

Table of Contents

Topic Number	Subject	Page Number
CHAPTER 10 - DIVISION OF DESIGN		
11	Organization	
11.1	Organization	10-1
CHAPTER 20 - DESIGNATION OF HIGHWAY ROUTES		
21	Highway Route Numbers	
21.1	Legislative Route Numbers and Descriptions	20-1
21.2	Sign Route Numbers	20-1
CHAPTER 40 - FEDERAL-AID		
41	Enabling Legislation	
41.1	General	40-1
42	Federal-Aid System	
42.1	National Highway System	40-1
42.2	Interstate	40-1
43	Federal-Aid Programs	
43.1	Surface Transportation Program (STP)	40-1
43.2	California Stewardship and Oversight Agreement with FHWA	40-1
43.3	Congestion Mitigation and Air Quality Improvement Program (CMAQ)	40-2
43.4	Bridge Replacement and Rehabilitation Program	40-2
43.5	Federal Lands Program	40-2
43.6	Highway Safety Improvement Program	40-2
43.7	Special Programs	40-2
44	Funding Determination	
44.1	Funding Eligibility	40-2
44.2	Federal Participation Ratio	40-3
44.3	Emergency Relief	40-3
CHAPTER 60 - NOMENCLATURE		
61	Abbreviations	
61.1	Official Names	60-1
62	Definitions	
62.1	Geometric Cross Section	60-1

Table of Contents

Topic Number	Subject	Page Number
62.2	Highway Structures	60-2
62.3	Highway Types	60-2
62.4	Interchanges and Intersections at Grade	60-5
62.5	Landscape Architecture	60-6
62.6	Right of Way	60-8
62.7	Pavement	60-8
62.8	Highway Operations	60-12
62.9	Drainage	60-13
62.10	Users	60-13

CHAPTER 80 - APPLICATION OF DESIGN STANDARDS

81	Project Development Overview	
81.1	Philosophy	80-1
81.2	Highway Context	80-1
81.3	Place Types	80-2
81.4	Type of Highway	80-4
81.5	Access Control	80-5
81.6	Design Standards and Highway Context	80-5
82	Application of Standards	
82.1	Highway Design Manual Standards	80-5
82.2	Approvals for Nonstandard Design	80-7
82.3	FHWA and AASHTO Standards and Policies	80-9
82.4	Mandatory Procedural Requirements	80-9
82.5	Effective Date for Implementing Revisions to Design Standards	80-9
82.6	Design Information Bulletins and Other Caltrans Publications	80-9
82.7	Traffic Engineering	80-10

CHAPTER 100 - BASIC DESIGN POLICIES

101	Design Speed	
101.1	Highway Design Speed	100-1
101.2	Highway Design Speed Standards	100-2
102	Design Capacity & Level of Service	
102.1	Design Capacity (Automobiles)	100-3

Table of Contents

Topic Number	Subject	Page Number
	102.2 Design Capacity and Quality of Service (Pedestrians and Bicycles)	100-4
103	Design Designation	
	103.1 Relation to Design	100-4
	103.2 Design Period	100-4
104	Control of Access	
	104.1 General Policy	100-5
	104.2 Access Openings	100-5
	104.3 Frontage Roads	100-5
	104.4 Protection of Access Rights	100-6
	104.5 Relation of Access Opening to a Median Opening	100-6
	104.6 Maintaining Local Community Access	100-6
	104.7 Cross References	100-6
105	Pedestrian Facilities	
	105.1 General Policy	100-6
	105.2 Sidewalks and Walkways	100-6
	105.3 Pedestrian Grade Separations	100-8
	105.4 Accessibility Requirements	100-9
	105.5 Guidelines for the Location and Design of Curb Ramps	100-10
	105.6 Pedestrian Crossings	100-11
106	Stage Construction and Utilization of Local Roads	
	106.1 Stage Construction	100-11
	106.2 Utilization of Local Roads	100-13
107	Roadside Installations	
	107.1 Roadway Connections	100-14
	107.2 Maintenance and Police Facilities on Freeways	100-14
	107.3 Location of Border Inspection Stations	100-14
108	Coordination with Other Agencies	
	108.1 Divided Nonfreeway Facilities	100-14
	108.2 Transit Loading Facilities	100-15
	108.3 Commuter and Light Rail Facilities Within State Right of Way	100-17
	108.4 Bus Loading Facilities	100-18
	108.5 Bus Rapid Transit	100-18

Table of Contents

Topic Number	Subject	Page Number
	108.6 High-Occupancy Toll and Express Toll Lanes	100-18
	108.7 Coordination with the FHWA	100-19
109	Scenic Values in Planning and Design	
	109.1 Basic Precepts	100-19
	109.2 Design Speed	100-19
	109.3 Aesthetic Factors	100-19
110	Special Considerations	
	110.1 Design for Overloaded Material Hauling Equipment	100-20
	110.2 Control of Water Pollution	100-21
	110.3 Control of Air Pollution	100-25
	110.4 Wetlands Protection	100-27
	110.5 Control of Noxious Weeds – Exotic and Invasive Species	100-27
	110.6 Earthquake Consideration	100-27
	110.7 Traffic Control Plans	100-28
	110.8 Safety Reviews	100-30
	110.9 Value Analysis	100-31
	110.10 Proprietary Items	100-31
	110.11 Conservation of Materials and Energy	100-31
	110.12 Tunnel Safety Orders	100-33
111	Material Sites and Disposal Sites	
	111.1 General Policy	100-35
	111.2 Investigation of Local Materials Sources	100-37
	111.3 Materials Information Furnished to Prospective Bidders	100-38
	111.4 Materials Arrangements	100-39
	111.5 Procedures for Acquisition of Material Sites and Disposal Sites	100-39
	111.6 Mandatory Material Sites and Disposal Sites on Federal-aid Projects	100-41
112	Contractor's Yard and Plant Sites	
	112.1 Policy	100-41
	112.2 Locating a Site	100-41
113	Geotechnical Design Report	
	113.1 Policy	100-41
	113.2 Content	100-42

Table of Contents

Topic Number	Subject	Page Number
	113.3 Submittal and Review	100-42
114	Materials Report	
	114.1 Policy	100-42
	114.2 Requesting Material Report(s)	100-42
	114.3 Content	100-42
	114.4 Preliminary Materials Report	100-43
	114.5 Review and Retention of Records	100-43
115	Designing for Bicycle Traffic	
	115.1 General	100-43
116	Bicyclists and Pedestrians on Freeways	
	116.1 General	100-44
CHAPTER 200 - GEOMETRIC DESIGN AND STRUCTURE STANDARDS		
201	Sight Distance	
	201.1 General	200-1
	201.2 Passing Sight Distance	200-1
	201.3 Stopping Sight Distance	200-2
	201.4 Stopping Sight Distance at Grade Crests	200-2
	201.5 Stopping Sight Distance at Grade Sags	200-2
	201.6 Stopping Sight Distance on Horizontal Curves	200-2
	201.7 Decision Sight Distance	200-3
202	Superelevation	
	202.1 Basic Criteria	200-3
	202.2 Standards for Superelevation	200-8
	202.3 Restrictive Conditions	200-9
	202.4 Axis of Rotation	200-9
	202.5 Superelevation Transition	200-16
	202.6 Superelevation of Compound Curves	200-19
	202.7 Superelevation on City Streets and County Roads	200-19
203	Horizontal Alignment	
	203.1 General Controls	200-19
	203.2 Standards for Curvature	200-19

Table of Contents

Topic Number	Subject	Page Number
	203.3 Alignment Consistency	200-21
	203.4 Curve Length and Central Angle	200-21
	203.5 Compound Curves	200-21
	203.6 Reversing Curves	200-21
	203.7 Broken Back Curves	200-21
	203.8 Spiral Transition	200-21
	203.9 Alignment at Bridges	200-21
204	Grade	
	204.1 General Controls	200-22
	204.2 Position with Respect to Cross Section	200-22
	204.3 Standards for Grade	200-22
	204.4 Vertical Curves	200-23
	204.5 Sustained Grades	200-23
	204.6 Coordination of Horizontal and Vertical Alignment	200-26
	204.7 Separate Grade Lines	200-26
	204.8 Grade Line of Structures	200-27
205	Road Connections and Driveways	
	205.1 Access Openings on Expressways	200-28
	205.2 Private Road Connections	200-30
	205.3 Urban Driveways	200-30
	205.4 Driveways on Frontage Roads and in Rural Areas	200-31
	205.5 Financial Responsibility	200-32
206	Pavement Transitions	
	206.1 General Transition Standards	200-32
	206.2 Pavement Widening	200-32
	206.3 Pavement Reductions	200-32
	206.4 Temporary Freeway Transitions	200-34
207	Airway-Highway Clearances	
	207.1 Introduction	200-34
	207.2 Clearances	200-34
	207.3 Submittal of Airway-Highway Clearance Data	200-34

