# Manual Change Transmittal

**Title:** DIVISION OF DESIGN HIGHWAY DESIGN MANUAL  
**SIXTH EDITION – CHANGE 07/02/18**

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The Table of Contents; List of Figures; List of Tables; Chapters: 10, 60-700, 900-1100; and the Index of the Sixth Edition, Highway Design Manual (HDM) have been revised. The changes to the HDM are summarized below with change sheets available on the Department Design website at: [http://www.dot.ca.gov/design/manuals/hdm.html](http://www.dot.ca.gov/design/manuals/hdm.html). Changes include the bullets itemized below along with typographical corrections and Index/Figure reference corrections. These changes are effective July 2, 2018, and shall be applied to on-going projects in accordance with HDM Index 82.5 – Effective Date for Implementing Revisions to Design Standards.

HDM Holders are encouraged to use the most recent version of the HDM available on-line at the above website. Should a HDM Holder choose to maintain a paper copy, the Holder is responsible for keeping their paper copy up to date and current. Using the latest version available on-line will ensure proper reference to the latest design standards and guidance. If you would like to be notified automatically of any significant changes or updates to the HDM, go to [http://www.dot.ca.gov/design/manuals/hdmlist.html](http://www.dot.ca.gov/design/manuals/hdmlist.html).

A summary of the most significant revisions made throughout the manual are as follows:

- Replaced mandatory and advisory standards with boldface and underlined standards, respectively.
- Replaced Design Exception Fact Sheet with Design Standard Decision Document.
- Replaced Traffic Liaison with another, more appropriate delegated contact depending on the context per HQ’s Division of Traffic Operations.
- Replaced metal beam guardrail with guardrail.

Enclosures available on the Department Design website at: [http://www.dot.ca.gov/design/manuals/hdm.html](http://www.dot.ca.gov/design/manuals/hdm.html).
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CHAPTER 10
DIVISION OF DESIGN

Topic 11 - Organization and Functions

Index 11.1 - Organization

The Division of Design (DOD), a part of Project Delivery, is comprised of the Engineering Program with the following offices: CADD and GIS, Highway Drainage Design, Innovative Design and Delivery, Performance Management, Project Support, Standards and Procedures, Storm Water Management Design; as well as the Landscape Architecture Program with the following offices: Landscape Architecture Standards and Procedures, Landscape Architecture Support and Planning, Professional Development, and Strategic Information & Business Management. Additionally, the Project Delivery Coordinators represent the Chief, DOD, in the California Department of Transportation (Department) Districts, maintaining liaison and coordinating District and Headquarters activities, ensuring consistent and uniform application of statewide policies, standards, procedures, guidelines and practices. See Figure 11.1 for information on the functional duties performed by the various offices in the DOD.

As the Chief Design Engineer within the DOD, the Chief, Division of Design provides technical and procedural advice and assistance to the Districts in support of the development of transportation projects as follows: establishes, maintains and monitors the project development process in accord with all applicable State and Federal laws and regulations; establishes engineering standards and procedures for application of standards on a statewide basis; approves exceptions to non-delegated boldface design standards; monitors project development related reports, facilitates performance management and process improvement activities. The Chief, DOD also is a member of the AASHTO Subcommittee on Design.
Figure 11.1

Division of Design Functional Organization Chart
environment. Highway planting provides planting to satisfy legal mandates, environmental mitigation requirements, Memoranda of Understanding or Agreement between the Department and local agencies for aesthetics or erosion control. Highway planting also includes roadside management strategies that improve worker safety by reducing the frequency and duration of worker exposure.

(5) Highway planting required due to the impacts of a roadway construction project must be programmed and funded by the parent roadway project.

(6) Highway planting, funded and maintained by the Department on conventional highways, is limited to planting that provides: safety improvements, erosion control/stormwater pollution prevention, revegetation, and required mitigation planting. Highway planting on freeways, controlled access highways and expressways, funded and maintained by the Department, is limited to areas that meet specific criteria. See Chapter 29 “Landscape Architecture” of the Project Development Procedures Manual (PDPM) for more detailed information regarding warranted planting.

(7) **Highway Planting Revegetation.** Highway planting revegetation provides planting as mitigation for native vegetation damaged or removed due to a roadway construction project. Highway planting revegetation may include irrigation systems as appropriate. Highway planting revegetation, required due to the impacts of a roadway construction project, must be programmed and funded by the parent roadway project.

(8) **Imported Topsoil.** Soil that is delivered onto a project from a commercial source and is fertile, friable soil of loamy character that contains organic matter.

(9) **Local Topsoil.** Existing soil obtained from the “A” and “O” soil horizons within the project limits, typically during excavation activities.

(10) **“O” Soil Horizon.** The surface layer consisting of loose and partly decaying organic matter.

(11) **Park and Ride.** A paved area for parking which provides a connection point for public access to a variety of modal options. See Topic 905.

(12) **Replacement Highway Planting.** Replacement highway planting replaces vegetation installed by the Department or others, that has been damaged or removed due to transportation project construction. Replacement highway planting may also include irrigation modifications and/or replacement. Replacement highway planting required due to the impacts of a roadway construction project must be programmed in conjunction with and funded from the parent roadway project.

(13) **Required Mitigation Planting.** Required mitigation planting provides planting and other work necessary to mitigate environmental impacts due to roadway construction. The word “required” indicates that the work is necessary to meet legally required environmental mitigation or permit requirements. Required mitigation planting may be performed within the operational right of way, immediately adjacent to the highway or at an offsite location as determined by the permit. A planting project for required mitigation due to the impacts of a roadway construction project must be programmed and funded by the parent roadway project.

(14) **Roadside Rehabilitation.** The primary purpose of this program is to provide for replacement, restoration and rehabilitation of existing roadside elements, including highway planting and irrigation, following damage by weather, acts of nature or deterioration. This program also provides for erosion control to comply with National Pollutant Discharge Elimination System (NPDES) permit requirements, design for safety features, and improvements for roadside appearance and coordination with community character.

(15) **Safety Roadside Rest Area System.** The safety roadside rest area system is a component of the highway system providing roadside areas where travelers can stop, rest and manage their travel needs. Planned with consideration of alternative stopping opportunities such as truck stops, commercial services, and vista...
or other persons to access in connection with a highway is fully or partially controlled by public authority.

(7) Easement. A right to use or control the property of another for designated purposes.

(8) Eminent Domain. The power to take private property for public use without the owner's consent upon payment of just compensation.

(9) Encroachment. In terms of exceptions and permits, includes, but is not limited to, any structure, object, or activity of any kind or character which is within the State right of way, but it is not a part of the State facility or serving a transportation need.

(10) Inverse Condemnation. The legal process which may be initiated by a property owner to compel the payment of just compensation, where the property has been taken for or damaged by a public purpose.

(11) Negotiation. The process by which property is sought to be acquired for project purposes through mutual agreement upon the terms for transfer of such property.

(12) Partial Acquisition. The acquisition of a portion of a parcel of property.

(13) Relinquishment. A transfer of the State's right, title, and interest in and to a highway, or portion thereof, to a city or county.

(14) Right of Access. The right of an abutting land owner for entrance to or exit from a public road.

(15) Severance Damages. Loss in value of the remainder of a parcel which may result from a partial taking of real property and/or from the project.

(16) Vacation. The reversion of title to the owner of the underlying fee where an easement for highway purposes is no longer needed.

62.7 Pavement

The following list of definitions includes terminologies that are commonly used in California as well as selected terms from the "AASHTO Guide for the Design of Pavement Structures" which may be used by FHWA, local agencies,
consultants, etc. in pavement engineering reports and research publications.

(1) **Asphalt Concrete.** See Hot Mix Asphalt (HMA).

(2) **Asphalt Rubber.** A blend of asphalt binder, reclaimed tire rubber, and certain additives in which the rubber component is at least 15 percent by weight of the total blend and has reacted in the hot asphalt binder sufficiently to cause swelling of the rubber particles.

(3) **Asphalt Treated Permeable Base (ATPB).** A highly permeable open-graded mixture of crushed coarse aggregate and asphalt binder placed as the base layer to assure adequate drainage of the structural section, as well as structural support.

(4) **Base.** A layer of selected, processed, and/or treated aggregate material that is placed immediately below the surface course. It provides additional load distribution and contributes to drainage and frost resistance.

(5) **Basement Soil/Material.** See Subgrade.

(6) **Borrow.** Natural soil obtained from sources outside the roadway prism to make up a deficiency in excavation quantities.

(7) **California R-Value.** A measure of resistance to deformation of the soils under saturated conditions and traffic loading as determined by the stabilometer test (CT301). The California R-value, also referred to as R-value, measures the supporting strength of the subgrade and subsequent layers used in the pavement structure. For additional information, see Topic 614.

(8) **Capital Preventive Maintenance.** Typically, Capital Preventive Maintenance (CAPM) consists of work performed to preserve the existing pavement structure utilizing strategies that preserve or extend pavement service life. The CAPM program is divided into pavement preservation and pavement rehabilitation. For further discussion see Topic 603.

(9) **Cement Treated Permeable Base (CTPB).** A highly permeable open-graded mixture of coarse aggregate, portland cement, and water placed as the base layer to provide adequate drainage of the structural section, as well as structural support.

(10) **Composite Pavement.** These are pavements comprised of both rigid and flexible layers. Currently, for purposes of the procedures in this manual, only flexible over rigid composite pavements are considered composite pavements.

(11) **Crack.** Separation of the pavement material due to thermal and moisture variations, consolidation, vehicular loading, or reflections from an underlying pavement joint or separation.

(12) **Crack, Seat, and Overlay (CSO).** A rehabilitation strategy for rigid pavements. CSO practice requires the contractor to crack and seat the rigid pavement slabs, and place a flexible overlay with a pavement reinforcing fabric (PRF) interlayer.

(13) **Crumb Rubber Modifier (CRM).** Scrap rubber produced from scrap tire rubber and other components, if required, and processed for use in wet or dry process modification of asphalt paving.

(14) **Deflection.** The downward vertical movement of a pavement surface due to the application of a load to the surface.

(15) **Dense Graded Asphalt Concrete (DGAC).** See Hot Mix Asphalt (HMA).

(16) **Depression.** Localized low areas of limited size that may or may not be accompanied by cracking.

(17) **Dowel Bar.** A load transfer device in a rigid slab usually consisting of a plain round steel bar.

(18) **Edge Drain System.** A drainage system, consisting of a slotted plastic collector pipe encapsulated in treated permeable material and a filter fabric barrier, with unslotted plastic pipe vents, outlets, and cleanouts, designed to drain both rigid and flexible pavement structures.

(19) **Embankment.** A prism of earth that is constructed from excavated or borrowed natural soil and/or rock, extending from original ground to the grading plane, and
designed to provide a stable support for the pavement structure.

(20) **Equivalent Single Axle Loads (ESAL's).** The number of 18-kip standard single axle load repetitions that would have the same damage effect to the pavement as an axle of a specified magnitude and configuration. See Index 613.3 for additional information.

(21) **Flexible Pavement.** Pavements engineered to transmit and distribute vehicle loads to the underlying layers. The highest quality layer is the surface course (generally asphalt binder mixes) which may or may not incorporate underlying layers of base and subbase. These types of pavements are called "flexible" because the total pavement structure bends or flexes to accommodate deflection bending under vehicle loads. For further discussion, see Chapter 630.

(22) **Grading Plane.** The surface of the basement material upon which the lowest layer of subbase, base, pavement surfacing, or other specified layer, is placed.

(23) **Gravel Factor (\(G_f\)).** Refers to the relative strength of a given material compared to a standard gravel subbase material. The cohesiometer values were used to establish the \(G_f\) currently used by Caltrans.

(24) **Hot Mix Asphalt (HMA).** Formerly known as asphalt concrete (AC), HMA is a graded asphalt concrete mixture (aggregate and asphalt binder) containing a small percentage of voids which is used primarily as a surface course to provide the structural strength needed to distribute loads to underlying layers of the pavement structure.

(25) **Hot Recycled Asphalt (HRA).** The use of reclaimed flexible pavement which is combined with virgin aggregates, asphalt, and sometimes rejuvenating agents at a central hot-mix plant and placed in the pavement structure in lieu of using all new materials.

(26) **Joint Seals.** Pourable, extrudable or premolded materials that are placed primarily in transverse and longitudinal joints in concrete pavement to deter the entry of water and incompressible materials (such as sand that is broadcast in freeze-thaw areas to improve skid resistance).

(27) **Lean Concrete Base.** Mixture of aggregate, portland cement, water, and optional admixtures, primarily used as a base for portland cement concrete pavement.

(28) **Longitudinal Joint.** A joint normally placed between roadway lanes in rigid pavements to control longitudinal cracking; and the joint between the traveled way and the shoulder.

(29) **Maintenance.** The preservation of the entire roadway, including pavement structure, shoulders, roadsides, structures, and such traffic control devices as are necessary for its safe and efficient utilization.

(30) **Open Graded Asphalt Concrete (OGAC).** See Open Graded Friction Course (OGFC).

(31) **Open Graded Friction Course (OGFC).** Formerly known as open graded asphalt concrete (OGAC), OGFC is a wearing course mix consisting of asphalt binder and aggregate with relatively uniform grading and little or no fine aggregate and mineral filler. OGFC is designed to have a large number of void spaces in the compacted mix as compared to hot mix asphalt. For further discussion, see Topic 631.

(32) **Overlay.** An overlay is a layer, usually hot mix asphalt, placed on existing flexible or rigid pavement to restore ride quality, to increase structural strength (load carrying capacity), and to extend the service life.

(33) **Pavement.** The planned, engineered system of layers of specified materials (typically consisting of surface course, base, and subbase) placed over the subgrade soil to support the cumulative vehicle loading anticipated during the design life of the pavement. The pavement is also referred to as the pavement structure and has been referred to as pavement structural section.

(34) **Pavement Design Life.** Also referred to as performance period, pavement design life is the period of time that a newly constructed or rehabilitated pavement is engineered to perform before reaching a condition that requires CAPM, (see Index 603.4). The
selected pavement design life varies depending on the characteristics of the highway facility, the objective of the project, and projected vehicle volume and loading.

(35) Pavement Drainage System. A drainage system used for both asphalt and rigid pavements consisting of a treated permeable base layer and a collector system which includes a slotted plastic pipe encapsulated in treated permeable material and a filter fabric barrier with unslotted plastic pipe as vents, outlets and cleanouts to rapidly drain the pavement structure. For further discussion, see Chapter 650.

(36) Pavement Preservation. Work done, either by contract or by State forces to preserve the ride quality, safety characteristics, functional serviceability and structural integrity of roadway facilities on the State highway system. For further discussion, see Topic 603.

(37) Pavement Service Life. Is the actual period of time that a newly constructed or rehabilitated pavement structure performs satisfactorily before reaching its terminal serviceability or a condition that requires major rehabilitation or reconstruction. Because of the many independent variables involved, pavement service life may be considerably longer or shorter than the design life of the pavement. For further discussion, see Topic 612.

(38) Pavement Structure. See Pavement.

(39) Pumping. The ejection of base material, either wet or dry, through joints or cracks, or along edges of rigid slabs resulting from vertical movements of the slab under vehicular traffic loading. This phenomena is especially pronounced with saturated structural sections.

(40) Raveling. Progressive disintegration of the surface course on asphalt concrete pavement by the dislodgement of aggregate particles and binder.

(41) Rehabilitation. Work undertaken to extend the service life of an existing facility. This includes placement of additional surfacing and/or other work necessary to return an existing roadway, including shoulders, to a condition of structural or functional adequacy, for the specified service life. This might include the partial or complete removal and replacement of portions of the pavement structure. Rehabilitation is divided into pavement rehabilitation activities and roadway rehabilitation activities (see Indexes 603.3 and 603.4).

(42) Resurfacing. A supplemental surface layer or replacement layer placed on an existing pavement to restore its riding qualities and/or to increase its structural (load carrying) strength.

(43) Rigid Pavement. Pavement engineered with a rigid surface course (typically Portland cement concrete or a variety of specialty cement mixes for rapid strength concretes) which may incorporate underlying layers of stabilized or unstabilized base or subbase materials. These types of pavements rely on the substantially higher stiffness of the rigid slab to distribute the vehicle loads over a relatively wide area of underlying layers and the subgrade. Some rigid slabs have reinforcing steel to help resist cracking due to temperature changes and repetitive loading.

(44) 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 or surface course is placed. Where the medians are so wide as to include areas of undisturbed land, a divided highway is considered as including two separate roadbeds.

(45) Asphalt Rubber Binder. A blend of asphalt binder modified with crumb rubber modifier (CRM) that may include less than 15 percent CRM by mass.

(46) Rubberized Hot Mix Asphalt (RHMA). Formerly known as rubberized asphalt concrete (RAC). RHMA is a material produced for hot mix applications by mixing either asphalt rubber or asphalt rubber binder with graded aggregate. RHMA may be gap- (RHMA-G) or open- (RHMA-O) graded.

(47) R-value. See California R-Value.
Serviceability. The ability at time of observation of a pavement to serve vehicular traffic (automobiles and trucks) which use the facility. The primary measure of serviceability is the Present Serviceability Index (PSI), which ranges from 0 (impossible road) to 5 (perfect road).

Settlement. Localized vertical displacement of the pavement structure due to slippage or consolidation of the underlying foundation, often resulting in pavement deterioration, cracking and poor ride quality.

Structural Section. See Pavement Structure.

Structural Section Drainage System. See Pavement Drainage System.

Subbase. Unbound aggregate or granular material that is placed on the subgrade as a foundation or working platform for the base. It functions primarily as structural support, but it can also minimize the intrusion of fines from the subgrade into the pavement structure, improve drainage, and minimize frost action damage.

Subgrade. Also referred to as basement soil, it is the portion of the roadbed consisting of native or treated soil on which pavement surface course, base, subbase, or a layer of any other material is placed.

Surface Course. One or more uppermost layers of the pavement structure engineered to carry and distribute vehicle loads. The surface course typically consists of a weather-resistant flexible or rigid layer, which provides characteristics such as friction, smoothness, resistance to vehicle loads, and drainage. In addition, the surface course minimizes infiltration of surface water into the underlying base, subbase and subgrade. A surface course may be composed of a single layer with one or multiple lifts, or multiple layers of differing materials.

Tie Bars. Deformed reinforcing bars placed at intervals that hold rigid pavement slabs in adjoining lanes and exterior lane-to-shoulder joints together and prevent differential vertical and lateral movement.

62.8 Highway Operations

Annual Average Daily Traffic. The average 24-hour volume, being the total number during a stated period divided by the number of days in that period. Unless otherwise stated, the period is a year. The term is commonly abbreviated as ADT or AADT.

Delay. The time lost while road users are impeded by some element over which the user has no control.

Density. The number of vehicles per mile on the traveled way at a given instant.

Design Vehicles. See Topic 404.

Design Volume. A volume determined for use in design, representing traffic expected to use the highway. Unless otherwise stated, it is an hourly volume.

Diverging. The dividing of a single stream of traffic into separate streams.

Headway. The time in seconds between consecutive vehicles moving past a point in a given lane, measured front to front.

Level of Service. A rating using qualitative measures that characterize operational conditions within a traffic stream and their perception by users.

Managed Lanes. Lanes that are proactively managed in response to changing operating conditions in efforts to achieve improved efficiency and performance. Typically employed on highways with increasing recurrent traffic congestion and limited resources.

(a) High-Occupancy Vehicle (HOV) Lanes--An exclusive lane for vehicles carrying the posted number of minimum occupants or carpools, either part time or full time.

(b) High Occupancy Toll (HOT) Lanes--An HOV lane that allows vehicles qualified as carpools to use the facility without a fee, while vehicles containing less than the required number of occupants to pay a toll. Tolls may change based on real time conditions (dynamic) or according to a schedule (static).
(c) Express Toll Lanes--Facilities in which all users are required to pay a toll, although HOVs may be offered a discount. Tolls may be dynamic or static.

(10) Merging. The converging of separate streams of traffic into a single stream.

(11) Running Time. The time the vehicle is in motion.

(12) Spacing. The distance between consecutive vehicles in a given lane, measured front to front.

(13) Speed.

(a) Design Speed--A speed selected to establish specific minimum geometric design elements for a particular section of highway or bike path.

(b) Operating Speed--The speed at which drivers are observed operating their vehicles during free-flow conditions. The 85th percentile of the distribution of a representative sample of observed speeds is used most frequently to measure the operating speed associated with a particular location or geometric feature.

(c) Posted Speed--The speed limit determined by law and shown on the speed limit sign.

(d) High Speed -- A speed greater than 45 mph.

(e) Low Speed -- A speed less than or equal to 45 mph.

(f) Running Speed--The speed over a specified section of highway, being the distance divided by running time. The average for all traffic, or component thereof, is the summation of distances divided by the summation of running times.

(14) Traffic. A general term used throughout this manual referring to the passage of people, vehicles and/or bicycles along a transportation route.

(15) Traffic Control Devices.

(a) Markings--All pavement and curb markings, object markers, delineators, colored pavements, barricades, channelizing devices, and islands used to convey regulations, guidance, or warning to users.

(b) Sign--Any traffic control device that is intended to communicate specific information to users through a word, symbol and/or arrow legend. Signs do not include highway traffic signals or pavement markings, delineators, or channelizing devices.

(c) Highway Traffic Signal--A power-operated control device by which traffic is warned or directed to take a specific action. These devices do not include signals at toll plazas, power-operated signs, illuminated pavement markers, warning lights, or steady burning electrical lamps.

(d) Changeable Message Sign--An electronic traffic sign used on roadways to give travelers information about traffic congestion, accidents, roadwork zones, speed limits or any dynamic information about current driving conditions.

(16) Volume. The number of vehicles passing a given point during a specified period of time.

(17) Weaving. The crossing of traffic streams moving in the same general direction accomplished by merging and diverging.

(18) Ramp Metering. A vehicular traffic management strategy which utilizes a system of traffic signals on freeway entrance and connector ramps to regulate the volume of vehicles entering a freeway corridor in order to maximize the efficiency of the freeway and thereby minimizing the total delay in the transportation corridor.

62.9 Drainage

See Chapter 800 for definition of drainage terms.

62.10 Users

(1) Bicycle. A device propelled via chain, belt or gears, exclusively by human power.

(2) Bus. Any vehicle owned or operated by a publicly owned or operated transit system, or operated under contract with a publicly owned or operated transit system, and used to provide
to the general public, regularly scheduled transportation for which a fare is charged. A general public paratransit vehicle is not a transit bus.

(3) **Bus Rapid Transit (BRT).** A flexible rubber-tired rapid-transit mode that combines stations, vehicles, services, exclusive running ways, and Intelligent Transportation System elements into an integrated system with a strong positive identity that evokes a unique image.

(4) **Commuter Rail.** Traditional rapid and heavy rail passenger service intended to provide travel options in suburban and urban areas. Corridor lengths are typically shorter than intercity passenger rail services. Top operating speeds are in the range of 90 to 110 miles per hour. The tracks may or may not be shared with freight trains and typically are in a separate right of way.

(5) **Conventional Rail.** Traditional intercity passenger rail and interregional freight rail. Top operating speeds are in the range of 60 to 110 miles per hour. The tracks may or may not be shared by passenger and freight trains and typically run within their own right of way corridor.

(6) **Design Vehicle.** The largest vehicle commonly expected on a particular roadway. Descriptions of these vehicles are found in Index 404.4.

(7) **Equestrian.** A rider on horseback.

(8) **High Speed Rail.** A type of intercity and interregional passenger rail service that operates significantly faster than conventional rail. Top operating speeds are typically 150 to 220 miles per hour. These trains may be powered by overhead high voltage lines or technologies such as Maglev. The tracks are grade separated within a separate controlled access right of way and may or may not be shared with freight trains.

(9) **Light Rail.** A form of urban transit that uses rail cars on fixed rails in a right of way that may or may not be grade separated. Motorized vehicles and bicycles may share the same transportation corridor. These railcars are typically electrically driven with power supplied from an overhead line rather than an electrified third rail. Top operating speeds are typically 60 miles per hour.

(10) **Pedestrian.** A person who is afoot or who is using any of the following: (a) a means of conveyance propelled by human power other than a bicycle, or (b) an electric personal assistive mobility device. Includes a person who is operating a self-propelled wheelchair, motorized tricycle, or motorized quadricycle and, by reason of physical disability, is otherwise unable to move about as a pedestrian as specified in part (a) above.

(11) **Street Car, Trams or Trolley.** A passenger rail vehicle which runs on tracks along public urban streets and also sometimes on separate rights of way. It may also run between cities and/or towns, and/or partially grade separated structures.

(12) **Transit.** Includes light rail; commuter rail; motorbus; street car, tram, trolley bus; BRT; automated guideway; and demand responsive vehicles. The most common application is for motorbus transit. See Index 404.4 for a description of the design vehicle as related to buses.

(13) **Vehicle.** A device to move, propel or draw a person upon a highway, except a device on rails or propelled exclusively by human power. This definition, abstracted from the CVC, is intended to refer to motor vehicles, excluding those devices necessary to provide mobility to persons with disabilities.
The California Road System (CRS) maps are the official functional classification maps approved by Federal highway Administration. These maps show functional classification of roads.

(2) Interstate Highways. The interstate highway system was originally designed to be high-speed interregional connectors and it is a portion of the National Highway System (NHS). In urban and suburban areas, a large percentage of vehicular traffic is carried on the interstate highway system, rather than on the local arterials and streets.

(3) State Routes. The State highway system is described in the California Streets and Highway Code, Division 1, Chapter 2 and they are further defined in this manual in Topic 62.3, Highway Types which provides definitions for freeways, expressways, and highways.

81.5 Access Control

Index 62.3 defines a controlled access highway and a conventional highway. The level of access control plays a part in determining the design standards that are to be utilized when designing a highway. See Index 405.6 for additional access control guidance.

81.6 Design Standards and Highway Context

The design standards were initially established to increase highway mobility and development, promoting a State transportation system that operated at selected levels of service consistent with projected traffic volumes and highway classification. Design standards revolved around FHWA’s controlling criteria, evolving over time to more fully consider adjacent community values, local decisions making, and area context.

The design guidance and standards in this manual have been developed with the intent of ensuring that:

- Designers have the ability to design for all modes of travel (vehicular, bicycle, pedestrian, truck and transit); and,
- Designers have the flexibility to tailor a project to the unique circumstances that relate to it and its location, while meeting driver expectation to achieve established project goals.

Designers should balance the interregional transportation needs with the needs of the communities they pass through. The design of projects should, when possible, expand the options for biking, walking, and transit use. In planning and designing projects, the project development team should work with locals that have any livable policies as revitalizing urban centers, building local economies, and preserving historic sites and scenic country roads. The “Main Streets: Flexibility in Planning, Design and Operations” published by the Department should be consulted for additional guidance as should the FHWA publication “Flexibility in Highway Design”.

Early consultation and discussion with the Project Delivery Coordinator and the District Design Liaison during the Project Initiation Document (PID) phase is also necessary to avoid issues that may arise later in the project development process. Design Information Bulletin 78 “Design Checklist for the Development of Geometric Plans” is a tool that can be used to identify and discuss design features that may deviate from standard.

