light emitting diode pedestrian signal modules shall conform to the chromaticity requirements in Section 5.3.2.1 and Figure C of the VTCSH while operating throughout the temperature range of -40°C to +74°C.

86-4.07C Electrical

- Light emitting diode pedestrian signal modules shall operate at a frequency of 60 Hz ±3 Hz over a voltage ranging from 95 V (ac) to 135 V (ac). The circuitry of light emitting diode pedestrian signal modules shall prevent perceptible flicker over the voltage range specified above. The fluctuations of line voltage shall have no visible effect on the luminous intensity of the indications. Rated voltage for the measurements shall be 120 V.
- On-board circuitry of the light emitting diode pedestrian signal modules shall include voltage surge protection to withstand high-repetition noise transients as stated in Section 2.1.6 of NEMA Standard TS2.
- Light emitting diode pedestrian signal modules shall be operationally compatible with currently used controller assemblies (solid state load switches, flashers and conflict monitors).
- Light emitting diode pedestrian signal modules and associated on-board circuitry shall meet Federal Communications Commission (FCC) Title 47, SubPart B, Section 15 regulations concerning the emission of electronic noise.

- Light emitting diode pedestrian signal modules shall provide a power factor of 0.90 or greater while operating throughout the temperature range of -40°C to +74°C.
- Total harmonic distortion (current and voltage) induced into an AC power line by light emitting diode pedestrian signal modules shall not exceed 20 percent while operating throughout the temperature range of -40°C to +74°C.

86-4.07D Testing

- The light emitting diode pedestrian signal modules tested or submitted for testing shall be representative of typical average production units. Modules shall be tested in conformance with the requirements in California Test 606. Optical testing shall be performed with the module mounted in a Type A Housing but without a visor or hood attached to the housing.

86-4.07D(1) Design Qualification Testing

- Design Qualification Testing shall be performed by the manufacturer on new light emitting diode pedestrian signal module designs, and on an existing design when a major design change has been implemented.
- A quantity of 2 units for each design shall be submitted for Design Qualification Testing. Test units shall be submitted to the Transportation Laboratory, after manufacturer's testing is complete.
- Manufacturer's test data shall be submitted with test units for Transportation Laboratory verification of Design Qualification Testing data.
- The sample light emitting diode pedestrian signal modules shall be energized for a minimum of 24 hours, at 100 percent on-time duty cycle, at or greater than 74°C before performing Design Qualification Testing. For Design Qualification Testing, specifications measured shall include but not be limited to:

A. The luminous intensity measurements shall be taken over the temperature range of -40°C to +74°C.
B. Color requirements shall be measured while operating throughout the temperature range of -40°C to +74°C.
C. Specified parameters shall be measured and used for quality comparison of Production Quality Assurance current measurement on production modules.
D. Modules shall be tested for compatibility with the controller unit, conflict monitor and load switch. Each module shall be connected to the output of a standard load switch connected to a voltage supply between the values of 95 V (ac) and 135 V (ac). The voltage developed across each module so connected shall not exceed 10 V rms as the input voltage is varied from 95 V (ac) rms to 135 V (ac) rms.
E. Mechanical vibration testing shall be in conformance with the requirements in Military Specification MIL-STD-883, Test Method 2007, using three 4-minute cycles along each x, y and z axis, at a force of 2.5 Gs, with a frequency sweep from 2 Hz to 120 Hz. The loosening of the lens or of internal components, or other physical damage shall be cause for rejection.

F. Temperature cycling shall be performed in conformance with the requirements in Military Specification MIL-STD-883, Test Method 1010. The temperature range shall be according to "Environmental Requirements." A minimum of 20 cycles shall be performed with a 30 minute transfer time between temperature extremes and a 30 minute dwell time at each temperature. Modules under test shall be tested under operating conditions. Failure of a module to function properly or evidence of cracking of the module lens or housing after temperature cycling shall be cause for rejection.

G. Moisture resistance testing shall be performed on modules mounted in a standard pedestrian signal housing in conformance to the requirements in NEMA Standard 250 for Type 4 enclosures. Evidence of internal moisture after testing shall be cause for rejection.

86-4.07D(2) Production Quality Control Testing

- The following Production Quality Control tests shall be performed on each new light emitting diode pedestrian signal module prior to shipment:

A. The ambient temperature for this measurement shall be greater than 25°C.

B. Each module not meeting minimum luminous intensity of 1,100 foot-lamberts shall be cause for rejection.

- The light emitting diode pedestrian signal modules tested or submitted for testing shall be representative of typical average production units. The manufacturer shall retain test results for 7 years.
- For the burn-in period, each light emitting diode pedestrian signal module shall be energized at rated voltage for a 30 minute stabilization period before the measurement is made.
- After burn-in, each light emitting diode pedestrian signal module shall be tested for rated initial intensity and for required power factor.
- Each light emitting diode pedestrian signal module shall be measured for current flow in amperes after burn-in. The measured current values shall be compared against rated values resulting from design qualification measurements under "Design Qualification Testing." The current flow shall not exceed the rated value. The measured ampere values with rated voltage shall be recorded as volt-ampere (VA) on the product labels.
- Each light emitting diode pedestrian signal module shall be visually inspected for exterior physical damage or assembly anomalies. Defects shall be cause for rejection.

86-4.07D(3) Production Quality Assurance Testing

- Production quality assurance testing may be performed on each new light emitting diode pedestrian signal module.
- The number of units tested (sample size) shall be determined by the quantity of each model in the shipment. The sample size shall conform to the requirements in American National Standard Institute/Acceptance Sampling in Quality Control, ANSI/ASQC Z1.4.

- The State will determine the sampling parameters to be used for the random sample testing.
- Specified parameters may be tested on the sample.
- Acceptance or rejection of the shipment shall conform to the requirements in ANSI/ASQC Z1.4 for shipments which are sampled randomly.
- Upon rejection of the shipment, the vendor shall arrange for pick-up of the shipment at no cost to the State.

86-4.07D(4) Certificate of Compliance

- The Contractor shall provide the Engineer with a Certificate of Compliance from the manufacturer in conformance with the provisions in Section 6-1.07, "Certificates of Compliance." The certificate shall certify that the light emitting diode pedestrian signal modules comply with the requirements of these specifications. The certificate shall also include a copy of applicable test reports on the modules.

86-4.08 SIGNAL MOUNTING ASSEMBLIES

- Signal mounting assemblies shall consist of $1^1/_2$-inch standard steel pipe or galvanized conduit, necessary fittings, slip-fitters and terminal compartments. Pipe fittings shall be ductile iron, galvanized steel, aluminum alloy Type AC-84B No. 380 or bronze. Mast arm slip-fitters, post top slip-fitters and terminal compartments shall be cast bronze or hot-dip galvanized ductile iron. After installation, any exposed threads of galvanized conduit brackets and areas of the brackets damaged by wrench or vise jaws shall be cleaned with a wire brush and painted with 2 applications of approved unthinned zinc-rich primer (organic vehicle type) conforming to the requirements in Section 91, "Paint." Aerosol cans shall not be used.
- Each terminal compartment shall be fitted with a terminal block containing a minimum of 12 poles, each with 2 screw type terminals. Each terminal shall be designed to accommodate at least five No. 14 conductors. A cover shall be provided on the compartment to give ready access to the terminal block. Where used to bracket mount signals, the terminal compartment shall be designed to bolt securely to a pole or standard.
- The horizontal dimension of mounting assembly members between the vertical centerline of the terminal compartment or slip-fitter and the vertical centerline of each signal face shall not exceed 11 inches, except where required to provide proper signal face alignment or permit programming of programmed visibility signal faces or when otherwise directed by the Engineer.
- Each mounting assembly shall be oriented to provide maximum horizontal clearance to the adjacent roadway.
- Mounting assembly members shall be either plumb or level, symmetrically arranged and securely assembled. Construction shall be such as to permit all conductors to be concealed.
- Mounting assemblies shall be watertight and free of sharp edges or protrusions which might damage conductor insulation.
- For post-top mounting of signals, a slip-fitter shall be used. The slip-fitter shall fit over a $4^1/_2$-inch outside diameter pipe or tapered standard end. Each

slip-fitter shall be provided with cadmium-plated steel set screws, arranged as shown on the plans. Each slip-fitter used to post-top mount signals with brackets shall be provided with an integral terminal compartment.

- Each mounting assembly shall be provided with positive locking, serrated fittings which, when mated with similar fittings on the signal faces shall prevent faces from rotating. Fittings shall permit fastening at increments of not more than 7 degrees.
- Signal faces shall not be installed at any intersection until all other signal equipment, including the complete controller assembly, is in place and ready for operation at that intersection, except that the signal faces may be mounted if they are not directed toward traffic or if they are covered.

86-4.09 FLASHING BEACONS

- Each beacon shall consist of a single section traffic signal face, conforming to the provisions in Section 86-4.01, "Vehicle Signal Faces," with yellow or red lens as shown on the plans.
- The beacon flasher unit shall be independent of the intersection flasher unit.

86-4.09A Backplates

- Each beacon shall be provided with a backplate conforming to the provisions in Section 86-4.04, "Backplates."

86-4.09B Visors

- Each beacon shall be provided with a full circle type visor conforming to the provisions in Section 86-4.01D, "Visors."

86-4.09C Flashing Beacon Control Assembly

- Each flashing beacon control assembly shall consist of switches, circuit breakers, terminal blocks, flasher, dimming relay, wiring and electrical components necessary to provide proper operation of the beacons, all housed in a single enclosure.

86-4.09C(1) Enclosure

- The enclosure shall be NEMA Type 3R, and shall be provided with dead front panel and a hasp to permit padlocking of the cover. The padlock will be furnished by others.
- The enclosure shall be hot-dip galvanized or, at the option of the Contractor, shall be provided with a factory applied rust resistant prime coat and finish coat.

86-4.09C(2) Circuit Breakers and Switches

- A 15-A circuit breaker shall be installed to control each ungrounded conductor entering the enclosure.
- A switch to permit manual operation of the sign lighting circuit shall be provided. Switches shall be of the single-hole-mounting toggle type, single-pole, single-throw, rated at 12 A, 120 V. Switches shall be furnished with an indicating nameplate reading "Auto - Test" and shall be connected in parallel with the load contacts of the photoelectric control circuit. A 15-A circuit breaker may be used in place of the toggle switch.

86-4.09C(3) Flasher

- The flasher shall conform to the requirements in Section 8, "Solid-State Flashers," of NEMA Standards Publication No. TS 1.
- The flasher shall be a solid-state device with no contact points or moving parts.
- The flasher shall provide 2 output circuits to permit alternate flashing of signal faces and shall be capable of carrying a minimum of 10 A per circuit at 120 V.

86-4.09C(4) Wiring

- Conductors and wiring in the enclosure shall conform to the provisions in Section 86-3.04C, "Cabinet Wiring."

86-4.09C(5) Terminal Blocks

- Terminal blocks shall be rated at 25 A, 600 V, shall be molded from phenolic or nylon material and shall be the barrier type with plated brass screw terminals and integral type marking strips.

86-4.09C(6) Dimming Relay

- A heavy duty dimming relay shall be provided to reduce the voltage to the lamps at night.
- Heavy duty relays shall be designed for continuous duty. Relays shall operate during ambient temperatures from -18°C to 71°C. Each relay shall operate in the 8-pin Jones-type socket shown on the plans.
- Relays shall be provided with double-pole, double-throw contacts. Contact points shall be of fine silver, silver-alloy or superior alternative material. Contact points and contact arms shall be capable of operation for 250,000 cycles with 20 A of tungsten load per contact at 120 V (ac), 60 Hz.
- Coils shall have a power consumption of 10 VA or less and shall be designed for continuous duty on 120 V (ac).
- Heavy duty relays shall be enclosed with a removable, clear plastic cover.

86-5 DETECTORS

86-5.01 VEHICLE DETECTORS

- Vehicle detectors shall be the type or types shown on the plans.
- All sensor units, control units and amplifiers shall conform to the provisions for the TEES as specified in Section 86-3.03, "Model 170 and Model 2070 Controller Assemblies." The units shall not be affected by transient voltages when tested in conformance with the requirements in California Test 667.
- After a power interruption the units shall return to normal operation within one minute.
- Each unit shall be provided with a light or meter, for each output circuit, to indicate when the detector is detecting a vehicle.
- Each detector shall operate over the range of voltages from 100 V to 135 V at 60 Hz.
- Circuitry shall be solid-state except relays with normally closed contacts may be used for the output circuit.
- Units shall be designed to provide ease of maintenance with easily accessible electronic components.

- Each detector shall provide vehicle detection without readjustment from -18°C to 71°C.
- Units shall use printed circuit boards designed to facilitate identification of components. This shall be done by either part identification markings or by providing a pictorial diagram showing physical location and identification of each component. Each printed circuit board shall have the following minimum quality requirements: NEMA FR-4 glass cloth base epoxy resin board, $^{1}/_{16}$ inch minimum thickness, organic solder masking and gold plated contacts.
- Intercomponent wiring shall be copper track with a minimum weight of 2 ounces per square foot. Printed circuit design shall be such that components may be removed and replaced without permanent damage to boards or tracks.
- Splices shall conform to the provisions in Section 86-2.09, "Wiring."

86-5.01A Inductive Loop Detectors

- Inductive loop detectors shall conform to the following:

86-5.01A(1) General

- The term "inductive loop detector" applies to a complete installation consisting of a loop or group of loops installed in the roadway, as shown on the plans, lead-in cable and a sensor unit with power supply installed in a controller cabinet.

86-5.01A(2) (Blank)

86-5.01A(3) Sensor Unit Construction

- "Card" type sensor units shall conform to the requirements in "Traffic Signal Control Equipment Specifications," issued by the Department, and to all addenda thereto current at the time of project advertising. Shelf mounted sensor units shall conform to the requirements in Section 11 of the NEMA Standards Publication No. TS 1.
- Capacitors or inductors necessary for loop tuning shall not be mounted external to the sensor unit.

86-5.01A(4) Construction Materials

- Conductor for each inductive loop detector shall be continuous and unspliced and shall conform to one of the following:

A. Type 1 loop wire shall be Type RHW-USE neoprene-jacketed or Type USE cross-linked polyethylene insulated, No. 12, stranded copper wire. The minimum insulation thickness at any point shall be 40 mils.
B. Type 2 loop wire shall consist of a conductor inside of plastic tubing. The conductor shall be Type THWN or Type XHHW, No. 14, stranded copper wire. The tubing shall be polyethylene or vinyl, rated for use at 105°C, and shall be resistant to oil and gasoline. The tubing shall have a maximum outside diameter of 0.27-inch and a minimum wall thickness of 0.028-inch. The conductors shall not be spliced inside the tubing.

- Conductors for loop detector lead-in cable shall be two No. 16 (19 x 29) stranded tinned copper. Loop detector lead-in cable shall conform to the calculated

cross sectional area of ASTM Designation: B 286, Table 1. The lead-in cable shall conform to one of the following:

A. Type B lead-in cable shall be insulated with 20 mils of high-density polyethylene. The conductors shall be twisted together with at least 2 turns per foot and the twisted pair shall be protected with a copper or aluminum polyester shield. A No. 20, minimum, copper drain wire shall be provided and connected to the equipment ground within the cabinet. The cable shall be provided with a high-density polyethylene or high-density polypropylene outer jacket with a nominal thickness of 32 mils. An amorphous interior moisture penetration barrier of nonhydroscopic polyethylene or polypropylene fillers shall be provided.
B. Type C lead-in cable shall conform to the requirements in International Municipal Signal Association (IMSA) Specification No. 50-2. A No. 20, minimum, copper drain wire shall be provided and connected to the equipment ground within the cabinet.

86-5.01A(5) Installation Details

- Installation and tests shall conform to the details and notes shown on the plans.
- Unless shown otherwise, each loop shall consist of 3 turns of conductor as specified in Section 86-5.01A(4), "Construction Materials."
- Slots cut in the pavement shall be washed clean, blown out and thoroughly dried before installing conductors. Residue resulting from slot cutting operations shall not be permitted to flow across shoulders or lanes occupied by public traffic and shall be removed from the pavement surface by vacuuming or other approved method before any residue flows off of the pavement surface. Residue from slot cutting operations shall be disposed of outside the highway right of way in conformance with the provisions in Section 7-1.13.
- After conductors are installed in the slots cut in the pavement, the slots shall be filled with sealant to within 1/8 inch of the pavement surface. The sealant shall be at least one inch thick above the top conductor in the saw cut. Before setting, surplus sealant shall be removed from the adjacent road surfaces without the use of solvents.
- The sealant for filling slots shall conform to one of the following:

Elastomeric Sealant

- Elastomeric sealant shall be a polyurethane material of a composition that will, within its stated shelf life, cure only in the presence of moisture. Sealant shall be suitable for use in both asphalt concrete and portland cement concrete.

- The cured sealant shall have the following performance characteristics:

Specification	ASTM Designation	Requirement
Hardness (indentation) at 25°C & 50% relative humidity. (Type A, Model 1700 only)	D 2240 Rex.	65-85
Tensile Strength: pulled at 508 mm per minute	D 412 Die C	3.45 MPa, min.
Elongation: pulled at 508 mm per minute	D 412 Die C	400%, min.
Flex at -40°C: 0.6-mm Free Film Bend (180°) over 13-mm Mandrel	—	No cracks
Weathering Resistance: Weatherometer 350 h cured 7 days at 25°C @ 50% relative humidity	D 822	Slight chalking
Salt Spray Resistance: 28 days at 38°C with 5% NaCl, Die C & pulled at 508 mm per minute	B 117	3.45 MPa, min. tensile 400%, min. elongation
Dielectric Constant over a temperature range of -30°C to 50°C	D 150	Less than 25% change

Asphaltic Emulsion Sealant

- Asphaltic emulsion sealant shall conform to the requirements in State Specification 8040-41A-15 and shall be used only for filling slots in asphalt concrete pavement. This material shall not be used in slots which exceed 5/8 inch in width or where the slope causes the material to run from the slot. The material shall not be thinned in excess of the manufacturer's recommendations and shall not be placed when the air temperature is less than 7°C.

Hot-Melt Rubberized Asphalt Sealant

- Hot-melt rubberized asphalt shall be in solid form at room temperature and fluid at an application temperature of 190°C to 205°C. Fumes from the material shall be non-toxic. Sealant shall be suitable for use in both asphalt concrete and portland cement concrete.
- Performance characteristics of the cured hot-melt rubberized asphalt shall be as follows:

Specification	ASTM Designation	Requirement
Cone Penetration, 25°C, 150 g, 5 s	D 5329, Sec. 6	3.5 mm, max.
Flow, 60°C	D 5329, Sec. 8	5 mm, max.
Resilience, 25°C	D 5329, Sec. 12	25%, min.
Softening Point	D 36	82°C, min.
Ductility, 25°C, 50 mm/min	D 113	300 mm, min.
Flash Point, COC, °C	D 92	288°C, min.
Viscosity, Brookfield Thermosel, No. 27 Spindle, 20 rpm, 190°C	D 4402	2.5-3.5 Pa·s

- The hot-melt rubberized asphalt shall be melted in a jacketed, double boiler type melting unit. Temperature of the heat transfer medium shall not exceed 245°C.
- Application of the hot-melt sealant shall be made with a pressure feed applicator or pour pot. Sealant shall be applied when the pavement surface temperature is greater than 4°C.

- Hot-melt sealant shall be packaged in containers clearly marked "Detector Loop Sealant" and specifying the batch and lot number of the manufacturer.
- Loop conductors shall be installed without splices and shall terminate in the nearest pull box. In addition to the requirements for splices in detector circuits, the open end of cable jackets or tubing shall be sealed in a manner similar to the splicing requirements to prevent the entrance of water. The loops shall be joined in the pull box in combination of series and parallel so that optimum sensitivity is obtained at the sensor unit. Final splices between loops and lead-in cable shall not be made until the operation of the loops under actual traffic conditions is approved by the Engineer.
- All loop conductors for each direction of travel for the same phase of a traffic signal system, in the same pull box, shall be spliced to a detector lead-in cable which shall be run from the pull box adjacent to the loop detector to a sensor unit mounted in the controller cabinet.
- All loop conductors for traffic monitoring shall terminate in a pull box or terminal strip in the traffic monitor station cabinet when a cabinet of that type is installed.
- Conductors for inductive loop traffic signal and traffic monitoring installations shall be identified and banded, in pairs, by lane, in the pull box adjacent to the loops and near the termination of the conductors in the controller or traffic monitoring station cabinet. Bands shall conform to the provisions in Section 86-2.09, "Wiring."
- If asphalt concrete surfacing is to be placed, the loop conductors shall be installed prior to placing the uppermost layer of asphalt concrete. The conductors shall be installed, as shown on the plans, in the compacted layer of asphalt concrete immediately below the uppermost layer. Installation details shall be as shown on the plans, except the sealant shall fill the slot flush to the surface.

86-5.01B (Blank)

86-5.01C Magnetic Detectors

- Magnetic detectors shall conform to the following:

86-5.01C(1) General

- The term "magnetic detector" applies to a complete installation consisting of a sensing element or group of sensing elements installed in the roadway as shown on the plans, lead-in cable and an amplifier with integral power supply installed in a controller cabinet.
- Each magnetic detector amplifier shall be a low noise, high gain amplifier designed for use with all types of magnetic detector sensing units as used by the State of California. Sensitivity of units shall be readily adjustable by a knob on the front panel. An indicator light shall be provided to indicate detector operation.
- The sensing elements shall be no larger than $2^1/_4$ inches in diameter and shall contain no moving parts or transistors. The element casing shall be constructed of non-ferrous materials suitable for use in the environment in which it will operate, and shall be sealed to prevent the entrance of moisture. The element shall be shaped to facilitate pushing into conduit and shall not have any sharp edges along its length. The overall length of the sensing element shall not exceed 21 inches.

- Magnetic detector sensing elements and amplifiers to be installed at any one intersection or any one traffic count station shall be of the same make and type.

86-5.01C(2) Performance Characteristics

- Each magnetic detector shall be capable of being activated by a voltage induced in the coil of the sensing element by the passage of a vehicle at any speed from 3 mph to 80 mph. Any vehicle passing within 18 inches of either end of the sensing element shall provide an output closure.

86-5.01C(3) Amplifier Unit Construction

- Each amplifier shall be provided with an integral power supply.
- Each amplifier shall be designed to provide ease of maintenance with all electronic components readily accessible.
- All input and output circuits for each amplifier shall enter via a single MS connector, circuitry for which shall be as shown in the following table:

Connector Circuitry For Magnetic Detector Amplifiers

MS Connector Circuit	18-8 Pin
Magnetic Detector (-)	A
Magnetic Detector (+)	B
120 V, (ac+)	C
Chassis Ground	D
Detector Common	E
Output N.O.	F
Output N.C.	G
Grounded Conductor, (ac-)	H

- All controls, indicator lights, fuseholders and connectors shall be mounted on the front panel of the amplifier.

86-5.01C(4) Construction Materials

- The cable from the pull box adjacent to the magnetic detector sensing element to the field terminals in the controller cabinet shall be the type specified for inductive loop detectors.

86-5.01C(5) Installation Details

- Magnetic detector sensing elements shall be installed within 3-inch, Type 3 conduit, as directed by the Engineer.
- Conduit shall extend across the full width of the traveled way (pull box to pull box) as shown on the plans. Bottom of conduit shall be placed 12 inches below top of pavement.

86-5.01D Removing or Abandoning Existing Pressure-Sensitive Detectors

- When a foundation for a pressure-sensitive vehicle detector is to be removed, the hole left by removing the detector frame and foundation shall be filled with minor concrete, except the roadway surface shall be reconstructed with material to match existing surfacing. Minor concrete shall conform to the provisions in Section 90-10, "Minor Concrete," except that the concrete shall contain not less than 420 pounds of cement per cubic yard for asphalt concrete surfaced roadways,

and not less than 590 pounds of cement per cubic yard for portland cement concrete surfaced roadways.

- When a foundation for a pressure-sensitive vehicle detector is to be abandoned, the top of the foundation, anchor bolts, frame and conduits shall be removed to a depth of not less than 6 inches below the surface of existing pavement. The resulting hole shall be backfilled with material to match existing surfacing.

86-5.02 PEDESTRIAN PUSH BUTTON ASSEMBLIES

- Where shown on the plans, pedestrian push button assemblies of substantial tamper-proof construction and signs shall be furnished and installed.
- The housing shall be either die-cast or permanent mold cast aluminum, or when specified shall be ultraviolet stabilized, self-extinguishing structural plastic. Plastic housings shall be black matching Color No. 17038, 27038 or 37038 of Federal Standard No. 595B, and shall be colored throughout. The assembly shall be rainproof and shall be shockproof in any weather condition.
- The pedestrian push button switch shall be a phenolic enclosed precision snap-acting type, single-pole, double-throw, switching unit, with screw type terminals, rated 15 A at 125 V (ac), and shall have the following characteristics:

A. Switching unit shall have a stainless steel plunger actuator and shall be provided with U-frame to permit recessed mounting in push button housing.
B. Switch shall have an operating force of 9 ounces to 13 ounces and a minimum release force of 4 ounces.
C. Pretravel shall be $^{1}/_{64}$ inch maximum.
D. Overtravel shall be $^{7}/_{32}$ inch minimum.
E. Differential travel shall be 0.0004-inch to 0.002-inch.
F. Actuator shall have a minimum diameter of 2 inches.

- Where a pedestrian push button is attached to a pole, the housing shall be shaped to fit the curvature of the pole and secured to provide a rigid installation. Saddles shall be provided to make a neat fit when required.
- Where a pedestrian push button is to be mounted on top of a $2^{1}/_{2}$-inch diameter post, the housing shall be provided with a slip-fitter fitting and screws for securing rigidly to the post.
- Pedestrian push button signs shall be porcelain enameled metal or structural plastic.
- Push button and sign shall be installed on the crosswalk side of the pole.
- Arrows on push button signs shall point in the same direction as the corresponding crosswalk.
- Where Type A push buttons are specified, each push button assembly shall be equipped with red and green indicator lamps. Lamps shall be so connected that, when the push button has been activated, the red lamp shall be energized and continue so until the next pedestrian walk interval, at which time the green lamp shall be energized in lieu of the red lamp. At the termination of the pedestrian walk interval, the lamps shall be de-energized until the next actuation of the push button.

Lenses for the lamps shall have a visible diameter of approximately $1^1/_4$ inches and a length of approximately $^7/_8$ inch.

- On the Type A or Type B push button assembly, the sign shall attach to and be securely supported by the framework.
- With Type C pedestrian push buttons, the instruction sign shall be mounted, using 2 straps and saddle brackets, on the same standard as the push button assembly. Straps and saddle brackets shall be as shown on the plans and shall be corrosion-resisting chromium nickel steel conforming to the requirements in ASTM Designation: A 167, Type 302. Theft-proof bolts shall be stainless steel with a chromium content of at least 17 percent and a nickel content of at least 8 percent.

86-6 LIGHTING

86-6.01 HIGH PRESSURE SODIUM LUMINAIRES

- High pressure sodium luminaires shall be the enclosed type with a horizontal burning lamp. Luminaires shall be the cutoff type. Each luminaire shall consist of a housing, a reflector, a refractor or a lens, a lamp socket, an integral ballast, a terminal strip and a lamp.
- Housings shall be fabricated from aluminum. Housings that are painted shall withstand a 1,000-hour salt spray test as specified in ASTM Designation: B 117.
- Other metal parts of the housing shall be fabricated from metal at least equal in corrosion resistance and finish to the metal in the housing.
- Each housing shall be provided with a slip-fitter capable of mounting on a 2-inch pipe tenon and of being adjusted 5 degrees from the axis of the tenon. The clamping brackets of the slip-fitter shall not bottom out on the housing bosses when adjusted within the ±5 degree range.
- No part of the slip-fitter mounting brackets on the luminaires shall develop a permanent set in excess of 0.020-inch when the $^3/_8$-inch diameter cap screws used for mounting are tightened to 10 foot-pounds.
- Luminaires to be mounted on horizontal mast arms, when tested in conformance with California Test 611, shall be capable of withstanding cyclic loading in (G = Acceleration of Gravity):

A. A vertical plane at a minimum peak acceleration level of 3.0 G peak-to-peak sinusoidal loading (same as 1.5 G peak) with the internal ballast removed, for a minimum of 2 million cycles without failure of any luminaire parts,

B. A horizontal plane perpendicular to the direction of the mast arm at a minimum peak acceleration level of 1.5 G peak-to-peak sinusoidal loading (same as 0.75-G peak) with the internal ballast installed, for a minimum of 2 million cycles without failure of any luminaire parts, and

C. A vertical plane at a minimum peak acceleration level of 1.0 G peak-to-peak sinusoidal loading (same as 0.5-G peak) with the internal ballast installed, for a minimum of 2 million cycles without failure of any luminaire parts.