Table of Contents

Topic Number	Subject	Page Number
208	Bridges, Grade Separation Structures, and Structure Approach Embankment	
208.1	Bridge Lane and Shoulder Width	200-35
208.2	Cross Slope	200-35
208.3	Median	200-41
208.4	Bridge Sidewalks	200-41
208.5	Open End Structures	200-41
208.6	Bicycle and Pedestrian Overcrossings and Undercrossings	200-41
208.7	Equestrian Undercrossings and Overcrossings	200-41
208.8	Cattle Passes, Equipment, and Deer Crossings	200-41
208.9	Railroad Underpasses and Overheads	200-42
208.10	Bridge Barriers and Railings	200-42
208.11	Structure Approach Embankment	200-44
209	Structure Approach Slabs	
209.1	Purpose and Application	200-48
209.2	General Considerations	200-48
209.3	Structure Approach System Drainage	200-51
209.4	Structure Approach Slab Rehabilitation Considerations	200-51
210	Reinforced Earth Slopes and Earth Retaining Systems	
210.1	Introduction	200-53
210.2	Construction Methods and Types	200-53
210.3	Alternative Earth Retaining Systems (AERS)	200-62
210.4	Value Engineering Change Proposal (VECP)	200-62
210.5	Aesthetic Consideration	200-62
210.6	Safety Railing, Fences, and Concrete Barriers	200-63
210.7	Design Responsibility	200-63
210.8	Guidelines for Type Selection and Plan Preparation	200-64
CHAPTER 300 – GEOMETRIC CROSS SECTION		
301	Traveled Way Standards	
301.1	Lane Width	300-1
301.2	Class II Bikeway (Bike Lane) Lane Width	300-1
301.3	Cross Slopes	300-2

Table of Contents

Topic Number	Subject	Page Number
302	Highway Shoulder Standards	
	302.1 Width	300-3
	302.2 Cross Slopes	300-3
	302.3 Tapered Edge	300-6
303	Curbs, Dikes, and Side Gutters	
	303.1 General Policy	300-6
	303.2 Curb Types and Uses	300-7
	303.3 Dike Types and Uses	300-9
	303.4 Curb Extensions	300-11
	303.5 Position of Curbs and Dikes	300-14
	303.6 Curbs and Dikes on Frontage Roads and Streets	300-14
304	Side Slopes	
	304.1 Side Slope Standards	300-14
	304.2 Clearance From Slope to Right of Way Line	300-16
	304.3 Slope Benches and Cut Widening	300-16
	304.4 Contour Grading and Slope Rounding	300-16
	304.5 Stepped Slopes	300-17
305	Median Standards	
	305.1 Width	300-17
	305.2 Median Cross Slopes	300-18
	305.3 Median Barriers	300-19
	305.4 Median Curbs	300-19
	305.5 Paved Medians	300-19
	305.6 Separate Roadways	300-19
306	Right of Way	
	306.1 General Standards	300-19
	306.2 Right of Way Through the Public Domain	300-19
307	Cross Sections for State Highways	
	307.1 Cross Section Selection	300-19
	307.2 Two-lane Cross Sections for New Construction	300-21
	307.3 Two-lane Cross Sections for 2R, 3R, and other Projects	300-21
	307.4 Multilane Divided Cross Sections	300-21

Table of Contents

Topic Number	Subject	Page Number
	307.5 Multilane All Paved Cross Sections with Special Median Widths	300-25
	307.6 Multilane Cross Sections for 2R and 3R Projects	300-25
	307.7 Reconstruction Projects	300-25
308	Cross Sections for Roads Under Other Jurisdictions	
	308.1 City Streets and County Roads	300-25
309	Clearances	
	309.1 Horizontal Clearances for Highways	300-26
	309.2 Vertical Clearances	300-32
	309.3 Tunnel Clearances	300-33
	309.4 Lateral Clearance for Elevated Structures	300-33
	309.5 Structures Across or Adjacent to Railroads	300-34
310	Frontage Roads	
	310.1 Cross Section	300-35
	310.2 Outer Separation	300-35
	310.3 Headlight Glare	300-35
CHAPTER 400 – INTERSECTIONS AT GRADE		
401	Factors Affecting Design	
	401.1 General	400-1
	401.2 Human Factors	400-1
	401.3 Traffic Considerations	400-2
	401.4 The Physical Environment	400-2
	401.5 Intersection Type	400-2
	401.6 Transit	400-3
402	Operational Features Affecting Design	
	402.1 Capacity	400-3
	402.2 Collisions	400-3
	402.3 On-Street Parking	400-4
	402.4 Consider All Users	400-4
	402.5 Speed-Change Areas	400-4
403	Principles of Channelization	
	403.1 Preference to Major Movements	400-4

Table of Contents

Topic Number	Subject	Page Number
	403.2 Areas of Conflict	400-4
	403.3 Angle of Intersection	400-5
	403.4 Points of Conflict	400-5
	403.5 Currently Not In Use	400-6
	403.6 Turning Traffic	400-6
	403.7 Refuge Areas	400-9
	403.8 Prohibited Turns	400-9
	403.9 Effective Signal Control	400-9
	403.10 Installation of Traffic Control Devices	400-9
	403.11 Summary	400-9
	403.12 Other Considerations	400-10
404	Design Vehicles	
	404.1 General	400-10
	404.2 Design Considerations	400-10
	404.3 Design Tools	400-11
	404.4 Design Vehicles and Related Definitions	400-12
	404.5 Turning Templates & Vehicle Diagrams	400-13
405	Intersection Design Standards	
	405.1 Sight Distance	400-14
	405.2 Left-turn Channelization	400-23
	405.3 Right-turn Channelization	400-25
	405.4 Traffic Islands	400-29
	405.5 Median Openings	400-30
	405.6 Access Control	400-32
	405.7 Public Road Intersections	400-34
	405.8 City Street Returns and Corner Radii	400-34
	405.9 Widening of 2-lane Roads at Signalized Intersections	400-34
	405.10 Roundabouts	400-34
406	Ramp Intersection Capacity Analysis	

Table of Contents

Topic Number	Subject	Page Number
CHAPTER 500 – TRAFFIC INTERCHANGES		
501	General	
	501.1 Concepts	500-1
	501.2 Warrants	500-1
	501.3 Spacing	500-1
502	Interchange Types	
	502.1 General	500-1
	502.2 Local Street Interchanges	500-2
	502.3 Freeway-to-freeway Interchanges	500-6
503	Interchange Design Procedure	
	503.1 Basic Data	500-8
	503.2 Reviews	500-8
504	Interchange Design Standards	
	504.1 General	500-11
	504.2 Freeway Entrances and Exits	500-11
	504.3 Ramps	500-15
	504.4 Freeway-to-Freeway Connections	500-35
	504.5 Auxiliary Lanes	500-36
	504.6 Mainline Lane Reduction at Interchanges	500-36
	504.7 Weaving Sections	500-36
	504.8 Access Control	500-38
CHAPTERS 600 – 670 – PAVEMENT ENGINEERING		
CHAPTER 600 – GENERAL ASPECTS		
601	Introduction	
602	Pavement Structure Layers	
	602.1 Description	600-1
603	Types of Pavement Projects	
	603.1 New Construction	600-3
	603.2 Widening	600-3
	603.3 Pavement Preservation	600-3
	603.4 Roadway Rehabilitation	600-5

Table of Contents

Topic Number	Subject	Page Number
	603.5 Reconstruction	600-5
	603.6 Temporary Pavements and Detours	600-5
	603.7 Stage Construction	600-6
604	Roles and Responsibilities	
	604.1 Roles and Responsibilities for Pavement Engineering	600-6
	604.2 Pavement Recommendations	600-7
	604.3 Other Resources	600-7
605	Record Keeping	
	605.1 Documentation	600-9
	605.2 Subsequent Revisions	600-9
606	Research and Special Designs	
	606.1 Research and Experimentation	600-9
	606.2 Special Designs	600-9
	606.3 Mechanistic-Emperical Design	600-10
	606.4 Proprietary Items	600-11
CHAPTER 610 – PAVEMENT ENGINEERING CONSIDERATIONS		
611	Factors in Selecting Pavement Types	
	611.1 Pavement Type Selection	610-1
	611.2 Selection Criteria	610-1
612	Pavement Design Life	
	612.1 Definition	610-1
	612.2 New Construction and Reconstruction	610-1
	612.3 Widening	610-2
	612.4 Pavement Preservation	610-2
	612.5 Roadway Rehabilitation	610-2
	612.6 Temporary Pavements and Detours	610-2
	612.7 Non-Structural Wearing Courses	610-2
613	Traffic Considerations	
	613.1 Overview	610-3
	613.2 Traffic Volume Projection	610-3
	613.3 Traffic Index Calculation	610-4