**Topic 82 - Application of Standards**

82.1 Highway Design Manual Standards

(1) General. The highway design criteria and policies in this manual provide a guide for the engineer to exercise sound judgment in applying standards, consistent with the above Project Development philosophy, in the design of projects. This guidance allows for flexibility in applying design standards and documenting design decisions that take the context of the
project location into consideration; which enables the designer to tailor the design, as appropriate, for the specific circumstances while maintaining safety.

The design standards used for any project should equal or exceed the minimum given in the Manual to the maximum extent feasible, taking into account costs (initial and life-cycle), traffic volumes, traffic and safety benefits, project goals, travel modes, facility type, right of way, socio-economic and environmental impacts, maintenance, etc. Because design standards have evolved over many years, many existing highways do not conform fully to current standards. It is not intended that current manual standards be applied retroactively to all existing State highways; such is neither warranted nor economically feasible. However, when warranted, upgrading of existing roadway features such as guardrail, lighting, superelevation, roadbed width, etc., should be considered, either as independent projects or as part of larger projects. A record of the decision not to upgrade existing non-standard design features are to be provided through the process described in Index 82.2.

This manual does not address temporary construction features. It is recognized that the construction conditions encountered are so diverse and variable that it is not practical to set geometric criteria. Guidance for use of traffic control devices for temporary construction zones can be found in Part 6 – Temporary Traffic Control of the California Manual on Uniform Traffic Control Devices (California MUTCD). Guidance for the engineering of pavements in temporary construction zones is available in Index 612.6. In this manual, design standards and guidance are described as follows (see Index 82.4 for other procedural requirements):

(2) Absolute Requirements. Design guidance related to requirements of law, policy, or statute that do not allow exception are phrased by the use of “is required”, “without exception”, “are to be”, “is to be”, “in no event”, or a combination of these terms.

(3) Controlling Criteria. The FHWA has designated the following ten controlling criteria for projects on the National Highway System (NHS) as comprehensive design standards which cover a multitude of design characteristics, allowing flexibility in application:

- Design Speed
- Lane Width
- Shoulder Width
- Horizontal Curve Radius
- Superelevation Rate
- Stopping Sight Distance
- Maximum Grade
- Cross Slope
- Vertical Clearance
- Design Loading Structural Capacity (non-geometric)

Design loading structural capacity criteria applies to all NHS facility types. See the Technical Publications – DES Manuals for further information.

The remaining geometric criteria listed above are applicable to the NHS as follows: (1) On high-speed roadways (Interstate highways, other freeways, and roadways with design speeds of greater than or equal to 50 mph), all the geometric criteria apply. The stopping sight distance criteria applies to horizontal alignments and vertical alignments except for sag vertical curves; and (2) On low-speed roadways (non-freeways with design speeds less than 50 mph), only the design speed criteria applies.

The two speed categories stated above that FHWA designates match the high- and low-speed definitions in Index 62.8(13) when considering that design speed and posted speed are set in 5 mph increments.

The design standards related to the geometric criteria are identified in Table 82.1A among other important geometric standards in this manual regardless of the design speed of the
roadway and whether or not the roadway is part of the NHS.

(4) Standards. Design standards are those considered most essential to achievement of overall design objectives. Many pertain to requirements of law or regulations such as those embodied in the FHWA's ten controlling criteria (see Index 82.1(3)). In addition to the FHWA's ten controlling criteria are “Caltrans-only” standards that have been identified by Caltrans as most essential pertaining to requirements of State law, policy or objectives. The design standards are shown in this manual as either **Boldface** type (listed in Table 82.1A) or *Underlined* type (listed in Table 82.1B) to indicate the approval authority for nonstandard design according to Index 82.2.

(5) Decision Requiring Other Approvals. There are design criteria decisions that are not bold or underlined text which require specific approvals from individuals to whom such decisions have been delegated. These individuals include, but are not limited to, District Directors, Project Delivery Coordinators or their combination as specified in this manual. These decisions should be documented as the individual approving desires.

(6) Permissive Standards. All guidance other than absolute requirements, standards, or decisions requiring other approvals, whether indicated by the use of “should”, “may”, or “can” are permissive.

(7) Other Caltrans Publications. In addition to the design standards in this manual, see Index 82.7 for general information on the Department’s traffic engineering policy, standards, practices and study warrants.

Caution must be exercised when using other Caltrans publications which provide guidelines for the design of highway facilities, such as HOV lanes. These publications do not contain design standards; moreover, the designs suggested in these publications do not always meet Highway Design Manual Standards. Therefore, all other Caltrans publications must be used in conjunction with this manual.

(9) Transportation Facilities Under the Jurisdiction of Others. Generally, if the local road or street is a Federal-aid route it should conform to AASHTO standards; see Topic 308 – Cross Sections for Roads Under Other Jurisdictions. Occasionally though, projects on the State highway system involve work on adjacent transportation facilities that are under the jurisdiction of cities and counties. Some of these local jurisdictions may have published standards for facilities that they own and operate. The guidance in this manual may be applicable, but it was prepared for use on the State highway system. Thus, when project work impacts adjacent transportation facilities that are under the jurisdiction of cities and counties, local standards and AASHTO guidance must be used in conjunction with this manual to encourage designs that are sensitive to the local context and community values. Agreeing on which standards will be used needs to be decided early in the project delivery process and on a project by project basis.

## 82.2 Approvals for Nonstandard Design

(1) **Boldface Standards.** Design features or elements which deviate from standards indicated in boldface type require the approval of the Chief, Division of Design. This approval authority has been delegated to the District Directors for projects on conventional highways and expressways, and for certain other facilities in accordance with the current District Design Delegation Agreement. Approval authority for design standards indicated in boldface type on all other facilities has been delegated to the Project Delivery Coordinators except as noted in Table 82.1A where: (a) the standard has been delegated to the District Director, (b) the standards in Chapters 600 through 670 requires the approval of the State Pavement Engineer, and (c) specifically delegated to the District Director.
per the current District Design Delegation Agreements and may involve coordination with the Project Delivery Coordinator. See the HQ Division of Design website for the most current District Design Delegation Agreements.

The current procedures and documentation requirements pertaining to the approval process for deviation from design standards indicated in boldface type as well as the dispute resolution process are contained in Chapter 21 of the Project Development Procedures Manual (PDPM).

Design exception approval must be obtained pursuant to the instructions in PDPM Chapter 9.

The Moving Ahead for Progress in the 21st Century Act (MAP-21) of 2012 allowed significant delegation to the states by FHWA to approve and administer portions of the Federal-Aid Transportation Program. MAP-21 further allowed delegation to the State DOT's and in response to this a Stewardship and Oversight Agreement (SOA) document between FHWA and Caltrans was signed. The SOA outlines the process to determine specific project related delegation to Caltrans. In general, the SOA delegates approval of deviations from design standards related to the ten controlling criteria on all Interstate projects whether FHWA has oversight responsibilities or not to Caltrans. Exceptions to this delegation would be for projects of FHWA Division Interest, which are determined on a project by project basis. See Index 43.2 for additional information. Consultation with FHWA should be sought as early in the project development process as possible. However, formal FHWA approval, if applicable, shall not be requested until the appropriate Caltrans representative has approved the design decision document.

FHWA approval is not required for deviations from "Caltrans-only" standards. Table 82.1A identifies these "Caltrans-only" standards. Where FHWA approval of a deviation from a design standard is required, only cite the standards that are identified by the FHWA as ten controlling criteria, see Index 82.1(3).

For local facilities crossing the State right of way see Index 308.1.

(2) Underlined Standards. The authority to approve deviations from standards indicated in underlined type has been delegated to the District Directors. A list of these standards is provided in Table 82.1B. Proposals for deviations from these standards can be discussed with the District Design Liaison during development of the approval documentation. The responsibility for the establishment of procedures for review, documentation, and long term retention of approved design decisions from these standards has also been delegated to the District Directors.

(3) Decisions Requiring Other Approvals. The authority to approve specific decisions identified in the text are also listed in Table 82.1C. The form of documentation or other instructions are provided as directed by the approval authority.

(4) Permissive Standards. A record of deviation from permissive standards and the disclosure of the engineering decisions in support of the deviation should be documented and placed in the project file. This principle of documentation also applies when following other Division of Design guidance, e.g., Design Information Bulletins and Design Memos. The form of documentation and other instructions on long term retention of these engineering decisions are to be provided as directed by the District approval authority.

(5) Local Agencies. Cities and counties are responsible for the design decisions they make on transportation facilities they own and operate. The responsible local entity is delegated authority to exercise their engineering judgment when utilizing the applicable design guidance and standards, including those for bicycle facilities established by Caltrans pursuant to the Streets and Highways Code Sections 890.6 and 890.8 and published in this manual. For further information on this delegation and the delegation process, see the Caltrans Local Assistance Procedures Manual, Chapter 11.
82.3 FHWA and AASHTO Standards and Policies

The standards in this manual generally conform to the standards and policies set forth in the AASHTO publications, "A Policy on Geometric Design of Highways and Streets" (2011) and "A Policy on Design Standards-Interstate System" (2005). A third AASHTO publication, the latest edition of the "Roadside Design Guide", focuses on creating safer roadsides. These three documents, along with other AASHTO and FHWA publications cited in 23 CFR Ch 1, Part 625, Appendix A, contain most of the current AASHTO policies and standards, and are approved references to be used in conjunction with this manual.

AASHTO policies and standards, which are established as nationwide standards, do not always satisfy California conditions. When standards differ, the instructions in this manual govern, except when necessary for FHWA project approval (Index 108.7, Coordination with the FHWA).

The use of publications and manuals that are developed by organizations other than the FHWA and AASHTO can also provide additional guidance not covered in this manual. The use of such guidance coupled with sound engineering judgment is to be exercised in collaboration with the guidance in this manual.

82.4 Mandatory Procedural Requirements

Required procedures and policies for which Caltrans is responsible, relating to project clearances, permits, licenses, required tests, documentation, value engineering, etc., are indicated by use of the word "must". Procedures and actions to be performed by others (subject to notification by Caltrans), or statements of fact are indicated by the word "will".

82.5 Effective Date for Implementing Revisions to Design Standards

Revisions to design standards will be issued with a stated effective date. It is understood that all projects will be designed to current standards unless a design decision has been approved in accordance with Index 82.2 or otherwise noted by separate Design Memorandum.

On projects where the project development process has started, the following conditions on the effective date of the new or revised standards will be applied:

- For all projects where the PS&E has not been finalized, the new or revised design standards shall be incorporated unless this would impose a significant delay in the project schedule or a significant increase in the project engineering or construction costs. The Project Delivery Coordinator or individual delegated authority must make the final determination on whether to apply the new or previous design standards on a project-by-project basis for roadway features.

- For all projects where the PS&E has been submitted to Headquarters Office Engineer for advertising or the project is under construction, the new or revised standards will be incorporated only if they are identified in the Change Transmittal as requiring special implementation.

For locally-sponsored projects, the Oversight Engineer must inform the funding sponsor within 15 working days of the effective date of any changes in design standards as defined in Index 82.2.

82.6 Design Information Bulletins and Other Caltrans Publications

In addition to the design standards in this manual, Design Information Bulletins (DIBs) establish policies and procedures for the various design specialties of the Department that are in the Division of Design. Some DIBs may eventually become part of this manual, while others are written with the intention to remain as design guidance in the DIB format. References to DIBs are made in this manual by the “base” DIB number only and considered to be the latest version available on the Department Design website. See the Department Design website for further information concerning DIB numbering protocol and postings.

Caution must be exercised when using other Caltrans publications, which provide guidelines for the design of highway facilities, such as HOV lanes. These publications do not contain design standards; moreover, the designs suggested in these publications do not always meet Highway Design Manual Standards. Therefore, all other Caltrans publications must be used in conjunction with this manual.
82.7 Traffic Engineering

The Division of Traffic Operations maintains engineering policy, standards, practices and study warrants to direct and guide decision-making on a broad range of design and traffic engineering features and systems, which are provided to meet the site-specific safety and mobility needs of all highway users.

The infrastructure within a highway or freeway corridor, segment, intersection or interchange is not “complete” for drivers, bicyclists and pedestrians unless it includes the appropriate traffic control devices; traffic safety systems; operational features or strategies; and traffic management elements and or systems. The presence or absence of these traffic elements and systems can have a profound effect on safety and operational performance. As such, they are commonly employed to remediate performance deficiencies and to optimize the overall performance of the “built” highway system.

For additional information visit the Division of Traffic Operations website at http://www.dot.ca.gov/trafficops/
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Design exception approval of Boldface Standards for nonfreeway facilities has been delegated to the Districts. In addition, some District delegations included Boldface Standards applicable to freeways. See your District Design Delegation Agreement for specific delegation.

(1) Caltrans-only Boldface Standard.

(2) Authority to approve deviations from this Boldface Standard is delegated to the State Pavement Engineer.
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Design exception approval of Boldface Standards for nonfreeway facilities has been delegated to the Districts. In addition, some District delegations included Boldface Standards applicable to freeways. See your District Design Delegation Agreement for specific delegation.

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<td>Ramp Terminals and Grade</td>
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<td>Single-lane Freeway-to-freeway Connector Design</td>
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<td>Merging Branch Connector Auxiliary Lanes</td>
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<td>Access Control at Ramp Terminal</td>
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<td>HOV Preferential Lane Restrictive Condition Auxiliary Lane</td>
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Clearance

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**Vehicular Design Speed**

<table>
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<th>Design Speed (mph)</th>
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<td>Freeways and expressways in mountainous terrain</td>
<td>50-80</td>
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<tr>
<td>Freeways in urban areas</td>
<td>55-80</td>
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<tr>
<td>Freeways and expressways in rural areas</td>
<td>70-80</td>
</tr>
<tr>
<td>Expressways in urban areas</td>
<td>50-70</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>Rural</td>
<td></td>
</tr>
<tr>
<td>Flat terrain</td>
<td>55-70</td>
</tr>
<tr>
<td>Rolling terrain</td>
<td>50-60</td>
</tr>
<tr>
<td>Mountainous terrain</td>
<td>40-50</td>
</tr>
<tr>
<td>Main Streets – Cities, Towns, and Community Centers</td>
<td>30-40</td>
</tr>
<tr>
<td>Urban</td>
<td></td>
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<tr>
<td>Arterials - Throughways</td>
<td>40-60</td>
</tr>
<tr>
<td>Arterials - Main Streets and Regional/Community Centers</td>
<td>30-40</td>
</tr>
<tr>
<td>Downtowns and City Centers</td>
<td>30</td>
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<tr>
<td><strong>LOCAL FACILITIES</strong>&lt;sup&gt;(1)&lt;/sup&gt;</td>
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<tr>
<td>Facilities crossing a freeway or expressway, connecting to a conventional highway or traversing a State facility</td>
<td>AASHTO&lt;sup&gt;(1)&lt;/sup&gt;</td>
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<tr>
<td>Facilities connecting to a freeway or expressway</td>
<td>35&lt;sup&gt;B/45&lt;/sup&gt;&lt;sup&gt;U&lt;/sup&gt;</td>
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</tbody>
</table>

<sup>(1)</sup> If outside of State right of way and no specific local standards apply, the minimum design speed shall be 30 miles per hour.

<sup>(2)</sup> For conventional highways eligible or designated as State scenic highways, see Index 109.2

### Topic 102 - Design Capacity & Level of Service

#### 102.1 Design Capacity (Automobiles)

Design capacity (automobiles) is the maximum volume of vehicle traffic for which a projected highway can provide a selected level of service. Design capacity varies with a number of factors, including:

(a) Level of service selected.
(b) Width of lanes.
(c) Number of lanes.
(d) Presence or absence of shoulders.
(e) Grades.
(f) Horizontal alignment.
(g) Operating speed.
(h) Lateral clearance.
(i) Side friction generated by parking, driveways, intersections, and interchanges.
(j) Volumes of trucks, transit, recreational vehicles, bicycles and pedestrians.
(k) Spacing and timing of traffic signals, and the required timing to accommodate pedestrian crossing.

Level of Service (LOS) is largely related to speed and density among many variables. Freeways should be designed to accommodate the design year peak hour traffic volumes and to operate at a LOS determined by District Planning and/or Traffic Operations. For a rough approximation of the number of lanes required on a multilane freeway, use the following design year peak hour traffic volumes per lane at the specified LOS:

<table>
<thead>
<tr>
<th>Level of Service</th>
<th>Design Year Peak Hour Vehicle Traffic Volume (Average Automobiles Per Lane Per Hour)</th>
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<tbody>
<tr>
<td>Urban C-E</td>
<td>1400-2400</td>
</tr>
<tr>
<td>Rural C-D</td>
<td>1000-1850</td>
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</table>
For conventional highways and expressways, District Planning and Traffic Operations should be consulted.

Automobile traffic volumes can be adjusted for the effect of grades and the mix of automobiles, trucks, and recreational vehicles if a more refined calculation is desired. In those cases, consult the "Highway Capacity Manual", published by the Transportation Research Board.

102.2 Design Capacity and Quality of Service (Pedestrians and Bicycles)

Sidewalks are to accommodate pedestrians at a Level of Service (LOS) equal to that of vehicles using the roadway, or better. More detailed guidance on design capacity for sidewalks is available in the “Highway Capacity Manual” (HCM), published by the Transportation Research Board. The HCM also has guidance regarding LOS for bicycle facilities for both on- and off-street applications. The LOS for on-street bicycle facilities should be equal to that of vehicles using the roadway or better. The design of off-street bicycle facilities can use the LOS methodology in the HCM when conditions justify deviations from the standards in Chapter 1000.

Topic 103 - Design Designation

103.1 Relation to Design

The design designation is a simple, concise expression of the basic factors controlling the design of a given highway. Following is an example of this expression:

\[
\begin{align*}
\text{ADT (2015)} & = 9800 & \text{D} & = 60 \% \\
\text{ADT (2035)} & = 20000 & \text{T} & = 12 \% \\
\text{DHV} & = 3000 & \text{V} & = 70 \text{ mph} \\
\text{ESAL} & = 4500000 & \text{TI}_{20} & = 11.0 \\
\text{CLIMATE REGION} & = \text{Desert}
\end{align*}
\]

The notation above is explained as follows:

ADT (2015) -- The average daily traffic, in number of vehicles, for the construction year.

ADT (2035) -- The average daily traffic for the future year used as a target in design.

CLIMATE REGION -- Climate Region as defined in Topic 615. In addition to establishing design requirements for the project, this information is used by the Resident Engineer during construction to determine which clauses in the Standard Specifications apply to the project.

DHV -- The two-way design hourly volume, vehicles.

D -- The percentage of the DHV in the direction of heavier flow.

ESAL -- The equivalent single axle loads forecasted for pavement engineering. See Topic 613.

T -- The truck traffic volume expressed as a percent of the DHV (excluding recreational vehicles).

TI$_{20}$ -- Traffic Index used for pavement engineering. The number in the subscript is the pavement design life used for pavement design. See Index 613.3(3).

V -- Design speed in miles per hour.

Within a project, one design designation should be used except when:

(a) The design hourly traffic warrants a change in the number of lanes, or

(b) A change in conditions dictates a change in design speed.

(c) The design daily truck traffic warrants a change in the Traffic Index.

The design designation should be stated in project initiation documents and project reports and should appear on the typical cross section for all new, reconstructed, or rehabilitation (including Capital Preventative Maintenance) highway construction projects.

103.2 Design Period

Geometric design of new facilities and reconstruction projects should normally be based on estimated traffic 20 years after completion of construction. With justification, design periods other than 20 years may be approved by the District Director with concurrence by the Project Delivery Coordinator.

For roundabout design period guidance, see Index 405.10.
Ramps and/or curb openings should be provided at midblock crosswalks and where pedestrians cross curbed channelization or median islands at intersections. Often, on traffic signalization, channelization, and similar projects, curbs are proposed to be modified only on portions of an existing intersection. In those cases, consideration should be given to installing retrofit curb ramps on all legs of the intersection.

(3) **Ramp Design.** Curb ramp designs should conform to current Standard Plans. See Index 105.4(3) for review procedures.

### 105.6 Pedestrian Crossings

There are various standards related to pedestrian crossings in this manual (e.g., the two curb ramps at each corner and pedestrian refuge island standards), as well as in DIB 82 (e.g., the curb ramp requirement) that depend on the existence of a pedestrian crossing as prescribed in the California Vehicle Code (CVC).

Pedestrian facilities that support pedestrian crossings occur at marked and unmarked crosswalks.

Per the CA MUTCD, a marked crosswalk is striped, including at midblock locations. An unmarked crosswalk is not striped and, per the CVC, depends on two elements: 1) it occurs at an intersection, and 2) it occurs where the sidewalk connects to the intersection. Without these two elements, there is no unmarked crosswalk.

Per the CVC, pedestrian crossings are provided across highways as marked or unmarked crosswalks, thereby requiring vehicles to yield to pedestrians (CVC 21950). Two examples in Figure 105.6 clarify the existence of unmarked crosswalks at “T” intersections, but may also apply to four legged intersections. This example is based on the following CVC citations:

- Section 275 - For the definition of crosswalk, see Index 62.4(5). Section 275 describes marked and unmarked crosswalks.
- Section 360 - A highway is a way or place of whatever nature, publicly maintained and open to the use of the public for purposes of vehicular travel. Highway includes street.

- Section 365 - An “intersection” is the area embraced within the prolongations of the lateral curb lines, or, if none, then the lateral boundary lines of the roadways, of two highways which join one another at approximately right angles or the area within which vehicles traveling upon different highways joining at any other angle may come in conflict.

- Section 530 - A “roadway” is that portion of a highway improved, designed, or ordinarily used for vehicular travel.

- Section 555 - A “sidewalk” is that portion of a highway, other than the roadway, set apart by curbs, barriers, markings or other delineation for pedestrian travel.

### Topic 106 - Stage Construction and Utilization of Local Roads

#### 106.1 Stage Construction

(1) **Cost Control Measures.** When funds are limited and costs increase, estimated project costs often exceed the amounts available in spite of the best efforts of the engineering staff. At such times the advantages of reducing initial project costs by some form of stage construction should be considered by the Project Delivery Team as an alternative to deferring the entire project. Stage construction may include one or more of the following:

(a) Shorten the proposed improvement, or divide it into segments for construction in successive years;

(b) Reduce number of lanes for initial construction. For example, a 4-lane freeway in a rural area with low current traffic volumes might be staged for two lanes initially with capacity adequate for at least 10 years after construction. Similarly, a freeway might be constructed initially four or six lanes wide with provision for future widening in the median to meet future traffic needs.

(c) Down scope geometric design features. This last expedient should be considered only as a last resort; geometric features such as alignment, grade, sight distance, weaving, or merging distance, are difficult
Figure 105.6

Typical Pedestrian Crossings at “T” Intersections

With a painted/raised median through the intersection, this portion is no longer part of the intersection – this directional travel lane does not join the crossroad, nor do vehicles come into conflict.

No unmarked crosswalk – sidewalk does not prolong or connect with sidewalk across the painted/raised median.

State Highway

Unmarked crosswalk – sidewalk connects through the intersection across break in painted/raised median or crossroad.

Example 1: State Highway with Partial Intersection

Unmarked crosswalk – sidewalk connects through the intersection across break in painted/raised median or crossroad.

Not an unmarked crosswalk if planter strip creates a barrier or location is not meeting the definition of a sidewalk and does not connect to the curb.

State Highway

Example 2: State Highway Intersection

Unmarked Crosswalk
Sidewalk
Planter Strip
Painted/Raised Median
(2) Drainage Culverts or Other Materials. The Materials Report must contain a sufficient number of alternatives that materially meet or exceed the culvert design life (and other drainage related) standards for the Project Engineer to establish the most maintainable, constructible, and cost effective alternative in conformance with FHWA regulations (23 CFR 635D).

(3) Corrosion. Corrosion studies are necessary when new culverts, culvert rehabilitation, or culvert extensions are part of the scope of the project. Studies should satisfy the requirements of the “Corrosion Guidelines”. Copies of the guidelines can be obtained from the Corrosion Technology Branch in DES Materials Engineering and Testing Services or on the DES Materials Engineering and Testing Services website.

(4) Materials or Disposal Sites. See Topic 111 “Material Sites and Disposal Sites” for conditions when sites need to be identified and how to document.

114.4 Preliminary Materials Report
Because resources and/or time are sometimes limited, it is not always possible to complete all the tests and studies necessary for a final Materials Report during the planning/scooping phase. In these instances, a Preliminary Materials Report may be issued using the best information available and good engineering judgment. Accurate traffic projections and design designations are still required for the Preliminary Materials Report. Preliminary Materials Reports should not be used for project reports or PS&E development. When used, Preliminary Materials Reports must document the sources of information used and assumptions made. It must clearly state that the Preliminary Materials Report is to be used for planning and initial cost estimating only and not for final design. The Department Pavement website contains supplemental guidance for developing preliminary pavement structures.

114.5 Review and Retention of Records
A copy of the Draft Materials Report is to be submitted for review and comment to the District Materials Engineer. The District Materials Engineer reviews the document for the Department to assure that it meets the standards, policies, and other requirements found in Department manuals, and supplemental district guidance (Index 604.2(2)). If it is found that the document meets these standards, the District Materials Engineer accepts the Materials Report. If not, the report is returned with comments to the submitter.

After resolution of the comments, a final copy of the Materials Report is submitted to the District Materials Engineer who then furnishes it to the Project Engineer. The original copy of the Materials Report must be permanently retained in the District’s project history file and be accessible for review by others when requested.

**Topic 115 - Designing for Bicycle Traffic**

115.1 General

Under the California Vehicle Code, bicyclists generally have the same rights and duties that motor vehicle drivers do when using the State highway system. For example, they make the same merging and turning movements, they need adequate sight distance, they need access to all destinations, etc. Therefore, designing for bicycle traffic and designing for motor vehicle traffic are similar and based on the same fundamental transportation engineering principles. The main differences between bicycle and motor vehicle operations are lower speed and acceleration capabilities, as well as greater sensitivity to out of direction travel and steep uphill grades. Design guidance that addresses the safety and mobility needs of bicyclists on Class II bikeways (bike lanes) is distributed throughout this manual. See Chapter 1000 for additional bicycle guidance for Class I bikeways (bike paths) and Class III bikeways (bike routes). See Design Information Bulletin (DIB) 89 for Class IV bikeways (separated bikeways) guidance.

All city, county, regional and other local agencies responsible for bikeways or roads except those freeway segments where bicycle travel is prohibited shall follow the bikeway design criteria established in this manual and the California MUTCD, as authorized in the Streets and Highways Code Sections 890.6 and 891(a). However, a local agency may utilize alternative design criteria as prescribed in the Streets and Highways Code Section 891(b).
The decision to develop bikeways should be made in consultation and coordination with local agencies responsible for bikeway planning to ensure connectivity and network development.

Generally speaking, bicycle travel can be enhanced by bikeways or improvements to the right-hand portion of roadways, where bicycles are required to travel. When feasible, a wider shoulder than minimum standard should be considered since bicyclists are required to ride to as far to the right as possible, and shoulders provide bicyclists an opportunity to pull over to let faster traffic pass.