- Each mast arm mounted luminaire may be furnished without a photoelectric unit receptacle. If a photoelectric unit receptacle is included, a raintight shorting cap shall be installed. If the luminaire housing is provided with a hole for the receptacle, the hole shall be closed, covered and sealed with weatherproof material, in a permanent manner.
- The surface of each reflector shall be specular and shall be protected by either an anodized finish or a silicate film. The reflector shall be shaped so that a minimum of light is reflected through the arc tube of the lamp.
- Each refractor or lens shall be mounted in a frame that is hinged to the housing and secured with a spring-loaded latch. Each refractor shall be made of glass or polycarbonate plastic. Each lens shall be made of heat and impact resistant glass.
- The optical system, consisting of the reflector, refractor or lens, lamp socket and lamp, shall be in a sealed chamber. Sealing shall be provided by a gasket between the reflector and refractor or lens and a gasket between the reflector and lamp socket. The chamber shall have provision for filtered flow of air in and out of the chamber due to lamp heat. Filtering shall be accomplished by either a separate filter or a filtering gasket.
- Each lamp socket shall be a porcelain enclosed mogul-multiple type. The shell shall contain integral lamp grips to assure electrical contact under conditions of normal vibration. The socket shall be mounted in the luminaire in a manner to permit pre-setting a variety of specified light distribution patterns. The socket shall be rated for 1,500 W and 600 V, and shall be rated for a 4-kV pulse.
- When the components are mounted on a down-opening door, the door shall be hinged and secured to the luminaire housing separately from the refractor or flat lens frame. The door shall be easily removable and replaceable. The door shall be secured to the housing in a manner to prevent its accidental opening when the refractor or flat lens frame is opened.
- Field wires connected to the luminaire shall terminate on a barrier type terminal block secured to the housing. The terminal screws shall be captive and equipped with wire grips for conductors up to No. 6. Each terminal position shall be clearly identified.
- The minimum light distribution for each luminaire shall be as shown on the isolux diagrams on the plans.
- The maximum brightness of each cutoff luminaire, with the lamp indicated, shall be as follows:

Cutoff Type

Lamp ANSI Code No.	Lamp Wattage	Maximum Brightness foot-lamberts
S55	150	40
S66	200	40
S50	250	50
S67	310	60
S51	400	75

- Brightness readings will be taken using a brightness meter with an acceptance angle of 1.5 degrees. When measured on the 90-degree and 270-degree lateral

angle line, the maximum brightness shall not exceed the above specified brightness when the meter is located at a horizontal distance of 120 feet and a vertical distance of 7.5 feet between the luminaire and the meter, or at an angle of 3 degrees 35 minutes from the horizontal to the line between the luminaire and the meter. Measurements shall be made from both the 90-degree line and the 270-degree line and averaged. The lamp used for each test shall be operated at the wattage necessary to produce a light output as follows:

Lamp Wattage	Lumens
150	16,000
200	22,000
250	27,000
310	37,000
400	50,000

86-6.01A High Pressure Sodium Lamp Ballasts

- Each ballast shall be designed for the type, characteristics and wattage of the lamp it is to operate and it shall provide the proper starting and operating waveforms, voltage and current. Ballasts shall provide reliable lamp starting and operation at ambient temperature down to -30°C for the rated life of the lamp.
- Ballasts shall be designed for continuous operation at ambient air temperatures from -20°C to 25°C without reduction in ballast life. Ballasts shall have a design life of not less than 100,000 hours. Ballasts shall be designed to operate for at least 180 cycles of 12 hours on and 12 hours off, with the lamp circuit in an open or short-circuited condition and without measurable reduction in the operating requirements.
- Ballasts shall be tested in conformance with the requirements in ANSI C82.6-1980, "Methods of Measurement of High-Intensity-Discharge Lamp Ballasts."
- Starting aids for ballasts of a given lamp wattage shall be interchangeable between ballasts of the same wattage and manufacturer without adjustment.
- A Certificate of Compliance conforming to the provisions in Section 6-1.07, "Certificates of Compliance," shall be submitted by the manufacturer with each lot of integral ballast luminaires and with each lot of ballasts designed for use outside of luminaires. The certificate shall state that the lot of ballasts meets, in every respect, the above requirements and the lamp-ballast specifications of the lamp manufacturer.
- The input voltage for ballasts shall be as shown on the plans or as specified in the special provisions.
- Each integral ballast shall consist of separate components, each of which shall be capable of being easily replaced. A starting aid which is encapsulated will be considered as a single component. Each component shall be provided with screw terminals, NEMA tab connectors or a single multi-circuit connector. All conductor terminals shall be identified as to the component terminal to which they connect.
- Heat-generating components shall be mounted so as to use the portion of the luminaire upon which they are mounted as a heat sink. Capacitors shall be located

as far as practicable from heat-generating components or shall be thermally shielded to limit the case temperature to 75°C.

- Transformers and inductors shall be resin-impregnated for protection against moisture. Capacitors, except those in starting aids, shall be metal cased and hermetically sealed.
- Ballasts to be located remote from the luminaire shall be the submersible type and shall conform to the provisions in Section 86-6.09C, "Submersible Type Transformers." All components, including starting aid, shall be enclosed in a single housing. Ballast leads shall extend a minimum of 12 inches from the case. Steel housings shall be galvanized or painted. Ballast housings shall be clearly labeled to indicate lamp type, lamp wattage and input voltage.
- Ballasts for high-pressure sodium lamps shall have a ballast characteristic curve which will intersect both of the lamp-voltage limit lines between the wattage limit lines and remain between the wattage limit lines throughout the full range of lamp voltage. This requirement shall be met not only at the rated input voltage of the ballast, but also at the lowest and highest input voltage for which the ballast is rated. Throughout the lifetime of the lamp, the ballast curve shall fall within the specified limits of lamp voltage and wattage.
- Ballasts for luminaires to be mounted on mast arms, brackets or lowering assemblies shall be located within the luminaire housing.

86-6.01A(1) Regulator Type Ballasts

- Regulator type ballasts shall conform to the following:

A. For nominal input voltage and lamp voltage, the ballast design center shall not vary more than 7.5 percent from rated lamp watts.
B. The ballast shall be designed so that a capacitance variance of ±6 percent will not cause more than a ±8 percent variation in lamp wattage regulation throughout rated lamp life for nominal input voltage.
C. The lamp current crest factor shall not exceed 1.8 for input voltage variation of ±10 percent at any lamp voltage from initial through life.

- Regulator type ballasts shall be lag-type or lead-type conforming to the following:

A. Lag-Type Regulator Ballasts.—Each lag-type regulator ballast shall have the primary and secondary windings electrically isolated and, when operated with the appropriate lamp, shall have the following characteristics and shall maintain the following lamp operation:

1. The power factor shall be not less than 90 percent throughout the life of the lamp at nominal line voltage with a nominally rated reference lamp.
2. Lamp wattage regulation spread at any lamp voltage from nominal through life shall not vary by more than 18 percent for ±10 percent input voltage variation.

B. Lead-Type Regulator Ballasts.—Each lead-type regulator ballast (CWA-constant wattage autoregulator) shall, when operated with the appropriate lamp, have the following characteristics and shall maintain the following lamp operation:

1. The power factor shall be not less than 90 percent when the ballast is operated at nominal line voltage with a nominally rated reference lamp.
2. Lamp wattage regulation spread at any lamp voltage from nominal through life shall not vary by more than 30 percent for ±10 percent input voltage variation.

86-6.01A(2) Autotransformer or Reactor Type Ballasts

Each nonregulating reactor, autotransformer, or high reactance ballast shall, when operated with the appropriate lamp, have the following characteristics and shall maintain the following lamp operations:

A. The power factor shall be not less than 90 percent when the ballast is operated at nominal line voltage with a nominally rated reference lamp.
B. Lamp wattage regulation spread at any lamp voltage from nominal through life shall not vary by more than 25 percent for ±5 percent input voltage variation.
C. For nominal input voltage and lamp voltage, the ballast design center shall not vary more than 7.5 percent from rated lamp watts.
D. The lamp current crest factor shall not exceed 1.8 for input voltage variation of ±5 percent at any lamp voltage from initial through life.

86-6.01B High Pressure Sodium Lamps

High pressure sodium lamps shall conform to the requirements in ANSI Standard: C 78, "Lamp Specifications, Physical and Electrical Characteristics of High-Intensity-Discharge Lamps," when tested in conformance with the requirements in ANSI Standard: C 78.388, "Methods of Measurement of High Pressure Sodium Lamp Characteristics." High-pressure sodium lamps shall have a minimum average rated life of 24,000 hours.

86-6.02 LOW PRESSURE SODIUM LUMINAIRES

Low pressure sodium luminaires shall be provided when shown on the plans or specified in the special provisions, and shall be completely assembled, furnished with a lamp and ballast and shall comply with the following requirements:

A. Low pressure sodium luminaires shall be the enclosed type with a horizontal burning lamp. Luminaires shall be either the semi-cutoff type or the cutoff type.
B. Luminaires shall be manufactured by a manufacturer who is regularly engaged in the manufacture of street lighting luminaires.
C. Each luminaire shall consist of a housing, a reflector, a refractor or a lens, a lamp socket, an integral ballast, a removable ballast tray, a lamp support,

a terminal strip, a capacitor and a slip fitter. The reflector may be an integral part of the housing.

D. The luminaire housing shall be of corrosion resistant die cast aluminum, of $^{1}/_{16}$ inch minimum thickness, corrosion resistant aluminum sheet and plate with concealed continuous welds, or of acrylonitrile-butadiene-styrene sheet material ($^{3}/_{32}$ inch, minimum nominal wall thickness), on a cast aluminum frame that provides mounting for all electrical components and the slip fitter. The housing shall be divided into optical and power compartments that are individually accessible for service and maintenance. Positioning and clamping of the luminaire to the pipe tenon shall be accomplished by tightening mounting bolts.

E. Painted exterior surfaces of the luminaire shall be finished with a fused coating of electrostatically applied polyester powder paint or other ultraviolet inhibiting film. Color shall be aluminum gray.

F. A high temperature neoprene, or equal, sealing ring shall be installed in the pipe tenon opening to prevent entry of water and insects into the power and optical compartments.

G. Access to the power unit assembly shall be through a weathertight hinged cover, secured with spring type latches or captive screws, to the luminaire housing.

H. Hardware shall be stainless steel or cadmium plated. Machine screws or bolts shall be used to secure removable components. Sheet metal screws shall not be used.

I. Semi-cutoff luminaires and molded refractor style (drop lens) cutoff luminaires shall be provided with a refractor. Other cutoff luminaires shall be provided with a flat lens.

J. Refractors shall be one piece injection molded polycarbonate of $^{3}/_{32}$ inch, minimum thickness, or one piece injection molded acrylic of $^{1}/_{8}$ inch minimum thickness. Flat lens shall be one piece polycarbonate of $^{3}/_{32}$ inch, minimum thickness. The refractor assembly and flat lens assembly shall be constructed to rigidly maintain its shape. The refractor assembly and the flat lens assembly shall be hinged and secured with spring type latches to the luminaire housing. The flat lens shall be mounted to a metal frame. Alternate methods of manufacturing the refractor may be approved provided minimum specified thicknesses are maintained. A sample refractor for testing will be required for alternate methods of manufacturing.

K. The lamp socket shall be of high temperature, flame retardant thermoset material with self-wiping contacts or may be of other equally durable material. The socket shall be rated for 660 W and 1,000 V.

L. Position of the lamp socket and the lamp support shall maintain the lamp in correct relationship with reflector and refractor for designed distribution pattern.

M. Isofootcandle distribution shall be ANSI Type III, short or Type IV, medium distribution, for cutoff or semi-cutoff luminaires.

N. With a 34-foot mounting height, each type of luminaire shall maintain a minimum of 0.2 foot-candle at least 90 feet each side, along the longitudinal roadway line below the luminaire, and a minimum of 0.35 foot-candle at a transverse roadway distance from the luminaire location equal to 1.5 times the luminaire mounting height.

O. Certified luminaire performance data shall be furnished as part of the Equipment List and Drawings in conformance with the provisions in Section 86-1.04. This data shall include complete photometric test data in the form of isofoot charts at a scale of one inch equals 20 feet, for the luminaire and lamp sizes indicated on the plans.

P. Alternate data may be in the form of horizontal foot-candle values recorded on a 15' x 15' area extending 90 feet longitudinally each side of the light source, and 15 feet behind and 90 feet in front of the light source, for the luminaire and lamp sizes and the mounting height indicated on the plans. The horizontal foot-candles levels in the data submitted shall equal or exceed the levels specified in these specifications. Failure to meet the referenced values will be justification for disapproval of the luminaires.

Q. The photometric test shall be performed and certified by an independent and recognized testing laboratory. Subsequent to the Contractors installation of any luminaires, field checks may be performed at random by the Engineer and calculated in conformance with the requirements in the Illuminating Engineering Society "Guide for Photometric Measurement of Roadway Lighting Installation (LM-50)" approved in July, 1974. Failure to meet or exceed the referenced values during field checks will be justification for replacement by the Contractor.

R. Low pressure sodium lamps shall conform to the following:

1. The lamps shall be 180 W, single ended, bayonet base, tubular gas discharge lamps suitable for street lighting use.
2. Low pressure sodium lamps shall have a minimum of 93 percent maintenance of initial lumens during rated life and shall comply with the following minimum performance requirements:

Lamp Designation	ANSI Code: L74-RF-180
Nominal Watts	180
Initial Lumens	33,000
Rated Ave. Life (@ 10 Hrs/Start)	18,000 h
Operating Position	Horizontal ±20°

3. Low pressure sodium lamps shall reach 80 percent of light output within 10 minutes and shall restrike within one minute after an outage due to power interruption or voltage drop at the lamp socket.
4. The base of the lamp shall have a device that will allow the installer to indicate the month and year of installation.
5. Ballasts for low pressure sodium luminaires shall be the autotransformer or high reactance type and, when operated with the

lamp, shall have the following characteristics and maintain the following lamp operation:

a. The power factor shall be not less than 90 percent when the ballast is operated at nominal line voltage.
b. Lamp wattage regulation spread, at any lamp voltage from nominal through life, shall not vary by more than ± 6 percent for ± 10 percent input voltage variation.
c. The lamp current crest factor shall not exceed 1.8 at nominal line voltage.
d. Ballast losses shall not exceed 24 percent for 180-W ballasts at nominal line voltage.

S. A single multi-circuit connector shall be provided for quick disconnection of ballast tray.

86-6.03 SOFFIT AND WALL LUMINAIRES

- Soffit and wall luminaires shall be of the type or types specified.
- Soffit and wall luminaires shall be weatherproof and corrosion resistant. Installation details and minimum light distribution shall be as shown on the plans.
- Each flush-mounted soffit luminaire shall consist of a metal body, a prismatic refractor mounted in a door frame, a prismatic glass or specular anodized aluminum reflector, a ballast and a lamp socket. The body shall have provisions for anchoring in concrete and shall be provided with 2 one-inch, minimum, conduit hubs. The refractor shall be glass and shall be clearly identified as to "street side." The door frame assembly shall be hinged, gasketed and secured to the body by at least 3 machine screws. The ballast shall be located either within the housing or in a ceiling pull box as shown on the plans.
- Each pendant soffit luminaire shall be enclosed and gasketed, and shall be furnished with aluminum finish. The reflector shall have a specular anodized aluminum finish. The refractor shall be made of heat-resistant polycarbonate or glass. The optical assembly shall be hinged and latched for lamp access and shall be provided with a device to prevent dropping. Each pendant soffit luminaire shall be furnished with a ballast and with a galvanized metal box for mounting the luminaire. The ballast shall be designed for operation in a raintight enclosure. The box shall be provided with a gasketed cover with 2 captive screws and 2 chains to prevent dropping.
- Each wall-mounted luminaire shall consist of a cast metal body, a prismatic refractor mounted in a door frame, an aluminum reflector with a specular anodized finish, an integral ballast and a lamp socket. The refractor shall be glass. A gasket shall be provided between the refractor and the body of the fixture. Each luminaire shall be provided with at least two $^{5}/_{16}$ inch minimum diameter mounting bolts.
- Cast aluminum bodies, which are to be cast into or mounted against concrete, shall be given a thick application of alkali-resistant bituminous paint on all surfaces to be in contact with concrete.
- Unless otherwise specified, each soffit luminaire and each wall luminaire shall be furnished with a 70-W high-pressure sodium lamp, with a minimum average

rated life of 24,000 hours. Each lamp socket shall be positioned to locate the light center of the lamp within 1/2 inch of the light center location for which the luminaire is designed.

- Ballasts for soffit and wall luminaires shall be the autotransformer, reactor or regulator type conforming to the provisions in Section 86-6.01A, "High Pressure Sodium Lamp Ballasts." Ballasts for wall luminaires shall be located in the luminaire housing or, when shown on the plans, in a pull box adjacent to the luminaire.

86-6.04 PEDESTRIAN CROSSING FIXTURES

- Pedestrian crossing fixtures shall consist of fluorescent lighting fixtures for pedestrian undercrossings and for pedestrian overcrossings as shown on the plans.

86-6.05 SIGN LIGHTING FIXTURES— MERCURY

- Each mercury sign lighting fixture shall be designed for mounting near the bottom of the sign panel on an overhead sign structure. The fixture shall be of an enclosed design and shall be raintight and corrosion resistant. Each fixture shall consist of a housing with door, a reflector, refractor or a flat lens, a lamp, a socket assembly, a ballast and a fuse block.
- When the fixture is located so that the light center of the lamp is 55 inches in front of, one foot below, and centered on a 10-foot high by 20-foot wide sign panel, the ratio of the maximum to minimum illuminance level on the panel shall not exceed 12 to 1 in 95 percent of the points measured. In addition, the illuminance gradient shall not exceed 2 to 1. Illuminance gradient is defined as the ratio of the minimum illuminance on any one-foot square of panel to that on any adjacent one-foot square of panel.
- The minimum horizontal foot-candle requirements shall conform to the "Isofoot Diagrams" shown on the plans.
- Each fixture shall be furnished with a mounting assembly that will permit the fixture to be mounted on the continuous slot channels shown on the plans. The mounting assembly shall be either cast aluminum, hot-dip galvanized steel plate or steel plate that has been galvanized and finished with a polymeric coating system.

Housing

- The housing shall have a door designed to hold a refractor or flat lens. Housings and doors shall be fabricated of sheet or cast aluminum. Sheet aluminum shall conform to the requirements in ASTM Designation: B 209 or B 209M for 5052-H32 aluminum sheet. Painting is not required. All external bolts, screws, hinges, hinge pins and door closure devices shall be of material which will not corrode in normal use.
- The housing shall be provided with holes to permit condensed water to drain.
- The door shall be hinged to the housing on the side of the fixture away from the sign panel and shall be provided with two captive latch bolts or other latching device. The door shall be provided with means to allow the door to be locked in the open position (50 degrees, minimum from the plane of the door opening) with a wind of 70 mph striking the door from either side.

- The juncture of the door and the housing shall be gasketed to provide a raintight and dusttight joint. The thickness of the gasket shall be $^1/_4$ inch, minimum.
- The maximum height of the fixture shall be 12 inches above the top of the mounting rails.
- When the fixture is mounted on the mounting channels without a mounting plate, 4 holes of $^7/_{16}$ inch diameter shall be provided. The distance between the front and back holes shall be $6^1/_2$ inches.

Reflector

- The reflector shall be one piece and shall be made from specularly finished aluminum protected with an electrochemically applied anodized finish or a chemically applied silicate film. The reflector shall be designed so that water deposited on it due to condensation will drain away. The reflector shall be secured to the housing with a minimum of 2 screws and shall be removable without removing any fixture parts. No reflectors shall be attached to the outside of the housing.

Refractor

- Refractors shall be made from borosilicate heat resistant glass. When a flat lens is used, the lens shall be made from heat resistant glass.
- The refractor shall be so designed or shielded that no fixture luminance is visible when the fixture is approached directly from the rear and the viewing level is the bottom of the fixture. When a shield is used it shall be an integral part of the door casting.

Lamp

- Each fixture shall be furnished with a 175-W mercury lamp conforming to ANSI C78.386-1989, Code: H39KC-175/DX. Lamps shall have a minimum average rated life of 16,000 hours.

Lamp Socket

- The lamp socket shall be a porcelain enclosed mogul type. The shell shall contain integral lamp grips to assure electrical contact under conditions of normal vibration. The center contact shall be spring-loaded. Shell and center contact shall be nickel plated brass. The socket shall be rated for 1,500 W and 600 V.

Ballast

- The ballast for each mercury sign fixture shall be designed for the characteristics and wattage of the lamp and it shall provide the proper starting voltage and operating waveforms, voltage and current. Ballasts shall provide reliable lamp starting and operation at ambient temperatures down to -25°C for the rated life of the lamp.
- Ballasts shall be designed for continuous operation at ambient air temperatures from -20°C to 25°C without reduction in ballast life. Ballasts shall have a design life of not less than 100,000 hours.
- Ballasts shall be tested in conformance with the requirement in ANSI Standard C82.6-1980, "Methods of Measurement of High-Intensity-Discharge Lamp

Ballasts." A Certificate of Compliance conforming to the provisions in Section 6-1.07, "Certificates of Compliance," shall be submitted by the manufacturer with each lot of sign lighting fixtures. The certificate shall state that the ballasts meet, in every respect, the above requirements and the lamp ballast specifications of the lamp manufacturer.

- Ballasts consisting of separate components shall conform to the following:

A. Each component shall be capable of being easily replaced. Each component shall be provided with screw terminals, NEMA tab connect or a single multi-circuit connector. All conductor terminals shall be identified as to the component terminal to which they connect.
B. Heat-generating components shall be mounted so as to use the portion of the sign lighting fixture upon which they are mounted as a heat sink. Capacitors shall be located as far as practicable from heat-generating components or shall be thermally shielded to limit the case temperature to 75°C.
C. Transformers and inductors shall be resin-impregnated for protection against moisture. Capacitors shall be metal cased and hermetically sealed.
D. Ballasts for mercury sign lighting fixtures shall be normal power factor reactor type or autotransformer regulator type (CWA-constant wattage autotransformer).
E. Reactor type ballast shall, when operated with the mercury lamp, have the following characteristics and shall maintain the following lamp operation:

1. The power factor shall be not less than 50 percent.
2. The lamp wattage shall not vary by more than a ±10 percent for a ±5 percent input voltage variation.
3. The lamp current crest factor shall not exceed 1.5 at rated input voltage.
4. Ballast losses shall not exceed 25 W.

F. Autotransformer regulator type ballast shall, when operated with the mercury lamp, have the following characteristics and shall maintain the following lamp operation:

1. The power factor shall be not less than 90 percent.
2. The lamp wattage shall not vary by more than ±7 percent for ±10 percent input voltage variation.
3. The lamp current crest factor shall not exceed 2.0 at rated input voltage.
4. Ballast losses shall not exceed 45 W.

Fuse Block

- Each fixture shall be provided with a barrier type fuse block for terminating field connections. The block shall be secured to the housing and shall be accessible without removal of any fixture parts. The block shall be mounted to leave a minimum of $^1/_2$ inch air space from the sidewalls of the housing. The block shall

be designed for easy removal of fuses with a fuse puller, shall be rated at 600 V and shall have box terminals. Fuses shall be $^{13}/_{32}$-inch diameter, $1^{1}/_{2}$-inch long ferrule type and shall be UL or ETL listed. For 120-V input fixtures, only the ungrounded conductor shall be fused and a solid link shall be provided between the neutral and the ballasts.

Wire Guard

- When shown on the plans, each sign lighting fixture shall be provided with a wire guard to prevent damage to the refractor or lens. The guard shall be constructed of $^{1}/_{4}$-inch minimum diameter galvanized steel wire and shall be either hot-dip galvanized or provided with an electroplated zinc coating conforming to the requirements in ASTM Designation: B 633, Service Condition SC4 with a clear chromate dip treatment. Guard elements shall be spaced so as to prevent rocks in excess of $1^{1}/_{2}$ inches in diameter from passing through.

86-6.06 SIGN LIGHTING FIXTURES— INCANDESCENT

- Each sign lighting fixture for an incandescent lamp shall be of the type shown on the plans or as specified in the special provisions.
- Sign lighting fixtures shall be UL or ETL listed for outdoor installation. The fixture shall consist of a hood with side outlet tapped for conduit and a symmetrical 10-inch steel reflector. The fixture shall be rated at 150 W minimum.
- The reflector shall have a white porcelain enamel finish.
- The fixture shall have a medium base socket.

86-6.065 INTERNALLY ILLUMINATED STREET NAME SIGNS

- Internally illuminated street name signs shall conform to the details shown on the plans.
- The general design of signs shall be as shown on the plans. Minor details of construction shown are typical and may be modified subject to approval by the Engineer.
- The sign fixture shall be designed and constructed to prevent deformation or failure when subjected to 70 mph wind loads in conformance with the requirements in the AASHTO publication, "Standard Specifications for Structural Supports of Highway Signs, Luminaires and Traffic Signals," and amendments thereto. The sign panels shall not deform or warp under a 70 mph wind loading. A Certificate of Compliance conforming to the provisions in Section 6-1.07, "Certificates of Compliance," shall be submitted by the manufacturer with each lot of internally illuminated street name signs. The certificate shall state that the internally illuminated street name signs meets the wind load requirements as described above.
- All material used in fabrication shall be new. If not covered herein, both the material and workmanship shall be of the best quality consistent with the intended purpose. All ferrous parts shall be galvanized or cadmium plated, unless otherwise specified herein or shown otherwise on the plans.
- Signs shall be Type A or Type B.

Housing

- The top and bottom shall be formed or extruded aluminum and shall be attached to formed or cast aluminum end fittings. The design shall provide

continuous sealing between top and bottom assemblies and the end fittings. The housing shall be rigidly constructed to resist torsional twist and warp. Provisions shall be made for ease of maintenance of all components. The opening or removal of one panel shall permit access to the interior of the sign and allow for replacement of lamps, ballasts and fuses.

- Photoelectric unit sockets will not be allowed.
- On Type A signs, both sides shall be hinged at the top to permit installation or removal of the sign panels, and to permit access to the interior of the sign.
- On Type B signs, the sign panels shall be slide-mounted into the housing.

Reflectors

- At the option of the Contractor, reflectors may be used to provide the required sign brightness. Reflectors, if used, shall be formed aluminum with acrylic baked white enamel surface having a minimum reflectance of 0.85.

Sign Panels

- The sign panels shall be slide-mounted or rigid mounted in a frame, with white legend, symbols, arrows, and border on each face, as shown on the plans. The background shall be green.
- The entire surface of the sign panel shall be evenly illuminated. The average of brightness readings for the letters shall be 150 foot-lamberts, minimum. The light transmission factor of the sign panel shall provide a letter to background brightness ratio of between 10 to 1 and 20 to 1. The luminance of the background shall not vary by more than 40 percent from the average of background brightness reading. The luminance of the letters, symbols and arrows shall not vary by more than 20 percent from the average brightness reading of letters, symbols and arrows.
- The sign panels shall be translucent panels of high impact resistant plastic of one of the following types:

A. Glass fiber reinforced acrylated resin.
B. Polycarbonate resin.
C. Cellulose acetate butyrate plastic.

- Paint on the outside of the plastic shall be protected by a plastic film which shall seal the front surface of the panel and filter out ultraviolet radiation. Paint shall be acrylic plastic type.
- All surfaces shall be free of blemishes in the plastic or coating that may impair the serviceability or detract from the general appearance and color matching of the sign.
- The white or green color shall not fade or darken when the sign is exposed to an accelerated test of ultraviolet light which is equivalent to 2 years of outdoor exposure. The green color of the sign, when not illuminated, shall conform to Color No. 14109 of Federal Standard 595B.
- The sign panels shall not crack or shatter when a one inch diameter, steel ball with a weight of 2.4 ounces is dropped from a height of 8.5 feet above the sign panel to any point of the sign panel. The panels shall be lying in a horizontal position and supported within their frame for this test.

Gaskets

- On Type A signs, gaskets shall be installed between the sign panel frame and the fixture housing to prevent the entrance of water between the frame and the fixture housing. Gaskets shall be uniform and even textured and shall be the closed cell, sponge neoprene type, designed for use at temperatures between -20°C and +74°C.
- Gaskets shall be neatly applied to thoroughly degreased, clean surfaces with a suitable heat-resistant adhesive which will not allow the gaskets to slip at temperatures between -20°C and +74°C.

Ballasts

- Ballasts shall be of the high power factor type and shall be capable of starting the lamps at -20°C and above.
- Ballasts for Type A signs shall be rated at 200 mA. Ballasts for Type B signs shall be rated at 430 mA. Ballasts shall be listed by UL or ETL for operation on 110 to 125 V, 60 Hz circuits, and shall conform to the requirements in ANSI Standard: C 82.1 and ANSI Standard: C 82.2.
- A separate ballast shall be provided for each lamp.

Lampholders

- Lampholders shall be listed by UL or ETL for outdoor use, shall be provided with silver coated contacts and waterproofed entrance leads for use with a rapid-start fluorescent lamp. Removal of the lamp from the socket shall de-energize the primary of the ballast. Each lampholder shall be provided with a heat-resistant, circular cross section, partially recessed neoprene ring to seal against the lamp ends and protect electrical contacts from moisture and dirt or other injurious elements.
- One lampholder for each lamp shall be of the spring-loaded type. The distance between the face of the lampholders for each lamp shall provide a compression of at least 0.10-inch on the spring-type lampholder when the lamp is in place. The lamp shall have positive mechanical and electrical contact when the lamp is in place. The socket on the spring-type lampholder shall have sufficient travel to permit installation of the lamp. Springs for lampholders shall not be part of the current carrying circuit. Lampholders shall match lamp requirements and shall not increase cathode filament circuit resistance by more than 0.10-Ω.

Lamps

- Lamps shall be of the types shown on the plans and shall conform to the requirements in ANSI Standard: C 78.