Table of Contents

Topic Number	Subject	Page Number
	613.4 Axle Load Spectra	610-5
	613.5 Specific Traffic Loading Considerations	610-8
614	Soil Characteristics	
	614.1 Engineering Considerations	610-15
	614.2 Unified Soil Classification System (USCS)	610-15
	614.3 California R-Value	610-16
	614.4 Expansive Soils	610-16
	614.5 Other Considerations	610-18
615	Climate	
616	Existing Pavement Type and Condition	
617	Materials	
	617.1 Availability of Materials	610-21
	617.2 Recycling	610-21
618	Maintainability and Constructibility	
	618.1 Maintainability	610-21
	618.2 Constructibility	610-22
619	Life-Cycle Cost Analysis	
	619.1 Life-Cycle Cost Analysis	610-23
	619.2 Life-Cycle Assessment	610-23
CHAPTER 620 – RIGID PAVEMENT		
621	Types of Rigid Pavements	
	621.1 Continuously Reinforced Concrete Pavement (CRCP)	620-1
	621.2 Jointed Plain Concrete Pavement (JPCP)	620-1
	621.3 Precast Panel Concrete Pavement (PPCP)	620-1
622	Engineering Requirements	
	622.1 Engineering Properties	620-1
	622.2 Performance Factors	620-4
	622.3 Types of Concrete	620-4
	622.4 Pavement Joints	620-5
	622.5 Transition Panels, Terminal Joints and Anchors	620-6
	622.6 Joint Seals	620-9

Table of Contents

Topic Number	Subject	Page Number
	622.7 Dowel Bars and Tie Bars	620-10
	622.8 Base Bond Breaker	620-11
	622.9 Texturing	620-11
	622.10 Pavement Smoothness	620-11
623	Engineering Procedure for New and Reconstruction Projects	
	623.1 Catalog	620-11
624	Engineering Procedures for Pavement Preservation	
	624.1 Preventive Maintenance	620-12
	624.2 Capital Preventive Maintenance (CAPM)	620-12
625	Engineering Procedures for Pavement Rehabilitation	
	625.1 Rehabilitation Warrants	620-26
	625.2 Rigid Pavement Rehabilitation Strategies	620-27
626	Other Considerations	
	626.1 Traveled Way	620-28
	626.2 Shoulder	620-28
	626.3 Intersections	620-32
	626.4 Roadside Facilities	620-32

CHAPTER 630 – FLEXIBLE PAVEMENT

631	Types of Flexible Pavements & Materials	
	631.1 Hot Mix Asphalt (HMA)	630-1
	631.2 Dense Graded HMA	630-1
	631.3 Gap Graded HMA	630-1
	631.4 Open Graded Friction Course (OGFC)	630-1
	631.5 Rubberized HMA (RHMA) Use	630-1
	631.6 Other Types of Flexible Pavement Surface Courses	630-2
	631.7 Warm Mix Asphalt Technology	630-2
	631.8 Pavement Interlayers	630-2
632	Asphalt Binder	
	632.1 Binder Classification	630-3
	632.2 Binder Selection	630-4

Table of Contents

Topic Number	Subject	Page Number
633	Engineering Procedures for New and Reconstruction Projects	
633.1	Empirical Method	630-4
633.2	Mechanistic-Empirical Method	630-9
634	Engineering Procedures for Flexible Pavement Preservation	
634.1	Preventive Maintenance	630-12
634.2	Capital Preventive Maintenance (CAPM)	630-12
635	Engineering Procedures for Flexible Pavement Rehabilitation	
635.1	Rehabilitation Warrants	630-13
635.2	Empirical Method	630-14
635.3	Rehabilitation of Existing RHMA-G Surface Flexible Pavement	630-25
635.4	Mechanistic-Empirical Method	630-26
636	Other Considerations	
636.1	Traveled Way	630-28
636.2	Shoulders	630-28
636.3	Intersections	630-28
636.4	Roadside Facilities	630-28
637	Engineering Analysis Software	630-29
CHAPTER 640 – COMPOSITE PAVEMENTS		
641	Types of Composite Pavement	
641.1	Asphalt Over Concrete Composite Pavement	640-1
641.2	Concrete Over Asphalt Composite Pavement	640-1
642	Engineering Criteria	
642.1	Engineering Properties	640-1
642.2	Performance Factors	640-1
643	Engineering Procedures for New Construction and Reconstruction	
643.1	Empirical Method	640-2
643.2	Mechanistic-Empirical Method	640-2
644	Engineering Procedures for Pavement Preservation	
644.1	Preventive Maintenance	640-2
644.2	Capital Preventive Maintenance (CAPM)	640-2

Table of Contents

Topic Number	Subject	Page Number
645	Engineering Procedures for Pavement and Roadway Rehabilitation	
645.1	Empirical Method	640-3
645.2	Mechanistic-Empirical Method	640-3
CHAPTER 650 – PAVEMENT DRAINAGE		
651	General Considerations	
651.1	Impacts of Drainage on Pavement	650-1
651.2	Drainage System Components and Requirements	650-1
652	Subsurface Drainage and Storm Water Management	
653	Other Considerations	
653.1	New Consideration Projects	650-6
653.2	Widening Projects	650-6
653.3	Rehabilitation and Reconstruction Projects	650-6
653.4	Ramps	650-6
653.5	Roadside Facilities	650-6
CHAPTER 660 – PAVEMENT FOUNDATIONS		
661	Engineering Considerations	
661.1	Description	660-1
661.2	Purpose	660-1
662	Types of Bases	
662.1	Aggregate Base	660-1
662.2	Treated Base	660-1
662.3	Treated Permeable Base	660-2
662.4	Subbase	660-2
663	Engineering Properties for Base and Subbase Materials	
663.1	Selection Criteria	660-3
663.2	Base and Subbase for Rigid Pavements	660-3
663.3	Base and Subbase for Flexible Pavements	660-3
664	Subgrade Enhancement	
664.1	Overview	660-3
664.2	Mechanical Subgrade Enhancement	660-6
664.3	Chemical Stabilization	660-6

Table of Contents

Topic Number	Subject	Page Number
	664.4 Subgrade Enhancement Geosynthetics	660-6
665	Subgrade Enhancement Geosynthetic Fabrics	
	665.1 Purpose	660-6
	665.2 Properties of Geosynthetics	660-7
	665.3 Required Tests	660-7
	665.4 Mechanical Stabilization Using SEG	660-7
	665.5 Selecting Geosynthetic Type and Design Parameters	660-7
	665.6 Application of SEG	660-9
	665.7 Other Design Considerations	660-10
	665.8 Subgrade R-value Enhancement with SEG	660-10
	665.9 SEG Abbreviations and Definitions	660-10
666	Foundation Strength Parameters for Mechanistic-Empirical Design of New Construction and Rehabilitation of Flexible Pavements	
	666.1 Resilient Modulus	660-11
CHAPTER 670 – TAPERS AND SHOULDER BACKING		
671	Pavement Tapers	
	671.1 Background and Purpose	670-1
	671.2 Engineering Requirements and Considerations	670-1
	671.3 Tapers into Existing Pavement or Structure	670-1
672	Shoulder Backing	
	672.1 Background and Purpose	670-1
	672.2 Alternate Materials and Admixtures	670-8
	672.3 Design	670-9
CHAPTER 700 – MISCELLANEOUS STANDARDS		
701	Fences	
	701.1 Type, Intent and Purpose of Fences	700-1
	701.2 Freeway and Expressway Access Control Fence	700-2
	701.3 Private Fences	700-3
	701.4 Temporary Fences	700-4
	701.5 Other Fences	700-4

Table of Contents

Topic Number	Subject	Page Number
702	Miscellaneous Traffic Items	
	702.1 References	700-4
703	Special Structures and Installation	
	703.1 Truck Weighing Facilities	700-5
	703.2 Rockfall Restraining Nets	700-5
704	Contrast Treatment	
	704.1 Policy	700-5
705	Materials and Color Selection	
	705.1 Special Treatments and Materials	700-5
	705.2 Colors for Steel Structures	700-5
706	Roadside Treatment	
	706.1 Roadside Management	700-6
	706.2 Vegetation Control	700-7
	706.3 Topsoil	700-7
	706.4 Irrigation Crossovers for Highway Construction Projects	700-7
	706.5 Water Supply Line (Bridge) and Sprinkler Control Conduit for Bridge	700-8
	706.6 Water Supply for Future Roadside Rest Areas, Vista Points, or Planting	700-8
707	Slope Treatment Under Structures	
	707.1 Policy	700-8
	707.2 Guidelines for Slope Treatment	700-8
	707.3 Procedure	700-9

CHAPTERS 800-890 – HIGHWAY DRAINAGE DESIGN

CHAPTERS 800 – GENERAL ASPECTS

801	General	
	801.1 Introduction	800-1
	801.2 Drainage Design Philosophy	800-1
	801.3 Drainage Standards	800-1
	801.4 Objectives of Drainage Design	800-2
	801.5 Economics of Design	800-2
	801.6 Use of Drainage References	800-3

Table of Contents

Topic Number	Subject	Page Number
802	Drainage Design Responsibilities	
	802.1 Functional Organization	800-3
	802.2 Culvert Committee	800-5
	802.3 Bank and Shore Protection Committee	800-5
803	Drainage Design Policies	
	803.1 Basic Policy	800-6
	803.2 Cooperative Agreements	800-6
	803.3 Up-Grading Existing Drainage Facilities	800-6
804	Floodplain Encroachments	
	804.1 Purpose	800-7
	804.2 Authority	800-7
	804.3 Applicability	800-7
	804.4 Definitions	800-7
	804.5 Procedures	800-8
	804.6 Responsibilities	800-8
	804.7 Preliminary Evaluation of Risks and Impacts for Environmental Document Phase	800-9
	804.8 Design Standards	800-10
	804.9 Coordination with the Local Community	800-10
	804.10 National Flood Insurance Program	800-10
	804.11 Coordination with FEMA	800-14
805	Preliminary Plans	
	805.1 Required FHWA Approval	800-14
	805.2 Bridge Preliminary Report	800-14
	805.3 Storm Drain Systems	800-15
	805.4 Unusual Hydraulic Structures	800-15
	805.5 Levees and Dams Formed by Highway Fills	800-15
	805.6 Geotechnical	800-15
	805.7 Data Provided by the District	800-15
806	Definitions of Drainage Terms	
	806.1 Introduction	800-16
	806.2 Drainage Terms	800-16