All transportation improvements are an opportunity to improve safety, access, and mobility for the bicycle mode of travel.

**Topic 116 - Bicyclists and Pedestrians on Freeways**

**116.1 General**

Seldom is a freeway shoulder open to bicycle, pedestrian or other non-motorized travel, but they can be opened for use if certain criteria assessing the safety and convenience of the freeway, as compared with available alternate routes, is met. However, a freeway should not be opened to bicycle or pedestrian use if it is determined to be incompatible. The District Traffic Engineer or designee and the Project Delivery Coordinator must approve any proposals to open freeways to bicyclists, pedestrian or other non-motorized use. See the California MUTCD and CVC Section 21960.

When a new freeway segment is to remain open or existing freeway segment is to be reopened to these modes, it is necessary to evaluate the freeway features for their compatibility with safe and efficient travel, including:

- Shoulder widths
- Drainage grates; see Index 1003.5(2)
- Expansion joints
- Utility access covers on shoulders
- Frequency and spacing of entrance/exit ramps
- Multiple-lane entrance/exit ramps
- Traffic volumes on entrance/exit ramps and on lanes merging into exit ramps
- Sight distance at entrance/exit ramps
- Freeway to freeway interchanges
- The presence and design of rumble strips
- Longitudinal edges and joints

If a freeway segment has no suitable non-freeway alternative and is closed because certain features are considered incompatible, the feasibility of eliminating or reducing the incompatible features should be evaluated. This evaluation may include removal, redesign, replacement, relocation or retrofitting of the incompatible feature, or installation of signing, pavement markings, or other traffic control devices.

Where no reasonable, convenient and safe non-freeway alternative exists within a freeway corridor, the Department should coordinate with local agencies to develop new routes, improve existing routes or provide parallel bicycle and pedestrian facilities within or adjacent to the freeway right of way. See Project Development Procedures Manual Chapter 1, Article 3 (Regional and System Planning) and Chapter 31 (Nonmotorized Transportation Facilities) for discussion of the development of non-freeway transportation alternatives.
CHAPTER 200  
GEOMETRIC DESIGN AND  
STRUCTURE STANDARDS  

Topic 201 - Sight Distance  

Index 201.1 - General  

Sight distance is the continuous length of highway ahead, visible to the highway user. Four types of sight distance are considered herein: passing, stopping, decision, and corner. Passing sight distance is used where use of an opposing lane can provide passing opportunities (see Index 201.2). Stopping sight distance is the minimum sight distance for a given design speed to be provided on multilane highways and on 2-lane roads when passing sight distance is not economically obtainable. Stopping sight distance also is to be provided for all users, including motorists and bicyclists, at all elements of interchanges and intersections at grade, including private road connections (see Topic 504, Index 405.1, & Figure 405.7). Decision sight distance is used at major decision points (see Indexes 201.7 and 504.2). Corner sight distance is used at intersections (see Index 405.1, Figure 405.7, and Figure 504.3I).  

Table 201.1 shows the minimum standards for stopping sight distance related to design speed for motorists. Stopping sight distances given in the table are suitable for Class II and Class III bikeways. The stopping sight distances are also applicable to roundabout design on the approach roadway, within the circulatory roadway, and on the exits prior to the pedestrian crossings. Also shown in Table 201.1 are the values for use in providing passing sight distance.  

See Chapter 1000 for Class I bikeway sight distance guidance.  

Chapter 3 of "A Policy on Geometric Design of Highways and Streets," AASHTO, contains a thorough discussion of the derivation of stopping sight distance.  

201.2 Passing Sight Distance  

Passing sight distance is the minimum sight distance required for the driver of one vehicle to pass another vehicle safely and comfortably. Passing must be accomplished assuming an oncoming vehicle comes into view and maintains the design speed, without reduction, after the overtaking maneuver is started.  

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Stopping (ft)</th>
<th>Passing (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>50</td>
<td>---</td>
</tr>
<tr>
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<td>100</td>
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</tr>
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<td>20</td>
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<td>2,600</td>
</tr>
<tr>
<td>80</td>
<td>930</td>
<td>2,700</td>
</tr>
</tbody>
</table>

(1) See Topic 101 for selection of design speed.  
(2) For sustained downgrades, refer to underlined standard in Index 201.3.  

The sight distance available for passing at any place is the longest distance at which a driver whose eyes are 3 ½ feet above the pavement surface can see the top of an object 4 ¼ feet high on the road. See Table 201.1 for the calculated values that are associated with various design speeds.  

In general, 2-lane highways should be designed to provide for passing where possible, especially those routes with high volumes of trucks or recreational vehicles. Passing should be done on tangent horizontal alignments with constant grades or a slight sag vertical curve. Not only are drivers reluctant to pass on a long crest vertical curve, but it is impracticable to design crest vertical curves to provide for passing sight distance because of high cost where crest cuts are involved. Passing sight
distance for crest vertical curves is 7 to 17 times longer than the stopping sight distance.

Ordinarily, passing sight distance is provided at locations where combinations of alignment and profile do not require the use of crest vertical curves.

Passing sight distance is considered only on 2-lane roads. At critical locations, a stretch of 3- or 4-lane passing section with stopping sight distance is sometimes more economical than two lanes with passing sight distance.

Passing on sag vertical curves can be accomplished both day and night because headlights can be seen through the entire curve.

See Part 3 of the California Manual on Uniform Traffic Control Devices (California MUTCD) for criteria relating to the placement of barrier striping for no-passing zones. Note, that the passing sight distances shown in the California MUTCD are based on traffic operational criteria. Traffic operational criteria are different from the design characteristics used to develop the values provided in Table 201.1 and Chapter 3 of AASHTO, A Policy on Geometric Design of Highways and Streets. The aforementioned table and AASHTO reference are also used to design the vertical profile and horizontal alignment of the highway. Consult the District Traffic Engineer or designee when using the California MUTCD criteria for traffic operating-control needs.

Other means for providing passing opportunities, such as climbing lanes or turnouts, are discussed in Index 204.5. Chapter 3 of AASHTO, A Policy on Geometric Design of Highways and Streets, contains a thorough discussion of the derivation of passing sight distance.

201.3 Stopping Sight Distance

The minimum stopping sight distance is the distance required by the user, traveling at a given speed, to bring the vehicle or bicycle to a stop after an object ½-foot high on the road becomes visible. Stopping sight distance for motorists is measured from the driver's eyes, which are assumed to be 3 ½ feet above the pavement surface, to an object ½-foot high on the road. See Index 1003.1(10) for Class I bikeway stopping sight distance guidance.

The stopping sight distances in Table 201.1 should be increased by 20 percent on sustained downgrades steeper than 3 percent and longer than one mile.

201.4 Stopping Sight Distance at Grade Crests

Figure 201.4 shows graphically the relationships between length of highway crest vertical curve, design speed, and algebraic difference in grades. Any one factor can be determined when the other two are known.

201.5 Stopping Sight Distance at Grade Sags

From the curves in Figure 201.5, the minimum length of vertical curve which provides headlight sight distance in grade sags for a given design speed can be obtained.

If headlight sight distance is not obtainable at grade sags, lighting may be considered. The District approval authority or Project Delivery Coordinator, depending upon the current District Design Delegation Agreement, and the District Traffic Engineer or designee shall be contacted to review proposed grade sag lighting to determine if such use is appropriate.

201.6 Stopping Sight Distance on Horizontal Curves

Where an object off the pavement such as a bridge pier, building, cut slope, or natural growth restricts sight distance, the minimum radius of curvature is determined by the stopping sight distance.

Available stopping sight distance on horizontal curves is obtained from Figure 201.6. It is assumed that the driver's eye is 3 ½ feet above the center of the inside lane (inside with respect to curve) and the object is ½-foot high. The line of sight is assumed to intercept the view obstruction at the midpoint of the sight line and 2 feet above the center of the inside lane when the road profile is flat (i.e. no vertical curve). Crest vertical curves can cause additional reductions in sight distance. The clear distance (m) is measured from the center of the inside lane to the obstruction.

The design objective is to determine the required clear distance from centerline of inside lane to a retaining wall, bridge pier, abutment, cut slope, or other obstruction for a given design speed. Using
the radius of 1,830 feet to obtain a superelevation of 5.4 percent. Also, Tables 202.2A through 202.2E use the following terms as defined:

1. “normal crown” (NC) designates a traveled way cross section used on curves that are so flat that the elimination of adverse cross slope is not needed, and thus the normal cross slope sections can be used. See Index 301.3 for further guidance.

2. “remove adverse crown” (RC) designates curves where the adverse cross slope should be eliminated by superelevating the entire roadway at the normal cross slope rate.

Maximum comfortable speed is determined by the formula given on Figure 202.2. It represents the speed on a curve where discomfort caused by centripetal acceleration is evident to a driver. AASHTO, A Policy on Geometric Design of Highways and Streets, states, “In general, studies show that the maximum side friction factors developed between new tires and wet concrete pavements range from about 0.5 at 20 miles per hour to approximately 0.35 at 60 miles per hour. In all cases, the studies show a decrease in friction values as speeds increase.

To use Figure 202.2, the designer must decide on the relative importance among three variables. Normally, when a nonstandard superelevation rate is approved, Figure 202.2 will be entered with the superelevation rate and a desired curve radius. It must then be determined whether the resulting maximum comfortable speed is adequate for the conditions or whether further adjustments to radius and superelevation may be needed.

Except for short radius curves, the standard superelevation rate results in very little side thrust at speeds less than 45 miles per hour. This provides maximum comfort for most drivers.

Superelevation for horizontal curves with radii of 10,000 feet and greater may be deleted in those situations where the combination of a flat grade and a superelevation transition would create undesirable drainage conditions on the pavement.

Superelevated cross slopes on curves extend the full width of the traveled way and shoulders, except that the shoulder slope on the low side should be not less than the minimum shoulder slope used on the tangents (see Index 304.3 for cross slopes under cut widening conditions).

On rural 2-lane roads, superelevation should be on the same plane for the full width of traveled way and shoulders, except on transitions (see Index 304.3 for cut widening conditions).

2. Bikeways. Superelevation design criteria in Index 202.2(1) also accommodates Class II, III, and IV bikeways. See Index 1003.1 for Class I guidance.

202.3 Restrictive Conditions

Lower superelevation rates than those given in either Table 202.2 or Figure 202.2 may be necessary in areas where restricted speed zones or ramp/street intersections are controlling factors. Other typical locations are short radius curves on ramps near the local road juncture, either at an intersection or where a loop connects with an overcrossing structure. Often, established street grades, curbs, or drainage may prove difficult to alter and/or superelevation transition lengths would be undesirably short.

Such conditions may justify a reduction in the superelevation rate, different rates for each half of the roadbed, or both. In any case, the superelevation rate provided should be appropriate for the conditions allowing for a smooth transition while providing the maximum level of comfort to the driver. Where standard superelevation rates cannot be attained, discussions should be held with the District Design Liaison and/or the Project Delivery Coordinator to determine the proper solution and the necessity of preparing a design standard decision document. In warping street or ramp surface areas for drainage, adverse superelevation should be avoided (see Figure 202.2).

202.4 Axis of Rotation

1. Undivided Highways. For undivided highways the axis of rotation for superelevation is usually the centerline of the roadbed. However, in special cases such as desert roads where curves are preceded by long relatively level tangents, the plane of superelevation may be rotated about
### Table 202.2A
Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{\text{max}}=4\%$

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<thead>
<tr>
<th>$e$ (%)</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
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<tr>
<td></td>
<td>$V_d$ (mph)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>R (ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NC</td>
<td>1410</td>
<td>2050</td>
<td>2830</td>
<td>3730</td>
<td>4770</td>
<td>5930</td>
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<td>154</td>
<td>250</td>
<td>371</td>
<td>533</td>
<td>711</td>
<td>926</td>
</tr>
</tbody>
</table>
Figure 204.5
Critical Lengths of Grade for Design

ASSUMED TYPICAL HEAVY TRUCK OF 200 lb/hp
The Headquarters Division of Traffic Operations should be consulted regarding the length of climbing and passing lanes, which will vary with the design speed of the highway, the traffic volume, and other factors.

(4) Turnouts

(a) General. On a two-lane highway where passing is limited, the California Vehicle Code requires slow-moving vehicles followed by five or more vehicles to turn off at designated turnouts or wherever sufficient area for a safe turnout exists. Designated turnouts may be constructed in hilly or mountainous terrain or on winding roads in other areas.

Where less than 4-foot shoulders are provided on ascending grades, consideration should be given to providing several short sections of 4 feet or wider shoulder as turnouts for bicycle passing. Frequent turnouts that are at least 30 feet in length are recommended on sustained uphill grades. These turnouts will allow safe passing of bicycles by other bicyclists and vehicles in addition to providing resting opportunities on the sustained grade for bicyclists.

(b) Length. Designated turnouts should be from 200 feet to 500 feet long including a short taper (usually 50 feet) at each end. Approach speeds, grades, traffic volumes, and available space are some factors to be considered in determining the length. The District Traffic Engineer or designee should be consulted if longer turnouts are desired.

(c) Width. Paved widths of at least 15 feet in fill sections and 12 feet in cut sections are recommended. Width is measured from the edge of traveled way. On the outside of curves along steep fill slopes or dropoffs, greater width or the installation of guardrail should be considered.

(d) Location. Turnouts should be located where there is stopping sight distance for approaching drivers to see vehicles leaving and re-entering the through lanes.

204.6 Coordination of Horizontal and Vertical Alignment

A proper balance between curvature and grades should be sought. When possible, vertical curves should be superimposed on horizontal curves. This reduces the number of sight restrictions on the project, makes changes in profile less apparent, particularly in rolling country, and results in a pleasing appearance. Where the change in horizontal alignment at a grade summit is moderate, a pleasing appearance may be attained by making the vertical curve overlap the horizontal curve.

When horizontal and vertical curves are superimposed, the combination of superelavation and profile grades may cause distortion in the outer pavement edges which could create drainage concerns or confuse drivers at night. In such situations edge of pavement profiles should be plotted and smooth curves introduced to eliminate any irregularities or distortion.

On highways in mountainous or rolling terrain where horizontal and vertical curves are superimposed at a grade summit or sag, the design speed of the horizontal curve should be at least equal to that of the crest or sag, and not more than 10 miles per hour less than the measured or estimated running (85th percentile) speed of vehicles on the approach roadway.

On long open curves, a uniform grade line should be used because a rolling profile makes for a poor appearance.

Horizontal and vertical curvature at intersections should be as flat as physical conditions permit.

See “Combination of Horizontal and Vertical Alignment” in Chapter III of AASHTO, A Policy on Geometric Design of Highways and Streets, for further guidance on a alignment consistency.

204.7 Separate Grade Lines

Separate or independent grade lines are appropriate in some cases for freeways and expressways.

They are not normally considered appropriate where medians are less than 65 feet wide (see Index 305.6). Exceptions to this may be minor differences between opposing grade lines in special situations.
the submission may be found at https://oeaaa.faa.gov/oeaaa/external/portal.jsp.

When required, four copies of FAA Form 7460-1, and accompanying scaled maps should be sent to:

Mail Processing Center
Federal Aviation Administration
Southwest Regional Office
Obstruction Evaluation Group
10101 Hillwood Parkway
Fort Worth, TX 76177
Fax: (817) 222-5920

Copies of FAA Form 7460-1 may be obtained from the Caltrans, Division of Aeronautics or at https://oeaaa.faa.gov/oeaaa/external/portal.jsp.

The scaled maps accompanying FAA Form 7460-1 should contain the following minimum information.

- Distance from project to nearest runway.
- Elevation of runway thresholds.
- Relationship between the proposed highway horizontal alignment and vertical profile to the nearest runway or heliport primary surface. Include elevations of objects referenced to the elevation of the end of the runway, such as overhead lights, signs, structures, landscaping, and vehicles.

One copy of FAA Form 7460-1 should be forwarded to the Division of Design for information and one copy to the Division of Aeronautics for information and land use compatibility review.

Topic 208 – Bridges, Grade Separation Structures, and Structure Approach Embankment

208.1 Bridge Lane and Shoulder Width

(1) State Highways. The clear width of all bridges, including grade separation structures, shall equal the full width of the traveled way and paved shoulders on the approaches with the following exceptions:

(a) Bridges to be constructed as replacements on existing 2-lane, 2-way roads shall not have less than a 32-foot wide roadbed for ADT less than 400, and not less than 40-foot wide roadbed for ADT greater than 400. (see Index 307.2).

(b) When the approach shoulder width is less than 4 feet, the minimum offset on each side shall be 4 feet, and shall be documented in accordance with Index 82.2.

The width should be measured normal to the center line between faces of curb or railing measured at the gutter line. For offsets to safety shape barriers see Figure 208.1.

For horizontal and vertical clearances, see Topic 309.

(2) Roads Under Other Jurisdictions.

(a) Overcrossing Widths--(See Index 308.1)

(b) Undercrossing Span Lengths--Initial construction should provide for the ultimate requirements. In areas where the local jurisdiction has a definite plan of development, the ultimate right of way width or at least that portion needed for the roadbed and sidewalks should be spanned.

If the undercrossing street or road has no median, one should be provided where necessary to accommodate left-turn lanes or the center piers of the undercrossing structure.

Where it appears that a 2-lane road will be adequate for the foreseeable future, but no right of way width has been established, a minimum span length sufficient for a 40-foot roadbed should be provided. Additional span length should be provided to permit future sidewalks where there is a foreseeable need. If it is reasonably foreseeable that more than two lanes will be required ultimately, a greater width should be spanned.

(c) For horizontal and vertical clearances, see Topic 309.

208.2 Cross Slope

The crown is normally centered on the bridge except for one-way bridges where a straight cross slope in one direction should be used. The cross slope should
Figure 207.2A
Airway-Highway Clearance Requirements
(Civil Airports)

* 7:1
** HORIZONTAL SURFACE 150’ ABOVE ESTABLISHED AIRPORT ELEVATION
*** 16-6’ FREEWAYS
15-0’ CONVENTIONAL HIGHWAYS
10-0’ PRIVATE ROADS

VISUAL OR NON-PRECISION APPROACH (SLOPE-E)

CONICAL SURFACE

PRECISION INSTRUMENT APPROACH

RUNWAY CENTERLINES

ISOMETRIC VIEW OF SECTION A-A

RUNWAY CENTERLINE

0’ for unpaved runways
200 for paved runways

10:1 Transition Surface

17 Min.

Shoulder Edge

Approach Area

Approach Surface

<table>
<thead>
<tr>
<th>RUNWAY STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPES OF RUNWAY</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>ITEM</td>
</tr>
<tr>
<td>DIM.</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>E</td>
</tr>
</tbody>
</table>

I UTILITY RUNWAY
II RUNWAYS LARGER THAN UTILITY
III VISIBILITY MINIMUMS GREATER THAN 3/4 MILE
IV VISIBILITY MINIMUMS AS LOW AS 3/4 MILE

PRECISION INSTRUMENT APPROACH SLOPE IS 50:1 FOR INNER 10,000 FEET AND 40:1 FOR AN ADDITIONAL 10,000 FEET
be the same as for the approach pavement (see Index 301.3 and Index 203.9).

208.3 Median

On multilane divided highways a bridge median that is 36 feet wide or less should be decked. Exceptions require individual analysis. See Traffic Safety Systems Guidance for median barrier warrants.

208.4 Bridge Sidewalks

Sidewalks on bridges should be provided wherever there are sidewalks or other pedestrian facilities that follow the highway. The minimum width of a bridge sidewalk shall be 6 feet. The recommended width should be 8 feet for pedestrian comfort. Bridges sidewalks in area types (see Index 81.2) with high levels of pedestrian activity may need to be greater than 8 feet (see Figure 208.10B).

208.5 Open End Structures

Embankment end slopes at open end structures should be no steeper than 1½:1 for all highways.

208.6 Bicycle and Pedestrian Overcrossings and Undercrossings

A bicycle overcrossing (BOC) or undercrossing (BUC) is a facility that provides a connection between bikeways or roads open to bicycling. They are considered Class I bikeways, or in certain situations may be considered Class IV bikeways. See Index 1003.1 for Class I bikeway guidance or DIB 89 for Class IV bikeways (separated bikeways) guidance.

A pedestrian overcrossing (POC) or undercrossing (PUC) is a facility that provides a connection between pedestrian walkways.

The minimum width of walkway for pedestrian overcrossing should be 8 feet. The minimum vertical clearance of a pedestrian undercrossing should be 10 feet. Skewed crossings should be avoided.

POC’s and PUC’s must be designed to comply with DIB 82.

See Topic 309 for vertical clearances.

208.7 Equestrian Undercrossings and Overcrossings

Such structures should normally provide a clear opening 10 feet high and 10 feet wide. Skewed crossings should be avoided. The structure should be straight so the entire length can be seen from each end. Sustained grades should be a maximum of 10 percent. Decomposed granite or similar material should be used for the trail surface. While flexible pavement is permissible, a rigid pavement should not be used. See Index 1003.4 for separation between bicycle paths and equestrian trails. See DIB 82 for when trails are open to pedestrians.

Design guidance for equestrian overcrossings is pending.

208.8 Cattle Passes, Equipment, and Deer Crossings

Private cattle passes and equipment crossings may be constructed when economically justified by a right of way appraisal, as outlined in Section 7.09.09.00 of the Right of Way Manual.

The standard cattle pass should consist of either a standard box culvert with an opening 8 feet wide and 8 feet high or a metal pipe 120 inches in diameter. The invert of metal pipe should be paved with concrete or bituminous paving material.

If equestrian traffic is expected to use the culvert a minimum 10 feet wide by 10 feet high structure may be provided. However, the user of the facility should be contacted to determine the specific requirements.

If conditions indicate a reasonable need for a larger than standard cattle pass, it may be provided if economically justified by the right of way appraisal.

In some cases the installation of equipment or deer crossings is justified on the basis of public interest or need rather than economics. Examples are:

(a) A deer crossing or other structure for environmental protection purposes.
(b) Equipment crossings for the Forest Service or other governmental agencies or as a right of way obligation.

These facilities should be installed where necessary as determined by consultation with the appropriate affected entities.

A clear line of sight should be provided through the structure.

208.9 Railroad Underpasses and Overheads

Generally, it is desirable to construct overheads rather than underpasses whenever it is necessary for a highway and railroad to cross. Railroads should be carried over highways only when there is no other reasonable alternative.

Some undesirable features of underpasses are:

(a) They create bottlenecks for railroad operations.
(b) It is difficult to widen the highway.
(c) Pumping plants are often required to drain the highway.
(d) They are likely to lead to cost participation controversies for initial and future construction.
(e) Shooflies (temporary tracks) are generally required during construction.
(f) Railroads are concerned about the structure maintenance and liability costs they incur.

Advantages of overheads are:

(a) Railroads can use most of their right of way for maintenance.
(b) Overheads can be widened at a relatively low cost and with little difficulty.
(c) Less damage may be incurred in the event of a derailment.
(d) Agreements for design and maintenance can be reached more easily with railroads.
(e) Initial costs are generally lower.

The State, the railroads, and the public in general can usually benefit from the construction of an overhead structure rather than an underpass.

See Topic 309 for vertical clearances.

208.10 Bridge Barriers and Railings

(1) General. There are four classes of railings, each intended to perform a different function.

(a) Vehicular Barrier Railings--The primary function of these railings is to retain and redirect errant vehicles.
(b) Combination Vehicular Barrier and Pedestrian Railings--These railings perform the dual function of retaining both vehicles and pedestrians on the bridge. They consist of two parts--A concrete parapet barrier, generally with a sidewalk, and metal handrail or fence-type railing.
(c) Pedestrian Railings--These railings prevent pedestrians from accidentally falling from the structure and, in the case of fence-type railing, reduce the risk of objects being dropped on the roadway below. See DIB 82 for additional requirements.
(d) Bicycle Railings--These railings retain bicycles and riders on the structure. They may be specifically designed for bicycles, or may be a combination type consisting of a vehicular barrier surmounted by a fence or metal handrail.

(2) Policies. To reduce the risk of objects being dropped or thrown upon vehicles, protective screening in the form of fence-type railings should be installed along new overcrossing structure sidewalks in urban areas (Sec. 92.6 California Streets and Highways Code). Screening should be considered for the opposite side of structures having one sidewalk. Screening should be installed at such other locations determined to be appropriate.

Railings and barriers with sidewalks should not be used on structures with posted speeds greater than 45 miles per hour without barrier separation. All structure railings with a sidewalk in the Standard Plans are approved for posted speeds up to 45 miles per hour. Any use of railings and barriers with sidewalks on structures with posted speeds greater than 45 miles per hour shall have a barrier separation between the roadway and the sidewalk. The barrier separation type and the
bridge rail selection requires approval by the District Traffic Engineer or designee.

The approved types of railings for use on bridge structures are listed below and illustrated in Figures 208.10A, B, and C. Railing types not listed are no longer in general use; however, they may be specified in those cases where it is desirable to match an existing condition.

The District should specify in the bridge site data submittal the rail type to be used after consideration has been given to the recommendations of the local agency (where applicable) and the DES-SD.

(3) Vehicular Barriers. See Figure 208.10A.

(a) Concrete Barrier Type 736 and 742--These vehicular barriers are for general use adjacent to traffic. Figure 208.1 illustrates the position of the barrier relative to the edge of traveled way.

(b) Concrete Barrier Type 80 and bridge metal rail barriers--Use of these barriers is intended in scenic areas where more see-through area is desired than is provided by a solid concrete parapet.

(4) Combination Railings. See Figure 208.10B.

(a) Barrier Railing Type 732SW--This is the barrier railing for general use when sidewalks are provided on a bridge. It must be accompanied with a tubular handrailing or a fence-type railing. See Index 208.4 for minimum width, however, this width may be varied as circumstances require.

(b) Barrier Railing Type 80SW--Similar to the Type 80, modified with a raised sidewalk and tubular handrailing. It is intended for use in lower speed scenic areas where more see-through area is desired than is provided by a solid concrete parapet. The minimum sidewalk width is 6 feet; however, this width may be varied as circumstances require.

(c) Chain Link Railing Type 7--This is the fence-type railing for general use with Type 732SW or Type 80SW barrier railing with sidewalk to reduce the risk of objects being dropped on the roadway below. When a sidewalk is provided on one side of a bridge and Type 736 barrier railing on the other side, Type 7 railing may be placed on top of the Type 736 as additional protection from dropped objects. Consideration should be given to the effect of the Type 7 railing on sight distance at the bridge ends and view over the side of the bridge. Lighting fixtures may be provided with Type 7 railings.

(d) Chain Link Railing Type 6--This railing may be used in lieu of Type 7 when special architectural treatment is required. It should not be used on curved alignment because of fabrication difficulties.

(e) Tubular Handrailing--This railing is used with Type 732SW, and Type 80SW to increase the combined rail height for the safety of pedestrians. It should be used in lieu of Type 7 where object dropping will not be a problem or at the ends of bridges to increase sight distance if fence-type railing would restrict sight distance.