Terminal Blocks

- All wiring connections in the fixture shall be terminated on molded, phenolic, barrier type, terminal blocks rated at 15 A, 1,000 V, and shall have integral type, white, waterproof marking strips. All current carrying parts of the terminal block shall be insulated from the fixture with integral plugs or strips to provide an insulating value in excess of the line-to-ground flashover voltage. If the Contractor elects to use sectionalized terminal blocks, each section shall be provided with an

integral barrier on each side and shall be capable of rigid mounting and alignment. Terminal screws shall be size No. 10, minimum.

Fuses

- Fuses shall be Type 3AG, miniature, slow blowing type with appropriate current and voltage ratings.
- The fuseholder shall be a panel-mounting type with threaded or bayonet type knob which grips the fuse tightly for extraction. A separate fuse shall be provided for each ballast.

Weep Holes

- Screened weep holes shall be provided at strategic locations in all members subject to the collection of moisture. Weep holes shall be shielded to prevent light leakage from the fixture.

Fasteners

- All fasteners, screws and hardware shall be of passive stainless steel (Type 302 or 304) or aluminum Type 6060-T6.

Mounting Assemblies

- The top of the fixture housing shall have 2 free-swinging mounting brackets. Each of the brackets shall be adjustable vertically for leveling the sign to either a straight or curved mast arm. The bracket assembly shall permit the fixture to swing perpendicular to the sign panel.
- Hinge pins for the free-swinging brackets shall have a minimum diameter of 1/4 inch.
- At least 16 feet of clearance shall be provided between the bottom of the fixture and the roadway.

Message

- The message, as shown on the plans, shall be displayed on both sign panels.
- If not shown on the plans, the message, and the size of symbols or arrows will be furnished by the Engineer at the request of the Contractor. Unless shown otherwise, letters shall be 8-inch upper case and 6-inch lower case, Series E.

Weight

- The total weight of the complete sign assembly, including lamps, ballasts, mounting brackets and appurtenances shall not exceed 65 pounds.

Conductors

- All fixture conductors shall be UL or ETL listed appliance wiring material (AWM) stranded copper wire with 28 mils, minimum, thermoplastic insulation, rated at 1,000 V and rated for use at 90°C. Conductors shall be No. 16, minimum, and shall match the color coding of the ballast leads.
- The size of conductors from the sign disconnect to the fuse block shall be as shown on the plans.
- All conductors within the fixture shall be secured with easily removable spring cross straps (not clamped) in the chassis or fixture. Straps shall be installed not more than 12 inches apart.

- Stranded copper conductors connected to screw type terminals shall terminate in approved crimp type ring connectors.
- Splices will not be permitted within the fixture unless approved in writing by the Engineer.

Equipment List and Drawings

- Within 15 days following approval of contract, the Contractor shall submit 3 sets of shop drawings and a list of equipment and materials the Contractor proposes to install, in conformance with the provisions in Section 5-1.02, "Plans and Working Drawings." The shop drawings shall show the message for each sign and shall include the size of letters, symbols or arrows, as shown on the plans or as furnished by the Engineer. The list of equipment shall include the name of the manufacturer of all materials and sufficient detail to identify the materials. If requested, the Contractor shall supply, without cost to the State, sufficient samples of materials to be used in the fabrication of the sign, or a complete sign assembly, to permit adequate testing and evaluation of conformance to the specified requirements.

86-6.07 PHOTOELECTRIC CONTROLS

- Photoelectric controls, as specified in the special provisions or as shown on the plans, shall be capable of switching multiple lighting systems directly.

86-6.07A Types

- The types of photoelectric controls shall be as follows:

A. Type I photoelectric control shall consist of a remote photoelectric unit and a test switch housed in an enclosure.
B. Type II photoelectric control shall consist of a remote photoelectric unit, a separate contactor located in a service equipment enclosure, and a test switch located in the service equipment enclosure unless shown otherwise.
C. Type III photoelectric control shall consist of a remote photoelectric unit, and a separate contactor and a test switch housed in an enclosure.
D. Type IV photoelectric control shall consist of a photoelectric unit which plugs into an EEI-NEMA twist lock receptacle integral with the luminaire.
E. Type V photoelectric control shall consist of a photoelectric unit, contactor and test switch located in a service equipment enclosure.

- A switch to permit manual operation of the lighting circuit shall be provided for each Type I, Type II, Type III and Type V photoelectric control. Switches shall be of the single-hole mounting toggle type, single-pole, single-throw, rated at 12 A and a voltage rating to match the circuit. Switches shall be furnished with an indicating nameplate reading "Auto-Test" and shall be connected in parallel with the load contacts of the photoelectric unit. Test switches shall not have an "OFF" position.
- Photoelectric units for Types I, II and III photoelectric controls, shall be pole-top mounted unless otherwise specified.

86-6.07B Equipment Details

- Equipment details shall conform to the following:

86-6.07B(1) Photoelectric Unit

- The photoelectric unit shall provide an output in response to changing light levels. The response level shall remain stable throughout the life of the control unit. Components of the unit shall not require periodic replacement.
- Units shall have a "turn-on" between one foot-candle and 5 foot-candles and a "turn-off" at between 1.5 times "turn-on" and 5 times "turn-on."
- Measurements shall be by the procedures set forth in EEI-NEMA Standards for Physical and Electrical Interchangeability of Light-Sensitive Control Devices Used in the Control of Roadway Lighting.
- Photoelectric controls, except Type IV and Type V, shall be furnished with a 4-inch minimum inside diameter pole-top mounting adaptor containing a terminal block and with cable supports or clamps to support pole wires.
- The photoelectric unit receptacle shall be the EEI-NEMA type. Mounting brackets shall be used where pole-top mounting is not possible. Photoelectric controls shall be installed at the locations shown on the plans and oriented as directed by the Engineer.
- For switching 480 V, 60 Hz circuits, a 100 VA, minimum, 480/120-V transformer shall be installed in the contactor enclosure to provide 120 V for the photoelectric control unit. Where more than one photoelectric unit is to be installed at the same location, a single transformer, with a volt-ampere rating capable of handling the total controlled load, may be used.
- Photoelectric units shall be screened to prevent artificial light from causing cycling.
- The photoelectric unit shall also conform to the following:

A. The supply voltage rating shall be 60 Hz, 105-130 V, 210-240 V, or 105-240 V, as specified.
B. The load rating shall be 800 W minimum, incandescent, mercury or fluorescent.
C. The operating temperature range shall be from -29°C to 65°C.
D. The power consumption shall be less than 10 W.
E. The unit shall be housed in a weatherproof enclosure.
F. The base of the unit shall be provided with a 3-prong, EEI-NEMA standard, twist-lock plug mounting.
G. Units shall be provided with a "fail-on" feature.

86-6.07B(2) Contactor

- The contactor shall have contacts rated to switch the specified lighting load and shall be normally open, unless otherwise specified.
- The contactor shall be either the mechanical armature type or the mercury displacement type. The contacts of the mechanical armature type contactor shall be either fine silver, silver alloy, or superior alternative material. The contactor shall have a minimum rating of 30 A, per contact, inductive load.

86-6.07B(3) Contactor and Test Switch Housing

- The enclosure for Type I and Type III photoelectric controls shall be NEMA Type 3R. The enclosure shall be provided with a factory applied rust resistant prime coat and finish coat. Two applications of paint to match the color of the standard shall be applied in conformance with the provisions in Section 86-2.16, "Painting." The enclosure may be hot-dip galvanized in lieu of painting. A minimum of $2^1/_2$ inches shall be provided between contactor terminals and end of enclosure for wiring connections. The enclosure shall be mounted on the same standard as the photoelectric unit at a height of approximately 6 feet above the base.

86-6.07B(4) Wiring

- Conductors between the photoelectric unit and an external contactor shall be No. 14 and shall be run inside the lighting standard or in conduit, unless otherwise shown on the plans.

86-6.07B(5) Terminal Blocks

- Terminal blocks shall be rated at 25 A, 600 V, shall be molded from phenolic or nylon material and shall be the barrier type with plated brass screw terminals and integral type marking strips.

86-6.08 (BLANK)

86-6.09 TRANSFORMERS

- Multiple to multiple and series to multiple transformers shall be of the single-phase, dry type designed for operation on a 60 Hz supply.

86-6.09A Electrical Requirements

- Transformer ratings shall be 120/480 V, 240/480 V or 480/120 V for multiple to multiple units and 6.6 A/120 V or 6.6 A/480 V for series to multiple units or other ratings as shown on the plans.
- Secondary 480-V windings shall be center tapped.
- Volt-ampere ratings shall be as shown on the plans.
- Transformer efficiency shall exceed 95 percent for multiple to multiple units and 80 percent for series to multiple units.
- Secondary voltage regulation and tolerance shall be ±3 percent from half load to full load for multiple to multiple units and +10 percent (maximum) at no load to ±3 percent at full load for series to multiple units.
- Transformers shall have a decal showing a connection diagram. The diagram shall show either color coding or tagging of wires with primary (H1, H2) or secondary (X1, X2) markers, and shall also show the primary and secondary voltage and volt-ampere rating.

86-6.09B Physical Requirements

- External leads for multiple to multiple and series to multiple secondary connections shall be Type USE, No. 10, rated 600 V (ac).
- Primary conductors for series to multiple transformers shall be rated for use on 5000-V (ac) circuits.
- Transformer leads shall extend a minimum of 12 inches from the case.

- Transformer insulation shall be NEMA 185°C or better.
- Series to multiple transformers shall withstand the application of 12,000 V (ac) from core to primary coil and from coil to coil for a one minute period.
- Series to multiple transformer secondaries and multiple to multiple transformers shall withstand the application of 2,200 V (ac) from core to coils and, for multiple units only, from coil to coil for a one minute period.
- The above tests shall be made immediately after operation of the transformer at full load for 24 hours.
- Non-submersible transformers shall be provided with metal half-shell coil protection, shall have moisture resistant, synthetic varnish impregnated windings and shall be suitable for outdoor operation in a raintight enclosure.
- Each transformer to be installed in a pull box shall be the submersible type and shall be provided with a handle and a hanger.

86-6.09C Submersible Type Transformers

- Submersible type transformers shall be securely encased in a rugged corrosion resistant, watertight case and shall withstand a 5-day test submerged in 2 feet of salt water (2 percent salt by weight) with 12-hour on and off periods. The operating periods shall be at full load.
- Leads of submersible transformers shall be brought out through one or more sealed hubs and shall be secured in a manner which will withstand a 100 pound static pull without loosening or leaking.

86-6.10 (BLANK)

86-6.11 FALSEWORK LIGHTING

- Falsework lighting shall consist of lighting to illuminate the pavement, portals and pedestrian walkways at or under openings in the falsework required for traffic.
- Lighting to provide pavement and portal illumination shall be provided at the locations shown on the plans or specified in the special provisions. Lighting to provide pedestrian walkway illumination shall be provided at all pedestrian openings through or under falsework.

86-6.11A General

- The Contractor shall submit a plan of the proposed lighting installations and shall not commence falsework opening construction until those plans have been reviewed and approved by the Engineer. Approval will be made in conformance with the provisions in Section 5-1.02, "Plans and Working Drawings."
- The Contractor shall design falsework lighting so that required maintenance can be performed with a minimum of inconvenience to public traffic. Closing of traffic lanes for routine maintenance will not be permitted on roadways with posted speed limits in excess of 25 mph.
- Illumination of pavement under falsework with portals less than 150 feet apart and illumination of falsework portals shall be provided only during the hours of darkness as defined in Division 1, Section 280, of the California Vehicle Code. Photoelectric switches shall be used to control those falsework lighting systems. Illumination of pavement under falsework with portals 150 feet or more apart and

illumination of all pedestrian openings through falsework shall be provided 24 hours per day.

- All lighting fixtures shall be aimed in such a manner as to preclude glare to oncoming motorists.
- Type NMC cable with No. 12 minimum, conductors with ground wire shall be used. The cable shall be fastened to the supporting structure at sufficient intervals to adequately support the cable and within 12 inches from every box or fitting. All conductors within 8 feet of ground shall be enclosed in a $^1/_2$ inch, or larger metal conduit.
- Each illumination system shall be on a minimum of one separate branch circuit at each bridge location. Each branch circuit shall be fused, not to exceed 20 A.
- For falsework lighting, the Contractor shall arrange with the serving utility to complete service connections. Energy, line extension, service, and service hookup costs shall be paid by the Contractor.
- Upon completion of the project or when directed by the Engineer, falsework lighting equipment shall become the property of the Contractor and shall be removed from the site of the work.
- The Contractor may propose a lighting plan which will provide light intensities equivalent to the systems specified herein. The Contractor shall supply sufficient data to permit evaluation of alternative methods.

86-6.11B Pavement Illumination

- For illumination of pavement at vehicular openings through falsework the following shall apply:

A. Lighting fixtures shall be provided with R/FL commercial type floodlamp holder with protective covers.
B. Fixtures shall be fully adjustable with brackets and locking screws and shall permit mounting directly to a standard metal junction box.
C. Lamps shall be medium-base 120 V (ac), 120 W (minimum), PAR-38 quartz-halogen floodlamps.
D. A continuous row of the type of fixtures required shall be installed at the location and spacing as specified in the special provisions. The fixtures shall be installed beneath the falsework structure, with the end fixtures not further than 10 feet inside the portal faces. Fixtures shall be installed and energized as a first order of work after the members supporting them have been erected.
E. Fixtures along the sides of the opening shall be placed no more than 4 feet behind or 2 feet in front of the roadway face of the temporary railing. Mounting heights of these fixtures shall be between 12 feet and 16 feet above the roadway surface and shall present an unobstructed light pattern on the pavement.

86-6.11C Portal Illumination

- For illumination of falsework portals the following shall apply:

A. On each side of each entrance portal, clearance guides consisting of plywood sheets, 4 feet wide by 8 feet high, shall be fastened vertically facing traffic with the bottom of the panel 3 feet to 4 feet above the roadway. The center of the panel shall be located approximately 3 feet horizontally behind the roadway face of the railing. The panels shall be freshly painted for each installation with not less than 2 applications of flat white paint, furnished and applied by the Contractor. Testing of paint will not be required.
B. When ordered by the Engineer, in order to improve the general appearance of the painted surfaces herein described, the Contractor shall repaint designated areas and that painting will be paid for as extra work as provided in Section 4-1.03D.
C. Falsework portals shall be illuminated on the side facing traffic with 150-W, minimum, PAR reflector floodlamps mounted on the structure directly over each vertical support adjacent to the traveled way, as needed to uniformly illuminate the exterior falsework beam, the clearance guides and the overhead clearance sign. Each lamp shall be supported approximately 16 feet above the pavement and approximately 6 feet in front of the portal face, the exact position to be as directed by the Engineer.
D. The above specified portal lighting and clearance guides shall be installed on the day that vertical members are erected.

86-6.11D Pedestrian Walkway Illumination

For illumination of pedestrian openings through or under falsework, the following shall apply:

A. Fixtures shall be flush mounted in the overhead protection shield, and shall be equipped with a clear polycarbonate diffuser lens, which is damage resistant. Lamps shall be standard incandescent 100 W, 120 V.
B. Fixtures shall be centered over the passageway at intervals of not more than 15 feet with the end fixtures not more than 7 feet inside the end of the pedestrian openings.
C. Pedestrian passageway light systems shall be installed as a first order of work after the overhead protection shield is erected.

86-7 REMOVING, REINSTALLING OR SALVAGING ELECTRICAL EQUIPMENT

86-7.01 REMOVING ELECTRICAL EQUIPMENT

Attention is directed to Section 15, "Existing Highway Facilities." Existing electrical equipment shown on the plans or specified in the special provisions to be removed and not reused or salvaged, and pull boxes, conduit and detector frames not reused, shall become the property of the Contractor and shall be removed from the highway right of way in conformance with the provisions in Section 7-1.13, "Disposal of Material Outside the Highway Right of Way," except, if not interfering with other construction, underground conduit may be abandoned in place after all conductors have been removed.

- Care shall be exercised in salvaging equipment so that it will not be damaged or destroyed and will remain in its existing condition whenever possible. Mast arms shall be removed from standards. Luminaires, signal heads, and signal mounting assemblies shall be removed from standards and mast arms.
- Attention is directed to the provisions in Section 7-1.11, "Preservation of Property," and 7-1.12, "Indemnification and Insurance." The Contractor will be required to repair or replace, at the Contractor's expense, any electrical equipment to be salvaged which, as determined by the Engineer, has been damaged or destroyed by reason of the Contractor's operations.
- Attention is directed to the provisions in Section 86-2.03, "Foundations," regarding foundations to be abandoned or removed.
- Holes resulting from removing pull boxes and detector frames shall be filled with material equivalent to the surrounding material.

86-7.02 REINSTALLING REMOVED ELECTRICAL EQUIPMENT

- When removed electrical equipment is to be reinstalled, the Contractor shall furnish and install all necessary materials and equipment, including signal mounting assemblies, anchor bolts, nuts, washers and concrete as required to complete the new installation.
- All traffic signal and flashing beacon faces to be reinstalled or to be part of a modified system shall be cleaned and relamped.
- All luminaires and sign lighting fixtures to be reinstalled shall be cleaned and relamped.
- Existing materials required to be reused and found to be unsatisfactory by the Engineer shall be replaced by new material and the cost therefor will be paid for as extra work as provided in Section 4-1.03D.

86-8 PAYMENT

86-8.01 PAYMENT

- The contract lump sum price or prices paid for signal, ramp metering, flashing beacon, lighting, sign illumination, traffic monitoring station, highway advisory radio systems, closed circuit television systems, or combinations thereof; for modifying or removing those systems; for temporary systems; or the lump sum or unit prices paid for various units of those systems; or the lump sum or per foot price paid for conduit of the various sizes, types and installation methods listed in the Engineer's Estimate shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in furnishing and installing, modifying, or removing the systems, combinations or units thereof, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer, including any necessary pull boxes (except when the type required is shown as a separate contract item); excavation and backfill; concrete foundations (except when shown as a separate contract item); pedestrian barricades; furnishing and installing illuminated street name signs; installing State-furnished sign panels on pedestrian barricades, on flashing beacon standards, and on traffic signal mast arms; restoring sidewalk, pavement and appurtenances damaged or destroyed during construction; salvaging existing materials; and making all required tests.

- If a portion or all of the poles for signal, lighting and electrical systems pursuant to Standard Specification Section 86, "Signals, Lighting and Electrical Systems," is fabricated more than 300 air line miles from both-Sacramento and Los Angeles, additional shop inspection expenses will be sustained by the State. Whereas it is and will be impracticable and extremely difficult to ascertain and determine the actual increase in such expenses, it is agreed that payment to the Contractor for furnishing such items from each fabrication site located more than 300 air line miles from both Sacramento and Los Angeles will be reduced $5,000; in addition, in the case where a fabrication site is located more than 3,000 air line miles from both Sacramento and Los Angeles, payment will be reduced an additional $3,000 per each fabrication site ($8,000 total per site).
- Full compensation for all additional materials and labor, not shown on the plans or specified, which are necessary to complete the installation of the various systems, shall be considered as included in the prices paid for the systems, or units thereof, and no additional compensation will be allowed therefor, except as provided in Section 86-1.06, "Maintaining Existing and Temporary Electrical Systems."
- When shown as a contract item, the contract price paid per foot for cast-in-drilled-hole concrete pile (signal foundation) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing reinforced concrete pile foundations of the size shown on the Engineer's Estimate, including drilling holes, disposing of the material resulting from drilling holes, furnishing and placing anchor bolt assemblies and reinforcing steel, complete in place, as shown on the plans, and as specified in these specifications and the special provisions and as directed by the Engineer.
- When shown as a contract item, non-reinforced portland cement concrete foundations will be measured and paid for by the cubic yard for foundation concrete in the same manner as provided for minor concrete (minor structure) in Section 51, "Concrete Structures."
- When shown as a separate contract item by the lump sum or per foot, interconnection conduit and cable shall include all interconnection conductors, but shall only include conduit and pull boxes containing interconnection cable and no other conductors. The quantity of interconnection conduit and cable to be paid for by the foot shall be the length of that conduit. Compensation for conduit containing interconnection cable and other conductors shall be considered as included in the contract price paid for the item requiring the other conductors.
- Full compensation for furnishing, installing, maintaining and removing falsework lighting equipment shall be considered as included in the contract prices paid for the items of work involved in the structure which requires the falsework lighting and no additional compensation will be allowed therefor.

SECTION 87: (BLANK)

MATERIALS

SECTION 88: ENGINEERING FABRICS

88-1.01 DESCRIPTION

- Engineering fabrics consisting of pavement reinforcing fabric, filter fabric and rock slope protection fabric shall conform to the provisions in this Section 88, "Engineering Fabrics."
- Engineering fabrics shall be placed in accordance with the various sections of these specifications requiring the use of an engineering fabric or as specified in the special provisions.
- A Certificate of Compliance for each kind of engineering fabric used on the project shall be furnished to the Engineer in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."
- Engineering fabrics shall be furnished in protective covers capable of protecting the fabric from ultraviolet rays, abrasion and water.

88-1.02 PAVEMENT REINFORCING FABRIC

- Pavement reinforcing fabric shall be 100 percent polypropylene staple fiber fabric material, needle-punched, thermally bonded on one side, and conform to the following:

Specification	Requirement
Weight, grams per square meter ASTM Designation: D 5261	140
Grab tensile strength (25-mm grip), kilonewtons, min. in each direction ASTM Designation: D 4632	0.45
Elongation at break, percent min. ASTM Designation: D 4632	50
Asphalt retention by fabric, grams per square meter. (Residual Minimum) ASTM Designation: D 6140	900

Note: Weight, grab, elongation and asphalt retention are based on Minimum Average Roll Value (MARV)

88-1.03 FILTER FABRIC

- Filter fabric shall be manufactured from polyester, nylon or polypropylene material, or any combination thereof. The fabric shall be permeable, nonwoven, shall not act as a wicking agent, and shall conform to the following:

Specification	Requirements	
	Edge Drains	Underdrains
Weight, grams per square meter, min. ASTM Designation: D 3776	135	135
Grab tensile strength (25-mm grip), kilonewtons, min. in each direction ASTM Designation: D 4632	0.22	0.40
Elongation at break, percent min. ASTM Designation: D 4632	10	30
Toughness, kilonewtons, min. (Percent elongation x grab tensile strength)	13	26
Permittivity, 1/sec., min. ASTM Designation: D 4491	0.5	0.5

- If filter fabric is to be exposed for more than 72 hours, all fabric of that type (underdrain or edge drain) shall be treated with ultraviolet ray (UV) protection. The treated fabric shall provide a minimum of 70 percent breaking strength retention after 500 hours exposure when tested in conformance with the requirements in ASTM Designation: D 4355. Unless otherwise specified, the Contractor shall submit samples of the treated filter fabric to the Transportation Laboratory at least 45 days prior to use.
- Filter fabric, not treated with UV protection, which is exposed for more than 72 hours shall be removed and replaced at the expense of the Contractor. The replacement fabric either shall be treated with UV protection or shall not be exposed for more than 72 hours.

88-1.04 ROCK SLOPE PROTECTION FABRIC

- Rock slope protection fabric shall be manufactured from polyester, nylon, polypropylene or polyvinylidene material or any combination thereof.
- Rock slope protection fabric shall be treated with ultraviolet ray (UV) protection. The UV treated fabric shall provide a minimum of 70 percent breaking strength retention after 500 hours exposure when tested in conformance with the requirements in ASTM Designation: D 4355. Unless otherwise specified, the Contractor shall submit samples of the treated fabric to the Transportation Laboratory at least 45 days prior to use.
- Rock slope protection fabric shall be, at the option of the Contractor, either woven filament or nonwoven type fabric.
- Woven filament type rock slope protection fabric shall be Type A or Type B as specified in the special provisions. The woven filament fabric shall be manufactured from individually extruded and quenched filaments, not from larger previously quenched fibers or films, and shall conform to the following:

Specification	Requirement	
	Type A	Type B
Weight, grams per square meter, min. ASTM Designation: D 3776	135	200
Grab tensile strength (25-mm grip), kilonewtons, min. in each direction ASTM Designation: D 4632	0.45	0.89
Elongation at break, percent max. ASTM Designation: D 4632	35	35
Toughness, kilonewtons, min. (Percent elongation x grab tensile strength)	15	31
Permittivity, 1/sec., min. ASTM Designation: D 4491	0.5	0.5

- Edges of woven filament fabric shall be either selvaged or serged.
- Nonwoven type rock slope protection fabric shall be Type A or Type B as specified in the special provisions and shall conform to the following:

Specification	Requirement	
	Type A	Type B
Weight, grams per square meter, min. ASTM Designation: D 3776	135	200
Grab tensile strength (25-mm grip), kilonewtons, min. in each direction ASTM Designation: D 4632	0.40	0.89
Elongation at break, percent min. ASTM Designation: D 4632	50	50
Toughness, kilonewtons, min. (Percent elongation x grab tensile strength)	26	53
Permittivity, 1/sec., min. ASTM Designation: D 4491	0.5	0.5

88-1.05 MEASUREMENT AND PAYMENT

- Engineering fabrics will be measured and paid for in conformance with the provisions specified in the various sections of these specifications requiring the use of an engineering fabric or as specified in the special provisions.

SECTION 89: (BLANK)

SECTION 90: PORTLAND CEMENT CONCRETE

90-1 GENERAL

90-1.01 DESCRIPTION

- Portland cement concrete shall be composed of cementitious material, fine aggregate, coarse aggregate, admixtures if used, and water, proportioned and mixed as specified in these specifications.
- The Contractor shall determine the mix proportions for concrete in conformance with these specifications. Unless otherwise specified, cementitious material shall be a combination of cement and mineral admixture. Cementitious material shall be either:

A. "Type IP (MS) Modified" cement; or
B. A combination of "Type II Modified" portland cement and mineral admixture; or
C. A combination of Type V portland cement and mineral admixture.

- Type III portland cement shall be used only as allowed in the special provisions or with the approval of the Engineer.
- Class 1 concrete shall contain not less than 675 pounds of cementitious material per cubic yard.
- Class 2 concrete shall contain not less than 590 pounds of cementitious material per cubic yard.
- Class 3 concrete shall contain not less than 505 pounds of cementitious material per cubic yard.
- Class 4 concrete shall contain not less than 420 pounds of cementitious material per cubic yard.
- Minor concrete shall contain not less than 550 pounds of cementitious material per cubic yard unless otherwise specified in these specifications or the special provisions.
- Unless otherwise designated on the plans or specified in these specifications or the special provisions, the amount of cementitious material used per cubic yard of concrete in structures or portions of structures shall conform to the following:

Use	Cementitious Material Content pounds/CY
Concrete designated by compressive strength:	
Deck slabs and slab spans of bridges	675 min., 800 max.
Roof sections of exposed top box culverts	675 min., 800 max.
Other portions of structures	590 min., 800 max.
Concrete not designated by compressive strength:	
Deck slabs and slab spans of bridges	675 min.
Roof sections of exposed top box culverts	675 min.
Prestressed members	675 min.
Seal courses	675 min.
Other portions of structures	590 min.
Concrete for precast members	590 min., 925 max.

- Whenever the 28-day compressive strength shown on the plans is greater than 3,600 psi, the concrete shall be designated by compressive strength. If the plans show a 28-day compressive strength that is 4,000 psi or greater, an additional 14 days will be allowed to obtain the specified strength. The 28-day compressive strengths shown on the plans that are 3,600 psi or less are shown for design information only and are not a requirement for acceptance of the concrete.
- Concrete designated by compressive strength shall be proportioned such that the concrete will attain the strength shown on the plans or specified in the special provisions.
- Before using concrete for which the mix proportions have been determined by the Contractor, or in advance of revising those mix proportions, the Contractor shall submit in writing to the Engineer a copy of the mix design.
- Compliance with cementitious material content requirements will be verified in conformance with procedures described in California Test 518 for cement content. For testing purposes, mineral admixture shall be considered to be cement. Batch proportions shall be adjusted as necessary to produce concrete having the specified cementitious material content.
- If any concrete has a cementitious material, portland cement, or mineral admixture content that is less than the minimum required, the concrete shall be removed. However, if the Engineer determines that the concrete is structurally adequate, the concrete may remain in place and the Contractor shall pay to the State $0.25 for each pound of cementitious material, portland cement, or mineral admixture that is less than the minimum required. The Department may deduct the amount from any moneys due, or that may become due, the Contractor under the contract. The deductions will not be made unless the difference between the contents required and those actually provided exceeds the batching tolerances permitted by Section 90-5, "Proportioning." No deductions will be made based on the results of California Test 518.
- The requirements of the preceding paragraph shall not apply to minor concrete or commercial quality concrete.