Table of Contents

Topic Number	Subject	Page Number
807	Selected Drainage References	
807.1	Introduction	800-35
807.2	Federal Highway Administration Hydraulic Publications	800-35
807.3	American Association of State Highway and Transportation Officials (AASHTO)	800-35
807.4	California Department of Transportation	800-36
807.5	U.S. Department of Interior – Geological Survey (USGS)	800-36
807.6	U.S. Department of Agriculture – Natural Resources Conservation Service (NRCS)	800-36
807.7	California Department of Water Resources and Caltrans	800-36
807.8	University of California – Institute of Transportation and Traffic Engineering (ITTE)	800-37
807.9	U.S. Army Corps of Engineers	800-37
808	Selected Computer Programs	
CHAPTER 810 – HYDROLOGY		
811	General	
811.1	Introduction	810-1
811.2	Objectives of Hydrologic Analysis	810-1
811.3	Peak Discharge	810-1
811.4	Flood Severity	810-2
811.5	Factors Affecting Runoff	810-2
812	Basin Characteristics	
812.1	Size	810-2
812.2	Shape	810-2
812.3	Slope	810-2
812.4	Land Use	810-3
812.5	Soil and Geology	810-3
812.6	Storage	810-3
812.7	Elevation	810-3
812.8	Orientation	810-3
813	Channel and Floodplain Characteristics	
813.1	General	810-4

Table of Contents

Topic Number	Subject	Page Number
	813.2 Length and Slope	810-4
	813.3 Cross Section	810-4
	813.4 Hydraulic Roughness	810-4
	813.5 Natural and Man-made Constrictions	810-4
	813.6 Channel Modifications	810-4
	813.7 Aggradation – Degradation	810-4
	813.8 Debris	810-5
814	Meteorological Characteristics	
	814.1 General	810-5
	814.2 Rainfall	810-6
	814.3 Snow	810-6
	814.4 Evapo-transpiration	810-6
	814.5 Tides and Waves	810-6
815	Hydrologic Data	
	815.1 General	810-7
	815.2 Categories	810-7
	815.3 Sources	810-7
	815.4 Stream Flow	810-8
	815.5 Precipitation	810-8
	815.6 Adequacy of Data	810-8
816	Runoff	
	816.1 General	810-8
	816.2 Overland Flow	810-8
	816.3 Subsurface Flow	810-8
	816.4 Detention and Retention	810-8
	816.5 Flood Hydrograph and Flood Volume	810-8
	816.6 Time of Concentration (T _c) and Travel Time (T _t)	810-10
817	Flood Magnitude	
	817.1 General	810-13
	817.2 Measurements	810-13
818	Flood Probability and Frequency	
	818.1 General	810-14

Table of Contents

Topic Number	Subject	Page Number
	818.2 Establishing Design Flood Frequency	810-15
	818.3 Stationarity and Climate Variability	810-16
819	Estimating Design Discharge	
	819.1 Introduction	810-15
	819.2 Empirical Methods	810-15
	819.3 Statistical Methods	810-21
	819.4 Hydrograph Methods	810-23
	819.5 Transfer of Data	810-24
	819.6 Hydrologic Software	810-26
	819.7 Region-Specific Analysis	810-26
CHAPTER 820 – CROSS DRAINAGE		
821	General	
	821.1 Introduction	820-1
	821.2 Hydrologic Considerations	820-1
	821.3 Selection of Design Flood	820-2
	821.4 Headwater and Tailwater	820-2
	821.5 Effects of Tide and Wind	820-3
822	Debris Control	
	822.1 Introduction	820-3
	822.2 Debris Control Methods	820-3
	822.3 Economics	820-4
	822.4 Classification of Debris	820-4
	822.5 Types of Debris Control Structures	820-4
823	Culvert Location	
	823.1 Introduction	820-4
	823.2 Alignment and Slope	820-5
824	Culvert Type Selection	
	824.1 Introduction	820-5
	824.2 Shape and Cross Section	820-5
825	Hydraulic Design of Culverts	
	825.1 Introduction	820-6

Table of Contents

Topic Number	Subject	Page Number
	825.2 Culvert Flow	820-6
	825.3 Computer Programs	820-6
	825.4 Coefficient of Roughness	820-7
826	Entrance Design	
	826.1 Introduction	820-7
	826.2 End Treatment Policy	820-7
	826.3 Conventional Entrance Designs	820-7
	826.4 Improved Inlet Designs	820-8
827	Outlet Design	
	827.1 General	820-8
	827.2 Embankment Protection	820-8
828	Diameter and Length	
	828.1 Introduction	820-10
	828.2 Minimum Diameter	820-10
	828.3 Length	820-10
829	Special Considerations	
	829.1 Introduction	820-10
	829.2 Bedding and Backfill	820-10
	829.3 Piping	820-11
	829.4 Joints	820-12
	829.5 Anchorage	820-12
	829.6 Irregular Treatment	820-12
	829.7 Siphons and Sag Culverts	820-12
	829.8 Currently Not In Use	820-13
	829.9 Dams	820-13
	829.10 Reinforced Concrete Box Modifications	820-13
CHAPTER 830 – TRANSPORTATION FACILITY DRAINAGE		
831	General	
	831.1 Basic Concepts	830-1
	831.2 Highway Grade Line	830-1
	831.3 Design Storm and Water Spread	830-1

Table of Contents

Topic Number	Subject	Page Number
	831.4 Other Considerations	830-2
	831.5 Computer Programs	830-5
832	Hydrology	
	832.1 Introduction	830-5
	832.2 Rational Method	830-5
	832.3 Time of Concentration	830-5
833	Roadway Cross Sections	
	833.1 Introduction	830-5
	833.2 Grade, Cross Slope, and Superelevation	830-5
834	Roadside Drainage	
	834.1 General	830-6
	834.2 Median Drainage	830-6
	834.3 Ditches and Gutters	830-6
	834.4 Overside Drains	830-7
835	Dikes and Berms	
	835.1 General	830-8
	835.2 Earth Berms	830-8
	835.3 Dikes	830-8
836	Curbs and Gutters	
	836.1 General	830-8
	836.2 Gutter Design	830-9
837	Inlet Design	
	837.1 General	830-9
	837.2 Inlet Types	830-9
	837.3 Location and Spacing	830-14
	837.4 Hydraulic Design	830-15
	837.5 Local Depressions	830-16
838	Storm Drains	
	838.1 General	830-17
	838.2 Design Criteria	830-17
	838.3 Hydraulic Design	830-17
	838.4 Standards	830-18

Table of Contents

Topic Number	Subject	Page Number
	838.5 Appurtenant Structures	830-19
839	Pumping Stations	
	839.1 General	830-20
	839.2 Pump Type	830-20
	839.3 Design Responsibilities	830-20
	839.4 Trash and Debris Considerations	830-20
	839.5 Maintenance Consideration	830-20
	839.6 Groundwater Considerations	830-21
CHAPTER 840 – SUBSURFACE DRAINAGE		
841	General	
	841.1 Introduction	840-1
	841.2 Subsurface (Groundwater) Discharge	840-1
	841.3 Preliminary Investigations	840-1
	841.4 Exploration Notes	840-1
	841.5 Category of System	840-2
842	Pipe Underdrains	
	842.1 General	840-3
	842.2 Single Installations	840-3
	842.3 Multiple Installations	840-3
	842.4 Design Criteria	840-3
	842.5 Types of Underdrain Pipe	840-4
	842.6 Design Service Life	840-4
	842.7 Pipe Selection	840-5
CHAPTER 850 – PHYSICAL STANDARDS		
851	General	
	851.1 Introduction	850-1
	851.2 Selection of Material and Type	850-1
852	Pipe Materials	
	852.1 Reinforced Concrete Pipe (RCP)	850-1
	852.2 Concrete Box and Arch Culverts	850-3
	852.3 Corrugated Steel Pipe, Steel Spiral Rib Pipe and Pipe Arches	850-3