(5) Pedestrian Railings. See Figure 208.10C

(a) Chain Link Railing Type 3--This railing is used on pedestrian structures to reduce the risk of objects being dropped on the roadway below.

(b) Chain Link Railing Type 7 (Modified)--This railing is similar to Type 7 except that it is mounted on the structure at the sidewalk level.

(c) Chain Link Railing--This railing is not as high as Types 3 or 7 and therefore, its use is restricted to those locations where object dropping or throwing will not be a problem.

(d) Chain Link Railing (Modification)--Existing railing may be modified for screening under the protective screening policy. The DES-SD should be contacted for details.

(6) Bicycle Railing. The height of bicycle rail shall not be less than 42.0 inches, measured from the top of the riding surface. In some cases the
bicycle railing shall be offset 15.0 inches behind the face of the vehicular rail. Contact DES, Office of Design and Technical Services for more information. Pedestrian railings and combination railings consisting of a concrete barrier surmounted by a fence or tubular railing are satisfactory for bicycles, if a minimum 42-inch height is met. Bicycles are not considered to operate on a sidewalk, except in special cases where signs specifically direct cyclists to use a bike path or the sidewalk.

As a general policy, bicycle railings should be installed at the following locations:

(a) On a Class I bikeway, except that a lower rail may be used if a curbed sidewalk, not signed for bicycle use, separates the bikeway from the rail or a shoulder at least 8 feet wide exists on the other side of the rail.

(b) On the outside of a Class II or III bikeway, unless a curbed sidewalk, not signed for bicycle use, separates the bikeway from the rail.

(c) In other locations where the designer deems it reasonable and appropriate.

(7) Bridge Approach Railings. Approach railings shall be installed at the ends of bridge railings exposed to approach traffic.

Refer to Traffic Safety Systems Guidance for placement and design criteria of guardrail.

208.11 Structure Approach Embankment

(1) General. Structure approach embankment is that portion of the fill material within approximately 150 feet longitudinally of the structure. Refer to Figure 208.11A for limits, the Standard Specifications, and Standard Special Provisions for more information.

Quality requirements for embankment material are normally specified only in the case of imported borrow. When select material or local borrow for use in structure abutment embankments is shown on the plans, the Resident Engineer (RE) is responsible for assuring the adequacy of the quantity and quality of the specified material. The Project Engineer should include adequate information and guidance in the RE File to assist the RE in fulfilling this responsibility.

(2) Foundations and Embankment Design. Overall performance of the highway approach to the bridge depends, to a significant degree, upon the long-term settlement/consolidation of the approach foundation and structure abutment embankment. A design that minimizes this post construction settlement/consolidation is essential. Factors that influence settlement/consolidation include soil types and depths, static and dynamic loads, ground water level, adjacent operations, and changes in any of the above. The PE must follow the foundation and embankment recommendations by the Division of Engineering Services, Geotechnical Services (DES-GS) and District Materials Engineer (DME). The DME and/or DES-GS must approve any deviations from their recommendations including Construction Change Orders (CCO’s).

The relative compaction of material within the embankment limits must be at least 95 percent, except for the outer 5 feet of embankment measured horizontally from the side slope (see Figure 208.11A). The DME and/or OSF may recommend using select material, local and/or imported borrow to assure that the compaction requirements are met and that shrink/swell problems are avoided. They may also recommend a height and duration of embankment surcharge to accelerate foundation consolidation.

Poor quality material, such as expansive soils, must be precluded from structure abutment embankments unless treated. If sufficient quality roadway excavation material is unavailable for constructing of structure abutment embankments, the designer may specify select material, local borrow, or imported borrow to satisfy the design requirements.

(3) Abutment Drainage. Special attention must be given to providing a positive drainage system that minimizes the potential for water damage to the structure approach embankment, see Chapter 870 for further details. The Division
Where ground water is likely to occur in any quantity, special provisions must be made to intercept the flow to prevent inundation of the backfill.

(c) Quantities. When the AERS procedure is not utilized, quantities for each item of work are usually developed for payment. Bid items must include, but not be limited to: excavation and backfill for the embedment depth, soil reinforcement, facing elements, and concrete for leveling pad construction. Additional bid items for inclusion are any drainage system, pervious backfill, concrete barrier, railings, and concrete gutters. Quantities should be tabulated on the plans for each wall.

(5) Earth Retaining Systems. The following miscellaneous details are applicable to all earth retaining systems:

(a) Utilities. Provisions must be made to relocate or otherwise accommodate utilities conflicting with the retaining wall. A utility opening for a Type 1 wall is shown on Standard Plan B3-9. Any other utility openings will require special design details and should be reviewed by DES-SD.

(b) Electroliers and Signs. Details for mounting electroliers and signs on earth retaining systems are designed by DES-SD. Requests for preparation of details should be made at least 3 months in advance of the PS&E submittal to District Officer Engineer date. To accommodate the base plates for overhead signs, a local enlargement may affect the horizontal clearance to both the edge of pavement and the right of way line. This type of enlargement should be considered at the time of establishing the wall layout and a need for a design standard decision document determined. For mounting details, furnish DES-SD a complete cross section of the roadway at the sign and the layout and profile of the earth retaining system.

(c) Fence and Railing Post Pockets. Post pocket details shown for cable railing in the Standard Plans may also be used for mounting chain link fence on top of retaining walls. Special details may be necessary to accommodate the reinforcement in soil reinforcement systems.

(d) Return Walls. Return walls should be considered for use on the ends of the walls to provide a finished appearance. Return walls are necessary when wall offsets are used or when the top of wall is stepped. Return walls for soil reinforcement systems will require special designs to accommodate the overlapping of soil reinforcing elements.

All special wall details such as sign bases, utility openings, drainage features, fences, and concrete barriers should be shown on the plan sheet of the wall concerned or included on a separate sheet with the wall plan sheets. Details should be cross-referenced on the wall sheets to the sheets on which they are shown.
2-lane pavement as one of the divided highway roadbeds.

The maximum algebraic difference in cross slope between same direction traffic lanes of divided highway roadbeds should be 4 percent.

The maximum difference in cross slope between the traveled way and the shoulder should not exceed 8 percent. This applies to new construction as well as pavement overlay projects.

At freeway entrances and exits, the maximum difference in cross slope between adjacent lanes, or between lanes and gore areas, should not exceed 5 percent.

**Topic 302 - Highway Shoulder Standards**

**302.1 Width**

The shoulder widths given in Table 302.1 shall be the minimum continuous usable width of paved shoulder on highways. Typically, on-street parking areas in urbanized areas is included in the shoulder.

Class II bikeways are typically part of the shoulder width, see Index 301.2. Where rumble strips are placed in the shoulder, the shoulder shall be a minimum of 4 feet width to the right of the grooved rumble strip when a vertical element, such as curb or guardrails present or a minimum of 3 feet width when a vertical element is not present. Shoulder rumble strip must not be placed in the Class II bike lane. Consult the District Traffic Safety Engineer during selection of rumble strip options and with the California MUTCD for markings in combination with rumble strip. Also see Standard Plans for rumble strip details.

See Design Information Bulletin Number 79, for 2R, 3R, certain storm damage, protective betterment, operational, and safety projects on two-lane conventional highways and three-lane conventional highways.

See Index 308.1 for shoulder width requirements on city streets or county roads. See shoulder definition, Index 62.1(9).

See Index 1102.2 for shoulder width requirements next to noise Barriers.

When shoulders are less than standard width, see Index 204.5(4) for bicycle turnout considerations.

**302.2 Cross Slopes**

(1) **General** - When a roadway crosses a bridge structure, the shoulders shall be in the same plane as the adjacent traveled way.

(2) **Left Shoulders** - In depressed median sections, shoulders to the left of traffic shall be sloped at 2 percent away from the traveled way.

In paved median sections, shoulders to the left of traffic shall be designed in the plane of the traveled way. Maintenance paving beyond the edge of shoulder should be treated as appropriate for the site, but consideration needs to be given to the added runoff and the increased water depth on the pavement (see discussion in Index 831.4(5) "Hydroplaning").

(3) **Right Shoulders** - In normal tangent sections, shoulders to the right of traffic shall be sloped at 2 percent to 5 percent away from the traveled way.

The above flexibility in the design of the right shoulder allows the designer the ability to conform to regional needs. Designers shall consider the following during shoulder cross slope design:

- In most areas a 5 percent right shoulder cross slope is desired to most expeditiously remove water from the pavement and to allow gutters to carry a maximum water volume between drainage inlets. The shoulders must have adequate drainage interception to control the "water spread" as discussed in Table 831.3 and Index 831.4. Conveyance of water from the total area transferring drainage and rainwater across each lane and the quantity of intercepting drainage shall also be a consideration in the selection of shoulder cross slope. Hydroplaning is discussed in Index 831.4 (5).
- In locations with snow removal operations it is desirable for right shoulders to slope
### Table 302.1

<table>
<thead>
<tr>
<th>Highway Type</th>
<th>Paved Shoulder Width (ft)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left</td>
<td>Right (8)</td>
</tr>
<tr>
<td><strong>Freeways &amp; Expressways</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 lanes (1)</td>
<td>--</td>
<td>8(6)</td>
</tr>
<tr>
<td>4 lanes (1)</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>6 or more lanes (1)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Auxiliary lanes</td>
<td>--</td>
<td>10</td>
</tr>
<tr>
<td>Freeway-to-freeway connections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single and two-lane connections</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Three-lane connections</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Single-lane ramps</td>
<td>4(2)</td>
<td>8</td>
</tr>
<tr>
<td>Multilane ramps</td>
<td>4(2)</td>
<td>8(3)</td>
</tr>
<tr>
<td>Multilane undivided</td>
<td>--</td>
<td>10</td>
</tr>
<tr>
<td>Collector-Distributor</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td><strong>Conventional Highways</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multilane divided</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-lanes</td>
<td>5</td>
<td>8(7)</td>
</tr>
<tr>
<td>6-lanes or more</td>
<td>8</td>
<td>8(7)</td>
</tr>
<tr>
<td>Urban areas with posted speeds less than or equal to 45 mph and curbed medians</td>
<td>2(4)</td>
<td>8(7)</td>
</tr>
<tr>
<td>Multilane undivided</td>
<td>--</td>
<td>8(7)</td>
</tr>
<tr>
<td>Collector-Distributor</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>RRR</td>
<td>See Index 307.3</td>
<td></td>
</tr>
<tr>
<td>New construction</td>
<td>See Table 307.2</td>
<td></td>
</tr>
<tr>
<td>Slow-moving vehicle lane</td>
<td>--</td>
<td>4(5)</td>
</tr>
<tr>
<td><strong>Local Facilities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontage roads</td>
<td>See Index 310.1</td>
<td></td>
</tr>
<tr>
<td>Local facilities crossing State facilities</td>
<td>See Index 308.1</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**

(1) Total number of lanes in both directions including separate roadways (see Index 305.6). If a lane is added to one side of a 4-lane facility (such as a truck climbing lane) then that side shall have 10 feet left and right shoulders. See Index 62.1.

(2) May be reduced to 2 feet upon concurrence from the Project Delivery Coordinator that a restrictive situation exists. 4 feet preferred in urban areas and/or when ramp is metered. See Index 504.3.

(3) May be reduced to 2 feet or 4 feet (4 feet preferred in urban areas) in the 2-lane section of a non-metered ramp, which transitions from a single lane upon concurrence from the Project Delivery Coordinator that a restrictive situation exists. May be reduced to 2 feet in ramp sections having 3 or more lanes. See Index 504.3(b).

(4) For posted speeds less than or equal to 35 mph, shoulder may be omitted (see Index 303.5(5)) except where drainage flows toward the curbed median.

(5) On right side of climbing or passing lane section only. See Index 301.2(1) for minimum width if bike lanes are present.

(6) 10-foot shoulders preferred.

(7) Where on-street parking is allowed, 10 feet shoulder width is preferred. Where bus stops are present, 10 feet shoulder width is preferred for the length of the bus stop. If a Class II bikeway is present, minimum shoulder width shall be 8 feet where on street parking is provided plus the minimum required width for the bike lane.

(8) Shoulders adjacent to abutment walls, retaining walls in cut locations, and noise barriers shall be not less than 10 feet wide. See Index 303.4 for minimum shoulder adjacent to bulbouts.
mounted except at low speeds and flat angles of approach.

(2) Types A1-8, A2-8, and A3-8. These 8-inch high curbs may be used in lieu of 6-inch curbs when requested by local authorities, if the curb criteria stated under Index 303.1 are satisfied and posted speeds are 35 miles per hour or less. This type of curb may impede curbside passenger loading and may make it more difficult to comply with curb ramp design (see Design Information Bulletin Number 82, “Pedestrian Accessibility Guidelines for Highway Projects”).

(3) Type H Curb. This type may be used on bridges where posted speeds are 40 miles per hour or less and where it is desired to match the approach roadway curb. Type H curb is often incorporated into bridge barrier/sidewalk combination railings (See Index 208.10(4)).

These types are sloped curbs:

(4) Types B1, B2, and B3 Curbs. Types B1-6, B2-6, and B3-6 are 6 inches high. Type B1-4, B2-4, and B3-4 are 4 inches high. Since all have a 1:1½ slope or flatter on the face, they are mounted more easily than Type A curbs. Typical uses of these curbs are for channelization including raised median islands. B2 curb with gutter pan also serves as drainage control.

(5) Type B4 Curb. Type B4 curb with gutter pan is 3 inches high and is typically used on ramp gores as described in Index 504.3(11). It may also be appropriate where a lower curb is desirable.

(6) Type D Curb. Type D curb is 4 inches or 6 inches high and is typically used for raised traffic islands, collector-distributor separation islands, or raised medians when posted speeds equal or exceed 45 miles per hour.

(7) Type E Curb. This essentially is a rolled gutter used only in special drainage situations.

Gutter pans are typically 2 feet wide but may be 1 foot to 4 feet in width, with a cross slope of typically 8.33 percent to increase the hydraulic capacity. Gutter pan cross slopes often need to be modified at curb ramps in order to meet accessibility requirements. See Design Information Bulletin Number 82, “Pedestrian Accessibility Guidelines for Highway Projects” for accessibility standards. Warping of the gutter pan should be limited to the portion within 2 feet to 3 feet of the gutter flow line to minimize adverse driving effects.

Curbs and gutter pans are cross section elements considered entirely outside the traveled way, see Index 301.1.

303.3 Dike Types and Uses

Use of dike is intended for drainage control and should not be used in place of curb. Dikes placed adjoining the shoulder, as shown in Figures 307.2, 307.4, and 307.5, provide a paved triangular gutter within the shoulder area. The dike sections provided on the Standard Plans are approved types to be used as stated below. Dikes should be selected as illustrated in Figure 303.3. Dikes should be designed so that roadway runoff is contained within the limits specified in Index 831.3. For most situations Type E dike is the preferred dike type as discussed below.

(1) Type A Dike. The use of Type A dike should be avoided. For RRR projects, Type A dike may be used in cut sections with slopes steeper than 3:1 and where existing conditions do not allow for construction of the wider Type D or E dikes. Compacted embankment material should be placed behind the back of dike as shown in Figure 303.3.

(2) Type C Dike. This low dike, 2 inches in height, may be used to confine small concentrations of runoff. The capacity of the shoulder gutter formed by this dike is small. Due to this limited capacity, the need for installing an inlet immediately upstream of the beginning of this dike type should be evaluated. This low dike can be traversed by a vehicle and allows the area beyond the surfaced shoulder to be used as an emergency recovery and parking area. The Type C dike is the only dike that may be used in front of
Figure 303.3
Dike Type Selection and Placement\(^{(1)}\)

**CUT SECTIONS**

![Type A Diagram]

**TYPE A**
RRR PROJECTS (Restrictive Conditions Only)\(^{(2)}\)

- ES
- Slope to Drain
- Existing Steeper than 3:1
- Compacted Embankment Material

![Type D & E Diagram]

**TYPE D & E**
ALTERNATIVE

- ES
- Slope to Drain
- Compacted Embankment Material

**FILL SECTIONS**

![Type D & E Diagram]

**TYPE D & E**

- ES
- 3’ for Type E
- 5’ for Type D
- 5%

![Type D & E Diagram]

**TYPE D & E**
RRR PROJECTS (Restrictive Conditions Only)\(^{(3)}\)

- ES
- 3’
- Existing Steeper than 3:1
- 5%

**CUT/FILL SECTIONS**

![Type C Diagram]

**TYPE C**

- ES
- CUT
- FILL

![Type F Diagram]

**TYPE F**\(^{(4)}\)

- ES
- CUT
- FILL

Notes:
(1) See Standard Plans for additional information and details.
(2) See Index 303.3(1) for restrictive conditions.
(3) See Index 303.3(3) and Index 303.3(4) for restrictive conditions for Types D and E respectively.
(4) Use under guardrail when dike is necessary for drainage control.
guardrail. In such cases, it is not necessary to place compacted embankment material behind Type C dike.

(3) *Type D Dike.* This 6-inch high dike provides about the same capacity as the Type A dike but has the same shape as the Type E dike. The quantity of material in the Type D dike is more than twice that of a Type E dike. It should only be used where there is a need to contain higher volumes of drainage. Compacted embankment material should be placed behind the back of dike as shown in Figure 303.3. For RRR projects that do not widen pavement, compacted embankment material may be omitted on existing fill slopes steeper than 3:1 when there is insufficient room to place the embankment material.

(4) *Type E Dike.* This 4-inch high dike provides more capacity than the Type C dike. Because Type E dike is easier to construct than Type D dike, and has greater drainage capacity than Type C dike, it is the preferred dike type for most installations. Compacted embankment material should be placed behind the back of dike as shown in Figure 303.3. For RRR projects that do not widen pavement, compacted embankment material may be omitted on existing fill slopes steeper than 3:1 where there is insufficient room to place the embankment material.

(5) *Type F Dike.* This 4-inch high dike is to be used where dike is necessary for drainage underneath a guardrail installation. This dike is placed directly under the face of guardrail installations.

303.4 Curb Extensions

(1) *Bulbouts.* A bulbout is an extension of the sidewalk into the roadway when there is marked on-street parking, see Index 402.3. Bulbouts should comply with the guidance provided in Figures 303.4A and B; noting that typical features are shown and that the specific site conditions need to be taken into consideration. Bulbouts provide queuing space and shorten crossing distances, thereby reducing pedestrian conflict time with mainline traffic. By placing the pedestrian entry point closer to traffic, bulbouts improve visibility between motorists, bicyclists, and pedestrians. They are most appropriate for urban conventional highways and Rural Main Streets with posted speeds 35 miles per hour or less. Curb extensions are not to extend into Class II Bikeways (Bike Lanes). The corner curb radii should be the minimum needed to accommodate the design vehicle, see Topic 404.

When used, bulbouts should be placed at all corners of an intersection.

When used at mid-block crossing locations, bulbouts should be used on both sides of the street.

The curb face of the bulbout should be setback a minimum of 2 feet as shown in Figures 303.4A and B. See the California MUTCD for on-street parking signs and markings.

Landscaping and appurtenant facilities located within a bulbout are to comply per Topic 405.

Bulbouts are considered pedestrian facilities and as such, compliance with DIB 82 is required. Avoid bulbouts on facilities where highway grade lines exceed 5 percent.

(2) *Busbulbs.* A busbulb is a bulbout longer than 25 feet which facilitates bus loading and unloading, and provides for enhanced bus mobility. Busbulbs reduce bus dwell times and provide travel time benefits to transit passengers. However, busbulbs can restrict the mobility of vehicular and bicycle traffic because they allow the bus to stop in their traveled way to load and unload passengers. Therefore, their impact on the mobility of the vehicular and bicycle traffic using the facility must be taken into consideration, and pursuant to the California Vehicle Code, busbulbs or other transit stops which require a transit vehicle to stop in the traveled way require approval from the Department. In lieu of a busbulb, a busbay may be considered which will not impact the mobility of the vehicular and bicycle users of the facility.

(3) *Busbays.* A busbay is an indentation in the curb which allows a bus to stop completely outside of vehicular and bicycle lanes.
Figure 303.4A

Typical Bulbout with Class II Bikeway (Bike Lane)

Legend:
- Direction of Travel
- Point of Curvature (POC)

Notes:
1. Curb transitions are to accommodate street sweeping equipment.
2. See Topic 303 for selection of curb type.
3. See California MUTCD for painting of curb adjacent to bulbout.
4. Curb return design varies per design vehicle; see Topic 404.
6. See Table 302.1 for shoulder width guidance.
7. Diagonal parking is shown, parallel parking is also permitted on local roads. See California MUTCD for parking space markings.
9. See Index 301.2 and California MUTCD for details.
10. See Topic 105 for details.
form a shallow valley in the center. Cross slopes should be 10:1 or flatter; 20:1 being preferred. Slopes as steep as 6:1 are acceptable in exceptional cases when necessary for drainage, stage construction, etc. Cross slopes in medians greater than 65 feet should be treated as separate roadways (see Index 305.6).

Paved medians, including those bordered by curbs, should be crowned at the center, sloping towards the sides at the slope of the adjacent pavement.

### 305.3 Median Barriers

### 305.4 Median Curbs
See Topic 303 for curb types and usage in medians and Index 405.5(1) for curbs in median openings.

### 305.5 Paved Medians

1. **Freeways.**
   - 6 or More Lanes--Medians 30 feet wide or less should be paved.
   - 4 Lanes--Medians 22 feet or less in width should be paved. Medians between 22 feet and 30 feet wide should be paved only if a barrier is installed. With a barrier, medians wider than 30 feet should not normally be paved. Where medians are paved, each half generally should be paved in the same plane as the adjacent traveled way.

2. **Nonfreeways.** Unplanted curbed medians generally are to be surfaced with minimum 0.15 foot of Portland cement concrete.

For additional information on median cross slopes see Index 305.2.

### 305.6 Separate Roadways

1. **General Policy.** Separate grade lines are not considered appropriate for medians less than 65 feet wide (see Index 204.7).

2. **Median Design.** The cross sections shown in Figure 305.6 with a 23-foot graded area left of traffic are examples of median treatment to provide maneuvering room for out-of-control users. This optional treatment may be used where extra recovery area is desired (see Index 307.6).

See Index 302.1 for shoulder widths and Index 302.2 for shoulder cross slopes.

### Topic 306 - Right of Way

#### 306.1 General Standards
The right of way widths for State highways, including frontage roads to be relinquished, should provide for installation, operation and maintenance of all cross section elements needed depending upon the type of facility, including median, traffic lanes, bicycle lanes, outside shoulders, sidewalks, recovery areas, slopes, sight lines, outer separations, ramps, walls, transit facilities and other essential highway appurtenances. For minimum clearance from the right of way line to the catch point of a cut or fill slope, see Index 304.2. Fixed minimum widths of right of way, except for 2-lane highways, are not specified because dimensions of cross-sectional elements may require narrow widths, and right of way need not be of constant width. The minimum right of way width on new construction for 2-lane highways should be 150 feet.

#### 306.2 Right of Way Through the Public Domain
Right of way widths to be obtained or reserved for highway purposes through lands of the United States Government or the State of California are determined by laws and regulations of the agencies concerned.

### Topic 307 - Cross Sections for State Highways

#### 307.1 Cross Section Selection
The cross section of a State highway is based upon the number of vehicles, including trucks, buses, bicycles, and safety, terrain, transit needs and pedestrians. Other factors such as sidewalks, bike paths and transit facilities, both existing and future should be considered. For 2-lane roads the roadbed width is influenced by the factors discussed under Index 307.2. The roadbed width for multilane facilities should be adequate to provide capacity for
Figure 305.6

Optional Median Designs for Freeways with Separate Roadways

NOTES:

Left Paved Shoulder Width
   10’ for 6-lane and 8-lane roadways
   5’ for 4-lane roadways

Side Slopes
   See Index 304.1
   ★ Superelevated section
apply. See minimum horizontal clearance, Index 309.1(3)(c).

(a) Necessary Highway Features.

Fixed objects, when they are necessary highway features, including, but not limited to, bridge piers, abutments, retaining walls, and noise barriers closer to the edge of traveled way than the distances listed above should be eliminated, moved, redesigned to be made yielding, or shielded in accordance with the following guidelines:

- Fixed objects, when they are necessary highway features, should be eliminated or moved outside the clear recovery zone to a location where they are unlikely to be hit.
- If necessary highway features such as sign posts or light standards cannot be eliminated or moved outside the clear recovery zone, they should be made yielding with a breakaway feature.
- If a fixed object, when they are necessary highway features, cannot be eliminated, moved outside the clear recovery zone, or modified to be made yielding, it should be shielded by guardrail, barrier or a crash cushion.

Shielding and breakaway features must be in conformance with the guidance found in Traffic Safety Systems Guidance. For input on the need for shielding at a specific location, consult District Traffic Operations.

Existing above-ground utilities and existing large trees as defined in Index 902.2(2) should conform to the guidance associated with necessary highway features stated above. When the planting of trees is being considered, see the additional discussion and standards in Chapter 900.

(b) Discretionary Fixed Objects.

Discretionary fixed objects are features or facilities that are not necessary for the safety, maintenance or operation of the highway, but may enhance livability and sustainability. These may include, but are not limited to, transportation art, gateway monuments, solar panels, and memorial/historical plaques or markers. See Subsection (4) for high speed rail clearance guidance. When discretionary fixed objects are constructed on freeways, expressways or conventional highways without curbs and posted speeds over 35 mph, they should be located beyond the clear recovery zone, at a minimum of 52 feet horizontally or 8 feet vertically upslope from the planned ultimate edge of traveled way. If discretionary fixed objects are to be placed less than the 52 feet horizontally or less than the 8 feet vertically upslope, they should be made breakaway or shielded behind existing guardrail, barrier or other safety device.

Where compliance with the guidelines stated in Subsections (2)(a) and (b) are impractical, the minimum horizontal clearance cited in Subsection (3) Minimum Clearances shall apply to the unshielded fixed object. These minimum horizontal clearances apply to yielding objects as well.

(3) Minimum Clearances. The following minimum horizontal clearances shall apply to all objects that are closer to the edge of traveled way than the clear recovery zone distances listed above:

(a) The minimum horizontal clearance to all objects, such as bridge rails and safety-shaped concrete barriers, as well as sand-filled barrels, guardrail, etc., on all freeway and expressway facilities, including auxiliary lanes, ramps, and collector-distributor roads, shall be equal to the standard shoulder width of the highway facility as stated in Table 302.1. A minimum clearance of 4 feet shall be provided where the standard shoulder width is less than 4 feet. Approach rail connections to bridge rail may require special treatment to maintain the standard shoulder width.
(b) The minimum horizontal clearance to walls, such as abutment walls, retaining walls in cut locations, and noise barriers on all facilities, including auxiliary lanes, ramps and collector-distributor roads, shall not be less than 10 feet per Table 302.1.

(c) On conventional highways, frontage roads, city streets and county roads within the State right of way (all without curbs), the minimum horizontal clearance shall be the standard shoulder width as listed in Tables 302.1 and 307.2, except that a minimum clearance of 4 feet shall be provided where the standard shoulder width is less than 4 feet. For RRR projects, widths are provided in DIB 79.