90-2 MATERIALS

90-2.01 CEMENT

- Unless otherwise specified, cement shall be either "Type IP (MS) Modified" cement, "Type II Modified" portland cement or Type V portland cement.
- "Type IP (MS) Modified" cement shall conform to the requirements for Type IP (MS) cement in ASTM Designation: C 595, and shall be comprised of an intimate and uniform blend of Type II cement and not more than 35 percent by weight of mineral admixture. The type and minimum amount of mineral admixture used in the manufacture of "Type IP (MS) Modified" cement shall be in conformance with the provisions in Section 90-4.08, "Required Use of Mineral Admixtures."
- "Type II Modified" portland cement shall conform to the requirements for Type II portland cement in ASTM Designation: C 150-02a.
- In addition, "Type IP (MS) Modified" cement and "Type II Modified" portland cement shall conform to the following requirements:

A. The cement shall not contain more than 0.60-percent by weight of alkalies, calculated as the percentage of Na_2O plus 0.658 times the percentage of K_2O, when determined by either direct intensity flame photometry or by the atomic absorption method. The instrument and procedure used shall be qualified as to precision and accuracy in conformance with the requirements in ASTM Designation: C 114;
B. The autoclave expansion shall not exceed 0.50-percent; and
C. Mortar, containing the cement to be used and Ottawa sand, when tested in conformance with California Test 527, shall not expand in water more than 0.010-percent and shall not contract in air more than 0.048-percent, except that when cement is to be used for precast prestressed concrete piling, precast prestressed concrete members, or steam cured concrete products, the mortar shall not contract in air more than 0.053-percent.

- Type III and Type V portland cements shall conform to the requirements in ASTM Designation: C 150-02a and the additional requirements listed above for "Type II Modified" portland cement, except that when tested in conformance with California Test 527, mortar containing Type III portland cement shall not contract in air more than 0.075-percent.
- Cement used in the manufacture of cast-in-place concrete for exposed surfaces of like elements of a structure shall be from the same cement mill.
- Cement shall be protected from exposure to moisture until used. Sacked cement shall be piled to permit access for tally, inspection, and identification of each shipment.
- Adequate facilities shall be provided to assure that cement meeting the provisions specified in this Section 90-2.01 shall be kept separate from other cement in order to prevent any but the specified cement from entering the work. Safe and suitable facilities for sampling cement shall be provided at the weigh hopper or in the feed line immediately in advance of the hopper, in conformance with California Test 125.

- If cement is used prior to sampling and testing as provided in Section 6-1.07, "Certificates of Compliance," and the cement is delivered directly to the site of the work, the Certificate of Compliance shall be signed by the cement manufacturer or supplier of the cement. If the cement is used in ready-mixed concrete or in precast concrete products purchased as such by the Contractor, the Certificate of Compliance shall be signed by the manufacturer of the concrete or product.
- Cement furnished without a Certificate of Compliance shall not be used in the work until the Engineer has had sufficient time to make appropriate tests and has approved the cement for use.

90-2.02 AGGREGATES

- Aggregates shall be free from deleterious coatings, clay balls, roots, bark, sticks, rags, and other extraneous material.
- Natural aggregates shall be thoroughly and uniformly washed before use.
- The Contractor, at the Contractor's expense, shall provide safe and suitable facilities, including necessary splitting devices for obtaining samples of aggregates, in conformance with California Test 125.
- Aggregates shall be of such character that it will be possible to produce workable concrete within the limits of water content provided in Section 90-6.06, "Amount of Water and Penetration."
- Aggregates shall have not more than 10 percent loss when tested for soundness in conformance with the requirements in California Test 214. The soundness requirement for fine aggregate will be waived, provided that the durability index, D_f, of the fine aggregate is 60, or greater, when tested for durability in conformance with California Test 229.
- If the results of any one or more of the Cleanness Value, Sand Equivalent, or aggregate grading tests do not meet the requirements specified for "Operating Range" but all meet the "Contract Compliance" requirements, the placement of concrete shall be suspended at the completion of the current pour until tests or other information indicate that the next material to be used in the work will comply with the requirements specified for "Operating Range."
- If the results of either or both the Cleanness Value and coarse aggregate grading tests do not meet the requirements specified for "Contract Compliance," the concrete that is represented by the tests shall be removed. However, if the Engineer determines that the concrete is structurally adequate, the concrete may remain in place, and the Contractor shall pay to the State $3.50 per cubic yard for paving concrete and $5.50 per cubic yard for the concrete represented by these tests and left in place. The Department may deduct the amount from any moneys due, or that may become due, the Contractor under the contract.
- If the results of either or both the Sand Equivalent and fine aggregate grading tests do not meet the requirements specified for "Contract Compliance," the concrete which is represented by the tests shall be removed. However, if the Engineer determines that the concrete is structurally adequate, the concrete may remain in place, and the Contractor shall pay to the State $3.50 per cubic yard for paving concrete and $5.50 per cubic yard for the concrete represented by these tests and left in place. The Department may deduct the amount from any moneys due, or that may become due, the Contractor under the contract.

- The 2 preceding paragraphs apply individually to the "Contract Compliance" requirements for coarse aggregate and fine aggregate. When both coarse aggregate and fine aggregate do not conform to the "Contract Compliance" requirements, both paragraphs shall apply. The payments specified in those paragraphs shall be in addition to any payments made in conformance with the provisions in Section 90-1.01, "Description."
- No single Cleanness Value, Sand Equivalent or aggregate grading test shall represent more than 300 cubic yards of concrete or one day's pour, whichever is smaller.
- When the source of an aggregate is changed, the Contractor shall adjust the mix proportions and submit in writing to the Engineer a copy of the mix design before using the aggregates.

90-2.02A Coarse Aggregate

- Coarse aggregate shall consist of gravel, crushed gravel, crushed rock, crushed air-cooled iron blast furnace slag or combinations thereof. Crushed air-cooled blast furnace slag shall not be used in reinforced or prestressed concrete.
- Coarse aggregate shall conform to the following quality requirements:

Tests	California Test	Requirements
Loss in Los Angeles Rattler (after 500 revolutions)	211	45% max.
Cleanness Value		
Operating Range	227	75 min.
Contract Compliance	227	71 min.

- In lieu of the above Cleanness Value requirements, a Cleanness Value "Operating Range" limit of 71, minimum, and a Cleanness Value "Contract Compliance" limit of 68, minimum, will be used to determine the acceptability of the coarse aggregate if the Contractor furnishes a Certificate of Compliance, as provided in Section 6-1.07, "Certificates of Compliance," certifying that:

A. coarse aggregate sampled at the completion of processing at the aggregate production plant had a Cleanness Value of not less than 82 when tested by California Test 227; and
B. prequalification tests performed in conformance with the requirements in California Test 549 indicated that the aggregate would develop a relative strength of not less than 95 percent and would have a relative shrinkage not greater than 105 percent, based on concrete.

90-2.02B Fine Aggregate

- Fine aggregate shall consist of natural sand, manufactured sand produced from larger aggregate or a combination thereof. Manufactured sand shall be well graded.
- Fine aggregate shall conform to the following quality requirements:

Test	California Test	Requirements
Organic Impurities	213	Satisfactory[a]
Mortar Strengths Relative to Ottawa Sand	515	95%, min.
Sand Equivalent:	217	
Operating Range		75, min.
Contract Compliance		71, min.

a Fine aggregate developing a color darker than the reference standard color solution may be accepted if it is determined by the Engineer, from mortar strength tests, that a darker color is acceptable.

In lieu of the above Sand Equivalent requirements, a Sand Equivalent "Operating Range" limit of 71 minimum and a Sand Equivalent "Contract Compliance" limit of 68 minimum will be used to determine the acceptability of the fine aggregate if the Contractor furnishes a Certificate of Compliance, as provided in Section 6-1.07, "Certificates of Compliance," certifying that:

A. fine aggregate sampled at the completion of processing at the aggregate production plant had a Sand Equivalent value of not less than 82 when tested by California Test 217; and
B. prequalification tests performed in conformance with California Test 549 indicated that the aggregate would develop a relative strength of not less than 95 percent and would have a relative shrinkage not greater than 105 percent, based on concrete.

90-2.03 WATER

In conventionally reinforced concrete work, the water for curing, for washing aggregates, and for mixing shall be free from oil and shall not contain more than 1,000 parts per million of chlorides as Cl, when tested in conformance with California Test 422, nor more than 1,300 parts per million of sulfates as SO_4, when tested in conformance with California Test 417. In prestressed concrete work, the water for curing, for washing aggregates, and for mixing shall be free from oil and shall not contain more than 650 parts per million of chlorides as Cl, when tested in conformance with California Test 422, nor more than 1,300 parts per million of sulfates as SO_4, when tested in conformance with California Test 417. In no case shall the water contain an amount of impurities that will cause either: 1) a change in the setting time of cement of more than 25 percent when tested in conformance with the requirements in ASTM Designation: C 191 or ASTM Designation: C 266; or 2) a reduction in the compressive strength of mortar at 14 days of more than 5 percent when tested in conformance with the requirements in ASTM Designation: C 109, compared to the results obtained with distilled water or deionized water tested in conformance with the requirements in ASTM Designation: C 109.

In non-reinforced concrete work, the water for curing, for washing aggregates and for mixing shall be free from oil and shall not contain more than 2,000 parts per million of chlorides as Cl, when tested in conformance with California

Test 422, or more than 1,500 parts per million of sulfates as SO_4, when tested in conformance with California Test 417.

In addition to the above provisions, water for curing concrete shall not contain impurities in a sufficient amount to cause discoloration of the concrete or produce etching of the surface.

Water reclaimed from mixer wash-out operations may be used in mixing concrete. The water shall not contain coloring agents or more than 300 parts per million of alkalis ($Na_2O + 0.658\ K_2O$) as determined on the filtrate. The specific gravity of the water shall not exceed 1.03 and shall not vary more than ±0.010 during a day's operations.

90-2.04 ADMIXTURE MATERIALS

Admixture materials shall conform to the requirements in the following ASTM Designations:

A. Chemical Admixtures—ASTM Designation: C 494.
B. Air-entraining Admixtures—ASTM Designation: C 260.
C. Calcium Chloride—ASTM Designation: D 98.
D. Mineral Admixtures—Coal fly ash; raw or calcined natural pozzolan as specified in ASTM Designation: C 618; silica fume conforming to the requirements in ASTM Designation: C 1240, with reduction of mortar expansion of 80 percent, minimum, using the cement from the proposed mix design.

Unless otherwise specified in the special provisions, mineral admixtures shall be used in conformance with the provisions in Section 90-4.08, "Required Use of Mineral Admixtures."

90-3 AGGREGATE GRADINGS

90-3.01 GENERAL

Before beginning concrete work, the Contractor shall submit in writing to the Engineer the gradation of the primary aggregate nominal sizes that the Contractor proposes to furnish. If a primary coarse aggregate or the fine aggregate is separated into 2 or more sizes, the proposed gradation shall consist of the gradation for each individual size, and the proposed proportions of each individual size, combined mathematically to indicate one proposed gradation. The proposed gradation shall meet the grading requirements shown in the table in this section, and shall show the percentage passing each of the sieve sizes used in determining the end result.

The Engineer may waive, in writing, the gradation requirements in this Section 90-3.01 and in Sections 90-3.02, "Coarse Aggregate Grading," 90-3.03, "Fine Aggregate Grading," and 90-3.04, "Combined Aggregate Gradings," if, in the Engineer's opinion, furnishing the gradation is not necessary for the type or amount of concrete work to be constructed.

Gradations proposed by the Contractor shall be within the following percentage passing limits:

Primary Aggregate Nominal Size	Sieve Size	Limits of Proposed Gradation
$1^1/_2$" x $^3/_4$"	1"	19 - 41
1" x No. 4	$^3/_4$"	52 - 85
1" x No. 4	$^3/_8$"	15 - 38
$^1/_2$" x No. 4	$^3/_8$"	40 – 78
$^3/_8$" x No. 8	$^3/_8$"	50 - 85
Fine Aggregate	No. 16	55 - 75
Fine Aggregate	No. 30	34 - 46
Fine Aggregate	No. 50	16 - 29

- Should the Contractor change the source of supply, the Contractor shall submit in writing to the Engineer the new gradations before their intended use.

90-3.02 COARSE AGGREGATE GRADING

- The grading requirements for coarse aggregates are shown in the following tables for each size of coarse aggregate:

Percentage Passing Primary Aggregate Nominal Sizes

Sieve Sizes	$1^1/_2$" x $^3/_4$"		1" x No. 4	
	Operating Range	Contract Compliance	Operating Range	Contract Compliance
2"	100	100	—	—
$1^1/_2$"	88-100	85-100	100	100
1"	X ± 18	X ± 25	88-100	86-100
$^3/_4$"	0-17	0-20	X ± 15	X ± 22
$^1/_2$"	—	—	—	—
$^3/_8$"	0-7	0-9	X ± 15	X ± 22
No. 4	—	—	0-16	0-18
No. 8	—	—	0-6	0-7

Sieve Sizes	$^1/_2$" x No. 4		$^3/_8$" x No. 8	
	Operating Range	Contract Compliance	Operating Range	Contract Compliance
2"	—	—	—	—
$1^1/_2$"	—	—	—	—
1"	—	—	—	—
$^3/_4$"	100	100	—	—
$^1/_2$"	82-100	80-100	100	100
$^3/_8$"	X ± 15	X ± 22	X ± 15	X ± 20
No. 4	0-15	0-18	0-25	0-28
No. 8	0-6	0-7	0-6	0-7

- In the above tables, the symbol X is the gradation that the Contractor proposes to furnish for the specific sieve size as provided in Section 90-3.01, "General."
- Coarse aggregate for the $1^1/_2$-inch, maximum, combined aggregate grading as provided in Section 90-3.04, "Combined Aggregate Gradings," shall be furnished in 2 or more primary aggregate nominal sizes. Each primary aggregate nominal size may be separated into 2 sizes and stored separately, provided that the combined material conforms to the grading requirements for that particular primary aggregate nominal size.
- When the one-inch, maximum, combined aggregate grading as provided in Section 90-3.04, "Combined Aggregate Gradings," is to be used, the coarse aggregate may be separated into 2 sizes and stored separately, provided that the combined material shall conform to the grading requirements for the 1" x No. 4 primary aggregate nominal size.

90-3.03 FINE AGGREGATE GRADING

- Fine aggregate shall be graded within the following limits:

Sieve Sizes	Percentage Passing	
	Operating Range	Contract Compliance
$^3/_8$"	100	100
No. 4	95-100	93-100
No. 8	65-95	61-99
No. 16	X ± 10	X ± 13
No. 30	X ± 9	X ± 12
No. 50	X ± 6	X ± 9
No. 100	2-12	1-15
No. 200	0-8	0-10

- In the above table, the symbol X is the gradation that the Contractor proposes to furnish for the specific sieve size as provided in Section 90-3.01, "General."
- In addition to the above required grading analysis, the distribution of the fine aggregate sizes shall be such that the difference between the total percentage passing the No. 16 sieve and the total percentage passing the No. 30 sieve shall be between 10 and 40, and the difference between the percentage passing the No. 30 and No. 50 sieves shall be between 10 and 40.
- Fine aggregate may be separated into 2 or more sizes and stored separately, provided that the combined material conforms to the grading requirements specified in this Section 90-3.03.

90-3.04 COMBINED AGGREGATE GRADINGS

- Combined aggregate grading limits shall be used only for the design of concrete mixes. Concrete mixes shall be designed so that aggregates are combined in proportions that shall produce a mixture within the grading limits for combined aggregates as specified herein.
- The combined aggregate grading, except when otherwise specified in these specifications or the special provisions, shall be either the $1^1/_2$-inch, maximum grading, or the one-inch, maximum grading, at the option of the Contractor.

Sieve Sizes	Percentage Passing			
	$1^1/_2$" Max.	1" Max.	$^1/_2$" Max.	$^3/_8$" Max.
2"	100	—	—	—
$1^1/_2$"	90-100	100	—	—
1"	50-86	90-100	—	—
$^3/_4$"	45-75	55-100	100	—
$^1/_2$"	—	—	90-100	100
$^3/_8$"	38-55	45-75	55-86	50 - 100
No. 4	30-45	35-60	45-63	45 - 63
No. 8	23-38	27-45	35-49	35 - 49
No. 16	17-33	20-35	25-37	25 - 37
No. 30	10-22	12-25	15-25	15 - 25
No. 50	4-10	5-15	5-15	5 - 15
No. 100	1-6	1-8	1-8	1 - 8
No. 200	0-3	0-4	0-4	0 - 4

- Changes from one grading to another shall not be made during the progress of the work unless permitted by the Engineer.

90-4 ADMIXTURES

90-4.01 GENERAL

- Admixtures used in portland cement concrete shall conform to and be used in conformance with the provisions in this Section 90-4 and the special provisions. Admixtures shall be used when specified or ordered by the Engineer and may be used at the Contractor's option as provided herein.
- Chemical admixtures and air-entraining admixtures containing chlorides as Cl in excess of one percent by weight of admixture, as determined by California Test 415, shall not be used in prestressed or reinforced concrete.
- Calcium chloride shall not be used in concrete except when otherwise specified.
- Mineral admixture used in concrete for exposed surfaces of like elements of a structure shall be from the same source and of the same percentage.
- Admixtures shall be uniform in properties throughout their use in the work. Should it be found that an admixture as furnished is not uniform in properties, its use shall be discontinued.
- If more than one admixture is used, the admixtures shall be compatible with each other so that the desirable effects of all admixtures used will be realized.

90-4.02 MATERIALS

- Admixture materials shall conform to the provisions in Section 90–2.04, "Admixture Materials."

90-4.03 ADMIXTURE APPROVAL

- No admixture brand shall be used in the work unless it is on the Department's current list of approved brands for the type of admixture involved.

- Admixture brands will be considered for addition to the approved list if the manufacturer of the admixture submits to the Transportation Laboratory a sample of the admixture accompanied by certified test results demonstrating that the admixture complies with the requirements in the appropriate ASTM Designation and these specifications. The sample shall be sufficient to permit performance of all required tests. Approval of admixture brands will be dependent upon a determination as to compliance with the requirements, based on the certified test results submitted, together with tests the Department may elect to perform.
- When the Contractor proposes to use an admixture of a brand and type on the current list of approved admixture brands, the Contractor shall furnish a Certificate of Compliance from the manufacturer, as provided in Section 6-1.07, "Certificates of Compliance," certifying that the admixture furnished is the same as that previously approved. If a previously approved admixture is not accompanied by a Certificate of Compliance, the admixture shall not be used in the work until the Engineer has had sufficient time to make the appropriate tests and has approved the admixture for use. The Engineer may take samples for testing at any time, whether or not the admixture has been accompanied by a Certificate of Compliance.
- If a mineral admixture is delivered directly to the site of the work, the Certificate of Compliance shall be signed by the manufacturer or supplier of the mineral admixture. If the mineral admixture is used in ready-mix concrete or in precast concrete products purchased as such by the Contractor, the Certificate of Compliance shall be signed by the manufacturer of the concrete or product.

90-4.04 REQUIRED USE OF CHEMICAL ADMIXTURES AND CALCIUM CHLORIDE

- When the use of a chemical admixture or calcium chloride is specified, the admixture shall be used at the dosage specified, except that if no dosage is specified, the admixture shall be used at the dosage normally recommended by the manufacturer of the admixture.
- Calcium chloride shall be dispensed in liquid, flake, or pellet form. Calcium chloride dispensed in liquid form shall conform to the provisions for dispensing liquid admixtures in Section 90-4.10, "Proportioning and Dispensing Liquid Admixtures."

90-4.05 OPTIONAL USE OF CHEMICAL ADMIXTURES

- The Contractor will be permitted to use Type A or F, water-reducing; Type B, retarding; or Type D or G, water-reducing and retarding admixtures as described in ASTM Designation: C 494 to conserve cementitious material or to facilitate any concrete construction application subject to the following conditions:

A. When a water-reducing admixture or a water-reducing and retarding admixture is used, the cementitious material content specified or ordered may be reduced by a maximum of 5 percent by weight, except that the resultant cementitious material content shall be not less than 505 pounds per cubic yard, and

B. When a reduction in cementitious material content is made, the dosage of admixture used shall be the dosage used in determining approval of the admixture.

• Unless otherwise specified, a Type C accelerating chemical admixture conforming to the requirements in ASTM Designation: C 494, may be used in portland cement concrete. Inclusion in the mix design submitted for approval will not be required provided that the admixture is added to counteract changing conditions that contribute to delayed setting of the portland cement concrete, and the use or change in dosage of the admixture is approved in writing by the Engineer.

90-4.06 REQUIRED USE OF AIR-ENTRAINING ADMIXTURES

• When air-entrainment is specified or ordered by the Engineer, the air-entraining admixture shall be used in amounts to produce a concrete having the specified air content as determined by California Test 504.

90-4.07 OPTIONAL USE OF AIR-ENTRAINING ADMIXTURES

• When air-entrainment has not been specified or ordered by the Engineer, the Contractor will be permitted to use an air-entraining admixture to facilitate the use of any construction procedure or equipment provided that the average air content, as determined by California Test 504, of 3 successive tests does not exceed 4 percent, and no single test value exceeds 5.5 percent. If the Contractor elects to use an air-entraining admixture in concrete for pavement, the Contractor shall so indicate at the time the Contractor designates the source of aggregate as provided in Section 40-1.015, "Cement Content."

90-4.08 REQUIRED USE OF MINERAL ADMIXTURES

• Unless otherwise specified, mineral admixture shall be combined with cement to make cementitious material.

• The calcium oxide content shall not exceed 10 percent when determined in conformance with the requirements in ASTM Designation: C 114. The available alkali content (as sodium oxide equivalent) shall not exceed 1.5 percent when determined in conformance with the requirements in ASTM Designation: C 311, or the total alkali content (as sodium oxide equivalent) shall not exceed 5.0 percent when determined in conformance with the requirements in ASTM Designation: D 4326.

• The amounts of cement and mineral admixture used in cementitious material shall be sufficient to satisfy the minimum cementitious material content requirements specified in Section 90-1.01, "Description," or Section 90-4.05, "Optional Use of Chemical Admixtures," and shall conform to the following:

A. The minimum amount of cement shall not be less than 75 percent by weight of the specified minimum cementitious material content;
B. The minimum amount of mineral admixture to be combined with cement shall be determined using one of the following criteria:

1. When the calcium oxide content of a mineral admixture is equal to or less than 2 percent by weight, the amount of mineral admixture shall not be less than 15 percent by weight of the total amount of cementitious material to be used in the mix;
2. When the calcium oxide content of a mineral admixture is greater than 2 percent, the amount of mineral admixture shall not be less than 25 percent by weight of the total amount of cementitious material to be used in the mix;
3. When a mineral admixture that conforms to the provisions for silica fume in Section 90-2.04, "Admixture Materials," is used, the amount of mineral admixture shall not be less than 10 percent by weight of the total amount of cementitious material to be used in the mix.

C. The total amount of mineral admixture shall not exceed 35 percent by weight of the total amount of cementitious material to be used in the mix. Where Section 90-1.01, "Description," specifies a maximum cementitious content in pounds per cubic yard, the total weight of cement and mineral admixture per cubic yard shall not exceed the specified maximum cementitious material content.

90-4.09 BLANK

90-4.10 PROPORTIONING AND DISPENSING LIQUID ADMIXTURES

- Chemical admixtures and air-entraining admixtures shall be dispensed in liquid form. Dispensers for liquid admixtures shall have sufficient capacity to measure at one time the prescribed quantity required for each batch of concrete. Each dispenser shall include a graduated measuring unit into which liquid admixtures are measured to within ±5 percent of the prescribed quantity for each batch. Dispensers shall be located and maintained so that the graduations can be accurately read from the point at which proportioning operations are controlled to permit a visual check of batching accuracy prior to discharge. Each measuring unit shall be clearly marked for the type and quantity of admixture.
- Each liquid admixture dispensing system shall be equipped with a sampling device consisting of a valve located in a safe and readily accessible position such that a sample of the admixture may be withdrawn slowly by the Engineer.
- If more than one liquid admixture is used in the concrete mix, each liquid admixture shall have a separate measuring unit and shall be dispensed by injecting equipment located in such a manner that the admixtures are not mixed at high concentrations and do not interfere with the effectiveness of each other. When air-entraining admixtures are used in conjunction with other liquid admixtures, the air-entraining admixture shall be the first to be incorporated into the mix.
- When automatic proportioning devices are required for concrete pavement, dispensers for liquid admixtures shall operate automatically with the batching control equipment. The dispensers shall be equipped with an automatic warning system in good operating condition that will provide a visible or audible signal at the point at which proportioning operations are controlled when the quantity of admixture measured for each batch of concrete varies from the preselected dosage

by more than 5 percent, or when the entire contents of the measuring unit are not emptied from the dispenser into each batch of concrete.

- Unless liquid admixtures are added to premeasured water for the batch, their discharge into the batch shall be arranged to flow into the stream of water so that the admixtures are well dispersed throughout the batch. Air-entraining admixtures may be dispensed directly into moist sand in the batching bins provided that adequate control of the air content of the concrete can be maintained.
- Liquid admixtures requiring dosages greater than one-half gallon per cubic yard shall be considered to be water when determining the total amount of free water as specified in Section 90-6.06, "Amount of Water and Penetration."
- Special admixtures, such as "high range" water reducers that may contribute to a high rate of slump loss, shall be measured and dispensed as recommended by the admixture manufacturer and as approved by the Engineer.

90-4.11 STORAGE, PROPORTIONING, AND DISPENSING OF MINERAL ADMIXTURES

- Mineral admixtures shall be protected from exposure to moisture until used. Sacked material shall be piled to permit access for tally, inspection, and identification of each shipment.
- Adequate facilities shall be provided to assure that mineral admixtures meeting the specified requirements are kept separate from other mineral admixtures in order to prevent any but the specified mineral admixtures from entering the work. Safe and suitable facilities for sampling mineral admixtures shall be provided at the weigh hopper or in the feed line immediately in advance of the hopper.
- Mineral admixtures shall be incorporated into concrete using equipment conforming to the requirements for cement weigh hoppers, and charging and discharging mechanisms in ASTM Designation: C 94, in Section 90-5.03, "Proportioning," and in this Section 90-4.11.
- When concrete is completely mixed in stationary paving mixers, the mineral admixture shall be weighed in a separate weigh hopper conforming to the provisions for cement weigh hoppers and charging and discharging mechanisms in Section 90-5.03A, "Proportioning for Pavement," and the mineral admixture and cement shall be introduced simultaneously into the mixer proportionately with the aggregate. If the mineral admixture is not weighed in a separate weigh hopper, the Contractor shall provide certification that the stationary mixer is capable of mixing the cement, admixture, aggregates and water uniformly prior to discharge. Certification shall contain the following:

A. Test results for 2 compressive strength test cylinders of concrete taken within the first third and 2 compressive strength test cylinders of concrete taken within the last third of the concrete discharged from a single batch from the stationary paving mixer. Strength tests and cylinder preparation will be in conformance with the provisions of Section 90-9, "Compressive Strength;"
B. Calculations demonstrating that the difference in the averages of 2 compressive strengths taken in the first third is no greater than 7.5 percent different than the averages of 2 compressive strengths taken in the last

third of the concrete discharged from a single batch from the stationary paving mixer. Strength tests and cylinder preparation will be in conformance with the provisions of Section 90-9, "Compressive Strength;" and

C. The mixer rotation speed and time of mixing prior to discharge that are required to produce a mix that meets the requirements above.

90-5 PROPORTIONING

90-5.01 STORAGE OF AGGREGATES

• Aggregates shall be stored or stockpiled in such a manner that separation of coarse and fine particles of each size shall be avoided and also that the various sizes shall not become intermixed before proportioning.

• Aggregates shall be stored or stockpiled and handled in a manner that shall prevent contamination by foreign materials. In addition, storage of aggregates at batching or mixing facilities that are erected subsequent to the award of the contract and that furnish concrete to the project shall conform to the following:

A. Intermingling of the different sizes of aggregates shall be positively prevented. The Contractor shall take the necessary measures to prevent intermingling. The preventive measures may include, but are not necessarily limited to, physical separation of stockpiles or construction of bulkheads of adequate length and height; and

B. Contamination of aggregates by contact with the ground shall be positively prevented. The Contractor shall take the necessary measures to prevent contamination. The preventive measures shall include, but are not necessarily limited to, placing aggregates on wooden platforms or on hardened surfaces consisting of portland cement concrete, asphalt concrete, or cement treated material.

• In placing aggregates in storage or in moving the aggregates from storage to the weigh hopper of the batching plant, any method that may cause segregation, degradation, or the combining of materials of different gradings that will result in any size of aggregate at the weigh hopper failing to meet the grading requirements, shall be discontinued. Any method of handling aggregates that results in excessive breakage of particles shall be discontinued. The use of suitable devices to reduce impact of falling aggregates may be required by the Engineer.

90-5.02 PROPORTIONING DEVICES

• Weighing, measuring, or metering devices used for proportioning materials shall conform to the requirements in Section 9-1.01, "Measurement of Quantities," and this Section 90-5.02. In addition, automatic weighing systems shall comply with the requirements for automatic proportioning devices in Section 90-5.03A, "Proportioning for Pavement." Devices shall be automatic to the extent that the only manual operation required for proportioning the aggregates, cement, and mineral admixture for one batch of concrete is a single operation of a switch or starter.