Table of Contents

Topic Number	Subject	Page Number
	852.4 Corrugated Aluminum Pipe, Aluminum Spiral Rib Pipe and Pipe Arches	850-6
	852.5 Structural Metal Plate	850-8
	852.6 Plastic Pipe	850-9
	852.7 Special Purpose Types	850-10
853	Pipe Liners and Linings for Culvert Rehabilitation	
	853.1 General	850-10
	853.2 Caltrans Host Pipe Structural Philosophy	850-10
	853.3 Problem Identification and Coordination	850-11
	853.4 Alternative Pipe Liner Materials	850-11
	853.5 Cementitious Pipe Lining	850-12
	853.6 Invert Paving with Concrete	850-12
	853.7 Structural Repairs with Steel Tunnel Liner Plate	850-14
854	Pipe Connections	
	854.1 Basic Policy	850-14
855	Design Service Life	
	855.1 Basic Concepts	850-17
	855.2 Abrasion	850-19
	855.3 Corrosion	850-30
	855.4 Protection of Concrete Pipe and Drainage Structures from Acids, Chlorides and Sulfates	850-31
	855.5 Material Susceptibility to Fire	850-34
856	Height of Fill	
	856.1 Construction Loads	850-34
	856.2 Concrete Pipe, Box and Arch Culverts	850-37
	856.3 Metal Pipe and Structural Plate Pipe	850-37
	856.4 Plastic Pipe	850-38
	856.5 Minimum Height of Cover	850-38
857	Alternative Materials	
	857.1 Basic Policy	850-55
	857.2 Alternative Pipe Culvert Selection Procedure Using AltPipe	850-57
	857.3 Alternative Pipe Culvert (APC) and Pipe Arch Culvert List	850-59

Table of Contents

Topic Number	Subject	Page Number
CHAPTER 860 – OPEN CHANNELS		
861	General	
	861.1 Introduction	860-1
	861.2 Hydraulic Considerations	860-2
	861.3 Selection of “Design Flood”	860-2
	861.4 Safety Considerations	860-2
	861.5 Maintenance Consideration	860-3
	861.6 Economics	860-3
	861.7 Coordination with Other Agencies	860-3
	861.8 Environment	860-3
	861.9 Unlined Channels	860-4
	861.10 Lined Channels	860-4
	861.11 Water Quality Channels	860-4
	861.12 References	860.4
862	Roadside Drainage Channel Location	
	862.1 General	860-4
	862.2 Alignment and Grade	860-5
	862.3 Point of Discharge	860-5
863	Channel Section	
	863.1 Roadside and Median Channels	860-5
	863.2 Triangular	860-5
	863.3 Trapezoidal	860-6
	863.4 Rectangular	860-6
864	Channel Stability Design Concepts	
	864.1 General	860-6
	864.2 Stable Channel Design Procedure	860-6
	864.3 Side Slope Stability	860-8
865	Channel Linings	
	865.1 Flexible Versus Rigid	860-8
	865.2 Rigid	860-9
	865.3 Flexible	860-9

Table of Contents

Topic Number	Subject	Page Number
	865.4 Composite Lining Design	860-11
	865.5 Bare Soil Design and Grass Lining	860-11
	865.6 Rolled Erosion Control Products	860-15
866	Hydraulic Design of Roadside Channels	
	866.1 General	860-16
	866.2 Flow Classifications	860-16
	866.3 Open Channel Flow Equations	860-17
	866.4 Water Surface Profiles	860-20
867	Channel Changes	
	867.1 General	860-20
	867.2 Design Considerations	860-21
868	Freeboard Considerations	
	868.1 General	860-21
	868.2 Height of Freeboard	860-21
CHAPTER 870 – BANK PROTECTION – EROSION CONTROL		
871	General	
	871.1 Introduction	870-1
	871.2 Design Philosophy	870-1
	871.3 Selected References	870-2
872	Planning and Location Studies	
	872.1 Planning	870-3
	872.2 Class and Type of Protection	870-4
	872.3 Geomorphology and Site Consideration	870-4
	872.4 Data Needs	870-24
	872.5 Rapid Assessment	870-24
873	Design Concepts	
	873.1 Introduction	870-25
	873.2 Design High Water and Hydraulics	870-25
	873.3 Armor Protection	870-26
	873.4 Training Systems	870-47
	873.5 Summary and Design Check List	870-54

Table of Contents

Topic Number	Subject	Page Number
873.6	Coordination with the Division of Engineering Services and Structures Maintenance and Investigations	870-55
CHAPTER 880 – SHORE PROTECTION		
881	General	
881.1	Introduction	880-1
881.2	Design Philosophy	880-1
881.3	Selected References	880-1
882	Planning and Location Studies	
882.1	Planning	880-2
882.2	Class and Type of Protection	880-3
882.3	Site Consideration	880-3
883	Design	
883.1	Introduction	880-4
883.2	Design High Water and Design Wave Height	880-4
883.3	Armor Protection	880-10
CHAPTER 890 – STORM WATER MANAGEMENT		
891	General	
891.1	Introduction	890-1
891.2	Philosophy	890-1
892	Storm Water Management Strategies	
892.1	General	890-1
892.2	Types of Strategies	890-1
892.3	Design Considerations	890-2
892.4	Mixing with Other Waste Streams	890-2
893	Maintenance Requirements for Storm Water Management Features	
893.1	General	890-3
CHAPTER 900 – LANDSCAPE ARCHITECTURE		
901	General	
901.1	Landscape Architecture Program	900-1
901.2	Cross References	900-1

Table of Contents

Topic Number	Subject	Page Number
902	Planting Guidance	
902.1	General Guidance for Freeways and Expressways	900-1
902.2	Sight Distance and Clear Recovery Zone Standards for Freeways and Expressways	900-3
902.3	Planting Guidance for Large Trees on Conventional Highways	900-4
902.4	Planting Procedures, Selection and Location	900-4
902.5	Irrigation Guidelines	900-7
903	Safety Roadside Rest Area Standards and Guidelines	
903.1	Minimum Standards	900-8
903.2	General	900-8
903.3	Site Selection	900-9
903.4	Facility Size and Capacity Analysis	900-10
903.5	Site Planning	900-11
903.6	Utility Systems	900-14
903.7	Structures	900-16
903.8	Security and Pedestrian Amenities	900-17
904	Vista Point Standards and Guidelines	
904.1	General	900-18
904.2	Site Selection	900-18
904.3	Design Features and Facilities	900-18
905	Park and Ride Standards and Guidelines	
905.1	General	900-19
905.2	Site Selection	900-19
905.3	Design Features and Facilities	900-20
CHAPTER 1000 – BICYCLE TRANSPORTATION DESIGN		
1001	Introduction	
1001.1	Bicycle Transportation	1000-1
1001.2	Streets and Highways Code References	1000-1
1001.3	Vehicle Code References	1000-1
1001.4	Bikeways	1000-2

Table of Contents

Topic Number	Subject	Page Number
1002	Bikeway Facilities	
	1002.1 Selection of the Type of Facility	1000-2
1003	Bikeway Design Criteria	
	1003.1 Class I Bikeways (Bike Paths)	1000-4
	1003.2 Class II Bikeways (Bike Lanes)	1000-13
	1003.3 Class III Bikeways (Bike Routes)	1000-13
	1003.4 Trails	1000-14
	1003.5 Miscellaneous Criteria	1000-15
CHAPTER 1100 – HIGHWAY TRAFFIC NOISE ABATEMENT		
1101	General Requirements	
	1101.1 Introduction	1100-1
	1101.2 Objective	1100-1
	1101.3 Terminology	1100-2
	1101.4 Procedures for Assessing Noise Impacts	1100-2
	1101.5 Prioritizing Construction of Retrofit Noise Barriers	1100-2
1102	Design Criteria	
	1102.1 General	1100-2
	1102.2 Noise Barrier Location	1100-2
	1102.3 Noise Barrier Height and Position	1100-3
	1102.4 Noise Barrier Length	1100-3
	1102.5 Alternative Noise Barrier Designs	1100-4
	1102.6 Noise Barrier Aesthetics	1100-5
	1102.7 Maintenance Consideration in Noise Barrier Design	1100-6
	1102.8 Emergency Access Considerations in Noise Barrier Design	1100-6
	1102.9 Drainage Openings in Noise Barrier	1100-7

List of Figures

Figure Number	Subject	Page Number
--------------------------	----------------	------------------------

CHAPTER 10 – DIVISION OF DESIGN

11.1	Division of Design Functional Organization Chart	10-2
------	--	------

CHAPTER 20 – DESIGNATION OF HIGHWAY ROUTES

21.1	Interstate Highway System in California	20-2
------	---	------

CHAPTER 60 – NOMENCLATURE

62.2	Types of Structures	60-4
------	---------------------	------

CHAPTER 100 – BASIC DESIGN POLICIES

105.6	Typical Pedestrian Crossings at “T” Intersections	100-12
110.12	California Mining and Tunneling Districts	100-36

CHAPTER 200 – GEOMETRIC DESIGN AND STRUCTURE STANDARDS

201.4	Stopping Sight Distance on Crest Vertical Curves	200-4
201.5	Stopping Sight Distance on Sag Vertical Curves	200-5
201.6	Stopping Sight Distance on Horizontal Curves	200-6
201.7	Decision Sight Distance on Crest Vertical Curves	200-7
202.2	Maximum Comfortable Speed on Horizontal Curves	200-15
202.5A	Superelevation Transition	200-17
202.5B	Superelevation Transition Terms & Definitions	200-18
202.6	Superelevation of Compound Curves	200-20
204.4	Vertical Curves	200-24
204.5	Critical Lengths of Grade for Design	200-25
205.1	Access Openings on Expressways	200-30
206.2	Typical Two-lane to Four-lane Transitions	200-33
207.2A	Airway-Highway Clearance Requirements (Civil Airports)	200-36
207.2B	Airway-Highway Clearance Requirements (Heliport)	200-37
207.2C	Airway-Highway Clearance Requirements (Military Airports)	200-38
207.2D	Airway-Highway Clearance Requirements (Navy Carrier Landing Practice Field)	200-39
208.1	Offsets to Safety-Shape Barriers	200-40
208.10A	Vehicular Railings for Bridge Structures	200-45
208.10B	Combination Vehicular Barrier and Pedestrian Railings for Bridge Structures	200-46