On conventional highways with curbs, typically in urban conditions, a minimum horizontal clearance of 1 foot 6 inches should be provided beyond the face of curbs to any obstruction. On curbed highway sections, a minimum clearance of 3 feet should be provided along the curb returns of intersections and near the edges of driveways to allow for design vehicle offtracking (see Topic 404). Where sidewalks are located immediately adjacent to curbs, fixed objects should be located beyond the back of sidewalk to provide an unobstructed area for pedestrians.

In areas without curbs, the face of Type 60 concrete barrier should be constructed integrally at the base of any retaining, pier, or abutment wall which faces traffic and is 15 feet or less from the edge of traveled way (right or left of traffic and measured from the face of wall). See Index 1102.2 for the treatment of noise barriers.

The minimum width of roadway openings between Temporary Railing (Type K) on bridge deck widening projects should be obtained from the HQ Transportation Permit Program.

The HQ Transportation Permit Program must be consulted on the use of the route by overwidth loads.

See Traffic Safety Systems Guidance for other requirements pertaining to clear recovery zone, guardrail at fixed objects and embankments, and crash cushions.

(4) High Speed Rail Clearances. When a high speed rail corridor is to be constructed longitudinally to a freeway, expressway or a conventional highway with posted speeds over 40 miles per hour, the nearest fixed object or feature associated with the operation of the rail facility should be located a minimum of 52 feet horizontally from the planned ultimate edge of the traveled way. See Index 62.10 for the definition of high speed rail. The terrain and the required highway features between the edge of traveled way and the rail facility to be constructed must be evaluated to determine on a case-by-case basis whether or not shielding behind guardrail, barrier or other safety device in conformance with the guidance found in Traffic Safety Systems Guidance is needed. For input on the need for shielding at a specific location, consult District Traffic Operations.

(5) Other Transportation Facilities. Contraflow BRT, light rail facilities, and heavy rail facilities are considered fixed objects and the clearances noted in Index 309.1 apply.

Parallel BRT facilities are preferred to have the following minimum separation between lanes:

- Freeways and Expressways** – 4 feet
- Conventional Highways (see also Index 108.5)
  - Posted Speeds over 40 miles per hour – 4 feet
  - Posted Speeds equal or greater than 25 miles per hour and up to 45 miles per hour in an urban environment – 2 feet, with curbed separation, 4 feet with 2-foot curbed separation recommended.

**Table 309.2B**  
*California Routes on the Rural and Single Interstate Routing System*

<table>
<thead>
<tr>
<th>ROUTE</th>
<th>FROM</th>
<th>TO</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-5</td>
<td>U. S. Border</td>
<td>I-805 just N. of U. S. Border</td>
</tr>
<tr>
<td>I-5</td>
<td>I-805 N. of San Diego</td>
<td>I-405 near El Toro</td>
</tr>
<tr>
<td>I-5</td>
<td>I-210 N. of Los Angeles</td>
<td>Oregon State Line</td>
</tr>
<tr>
<td>I-8</td>
<td>I-805 near San Diego</td>
<td>Arizona State Line</td>
</tr>
<tr>
<td>I-10</td>
<td>I-210 near Pomona</td>
<td>Arizona State Line</td>
</tr>
<tr>
<td>I-15</td>
<td>I-8 near San Diego</td>
<td>Nevada State Line</td>
</tr>
<tr>
<td>I-40</td>
<td>Junction at I-15 near Barstow</td>
<td>Arizona State Line</td>
</tr>
<tr>
<td>I-80</td>
<td>I-680 near Cordelia</td>
<td>Nevada State Line</td>
</tr>
<tr>
<td>I-205</td>
<td>Junction at I-580</td>
<td>Junction at I-5</td>
</tr>
<tr>
<td>I-210</td>
<td>I-5 N. of Los Angeles</td>
<td>I-10 near Pomona</td>
</tr>
<tr>
<td>I-215</td>
<td>I-15 near Temecula</td>
<td>I-15 near Devore</td>
</tr>
<tr>
<td>I-280</td>
<td>Junction at I-680 in San Jose</td>
<td>At or near south city limits of San Francisco to provide access to Hunter's Point</td>
</tr>
<tr>
<td>I-405</td>
<td>I-5 near El Toro</td>
<td>Palo Verde Avenue just N. of I-605</td>
</tr>
<tr>
<td>I-505</td>
<td>Junction at I-80</td>
<td>Junction at I-5</td>
</tr>
<tr>
<td>I-580</td>
<td>I-680 near Dublin</td>
<td>Junction at I-5</td>
</tr>
<tr>
<td>I-605</td>
<td>I-405 near Seal Beach</td>
<td>I-210</td>
</tr>
<tr>
<td>I-680</td>
<td>Junction at I-280 in San Jose</td>
<td>I-80 near Cordelia</td>
</tr>
<tr>
<td>I-805</td>
<td>I-5 just N. of U. S. Border</td>
<td>I-5 N. of San Diego</td>
</tr>
</tbody>
</table>
309.2 Vertical Clearances

(1) Major Structures. Freeways and Expressways, All construction except overlay projects – 16 feet 6 inches shall be the minimum vertical clearance over the roadbed of the State facility (e.g., main lanes, shoulders, ramps, collector-distributor roads, speed change lanes, etc.). Freeways and Expressways, Overlay Projects – 16 feet shall be the minimum vertical clearance over the roadbed of the State facility. Conventional Highways, Parkways, and Local Facilities, All Projects – 15 feet shall be the minimum vertical clearance over the traveled way and 14 feet 6 inches shall be the minimum vertical clearance over the shoulders of all portions of the roadbed.

(2) Minor Structures. Pedestrian over-crossings shall have a minimum vertical clearance 2 feet greater than the standard for major structures for the State facility in question. Sign structures shall have a vertical clearance of 18 feet over the roadbed of the State facility.

(3) Rural Interstates and Single Routing in Urban Areas: This subset of the Interstate System is composed of all rural Interstates and a single routing in urban areas. Those routes described in Table 309.2B and Figure 309.2 are given special attention in regards to minimum vertical clearance as a result of agreements between the FHWA and the Department of Defense. Vertical clearance for structures on this system shall meet the standards listed above for freeways and expressways. In addition to the standards listed above, vertical clearances of less than 16 feet over any portion of this system must be approved by FHWA in coordination with Surface Deployment and Distribution Command Transportation Engineering Agency (SDDCTEA). Documentation in the form of a Design Standard Decision Document must be submitted to FHWA to obtain approval for less than 16 feet of vertical clearance. Vertical clearances of less than 16 feet over any Interstate will require FHWA/SDDCTEA notification. See http://www.fhwa.dot.gov/design/090415.cfm

(4) General Information. The standards listed above and summarized in Table 309.2A are the minimum allowable on the State highway system for the facility and project type listed. For the purposes of these vertical clearance standards, all projects on the freeway and expressway system other than overlay projects shall be considered to be covered by the "new construction" standard.

When approved by a design exception (see HDM Index 82.2) clearances less than the values given above may be allowed on a case by case basis given adequate justification based upon engineering judgment, economic, environmental or right of way considerations. Typical instances where lesser values may be approved are where the structure is protected by existing lower structures on either side or where a project includes an existing structure that would not be feasible to modify to the current standard. In no case should vertical clearance be reduced below 15 feet over the traveled way or 14 feet 6 inches over the shoulders over any portion of a State highway facility.

Efforts should be made to avoid decreasing the existing vertical clearance whenever possible and consideration should be given to the feasibility of increasing vertical clearance on projects involving structural section removal and replacement. Any project that would reduce vertical clearances below 16 feet 6 inches or lead to an increase in the vertical clearance should be brought to the attention of the Project Delivery Coordinator or District approval authority, depending upon the current District Design Delegation Agreement, the District Permit Engineer and the Regional Permit Manager at the earliest possible date.

The Regional Permit Manager should be informed of any changes (temporary or permanent) in vertical clearance.
challenges with visibility between turning vehicles and pedestrians. Multiple right-turn-only lanes should not be free right-turns when there is a pedestrian crossing. If there is a pedestrian crossing on the receiving leg of multiple right-turn-only lanes, the intersection should be controlled by a pedestrian signal head, or geometrically designed such that pedestrians cross only one turning lane at a time.

Locations with right-turn-only lanes should provide a minimum 4-foot width for bicycle use between the right-turn and through lane when bikes are permitted, except where posted speed is greater than 40 miles per hour, the minimum width should be 6 feet. Configurations that create a weaving area without defined lanes should not be used.

For signing and delineation of bicycle lanes at intersections, consult District Traffic Operations.

Figure 403.6B depicts an intersection with a left-turn-only bicycle lane, which should be considered when bicycle left-turns are common. A left-turn-only bicycle lane may be considered at any intersection and should always be considered as a tool to provide mobility for bicyclists. Signing and delineation options for bicycle left-turn-only lanes are shown in the California MUTCD.

(2) Design of Intersections at Interchanges. The design of at-grade intersections at interchanges should be accomplished in a manner that will minimize confusion of motorists, bicyclists, and pedestrians. Higher speed, uncontrolled entries and exits from freeway ramps should not be used at the intersection of the ramps with the local road. The smallest curb return radius should be used that accommodates the design vehicle. Intersections with interior angles close to 90 degrees reduce speeds at conflict points between motorists, bicyclists, and pedestrians. The intersection skew guidance in Index 403.3 applies to all ramp termini at the local road.

403.7 Refuge Areas
Traffic islands should be used to provide refuge areas for bicyclists and pedestrians. See Index 405.4 for further guidance.

403.8 Prohibited Turns
Traffic islands may be used to direct bicycle and motorized vehicle traffic streams in desired directions and prevent undesirable movements. Care should be taken so that islands used for this purpose accommodate convenient and safe pedestrian and bicycle crossings, drainage, and striping options. See Topic 303.

403.9 Effective Signal Control
At intersections with complex turning movements, channelization is required for effective signal control. Channelization permits the sorting of approaching bicycles and motorized vehicles which may move through the intersection during separate signal phases. Pedestrians may also have their own signal phase. This requirement is of particular importance when traffic-actuated signal controls are employed.

The California MUTCD has warrants for the placement of signals to control vehicular, bicycle and pedestrian traffic. Pedestrian activated devices, signals or beacons are not required, but must be evaluated where directional, multilane, pedestrian crossings occur. These locations may include:

- Mid-block street crossings;
- Channelized turn lanes;
- Ramp entries and exits; and
- Roundabouts.

The evaluation, selection, programming and use of a chosen device should be done with guidance from District Traffic Operations.

403.10 Installation of Traffic Control Devices
Channelization may provide locations for the installation of essential traffic control devices, such as “STOP” and directional signs. See Index 405.4 for information about the design of traffic islands.

403.11 Summary
- Give preference to the major move(s).
• Reduce areas of conflict.
• Reduce the duration of conflicts.
• Cross traffic at right angles or skew no more than 75 degrees. (90 degrees preferred.)
• Separate points of conflict.
• Provide speed-change areas and separate turning lanes where appropriate.
• Provide adequate width to shadow turning traffic.
• Restrict undesirable moves with traffic islands.
• Coordinate channelization with effective signal control.
• Install signs in traffic islands when necessary but avoid building conflicts one or more modes of travel.
• Consider all users.

403.12 Other Considerations
• An advantage of curbed islands is they can serve as pedestrian refuge. Where curbing is appropriate, consideration should be given to mountable curbs. See Topic 303 for more guidance.
• Avoid complex intersections that present multiple choices of movement to the motorist and bicyclist.
• Traffic safety should be considered. Collision records provide a valuable guide to the type of channelization needed.

Topic 404 - Design Vehicles

404.1 General
Any vehicle, whether car, bus, truck, or recreational vehicle, while turning a curve, covers a wider path than the width of the vehicle. The outer front tire can generally follow a circular curve, but the inner rear tire will swing in toward the center of the curve.

Some terminology is vital to understanding the engineering concepts related to design vehicles. See Index 62.4 Interchanges and Intersection at Grade for terminology.

404.2 Design Considerations
It may not be necessary to provide for design vehicle turning movements at all intersections along the State route if the design vehicle’s route is restricted or it is not expected to use the cross street frequently. Discuss with Traffic Operations and the local agency before a turning movement is not provided. The goal is to minimize possible conflicts between vehicles, bicycles, pedestrians, and other users of the roadway, while providing the minimum curb radii appropriate for the given situation.

Both the tracking width and swept width should be considered in the design of roadways for use of the roadway by design vehicles.

Tracking width lines delineate the path of the vehicle tires as the vehicle moves through the turn.

Swept width lines delineate the path of the vehicle body as the vehicle moves through the turn and will therefore always exceed the tracking width. The following list of criteria is to be used to determine whether the roadway can accommodate the design vehicle.

(1) Traveled way.

(a) To accommodate turn movements (e.g., at intersections, driveways, alleys, etc.), the travel way width and intersection design should be such that tracking width and swept width lines for the design vehicle do not cross into any portion of the lane for opposing traffic. Encroachment into the shoulder and bike lane is permitted.

(b) Along the portion of roadway where there are no turning options, vehicles are required to stay within the lane lines. The tracking and swept widths lines for the design vehicle shall stay within the lane as defined in Index 301.1 and Table 504.3. This includes no encroachment into Class II bike lanes.

(2) Shoulders. Both tracking width and swept width lines may encroach onto paved shoulders to accommodate turning. For design projects where the tracking width lines are shown to encroach onto paved shoulders, the shoulder pavement structure should be engineered to sustain the weight of the design vehicle. See Index 613 for general traffic loading.
Figure 404.5G
60-Foot Articulated Bus Design Vehicle

* Radius to outside wheel at beginning of curve.

LEGEND

| Swept Width (Body) | Tracking Width (Tires) |

ARTICULATED BUS

Width : 8.5'
Track : 8.5'
Lock to Lock Time : 6 seconds
Steering Lock Angle : 38.3 degrees
Articulating Angle : 50.0 degrees

Note: For definitions, see Indexes 404.1 and 404.5.
At signalized intersections the values for corner sight distances given in Table 405.1A should also be applied whenever possible. Even though traffic flows are designed to move at separate times, unanticipated conflicts can occur due to violation of signal, right turns on red, malfunction of the signal, or use of flashing red/yellow mode.

### Table 405.1A
Corner Sight Distance (7-1/2 Second Criteria)

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Corner Sight Distance (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>275</td>
</tr>
<tr>
<td>30</td>
<td>330</td>
</tr>
<tr>
<td>35</td>
<td>385</td>
</tr>
<tr>
<td>40</td>
<td>440</td>
</tr>
<tr>
<td>45</td>
<td>495</td>
</tr>
<tr>
<td>50</td>
<td>550</td>
</tr>
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<td>55</td>
<td>605</td>
</tr>
<tr>
<td>60</td>
<td>660</td>
</tr>
<tr>
<td>65</td>
<td>715</td>
</tr>
<tr>
<td>70</td>
<td>770</td>
</tr>
</tbody>
</table>

Where restrictive conditions exist, similar to those listed in Index 405.1(2)(a), the minimum value for corner sight distance at both signalized and unsignalized intersections shall be equal to the stopping sight distance as given in Table 201.1, measured as previously described.

(c) Private Road Intersections (Refer to Index 205.2) and Rural Driveways (Refer to Index 205.4)--The minimum corner sight distance shall be equal to the stopping sight distance as given in Table 201.1, measured as previously described.

(d) Urban Driveways (Refer to Index 205.3)--Corner sight distance requirements as described above are not applied to urban driveways.

### Table 405.1B
Application of Sight Distance Requirements

<table>
<thead>
<tr>
<th>Intersection Types</th>
<th>Sight Distance</th>
<th>Intersection Types</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stopping</td>
<td>Corner</td>
</tr>
<tr>
<td>Private Roads</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Public Streets and Roads</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Signalized Intersections</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>State Route Intersections &amp; Route Direction Changes, with or without Signals</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**NOTES:**

1. Per Index 405.1(2)(c), the minimum corner sight distance shall be equal to the stopping sight distance as given in Table 201.1. See Index 405.1(2)(a) for setback requirements.
2. Apply corner sight distance requirements at signalized intersections whenever possible due to unanticipated violations of the signals or malfunctions of the signals. See Index 405.1(2)(b).

(4) **Acceleration Lanes for Turning Moves onto State Highways.** At rural intersections, with “STOP” control on the local cross road, acceleration lanes for left and right turns onto the State facility should be considered. At a minimum, the following features should be evaluated for both the major highway and the cross road:

- divided versus undivided
- number of lanes
• design speed
• gradient
• lane, shoulder and median width
• traffic volume and composition of highway users, including trucks and transit vehicles
• turning volumes
• horizontal curve radii
• sight distance
• proximity of adjacent intersections
• types of adjacent intersections

For additional information and guidance, refer to AASHTO, A Policy on Geometric Design of Highways and Streets, the District Traffic Engineer or designee, the District Design Liaison, and the Project Delivery Coordinator.

405.2 Left-turn Channelization

(1) General. The purpose of a left-turn lane is to expedite the movement of through traffic by, controlling the movement of turning traffic, increasing the capacity of the intersection, and improving safety characteristics.

The District Traffic Branch normally establishes the need for left-turn lanes.

(2) Design Elements.

(a) Lane Width – The lane width for both single and double left-turn lanes on State highways shall be 12 feet.

For conventional State highways with posted speeds less than or equal to 40 miles per hour and AADTT (truck volume) less than 250 per lane that are in urban, city or town centers (rural main streets), the minimum lane width shall be 11 feet.

When considering lane width reductions adjacent to curbed medians, refer to Index 303.5 for guidance on effective roadway width, which may vary depending on drivers’ lateral positioning and shy distance from raised curbs.

(b) Approach Taper -- On conventional highways without a median, an approach taper provides space for a left-turn lane by moving traffic laterally to the right. The approach taper is unnecessary where a median is available for the full width of the left-turn lane. Length of the approach taper is given by the formula on Figures 405.2A, B and C.

Figure 405.2A shows a standard left-turn channelization design in which all widening is to the right of approaching traffic and the deceleration lane (see below) begins at the end of the approach taper. This design should be used in all situations where space is available, usually in rural and semi-rural areas or in urban areas with high traffic speeds and/or volumes.

Figures 405.2B and 405.2C show alternate designs foreshortened with the deceleration lane beginning at the 2/3 point of the approach taper so that part of the deceleration takes place in the through traffic lane. Figure 405.2C is shortened further by widening half (or other appropriate fraction) on each side. These designs may be used in urban areas where constraints exist, speeds are moderate and traffic volumes are relatively low.

(c) Bay Taper -- A reversing curve along the left edge of the traveled way directs traffic into the left-turn lane. The length of this bay taper should be short to clearly delineate the left-turn move and to discourage through traffic from drifting into the left-turn lane. Table 405.2A gives offset data for design of bay tapers. In urban areas, lengths of 60 feet and 90 feet are normally used. Where space is restricted and speeds are low, a 60-foot bay taper is appropriate. On rural high-speed highways, a 120-foot length is considered appropriate.

(d) Deceleration Lane Length -- Design speed of the roadway approaching the intersection should be the basis for determining deceleration lane length. It is desirable that deceleration take place entirely off the through traffic lanes. Deceleration lane lengths are given in Table 405.2B; the bay taper length is
included. Where partial deceleration is permitted on the through lanes, as in Figures 405.2B and 405.2C, design speeds in Table 405.2B may be reduced 10 miles per hour to 20 miles per hour for a lower entry speed. In urban areas where cross streets are closely spaced and deceleration lengths cannot be achieved, the District Traffic branch should be consulted for guidance.

(e) Storage Length -- At unsignalized intersections, storage length may be based on the number of turning vehicles likely to arrive in an average 2-minute period during the peak hour. At a minimum, space for 2 vehicles should be provided at 25 feet per vehicle. If the peak hour truck traffic is 10 percent or more, space for at least one passenger car and one truck should be provided. Bus usage may require a longer storage length and should be evaluated if their use is anticipated.

At signalized intersections, the storage length may be based on one and one-half to two times the average number of vehicles that would store per signal cycle depending on cycle length, signal phasing, and arrival and departure rates. At a minimum, storage length should be calculated in the same manner as unsignalized intersection. The District Traffic Branch should be consulted for this information.

When determining storage length, the end of the left-turn lane is typically placed at least 3 feet, but not more than 30 feet, from the nearest edge of shoulder of the intersecting roadway. Although often set by the placement of a crosswalk line or limit line, the end of the storage lane should always be located so that the appropriate turning template can be accommodated.

### Table 405.2A
Bay Taper for Median Speed-change Lanes

<table>
<thead>
<tr>
<th>Distance From Point &quot;A&quot;</th>
<th>&quot;B'&quot;</th>
<th>&quot;C&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 7.5 10.0</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>15 22.5 30.0</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>45 57.5 90.0</td>
<td>55</td>
<td>82.5</td>
</tr>
<tr>
<td>60 90.0 120.0</td>
<td>100</td>
<td>110</td>
</tr>
</tbody>
</table>

#### NOTES:
1. The table gives offsets from a base line parallel to the edge of traveled way at intervals measured from point "A". Add "E" for measurements from edge of traveled way.
2. Where edge of traveled way is a curve, neither base line nor taper between B & C will be a tangent. Use proportional offsets from B to C.
3. The offset "E" is usually 2 ft along edge of traveled way for curved medians; Use "E" = 0 ft. for striped medians.

### Table 405.2B
Deceleration Lane Length

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Length to Stop (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>235</td>
</tr>
<tr>
<td>40</td>
<td>315</td>
</tr>
<tr>
<td>50</td>
<td>435</td>
</tr>
<tr>
<td>60</td>
<td>530</td>
</tr>
</tbody>
</table>
(3) **Double Left-turn Lanes.** At signalized intersections on multilane conventional highways and on multilane ramp terminals, double left-turn lanes should be considered if the left-turn demand is 300 vehicles per hour or more. The lane widths and other design elements of left-turn lanes given under Index 405.2(2) applies to double as well as single left-turn lanes.

The design of double left-turn lanes can be accomplished by adding one or two lanes in the median. See "Complete Intersections: A Guide to Reconstructing Intersections and Interchanges for Bicyclists and Pedestrians", published by Headquarters, Division of Traffic Operations, for the various treatments of double left-turn lanes.

(4) **Two-way Left-turn Lane (TWLTL).** The TWLTL consists of a striped lane in the median of an arterial and is devised to address the special capacity and safety problems associated with high-density strip development. It can be used on 2-lane highways as well as multilane highways. Normally, the District Traffic Operations Branch should determine the need for a TWLTL.

The minimum width for a TWLTL shall be **12 feet** (see Index 301.1). The preferred width is 14 feet. Wider TWLTL's are occasionally provided to conform with local agency standards. However, TWLTL's wider than 14 feet are not recommended, and in no case should the width of a TWLTL exceed 16 feet. Additional width may encourage drivers in opposite directions to use the TWLTL simultaneously.

### 405.3 Right-turn Channelization

(1) **General.** For right-turning traffic, delays are less critical and conflicts less severe than for left-turning traffic. Nevertheless, right-turn lanes can be justified on the basis of capacity, analysis, and crash experience.

In rural areas a history of high speed rear-end collisions may warrant the addition of a right-turn lane.

In urban areas other factors may contribute to the need such as:

- High volumes of right-turning traffic causing backup and delay on the through lanes.
- Conflicts between crossing pedestrians and right-turning vehicles and bicycles.
- Frequent rear-end and sideswipe collisions involving right-turning vehicles.

Where right-turn channelization is proposed, lower speed right-turn lanes should be provided to reduce the likelihood of conflicts between vehicles, pedestrians, and bicyclists.

(2) **Design Elements.**

(a) **Lane and Shoulder Width—**Index 301.1 shall be used for right-turn lane width requirements. **Shoulder width shall be a minimum of 4 feet.** Although not desirable, lane and shoulder widths less than those given above can be considered for right-turn lanes under the following conditions pursuant to Index 82.2:

- In urban, city or town centers (rural main streets) with posted speeds less than 40 miles per hour in severely constrained situations, if truck or bus use is low, consideration may be given to reducing the right-turn lane width to 10 feet.

- Shoulder widths may also be considered for reduction under constricted situations. Whenever possible, at least a 2-foot shoulder should be provided where the right-turn lane is adjacent to a curb. Entire omission of the shoulder should only be considered in constrained situations and where an 11-foot lane can be constructed.

Gutter pans can be included within a shoulder, but cannot be included as part of the travel lane width. Additional right of way for a future right-turn lane should be considered when an intersection is being designed.
Figure 405.2A
Standard Left-turn Channelization

EQUATION:

\[ L = \frac{W}{2} \times \frac{V}{24} \times \frac{V}{45} \]

Where:
- \( L \) = Length of Approach Taper - feet
- \( W \) = Design Speed - mph
- \( V \) = Width of Mid-Island Lane - feet

NOTES:

1. Where width is restricted, shoulder width may be reduced and parking restricted with an approved design exception pursuant to Section 822.4.
2. Bay taper length = 50 feet to 120 feet (See Table 405.2A).
3. For deceleration lane length see Table 405.2B.
4. Where both sides of roadway are widened, use a fraction of \( W \) that is proportional to widening on each side.
### Table 405.4
Parabolic Curb Flares Commonly Used

[Diagram of parabolic curb flare]

<table>
<thead>
<tr>
<th>Distance</th>
<th>Length of Flare</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>40</th>
<th>45</th>
<th>50</th>
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<tr>
<td><strong>1:5 FLARES</strong></td>
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<td></td>
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<td>3.20</td>
<td>5.00</td>
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<td>10.00</td>
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<tr>
<td><strong>1:15 FLARES</strong></td>
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</tbody>
</table>

\[ Y = \frac{W \times X^2}{L^2} \]

- \( L \) = Length of flare in feet
- \( W \) = Maximum offset in feet
- \( X \) = Distance along base line in feet
- \( Y \) = Offset from base line in feet

\[ W \text{ is shown in table thus } \]

The formula \( Y = \frac{W \times X^2}{L^2} \) is used to calculate the offset from the base line for given distances and flare lengths.

[Diagram of parabolic flare formula]

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May 7, 2012
Figure 405.4
Pedestrian Refuge Island

than at three-mile intervals. See Traffic Safety Systems Guidance for additional information on the design of emergency passageways.

Emergency passageways should be located only where decision sight distance is available (see Table 201.7).

Median openings at close intervals on other types of highways create conflicts with high speed through traffic. Median openings should be spaced at intervals no closer than 1600 feet. If a median opening falls within 300 feet of an access opening, it should be placed opposite the access opening.

(3) **Length of Median Opening.** For any three or four-leg intersection on a divided highway, the length of the median opening should be at least as great as the width of the crossroads pavement, median width, and shoulders. An important factor in designing median openings is the path of the design vehicle making a minimum left turn at 5 miles per hour to 10 miles per hour. The length of median opening varies with width of median and angle of intersecting road.

Usually a median opening of 60 feet is adequate for 90 degree intersections with median widths of 22 feet or greater. When the median width is less than 22 feet, a median opening of 70 feet is needed. When the intersection angle is other than 90 degrees, the length of median opening should be established by using truck turn templates (see Index 404.3).