- Proportioning devices shall be tested at the expense of the Contractor as frequently as the Engineer may deem necessary to ensure their accuracy.
- Weighing equipment shall be insulated against vibration or movement of other operating equipment in the plant. When the plant is in operation, the weight of each batch of material shall not vary from the weight designated by the Engineer by more than the tolerances specified herein.
- Equipment for cumulative weighing of aggregate shall have a zero tolerance of ±0.5-percent of the designated total batch weight of the aggregate. For systems with individual weigh hoppers for the various sizes of aggregate, the zero tolerance shall be ±0.5-percent of the individual batch weight designated for each size of aggregate. Equipment for cumulative weighing of cement and mineral admixtures shall have a zero tolerance of ±0.5-percent of the designated total batch weight of the cement and mineral admixture. Equipment for weighing cement or mineral admixture separately shall have a zero tolerance of ±0.5-percent of their designated individual batch weights. Equipment for measuring water shall have a zero tolerance of ±0.5-percent of its designated weight or volume.
- The weight indicated for any batch of material shall not vary from the preselected scale setting by more than the following:

A. Aggregate weighed cumulatively shall be within 1.0 percent of the designated total batch weight of the aggregate. Aggregates weighed individually shall be within 1.5 percent of their respective designated batch weights;
B. Cement shall be within 1.0 percent of its designated batch weight. When weighed individually, mineral admixture shall be within 1.0 percent of its designated batch weight. When mineral admixture and cement are permitted to be weighed cumulatively, cement shall be weighed first to within 1.0 percent of its designated batch weight, and the total for cement and mineral admixture shall be within 1.0 percent of the sum of their designated batch weights; and
C. Water shall be within 1.5 percent of its designated weight or volume.

- Each scale graduation shall be approximately 0.001 of the total capacity of the scale. The capacity of scales for weighing cement, mineral admixture, or cement plus mineral admixture and aggregates shall not exceed that of commercially available scales having single graduations indicating a weight not exceeding the maximum permissible weight variation above, except that no scale shall be required having a capacity of less than 1,000 pounds, with one-pound graduations.

90-5.03 PROPORTIONING

- Proportioning shall consist of dividing the aggregates into the specified sizes, each stored in a separate bin, and combining them with cement, mineral admixture, and water as provided in these specifications. Aggregates shall be proportioned by weight.
- At the time of batching, aggregates shall have been dried or drained sufficiently to result in a stable moisture content such that no visible separation of water from aggregate will take place during transportation from the proportioning

plant to the point of mixing. In no event shall the free moisture content of the fine aggregate at the time of batching exceed 8 percent of its saturated, surface-dry weight.

- Should separate supplies of aggregate material of the same size group, but of different moisture content or specific gravity or surface characteristics affecting workability, be available at the proportioning plant, withdrawals shall be made from one supply exclusively and the materials therein completely exhausted before starting upon another.
- Bulk "Type IP (MS) Modified" cement shall be weighed in an individual hopper and shall be kept separate from the aggregates until the ingredients are released for discharge into the mixer.
- Bulk cement and mineral admixture may be weighed in separate, individual weigh hoppers or may be weighed in the same weigh hopper and shall be kept separate from the aggregates until the ingredients are released for discharge into the mixer. If the cement and mineral admixture are weighed cumulatively, the cement shall be weighed first.
- When cement and mineral admixtures are weighed in separate weigh hoppers, the weigh systems for the proportioning of the aggregate, the cement, and the mineral admixture shall be individual and distinct from all other weigh systems. Each weigh system shall be equipped with a hopper, a lever system, and an indicator to constitute an individual and independent material weighing device. The cement and the mineral admixture shall be discharged into the mixer simultaneously with the aggregate.
- The scales and weigh hoppers for bulk weighing cement, mineral admixture, or cement plus mineral admixture shall be separate and distinct from the aggregate weighing equipment.
- For batches with a volume of one cubic yard or more, the batching equipment shall conform to one of the following combinations:

A. Separate boxes and separate scale and indicator for weighing each size of aggregate.
B. Single box and scale indicator for all aggregates.
C. Single box or separate boxes and automatic weighing mechanism for all aggregates.

- In order to check the accuracy of batch weights, the gross weight and tare weight of batch trucks, truck mixers, truck agitators, and non-agitating hauling equipment shall be determined when ordered by the Engineer. The equipment shall be weighed at the Contractor's expense on scales designated by the Engineer.

90-5.03A PROPORTIONING FOR PAVEMENT

- Aggregates and bulk cement, mineral admixture, and cement plus mineral admixture for use in pavement shall be proportioned by weight by means of automatic proportioning devices of approved type conforming to these specifications.
- The Contractor shall install and maintain in operating condition an electronically actuated moisture meter that will indicate, on a readily visible scale,

changes in the moisture content of the fine aggregate as it is batched within a sensitivity of 0.5-percent by weight of the fine aggregate.

- The batching of cement, mineral admixture, or cement plus mineral admixture and aggregate shall be interlocked so that a new batch cannot be started until all weigh hoppers are empty, the proportioning devices are within zero tolerance, and the discharge gates are closed. The interlock shall permit no part of the batch to be discharged until all aggregate hoppers and the cement and mineral admixture hoppers or the cement plus mineral admixture hopper are charged with weights that are within the tolerances specified in Section 90-5.02, "Proportioning Devices."
- When interlocks are required for cement and mineral admixture charging mechanisms and cement and mineral admixtures are weighed cumulatively, their charging mechanisms shall be interlocked to prevent the introduction of mineral admixture until the weight of cement in the cement weigh hopper is within the tolerances specified in Section 90-5.02, "Proportioning Devices."
- The discharge gate on the cement and mineral admixture hoppers or the cement plus mineral admixture hopper shall be designed to permit regulating the flow of cement, mineral admixture, or cement plus mineral admixture into the aggregate as directed by the Engineer.
- When separate weigh boxes are used for each size of aggregate, the discharge gates shall permit regulating the flow of each size of aggregate as directed by the Engineer.
- Material discharged from the several bins shall be controlled by gates or by mechanical conveyors. The means of withdrawal from the several bins, and of discharge from the weigh box, shall be interlocked so that not more than one bin can discharge at a time, and so that the weigh box cannot be tripped until the required quantity from each of the several bins has been deposited therein. Should a separate weigh box be used for each size of aggregate, all may be operated and discharged simultaneously.
- When the discharge from the several bins is controlled by gates, each gate shall be actuated automatically so that the required weight is discharged into the weigh box, after which the gate shall automatically close and lock.
- The automatic weighing system shall be designed so that all proportions required may be set on the weighing controller at the same time.

90-6 MIXING AND TRANSPORTING

90-6.01 GENERAL

- Concrete shall be mixed in mechanically operated mixers, except that when permitted by the Engineer, batches not exceeding a third of a cubic yard may be mixed by hand methods in conformance with the provisions in Section 90-6.05, "Hand-Mixing."
- Equipment having components made of aluminum or magnesium alloys that would have contact with plastic concrete during mixing, transporting, or pumping of portland cement concrete shall not be used.
- Concrete shall be homogeneous and thoroughly mixed, and there shall be no lumps or evidence of undispersed cement, mineral admixture, or cement plus mineral admixture.

- Uniformity of concrete mixtures will be determined by differences in penetration as determined by California Test 533, or slump as determined by ASTM Designation: C 143, and by variations in the proportion of coarse aggregate as determined by California Test 529.
- When the mix design specifies a penetration value, the difference in penetration, determined by comparing penetration tests on 2 samples of mixed concrete from the same batch or truck mixer load, shall not exceed $^1/_2$ inch. When the mix design specifies a slump value, the difference in slump, determined by comparing slump tests on 2 samples of mixed concrete from the same batch or truck mixer load, shall not exceed the values given in the table below. Variation in the proportion of coarse aggregate will be determined by comparing the results of tests of 2 samples of mixed concrete from the same batch or truck mixer load and the difference between the 2 results shall not exceed 170 pounds per cubic yard of concrete.

Average Slump	Maximum Permissible Difference
Less than 4"	1"
4" to 6"	$1^1/_2$"
Greater than 6" to 9"	2"

- The Contractor, at the Contractor's expense, shall furnish samples of the freshly mixed concrete and provide satisfactory facilities for obtaining the samples.

90-6.02 MACHINE MIXING

- Concrete mixers may be of the revolving drum or the revolving blade type, and the mixing drum or blades shall be operated uniformly at the mixing speed recommended by the manufacturer. Mixers and agitators that have an accumulation of hard concrete or mortar shall not be used.
- The temperature of mixed concrete, immediately before placing, shall be not less than 50° F or more than 90° F. Aggregates and water shall be heated or cooled as necessary to produce concrete within these temperature limits. Neither aggregates nor mixing water shall be heated to exceed 150° F. If ice is used to cool the concrete, discharge of the mixer will not be permitted until all ice is melted.
- The batch shall be so charged into the mixer that some water will enter in advance of cementitious materials and aggregates. All water shall be in the drum by the end of the first fourth of the specified mixing time.
- Cementitious materials shall be batched and charged into the mixer by means that will not result either in loss of cementitious materials due to the effect of wind, in accumulation of cementitious materials on surfaces of conveyors or hoppers, or in other conditions that reduce or vary the required quantity of cementitious material in the concrete mixture.
- Paving and stationary mixers shall be operated with an automatic timing device. The timing device and discharge mechanism shall be interlocked so that during normal operation no part of the batch will be discharged until the specified mixing time has elapsed.
- The total elapsed time between the intermingling of damp aggregates and all cementitious materials and the start of mixing shall not exceed 30 minutes.

- The size of batch shall not exceed the manufacturer's guaranteed capacity.
- When producing concrete for pavement or base, suitable batch counters shall be installed and maintained in good operating condition at jobsite batching plants and stationary mixers. The batch counters shall indicate the exact number of batches proportioned and mixed.
- Concrete shall be mixed and delivered to the jobsite by means of one of the following combinations of operations:

A. Mixed completely in a stationary mixer and the mixed concrete transported to the point of delivery in truck agitators or in non-agitating hauling equipment (central-mixed concrete).
B. Mixed partially in a stationary mixer, and the mixing completed in a truck mixer (shrink-mixed concrete).
C. Mixed completely in a truck mixer (transit-mixed concrete).
D. Mixed completely in a paving mixer.

- Agitators may be truck mixers operating at agitating speed or truck agitators. Each mixer and agitator shall have attached thereto in a prominent place a metal plate or plates on which is plainly marked the various uses for which the equipment is designed, the manufacturer's guaranteed capacity of the drum or container in terms of the volume of mixed concrete and the speed of rotation of the mixing drum or blades.
- Truck mixers shall be equipped with electrically or mechanically actuated revolution counters by which the number of revolutions of the drum or blades may readily be verified.
- When shrink-mixed concrete is furnished, concrete that has been partially mixed at a central plant shall be transferred to a truck mixer and all requirements for transit-mixed concrete shall apply. No credit in the number of revolutions at mixing speed shall be allowed for partial mixing in a central plant.

90-6.03 TRANSPORTING MIXED CONCRETE

- Mixed concrete may be transported to the delivery point in truck agitators or truck mixers operating at the speed designated by the manufacturer of the equipment as agitating speed, or in non-agitating hauling equipment, provided the consistency and workability of the mixed concrete upon discharge at the delivery point is suitable for adequate placement and consolidation in place, and provided the mixed concrete after hauling to the delivery point conforms to the provisions in Section 90-6.01, "General."
- Truck agitators shall be loaded not to exceed the manufacturer's guaranteed capacity and shall maintain the mixed concrete in a thoroughly mixed and uniform weight during hauling.
- Bodies of non-agitating hauling equipment shall be constructed so that leakage of the concrete mix, or any part thereof, will not occur at any time.
- Concrete hauled in open-top vehicles shall be protected during hauling against rain or against exposure to the sun for more than 20 minutes when the ambient temperature exceeds 75° F.

- No additional mixing water shall be incorporated into the concrete during hauling or after arrival at the delivery point, unless authorized by the Engineer. If the Engineer authorizes additional water to be incorporated into the concrete, the drum shall be revolved not less than 30 revolutions at mixing speed after the water is added and before discharge is commenced.
- The rate of discharge of mixed concrete from truck mixer-agitators shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.
- When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge shall be completed within 1.5 hours or before 250 revolutions of the drum or blades, whichever occurs first, after the introduction of the cement to the aggregates. Under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is 85° F or above, the time allowed may be less than 1.5 hours.
- When non-agitating hauling equipment is used for transporting concrete to the delivery point, discharge shall be completed within one hour after the addition of the cement to the aggregates. Under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is 85° F or above, the time between the introduction of cement to the aggregates and discharge shall not exceed 45 minutes.
- Each load of concrete delivered at the jobsite shall be accompanied by a weighmaster certificate showing the mix identification number, non-repeating load number, date and time at which the materials were batched, the total amount of water added to the load, and for transit-mixed concrete, the reading of the revolution counter at the time the truck mixer is charged with cement. This weighmaster certificate shall also show the actual scale weights (pounds) for the ingredients batched. Theoretical or target batch weights shall not be used as a substitute for actual scale weights.
- Weighmaster certificates shall be provided in printed form, or if approved by the Engineer, the data may be submitted in electronic media. Electronic media shall be presented in a tab-delimited format on a $3^1/_2$-inch diskette with a capacity of at least 1.4 megabytes. Captured data, for the ingredients represented by each batch shall be "line feed, carriage return" (LFCR) and "one line, separate record" with allowances for sufficient fields to satisfy the amount of data required by these specifications.
- The Contractor may furnish a weighmaster certificate accompanied by a separate certificate that lists the actual batch weights or measurements for a load of concrete provided that both certificates are imprinted with the same non-repeating load number that is unique to the contract and delivered to the jobsite with the load.
- Weighmaster certificates furnished by the Contractor shall conform to the provisions in Section 9-1.01, "Measurement of Quantities."

90-6.04 TIME OR AMOUNT OF MIXING

- Mixing of concrete in paving or stationary mixers shall continue for the required mixing time after all ingredients, except water and admixture, if added with the water, are in the mixing compartment of the mixer before any part of the

batch is released. Transfer time in multiple drum mixers shall not be counted as part of the required mixing time.

- The required mixing time, in paving or stationary mixers, of concrete used for concrete structures, except minor structures, shall be not less than 90 seconds or more than 5 minutes, except that when directed by the Engineer in writing, the requirements of the following paragraph shall apply.
- The required mixing time, in paving or stationary mixers, except as provided in the preceding paragraph, shall be not less than 50 seconds or more than 5 minutes.
- The minimum required revolutions at the mixing speed for transit-mixed concrete shall not be less than that recommended by the mixer manufacturer, but in no case shall the number of revolutions be less than that required to consistently produce concrete conforming to the provisions for uniformity in Section 90-6.01, "General."

90-6.05 HAND-MIXING

- Hand-mixed concrete shall be made in batches of not more than one-third cubic yard and shall be mixed on a watertight, level platform. The proper amount of coarse aggregate shall be measured in measuring boxes and spread on the platform and the fine aggregate shall be spread on this layer, the 2 layers being not more than one foot in total depth. On this mixture shall be spread the dry cement and mineral admixture and the whole weight turned no fewer than 2 times dry; then sufficient clean water shall be added, evenly distributed, and the whole weight again turned no fewer than 3 times, not including placing in the carriers or forms.

90-6.06 AMOUNT OF WATER AND PENETRATION

- The amount of water used in concrete mixes shall be regulated so that the penetration of the concrete as determined by California Test 533 or the slump of the concrete as determined by ASTM Designation: C 143 is within the "Nominal" values shown in the following table. When the penetration or slump of the concrete is found to exceed the nominal values listed, the mixture of subsequent batches shall be adjusted to reduce the penetration or slump to a value within the nominal range shown. Batches of concrete with a penetration or slump exceeding the maximum values listed shall not be used in the work. When Type F or Type G chemical admixtures are added to the mix, the penetration requirements shall not apply and the slump shall not exceed 9 inches after the chemical admixtures are added.

Type of Work	Nominal		Maximum	
	Penetration inches	Slump inches	Penetration inches	Slump inches
Concrete Pavement	0 - 1	—	$1^1/_2$	—
Non-reinforced concrete facilities	0 - $1^1/_2$	—	2	—
Reinforced concrete structures				
Sections over 12 inches thick	0 - $1^1/_2$	—	$2^1/_2$	—
Sections 12 inches thick or less	0 - 2	—	3	—
Concrete placed under water	—	6-8	—	9
Cast-in-place concrete piles	$2^1/_2$ - $3^1/_2$	5-7	4	8

- The amount of free water used in concrete shall not exceed 310 pounds per cubic yard, plus 20 pounds for each required 100 pounds of cementitious material in excess of 550 pounds per cubic yard.
- The term free water is defined as the total water in the mixture minus the water absorbed by the aggregates in reaching a saturated surface-dry condition.
- Where there are adverse or difficult conditions that affect the placing of concrete, the above specified penetration and free water content limitations may be exceeded providing the Contractor is granted permission by the Engineer in writing to increase the cementitious material content per cubic yard of concrete. The increase in water and cementitious material shall be at a ratio not to exceed 30 pounds of water per added 100 pounds of cementitious material per cubic yard. The cost of additional cementitious material and water added under these conditions shall be at the Contractor's expense and no additional compensation will be allowed therefor.
- The equipment for supplying water to the mixer shall be constructed and arranged so that the amount of water added can be measured accurately. Any method of discharging water into the mixer for a batch shall be accurate within 1.5 percent of the quantity of water required to be added to the mix for any position of the mixer. Tanks used to measure water shall be designed so that water cannot enter while water is being discharged into the mixer and discharge into the mixer shall be made rapidly in one operation without dribbling. All equipment shall be arranged so as to permit checking the amount of water delivered by discharging into measured containers.

90-7 CURING CONCRETE

90-7.01 METHODS OF CURING

- Newly placed concrete shall be cured by the methods specified in this Section 90-7.01 and the special provisions.

90-7.01A Water Method

- The concrete shall be kept continuously wet by the application of water for a minimum curing period of 7 days after the concrete has been placed.
- When a curing medium consisting of cotton mats, rugs, carpets, or earth or sand blankets is to be used to retain the moisture, the entire surface of the concrete shall be kept damp by applying water with a nozzle that so atomizes the flow that a

mist and not a spray is formed, until the surface of the concrete is covered with the curing medium. The moisture from the nozzle shall not be applied under pressure directly upon the concrete and shall not be allowed to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface. At the expiration of the curing period, the concrete surfaces shall be cleared of all curing mediums.

- At the option of the Contractor, a curing medium consisting of white opaque polyethylene sheeting extruded onto burlap may be used to cure concrete structures. The polyethylene sheeting shall have a minimum thickness of 4 mil, and shall be extruded onto 10-ounce burlap.
- At the option of the Contractor, a curing medium consisting of polyethylene sheeting may be used to cure concrete columns. The polyethylene sheeting shall have a minimum thickness of 10 mil achieved in a single layer of material.
- If the Contractor chooses to use polyethylene sheeting or polyethylene sheeting on burlap as a curing medium as specified above, these mediums and any joints therein shall be secured as necessary to provide moisture retention and shall be within 3 inches of the concrete at all points along the surface being cured. When these mediums are used, the temperature of the concrete shall be monitored during curing. If the temperature of the concrete cannot be maintained below 140° F, this method of curing shall be discontinued, and one of the other curing methods allowed for the concrete shall be used.
- When concrete bridge decks and flat slabs are to be cured without the use of a curing medium, the entire surface of the bridge deck or slab shall be kept damp by the application of water with an atomizing nozzle as specified in the preceding paragraph, until the concrete has set, after which the entire surface of the concrete shall be sprinkled continuously with water for a period of not less than 7 days.

90-7.01B Curing Compound Method

- Surfaces of the concrete that are exposed to the air shall be sprayed uniformly with a curing compound.
- Curing compounds to be used shall be as follows:

A. Pigmented curing compound conforming to the requirements in ASTM Designation: C 309, Type 2, Class B, except the resin type shall be poly-alpha-methylstyrene.
B. Pigmented curing compound conforming to the requirements in ASTM Designation: C 309, Type 2, Class B.
C. Pigmented curing compound conforming to the requirements in ASTM Designation: C 309, Type 2, Class A.
D. Non-pigmented curing compound conforming to the requirements in ASTM Designation: C 309, Type 1, Class B.
E. Non-pigmented curing compound conforming to the requirements in ASTM Designation: C 309, Type 1, Class A.
F. Non-pigmented curing compound with fugitive dye conforming to the requirements in ASTM Designation: C 309, Type 1-D, Class A.

- The infrared scan for the dried vehicle from curing compound (A) in the preceeding list shall match the infrared scan on file at the Transportation Laboratory.
- The loss of water for each type of curing compound, when tested in conformance with the requirements in California Test 534, shall not be more than 0.15-kilograms per meter squared in 24 hours.
- The curing compound to be used will be specified elsewhere in these specifications or in the special provisions.
- When the use of curing compound is required or permitted elsewhere in these specifications or in the special provisions and no specific kind is specified, any of the curing compounds listed above may be used.
- Curing compound shall be applied at a nominal rate of one gallon per 150 square feet, unless otherwise specified.
- At any point, the application rate shall be within ±50 square feet per gallon of the nominal rate specified, and the average application rate shall be within ±25 square feet per gallon of the nominal rate specified when tested in conformance with the requirements in California Test 535. Runs, sags, thin areas, skips, or holidays in the applied curing compound shall be evidence that the application is not satisfactory.
- Curing compounds shall be applied using power operated spray equipment. The power operated spraying equipment shall be equipped with an operational pressure gage and a means of controlling the pressure. Hand spraying of small and irregular areas that are not reasonably accessible to mechanical spraying equipment, in the opinion of the Engineer, may be permitted.
- The curing compound shall be applied to the concrete following the surface finishing operation, immediately before the moisture sheen disappears from the surface, but before any drying shrinkage or craze cracks begin to appear. In the event of any drying or cracking of the surface, application of water with an atomizing nozzle as specified in Section 90-7.01A, "Water Method," shall be started immediately and shall be continued until application of the compound is resumed or started; however, the compound shall not be applied over any resulting freestanding water. Should the film of compound be damaged from any cause before the expiration of 7 days after the concrete is placed in the case of structures and 72 hours in the case of pavement, the damaged portion shall be repaired immediately with additional compound.
- At the time of use, compounds containing pigments shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. A paddle shall be used to loosen all settled pigment from the bottom of the container, and a power driven agitator shall be used to disperse the pigment uniformly throughout the vehicle.
- Agitation shall not introduce air or other foreign substance into the curing compound.
- The manufacturer shall include in the curing compound the necessary additives for control of sagging, pigment settling, leveling, de-emulsification, or other requisite qualities of a satisfactory working material. Pigmented curing compounds shall be manufactured so that the pigment does not settle badly, does not cake or

thicken in the container, and does not become granular or curdled. Settled pigment shall be a thoroughly wetted, soft, mushy mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily redispersed, with minimum resistance to the sideways manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency.

- Curing compounds shall remain sprayable at temperatures above 40° F and shall not be diluted or altered after manufacture.
- The curing compound shall be packaged in clean 274-gallon totes, 55-gallon barrels, or 5-gallon pails, or shall be supplied from a suitable storage tank located at the jobsite. The containers shall comply with "Title 49, Code of Federal Regulations, Hazardous Materials Regulations." The 274-gallon totes, and the 55-gallon barrels shall have removable lids and airtight fasteners. The 5-gallon pails shall be round and have standard full open head and bail. Lids with bungholes shall not be permitted. Settling or separation of solids in containers, except tanks, must be completely redispersed with low speed mixing prior to use, in conformance with these specifications and the manufacturer's recommendations. Mixing shall be accomplished either manually by use of a paddle or by use of a mixing blade driven by a drill motor, at low speed. Mixing blades shall be the type used for mixing paint. On site storage tanks shall be kept clean and free of contaminants. Each tank shall have a permanent system designed to completely redisperse settled material without introducing air or other foreign substances.
- Steel containers and lids shall be lined with a coating that will prevent destructive action by the compound or chemical agents in the air space above the compound. The coating shall not come off the container or lid as skins. Containers shall be filled in a manner that will prevent skinning. Plastic containers shall not react with the compound.
- Each container shall be labeled with the manufacturer's name, kind of curing compound, batch number, volume, date of manufacture, and volatile organic compound (VOC) content. The label shall also warn that the curing compound containing pigment shall be well stirred before use. Precautions concerning the handling and the application of curing compound shall be shown on the label of the curing compound containers in conformance with the Construction Safety Orders and General Industry Safety Orders of the State of California.
- Containers of curing compound shall be labeled to indicate that the contents fully comply with the rules and regulations concerning air pollution control in the State of California.
- When the curing compound is shipped in tanks or tank trucks, a shipping invoice shall accompany each load. The invoice shall contain the same information as that required herein for container labels.
- Curing compound will be sampled by the Engineer at the source of supply or at the jobsite or at both locations.
- Curing compound shall be formulated so as to maintain the specified properties for a minimum of one year. The Engineer may require additional testing before use to determine compliance with these specifications if the compound has not been used within one year or whenever the Engineer has reason to believe the compound is no longer satisfactory.

- Tests will be conducted in conformance with the latest ASTM test methods and methods in use by the Transportation Laboratory.

90-7.01C Waterproof Membrane Method

- The exposed finished surfaces of concrete shall be sprayed with water, using a nozzle that so atomizes the flow that a mist and not a spray is formed, until the concrete has set, after which the curing membrane shall be placed. The curing membrane shall remain in place for a period of not less than 72 hours.
- Sheeting material for curing concrete shall conform to the requirements in AASHTO Designation: M 171 for white reflective materials.
- The sheeting material shall be fabricated into sheets of such width as to provide a complete cover for the entire concrete surface. Joints in the sheets shall be securely cemented together in such a manner as to provide a waterproof joint. The joint seams shall have a minimum lap of 0.33-foot.
- The sheets shall be securely weighted down by placing a bank of earth on the edges of the sheets or by other means satisfactory to the Engineer.
- Should any portion of the sheets be broken or damaged before the expiration of 72 hours after being placed, the broken or damaged portions shall be immediately repaired with new sheets properly cemented into place.
- Sections of membrane that have lost their waterproof qualities or have been damaged to such an extent as to render them unfit for curing the concrete shall not be used.

90-7.01D Forms-In-Place Method

- Formed surfaces of concrete may be cured by retaining the forms in place. The forms shall remain in place for a minimum period of 7 days after the concrete has been placed, except that for members over 20 inches in least dimension the forms shall remain in place for a minimum period of 5 days.
- Joints in the forms and the joints between the end of forms and concrete shall be kept moisture tight during the curing period. Cracks in the forms and cracks between the forms and the concrete shall be resealed by methods subject to the approval of the Engineer.

90-7.02 CURING PAVEMENT

- The entire exposed area of the pavement, including edges, shall be cured by the waterproof membrane method, or curing compound method using curing compound (A) or (B) as the Contractor may elect. Should the side forms be removed before the expiration of 72 hours following the start of curing, the exposed pavement edges shall also be cured. If the pavement is cured by means of the curing compound method, the sawcut and all portions of the curing compound that have been disturbed by sawing operations shall be restored by spraying with additional curing compound.
- Curing shall commence as soon as the finishing process provided in Section 40-1.10, "Final Finishing," has been completed. The method selected shall conform to the provisions in Section 90-7.01, "Methods of Curing."
- When the curing compound method is used, the compound shall be applied to the entire pavement surface by mechanical sprayers. Spraying equipment shall be of the fully atomizing type equipped with a tank agitator that provides for continual

agitation of the curing compound during the time of application. The spray shall be adequately protected against wind, and the nozzles shall be so oriented or moved mechanically transversely as to result in the minimum specified rate of coverage being applied uniformly on exposed faces. Hand spraying of small and irregular areas, and areas inaccessible to mechanical spraying equipment, in the opinion of the Engineer, will be permitted. When the ambient air temperature is above 60° F, the Contractor shall fog the surface of the concrete with a fine spray of water as specified in Section 90-7.01A, "Water Method." The surface of the pavement shall be kept moist between the hours of 10:00 a.m. and 4:30 p.m. on the day the concrete is placed. However, the fogging done after the curing compound has been applied shall not begin until the compound has set sufficiently to prevent displacement. Fogging shall be discontinued if ordered in writing by the Engineer.

90-7.03 CURING STRUCTURES

- Newly placed concrete for cast-in-place structures, other than highway bridge decks, shall be cured by the water method, the forms-in-place method, or, as permitted herein, by the curing compound method, in conformance with the provisions in Section 90-7.01, "Methods of Curing."
- The curing compound method using a pigmented curing compound may be used on concrete surfaces of construction joints, surfaces that are to be buried underground, and surfaces where only ordinary surface finish is to be applied and on which a uniform color is not required and that will not be visible from a public traveled way. If the Contractor elects to use the curing compound method on the bottom slab of box girder spans, the curing compound shall be curing compound (A).
- The top surface of highway bridge decks shall be cured by both the curing compound method and the water method. The curing compound shall be curing compound (A).
- Concrete surfaces of minor structures, as defined in Section 51-1.02, "Minor Structures," shall be cured by the water method, the forms-in-place method or the curing compound method.
- When deemed necessary by the Engineer during periods of hot weather, water shall be applied to concrete surfaces being cured by the curing compound method or by the forms-in-place method, until the Engineer determines that a cooling effect is no longer required. Application of water for this purpose will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."

90-7.04 CURING PRECAST CONCRETE MEMBERS

- Precast concrete members shall be cured in conformance with any of the methods specified in Section 90-7.01, "Methods of Curing." Curing shall be provided for the minimum time specified for each method or until the concrete reaches its design strength, whichever is less. Steam curing may also be used for precast members and shall conform to the following provisions:

A. After placement of the concrete, members shall be held for a minimum 4-hour presteaming period. If the ambient air temperature is below 50° F,

steam shall be applied during the presteaming period to hold the air surrounding the member at a temperature between 50° F and 90° F.

B. To prevent moisture loss on exposed surfaces during the presteaming period, members shall be covered as soon as possible after casting or the exposed surfaces shall be kept wet by fog spray or wet blankets.