List of Figures

Figure Number	Subject	Page Number
208.10C	Pedestrian Railings for Bridge Structures	200-47
208.11A	Limits of Structure Approach Embankment Material	200-49
208.11B	Abutment Drainage Details	200-50
209.1	Structure Analysis Slab Layout	200-52
209.4A	Structure Approach Drainage Details (Rehabilitation)	200-54
209.4B	New Structure Approach Pavement Transition Details	200-55
210.8	Type Selection and PS&E Process for Reinforced Earth Slopes and Earth Retaining Systems	200-66

CHAPTER 300 – GEOMETRIC CROSS SECTION

301.2A	Typical Class II Bikeway (Bike Lane) Cross Section	300-5
303.3	Dike Type Selection and Placement	300-10
303.4A	Typical Bulbout with Class II Bikeway (Bike Lane)	300-12
303.4B	Typical Bulbout without Class II Bikeway (Bike Lane)	300-13
305.6	Optional Median Designs for Freeways with Separate Roadways	300-20
307.2	Geometric Cross Sections for Two-lane Highways (New Construction)	300-22
307.4	Geometric Cross Sections for Freeways and Expressways	300-23
307.5	Geometric Cross Sections for All Paved Multilane Highways	300-24
309.2	Department of Defense Rural and Single Interstate Routes	300-30
309.5A	Typical Horizontal Railroad Clearances from Grade Separated Structures	300-36
309.5B	Permanent Railroad Clearance Envelope	300-37

CHAPTER 400 - INTERSECTIONS AT GRADE

403.3A	Angle of Intersection (Minor Leg Skewed to the Right)	400-6
403.3B	Class II Bikeway Crossing Railroad	400-6
403.6A	Typical Bicycle and Motor Vehicle Movements at Intersections of Multilane Streets without Right-Turn-Only Lanes	400-7
403.6B	Bicycle Left-Turn-Only Lane	400-8
404.5A	STAA Design Vehicle – 56-Foot Radius	400-15
404.5B	STAA Design Vehicle – 67-Foot Radius	400-16
404.5C	California Legal Design Vehicle – 50-Foot Radius	400-17
404.5D	California Legal Design Vehicle – 60-Foot Radius	400-18
404.5E	40-Foot Bus Design Vehicle	400-19

List of Figures

Figure Number	Subject	Page Number
404.5F	45-Foot Bus & Motorhome Design Vehicle	400-20
404.5G	60-Foot Articulated Bus Design Vehicle	400-21
405.2A	Standard Left-turn Channelization	400-26
405.2B	Minimum Median Left-turn Channelization (Widening on One Side of Highway)	400-27
405.2C	Minimum Median Left-turn Channelization (Widening on Both Sides in Urban Areas with Short Blocks)	400-28
405.4	Pedestrian Refuge Island	400-32
405.5	Typical Design for Median Openings	400-33
405.7	Public Road Intersections	400-35
405.9	Widening of Two-lane Roads at Signalized Intersections	400-36
405.10	Roundabout Geometric Elements	400-41
406A	Spread Diamond	400-44
406B	Tight Diamond	400-45
406C	Two-quadrant Cloverleaf	400-46

CHAPTER 500 - TRAFFIC INTERCHANGES

502.2	Typical Local Street Interchanges	500-3
502.3	Typical Freeway-to-freeway Interchanges	500-9
504.2A	Single Lane Freeway Entrance	500-12
504.2B	Single Lane Freeway Exit	500-13
504.2C	Location of Freeway Ramps on a Curve	500-14
504.3A	Typical Freeway Entrance Loop Ramp Metering (1 GP Lane + 1 HOV Preferential Lane)	500-18
504.3B	Typical Successive Freeway Entrance Ramp Metering (1 GP Lane + 1 HOV Preferential Lane)	500-19
504.3C	Restrictive Condition Freeway Entrance Ramp Metering (1 GP Lane)	500-20
504.3D	Restrictive Condition Freeway Entrance Loop Ramp Metering (1 GP Lane)	500-21
504.3E	Typical Multilane Freeway Diagonal Entrance Ramp Metering (2 GP Lanes + 1 HOV Preferential Lane)	500-23
504.3F	Typical Multilane Freeway Loop Entrance Ramp Metering (2 GP Lanes + 1 HOV Preferential Lane)	500-24
504.3G	Typical Freeway-to-Freeway Connector Ramp Metering (1 GP Lane + 1 HOV Preferential Lane)	500-26
504.3H	Typical Freeway-to-Freeway Connector Ramp Metering (2 GP Lanes + 1 HOV Preferential Lane)	500-27

List of Figures

Figure Number	Subject	Page Number
504.3I	Location of Ramp Intersections on the Crossroads	500-31
504.3J	Transition to Two-lane Exit Ramp	500-33
504.3K	Two-Lane Connectors and Entrance/Exit Ramps	500-34
504.4	Diverging Branch Connections	500-37
504.7A	Design Curve for Freeway and Collector Weaving	500-40
504.7B	Lane Configuration of Weaving Sections	500-41
504.7D	Percentage Distribution of On- and Off-ramp Traffic in Outer Through Lane and Auxiliary Lane (Level of Service D Procedure)	500-43
504.7E	Percentage of Ramp Traffic in the Outer Through Lane (No Auxiliary Lane) (Level of Service D Procedure)	500-44
504.8	Typical Examples of Access Control at Interchanges	500-45

CHAPTERS 600-670 - PAVEMENT ENGINEERING

CHAPTER 600 – GENERAL ASPECTS

602.1	Basic Pavement Layers of the Roadway	600-4
-------	--------------------------------------	-------

CHAPTER 610 – PAVEMENT ENGINEERING CONSIDERATIONS

613.5A	Shoulder Design for TI Equal to Adjacent Lane TI	600-11
613.5B	Shoulder Design for TI Less than Adjacent Lane TI	600-12
615.1	Pavement Climate Regions	600-20

CHAPTER 620 – RIGID PAVEMENT

621.1	Types of Rigid Pavement	620-2
622.5A	Concrete Pavement to Asphalt Pavement Transition Panel	620-6
622.5B	Wide Flange Connection Between CRCP and Existing Pavement or Structure Approach Slab	620-8
622.5C	Pavement Anchor Connection Between CRCP and Existing Pavement or Structure Approach Slab	620-8
623.1	Rigid Pavement Catalog Decision Tree	620-13
626.1	Preferred Limits of Rigid Pavement at Flexible Pavement Ramp or Connector Gore Area	620-30
626.2A	Rigid Pavement and Shoulder Details Nomenclature Illustration	620-34
626.2B	Rigid Shoulders Through Ramp and Gore Areas	620-35
626.2C	Widened Slab Shoulder with Concrete Remainder Designs	620-36
626.4	Rigid Bus Pad	620-37

List of Figures

Figure Number	Subject	Page Number
--------------------------	----------------	------------------------

CHAPTER 650 – PAVEMENT DRAINAGE

651.2A	Typical Section with Treated Permeable Base Drainage Layer	650-2
651.2B	Cross Drain Interceptor Details for Use with Treated Permeable Base	650-3
651.2C	Cross Drain Interceptor Trenches	650-5

CHAPTER 660 – PAVEMENT FOUNDATIONS

665.5	Flowchart for SEG Selection	660-8
-------	-----------------------------	-------

CHAPTER 670 – TAPERS AND SHOULDER BACKING

671.2A	Tapering Into a Previously Overlaid Pavement	670-2
671.2B	New Structure Approach Pavement Transition Details	670-3
671.3A	Transverse Transition Tapers for Pavement Preservation Projects	670-5
671.3B	Longitudinal Tapers at Shoulders, Curbs, Dikes, Inlets, and Guardrail	670-6
671.3C	Transition Taper Underneath Overcrossing/Bridge	670-7
672.3A	Typical Application of Shoulder Backing	670-10
672.3B	Alternative Placement for Existing Slopes Steeper than 6:1	670-10
672.3C	Placement of Shoulder Backing Thickness Greater Than 0.5 foot for Slope Repair	670-11
672.3D	Placement of Shoulder Backing Behind Dikes	670-11
672.3E	Longitudinal Drainage (Roadside Ditches/Gutters)	670-12

CHAPTERS 800-890 - HIGHWAY DRAINAGE DESIGN

CHAPTER 800 - GENERAL ASPECTS

804.7A	Technical Information for Location Hydraulic Study	800-11
804.7B	Floodplain Evaluation Report Summary	800-13