(4) **Cross Slope.** The cross slope in the median opening should be limited to 5 percent. Crossovers on curves with super elevation exceeding 5 percent should be avoided. This cross slope may be exceeded when an existing 2-lane roadbed is converted to a 4-lane divided highway. The elevation of the new construction should be based on the 5 percent cross slope requirement when the existing roadbed is raised to its ultimate elevation.

(5) **References.** For information related to the design of intersections and median openings, "A Policy on Geometric Design of Highways and Streets," AASHTO, should be consulted.

### 405.6 Access Control

The basic guidance which govern the extent to which access rights are to be acquired at interchanges (see Topic 104, Index 205.1 and 504.8 and the PDPM) also apply to intersections at grade on expressways. Cases of access control which frequently occur at intersections are shown in Figure 405.7. This illustration does not presume to cover all situations. Where required by traffic conditions, access should be extended in order to ensure proper operation of the expressway lanes. Reasonable variations which observe the basic principles referred to above are acceptable.

However, negative impacts on the mobility needs of pedestrians, bicyclists, equestrians, and transit users need to be assessed. Pedestrians and bicyclists are sensitive to additional out of direction travel.
elevated and the cross street retains a straight profile. Type L-1’s are suitable where physical, geometric or right of way restrictions do not permit a spread diamond configuration. Compact diamonds have the disadvantage of requiring wider overcrossing or longer span undercrossing to provide corner sight distance and have limited capacity between intersections. Once the area around the interchange is developed, Type L-1 is challenging to expand to accommodate growth.

The spread diamond (Type L-2) is adaptable where the grade of the cross street is changed to pass over or under the freeway. The ramp terminals are spread in order to achieve maximum sight distance and minimum intersection cross slope, commensurate with construction and right of way costs, travel distance, and general appearance. A spread diamond has the advantage of flatter ramp grades, greater crossroads left-turn storage capacity, and the flexibility of permitting the construction of future loop ramps if required.

The split diamond with braids (Type L-3) may be appropriate where two major crossroads are closely spaced.

(b) Interchanges with Parallel Street Systems--Types L-4, L-5 and L-6 are interchange systems used where the freeway alignment is placed between parallel streets. Types L-4 and L-5 are used where the parallel streets will operate with one-way traffic. In Type L-4 slip ramps merge with the frontage street and in Type L-5 the ramps terminate at the intersection of the frontage road with the cross street, forming five-legged intersections. In Type L-6 the freeway ramps connect with two-way parallel streets. The parallel streets in the Types L-4, L-5 and L-6 situation are usually too close to the freeway to permit ramp intersections on the cross street between the parallel frontage streets.

The "hook" ramps of the Type L-6 are often forced into tight situations that lead to less than desirable geometrics. The radius of the curve at the approach to the intersection should exceed 150 feet and a tangent of at least 150 feet should be provided between the last curve on the ramp and the ramp terminal.

Special attention should always be given to exit ramps that end in a hook to ensure that adequate sight distance around the curve, adequate deceleration length prior to the curve or end of anticipated queue, and adequate superelevation for anticipated driving speeds can be developed. Type L-6 can only be considered when all other interchange types are not acceptable.

(c) Cloverleaf Interchanges--The simplest cloverleaf interchange is the two-quadrant cloverleaf, Type L-7 or Type L-8, or a combination where the two loops are on the same side of the cross street. Type L-7 eliminates the need for left-turn storage lanes, on or under the structure, thus reducing the structure costs. These interchanges should be used only in connection with controls which preclude the use of diamond ramps in all four quadrants. These controls include right of way controls, a railroad track paralleling the cross street, and a short weaving distance to the next interchange.

The Type L-9, partial cloverleaf interchange, provides loop on-ramps in addition to the four diamond-type ramps. This interchange is suitable for large volume turning movements. Left-turn movements from the crossroads are eliminated, thereby permitting two-phase operation at the ramp intersections when signalized. Because of this feature, the Type L-9 interchange usually has capacity to handle the higher volume traffic on the crossroad.

The four-quadrant cloverleaf interchange (Type L-10) offers free-flow characteristics for all movements. It has the disadvantage of a higher cost than a diamond or partial cloverleaf design, as well as a relatively short weaving section between the loop ramps which limits capacity. For this reason this type of interchange is not desirable. Collector-distributor roads should be incorporated in the design of four-quadrant cloverleaf interchanges to separate the weaving conflicts from the through freeway traffic.

(d) Trumpet Interchanges--A trumpet design, Type L-11 or L-12, may be used when a crossroads terminates at a freeway. This design should not be used if future extension of the crossroads is probable. The diamond interchange is
preferable if future extension of the crossroads is expected.

(e) Single Point Interchange (SPI)--The Type L-13 is a concept which essentially combines two separate diamond ramp intersections into one large at-grade intersection. It is also known as an urban interchange. Additional information on SPI’s is provided in the Single Point Interchange Planning, Design and Operational Guidelines (SPI Guidelines), issued by memorandum on June 15, 2001.

Type L-13 requires approximately the same right of way as the compact diamond. However, the construction cost is substantially higher due to the structure requirements. The capacity of the L-13 can exceed that of a compact diamond if long signal times can be provided and left turning volumes are balanced.

This additional capacity may be offset if nearby intersection queues interfere with weaving and storage between intersections. The disadvantages of the L-13 are: 1) future expansion of the interchange is extremely difficult; 2) stage construction for retrofit situations is costly; 3) long structure spans require higher than normal profiles and deeper structure depths; and 4) poor bicycle and pedestrian circulation.

(f) Other Types of Interchanges--New or experimental interchanges must have the Project Delivery Coordinator and the Headquarters Chief, Division of Traffic Operations concurrence before selection. Concurrence may require additional studies and documentation.

502.3 Freeway-to-Freeway Interchanges

(I) General. The function of the freeway-to-freeway interchange is to link freeway segments together so as to provide the highest level of service in terms of mobility. Parameters such as cost, environment, community values, traffic volumes, route continuity, driver expectation and safety should all be considered. Route continuity, providing for the designated route to continue as the through movement through an interchange, reduces lane changes, simplifies signing, and reduces driver confusion.

Interstate routes shall maintain route continuity. Where both the designated route and heavier traffic volume route are present, the interchange configuration shall keep the designated route to the left through the interchange.

(2) Design Considerations.

(a) Cost--The differential cost between interchange types is often significant. A cost-effective approach will tend to assure that an interchange is neither over nor underdesigned. Decisions as to the relative values of the previously mentioned parameters must be consistent with decisions reached on adjacent main line freeways.

(b) System Balance--The freeway-to-freeway interchange is a critical link in the total freeway system. The level of traffic service provided will have impact upon the mobility and overall effectiveness of the entire roadway system. For instance, traffic patterns will adjust to avoid repetitive bottlenecks, and to the greatest degree possible, to temporary closures, accidents, etc. The freeway-to-freeway interchange should provide flexibility to respond to these needs so as to maximize the cost effectiveness of the total system.

(c) Provide for all Traffic Movements--All interchanges must provide for each of the eight basic movements (or four basic movements in the case of a three-legged interchange), except in the most extreme circumstances. Less than “full interchanges” may be considered on a case-by-case basis for applications requiring special access for managed lanes (e.g., transit, HOVs, HOT lanes) or park and ride lots. Partial interchanges usually have undesirable operational characteristics. If circumstances exist where a partial interchange is considered appropriate as an initial phase improvement, then commitments need to be included in the request to accommodate the ultimate design. These commitments may include purchasing the right of way.
required during the initial phase improvements.

(d) Local Traffic Service—In metropolitan areas a freeway-to-freeway interchange is usually superimposed over an existing street system. Local and through traffic requirements are often in conflict.

Combinations of local and freeway-to-freeway interchanges can result in designs that are both costly and so complex that the important design concepts of simplicity and consistency are compromised. Therefore, alternate plans separating local and freeway-to-freeway interchanges should be fully explored. Less than desirable local interchange spacing may result; however, this may be compensated for by upgrading the adjacent local interchanges and street system.

Local traffic service interchanges should not be located within freeway-to-freeway interchanges unless geometric standards and level of service will be substantially maintained.

(e) Alignment—It is not considered practical to establish fixed freeway-to-freeway interchange alignment standards. An interchange must be designed to fit into its environment. Alignment is often controlled by external factors such as terrain, buildings, street patterns, route adoptions, and community value considerations. Normally, loops have radii in the range of 150 feet to 200 feet and direct connections should have minimum radii of 850 feet. Larger radii may be proper in situations where the skew or other site conditions will result in minimal increased costs. Direct connection radii of at least 1,150 feet are desirable from a traffic operational standpoint. High alignment and sight distance standards should be provided where possible.

Drivers have been conditioned to expect a certain standard of excellence on California freeways. The designer's challenge is to provide the highest possible standards consistent with cost and level of service.

(3) Types. Several freeway-to-freeway interchange design configurations are shown on Figure 502.3. Many combinations and variations may be formed from these basic interchange types.

(a) Four-Level-Interchange—Direct connections are appropriate in lieu of loops when required by traffic demands or other specific site conditions. The Type F-1 interchange with all direct connections provides the maximum in mobility and safety. However, the high costs associated with this design require that the benefits be fully substantiated.

The Type F-1 Alternative "A" interchange utilizes a single divergence ramp for traffic bound for the other freeway; then provides a secondary directional split. Each entrance ramp on a Type F-1A interchange is provided separately. The advantages of the Type F-1A are: 1) reduced driver confusion since there is only one exit to the other freeway, and 2) operations at the entrance may be improved since the ramps merge with the mainline one at a time.

The Type F-1 Alternative "B" interchange provides separate directional exit ramps and then merges the entering traffic into a single ramp before converging with the mainline. Since the Type F-1B combines traffic from two ramps before entering the freeway, it is important to verify that adequate weaving capacity is provided beyond the entrance. Separating the directional split of exiting traffic reduces the volume to each of the two ramps and therefore may improve the level of service of the weave section prior to the exit.

Design for a four-level interchange may combine the configuration of the Type F1-A and F1-B interchange to best suit the conditions at a given location.

(b) Combination Interchanges—The three-quadrant cloverleaf, Type F-2, with one direct connection may be necessary where
a single move carries too much traffic for a loop ramp or where the one quadrant is restricted by environmental, topographic, or right of way controls.

The two-loop, two-direct connection interchange, Type F-3, is often an appropriate solution. The weaving conflicts which ordinarily constitute the most restrictive traffic constraint are eliminated, yet cost and right of way requirements may be kept within reasonable bounds. Consideration should be given to providing an auxiliary lane in advance of the loop off-ramps to provide for vehicle deceleration.

(c) Four-Quadrant Cloverleaf--The four-quadrant cloverleaf with collector-distributor roads, Type F-4, is ordinarily the most economical freeway-to-freeway interchange solution when all turning movements are provided. The four-quadrant cloverleaf is generally applicable in situations where turning volumes are low enough to be accommodated in the short weaving sections. It should be designed with collector-distributor roads to separate weaving conflicts from the through freeway traffic.

(d) Freeway Terminal Junction--Types F-5, F-6, F-7, and F-8 are examples of interchange designs where one freeway terminates at the junction with another freeway. In general, the standard of alignment provided on the left or median lane connection from the terminating freeway should equal or approach as near as possible that of the terminating freeway. Terminating the median lane on a loop should be avoided. It is preferable that both the designated route and the major traffic volume be to the left at the branch connection diverge. The choice between Types F-7 and F-8 should include considerations of traffic volumes, and route continuity. When these considerations are in conflict, the choice is made on the basis of judgment of their relative merits.

Topic 503 - Interchange Design Procedure

503.1 Basic Data

Data relative to community service, traffic, physical and economic factors, and potential area development which may materially affect design, should be obtained prior to interchange design. Specifically, the following information should be available:

(a) The location and standards of existing and proposed local streets including types of traffic control.

(b) Existing, proposed and potential for development of land, including such developments as employment centers, retail services and shopping centers, recreational facilities, housing developments, schools, and other institutions.

(c) A vehicle traffic flow diagram showing average daily traffic and design hourly volumes, as well as time of day (a.m. or p.m.), anticipated on the freeway ramps and affected local streets or roads.

(d) Current and future bicycle and pedestrian access through the community.

(e) The relationship with adjacent interchanges.

(f) The location of major utilities, railroads, or airports.

(g) The presence of dedicated lanes and associated ramps and connections, including HOV lanes, Bus (BRT) lanes and Express lanes.

(h) The planned ultimate build-out for the freeway facility.

(i) Existing and planned rail facilities.

503.2 Reviews

Interchanges are among the major design features which are to be reviewed by the Project Delivery Coordinator and/or District Design Liaison, District Traffic Engineer or designee, other Headquarters staff, and the FHWA Transportation Engineer, as appropriate. Major design features include the freeway alignment, geometric cross
section, geometric design and intersection control of ramp termini, location of separation structures, closing of local roads, frontage road construction, bicycle and pedestrian facilities and work on local roads. Particularly close involvement should occur during preparation of the project initiation document and project report (see the Project Development Procedures Manual). Such reviews can be particularly valuable when exceptions to design standards are being considered and alternatives are being sought. The geometric features of all interchanges or modifications to existing interchanges must be approved by the Project Delivery Coordinator.

**Topic 504 - Interchange Design Standards**

**504.1 General**

Topic 504 discusses the standards that pertain to both local service interchanges (various ramp configurations) and freeway-to-freeway connections. The design standards, policies and practices covered in Indexes 504.2, and 504.5 through 504.8 are typically common to both ramp and connector interchange types. Indexes 504.3 and 504.4 separately discuss ramp standards and freeway-to-freeway connector standards, respectively.

**504.2 Freeway Entrances and Exits**

(1) **Basic Policy.** All freeway entrances and exits, except for direct connections with median High-Occupancy Vehicle (HOV) lanes, Express Toll lanes or BRT lanes, shall connect to the right of through traffic.

(2) **Standard Designs.** Design of freeway entrances and exits should conform to the standard designs illustrated in Figure 504.2A-B (single lane), and Figure 504.3K (two-lane entrances and exits) and/or Figure 504.4 (diverging branch connections), as appropriate.

The minimum deceleration length shown on Figure 504.2B shall be provided prior to the first curve beyond the exit nose to assure adequate distance for vehicles to decelerate before entering the curve. The same standard should apply for the first curve after the exit from a collector-distributor road. The range of minimum "DL" (distance) vs. "R" (radius) is given in the table in Figure 504.2B. Strong consideration should be given to lengthening the "DL" distance given in the table when the subsequent curve is a descending loop or hook ramp, or if the upstream condition is a sustained downgrade (see AASHTO, A Policy on Geometric Design of Highways and Streets, for additional information).

The exit nose shown on Figure 504.2B may be located downstream of the 23-foot dimension; however, the maximum paved width between the mainline and ramp shoulder edges should be 20 feet. Also, see pavement cross slope requirements in Index 504.2(5).

Contrasting surface treatment beyond the gore pavement should be provided on both entrance and exit ramps as shown on Figures 504.2A, 504.2B, and 504.3K. This treatment can both enhance aesthetics and minimize maintenance efforts. It should be designed so that a driver will be able to identify and differentiate the contrasting surface treatment from the pavement areas that are intended for regular or occasional vehicular use (e.g., traveled way, shoulders, paved gore, etc.).

Consult with the District Landscape Architect, District Materials Engineer, and District Maintenance Engineer to determine the appropriate contrasting surface treatment of the facility at a specific location.

Refer to the HOV Guidelines for additional information specific to direct connections to HOV lanes.

(3) **Location on a Curve.** Freeway entrances and exits should be located on tangent sections wherever possible in order to provide maximum sight distance and optimum traffic operation. Where curve locations are necessary, the ramp entrance and exit tapers should be curved also. The radius of the exit taper should be about the same as the freeway edge of traveled way in order to develop the same degree of divergence as the standard design (see Figure 504.2C).
Figure 504.2A
Single Lane Freeway Entrance

NOTES:
1. On freeway to freeway connections, the right paved shoulder shall be 10'- Table 302.1.
2. On single- and two-lane freeway to freeway connections, the left paved shoulder shall be 5'- Table 302.1.
3. Where freeway is not on tangent alignment, select radius to approximate lane of convergence (See Index 504.2(3)).
4. Locate as if it were to center of a 1:1 radius curb nose.
5. 2% super elevation may be acceptable for the 3,000' radius curve on entrance ramps.
6. Contrasting surface treatment (See Index 504.2(2)).
7. See Index 504.2(6) for pedestrian and bicycle ramp crossings on freeways where bicycle or pedestrian travel is prohibited.
8. See Index 302.1 for shoulder width standards.
Figure 504.2B

Single Lane Freeway Exit

See Index 504.2(4) for decision sight distance to exit nose.

<table>
<thead>
<tr>
<th>R (ft)</th>
<th>Min. DL (ft)</th>
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</tr>
<tr>
<td>300 - 499</td>
<td>470</td>
<td></td>
</tr>
<tr>
<td>500 - 999</td>
<td>420</td>
<td></td>
</tr>
<tr>
<td>1,000 &amp; over</td>
<td>270</td>
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</tr>
</tbody>
</table>

NOTES:

1. Minimum length between exit nose and end of ramp is 525' for full stop at end of ramp.
2. "DL" distance should be lengthened for descending, short radius curves, or if entered from a sustained downgrade.
3. On freeway to freeway connections the right paved shoulder shall be 10'. - Table 302.1
4. On single- and two-lane freeway to freeway connections the left paved shoulder shall be 5'. - Table 302.1
5. Contrasting surface treatment (See Index 504.2(2)) (Advisory standard)

See Index 302.1 for shoulder width standards.
On entrance ramps the distance from the inlet nose (14-foot point) to the end of the acceleration lane taper should equal the sum of the distances shown on Figure 504.2A. The 50:1 (longitudinal to lateral) taper may be curved to fit the conditions, and the 3,000-foot radius curve may be adjusted (see Figure 504.2A, note 3).

When an exit must be located where physical restrictions to visibility cannot be corrected by cut widening or object removal, an auxiliary lane in advance of the exit should be provided. The length of auxiliary lane should be a minimum 600 feet, 1,000 feet preferred.

(4) Design Speed Considerations. In the design of interchanges it is important to provide vertical and horizontal alignment standards which are consistent with driving conditions expected on branch connections. Sight distance on crest vertical curves should be consistent with expected approach speeds.

(a) Freeway Exit--The design speed at the exit nose should be 50 miles per hour or greater for both ramps and branch connections.

(b) Freeway Entrance--The design speed at the inlet nose should be consistent with approach alignment standards. If the approach is a branch connection or diamond ramp with high alignment standards, the design speed should be at least 50 miles per hour.

(c) Ramps--See Index 504.3(1)(a).

(d) Freeway-to-Freeway Connections--See Index 504.4(2).

(5) Grades. Grades for freeway entrances and exits are controlled primarily by the requirements of sight distance. Ramp profile grades should not exceed 8 percent with the exception of descending entrance ramps and ascending exit ramps, where a 1 percent steeper grade is allowed. However, the 1 percent steeper grade should be avoided on descending loops to minimize overdriving of the ramp (see Index 504.3 (8)).

Profile grade considerations are of particular concern through entrance and exit gore areas. In some instances the profile of the ramp or connector, or a combination of profile and cross slope, is sufficiently different than that of the freeway through lanes that grade breaks across the gore may become necessary. Where adjacent lanes or lanes and paved gore areas at freeway entrances and exits are not in the same plane, the algebraic difference in pavement cross slope should not exceed 5 percent (see Index 301.3). The paved gore area is typically that area between the diverging or converging edge of traveled ways and the 23-foot point.

In addition to the effects of terrain, grade lines are also controlled by structure clearances (see Indexes 204.6 and 309.2). Grade lines for overcrossing and undercrossing roadways...
should conform to the requirements of HDM Topic 104 Roads Under Other Jurisdictions.

(a) Freeway Exits--Vertical curves located just beyond the exit nose should be designed with a minimum 50 miles per hour stopping sight distance. Beyond this point, progressively lower design speeds may be used to accommodate loop ramps and other geometric features.

Ascending off-ramps should join the crossroads on a reasonably flat grade to expedite truck starts from a stopped condition. If the ramp ends in a crest vertical curve, the last 50 feet of the ramp should be on a 5 percent grade or less. There may be cases where a drainage feature is necessary to prevent crossroads water from draining onto the ramp.

On descending off-ramps, the sag vertical curve at the ramp terminal should be a minimum of 100 feet in length.

(b) Freeway Entrances--Entrance profiles should approximately parallel the profile of the freeway for at least 100 feet prior to the inlet nose to provide intervisibility in merging situations. The vertical curve at the inlet nose should be consistent with approach alignment standards.

Where truck volumes (three-axle or more) exceed 20 vehicles per hour on ascending entrance ramps to freeways and expressways with sustained upgrades exceeding 2 percent, a 1,500-foot length of auxiliary lane should be provided in order to ensure satisfactory operating conditions. Additional length may be warranted based on the thorough analysis of the site specific grades, traffic volumes, and calculated speeds; and after consultation with the District Traffic Safety Engineer or designee and the Project Delivery Coordinator or District Design Liaison. Also, see Index 204.5 "Sustained Grades".

504.3 Ramps

(1) General.

(a) Design Speed--When ramps terminate at an intersection at which all traffic is expected to make a turning movement, the minimum design speed along the ramp should be 25 miles per hour. When a “through” movement is provided at the ramp terminus, the minimum ramp design speed should meet or exceed the design speed of the highway facility for which the through movement is provided. The design speed along the ramp will vary depending on alignment and controls at each end of the ramp. An acceptable approach is to set design speeds of 25 miles per hour and 50 miles per hour at the ramp terminus and exit nose, respectively, the appropriate design speed for any intermediate point on the ramp is then based on its location relative to those two points. When short radius curves with relatively lower design speeds are used, the vertical sight distance should be consistent with approach vehicle speeds. See Index 504.2(4) for additional information regarding design speed for ramps.

(b) Lane Width--Ramp lanes shall be a minimum of 12 feet in width. Where ramps have curve radii of 300 feet or less, measured along the outside edge of traveled way for single lane ramps or along the outside lane line for multilane ramps, with a central angle greater than 60 degrees, the single ramp lane, or the lane furthest to the right if the ramp is multilane, shall be widened in accordance with Table 504.3 in order to accommodate large truck wheel paths. See Topic 404. Consideration may be given to widening more than one lane on a multilane ramp with short radius curves if there is a likelihood of considerable transit or truck usage of that lane.
Table 504.3
Ramp Widening for Trucks

<table>
<thead>
<tr>
<th>Ramp Radius (ft)</th>
<th>Widening (ft)</th>
<th>Lane Width (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;150</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>150 – 179</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>180 – 209</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>210 – 249</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>250 – 299</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>&gt;300</td>
<td>0</td>
<td>12</td>
</tr>
</tbody>
</table>

(c) Shoulder Width—Shoulder widths for ramps shall be as indicated in Table 302.1. Typical ramp shoulder widths are 4 feet on the left and 8 feet on the right.

(d) Lane Drops—Typically, lane drops are to be accomplished over a distance equal to WV. Where ramps are metered, the recommended lane drop taper past the meter limit line is 50 to 1 (longitudinal to lateral). Depending on approach geometry and speed, the lane drop transition between the limit line and the 6-foot separation point should be accomplished with a taper of between 30:1 and 50:1 (longitudinal to lateral). This is further explained in Index 504.3(2)(b) for metered multilane entrance ramps. However, the lane drop taper past the limit line shall not be less than 15 to 1.

Lane drop tapers should not extend beyond the 6-foot point (the beginning of the weaving length) without the provision of an auxiliary lane.

(e) Lane Additions -- Lane additions to ramps are usually accomplished by use of a 120-foot bay taper. See Table 405.2A for the geometrics of bay tapers.

(2) Ramp Metering

Caltrans Deputy Directive (DD) No. 35-R1, Ramp Metering, contains the statewide policy for ramp metering which delegates responsibility for its implementation in part through the Ramp Metering Design Manual (RMDM). DD 35-R1 specifies that provisions for entrance ramp metering shall be included in any project that proposes additional capacity, modification of an existing interchange, or construction of a new interchange, within the freeway corridors identified in the Ramp Metering Development Plan (RMDP), regardless of funding source. Projects designed for new or existing freeway segments experiencing recurring traffic congestion and/or a high frequency of vehicle collisions may include provisions for entrance ramp metering, whether or not the freeway segment locations are listed in the RMDP.

All geometric designs for ramp metering installations must be discussed with the Project Delivery Coordinator or District Design Liaison. Design features or elements which deviate from design standards require the approvals described in Index 82.2.

See the RMDM for ramp metering guidance, procedures, and policies to be used in conjunction with the guidance in this manual. Where traffic-related ramp metering guidance is noted in this Chapter, reference is made to the RMDM for exception instructions and further information.

Geometric ramp design for operational improvement projects which include ramp metering should be based on current peak-hour traffic volume. If this current data is not available it should be obtained before proceeding with design. Peak hour traffic data from the annual Caltrans Traffic Volumes book is not adequate for this application.

The design advice and typical designs that follow should not be directly applied to ramp meter installation projects, especially retrofit designs. Every effort should be made by the designer to exceed the recommended minimum standards provided herein, where conditions are not restrictive.

(a) Metered Freeway Entrance Ramps
(1 General Purpose (GP) + 1 HOV Preferential Lane)

According to the RMDM, a High-Occupancy Vehicle (HOV) preferential lane shall be provided where ramp meters are installed, and each HOV preferential
lane should be metered. See the RMDM for exception procedures from the Ramp Metering policy. See Figures 504.3A and 504.3B for typical freeway entrance ramp metering (1 GP Lane + 1 HOV Preferential Lane).

Due to the operational benefits of an auxiliary lane, the merge from the metered entrance ramp to the freeway should include an auxiliary lane with a minimum length of 300 feet beyond the ramp convergence point. See Figure 504.3A.

Where truck volumes (3-axle or more) are 5 percent or greater on ascending entrance ramps to freeways with sustained upgrades exceeding 3 percent (i.e., at least throughout the merge area), a minimum 1000-foot length of auxiliary lane should be provided beyond the ramp convergence point.

When ramp volumes exceed 1,500 vph, a 1,000-foot minimum length of auxiliary lane should be provided beyond the ramp convergence point. If an auxiliary lane is included, the ramp lane transition may be extended to the convergence point. However, the proximity of the nearest interchange may warrant weaving analysis to determine the acceptability of extending the ramp lane transition beyond the 6-foot separation point. A longer auxiliary lane should be considered where mainline/ramp gradients and truck volumes warrant additional length.

(b) HOV Preferential Lane

Ramp meter installations should operate in conjunction with, and complement other transportation management system elements and transportation modes. As such, ramp meter installations should include preferential treatment of carpools and transit riders. Specific treatment(s) must be tailored to the unique conditions at each ramp location.