C. Enclosures for steam curing shall allow free circulation of steam about the member and shall be constructed to contain the live steam with a minimum moisture loss. The use of tarpaulins or similar flexible covers will be permitted, provided they are kept in good repair and secured in such a manner as to prevent the loss of steam and moisture.

D. Steam at the jets shall be at low pressure and in a saturated condition. Steam jets shall not impinge directly on the concrete, test cylinders, or forms. During application of the steam, the temperature rise within the enclosure shall not exceed 40° F per hour. The curing temperature throughout the enclosure shall not exceed 150° F and shall be maintained at a constant level for a sufficient time necessary to develop the required transfer strength. Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperature is representative of the average temperature of the enclosure.

E. Temperature recording devices that will provide an accurate, continuous, permanent record of the curing temperature shall be provided. A minimum of one temperature recording device per 200 feet of continuous bed length will be required for checking temperature.

F. Members in pretension beds shall be detensioned immediately after the termination of steam curing while the concrete and forms are still warm, or the temperature under the enclosure shall be maintained above 60° F until the stress is transferred to the concrete.

G. Curing of precast concrete will be considered completed after termination of the steam curing cycle.

90-7.05 CURING PRECAST PRESTRESSED CONCRETE PILES

Newly placed concrete for precast prestressed concrete piles shall be cured in conformance with the provisions in Section 90-7.04, "Curing Precast Concrete Members," except that piles in a corrosive environment shall be cured as follows:

A. Piles shall be either steam cured or water cured. If water curing is used, the piles shall be kept continuously wet by the application of water in conformance with the provisions in Section 90-7.01A, "Water Method."

B. If steam curing is used, the steam curing provisions in Section 90-7.04, "Curing Precast Concrete Members," shall apply except that the piles shall be kept continuously wet for their entire length for a period of not less than 3 days, including the holding and steam curing periods.

90-7.06 CURING SLOPE PROTECTION

Concrete slope protection shall be cured in conformance with any of the methods specified in Section 90-7.01, "Methods of Curing."

- Concreted-rock slope protection shall be cured in conformance with any of the methods specified in Section 90-7.01, "Methods of Curing," or with a blanket of earth kept wet for 72 hours, or by sprinkling with a fine spray of water every 2 hours during the daytime for a period of 3 days.

90-7.07 CURING MISCELLANEOUS CONCRETE WORK

- Exposed surfaces of curbs shall be cured by pigmented curing compounds as specified in Section 90-7.01B, "Curing Compound Method."
- Concrete sidewalks, gutter depressions, island paving, curb ramps, driveways, and other miscellaneous concrete areas shall be cured in conformance with any of the methods specified in Section 90-7.01, "Methods of Curing."
- Shotcrete shall be cured for at least 72 hours by spraying with water, by a moist earth blanket, or by any of the methods provided in Section 90-7.01, "Methods of Curing."
- Mortar and grout shall be cured by keeping the surface damp for 3 days.
- After placing, the exposed surfaces of sign structure foundations, including pedestal portions, if constructed, shall be cured for at least 72 hours by spraying with water, by a moist earth blanket, or by any of the methods provided in Section 90-7.01, "Methods of Curing."

90-8 PROTECTING CONCRETE

90-8.01 GENERAL

- In addition to the provisions in Section 7-1.16, "Contractor's Responsibility for the Work and Materials," the Contractor shall protect concrete as provided in this Section 90-8.
- Concrete shall not be placed on frozen or ice-coated ground or subgrade nor on ice-coated forms, reinforcing steel, structural steel, conduits, precast members, or construction joints.
- Under rainy conditions, placing of concrete shall be stopped before the quantity of surface water is sufficient to damage surface mortar or cause a flow or wash of the concrete surface, unless the Contractor provides adequate protection against damage.
- Concrete that has been frozen or damaged by other causes, as determined by the Engineer, shall be removed and replaced by the Contractor at the Contractor's expense.

90-8.02 PROTECTING CONCRETE STRUCTURES

- Structure concrete and shotcrete used as structure concrete shall be maintained at a temperature of not less than 45° F for 72 hours after placing and at not less than 40° F for an additional 4 days. When required by the Engineer, the Contractor shall submit a written outline of the proposed methods for protecting the concrete.

90-8.03 PROTECTING CONCRETE PAVEMENT

- Pavement concrete shall be maintained at a temperature of not less than 40° F for 72 hours. When required by the Engineer, the Contractor shall submit a written outline of the proposed methods for protecting the concrete.
- Except as provided in Section 7-1.08, "Public Convenience," the Contractor shall protect concrete pavement against construction and other activities that

abrade, scar, discolor, reduce texture depth, lower coefficient of friction, or otherwise damage the surface. Stockpiling, drifting, or excessive spillage of soil, gravel, petroleum products, and concrete or asphalt mixes on the surface of concrete pavement is prohibited unless otherwise specified in these specifications, the special provisions or permitted by the Engineer.

- When ordered by the Engineer or shown on the plans or specified in the special provisions, pavement crossings shall be constructed for the convenience of public traffic. The material and work necessary for the construction of the crossings, and their subsequent removal and disposal, will be paid for at the contract unit prices for the items of work involved and if there are no contract items for the work involved, payment for pavement crossings will be made by extra work as provided in Section 4-1.03D, "Extra Work." Where public traffic will be required to cross over the new pavement, Type III portland cement may be used in concrete, if permitted in writing by the Engineer. The pavement may be opened to traffic as soon as the concrete has developed a modulus of rupture of 550 psi. The modulus of rupture will be determined by California Test 523.
- No traffic or Contractor's equipment, except as hereinafter provided, will be permitted on the pavement before a period of 10 days has elapsed after the concrete has been placed, nor before the concrete has developed a modulus of rupture of at least 550 psi. Concrete that fails to attain a modulus of rupture of 550 psi within 10 days shall not be opened to traffic until directed by the Engineer.
- Equipment for sawing weakened plane joints will be permitted on the pavement as specified in Section 40-1.08B, "Weakened Plane Joints."
- When requested in writing by the Contractor, the tracks on one side of paving equipment will be permitted on the pavement after a modulus of rupture of 350 psi has been attained, provided that:

  A. Unit pressure exerted on the pavement by the paver shall not exceed 20 psi;
  B. Tracks with cleats, grousers, or similar protuberances shall be modified or shall travel on planks or equivalent protective material, so that the pavement is not damaged; and
  C. No part of the track shall be closer than one foot from the edge of pavement.

- In case of visible cracking of, or other damage to the pavement, operation of the paving equipment on the pavement shall be immediately discontinued.
- Damage to the pavement resulting from early use of pavement by the Contractor's equipment as provided above shall be repaired by the Contractor at the Contractor's expense.
- The State will furnish the molds and machines for testing the concrete for modulus of rupture, and the Contractor, at the Contractor's expense, shall furnish the material and whatever labor the Engineer may require.

90-9 COMPRESSIVE STRENGTH

90-9.01 GENERAL

- Concrete compressive strength requirements consist of a minimum strength that shall be attained before various loads or stresses are applied to the concrete and, for concrete designated by strength, a minimum strength at the age of 28 days or at the age otherwise allowed in Section 90-1.01, "Description." The various strengths required are specified in these specifications or the special provisions or are shown on the plans.
- The compressive strength of concrete will be determined from test cylinders that have been fabricated from concrete sampled in conformance with the requirements of California Test 539. Test cylinders will be molded and initially field cured in conformance with California Test 540. Test cylinders will be cured and tested after receipt at the testing laboratory in conformance with the requirements of California Test 521. A strength test shall consist of the average strength of 2 cylinders fabricated from material taken from a single load of concrete, except that, if any cylinder should show evidence of improper sampling, molding, or testing, that cylinder shall be discarded and the strength test shall consist of the strength of the remaining cylinder.
- When concrete compressive strength is specified as a prerequisite to applying loads or stresses to a concrete structure or member, test cylinders for other than steam cured concrete will be cured in conformance with Method 1 of California Test 540. The compressive strength of concrete determined for these purposes will be evaluated on the basis of individual tests.
- When concrete is designated by 28-day compressive strength rather than by cementitious material content, the concrete strength to be used as a basis for acceptance of other than steam cured concrete will be determined from cylinders cured in conformance with Method 1 of California Test 540. If the result of a single compressive strength test at the maximum age specified or allowed is below the specified strength but is 95 percent or more of the specified strength, the Contractor shall, at the Contractor's expense, make corrective changes, subject to approval of the Engineer, in the mix proportions or in the concrete fabrication procedures, before placing additional concrete, and shall pay to the State $10 for each in-place cubic yard of concrete represented by the deficient test. If the result of a single compressive strength test at the maximum age specified or allowed is below 95 percent of the specified strength, but is 85 percent or more of the specified strength, the Contractor shall make the corrective changes specified above, and shall pay to the State $15 for each in-place cubic yard of concrete represented by the deficient test. In addition, such corrective changes shall be made when the compressive strength of concrete tested at 7 days indicates, in the judgment of the Engineer, that the concrete will not attain the required compressive strength at the maximum age specified or allowed. Concrete represented by a single test that indicates a compressive strength of less than 85 percent of the specified 28-day compressive strength will be rejected in conformance with the provisions in Section 6-1.04, "Defective Materials."
- If the test result indicates that the compressive strength at the maximum curing age specified or allowed is below the specified strength, but is 85 percent or more

of the specified strength, payments to the State as required above shall be made, unless the Contractor, at the Contractor's expense, obtains and submits evidence acceptable to the Engineer that the strength of the concrete placed in the work meets or exceeds the specified 28-day compressive strength. If the test result indicates a compressive strength at the maximum curing age specified or allowed below 85 percent, the concrete represented by that test will be rejected, unless the Contractor, at the Contractor's expense, obtains and submits evidence acceptable to the Engineer that the strength and quality of the concrete placed in the work are acceptable. If the evidence consists of tests made on cores taken from the work, the cores shall be obtained and tested in conformance with the requirements in ASTM Designation: C 42.

- No single compressive strength test shall represent more than 320 cubic yards.
- When a precast concrete member is steam cured, the compressive strength of the concrete will be determined from test cylinders that have been handled and stored in conformance with Method 3 of California Test 540. The compressive strength of steam cured concrete will be evaluated on the basis of individual tests representing specific portions of production. When the concrete is designated by 28-day compressive strength rather than by cementitious material content, the concrete shall be considered to be acceptable whenever its compressive strength reaches the specified 28-day compressive strength provided that strength is reached in not more than the maximum number of days specified or allowed after the member is cast.
- When concrete is specified by compressive strength, prequalification of materials, mix proportions, mixing equipment, and procedures proposed for use will be required prior to placement of the concrete. Prequalification shall be accomplished by the submission of acceptable certified test data or trial batch reports by the Contractor. Prequalification data shall be based on the use of materials, mix proportions, mixing equipment, procedures, and size of batch proposed for use in the work.
- Certified test data, in order to be acceptable, shall indicate that not less than 90 percent of at least 20 consecutive tests exceed the specified strength at the maximum number of cure days specified or allowed, and none of those tests are less than 95 percent of specified strength. Strength tests included in the data shall be the most recent tests made on concrete of the proposed mix design and all shall have been made within one year of the proposed use of the concrete.
- Trial batch test reports, in order to be acceptable, shall indicate that the average compressive strength of 5 consecutive concrete cylinders, taken from a single batch, at not more than 28 days (or the maximum age allowed) after molding shall be at least 580 psi greater than the specified 28-day compressive strength, and no individual cylinder shall have a strength less than the specified strength at the maximum age specified or allowed. Data contained in the report shall be from trial batches that were produced within one year of the proposed use of specified strength concrete in the project. Whenever air-entrainment is required, the air content of trial batches shall be equal to or greater than the air content specified for the concrete without reduction due to tolerances.

- Tests shall be performed in conformance with either the appropriate California Test methods or the comparable ASTM test methods. Equipment employed in testing shall be in good condition and shall be properly calibrated. If the tests are performed during the life of the contract, the Engineer shall be notified sufficiently in advance of performing the tests in order to witness the test procedures.
- The certified test data and trial batch test reports shall include the following information:

A. Date of mixing.
B. Mixing equipment and procedures used.
C. The size of batch in cubic yards and the weight, type, and source of all ingredients used.
D. Penetration of the concrete.
E. The air content of the concrete if an air-entraining admixture is used.
F. The age at time of testing and strength of all concrete cylinders tested.

- Certified test data and trial batch test reports shall be signed by an official of the firm that performed the tests.
- When approved by the Engineer, concrete from trial batches may be used in the work at locations where concrete of a lower quality is required and the concrete will be paid for as the type or class of concrete required at that location.
- After materials, mix proportions, mixing equipment, and procedures for concrete have been prequalified for use, additional prequalification by testing of trial batches will be required prior to making changes that, in the judgment of the Engineer, could result in a strength of concrete below that specified.
- The Contractor's attention is directed to the time required to test trial batches and the Contractor shall be responsible for production of trial batches at a sufficiently early date so that the progress of the work is not delayed.
- When precast concrete members are manufactured at the plant of an established manufacturer of precast concrete members, the mix proportions of the concrete shall be determined by the Contractor, and a trial batch and prequalification of the materials, mix proportions, mixing equipment, and procedures will not be required.

90-10 MINOR CONCRETE

90-10.01 GENERAL

- Concrete for minor structures, slope paving, curbs, sidewalks and other concrete work, when designated as minor concrete on the plans, in the specifications, or in the contract item, shall conform to the provisions specified herein.
- The Engineer, at the Engineer's discretion, will inspect and test the facilities, materials and methods for producing the concrete to ensure that minor concrete of the quality suitable for use in the work is obtained.

90-10.02 MATERIALS

- Minor concrete shall conform to the following requirements:

90-10.02A Cementitious Material

Cementitious material shall conform to the provisions in Section 90-1.01, "Description."

90-10.02B Aggregate

Aggregate shall be clean and free from deleterious coatings, clay balls, roots, and other extraneous materials.

The Contractor shall submit to the Engineer for approval, a grading of the combined aggregate proposed for use in the minor concrete. After acceptance of the grading, aggregate furnished for minor concrete shall conform to that grading, unless a change is authorized in writing by the Engineer.

The Engineer may require the Contractor to furnish periodic test reports of the aggregate grading furnished. The maximum size of aggregate used shall be at the option of the Contractor, but in no case shall the maximum size be larger than $1^1/_2$ inch or smaller than $^3/_4$ inch.

The Engineer may waive, in writing, the gradation requirements in this Section 90-10.02B if, in the Engineer's opinion, the furnishing of the gradation is not necessary for the type or amount of concrete work to be constructed.

90-10.02C Water

Water used for washing, mixing, and curing shall be free from oil, salts, and other impurities that would discolor or etch the surface or have an adverse affect on the quality of the concrete.

90-10.02D Admixtures

The use of admixtures shall conform to the provisions in Section 90-4, "Admixtures."

90-10.03 PRODUCTION

Cementitious material, water, aggregate, and admixtures shall be stored, proportioned, mixed, transported, and discharged in conformance with recognized standards of good practice that will result in concrete that is thoroughly and uniformly mixed, that is suitable for the use intended, and that conforms to requirements specified herein. Recognized standards of good practice are outlined in various industry publications such as are issued by American Concrete Institute, AASHTO, or the Department.

The cementitious material content of minor concrete shall conform to the provisions in Section 90-1.01, "Description."

The amount of water used shall result in a consistency of concrete conforming to the provisions in Section 90-6.06, "Amount of Water and Penetration." Additional mixing water shall not be incorporated into the concrete during hauling or after arrival at the delivery point, unless authorized by the Engineer.

Discharge of ready-mixed concrete from the transporting vehicle shall be made while the concrete is still plastic and before stiffening occurs. An elapsed time of 1.5 hours (one hour in non-agitating hauling equipment), or more than 250 revolutions of the drum or blades, after the introduction of the cementitious material to the aggregates, or a temperature of concrete of more than 90° F will be considered conditions contributing to the quick stiffening of concrete. The

Contractor shall take whatever action is necessary to eliminate quick stiffening, except that the addition of water will not be permitted.

- The required mixing time in stationary mixers shall be not less than 50 seconds or more than 5 minutes.
- The minimum required revolutions at mixing speed for transit-mixed concrete shall be not less than that recommended by the mixer manufacturer, and shall be increased, if necessary, to produce thoroughly and uniformly mixed concrete.
- Each load of ready-mixed concrete shall be accompanied by a weighmaster certificate that shall be delivered to the Engineer at the discharge location of the concrete, unless otherwise directed by the Engineer. The weighmaster certificate shall be clearly marked with the date and time of day when the load left the batching plant and, if hauled in truck mixers or agitators, the time the mixing cycle started.
- A Certificate of Compliance conforming to the provisions in Section 6–1.07, "Certificates of Compliance," shall be furnished to the Engineer, prior to placing minor concrete from a source not previously used on the contract, stating that minor concrete to be furnished meets contract requirements, including minimum cementitious material content specified.

90-10.04 CURING MINOR CONCRETE

- Curing minor concrete shall conform to the provisions in Section 90-7, "Curing Concrete."

90-10.05 PROTECTING MINOR CONCRETE

- Protecting minor concrete shall conform to the provisions in Section 90-8, "Protecting Concrete," except the concrete shall be maintained at a temperature of not less than 40° F for 72 hours after placing.

90-10.06 MEASUREMENT AND PAYMENT

- Minor concrete will be measured and paid for in conformance with the provisions specified in the various sections of these specifications covering concrete construction when minor concrete is specified in the specifications, shown on the plans, or indicated by contract item in the Engineer's Estimate.

90-11 MEASUREMENT AND PAYMENT

90-11.01 MEASUREMENT

- Portland cement concrete will be measured in conformance with the provisions specified in the various sections of these specifications covering construction requiring concrete.
- When it is provided that concrete will be measured at the mixer, the volume in cubic feet shall be computed as the total weight of the batch in pounds divided by the density of the concrete in pounds per cubic foot. The total weight of the batch shall be calculated as the sum of all materials, including water, entering the batch. The density of the concrete will be determined in conformance with the requirements in California Test 518.

90-11.02 PAYMENT

- Portland cement concrete will be paid for in conformance with the provisions specified in the various sections of these specifications covering construction requiring concrete.
- Full compensation for furnishing and incorporating admixtures required by these specifications or the special provisions will be considered as included in the contract prices paid for the concrete involved and no additional compensation will be allowed therefor.
- Should the Engineer order the Contractor to incorporate any admixtures in the concrete when their use is not required by these specifications or the special provisions, furnishing the admixtures and adding them to the concrete will be paid for as extra work as provided in Section 4-1.03D, "Extra Work."
- Should the Contractor use admixtures in conformance with the provisions in Section 90-4.05, "Optional Use of Chemical Admixtures," or Section 90-4.07, "Optional Use of Air-entraining Admixtures," or should the Contractor request and obtain permission to use other admixtures for the Contractor's benefit, the Contractor shall furnish those admixtures and incorporate them into the concrete at the Contractor’s expense and no additional compensation will be allowed therefor.

SECTION 91: PAINT

91-1 MATERIALS

91-1.01 DESCRIPTION

- These specifications are intended to specify paints that will meet service requirements for highway construction.
- Paint shall be homogeneous, free of contaminant and of a consistency suitable for use in the capacity for which it is specified. Finished paint shall be well ground, and the pigment shall be properly dispersed in the vehicle conforming to the requirements of the paint. The dispersion shall be of such nature that the pigment does not settle badly, does not cake or thicken in the container and does not become granular or curdled. Any settlement of pigment in the paint shall be a thoroughly wetted soft mushy mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily redispersed, with minimum resistance to the sidewise manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency. The manufacturer shall include in the paints the necessary additives for control of sagging, pigment settling, leveling, drying, drier absorption and skinning or other requisite qualities of a satisfactory working material. The paint shall possess satisfactory properties, in all respects which affect its application, adhesion and curing and shall be formulated to retain these properties for a minimum of one year.
- Attention is directed to Section 7-1.01F, "Air Pollution Control."
- The Engineer may require additional testing of any paint that has not been used within one year of manufacture.

91-1.02 SAMPLING AND TESTING

- Paint will be sampled at the place of manufacture as provided in Section 6-1.06, "Plant Inspection." In addition, an unopened container of each batch of paint shall be furnished to the Engineer at the job site for testing. Application will not be permitted until the job-sampled paint has been approved by the Engineer. Check samples of the paint as it is being applied will be taken at intervals determined by the Engineer.
- Tests will be conducted in conformance with the latest test methods of the American Society for Testing and Materials, Federal Test Method Standard No. 141 and methods in use by the Transportation Laboratory.

91-1.03 MANUFACTURING AND PACKAGING

- Manufactured paints shall be prepared at the factory ready for application. The addition of thinner or other material to the paint after the paint has been shipped will not be permitted, unless so specified.
- The paint shall be furnished in new, round containers of not more than 6-gallon capacity. The containers shall be standard full open head with bails, shall be nonreactive with contents and shall have compatible gaskets. The containers shall comply with the U.S. Department of Transportation or the Interstate Commerce Commission regulations, as applicable. Lids with bungholes will not be permitted.
- No paint shall be used until approved by the Engineer.

- All containers of paint shall be labeled showing the exact title of the paint specification, State specification number, manufacturer's product number, manufacturer's name, date of manufacture, State lot number and manufacturer's batch number.
- Precautions concerning the handling and the application of paint shall be shown on the label of paint and solvent containers in conformance with the Construction Safety Orders and General Industry Safety Orders of the State of California.

91-1.04 MATERIALS

- The raw materials for use in the various paint formulas shall conform to the specifications designated by ASTM Designation number or by State Specification number or by Federal or Department of Defense (DOD) specification number or paint material code number under the various paint classifications hereinafter specified. Subsequent amendments to the specifications quoted shall apply to all raw materials and finished products. No "or equal" substitutions for any specified material shall be made without written consent of the Engineer.
- For paints designated by State Specification number, copies of the State Specifications may be obtained from the Transportation Laboratory.
- Zinc-rich primer shall be of commercial quality, approved by the Department and shall be on the Department's list of approved brands prior to being used in the work. Brands of zinc-rich primer will be considered for addition to the approved list if the manufacturer of the primer submits to the Transportation Laboratory, Sacramento, California, a sample of the primer accompanied by certified test results which verify that the primer complies with the requirements in the appropriate State Specification. The sample shall be sufficient to permit performance of all required tests. Approval of primer brands will be dependent upon a determination as to compliance with the specifications, based on the certified test results submitted, together with any tests the Department may elect to perform.

91-2 PAINTS FOR METAL

91-2.01 DESCRIPTION

- Paints for metal shall be as specified in the special provisions.

91-2.02 THROUGH 91 -2.07 (BLANK)

91-3 PAINTS FOR TIMBER

91-3.01 WOOD PRIMER, LATEX-BASE

Classification:

- This specification covers a ready-mixed priming paint for use on unpainted wood or exterior woodwork. It shall comply, in all respects, with Federal Specification TT-P-001984 (latest revision).

91-3.02 PAINT, LATEX-BASE FOR EXTERIOR WOOD, WHITE AND TINTS

Classification:

- This specification covers a ready-mixed paint for use on wood surfaces subject to outside exposures. This paint shall comply, in all respects, with Federal Specification TT-P-96 (latest revision).
- Unpainted wood shall first be primed with wood primer conforming to the provisions in Section 91-3.01, "Wood Primer, Latex-Base."

91-4 MISCELLANEOUS PAINTS

91-4.01 THROUGH 91 -4.04 (BLANK)

91-4.05 PAINT; ACRYLIC EMULSION, EXTERIOR WHITE AND LIGHT AND MEDIUM TINTS

Classification:

- This specification covers an acrylic emulsion paint designed for use on exterior masonry. This paint shall comply in all respects to Federal Specification TT-P-19 (latest revision), Paint, Acrylic Emulsion, Exterior.
- This paint may be tinted by using "universal" or "all purpose" concentrates.

SECTION 92: ASPHALTS

92-1.01 DESCRIPTION

• Asphalt shall consist of refined petroleum or a mixture of refined liquid asphalt and refined solid asphalt, prepared from crude petroleum. Asphalt shall be:

A. Free from residues caused by the artificial distillation of coal, coal tar, or paraffin.
B. Free from water.
C. Homogeneous.

92-1.02 MATERIALS

92-1.02(A) General

• The Contractor shall furnish asphalt in conformance with the Department's "Certification Program for Suppliers of Asphalt." The Department maintains the program requirements, procedures, and a list of approved suppliers at:

http://www.dot.ca.gov/hq/esc/Translab/fpmcoc.htm.

• The Contractor shall ensure the safe transportation, storage, use, and disposal of asphalt.
• The Contractor shall prevent the formation of carbonized particles caused by overheating asphalt during manufacturing or construction.

92-1.02(B) Grades

• Performance graded (PG) asphalt binder shall conform to the following:

Performance Graded Asphalt Binder

Property	AASHTO Test Method	Specification Grade PG 58-22[a]	PG 64-10	PG 64-16	PG 64-28	PG 70-10
Original Binder						
Flash Point, Min. °C	T48	230	230	230	230	230
Solubility, Min. % [b]	T44	99	99	99	99	99
Viscosity at 135°C, [c] Max., Pa·s	T316	3.0	3.0	3.0	3.0	3.0
Dynamic Shear, Test Temp. at 10 rad/s, °C	T315	58	64	64	64	70
Min. G*/sin(delta), kPa		1.00	1.00	1.00	1.00	1.00
RTFO Test [e], Mass Loss, Max., %	T240	1.00	1.00	1.00	1.00	1.00
RTFO Test Aged Binder						
Dynamic Shear, Test Temp. at 10 rad/s, °C	T315	58	64	64	64	70
Min. G*/sin(delta), kPa		2.20	2.20	2.20	2.20	2.20
Ductility at 25°C Min., cm	T51	75	75	75	75	75
PAV [f] Aging, Temperature, °C	R28	100	100	100	100	110
RTFO Test and PAV Aged Binder						
Dynamic Shear, Test Temp. at 10 rad/s, °C	T315	22 [d]	31 [d]	28 [d]	22 [d]	34 [d]
Min. G*sin(delta), kPa		5000	5000	5000	5000	5000
Creep Stiffness, Test Temperature, °C	T313	-12	0	-6	-18	0
Max. S-value, MPa		300	300	300	300	300
Min. M-value		0.300	0.300	0.300	0.300	0.300

Notes:

a. For use as asphalt rubber base stock for high mountain and high desert area.

b. The Engineer will waive this specification if the supplier is a Quality Supplier as defined by the Department's "Certification Program for Suppliers of Asphalt."

c. The Engineer will waive this specification if the supplier certifies the asphalt binder can be adequately pumped and mixed at temperatures meeting applicable safety standards.

d. Test the sample at 3°C higher if it fails at the specified test temperature.G*sin(delta) shall remain 5000 kPa maximum.

e. "RTFO Test" means the asphaltic residue obtained using the Rolling Thin Film Oven Test, AASHTO Test Method T240 or ASTM Designation: D 2872.

f. "PAV" means Pressurized Aging Vessel.

- Performance based asphalt (PBA) binder shall conform to the following:

Performance Based Asphalt Binder

Property	AASHTO Test Method	Specification Grade PBA 6a	PBA 6a (mod)	PBA 6b	PBA 7
Absolute Visc. (60°C), Pa·s($x10^{-1}$) [a]	T202				
Original Binder, Min.		2000	2000	2000	1100
RTFO Test Aged Residue [b], Min.		5000	5000	5000	3000
Kinematic Visc. (135°C),$m^2/s(x10^6)$	T201				
Original Binder, Max.		2000	2000	2000	2000
RTFO Test Aged Residue, Min.		275	275	275	275
Absolute Visc. Ratio (60°C), Max.	—				
RTFO Test Visc./Orig. Visc.		4.0	4.0	4.0	4.0
Flash Point, Cleveland Open Cup, °C	T48				
Original Binder, Min.		232	232	232	232
Mass Loss After RTFO Test, %	T240	0.60	0.60	0.60	0.60
Solubility in Trichloroethylene, % [c]	T44				
Original Binder, Min.		Report	Report	Report	Report
Ductility (25°C, 5 cm/min), cm	T51				
RTFO Test Aged Residue [b], Min.		60	60	60	75
On RTFO Test Aged Residue, °C	[f]				
1 to 10 rad/sec: SSD [e] ≥ 0 and					
Phase Angle (at 1 rad/sec) < 72°		—	35	—	—
On Residue from:	R28				
PAV [g] at temp., °C		100	100	100	110
Or Residue from Tilt Oven[f]					
(@113°C), hours		36	36	36	72
[e] SSD ≥ -115(SSV)-50.6, °C	[f]	—	—	—	25
Stiffness,	T313				
Test Temperature, °C		-24	-24	-30	-6
Max. S-value, MPa		300	300	300	300
Min. M-value		0.300	0.300	0.300	0.300

Notes:

a. Absolute viscosity (60°C) will be determined at one sec^{-1} using ASTM Designation: D 4957 with Asphalt Institute vacuum capillary viscometers.

b. "RTFO Test Aged Residue" means the asphaltic residue obtained using the Rolling Thin Film Oven Test (RTFO Test), AASHTO Test Method T240 or ASTM Designation: D 2872.

c. There is no requirement; however results of the test shall be reported as part of the certified copy of test results furnished with the Certificate of Compliance.

d. "Residue from Tilt Oven " means the asphalt obtained using California Test 374, Method B, "Method for Determining Asphalt Durability Using the California Tilt-Oven Durability Test."

e. "SSD" means Shear Susceptibility of Delta; "SSV" means Shear Susceptibility of Viscosity.

f. California Test 381.

g. "PAV" means Pressurized Aging Vessel.