CHAPTER 810 - HYDROLOGY

813.1	Post-Fire Debris	810-5
816.5	Typical Flood Hydrograph	810-9
816.6	Velocities for Upland Method of Estimating Travel Time for Shallow Concentrated Flow	810-12
816.7	Digital Elevation Map (DEM)	810-13
817.2	Gaging Station	810-14
817.3	High Water Marks	810-14

List of Figures

Figure Number	Subject	Page Number
818.1	Overtopping Flood	810-15
818.2	Maximum Historic Flood	810-15
819.2A	Runoff Coefficients for Undeveloped Areas	810-19
819.2C	Regional Flood-Frequency Equations	810-22
819.4A	Basic Steps to Developing and Applying a Rainfall-runoff Model for Predicting the Required Design Flow	810-25
819.7A	Desert Regions in California	810-30
819.7B	Example Depth-Area Reduction Curve	810-33
819.7C	San Bernardino County Hydrograph for Desert Areas	810-38
819.7D	USBR Example S-Graph	810-39
819.7E	Soil Slips vs. Slope Angle	810-45
819.7F	Alluvial Fan	810-45
819.7H	Recommended Bulking Factor Selection Process	810-50
CHAPTER 830 - TRANSPORTATION FACILITY DRAINAGE		
837.1	Storm Drain Inlet Types	830-12
CHAPTER 850 - PHYSICAL STANDARDS		
855.1	Minor Bedload Abrasion	850-20
855.2	Abrasion Test Panels	850-21
855.3A	Minimum Thickness of Metal Pipe for 50-Year Maintenance-Free Service Life	850-32
855.3B	Chart for Estimating Years to Perforation of Steel Culverts	850-33
CHAPTER 860 - OPEN CHANNELS		
861.1	Small Roadside Channel	860-1
861.2	Roadside Channel Outlet to Storm Drain at Drop Inlet	860-1
861.3	Concrete Lined Channel with Excessive Weed Growth	860-3
862.1	Small-Rock Lined Channel Outside of Clear Recovery Zone	860-5
863.1	Small-Rock Lined Channel with Rounded Bottom	860-5
865.1	Steep-Sloped Channel with Composite Vegetative Lining	860-9
865.2	Concrete Lined Channel	860-9
865.3	Long-Term Flexible Lining	860-10
865.4	Grass-Lined Median Channel	860-12
864.3C	Specific Energy Diagram	860-19

List of Figures

Figure Number	Subject	Page Number
--------------------------	----------------	------------------------

CHAPTER 870 - BANK PROTECTION - EROSION CONTROL

872.1	Stream Classification	870-9
872.2	Diagram of Braided River Channel	870-10
872.3	Bed Load and Suspended Load	870-13
872.4	Longitudinal Encroachments	870-14
872.5	Slope Failure Due to Loss of Toe	870-17
872.6	Mature Valley with Meandering Stream	870-21
872.7	Alternative Highway Locations Across Debris Cone	870-23
872.8	Alluvial Fan	870-23
872.9	Desert Wash Longitudinal Encroachment	870-23
872.10	Stage Construction	870-24
873.3A	Stone Shape	870-31
873.3B	Medium Density Vegetation	870-40
873.3D	Rock Slope Protection	870-41
873.3C	Gabion Lined Streambank	870-42
873.3E	Concreted-Rock Slope Protection	870-43
873.3F	Toe Failure – Concreted RSP	870-43
873.4A	Thalweg Redirection Using Bendway Weirs	870-47
873.4B	Bendway Weir Typical Cross Section and Layout	870-49
873.4C	Bendway Weir Rock Size Chart	870-50
873.4D	Example of Spur Design	870-52
873.4E	Bridge Abutment Guide Banks	870-51
873.6A	Bridge Abutment Failure Example	870-55
873.6B	Habitat Enhancement Example	870-56
873.6C	Lateral Stream Migration Within a Canyon Setting Example	870-56

CHAPTER 880 - SHORE PROTECTION

883.2A	Nomenclature of Tidal Ranges	880-5
883.2B	Significant Wave Height Prediction Nomograph	880-8
883.2C	Design Breaker Wave	880-9
883.2D	Global Sea Level Rise Projections	880-11
883.2E	Wave Run-up on Smooth Impermeable Slope	880-12

List of Figures

Figure Number	Subject	Page Number
883.2F	RSP Lined Ocean Shore	880-12
883.2G	Rock Slope Protection	880-16
883.2H	Typical Groin Layout with Resultant Beach Configuration	880-19
883.2I	Alignment of Groins to an Oblique Sea Warrants Shortening Proportional to Cosine of Obliquity	880-19
883.2J	Typical Stone Dike Groin Details	880-20

CHAPTER 890 - STORM WATER MANAGEMENT

892.3	Example of a Cumulative Hydrograph with and without Detention	890-4
-------	---	-------

CHAPTER 1000 - BICYCLE TRANSPORTATION DESIGN

1003.1A	Two-way Class I Bikeway (Bike Path)	1000-6
1003.1B	Typical Cross Section of Class I Bikeway (Bike Path) Parallel to Highway	1000-7
1003.1C	Minimum Lengths of Bicycle Path Crest Vertical Curve (L) Based on Stopping Sight Distance (S)	1000-11
1003.1D	Minimum Lateral Clearance (<i>m</i>) on Bicycle Path Horizontal Curves	1000-12
1003.5	Railroad Crossing Class I Bikeway	1000-15

List of Tables

Table Number	Subject	Page Number
-----------------	---------	----------------

CHAPTER 80 - APPLICATION OF DESIGN STANDARDS

82.1A	Boldface Standards	80-11
82.1B	Underlined Standards	80-15
82.1C	Decision Requiring Other Approvals	80-19

CHAPTER 100 - BASIC DESIGN POLICIES

101.2	Vehicular Design Speed	100-3
-------	------------------------	-------

CHAPTER 200 - GEOMETRIC DESIGN AND STRUCTURE STANDARDS

201.1	Sight Distance Standards	200-1
201.7	Decision Sight Distance	200-3
202.2A	Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{max}=4\%$	200-10
202.2B	Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{max}=6\%$	200-11
202.2C	Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{max}=8\%$	200-12
202.2D	Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{max}=10\%$	200-13
202.2E	Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{max}=12\%$	200-14
204.3	Maximum Grades for Type of Highway and Terrain Conditions	200-22
204.8	Falsework Span and Depth Requirements	200-29
210.2	Types of Reinforced Earth Slopes and Earth Retaining Systems	200-57

CHAPTER 300 - GEOMETRIC CROSS SECTION

302.1	Boldface Standards for Paved Shoulder Width on Highways	300-4
303.1	Selection of Curb Type	300-8
307.2	Shoulder Widths for Two-lane Roadbed New Construction Projects	300-21
309.2A	Minimum Vertical Clearances	300-29
309.2B	California Routes on the Rural and Single Interstate Routing System	300-31
309.5A	Minimum Vertical Clearances Above Highest Rail	300-34
309.5B	Minimum Horizontal Clearances to Centerline of Nearest Track	300-38

CHAPTER 400 - INTERSECTIONS AT GRADE

401.3	Vehicle Characteristics/Intersection Design Elements Affected	400-2
405.1A	Corner Sight Distance (7-1/2 Second Criteria)	400-22
405.1B	Application of Sight Distance Requirements	400-22
405.2A	Bay Taper for Median Speed-change Lanes	400-24

List of Tables

Table Number	Subject	Page Number
405.2B	Deceleration Lane Length	400-24
405.4	Parabolic Curb Flares Commonly Used	400-31
406	Vehicle Traffic Flow Conditions at Intersections at Various Levels of Operation	400-43
CHAPTER 500 - TRAFFIC INTERCHANGES		
504.3	Ramp Widening for Trucks	500-16
504.7C	Percent of Through Traffic Remaining in Outer Through Lane (Level of Service D Procedure)	500-42
CHAPTERS 600-670 – PAVEMENT ENGINEERING		
CHAPTER 610 - PAVEMENT ENGINEERING CONSIDERATIONS		
612.2	Pavement Design Life for New Construction and Rehabilitation	610-2
613.3A	ESAL Constants	610-6
613.3B	Lane Distribution Factors for Multilane Highways	610-6
613.3C	Conversion of ESAL to Traffic Index	610-7
613.5A	Traffic Index (TI) Values for Ramps and Connectors	610-8
613.5B	Minimum TI's for Safety Roadside Rest Areas	610-15
614.2	Unified Soil Classification System (from ASTM D 2487)	610-17
CHAPTER 620 – RIGID PAVEMENT		
622.1	Concrete Properties Used in Developing Rigid Pavement Design Catalog	620-3
622.2	Concrete Pavement Performance Factors	620-4
622.5	Use of Terminal Joints, Expansion Joint, Wide Flange Beam, and Anchors in CRCP	620-7
623.1A	Relationship Between Subgrade Type	620-12
623.1B	Rigid Pavement Catalog (North Coast, Type I Subgrade Soil)	620-14
623.1C	Rigid Pavement Catalog (North Coast, Type II Subgrade Soil)	620-15
623.1D	Rigid Pavement Catalog (South Coast/Central Coast, Type I Subgrade Soil)	620-16
623.1E	Rigid Pavement Catalog (South Coast/Central Coast, Type II Subgrade Soil)	620-17
623.1F	Rigid Pavement Catalog (Inland Valley, Type I Subgrade Soil)	620-18
623.1G	Rigid Pavement Catalog (Inland Valley, Type II Subgrade Soil)	620-19
623.1H	Rigid Pavement Catalog (Desert, Type I Subgrade Soil)	620.20
623.1I	Rigid Pavement Catalog (Desert, Type II Subgrade Soil)	620-21
623.1J	Rigid Pavement Catalog (Low Mountain/South Mountain, Type I Subgrade Soil)	620-22