Where restrictive conditions, vehicle volumes less than 500 vehicles per hour (vph), or other engineering judgement exist in support of an exception to the HOV preferential lane, see Figures 504.3C and 504.3D. In restrictive conditions, a minimum 500-foot auxiliary lane should be provided beyond the ramp convergence point when truck volumes (3-axle or more) are 5 percent or greater on ascending entrance ramps to freeways with sustained upgrades exceeding 3 percent (i.e., at least throughout the merge area).

In general, the vehicle occupancy requirement for ramp meter HOV preferential lanes is typically two or more persons per vehicle. At some locations, a higher vehicle occupancy requirement may be necessary. The occupancy requirement should be based on the HOV demand and should match with other HOV facilities in the vicinity.

A HOV preferential lane should typically be placed on the left; however, demand and operational characteristics at the ramp entrance may dictate otherwise. Design of the HOV preferential lane at a metered entrance ramp requires the review and concurrence of the Caltrans District Traffic Operations Branch responsible for ramp metering.

Access to the HOV preferential lane may be provided in a variety of ways depending on interchange type and available storage length for queued vehicles. Where queued vehicles in the general purpose (GP) lane may block access to the HOV preferential lane, consider providing direct or separate access. To avoid trapping GP traffic in an HOV preferential lane, the signing and pavement marking at the ramp entrance should direct motorists into the GP lane(s). See the RMDM, Chapter 3 for signing and pavement markings. Designs should consider pedestrian/bicycle volumes, especially when the entrance ramp is located near a school or the local highway facility includes a designated bicycle lane or route. See Index 403.6 for right-turn-only lane guidance where bicycle travel is permitted. Contact the District Traffic Safety Engineer or designee and the Project Delivery Coordinator or District Design
Figure 504.3A
Typical Freeway Entrance Loop Ramp Metering
(1 GP Lane + 1 HOV Preferential Lane)
Figure 504.3D
Restrictive Condition Freeway Entrance Loop Ramp Metering
(1 GP Lane)
Liaison to discuss the application of specific design and/or general issues related to the design of HOV preferential lane access.

Signing for a HOV preferential lane should be placed to clearly indicate which lane is designated for HOVs. Real-time signing at the ramp entrance, such as an overhead changeable message sign, may be necessary at some locations if pavement delineation and normal signing do not provide drivers with adequate lane usage information. To avoid leading Single-Occupancy Vehicles (SOV) into a HOV preferential lane, pavement delineation at the ramp entrance should lead drivers into the SOV lane.

(c) Metered Multilane Freeway Entrance Ramps

The number of metered lanes at an entrance ramp is the number of both metered general purpose (GP) and high-occupancy vehicle (HOV) preferential lanes at the limit line. The minimum number of metered GP lanes is determined based on GP traffic demand. The number of metered HOV preferential lanes is determined based on HOV demand using the same guidelines as GP traffic demand, as well as the HOV preferential lane policy.

A multilane ramp segment may be provided to increase vehicle storage within the available ramp length. At on-ramps with peak hour volume between 500 and 900, a two-lane ramp meter may be provided to double the vehicles stored within the available storage area. See RMDM for additional multilane freeway entrance ramp guidance.

Figures 504.3E and 504.3F illustrate typical designs for metered multilane diagonal and loop freeway entrance ramps. On multilane loop ramps, typically only the right lane needs to be widened to accommodate design vehicle off-tracking. See Index 504.3(1)(b).

Three-lane metered ramps are typically needed to serve peak (i.e., commute) hour traffic along urban and suburban freeway corridors. The adverse effects of bus and truck traffic on the operation of these ramps (i.e., off-tracking, sight restriction, acceleration characteristics on upgrades, etc.) is minimized when the ramp alignment is tangential or consists of curve radii not less than 300 feet. Proposed three-lane loop and four-lane entrance ramps require the review and approval by the Deputy District Director of Traffic Operations.

On multi-lane entrance ramps, the multi-lane segment should transition to a single lane width between the ramp meter limit line and the 6-foot separation point (from the mainline edge of traveled way).

The lane drop transition should be accomplished with a taper of 50:1 (longitudinal to lateral) unless a lesser taper is warranted by site and/or project specific conditions which control the ramp geometry and/or anticipated maximum speed of ramp traffic. For example, "loop" entrance ramps would normally not allow traffic to attain speeds which would warrant a 50:1 (longitudinal to lateral) lane drop taper. Also, in retrofit situations, existing physical, environmental or right of way constraints may make it impractical to provide a 50:1 taper, especially if the maximum anticipated approach speed will be less than 50 miles per hour. Therefore, depending on approach geometry and speed, the lane drop transition between the limit line and the 6-foot separation point should be accomplished with a taper of between 30:1 and 50:1 (longitudinal to lateral). However, the lane drop taper past the limit line shall not be less than 15 to 1.

The merge from the metered entrance ramp to the freeway should include a 300-foot minimum auxiliary lane beyond the ramp convergence point.

Where truck volumes (3-axle or more) are 5 percent or greater on ascending entrance ramps to freeways with sustained upgrades exceeding 3 percent (i.e. at least
placement guidance of fixed objects such as controller cabinets. Refer to HDM Index 107.2 and the Standard Plans for the layout and pavement structure section details of an MVP. See the RMDM for exception procedures to this policy.

(3) Location and Design of Ramp Intersections on the Crossroads.

Factors which influence the location of ramp intersections on the crossroads include sight distance, construction and right of way costs, bicycle and pedestrian mobility, circuitous travel for left-turn movements, crossroads gradient at ramp intersections, storage requirements for left-turn movements off the crossroads, and the proximity of other local road or bicycle path intersections.

Ramp intersections with local roads are intersections at grade. Chapter 400 and the references therein contain general guidance. For ramp intersections, a wrong-way movement onto an off-ramp can have severe consequences. The California MUTCD also contains guidance for signing and striping to deter wrong-way movements.

Interchange Types L-7, L-8, and L-9 are partial cloverleaf designs with ramps at a right angle to the crossroad where the off-ramps and on-ramps are adjacent to each other on the same side of the crossroad that offer benefits for non-motorized travel modes; however, additional design considerations as follows may be appropriate in order to deter wrong-way movements:

- The entrance and exit ramps should be clearly visible from the crossroad. Concrete barrier or guardrail placed between the ramps can block the view from the crossroad. If feasible, the concrete barrier or guardrail channelization feature should be set back from the crossroad edge of shoulder 20 to 50 feet with a raised traffic island placed from the ramp termini to the begin point of the separation feature. See Index 405.4 for further traffic island guidance. Consult the District Traffic Safety Branch for available options.

- Vehicles turning left onto an on-ramp are to be prevented, to the maximum extent feasible, from turning prematurely onto the off-ramp by placing or extending a curbed median on the crossroad to physically discourage this move. Attention needs to be given to accommodating truck turn templates for design vehicles entering and exiting the freeway. See Index 404.5 for further turning template guidance. Truck aprons could be provided if the size of an intersections becomes too large for an occasional truck. See Index 405.10, Roundabouts, and the references therein for design guidance on truck aprons.

Isolated off-ramps are to be avoided to minimize the potential for wrong-way movements. If the isolated off-ramp is necessary, the leading curb return from the perspective of a vehicle on the crossroad approaching from the same side as the off-ramp is made with a short radius curve of 3 to 5 feet. State or local roads and driveways opposite isolated off-ramps are to be avoided as there is no corresponding on-ramp for cross traffic to take. See this chapter for further interchange and ramp guidance.

Ramp terminals should connect where the grade of the overcrossing is 4 percent or less to avoid potential overturning of trucks.

For left-turn maneuvers from an off-ramp at an unsignalized intersection, the length of crossroads open to view should be greater than the product of the prevailing speed of vehicles on the crossroads, and the time required for a stopped vehicle on the ramp to execute a left-turn maneuver. This time is estimated to be 7½ seconds.

When proposing uncontrolled entries and exits from freeway ramps with local roads, see the Design of Intersections at Interchanges guidance in Index 403.6(2).

Horizontal sight restrictions may be caused by bridge railings, bridge piers, or slopes. Sight distance is measured between the center of the outside lane approaching the ramp and the eye of the driver of the ramp vehicle assumed 8 feet back from the edge of shoulder at the
crossroads. Figure 504.3I illustrates the determination of ramp setback from an overcrossing structure on the basis of sight distance controlled by the bridge rail. The same relationship exists for sight distance controlled by bridge piers or slopes.

Where ramp set back for the 7½ second criterion is unobtainable, sight distance should be provided by flaring the end of the overcrossing structures or setting back the piers or end slopes of an undercrossing structure.

If signals are warranted within 5 years of construction, consideration may be given to installing signals initially in lieu of providing horizontal sight distance which meets the 7½ second criterion. See Part 4 of the California MUTCD, 4B.107(CA). However, this is not desirable and corner sight distance commensurate with design speed should be provided where obtainable (see AASHTO, A Policy on Geometric Design of Highways and Streets).

For additional information on sight distance requirements at signalized intersections, see Index 405.1.

The minimum distance (curb return to curb return) between ramp intersections and local road intersections shall be 400 feet.

The preferred minimum distance should be 500 feet. This does not apply to Resurfacing, Restoration and Rehabilitation (3R), ramp widening, restriping or other projects which do not reconfigure the interchange. This standard does apply to projects proposing to realign a local street.

Where intersections are closely spaced, traffic operations are often inhibited by short weave distance, storage lengths, and signal phasing. In addition it is difficult to provide proper signing and delineation. The District Traffic Branch should be consulted regarding traffic engineering studies needed to determine the appropriate signage, delineation, and form of intersection control.

(4) Superelevation for Ramps. The factors controlling superelevation rates discussed in Topic 202 apply also to ramps. As indicated in Index 202.2 use the 12 percent $e_{\text{max}}$ rate except where snow and ice conditions prevail. In restrictive cases where the length of curve is too short to develop standard superelevation, the highest obtainable rate should be used (see Index 202.5). If feasible, the curve radius can be increased to reduce the standard superelevation rate. Both edge of traveled way and edge of shoulder should be examined at ramp junctions to assure a smooth transition.

Under certain restrictive conditions the standard superelevation rate discussed above may not be required on the curve nearest the ramp intersection of a ramp. The specific conditions under which lower superelevation rates would be considered must be evaluated on a case-by-case basis and must be discussed with the Project Delivery Coordinator or the District Design Liaison and then documented as required by the Project Delivery Coordinator.

(5) Single-lane Ramps. Single lane ramps are those ramps that either enter into or exit from the freeway as a single lane. These ramps are often widened near the ramp intersection with the crossroads to accommodate turning movements onto or from the ramp. When additional lanes are provided near an entrance ramp intersection, the lane drop should be accomplished over a distance equal to WV. The lane to be dropped should be on the right so that traffic merges left.

Exit ramps in metropolitan areas may require multiple lanes at the intersection with the crossroads to provide additional storage and capacity. If the length of a single lane ramp exceeds 1,000 feet, an additional lane should be provided on the ramp to permit passing maneuvers. Figure 504.3J illustrates alternative ways of transitioning a single lane exit ramp to two lanes. The decision to use Alternate A or Alternate B is generally based on providing the additional lane for the minor movement.

(6) Two-lane Exit Ramps. Where design year estimated volumes exceed 1500 equivalent passenger cars per hour, a 2-lane ramp should be provided. Provisions should be made for
Figure 504.3I

Location of Ramp Intersections on the Crossroads

Unsignalized and based on 7.5 second horizontal sight distance criteria

\[
c = d \left( \frac{b - (a + 6)}{b} \right)
\]

\( a = \) Distance from edge of traveled way to bridge railing.

\( b = \) Distance from center of near lane to eye of ramp vehicle driver. Ramp driver’s eye is assumed to be located 10’ from the edge of shoulder, but not less than 15’ from the ETW (therefore, \( b = 6’ + \) shoulder width + 10’). See Index 405.1.

\( c = \) Ramp set back from end of bridge railing.

\( d = \) Corner Sight distance along highway from intersection. (See Table above) Sight distance is measured from a 3½’ eye height on the ramp to a 4¼’ object height on the crossroad.

\( V = \) Anticipated prevailing speed on crossroad.

**NOTE:**

1. See the California MUTCD for limit line placement and guidance.
possible widening to three or more lanes at the crossroads intersection. Figure 504.3K illustrates the standard design for a 2-lane exit. An auxiliary lane approximately 1,300 feet long should be provided in advance of a 2-lane exit. For volumes less than 1500 but more than 900, a one-lane width exit ramp should be provided with provision for adding an auxiliary lane and an additional lane on the ramp.

(7) Two-lane Entrance Ramps. These ramps are discouraged in congested corridors. Early discussion with the Project Delivery Coordinator, District Design Liaison and the District Traffic Engineer or designee is recommended whenever two-lane entrance ramps are being considered.

(8) Loop Ramps. Normally, loop ramps should have one lane and shoulders unless a second lane is needed for capacity or ramp metering purposes. Consideration should be given to providing a directional ramp when loop volumes exceed 1500 vehicles per hour. If two lanes are provided, normally only the right lane needs to be widened for trucks. See Topic 404 for additional discussion on lane widths and design of ramp intersections to accommodate the design vehicle. See Index 504.3(1) for a discussion regarding on-ramp widening for trucks.

Radii for loop ramps should normally range from 150 feet to 200 feet. Increasing the radii beyond 200 feet is typically not cost effective as the slight increase in design speed is usually outweighed by the increased right of way requirements and the increased travel distance. Curve radii of less than 120 feet should also be avoided. Extremely tight curves lead to increased off-tracking by trucks and increase the potential for vehicles to enter the curve with excessive speed. Therefore, consider providing the ramp lane pavement structure on shoulders for curves with a radius less than 300 feet (see Indexes 626.1 and 636.1).

Of particular concern in the design of loop ramps are the constraints imposed on large trucks. Research indicates that trucks often enter loops with excessive speed, either due to inadequate deceleration on exit ramps or due to driver efforts to maintain speed on entrance ramps to facilitate acceleration and merging. Where the loop is of short radius and is also on a steep descent (over 6 percent), it is important to develop the standard 2/3 full superelevation rate by the beginning of the curve (see Index 504.2(5)). When accommodating design vehicles in Rural Developing Corridors that are largely composed of industrial, commercial or retail buildings located separately from housing, the following considerations may be necessary to meet the standard 2/3 full superelevation rate on loop entrance ramps:

- Begin the ramp with a short tangent (75 feet to 100 feet) that diverges from the cross street at an angle of 4 to 9 degrees.
- Provide additional tangent length as site conditions allow.

The Angle of Intersection guidance in Index 403.3 applies to all on-ramps including loops.

(9) Distance Between Successive On-ramps. The minimum distance between two successive on-ramps to a freeway lane should be the distance needed to provide the standard on-ramp acceleration taper shown on Figure 504.2A. This distance should be about 1,000 feet unless the upstream ramp adds an auxiliary lane in which case the downstream ramp should merge with the auxiliary lane in a standard 50:1 (longitudinal to lateral) convergence. The distance between on-ramp noses will then be controlled by interchange geometry.

(10) Distance Between Successive Exits. The minimum distance between successive exit ramps for guide signing should be 1,000 feet on the freeway and 600 feet on collector-distributor roads.

(11) Curbs. Curbs should not be used on ramps except in the following locations:

(a) A Type D curb or 4-inch Type B curb (see Index 303.2) may be used on both sides of the separation between freeway lanes and a parallel collector-distributor road.

(b) A B4 curb may be used as shown in Figure 504.2A to control drainage or where
the gore cross slope would be greater than allowed in Index 504.2(5). When the optional B4 curb is used at the entrance ramp inlet nose, the shoulder adjacent to the curb should be the same width as the ramp shoulder approaching the curb. The B4 gutter pan can be included as part of the shoulder width. As stated in Index 405.4(2), curbs are typically discouraged where posted speeds are over 40 miles per hour. Curbs at gore areas must be determined on a case-by-case basis.

(c) Curbs may be used where necessary at the ramp connection with the local street for the protection of pedestrians, for channelization, and to provide compatibility with the local facility.

(d) The Type E curb may be used only in special drainage situations, for example, where drainage parallels and flows against the face of a retaining wall.

In general, curbs should not be used on the high side of ramps or in off-ramp gore areas except at collector-distributor roads. The off-tracking of trucks should be analyzed when considering curbs on ramps.

(12) Dikes. Dikes may be used where necessary to control drainage. For additional information see Index 303.3.

504.4 Freeway-to-Freeway Connections

(1) General. All of the design criteria discussed in Indexes 501.3, 504.2 and 504.3 apply to freeway-to-freeway connectors, except as discussed or modified below.

(2) Design Speed. The design speed for single lane directional and all branch connections should be a minimum of 50 miles per hour. When smaller radius curves, with lower design speeds, are used the vertical sight distance should be consistent with approaching vehicle speeds. Design speed for loop connectors should be consistent with the radii guidance discussed in Index 504.3(8).

(3) Grades. The maximum profile grade on freeway-to-freeway connections should not exceed 6 percent. Flatter grades and longer vertical curves than those used on ramps are needed to obtain increased stopping sight distance for higher design speeds.

(4) Shoulder Width.

(a) Single-lane and Two-lane Connections--The width of shoulders on single-lane and two-lane (except as described below) freeway-to-freeway connectors shall be 5 feet on the left and 10 feet on the right. A single lane freeway-to-freeway connector that has been widened to two lanes solely to provide passing opportunities and not due to capacity requirements shall have a 5-foot left shoulder and at least a 5-foot right shoulder (see Index 504.4(5)).

(b) Three-lane Connections--The width of shoulders on three-lane connectors shall be 10 feet on both the left and right sides.

(5) Single-lane Connections. Freeway-to-freeway connectors may be single lane or multilane. Where design year volume is between 900 and 1500 equivalent passenger cars per hour, initial construction should provide a single lane connection with the capability of adding an additional lane. Single lane directional connectors should be designed using the general configurations shown on Figure 504.2A and 504.2B, but utilizing the flatter divergence angle shown in Figure 504.4. Single lane loop connectors may use a diverge angle of as much as that shown on Figure 504.2B for ramps, if necessary. The choice will depend upon interchange configuration and driver expectancy. Single lane connectors in excess of 1,000 feet in length should be widened to two lanes to provide for passing maneuvers (see Index 504.4(4)).

(6) Branch Connections. A branch connection is defined as a multilane connection between two freeways. A branch connection should be provided when the design year volume exceeds 1500 equivalent passenger cars per hour.

Merging branch connections should be designed as shown in Figure 504.3K. Diverging branch connections should be designed as shown in Figure 504.4. The diverging branch connection leaves the main...
freeway lanes on a flatter angle shown in Figure 504.4 than the standard 2-lane ramp exit connection shown in Figure 504.3K. The standard ramp exit connects to a local street. The diverging branch connection connects to another freeway and has a flatter angle that allows a higher departure speed.

At a branch merge, a 2,500-foot length of auxiliary lane should be provided beyond the merge of one lane of the inlet, except where it does not appear that capacity on the freeway will be reached until five or more years after the 20 year design period. In this case the length of auxiliary lane should be a minimum of 1,000 feet. For diverging connections where less than capacity conditions beyond the design year are anticipated, the length of auxiliary lane in advance of the exit should be 1,300 feet.

(7) **Lane Drops.** The lane drop taper on a freeway-to-freeway connector should not be less than WV.

(8) **Metering.** Any decision to meter freeway-to-freeway connectors must be carefully considered as driver expectancy on these types of facilities is for high-speed uninterrupted flow. If metering is anticipated on a connector, discussions with the Project Delivery Coordinator and the District Traffic Engineer or designee should take place as early as possible. Issues of particular concern are adequate deceleration lengths to the end of the queue, potential need to widen shoulders if sight distance is restricted (particularly on-ramps with 5-foot shoulders on each side), and the potential for queuing back onto the freeway.

504.5 Auxiliary Lanes

In order to ensure satisfactory operating conditions, auxiliary lanes may be added to the basic width of traveled way.

Where an entrance ramp of one interchange is closely followed by an exit ramp of another interchange, the acceleration and deceleration lanes should be joined with an auxiliary lane. Auxiliary lanes are frequently used when the weaving distance, measured as shown in Figure 504.2A is less than 2,000 feet. Where interchanges are more widely spaced and ramp volumes are high, the need for an auxiliary lane between the interchanges should be determined in accordance with Index 504.7.

Auxiliary lanes may be used for the orientation of traffic at 2-lane ramps or branch connections as illustrated on Figure 504.3K and Figure 504.4. The length and number of auxiliary lanes in advance of 2-lane exits are based on percentages of turning traffic and a weaving analysis.

Auxiliary lanes should be considered on all freeway entrance ramps with significant truck volumes. The grade, volumes and speeds should be analyzed to determine the need for auxiliary lanes. An auxiliary lane would allow entrance ramp traffic to accelerate to a higher speed before merging with mainline traffic, or simply provide more opportunity to merge. See Index 504.2 for specific requirements.

504.6 Mainline Lane Reduction at Interchanges

The basic number of mainline lanes should not be dropped through a local service interchange. The same standard should also be applied to freeway-to-freeway interchanges where less than 35 percent of the traffic is turning (see Figure 504.4). Where more than 35 percent of the freeway traffic is turning, consideration may be given to reducing the number of lanes. No decision to reduce the number of lanes should be made without the approval of the District Traffic Operations Unit. Additionally, adequate structure clearance (both horizontal and vertical) should be provided to accommodate future construction of the dropped lane if required.

Where the reduction in traffic volumes is sufficient to warrant a decrease in the basic number of lanes, a preferred location for the lane drop is beyond the influence of an interchange and preferably at least one-half mile from the nearest exit or inlet nose. It is desirable to drop the right lane on tangent alignment with a straight or sag profile so vehicles can merge left with good visibility to the pavement markings in the merge area (see Index 201.7).

504.7 Weaving Sections

A weaving section is a length of one-way roadway where vehicles are crossing paths, changing lanes, or merging with through traffic as they enter or exit a freeway or collector-distributor road.
Figure 504.4
Diverging Branch Connections

CASE 1: LESS THAN 35% TURNING TRAFFIC
CASE 2: 35% TO 50% TURNING TRAFFIC
CASE 3: MORE THAN 50% TURNING TRAFFIC

NOTES:
1. Turnover volumes expressed as a percent of total approach volume.
2. Figure indicates pavement widening. See the MUTCD and California Supplement for further requirements.
A single weaving section has an inlet at the upstream end and an exit at the downstream end. A multiple weaving section is characterized by more than one point of entry followed by one or more points of exit.

A rough approximation for adequate length of a weaving section is one foot of length per weaving vehicle per hour. This rate will approximately provide a Level of Service (LOS) C.

There are various methods for analyzing weaving sections. Two methods which provide valid results are described below.

The Leisch method, which is usually considered the easiest to use, is illustrated in Figure 504.7A. This method was developed by Jack Leisch & Associates and may be used to determine the length of weaving sections for both freeways and collector-distributor roads. The Leisch weaving charts determine the level of service for the weaving volumes for the length of the weaving section from the first panel on the lower left of the chart. The analysis is dependent on whether the section is balanced or unbalanced, as defined in Figure 504.7B. The level of service for the total volume over all lanes of the weaving section is then found from the panels on the right of the chart. The weaving chart should not be extrapolated.

Pages 234-238 of the 1965 Highway Capacity Manual (HCM) provide a method for determining the adequacy of weaving sections near single lane ramps. It is often referred to as the LOS D method. This method is also documented in Traffic Bulletin 4 which is available from the District Division of Traffic Operations. The LOS D method can be used to project volumes along a weaving section. These volumes can be compared to the capacities along the same weaving section.

Volumes in passenger car equivalents per hour (PCEPH) should be adjusted for freeway grade and truck volumes. Table 504.7C and Figures 504.7D and E are reprinted from the 1965 HCM and provide information regarding vehicle distribution by lane.

The results obtained from Figure 504.7A (the Leisch Method) for single-lane ramps with an auxiliary lane and weaving rates exceeding 2500 PCEPH should be checked using the LOS D method.

Weaving capacity analyses other than those described above should not be used on California highways. Other methods, such as the one contained in the 1994 HCM, may not always produce accurate results.

The criteria contained within this Index apply to:

- New interchanges.
- Modifications to existing interchanges including access control revisions for new ramps or the relocation/elimination of existing ramps.
- Projects to increase mainline capacity when existing interchanges do not meet interchange spacing requirements.

Weaving sections in urban areas should be designed for LOS C or D. Weaving sections in rural areas should be designed for LOS B or C. Design rates for lane balanced weaving sections where at least one ramp or connector will be two lanes should not result in a LOS lower than the middle of LOS D using Figure 504.7A. Mainline through capacity is optimized when weaving movements operate at least one level of service better than the mainline level of service. In determining acceptable hourly operating volumes, peak hour factors should be used.

The minimum weaving length, measured as shown on Figures 504.2A and 504.2B shall be 2,000 feet in urban areas, 5,000 feet outside urban areas, and 5,000 feet between freeway-to-freeway interchanges and other interchanges. The volumes used must be volumes unconstrained by metering regardless of whether metering will be used. It should be noted that a weaving analysis must be considered over an entire freeway segment as weaving can be affected by other nearby ramps.

The District Traffic Operations Branch should be consulted for difficult weaving analysis problems.

### 504.8 Access Control

Access rights shall be acquired along interchange ramps to their junction with the nearest public road. At such junctions, for new construction, access control should extend 100 feet beyond the end of the curb return or ramp radius in urban areas and 300 feet in rural areas, or as far as necessary to ensure that entry onto the facility does not impair operational characteristics. Access control shall extend at least 50 feet beyond the end of the curb return, ramp radius, or taper.
CHAPTER 670
TAPERS AND SHOULDERS
BACKING

Topic 671 - Pavement Tapers

Index 671.1  Background and Purpose

Pavement tapers are a common design detail for asphalt layer overlays and other projects where new pavement surface has a higher profile than existing pavement surface or curbs. The goal of tapers is to provide a smooth unnoticeable transition from pavement to pavement. Tapers are intended to provide a reasonable cost alternative to engineering a profile for every transition. However, in some cases, an engineered profile may be more cost-effective than a taper.

This section provides information on the best design practices for transition tapers that meet geometric, operational, constructability, as well as other pavement surface and drainage standard practices. The tapers presented in this index meet the Caltrans standards and requirements for grade breaks in Index 204.4. The pavement tapers discussed herein do not address every possible situation that can be encountered on projects throughout the State. Good engineering judgment should still be exercised when developing transition taper details for a specific project. This index only addresses permanent pavement transition tapers used on overlay and other pavement projects.

671.2  Engineering Requirements and Considerations

(1) Minimum Thickness Requirement. In order for tapers to be constructable, maintainable and meet performance requirements:

(a) The minimum thickness for an asphalt pavement taper should be no less than 3 times the maximum aggregate size (example 0.15’ for ½” aggregate and 0.20’ for ¾” aggregate.)

(b) The minimum thickness of the overall surface course layer (existing and new) in the taper should be no less than that of the adjoining existing pavement.

(c) When tapering into an existing pavement that was previously overlaid (pavement preservation or rehabilitation), the new taper should overlap the taper of the previous overlay to avoid creating a “dip” or “weak spot” in the pavement (see Figure 671.2A).