92-1.02(C) Sampling

- The Contractor shall provide a sampling device in the asphalt feed line connecting the plant storage tanks to the asphalt weighing system or spray bar. The sampling device shall be accessible between 24 inches and 30 inches above the platform. The Contractor shall provide a receptacle for flushing the sampling device.
- The sampling device shall include a valve:

  A. With a diameter between 1/2 inch and 3/4 inch.
  B. Manufactured in a manner that a one-quart sample may be taken slowly at any time during plant operations.
  C. Maintained in good condition.

- The Contractor shall replace failed valves.
- In the presence of the Engineer, the Contractor shall take 2 one-quart samples per operating day. The Contractor shall provide round friction top containers with one-quart capacity for storing samples.

92-1.03 APPLYING ASPHALT

- Unless otherwise specified, the Contractor shall heat and apply asphalt in conformance with the provisions in Section 93, "Liquid Asphalts."
- The Contractor shall apply paving asphalt at a temperature between 250° F and 375° F. The Engineer will determine the exact temperature of paving asphalt.

92-1.04 MEASUREMENT

- If asphalt is paid as a contract work item on a weight basis, the Department will measure asphalt by the ton in conformance with the provisions for determining the weight for payment of liquid asphalt in Section 93, "Liquid Asphalts."
- The Engineer will determine the weight of asphalt from volumetric measurements if the Contractor:

  A. Uses partial loads of asphalt.
  B. Uses asphalt at locations other than a mixing plant and no suitable scales are available with 20 miles.
  C. Delivers asphalt conforming to either of the following:

     1. In calibrated trucks and each tank is accompanied by its measuring stick and calibration card.
     2. In trucks equipped with a calibrated thermometer that determines the asphalt temperature at the time of delivery and equipped with a vehicle tank meter in conformance with the provisions in Section 9-1.01, "Measurement of Quantities," for weighing, measuring, and metering devices.

- If the Contractor furnishes asphalt concrete from a mixing plant producing material for only one project, the Department will determine the amount from volumetric measurements by measuring the amount in the tank at the start and the

end of the project provided the tank is calibrated and equipped with its measuring stick and calibration card. The Engineer will determine pay quantities in conformance with the following:

A. Before converting the volume to weight, the Engineer will reduce the volume measured to that which the asphalt would occupy at 60° F.
B. The Engineer will use 235 gallons per ton and 8.51 pounds per gallon for the average weight and volume for both PG and PBA grades of asphalt at 60° F.
C. The Engineer will use the Conversion Table in Section 93, "Liquid Asphalts."

SECTION 93: LIQUID ASPHALTS

93-1.01 DESCRIPTION

Liquid asphalts shall consist of materials conforming to the following classifications. The grades of liquid asphalt shall conform to the requirements specified in the tables set forth below:

A. Slow curing products designated by the letters SC, shall consist of natural crude oils or residual oils from crude petroleum.
B. Medium curing products designated by the letters MC, shall consist of paving asphalt conforming to the provisions in Section 92, "Asphalts," fluxed or blended with kerosene.

Slow Curing Products

Specification Designation	Test Method	SC-70	SC-250	SC-800	SC-3000
Flash Point, Cl.O.C. °C, min.	AASHTO T48	65	80	90	105
Kinematic Viscosity at 60°C, square meter per second ($x10^{-6}$)	AASHTO T201	70-140	250-500	800-1600	3000-6000
Water, % max.	AASHTO T55	0.5	0.5	0.5	0.5
Distillation: Total Distillate to 360°C, square meter per second ($x10^{-8}$) Vol. %	AASHTO T78	10-30	4-20	2-12	0-5
Tests on Residue from Distillation:					
Kinematic Viscosity Test at 60°C, square meter per second ($x10^{-8}$)	AASHTO T201	4-70	8-85	20-140	40-350
Heptane Xylene Equiv., % max.[a]	AASHTO T102	35	35	35	35
Asphalt Residue of 100 Pen., % min.	ASTM D243	50	60	70	80
Ductility of Asphalt Residue at 25°C, mm min.	AASHTO T51	1000	1000	1000	1000
Solubility in Trichloro-ethylene, % min.	AASHTO T44	99.5	99.5	99.5	99.5

a Normal spot test and glass plate test repeated at end of 24-hour period will not be required.

Medium Curing Products

Specification Designation	AASHTO Test Method	MC-70	MC-250	MC-800	MC-3000
Flash Point (Open Tag) °C, min.	T79	40	65	65	65
Kinematic Viscosity at 60°C, square meter per second ($x10^{-6}$)	T201	70-140	250-500	800-1600	3000-6000
Water, % max.	T55	0.2	0.2	0.2	0.2
Distillation: Distillate (percent of total distillate to 360°C)					
To 225°C	T78	0-20	0-10	0-3	0-2
To 260°C	T78	20-60	15-55	0-35	0-15
To 315°C	T78	65-90	60-87	45-80	15-75
Residue from distillation to 360°C. Volume percent of sample by difference min.	T78	55	67	75	80
Tests on Residue from Distillation:					
Penetration 25°C	T49	120-250	120-250	120-250	120-250
Duct., 25°C, mm min.[a]	T51	1000	1000	1000	1000
Solubility in Trichloro-ethylene, % min.	T44	99.5	99.5	99.5	99.5
Heptane Xylene Equiv., % max.[b]	T102	35	35	35	35

a If penetration of residue is more than 200 and its ductility at 25°C, is less than 1000, the material will be acceptable if its ductility at 15°C, is 1000+.

b Normal spot test and glass plate test repeated at end of 24-hour period will not be required.

93-1.02 TEST REPORT

- The vendor shall make available for review a certified copy of tests representing any shipment.
- If liquid asphalt is used prior to sampling and testing, a Certificate of Compliance, as provided in Section 6-1.07, "Certificates of Compliance," shall accompany each shipment of asphalt to the work. The certificate shall include the shipment number, type of material, specific gravity of the material, refinery, consignee, destination, quantity, contract or purchase order number and date of shipment. The certificate shall state that the material complies with the specifications detailed in this section and shall be signed by the vendor or the vendor's representative.
- Liquid asphalt furnished without a Certificate of Compliance shall not be used in the work until the Engineer has had sufficient time to make appropriate tests and has approved the liquid asphalt for use.

93-1.03 MIXING AND APPLYING

- Attention is directed to Sections 7-1.11 "Preservation of Property," and 7-1.12, "Indemnification and Insurance." Liquid asphalt shall be prevented from spraying upon adjacent pavements, that portion of the traveled way being used by traffic, structures, railings and barriers, markers, trees and shrubbery that are not to be

removed, adjacent property and improvements, and other highway improvements or facilities not mentioned herein.

- Unless otherwise specified in these specifications or in the special provisions, the various grades of liquid asphalt shall be applied at temperatures within the limits specified in the table of application temperatures below. When liquid asphalt is to be mixed with aggregate, the temperature of the aggregate, at the time of adding the liquid asphalt, shall not exceed that shown in the column of pugmill mixing temperatures.
- At no time, after loading into a tank car or truck for transportation to the site of the work, shall the temperature of the liquid asphalt be raised above that given in the last column of the following table, unless authorized by the Engineer.

Application Temperatures Of Liquid Asphalts

Grade of Liquid Asphalt	Pug Mill Mixing Temperature of Aggregate	Distributor Application Temperature	
	Max. ° F	Min.° F	Max.° F
SC-70	—	105	175
SC-250	200	140	230
SC-800	225	175	255
SC-3000	260	215	290
MC-70	—	105	175
MC-250	200	140	230
MC-800	225	175	255
MC-3000	260	215	290

- Liquid asphalt shall be heated by a retort or by steam coils in such a manner that steam will not be introduced directly into the liquid asphalt during heating. The Contractor shall furnish and keep available at all times, an accurate thermometer suitable for determining the temperature of the liquid asphalt being applied.
- Distributor trucks shall be of the pressure type with insulated tanks. The use of gravity distributors will not be permitted. Spray bars shall have a minimum length of 9 feet and shall be of the full circulating type. The spray bar shall be adjustable to permit positioning at various heights above the surface to be treated. The valves shall be operated by levers so that one or all valves may be quickly opened or closed in one operation.
- Spreading by means of cab controlled valves will be permitted in the application of seals. The valves which control the flow from nozzles shall act positively so as to provide a uniform unbroken spread of bituminous material on the surface. The distributor shall be equipped with devices and charts to provide for accurate and rapid determination and control of the amount of bituminous material being applied and with a bitumeter of the auxiliary wheel type registering speed in feet per minute, and trip and total distance in feet. The spreading equipment shall be designed so that uniform application of bituminous material, in controlled amounts, may be made ranging from 0.02-gallon to one gallon per square yard of surface and with a range of pressure from 25 psi to 75 psi. If a spray bar extension is used to cover a greater width, it shall be of the full circulating type.

The distributor shall be equipped with a hose and nozzle to be used for spraying areas which are inaccessible to the distributor. The distributor shall also be equipped with pressure gages and an accurate thermometer for determination of temperatures of the bituminous material. Distributor and booster tanks shall be so maintained at all times as to prevent dripping of bituminous material from any part of the equipment.

- In order to secure uniform distribution at the junction of 2 applications, the distribution shall be promptly stopped when the uniform flow decreases, indicating the tank is about empty.
- The Department reserves the right to order the use of any equipment discontinued which, in the opinion of the Engineer, fails to produce a satisfactory distribution of asphalt in accordance with the specifications.
- Spreading liquid asphalt will not be permitted when the surface to be treated is appreciably damp, or when weather conditions are unsuitable, or when the atmospheric temperature is below the minimum temperature specified for the particular type of work.
- Disposing of excess liquid asphalt within sight of the highway will not be permitted. Distributors shall stop spreading asphalt while traffic is passing, if directed by the Engineer.
- Liquid asphalt delivered to the work shall not be used for any purpose other than that provided for in the specifications.
- The Contractor shall provide a satisfactory method of accurately measuring the volume of liquid asphalt in the storage tanks and in each spreading unit at any time.

93-1.04 MEASUREMENT

- When liquid asphalt is to be paid for as a contract item of work, the unit of measurement shall be a ton.
- Quantities of liquid asphalt wasted or disposed of in a manner not called for under the specifications, or remaining on hand after completion of the work, will not be paid for.
- Except as provided in this Section 93-1.04 for volumetric measurement of pay quantities, and unless otherwise provided in these specifications or in the special provisions, quantities of liquid asphalt to be paid for by the ton will be determined in conformance with the provisions in Section 9-1.01, "Measurement of Quantities," and the following.
- Railroad car weight will be accepted as the basis for computing pay quantities for shipments of liquid bituminous products only when the material is not to be loaded into trucks and provided that the loaded car is weighed on track scales. The tare stenciled on the car, unless proven to be erroneous, will be used in determining the net content. If bituminous products were weighed on railroad car scales, the Contractor shall furnish duplicate railroad weight tags to the Engineer. When railroad car weight is to be accepted as a basis for computing pay quantities, the cars shall not be released by the Contractor until inspected by the Engineer to determine that they are completely empty.
- When asphalt concrete is to be obtained from commercial plants, the products from which will not be devoted solely to the one project and liquid asphalt is to be paid for as a separate contract item of work, the weight of asphalt to be paid for will

be determined by multiplying the weight of the completed mixture by a factor of x / (100+x) where x is the ordered asphalt content expressed as percent of the weight of dry aggregate.

- When partial loads of liquid asphalt are used in the work at locations other than at a mixing plant and no suitable scales are available within 20 miles of the location where the material is used, the weight of liquid asphalt remaining on the transporting vehicle may be determined by the Engineer from volumetric measurements, provided that the liquid asphalt is delivered in calibrated tanks, and each tank is accompanied by its proper measuring stick and calibration card. In lieu of calibrated tanks and measuring sticks for determining the delivered volume of partial loads of liquid asphalt, the liquid asphalt may be delivered in a truck equipped with a proper vehicle tank meter which complies with the requirements for weighing, measuring, and metering devices in Section 9-1.01, "Measurement of Quantities," and equipped with a calibrated thermometer to accurately determine the temperature of the liquid asphalt at the time of delivery.
- When asphalt concrete is obtained from a mixing plant producing material for only one project, in lieu of starting the project with an empty plant tank and weighing any liquid asphalt remaining at the end of the project, the amount of liquid asphalt in a plant tank at the start of a project or at the end of a project may be determined from volumetric measurements, provided that the tank is calibrated and equipped with a proper measuring stick and calibration card. Pay quantities shall be determined in accordance with the following procedure.
- When pay quantities of liquid asphalt are determined from volumetric measurements as above provided, the volume at any other temperature shall be reduced to the volume the material would occupy at 60° F before converting the volume to weight. The following table shall be used to convert the volumes from gallons to weight, and the Conversion Table at the end of this Section 93-1.04 shall be used to convert the volume at any other temperature to the volume at 60° F. Slow curing and medium curing liquid asphalts of the same grade, shall be considered to have equal weight per volume.

Average Weight And Volumes Of Liquid Asphalt

Grade of Liquid Asphalt	Gallons per ton at 60° F	Pounds per Gallon at 60° F
70	253	7.90
250	249	8.03
800	244	8.16
3000	240	8.30

- The following Legend and Conversion Table will be used to convert volumes of liquid asphalt products, Grades 70 to 3000, inclusive, and paving asphalt Grades PG 58-22, 64-10, 64-16, 64-28, and 70-10, and PBA 6a, 6a (mod), 6b, and 7.

Legend: t=observed temperature in degrees Celsius.
A=multiplier for reducing volumes to the basis of 60° F, for asphalts with density at 60° F of 60.3 pcf or higher.
B=multiplier for reducing volumes to the basis of 60° F, for asphalts with density at 60° F of 53.1 to 60.2 pcf.

Conversion Table

t	A	B	t	A	B	t	A	B
-13	1.0257	1.0294	22	1.0133	1.0152	57	1.0010	1.0012
-12	1.0253	1.0290	23	1.0129	1.0148	58	1.0007	1.0008
-11	1.0250	1.0286	24	1.0126	1.0144	59	1.0003	1.0004
-10	1.0246	1.0282	25	1.0122	1.0140	60	1.0000	1.0000
-9	1.0243	1.0277	26	1.0119	1.0136	61	0.9996	0.9996
-8	1.0239	1.0273	27	1.0115	1.0132	62	0.9993	0.9992
-7	1.0236	1.0269	28	1.0112	1.0128	63	0.9989	0.9988
-6	1.0232	1.0265	29	1.0108	1.0124	64	0.9986	0.9984
-5	1.0228	1.0261	30	1.0105	1.0120	65	0.9982	0.9980
-4	1.0225	1.0257	31	1.0101	1.0116	66	0.9979	0.9976
-3	1.0221	1.0253	32	1.0098	1.0112	67	0.9975	0.9972
-2	1.0218	1.0249	33	1.0094	1.0108	68	0.9972	0.9968
-1	1.0214	1.0245	34	1.0091	1.0104	69	0.9968	0.9964
0	1.0211	1.0241	35	1.0087	1.0100	70	0.9965	0.9960
1	1.0207	1.0237	36	1.0084	1.0096	71	0.9961	0.9956
2	1.0204	1.0233	37	1.0080	1.0091	72	0.9958	0.9952
3	1.0200	1.0229	38	1.0077	1.0087	73	0.9954	0.9948
4	1.0197	1.0225	39	1.0073	1.0083	74	0.9951	0.9944
5	1.0193	1.0221	40	1.0070	1.0079	75	0.9947	0.9940
6	1.0189	1.0217	41	1.0066	1.0075	76	0.9944	0.9936
7	1.0186	1.0212	42	1.0063	1.0071	77	0.9940	0.9932
8	1.0182	1.0208	43	1.0059	1.0067	78	0.9937	0.9928
9	1.0179	1.0204	44	1.0056	1.0063	79	0.9933	0.9924
10	1.0175	1.0200	45	1.0052	1.0059	80	0.9930	0.9920
11	1.0172	1.0196	46	1.0049	1.0055	81	0.9926	0.9916
12	1.0168	1.0192	47	1.0045	1.0051	82	0.9923	0.9912
13	1.0165	1.0188	48	1.0042	1.0047	83	0.9919	0.9908
14	1.0161	1.0184	49	1.0038	1.0043	84	0.9916	0.9904
15	1.0158	1.0180	50	1.0035	1.0039	85	0.9913	0.9900
16	1.0154	1.0176	51	1.0031	1.0035	86	0.9909	0.9897
17	1.0151	1.0172	52	1.0028	1.0031	87	0.9906	0.9893
18	1.0147	1.0168	53	1.0024	1.0027	88	0.9902	0.9889
19	1.0144	1.0164	54	1.0021	1.0023	89	0.9899	0.9885
20	1.0140	1.0160	55	1.0017	1.0019	90	0.9895	0.9881
21	1.0136	1.0156	56	1.0014	1.0016	91	0.9892	0.9877

Conversion Table - Continued

t	A	B	t	A	B	t	A	B
92	0.9888	0.9873	127	0.9768	0.9736	162	0.9648	0.9601
93	0.9885	0.9869	128	0.9764	0.9732	163	0.9645	0.9597
94	0.9881	0.9865	129	0.9761	0.9728	164	0.9641	0.9593
95	0.9878	0.9861	130	0.9757	0.9724	165	0.9638	0.9589
96	0.9874	0.9857	131	0.9754	0.9720	166	0.9634	0.9585
97	0.9871	0.9853	132	0.9750	0.9716	167	0.9631	0.9581
98	0.9867	0.9849	133	0.9747	0.9713	168	0.9628	0.9578
99	0.9864	0.9845	134	0.9744	0.9709	169	0.9624	0.9574
100	0.9861	0.9841	135	0.9740	0.9705	170	0.9621	0.9570
101	0.9857	0.9837	136	0.9737	0.9701	171	0.9617	0.9566
102	0.9854	0.9834	137	0.9733	0.9697	172	0.9614	0.9562
103	0.9850	0.9830	138	0.9730	0.9693	173	0.9611	0.9558
104	0.9847	0.9826	139	0.9726	0.9689	174	0.9607	0.9555
105	0.9843	0.9822	140	0.9723	0.9685	175	0.9604	0.9551
106	0.9840	0.9818	141	0.9720	0.9682	176	0.9600	0.9547
107	0.9836	0.9814	142	0.9716	0.9678	177	0.9597	0.9543
108	0.9833	0.9810	143	0.9713	0.9674	178	0.9594	0.9539
109	0.9830	0.9806	144	0.9709	0.9670	179	0.9590	0.9535
110	0.9826	0.9802	145	0.9706	0.9666	180	0.9587	0.9532
111	0.9823	0.9798	146	0.9703	0.9662	181	0.9583	0.9528
112	0.9819	0.9794	147	0.9699	0.9658	182	0.9580	0.9524
113	0.9816	0.9790	148	0.9696	0.9654	183	0.9577	0.9520
114	0.9812	0.9787	149	0.9692	0.9651	184	0.9573	0.9516
115	0.9809	0.9783	150	0.9689	0.9647	185	0.9570	0.9513
116	0.9805	0.9779	151	0.9685	0.9643	186	0.9567	0.9509
117	0.9802	0.9775	152	0.9682	0.9639	187	0.9563	0.9505
118	0.9799	0.9771	153	0.9679	0.9635	188	0.9560	0.9501
119	0.9795	0.9767	154	0.9675	0.9631	189	0.9556	0.9497
120	0.9792	0.9763	155	0.9672	0.9627	190	0.9553	0.9493
121	0.9788	0.9759	156	0.9668	0.9624	191	0.9550	0.9490
122	0.9785	0.9755	157	0.9665	0.9620	192	0.9546	0.9486
123	0.9781	0.9751	158	0.9662	0.9616	193	0.9543	0.9482
124	0.9778	0.9748	159	0.9658	0.9612	194	0.9540	0.9478
125	0.9774	0.9744	160	0.9655	0.9608	195	0.9536	0.9474
126	0.9771	0.9740	161	0.9651	0.9604	196	0.9533	0.9471

Conversion Table - Continued

t	A	B	t	A	B	t	A	B
197	0.9529	0.9467	232	0.9412	0.9335	267	0.9296	0.9204
198	0.9526	0.9463	233	0.9409	0.9331	268	0.9292	0.9201
199	0.9523	0.9459	234	0.9405	0.9327	269	0.9289	0.9197
200	0.9519	0.9455	235	0.9402	0.9324	270	0.9286	0.9193
201	0.9516	0.9452	236	0.9399	0.9320	271	0.9282	0.9190
202	0.9513	0.9448	237	0.9395	0.9316	272	0.9279	0.9186
203	0.9509	0.9444	238	0.9392	0.9312	273	0.9276	0.9182
204	0.9506	0.9440	239	0.9389	0.9309	274	0.9273	0.9179
205	0.9503	0.9437	240	0.9385	0.9305	275	0.9269	0.9175
206	0.9499	0.9433	241	0.9382	0.9301	276	0.9266	0.9171
207	0.9496	0.9429	242	0.9379	0.9297	277	0.9263	0.9168
208	0.9492	0.9425	243	0.9375	0.9294	278	0.9259	0.9164
209	0.9489	0.9421	244	0.9372	0.9290	279	0.9256	0.9160
210	0.9486	0.9418	245	0.9369	0.9286	280	0.9253	0.9156
211	0.9482	0.9414	246	0.9365	0.9283	281	0.9249	0.9153
212	0.9479	0.9410	247	0.9362	0.9279	282	0.9246	0.9149
213	0.9476	0.9406	248	0.9359	0.9275	283	0.9243	0.9145
214	0.9472	0.9403	249	0.9355	0.9271	284	0.9240	0.9142
215	0.9469	0.9399	250	0.9352	0.9268	285	0.9236	0.9138
216	0.9466	0.9395	251	0.9349	0.9264	286	0.9233	0.9134
217	0.9462	0.9391	252	0.9345	0.9260	287	0.9230	0.9131
218	0.9459	0.9387	253	0.9342	0.9256	288	0.9226	0.9127
219	0.9456	0.9384	254	0.9339	0.9253	289	0.9223	0.9123
220	0.9452	0.9380	255	0.9335	0.9249	290	0.9220	0.9120
221	0.9449	0.9376	256	0.9332	0.9245	291	0.9217	0.9116
222	0.9445	0.9372	257	0.9329	0.9242	292	0.9213	0.9112
223	0.9442	0.9369	258	0.9325	0.9238	293	0.9210	0.9109
224	0.9439	0.9365	259	0.9322	0.9234	294	0.9207	0.9105
225	0.9435	0.9361	260	0.9319	0.9230	295	0.9203	0.9101
226	0.9432	0.9357	261	0.9316	0.9227	296	0.9200	0.9098
227	0.9429	0.9354	262	0.9312	0.9223	297	0.9197	0.9094
228	0.9425	0.9350	263	0.9309	0.9219	298	0.9194	0.9090
229	0.9422	0.9346	264	0.9306	0.9216	299	0.9190	0.9087
230	0.9419	0.9342	265	0.9302	0.9212	300	0.9187	0.9083
231	0.9415	0.9339	266	0.9299	0.9208	301	0.9184	0.9079

Conversion Table - Continued

t	A	B	t	A	B	t	A	B
302	0.9180	0.9076	337	0.9066	0.8949	372	0.8953	0.8823
303	0.9177	0.9072	338	0.9063	0.8945	373	0.8950	0.8820
304	0.9174	0.9068	339	0.9060	0.8942	374	0.8947	0.8816
305	0.9171	0.9065	340	0.9057	0.8938	375	0.8944	0.8813
306	0.9167	0.9061	341	0.9053	0.8934	376	0.8940	0.8809
307	0.9164	0.9058	342	0.9050	0.8931	377	0.8937	0.8806
308	0.9161	0.9054	343	0.9047	0.8927	378	0.8934	0.8802
309	0.9158	0.9050	344	0.9044	0.8924	379	0.8931	0.8798
310	0.9154	0.9047	345	0.9040	0.8920	380	0.8928	0.8795
311	0.9151	0.9043	346	0.9037	0.8916	381	0.8924	0.8791
312	0.9148	0.9039	347	0.9034	0.8913	382	0.8921	0.8788
313	0.9144	0.9036	348	0.9031	0.8909	383	0.8918	0.8784
314	0.9141	0.9032	349	0.9027	0.8906	384	0.8915	0.8781
315	0.9138	0.9028	350	0.9024	0.8902	385	0.8911	0.8777
316	0.9135	0.9025	351	0.9021	0.8898	386	0.8908	0.8774
317	0.9131	0.9021	352	0.9018	0.8895	387	0.8905	0.8770
318	0.9128	0.9018	353	0.9014	0.8891	388	0.8902	0.8767
319	0.9125	0.9014	354	0.9011	0.8888	389	0.8899	0.8763
320	0.9122	0.9010	355	0.9008	0.8884	390	0.8895	0.8760
321	0.9118	0.9007	356	0.9005	0.8880	391	0.8892	0.8756
322	0.9115	0.9003	357	0.9002	0.8877	392	0.8889	0.8752
323	0.9112	0.8999	358	0.8998	0.8873	393	0.8886	0.8749
324	0.9109	0.8996	359	0.8995	0.8870	394	0.8883	0.8745
325	0.9105	0.8992	360	0.8992	0.8866	395	0.8880	0.8742
326	0.9102	0.8988	361	0.8989	0.8863	396	0.8876	0.8738
327	0.9099	0.8985	362	0.8985	0.8859	397	0.8873	0.8735
328	0.9096	0.8981	363	0.8982	0.8855	398	0.8870	0.8731
329	0.9092	0.8978	364	0.8979	0.8852	399	0.8867	0.8728
330	0.9089	0.8974	365	0.8976	0.8848	400	0.8864	0.8724
331	0.9086	0.8970	366	0.8973	0.8845	401	0.8860	0.8721
332	0.9083	0.8967	367	0.8969	0.8841	402	0.8857	0.8717
333	0.9079	0.8963	368	0.8966	0.8838	403	0.8854	0.8714
334	0.9076	0.8960	369	0.8963	0.8834	404	0.8851	0.8710
335	0.9073	0.8956	370	0.8960	0.8830	405	0.8848	0.8707
336	0.9070	0.8952	371	0.8956	0.8827	406	0.8844	0.8703

Conversion Table - Continued

t	A	B	t	A	B	t	A	B
407	0.8841	0.8700	442	0.8730	0.8578	477	0.8621	0.8457
408	0.8838	0.8696	443	0.8727	0.8574	478	0.8617	0.8454
409	0.8835	0.8693	444	0.8724	0.8571	479	0.8614	0.8450
410	0.8832	0.8689	445	0.8721	0.8567	480	0.8611	0.8447
411	0.8829	0.8686	446	0.8718	0.8564	481	0.8608	0.8443
412	0.8825	0.8682	447	0.8715	0.8560	482	0.8605	0.8440
413	0.8822	0.8679	448	0.8711	0.8557	483	0.8602	0.8437
414	0.8819	0.8675	449	0.8708	0.8553	484	0.8599	0.8433
415	0.8816	0.8672	450	0.8705	0.8550	485	0.8596	0.8430
416	0.8813	0.8668	451	0.8702	0.8546	486	0.8593	0.8426
417	0.8809	0.8665	452	0.8699	0.8543	487	0.8589	0.8322
418	0.8806	0.8661	453	0.8696	0.8540	488	0.8586	0.8318
419	0.8803	0.8658	454	0.8693	0.8536	489	0.8583	0.8315
420	0.8800	0.8654	455	0.8689	0.8533	490	0.8580	0.8311
421	0.8797	0.8651	456	0.8686	0.8529	491	0.8577	0.8308
422	0.8794	0.8647	457	0.8683	0.8526	492	0.8574	0.8406
423	0.8790	0.8644	458	0.8680	0.8522	493	0.8571	0.8403
424	0.8787	0.8640	459	0.8677	0.8519	494	0.8568	0.8399
425	0.8784	0.8637	460	0.8674	0.8515	495	0.8565	0.8396
426	0.8781	0.8633	461	0.8671	0.8512	496	0.8561	0.8392
427	0.8778	0.8630	462	0.8667	0.8509	497	0.8558	0.8389
428	0.8775	0.8626	463	0.8664	0.8505	498	0.8555	0.8386
429	0.8771	0.8623	464	0.8661	0.8502	499	0.8552	0.8382
430	0.8768	0.8619	465	0.8658	0.8498	500	0.8549	0.8379
431	0.8765	0.8616	466	0.8655	0.8495	501	0.8546	0.8376
432	0.8762	0.8612	467	0.8652	0.8491	502	0.8543	0.8372
433	0.8759	0.8609	468	0.8649	0.8488	503	0.8540	0.8369
434	0.8756	0.8605	469	0.8646	0.8485	504	0.8537	0.8365
435	0.8752	0.8602	470	0.8642	0.8481	505	0.8534	0.8362
436	0.8749	0.8598	471	0.8639	0.8478	506	0.8530	0.8359
437	0.8746	0.8595	472	0.8636	0.8474	507	0.8527	0.8355
438	0.8743	0.8591	473	0.8633	0.8471	508	0.8524	0.8352
439	0.8740	0.8588	474	0.8630	0.8467	509	0.8521	0.8348
440	0.8737	0.8584	475	0.8627	0.8464	510	0.8518	0.8345
441	0.8734	0.8581	476	0.8624	0.8461	511	0.8515	0.8342

Conversion Table - Continued

t	A	B	t	A	B	t	A	B
512	0.8512	0.8338	537	0.8435	0.8255	562	0.8358	0.8172
513	0.8509	0.8335	538	0.8432	0.8251	563	0.8355	0.8168
514	0.8506	0.8332	539	0.8429	0.8248	564	0.8352	0.8165
515	0.8503	0.8328	540	0.8426	0.8245	565	0.8349	0.8162
516	0.8500	0.8325	541	0.8423	0.8241	566	0.8346	0.8158
517	0.8496	0.8322	542	0.8420	0.8238	567	0.8343	0.8155
518	0.8493	0.8318	543	0.8417	0.8235	568	0.8340	0.8152
519	0.8490	0.8315	544	0.8413	0.8231	569	0.8337	0.8149
520	0.8487	0.8311	545	0.8410	0.8228	570	0.8334	0.8145
521	0.8484	0.8308	546	0.8407	0.8225	571	0.8331	0.8142
522	0.8481	0.8305	547	0.8404	0.8221	572	0.8328	0.8139
523	0.8478	0.8301	548	0.8401	0.8218	573	0.8325	0.8135
524	0.8475	0.8298	549	0.8398	0.8215	574	0.8322	0.8132
525	0.8472	0.8295	550	0.8395	0.8211	575	0.8319	0.8129
526	0.8469	0.8291	551	0.8392	0.8208	576	0.8316	0.8126
527	0.8466	0.8288	552	0.8389	0.8205	577	0.8313	0.8122
528	0.8463	0.8285	553	0.8386	0.8201	578	0.8310	0.8119
529	0.8459	0.8281	554	0.8383	0.8198	579	0.8307	0.8116
530	0.8456	0.8278	555	0.8380	0.8195	580	0.8304	0.8112
531	0.8453	0.8275	556	0.8377	0.8191	581	0.8301	0.8109
532	0.8450	0.8271	557	0.8374	0.8188	582	0.8298	0.8106
533	0.8447	0.8268	558	0.8371	0.8185	583	0.8295	0.8103
534	0.8444	0.8265	559	0.8368	0.8182	584	0.8292	0.8099
535	0.8441	0.8261	560	0.8365	0.8178	585	0.8289	0.8096
536	0.8438	0.8258	561	0.8362	0.8175	586	0.8286	0.8093

SECTION 94: ASPHALTIC EMULSIONS

94-1.01 DESCRIPTION

- Asphaltic emulsions shall be composed of a bituminous material uniformly emulsified with water and an emulsifying or stabilizing agent. Polymer modified asphaltic emulsion shall also contain a polymer.