List of Tables

Table Number	Subject	Page Number
623.1K	Rigid Pavement Catalog (Low Mountain/South Mountain, Type II Subgrade Soil)	620-23
623.1L	Rigid Pavement Catalog (High Mountain/High Desert, Type I Subgrade Soil)	620-24
623.1M	Rigid Pavement Catalog (High Mountain/High Desert, Type II Subgrade Soil)	620-25
625.2	Thicknesses for Crack, Seat, and Flexible Overlay	620-29
626.2	Shoulder Concrete Pavement Designs (“S” Dimension)	620-36

CHAPTER 630 – FLEXIBLE PAVEMENT

632.1	Asphalt Binder Performance Grade Selection	630-5
633.1	Gravel Equivalents (GE) and Thickness of Structural Layers (ft)	630-8
633.2	Selection ME Project Testing Level	630-11
633.3	Minimum Reliability Depending on Project Testing Level	630-11
635.2A	Tolerable Deflections at the Surface (TDS) in 0.001 inches	630-17
635.2B	Gravel Equivalence Needed to Reduce Surface Deflection	630-18
635.2C	Commonly Used G_f for Flexible Pavement Rehabilitation	630-19
635.2D	Reflective Crack Retardation Equivalencies (Thickness in ft)	630-20
636.4	Minimum Pavement Structures for Park and Ride Facilities	630-29

CHAPTER 660 – PAVEMENT FOUNDATIONS

663.2	Base and Subbase Material Properties for Rigid Pavement Catalog	660-4
663.3	Gravel Factor and California R-values for Base and Subbases Used in Flexible Pavement Design	660-5
666.1A	Typical Resilient Modulus and Poisson’s Ratio for Standard Base and Subbase Materials Used in ME-Based Flexible Pavement Design	660-13
666.1B	Typical Resilient Modulus and Poisson’s Ratio for Subgrade Soils Used in ME-Based Flexible Pavement Design	660-13

CHAPTER 700 – MISCELLANEOUS STANDARDS

701.5	Slatted CL-6 Post & Footing Dimensions	700-4
-------	--	-------

CHAPTERS 800-890 - HIGHWAY DRAINAGE DESIGN

CHAPTER 800 - GENERAL ASPECTS

808.1	Summary of Related Computer Programs and Web Applications	800-38
-------	---	--------

CHAPTER 810 - HYDROLOGY

816.6A	Roughness Coefficients for Sheet Flow	810-11
--------	---------------------------------------	--------

List of Tables

Table Number	Subject	Page Number
816.6B	Intercept Coefficients for Shallow Concentrated Flow	810-11
819.2B	Runoff Coefficients for Developed Areas	810-20
819.2C	Regional Flood-Frequency Equations	810-21
819.5A	Summary of Methods for Estimating Design Discharge	810-27
819.7A	Region Regression Equations for California's Desert Regions	810-31
819.7B	Runoff Coefficients for Desert Areas	810-32
819.7C	Watershed Size for California Desert Regions	810-32
819.7D	Hydrologic Soil Groups	810-34
819.7E	Curve Numbers for Land Use-Soil Combinations	810-36
819.7F	Channel Routing Methods	810-40
819.7G	Channel Method Routing Guidance	810-41
819.7H	Design Storm Durations	810-42
819.7I	Bulking Factors & Types of Sediment Flow	810-44
819.7J	Adjustment-Transportation Factor Table	810-49
CHAPTER 830 - TRANSPORTATION FACILITY DRAINAGE		
831.3	Desirable Roadway Drainage Guidelines	830-3
838.4	Minimum Pipe Diameter for Storm Drain Systems	830-18
CHAPTER 840 - SUBSURFACE DRAINAGE		
842.4	Suggested Depth and Spacing of Pipe Underdrains for Various Soil Types	840-5
CHAPTER 850 - PHYSICAL STANDARDS		
852.1	Manning "n" Value for Alternative Pipe Materials	850-2
853.1A	Allowable Alternative Pipe Liner Materials	850-11
853.1B	Guide for Plastic Pipeliner Selection in Abrasive Conditions to Achieve 50 Years of Maintenance-Free Service Life	850-13
854.1	Joint Leakage Selection Criteria	850-18
855.2A	Abrasion Levels and Materials	850-22
855.2B	Bed Materials Moved by Various Flow Depths and Velocities	850-26
855.2C	Guide for Anticipated Service Life Added to Steel Pipe by Abrasive Resistant Protective Coating	850-27
855.2D	Guide for Anticipated Wear to Metal Pipe by Abrasive Channel Materials	850-28
855.2E	Relative Abrasion Resistance Properties of Pipe and Lining Materials	850-28

List of Tables

Table Number	Subject	Page Number
855.2F	Guide for Minimum Material Thickness of Abrasive Resistant Invert Protection to Achieve 50 Years of Maintenance-Free Service Life	850-29
855.4A	Guide for the Protection of Cast-In-Place and Precast Reinforced and Unreinforced Concrete Structures Against Acid and Sulfate Exposure Conditions	850-35
855.4B	Guide for Minimum Cover Requirements for Cast-In-Place and Precast Reinforced Concrete Structures for 50-Year Design Life in Chloride Environments	850-36
856.3A	Corrugated Steel Pipe Helical Corrugations	850-39
856.3B	Corrugated Steel Pipe Helical Corrugations	850-40
856.3C	Corrugated Steel Pipe 2 $\frac{2}{3}$ " x $\frac{1}{2}$ " Annular Corrugations	850-41
856.3D	Corrugated Steel Pipe Arches 2 $\frac{2}{3}$ " x $\frac{1}{2}$ " Helical or Annular Corrugations	850-42
856.3E	Steel Spiral Rib Pipe $\frac{3}{4}$ " x 1" Ribs at 11 $\frac{1}{2}$ " Pitch	850-43
856.3F	Steel Spiral Rib Pipe $\frac{3}{4}$ " x 1" Ribs at 8 $\frac{1}{2}$ " Pitch	850-44
856.3G	Steel Spiral Rib Pipe $\frac{3}{4}$ " x $\frac{3}{4}$ " Ribs at 7 $\frac{1}{2}$ " Pitch	850-45
856.3H	Corrugated Aluminum Pipe Annular Corrugations	850-46
856.3I	Corrugated Aluminum Pipe Helical Corrugations	850-47
856.3J	Corrugated Aluminum Pipe Arches 2 $\frac{2}{3}$ " x $\frac{1}{2}$ " Helical or Annular Corrugations	850-48
856.3K	Aluminum Spiral Rib Pipe $\frac{3}{4}$ " x 1" Ribs at 11 $\frac{1}{2}$ " Pitch	850-49
856.3L	Aluminum Spiral Rib Pipe $\frac{3}{4}$ " x $\frac{3}{4}$ " Ribs at 7 $\frac{1}{2}$ " Pitch	850-50
856.3M	Structural Steel Plate Pipe 6" x 2" Corrugations	850-51
856.3N	Structural Steel Plate Pipe Arches 6" x 2" Corrugations	850-52
856.3O	Structural Aluminum Plate Pipe 9" x 2 $\frac{1}{2}$ " Corrugations	850-53
856.3P	Structural Aluminum Plate Pipe Arches 9" x 2 $\frac{1}{2}$ " Corrugations	850-54
856.4	Thermoplastic Pipe Fill Height Tables	850-55
856.5	Minimum Thickness of Cover for Culverts	850-56
857.2	Allowable Alternative Materials	850-58

CHAPTER 860 - OPEN CHANNELS

865.1	Concrete Channel Linings	860-9
865.2	Permissible Shear and Velocity for Selected Lining Materials	860-13
866.3A	Average Values for Manning's Roughness Coefficient (n)	860-18
868.2	Guide to Freeboard Height	860-21

CHAPTER 870 - BANK PROTECTION – EROSION CONTROL

872.1	Guide to Selection of Protection	870-5
-------	----------------------------------	-------

List of Tables

Table Number	Subject	Page Number
872.2	Failure Modes and Effects Analysis for Riprap Revetment	870-18
873.3A	RSP Class by Median Particle Size	870-32
873.3B	RSP Class by Median Particle Weight	870-33
CHAPTER 880 - SHORE PROTECTION		
883.2	Dimensionless Breaker Parameter and Wave Types	880-14
CHAPTER 900 - LANDSCAPE ARCHITECTURE		
902.3	Large Tree Setback Requirements on Conventional Highways	900-5
903.5	Vehicle Parking Stall Standards	900-13
CHAPTER 1000 - BICYCLE TRANSPORTATION DESIGN		
1003.1	Bike Path Design Speeds	1000-9