94-1.02 REQUIREMENTS

- The asphaltic emulsion shall be homogeneous. Within 30 days after delivery and provided separation has not been caused by freezing, the asphaltic emulsion shall be homogeneous after thorough mixing. The polymer used in the manufacture of polymer modified asphaltic emulsion shall be, at the option of the Contractor, either neoprene, ethylene vinyl acetate or a blend of butadiene and styrene.
- The asphaltic emulsion shall conform to the provisions prescribed in the Tables following Section 94-1.04, "Method of Test."

94-1.03 SAMPLING

- Samples of asphaltic emulsion shall be taken in conformance with the requirements in AASHTO Designation: T 40, "Sampling Bituminous Materials." If the polymer content of polymer modified asphaltic emulsion is to be determined by California Test 401, a one-quart sample each of base asphalt and polymer used in the manufacture of the asphaltic emulsion to be used in the work shall be submitted to the Transportation Laboratory at least 10 days prior to beginning seal coat work.
- Samples shall be stored in clean, airtight sealed containers at a temperature of not less than 40° F until tested.

94-1.04 METHOD OF TEST

- The properties of the asphaltic emulsions given in Tables 1, 2, 3 and 4 shall be determined in conformance with the requirements in AASHTO Designation: T 59, "Testing Emulsified Asphalt," unless otherwise noted.

TABLE I: Requirements for Anionic Asphaltic Emulsion

Type	Rapid-Setting				Medium-Setting						Slow-Setting			
Grade	RS1		RS2		MS1		MS2		MS2h		SS1		SS1h	
Properties	min	max	min	max	min	max	min	max	min	max	min	max	min	max
Tests on Emulsions:														
Viscosity, SSF @ 25°C, sec	20	100	—	—	20	100	100	—	100	—	20	100	20	100
Viscosity, SSF @ 50°C, sec	—	—	75	400	—	—	—	—	—	—	—	—	—	—
Settlement, 5 days, %[a]	—	5	—	5	—	5	—	5	—	5	—	5	—	5
Storage stability test, 1 day, %[b]	—	1	—	1	—	1	—	1	—	1	—	1	—	1
Demulsibility, 35 ml, 0.02 *N* $CaCl_2$, % [c]	60	—	60	—	—	—	—	—	—	—	—	—	—	—
Coating ability and water resistance:														
Coating, dry aggregate	—		—		good		good		good		—		—	
Coating, after spraying	—		—		fair		fair		fair		—		—	
Coating, wet aggregate	—		—		fair		fair		fair		—		—	
Coating, after spraying	—		—		fair		fair		fair		—		—	
Cement mixing test, %	—	—	—	—	—	—	—	—	—	—	—	2.0	—	2.0
Sieve test, %	—	0.10	—	0.10	—	0.10	—	0.10	—	0.10	—	0.10	—	0.10
Residue by distillation, %	55	—	63	—	55	—	65	—	65	—	57	—	57	—
Tests on Residue from Distillation Test:														
Penetration, 25°C	100[d]	200	100[d]	200	100	200	100	200	40	90	100	200	40	90
Ductility, 25°C, 50 mm/min, mm	400	—	400	—	400	—	400	—	400	—	400	—	400	—
Solubility in trichloroethylene, %	97.5	—	97.5	—	97.5	—	97.5	—	97.5	—	97.5	—	97.5	—

a The test requirement for settlement may be waived when the asphaltic emulsion is used in less than 5 days' time; or the Engine er may require that the settlement test be run from the time the sample is received until the asphaltic emulsion is used, if the elapsed time is less than 5-days.

b The 24-hour (1 day) storage stability test may be used instead of the 5 day settlement test.

c The demulsibility test shall be made within 30 days from date of shipment.

d A harder base asphalt meeting current asphalt specifications may be specified with the provisions that the test requirements on the Residue from Distillation be waived.

TABLE 2: Requirements for Cationic Asphaltic Emulsion

Properties	Type	Rapid-Setting				Medium-Setting						Slow-Setting			
	Grade	CRS1		CRS2		CMS2S		CMS2		CMS2h		CSS1		CSS1h	
		min	max	min	max	min	max	min	max	min	max	min	max	min	max
Tests on Emulsions:															
Viscosity, SSF @ 25°C, sec		—	—	—	—	—	—	—	—	—	—	20	100	20	100
Viscosity, SSF @ 50°C, sec		20	100	100	400	50	450	50	450	50	450	—	—	—	—
Settlement, 5 days, %[a]		—	5	—	5	—	5	—	5	—	5	—	5	—	5
Storage stability test, 1 day, %[b]		—	1	—	1	—	1	—	1	—	1	—	1	—	1
Demulsibility, 35 ml, 0.8% sodium dioctyl sulfosuccinate, %[c]		40	—	40	—	—	—	—	—	—	—	—	—	—	—
Coating ability and water resistance:															
Coating, dry aggregate		—		—		good		good		good		—		—	
Coating, after spraying		—		—		fair		fair		fair		—		—	
Coating, wet aggregate		—		—		fair		fair		fair		—		—	
Coating, after spraying		—		—		fair		fair		fair		—		—	
Particle charge test		positive		positive		positive		positive		positive		positive[e]		positive[e]	
Sieve test, %		—	0.10	—	0.10	—	0.10	—	0.10	—	0.10	—	0.10	—	0.10
Cement mixing test, %		—	—	—	—	—	—	—	—	—	—	—	2.0	—	2.0
Distillation:															
Oil distillate by vol. of emulsion, %		—	3	—	3	—	20	—	12	—	12	—	—	—	—
Residue, %		60	—	65	—	60	—	65	—	65	—	57	—	57	—
Tests on Residue from Distillation Test:															
Penetration, 25°C		100[d]	250	100[d]	250	100	250	100	250	40	90	100	250	40	90
Ductility, 25°C, 50 mm/min, mm		400	—	400	—	400	—	400	—	400	—	400	—	400	—
Solubility in trichloroethylene, %		97.5	—	97.5	—	97.5	—	97.5	—	97.5	—	97.5	—	97.5	—

a The test requirement for settlement may be waived when the asphaltic emulsion is used in less than 5 days' time; or the Engineer may require that the settlement test be run from the time the sample is received until the asphaltic emulsion is used, if the elapsed time is less than 5 days.
b The 24-hour (1 day) storage stability test may be used instead of the 5-day settlement test.
c The demulsibility test shall be made within 30 days from date of shipment.
d A harder base asphalt meeting current paving asphalt specifications may be specified with the provision that the test requirements on the Residue from Distillation be waived.
e Shall meet a pH requirement of 6.7 maximum (ASTM Designation: E 70) if the Particle Charge Test result is inconclusive.

TABLE 3: Requirements for Polymer Modified Asphaltic Emulsion

Properties	Type	Anionic				Cationic			
	Grade	PMRS2		PMRS2h		PMCRS2		PMCRS2h	
		min	max	min	max	min	max	min	max
Tests on Emulsions:									
Viscosity, SSF @ 50°C, sec		75	300	75	300	75	300	75	300
Settlement, 5 days, %		—	5	—	5	—	5	—	5
Storage Stability, 1 day, %		—	1	—	1	—	1	—	1
Sieve Test, %		—	0.30	—	0.30	—	0.30	—	0.30
Demulsibility, %		60	—	60	—	40	—	40	—
Particle Charge		—		—		Positive		Positive	
Ash Content, %[a]		—	0.2	—	0.2	—	0.2	—	0.2
Residue by Evaporation, %[d]		65	—	65	—	65	—	65	—
Test on Residue from Evaporation Test:									
Penetration, 25°C[b]		100	200	40	90	100	200	40	90
Ductility, 25°C, mm[c]		400	—	400	—	400	—	400	—
and either:									
Torsional Recovery, %[e]		18	—	18	—	18	—	18	—
or									
Polymer Content, %[f] (by weight)		2.5	—	2.5	—	2.5	—	2.5	—

a ASTM Designation: D 3723
b AASHTO Designation: T 49
c AASHTO Designation: T 51
d California Test 331
e California Test 332
f California Test 401

When Test for polymer content of polymer modified asphaltic emulsion is used, see sampling requirements in Section 94-1.03, "Sampling."

TABLE 4: Requirements for Quick-Setting Asphaltic Emulsion

Properties	Type	Anionic				Cationic			
	Grade	QS1		QS1h		CQS1		CQS1h	
		min	max	min	max	min	max	min	max
Tests on Emulsions:									
Viscosity, SSF @ 50°C, sec		15	90	15	90	15	90	15	90
Sieve Test, %		—	0.30	—	0.30	—	0.30	—	0.30
Storage Stability, 1 day, %		—	1	—	1	—	1	—	1
Residue by Distillation, %		57	—	57	—	57	—	57	—
Particle Charge		negative		negative		positive		positive	
Tests on Residue from Distillation Test:									
Penetration, 25°C[a]		100	200	40	90	100	200	40	90
Ductility, 25°C, mm[b]		400	—	400	—	400	—	400	—
Solubility in trichloroeythylene, %[c]		97	—	97	—	97	—	97	—

a AASHTO Designation: T 49
b AASHTO Designation: T 51
c AASHTO Designation: T 44
If the result of the particle charge test is inconclusive, the asphaltic emulsion shall be tested for pH in conformance with the requirements in ASTM Designation: E 70. Grade QS1h asphaltic emulsion shall have a minimum pH of 7.3. Grade CQS1h asphaltic emulsion shall have a maximum ph of 6.7.

94-1.05 TEST REPORT

- The vendor shall make available for review a certified copy of tests representing any shipment.
- If asphaltic emulsion is used prior to sampling and testing, a Certificate of Compliance, in conformance with the provisions in Section 6-1.07, "Certificates of Compliance," shall accompany each shipment of asphaltic emulsion to the work. The certificate shall include the shipment number, type of material, specific gravity of the material, refinery, consignee, destination, quantity, contract or purchase order number and date of shipment. The certificate shall state that the material complies with the specifications detailed in this section and shall be signed by the vendor or the vendor's representative.
- Asphaltic emulsion furnished without a Certificate of Compliance shall not be used in the work until the Engineer has had sufficient time to make appropriate tests and has approved the asphaltic emulsion for use.

94-1.06 APPLYING

- Asphaltic emulsion shall be reheated, if necessary, but at no time after loading into a tank car or truck for transporting to the site of the work shall the temperature of the emulsion be raised above 160° F, unless permitted by the Engineer. During all reheating operations the asphaltic emulsion shall be agitated to prevent localized overheating. Asphaltic emulsion shall be applied in conformance with the provisions in Section 93, "Liquid Asphalts," and the following additional requirements.
- Setting Grade 1 asphaltic emulsions, except when used for fog seal coats, shall be applied at a temperature between 75° F and 130° F, and Setting Grade 2 asphaltic emulsions shall be applied at a temperature between 110° F and 185° F, unless otherwise directed by the Engineer.
- Asphaltic emulsions shall not be permitted to cool to a temperature of less than 40° F.

94-1.07 MEASUREMENT

- When asphaltic emulsion is to be paid for as a contract item of work, the unit of measurement shall be a ton.
- When water is added to asphaltic emulsion, the quantities of asphaltic emulsion to be paid for will be determined prior to the addition of the water.
- Quantities of asphaltic emulsion wasted or disposed of in a manner not called for under the specifications or remaining on hand after completion of the work, will not be paid for.
- Except as provided in this Section 94-1.07 for volumetric measurement of pay quantities, and unless otherwise provided in these specifications or in the special provisions, quantities of asphaltic emulsion to be paid for by the ton will be determined in accordance with the procedure specified for determining the weight for payment of liquid asphalt as set forth in Section 93, "Liquid Asphalts."
- When partial loads of asphaltic emulsion are used in the work at locations other than at a mixing plant and no suitable scales are available within 20 miles of the location where the emulsion is used, the weight of emulsion remaining on the transporting vehicle may be determined by the Engineer from volumetric

measurements, provided that the emulsion is delivered in calibrated tanks and each tank is accompanied by its proper measuring stick and calibration card. In lieu of calibrated tanks and measuring sticks for determining the delivered volume of partial loads of asphaltic emulsion, the emulsion may be delivered in a truck equipped with a proper vehicle tank meter which complies with the requirements for weighing, measuring and metering devices in Section 9-1.01, "Measurement of Quantities," and equipped with a calibrated thermometer to accurately determine the temperature of the emulsion at the time of delivery.

- When pay quantities of asphaltic emulsion are determined from volumetric measurements as above provided, the volume at any other temperature shall be reduced to the volume the emulsion would occupy at 60° F, before converting the volume to weight. The following table shall be used to convert volumes from gallons to weight and the table at the end of this Section 94-1.07 shall be used to convert the volume at any other temperature to the volume at 60° F.

AVERAGE WEIGHT AND VOLUME OF ASPHALTIC EMULSION

Type of Emulsion	Gallons per Ton at 60° F	Pounds per Gallon at 60° F
All types	240	8.33

CONVERSION TABLE

t	M	t	M	t	M	t	M
60	1.00000	83	0.99425	106	0.98850	129	0.98275
61	0.99975	84	0.99400	107	0.98825	130	0.98250
62	0.99950	85	0.99375	108	0.98800	131	0.98225
63	0.99925	86	0.99350	109	0.98775	132	0.98200
64	0.99900	87	0.99325	110	0.98750	133	0.98175
65	0.99875	88	0.99300	111	0.98725	134	0.98150
66	0.99850	89	0.99275	112	0.98700	135	0.98125
67	0.99825	90	0.99250	113	0.98675	136	0.98100
68	0.99800	91	0.99225	114	0.98650	137	0.98075
69	0.99775	92	0.99200	115	0.98625	138	0.98050
70	0.99750	93	0.99175	116	0.98600	139	0.98025
71	0.99725	94	0.99150	117	0.98575	140	0.98000
72	0.99700	95	0.99125	118	0.98550	141	0.97975
73	0.99675	96	0.99100	119	0.98525	142	0.97950
74	0.99650	97	0.99075	120	0.98500	143	0.97925
75	0.99625	98	0.99050	121	0.98475	144	0.97900
76	0.99600	99	0.99025	122	0.98450	145	0.97875
77	0.99575	100	0.99000	123	0.98425	146	0.97850
78	0.99550	101	0.98975	124	0.98400	147	0.97825
79	0.99525	102	0.98950	125	0.98375	148	0.97800
80	0.99500	103	0.98925	126	0.98350	149	0.97775
81	0.99475	104	0.98900	127	0.98325	150	0.97750
82	0.99450	105	0.98875	128	0.98300	151	0.97725

t = observed temperature in degrees Fahrenheit
M = multiplier for reducing volumes to the basis of 60° F

SECTION 95: EPOXY

95-1 GENERAL

95-1.01 DESCRIPTION

- These specifications are intended to specify epoxy that will meet service requirements for highway construction.
- Epoxy shall be furnished as 2 components, which shall be mixed together at the site of the work.

95-1.02 SAMPLING AND TESTING

- Epoxy shall not be used prior to sampling and testing unless its use is permitted prior to sampling and testing in conformance with the provisions in Section 6-1.07, "Certificates of Compliance."
- Tests will be conducted in conformance with the latest test methods of the American Society for Testing and Materials, and California Test Methods in use by the Transportation Laboratory.
- Epoxy components shall be formulated to maintain the specified properties for a minimum of one year. The Engineer may require additional testing of any epoxy component that has not been used within one year of manufacture.

95-1.03 PACKAGING, LABELING AND STORING

- Each component shall be packaged in containers of size proportional to the amount of that component in the mix so that one container of each component is used in mixing one batch of epoxy. The containers shall be of such design that all of the contents may be readily removed and shall be well sealed to prevent leakage. The containers and labeling shall meet U.S. Department of Transportation Hazardous Material Shipping Regulations, and the containers shall be of a material, or lined with a material, of such character as to resist any action by the components. Each container shall be clearly labeled with the ASTM Designation: C881 Class and Type; designation (Component A or B); manufacturer's name; date of manufacture; batch number (a batch shall consist of a single charge of all components in a mixing chamber); all directions for use (as specified elsewhere) and such warning or precautions concerning the contents as may be required by State or Federal Laws and Regulations. The manufacturer of the finished epoxy components shall furnish a Certificate of Compliance in conformance with the provisions in Section 6-1.07, "Certificates of Compliance," and a copy of the label for each material. The certificate shall include a list, by Title and Section, of the State and Federal packaging and labeling laws and regulations that the manufacturer has complied with.
- Attention is directed to the characteristic of some epoxy components to crystallize or thicken excessively prior to use when stored at temperatures below 35° F. Any material which shows evidence of crystallization or a permanent increase in viscosity or settling of pigments which cannot be readily redispersed with a paddle shall not be used.

95-1.04 DIRECTIONS FOR USE

- At the time of mixing, components A and B shall be at a temperature between 60° F and 85° F, unless otherwise specified. Any heating of the adhesive components shall be done by application of indirect heat. Immediately prior to mixing, each component shall be thoroughly mixed with a paddle. Separate paddles shall be used to stir each component. Immediately prior to use, the 2 components shall be thoroughly mixed together in the specified ratios. No solvent shall be added to any epoxy.
- After mixing, epoxies shall be placed in the work and any overlaying or inserted material which is to be bonded to the work by the epoxy shall also be placed before thickening of the epoxy has begun. Surfaces upon which epoxy is to be placed shall be free of rust, paint, grease, asphalt, and loose and deleterious material. When epoxy is used as a binder to make epoxy concrete or mortar, the 2 components of epoxy shall be thoroughly mixed together before the aggregate is added and, unless otherwise specified, the mix proportions shall consist of one part of binder to approximately 4 parts of aggregate, by volume. Aggregate for use in epoxy concrete and mortar shall be clean and shall have a moisture content of not more than 0.50-percent when tested by California Test 226. Surfaces against which epoxy concrete and mortar are to be placed shall be primed with a coat of the epoxy used just prior to placing the concrete or mortar.

95-2 TYPES OF EPOXIES

95-2.01 BINDER (ADHESIVE), EPOXY RESIN BASE

Classification:

- This specification covers a low viscosity epoxy formulated primarily for use in making high-strength epoxy concrete and epoxy mortar and in pressure grouting of cracks in concrete. For load bearing applications, use ASTM Designation: C881, Type IV, Grade 1, Class B or C. Class B or C shall be used depending on the substrate and ambient temperatures. Use Grade B for atmospheric and surface temperatures as low as 40° F. Use Class C when temperatures are 60° F or higher. For non-load bearing applications use ASTM Designation: C881, Type I, Grade 1, Class B or C. Apply no thicker than recommended by the manufacturer. Thick sections of this epoxy are not suitable for use in freeze thaw environments. In a freeze-thaw environment, increase the aggregate loading to improve the properties of the epoxy concrete.

Directions for Use:

- Mix in conformance with the manufacturer's written recommendations. No more material shall be mixed than can be used within the pot-life from the time mixing operations are started.

95-2.02 (BLANK)

95-2.03 EPOXY RESIN ADHESIVE FOR BONDING NEW CONCRETE TO OLD CONCRETE

Classification:

This specification covers a low viscosity paste epoxy formulated primarily for use in bonding new portland cement concrete to hardened portland cement concrete. The epoxy shall meet the specification requirements of ASTM Designation: C881, Type V, Grade 2. This epoxy is available in 2 Classes: Class C for general use at temperature greater than 60° F and Class B for use when cure temperatures are below 60° F and above 40° F, or when a faster cure is required.

Directions for Use:

The mixing ratio and use shall be in conformance with the manufacturer's written recommendations. When measuring as individual Components A and B, stir and tap the measuring containers to remove possible air voids. The ingredients in Components A and B shall be thoroughly dispersed such that each component forms a uniform paste. Do not mix more material than can be spread within the pot life from the time mixing operations are started. The spreading rate shall be sufficient to thoroughly coat the surface. Spread the mixed adhesive by brush or roller over blast-cleaned concrete at a rate recommended by the manufacturer. The new concrete shall be placed against the adhesive coating on the old concrete before the adhesive has set. If the adhesive has set and is not tacky prior to placing the new concrete, a new coating of adhesive shall be applied.

95-2.04 RAPID SET EPOXY ADHESIVE FOR PAVEMENT MARKERS

Classification:

This specification covers a high viscosity paste, rapid set epoxy formulated primarily for use in bonding pavement markers to portland cement concrete and asphalt concrete. The adhesive shall meet ASTM Designation: C881, Type IV, Grade 3, Class B and C except that the gel time may be shorter than 30 minutes. The adhesive shall conform to these requirements and the following.

Characteristics of Combined Components:

All tests shall be performed in conformance with the requirements in California Test 434.

Property	Requirement
Gel time, minutes, maximum, at 77° F	30
Bond Strength to Concrete, Time, minutes (maximum) to reach not less than 200 psi	
at 77° F ±2° F	35
at 50° F ±2° F	45
Slant Shear Strength	
2 days at 77° F ±2° F, psi	1,000
14 days at 77° F ±2° F, plus water soak, psi	1,500
Tensile Adhesion and Cohesion	
Ceramic marker bottom, psi	700 min.
Ceramic marker bottom, including post cure, psi	700 min.
Retroreflective pavement marker bottom, psi	500 min.
Color of mixed epoxy	gray
Glass transition temperature, Tg, samples conditioned at 77° F for 24 hours, ASTM Designation: D 4065	86 F min.

Directions for Use:

- Components A and B shall be mixed in conformance with the manufacturer's written recommendations. When an automatic proportioning and mixing machine is used, the temperature of the components shall be maintained by indirect heating or cooling, so that the adhesive will meter, mix and extrude properly. The maximum temperature shall be such that after proper mixing no excess adhesive shall flow from under the marker other than that specified in Section 85-1.06, "Placement."

95-2.05 STANDARD SET EPOXY ADHESIVE FOR PAVEMENT MARKERS

Classification:

- This specification covers a high viscosity paste standard set epoxy formulated primarily for use in bonding pavement markers to portland cement concrete and asphalt concrete. The epoxy shall meet ASTM Designation C881, Type IV, Viscosity grade 3, Classes B or C, except that the gel time may be shorter than 30 minutes.

Characteristics of Combined Components:

- All tests shall be performed in conformance with the requirements in California Test 434.

Property	Requirement
Gel time, minutes, maximum, at 77° F	30
Bond Strength to Concrete, Time (maximum) to reach not less than 200 psi	
at 77° F ±2° F	3.5 hours
at 55° F ±2° F	24 hours
Slant Shear Strength	
2 days at 77° F ±2° F, psi	1,000 min.
14 days at 77° F ±2° F, plus water soak, psi	1,500 min.
Tensile Adhesion and Cohesion	
Ceramic marker bottom, psi	700 min.
Ceramic marker bottom, including post cure, psi	700 min.
Reflective pavement marker bottom, psi	500 min.
Color of Mixed Components	gray
Glass transition temperature, Tg, samples conditioned at 77° F for 24 hours, ASTM Designation: D 4065	86° F min.

Directions for Use:

Components A and B shall be mixed in conformance with the manufacturer's written recommendations. When an automatic proportioning and mixing machine is used, the temperature of the components shall be maintained by indirect heating or cooling, so that the adhesive will meter, mix and extrude properly. The maximum temperature shall be such that after proper mixing no excess adhesive shall flow from under the marker other than that specified in Section 85-1.06, "Placement."

95-2.06 (BLANK)

95-2.07 (BLANK)

95-2.08 (BLANK)

95-2.09 EPOXY SEALANT FOR INDUCTIVE LOOPS

Classification:

This specification covers a high viscosity liquid epoxy formulated primarily for use in sealing inductive wire loops and leads imbedded in asphalt concrete and portland cement concrete for traffic signal controls and vehicle counters. This epoxy is to be used for repair work on existing spalls, cracks and other deformations in and around saw cuts housing inductor loops and leads. The rapid cure allows minimum traffic delay. This sealant is suitable for use in freeze-thaw areas. The epoxy shall meet ASTM Designation: C 881, Type I, Grade 2 and the following requirements.

Characteristics of Combined Components:

All tests shall be performed in conformance with the requirements in California Test 434.

Property	Requirement
Gel time, minutes, maximum	30
On 0.125-inch cast sheet, cured 18 hours at 77° F, + 5 hours at 160° F	
Tensile Strength, psi	400 min.
Elongation, percent	90 min.
Shore D Hardness	45 min.

Directions for Use:

- Saw cuts shall be cleaned with compressed air to remove all excess moisture and debris. For repairing damaged saw cuts, all loose spalled material shall be cleaned away from the saw cut, chipping back to sound asphalt concrete or portland cement concrete and all loose material cleaned from loop wires.
- The mixing ratio shall be in conformance with the manufacturer's recommendations. No more material shall be mixed than can be used within the gel time from the time mixing operations are started.
- When automatic mixing equipment is used for mixing the sealant, the provisions in the twelfth paragraph in Section 85-1.06, "Placement," shall apply.

95-2.10 (BLANK)

95-2.11 EPOXY RESIN ADHESIVE FOR INJECTION GROUTING OF PORTLAND CEMENT CONCRETE PAVEMENTS

Directions for Use:

- Both components and the mixed material shall contain no solvents. The mixing ratio of the components in terms of volume and weight shall be clearly stated. The material shall be suitable for use in the mixing equipment used by the applicator. Epoxy adhesive samples shall be furnished to the Engineer for testing at least 12 days before the expected time of use.

Characteristics of Adhesive:

Test[a]	California Test	Requirement
Brookfield Viscosity, No. 3 Spindle at 20 rpm, Poise at 77°F	434, Part 4	0.9 max.
Gel time, minutes	434, Part 1	2 to 15
Slant Shear Strength on Dry Concrete, psi, after 4 days of cure in air at 77° F ±2° F	434, Part 5[b]	6,000 min.
Slant Shear Strength on Wet Concrete, psi, after 4 days of cure in air at 77° F ±2° F	434, Part 5[b]	3,500 min.
Tensile Strength, psi	434, Part 7, except test after 4 days of cure at 77° F ±2° F	4,500 min.
Elongation, %	434, Part 7, except test after 4 days of cure at 77° F ±2° F	10 max.

a The mixing ratio used will be that recommended by the manufacturer.

b For slant shear strength on concrete, delete Sections B-1 and B-5 of California Test 434, Part 5. For dry concrete, use Step "2" below only. For wet concrete, use both Steps "1" & "2":

1 Soak blocks in water for 24 hours at 77° F ±2° F. Remove and wipe off excess water.

2 Mix epoxy as described in California Test 434, Part 1, and apply a coat approximately 0.010-inch thick to each diagonal surface. Place four 0.125-inch square pieces of shim stock 0.012-inch thick on one block to control final film thickness. Before pressing the coated surfaces together, leave the blocks so that the coated surfaces are horizontal until the epoxy reacts slightly to prevent excessive flow.

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