(2) Transition Taper Slopes. The taper slope should be 200:1 or flatter, with taper slope of 400:1 being preferred in highways with design speeds of 65 mph or higher. At locations where taper slopes flatter than 400:1 are desired, engineered profiles should be used because they are often shorter, less expensive, and easier to construct than the pavement taper.

(3) Design Life Requirements for Tapers. For new construction, widening, and rehabilitation/reconstruction projects, the minimum thickness of the pavement structure (existing plus surface course overlay) for pavement tapers must meet the minimum pavement design life requirements for the project as discussed in Topic 612. This is intended to prevent creating isolated “weak spots” in the pavement that may require additional maintenance and repair in the future. On rehabilitation and reconstruction projects, where the pavement structure of the taper does not meet the pavement design life requirements, the pavement structure or part of it will need to be removed and replaced. Deviations from this requirement or decision not to reconstruct the pavement sections underneath bridges will require a design standard decision document from Headquarters Pavement Program for pavement design life (see Index 612.2 and 612.5). Since pavement preservation projects (preventive maintenance and CAPM projects) are not designed for structural capacity, the minimum thickness of the pavement structure for the pavement taper needs only to match or exceed the existing pavement structure. See Figure 671.2B for further details.

671.3  Tapers into Existing Pavement or Structure

Figures 671.3A to 671.3C provide details on how to construct pavement tapers.
**Figure 671.2A**

Tapering Into a Previously Overlaid Pavement

**NOTES:**

(1) Minimum thickness should match thickness of previous overlay.

(2) No Scale.
Figure 671.2B
New Structure Approach Pavement Transition Details

NOTES:

(1) Use Maximum Overlay Thickness or 3x maximum aggregate size, whichever is less.

(2) Cold plane as needed to conform overlay with existing pavement.

(3) No Scale.
(1) Tapers into an Existing Asphalt Pavement. Where a new pavement structure or an overlay is tapering into an existing asphalt pavement that is not part of the project, the following apply:

(a) For preventive maintenance projects (thin asphalt overlays of 0.10’ or less), the Design Engineer should follow the taper details in Figure 671.3A.

(b) For CAPM projects, taper the overlay using the same details used for OGFC taper to existing OGFC or HMA pavement surface course (See Figure 671.3A)

(c) For rehabilitation projects, taper the overlay using the taper details shown in Figure 671.3A for HMA taper to existing HMA surface course.

(2) Tapers into an Existing Concrete Pavement. Where a new pavement structure or an overlay is tapering into an existing pavement that is not part of the project or into/under a structure, grinding existing concrete pavement to create a taper is not recommended because it shortens the life of the concrete pavement. Because it is not always practical to remove and replace concrete pavement for every overlay, the following guidance should be followed regarding tapers for concrete pavement.

(a) For preventive maintenance projects (thin asphalt overlays of 0.10’ or less), the taper should follow the taper details for OGFC overlay over asphalt pavement found in Figure 671.3A or reduce the thickness of overlay to 0.08’ at end of taper and roll down edge to minimize raveling. For under structures, existing concrete surface may remain.

(b) For CAPM projects, either taper the overlay down using the same details used for OGFC (See Figure 671.3A) or replace the concrete pavement slab. For under structures, the existing concrete surface may remain but should be repaired and ground or rebuilt as needed in accordance with CAPM strategies for concrete pavement in Index 624.2.

(c) For rehabilitation projects, do not grind the concrete pavement to accommodate a taper. Instead, remove concrete pavement within the taper section and replace with a new pavement structure that will meet the design life requirements for the project as defined in Topic 612.

(d) When grinding concrete pavement, meet the following two conditions:
   - Use a diamond grinder, not a planing machine.
   - Never grind more than 1 inch or reduce the thickness of the concrete pavement slab to less than 0.65 foot.

If neither of these conditions can be attained with the taper detail, then remove and replace the concrete pavement slabs and the underlying base as needed for the transition taper section to match the existing pavement surface.

(3) Longitudinal Tapers at Shoulders, Curbs, Dikes, Inlets, and Guardrail. Detailed drawings and information on the best design practices for longitudinal tapers at shoulders, curbs, dikes, inlets, and guardrail are shown in Figure 671.3B.

(4) Tapers Into or Under Structures. Figure 671.3C provides a layout and information for transition tapers under an existing structure. The following guidance should be followed when designing tapers underneath overcrossings or into bridges:

(a) Compare the cost and constructability of very flat tapers (400:1 or flatter) vs. engineered profiles to ensure that the less expensive and easier to construct alternative is used when replacing pavement underneath a structure.

(b) The minimum thickness of the pavement structure for transition tapers into or under bridges must meet the minimum design life requirements discussed in Index 671.2(4) for new construction, widening, rehabilitation, and reconstruction projects.
Figure 671.3A

Transverse Transition Tapers for Pavement Preservation Projects

NOTES:
(1) Minimum thickness should match thickness of the top lift.
(2) See HDM for minimum thickness.
(3) Same thickness as OGFC overlay or 0.10’, whichever is less.
(4) Do not use HMA to bring the shoulders up to grade when traveled way is OGFC.

LEGEND:
HMA = Hot Mix Asphalt
OGFC = Open Graded Friction Course
Figure 671.3B

Longitudinal Tapers at Shoulders, Curbs, Dikes, Inlets, and Guardrail

NOTES:

(1) Additional design and safety criteria may apply for guardrail, for further info, see Traffic Safety Systems Guidance or District Traffic.

(2) When grinding or paving next to guardrail or obstacle, reconstructing guardrail will be necessary to accommodate grinding machines and compaction equipment.

(3) Contact District Landscape and Maintenance regarding the appropriate treatment for weed abatement.

(4) OGFC applies only when used as a surface course, omit details for this course when OGFC is not used.

(5) See HDM Topic 302 for maximum allowable cross-slopes.

(6) For additional information on dikes, see HDM Topic 303, and Standard Plan A78B.

(7) Verify with Hydraulics to see if dike needs to be raised to maintain capacity of gutter.

(8) Verify with District Hydraulics if additional drainage is required at the conform on the shoulder or at bridge approach slabs in order to avoid ponding.
Generally, all costs for the removal of the existing freeway fence and the installation and future maintenance of a nonstandard fence are to be the property owner's responsibility under the terms of the encroachment permit authorizing the substitution. On new construction, the property owner is to assume similar costs and responsibilities subject to a credit for the value of a standard fence.

(4) Location of Fences. Normally, fences on freeways should be placed adjacent to, but on the freeway side of the right of way line.

Fences in the outer separation normally should be placed as shown in Figure 307.4 so that the area outside of the fence may be relinquished to the local agency.

When viewed at a flat angle, chain link fencing restricts sight distance. This fact should be considered in the location of such fencing at intersections. To eliminate hand maintenance, right-angle jogs should be avoided.

(5) Locked Gates. Locked gates may be provided in access control fences in special situations. A proposal for a locked gate must address a necessity. Although openings controlled by locked gates do not constitute access openings in the usual sense of access control, they must be shown on the plans. When locked gates are proposed there must be a specific reason for each gate. All gates must be kept locked and secured. Locked gates fall into two categories:

(a) Locked gates to be used exclusively for access by highway maintenance forces do not require FHWA approval and may be approved by the District Director. The integrity and security of this access must always be assured. Maintenance forces must also keep gates locked when not being used for the access of persons or equipment. When locked gates are to be used exclusively by highway maintenance forces, one or more of the following criteria apply:

- A circuitous route would be eliminated.
- The gate access would minimize the exposure of maintenance workers to highway traffic.
- Parking is available outside the gate.
- The gate would allow slow moving equipment to be kept off the highway.
- The site is not accessible to maintenance personal or equipment from the freeway.

(b) Proposals for locked gates to be used by utility companies must be submitted to the District Director for approval. The gate submittal must present all pertinent facts and alternate solutions.

Locked gates to be used by other public agencies or by non-utility entities require FHWA approval if the gate is on an Interstate route.

When proposals for locked gates requiring FHWA approval are included in the plans for new construction, including landscaping projects, FHWA approval of such gates will be included in FHWA approval of the project PS&E. Subsequent installations requiring FHWA approval must be submitted separately to FHWA by the Division of Design after approval by the Chief, Division of Design.

701.3 Private Fences

(1) Placement. Caltrans will construct or pay the cost of fences on private property only as a right of way consideration to mitigate damages. Caltrans' construction of such fences should be limited to:

(a) The reconstruction or replacement of existing fences.

(b) The construction of fences across property that had been previously enclosed by fences.

These criteria apply to all private as well as public lands.

(2) Private Fences Inside the State Right of Way. Private fences may be constructed within the State right of way via Encroachment Permit to restrict access to facilities (e.g., canals)
crossing under or through Department-owned property. A Maintenance Agreement must be executed to provide for future maintenance of the fence and allow access to the private utility.

701.4 Temporary Fences

(1) Placement. Temporary fences are located where necessary in accordance with construction contractor activities and where the right of way rights have been acquired.

(2) Types of Fences. Temporary fence design should conform to the needs of the situation and the length of time to be used. In most access control or demarcation applications the fence fabric will conform to permanent fence standards, while lesser requirements may apply to posts and post footings to more readily accommodate removal when no longer needed.

Temporary fence used during reconstruction of private fences must be of a type adequate to meet the permanent private fence purposes.

701.5 Other Fences

(1) ESA and Species Protection Fences. District Environmental Unit staff must specify the required placement limits and locations for ESA and species protection fences.

ESA fence material requirements are described in Section 14 of the Standard Specifications.

Species protection fences will be uniquely designed to meet the needs of the target species. District Environmental staff will provide information on the necessary design parameters. In many instances, species protection fence will be able to be directly attached to existing freeway or expressway access control fence and thus preclude the need for separate posts. Where species protection fence is to be constructed along conventional highways, it must be constructed inside the State right of way and should not be attached to any private fence that may exist.

(2) Enclosure Fences. Because these fences are commonly intended to provide security for Caltrans facilities, the facility type and location will often dictate the fence design to be used. Standard chain link (CL-6) fence is most common, but additions (barbed wire extension arms) or alternative designs may be considered. When slats are included as an element of the design, wind forces must be considered and there will be a resulting increase in the size and depth of embedment of fence posts as well as an increase in the size of the concrete footing. Table 701.5 provides recommended post size and embedment along with footing size for CL-6 slatted fence under an assumption of relatively weak soil resistance (indicated as “unconstrained”) as well as for situations where the fence is installed through paved areas (common at maintenance stations, indicated as “constrained”), and a design wind velocity of 105 mph. For differing fence heights, wind velocities, or soil conditions, special analysis may be warranted. Contact the Office of Highway Drainage Design in Headquarters for assistance.

Table 701.5

<table>
<thead>
<tr>
<th>Condition</th>
<th>Post NPS (Standard Cut)</th>
<th>Footing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dia.</td>
<td>Depth</td>
</tr>
<tr>
<td>Unconstrained</td>
<td>4”</td>
<td>18”</td>
</tr>
<tr>
<td>Constrained</td>
<td>4”</td>
<td>18”</td>
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Typically District Maintenance or Traffic Operations will specify any unique design requirements for enclosure fences as they will assume responsibility after construction.

Topic 702 - Miscellaneous Traffic Items

702.1 References


**Topic 703 - Special Structures and Installation**

**703.1 Truck Weighing Facilities**

The Division of Traffic Operations coordinates the design and construction of truck weighing facilities with the California Highway Patrol in Sacramento. Typical plans showing geometric details of these facilities are available from the Headquarters Division of Traffic Operations. Districts should refer truck weighing facility maintenance issues to their District maintenance units.

See Index 107.1 for additional details on roadway connections for truck weighing facilities.

**703.2 Rockfall Restraining Nets**

Rockfall Restraining Nets are protective devices designed to control large rockfall events and prevent rock from reaching the traveled way. The systems consist of rectangular panels of woven wire rope vertically supported by steel posts and designed with frictional brake elements capable of absorbing and dissipating high energies. For additional information on the characteristics and applications for rockfall restraining nets, designers should contact the Division of Engineering Services - Geotechnical Services (DES-GS).

**Topic 704 - Contrast Treatment**

**704.1 Policy**

In general, delineation should be composed of the standard patterns discussed in Part 3 of the California MUTCD.

Markings include lines and markings applied to the pavement, raised pavement markers, delineators, object markers, and special pavement treatments.

Contrast treatment is designed primarily to provide a black color contrast with an adjacent white surface. Normally, contrast treatment should be used only in special cases such as the following:

(a) To provide continuity of surface texture for the guidance of drivers through construction areas.

(b) To provide added emphasis on an existing facility where driver behavior has demonstrated that standard signs and markings have proven inadequate.

When contrast treatment is applied, a slurry seal should be used.

See Part 3 of the California MUTCD for additional information on contrast treatment.

**Topic 705 - Materials and Color Selection**

**705.1 Special Treatments and Materials**

Special materials or treatments, such as painted concrete, or vinyl-clad fences, are sometimes proposed for aesthetic reasons, or to comply with special requirements.

The following guidelines are to be used for the selection of these items:

(a) Concrete should not be painted unless exceptional circumstances exist, due to the continuing and expensive maintenance required. Concrete subject to unintentional staining should be textured during construction to minimize the visibility of stains, if other methods of controlling stain-producing runoff or dripping cannot be accomplished.

(b) Vinyl-clad fences are sometimes specified for aesthetic reasons. The cost of this material is higher than that of galvanized steel. Special consideration should be given to the life-cycle cost and maintainability of vinyl-clad fencing prior to selection for use. The use of black or green vinyl-clad mesh for access control fencing, safety fencing at the top of retaining walls, and pedestrian overcrossing fencing is acceptable.

**705.2 Colors for Steel Structures**

Colors for steel bridges and steel sign structures may be green, gray, or neutral tones of brown, tan, or light blue.

Criteria for selection of colors are:

(a) General continuity along any given route.

(b) Coordination of color schemes with adjacent Districts for interdistrict routes.
Requests from local agencies for improvement of aesthetics in their community.

Color selection for steel bridges should be mutually satisfactory to the Division of Engineering Services and the District. The Division of Engineering Services (DES) will initiate the color selection process by submitting the proposed color to the District Landscape Architect for review. The color for steel sign structures will be selected by the District Landscape Architect.

**Topic 706 - Roadside Treatment**

**706.1 Roadside Management**

A key concept in roadside management is that roadway and roadside design should consider the full life-cycle cost of transportation improvements including the long-term cost of maintenance. The design alternative with the lowest initial construction cost may not be the best solution if this approach will include high recurring maintenance costs. Designers should strive to select design approaches that do not require extensive recurring long-term activities.

A second key roadside management concept is that roadway and roadside design should contribute to the safety of Department maintenance workers by incorporating techniques that eliminate or reduce worker exposure to traffic. More specifically, these management concepts include the following techniques:

- Eliminate the need for recurrent maintenance activities such as vegetation control, herbicide application, pruning, mowing and graffiti removal;
- Facilitate the automation of recurrent maintenance activities such as herbicide application, mowing and litter collection;
- Locate facilities that require recurrent maintenance activity outside the clear recovery zone, or within protected areas;
- Provide safe maintenance worker access to facilities that require recurrent maintenance activity.

To implement this second roadside management concept, the following conditions must be considered in roadway and roadside design projects:

- **Guardrail**, including standard railing, terminal system end treatments, guard railing at structure approach and departures, and at fixed objects should include vegetation control. For more detailed information regarding placement of vegetation control consult with both the District Landscape Architect and District Maintenance. See the Standard Plans for minor concrete vegetation control.

- **Thrie beam barrier**, including single thrie beam barrier, double thrie beam barrier, at structure approach and at fixed objects should include vegetation control. For more detailed information regarding placement of vegetation control consult with both the District Landscape Architect and District Maintenance. See the Standard Plans for minor concrete vegetation control.

- **Unpaved narrow strips** often result from the construction of noise barriers or concrete barriers beyond the paved shoulder edge. Unpaved strips 15 feet or less in width, parallel and immediately adjacent to the roadway, should be paved to the barrier or wall. Paving these areas eliminates the need for manual vegetation control, and allows automated equipment to remove litter and debris. Pavement requirements are consistent with the guidance contained in this manual. Contrasting surface treatment such as markings, delineation, or color may also be provided so drivers can distinguish these areas from those intended for vehicular use.

- **Unpaved areas greater than 15 feet in width** may include vegetation control techniques such as weed control mats, patterned asphalt or stamped concrete paving, or the planting of low maintenance vegetation such as native grasses. Consult the District Landscape Architect and District Maintenance to select an appropriate vegetation control technique.

- **Plants**, which at maturity may encroach upon required site distances, should be removed. Consult the District Landscape Architect to identify potential encroaching plant material.
CHAPTER 900
LANDSCAPE ARCHITECTURE

 Topic 901 - General

Index 901.1 - Landscape Architecture Program

The Landscape Architecture Program is responsible for the development of policies, programs, procedures, and standards for all aspects of the Roadside Program which consists of highway planting, replacement highway planting, mitigation planting, highway planting revegetation, highway planting restoration, roadside rehabilitation, roadside protection and restoration, roadside improvements, safety roadside rest areas, scenic highways, classified landscaped freeways, transportation art, gateway monuments, community identification, blue star memorial highways, and planting in conjunction with noise barriers.

This chapter provides boldface, underlined and permissive standards as defined in Index 82.1. The Chief, Division of Design is responsible for approving exceptions to all boldface standards unless delegated as noted in Index 82.2(1). District Directors are responsible for approving exceptions to all underlined standards as discussed in Index 82.2(2). All other guidance in this Chapter pertaining to the design of planting and irrigation systems as well as when noted in the text is the responsibility of the Landscape Architecture Program. See the Project Development Procedures Manual (PDPM) Chapter 29 regarding process and procedures for approval of deviations from Landscape standards.

901.2 Cross References

- Several highway landscape architectural terms are defined in Index 62.5 of this manual.
- The PDPM contains general definitions, policies, and procedures concerning planting and conservation of vegetation and explains procedures and responsibilities for developing highway planting projects.
- The Preliminary Environmental Analysis Report (PEAR), included in the Standard Environmental Reference, contains guidelines and responsibilities for determining scenic resources during the project development process. http://www.dot.ca.gov/ser/pear.htm
- Chapter 500 of the Encroachments Permits Manual contains procedures and guidelines for planting design and administering planting by others, through permit projects.
- Chapters 4-20 and 4-21 of the Construction Manual discuss materials and methods involved in erosion control and planting and irrigation. Allowable options are described for materials and work methods called for in the project specifications as well as Landscape Architect involvement during construction.
- Chapter E of the Maintenance Manual contains instructions about the maintenance of highway planting and other roadside features. Chapter C2 of the Maintenance Manual contains instructions about the maintenance of native and naturalized roadside vegetation.
- The Landscape Architecture Program’s website further explains the Department’s policy and provides guidance for landscape architectural work, including water conservation. The website is located at: http://www.dot.ca.gov/design/lap/.

Topic 902 - Planting Guidance

902.1 General Guidance for Freeways and Expressways

This section provides standards and guidelines for the design of planting and irrigation systems.

Highway planting is vegetation placed for aesthetic, environmental mitigation, storm water pollution prevention, or erosion control purposes, and includes necessary irrigation systems, inert materials, and mulches.

In addition, highway planting is used to satisfy the need for headlight glare reduction, fire retardance, windbreak protection, or graffiti reduction on retaining walls and noise barriers.

(1) Design Considerations. Design planting and irrigation systems to achieve a balance between aesthetics, safety, maintainability, cost-effectiveness, water and resource
Planting and irrigation design should respond to the following community goals:

(a) Aesthetics. Select plants and replacement planting to integrate the facility with the adjacent community or natural surroundings; buffer objectionable views of the highway facility for adjacent homes, schools, parks, etc.; soften visual impacts of large structures or graded slopes; screen objectionable or distracting views; frame or enhance good views; and provide visually attractive interchanges as entrances to communities.

Select and arrange regionally appropriate drought tolerant native and non-native plants to be visually and culturally compatible with local indigenous plant communities and the surrounding landscape.

Place plants according to the perspective of the viewer. For example, compositions viewed by freeway motorists should be simplified and large scale. Compositions primarily viewed by pedestrians may be designed with greater detail.

Integrate the highway improvement within the existing environment using contour grading that preserves existing natural topographic features and plant material.

(b) Safety. Planting and irrigation facilities are designed for the safety of both highway workers and the public.

To understand potential hazards to maintenance workers, designers should be familiar with Topic 706 as well as Chapter 8, "Protection of Workers", of the Maintenance Manual.

Select and locate plants to maintain sight distance and clear recovery zone distances. Planting, without exception, must not interfere with the function of safety devices (e.g., barriers, guardrail) and traffic control devices (e.g., signals and signs), shoulders and the view from the roadway of bicyclists and pedestrians.

Highway planting and irrigation work should incorporate design for safety concepts that include, but are not limited to, the following:

- Access - Provide access gates for maintenance personnel from local streets and frontage roads. Provide paved maintenance vehicle pullout areas away from traffic on high volume highways and other areas where access cannot be made from local streets and roads. Maintenance access roads provide access to the center of loop areas or other wide, flat areas.

- Minimize Exposure to Traffic and Reduce the Need for Shoulder or Lane Closures - Locate vegetation away from shoulder areas, gore areas, and narrow island areas between ramps and the traveled way to reduce the need for shoulder or lane closures to perform pruning or other maintenance operations. Narrow areas and areas beyond freeway gore entrances and exits should be paved. See Index 504.4(2) for further contrasting surface treatment guidance.

- Median Planting - Median planting should not be permitted on freeways. Exceptions for the planting of freeway medians are approved by the District Director if the planting can be maintained.

(c) Maintainability. Planting and irrigation designs should minimize ongoing intensive maintenance activities through field observation and discussion with maintenance personnel during project development. Ongoing communication between designers, landscape specialists, landscape maintenance personnel, and construction inspectors will ensure that maintenance concerns are addressed.

Select and locate plants to reduce application of herbicides.

Specify plant establishment and irrigation test periods of sufficient time to identify
use a pedestrian facility when adjacent to a bike path. Thus, the bike path would be only for bicycles if there is an adjacent pedestrian facility. This may be either immediately adjacent or with a separation between the pedestrian facility and the bike path. The separation may be—but not limited to—fences, railings, solid walls, or landscaping. If a separation is used, it should not obstruct stopping sight distance along curves or corner sight distance at intersections with roadways or other paths.

(3) Clearance to Obstructions. A minimum 2-foot horizontal clearance from the paved edge of a bike path to obstructions shall be provided. See Figure 1003.1A. 3 feet should be provided. Adequate clearance from fixed objects is needed regardless of the paved width. If a path is paved contiguous with a continuous fixed object (e.g., fence, wall, and building), a 4-inch white edge line, 2 feet from the fixed object, is recommended to minimize the likelihood of a bicyclist hitting it. The clear width of a bicycle path on structures between railings shall be not less than 10 feet. It is desirable that the clear width of structures be equal to the minimum clear width of the path plus shoulders (i.e., 14 feet).

The vertical clearance to obstructions across the width of a bike path shall be a minimum of 8 feet and 7 feet over shoulder. Where practical, a vertical clearance of 10 feet is desirable.

(4) Signing and Delineation. For application and placement of signs, see the California MUTCD, Section 9B. For pavement marking guidance, see the California MUTCD, Section 9C.

(5) Intersections with Highways. Intersections are an important consideration in bike path design. Bicycle path intersection design should address both cross-traffic and turning movements. If alternate locations for a bike path are available, the one with the most beneficial intersection characteristics should be selected.

Where motor vehicle cross traffic and bicycle traffic is heavy, grade separations are desirable to eliminate intersection conflicts. Where grade separations are not feasible, assignment of right of way by traffic signals should be considered. Where traffic is not heavy, "STOP" or "YIELD" signs for either the path or the cross street (depending on volumes) may suffice.

Bicycle path intersections and their approaches should be on relatively flat grades. Stopping sight distances at intersections should be checked and adequate warning should be given to permit bicyclists to stop before reaching the intersection, especially on downgrades. When contemplating the placement of signs the designer is to discuss the proposed sign details with their District Traffic Safety Engineer or designee so that conflicts may be minimized. Bicycle versus motor vehicle collisions may occur more often at intersections, where bicyclists misuse pedestrian crosswalks; thus, this should be avoided.

When crossing an arterial street, the crossing should either occur at the pedestrian crossing, where vehicles can be expected to stop, or at a location completely out of the influence of any intersection to permit adequate opportunity for bicyclists to see turning vehicles. When crossing at midblock locations, right of way should be assigned by devices such as "YIELD" signs, "STOP" signs, or traffic signals which can be activated by bicyclists. Even when crossing within or adjacent to the pedestrian crossing, "STOP" or "YIELD" signs for bicyclists should be placed to minimize potential for conflict resulting from turning autos. Where bike path "STOP" or "YIELD" signs are visible to approaching motor vehicle traffic, they should be shielded to avoid confusion. In some cases, Bike Xing signs may be placed in advance of the crossing to alert motorists. Ramps should be installed in the curbs, to preserve the utility of the bike path. Ramps should be the same width as the bicycle paths. Curb cuts and ramps should provide a smooth transition between the bicycle paths and the roadway.

Assignment of rights of way is necessary where bicycle paths intersect roadways or other bicycle paths. See the California MUTCD, Section 9B.03 and Figure 9B-7 for guidance on
NOTES:

(1) See Index 1003.1(15) for pavement structure guidance of bike path.

(2) For sign clearances, see California MUTCD, Figure 9B-1. Also, for clearance over the shoulder see Index 1003.1(3).

(3) The AASHTO Guide for the Development of Bicycle Facilities provides detailed guidance for creating a forgiving Class I bikeway environment.

* 1% cross-slope minimum.
of Footing line and Retaining Wall height should be shown on the plans.

- The original ground (OG) line and any known utilities should be shown on the Soundwall Plan sheets.

3 Pay Quantities. Soundwalls are to be measured by the square foot between the elevation lines shown on the plans and the length of the wall. Soundwall footings are to be paid as minor concrete and concrete barriers are to be paid for as concrete barrier (modified). Piles are to be paid for separately to facilitate minor changes in the field.

Refer to the Standard Special Provisions for more information on measurement and pay quantities.

When calculating costs for determining “reasonableness,” all pay quantities associated with the proposed soundwalls should be included in the analysis. Refer to the California Traffic Noise Analysis Protocol for a discussion on this topic.

4 Working Drawings. Working Drawings are no longer required for state designed masonry block soundwalls in view of the fact that all the information necessary to construct the wall should be shown in the contract plans. The Special Provisions for Alternative Soundwall systems should require the successful bidder to submit four (4) sets of drawings for initial review and between six (6) and twelve (12) additional sets, as requested by the Engineer, for final approval and use during construction. Refer to Bridge Reference Specification 51-561(51SWAL) for more information.

5 Preliminary Site Data. In using the "Top of Soundwall/Bottom of Concrete Barrier" line concept, it is important that the preliminary site data be as complete as possible. To eliminate or minimize construction change orders the following guidance is provided:

- Provide accurate ground line profiles.
- Select only standard or pre-approved design alternative soundwall types.
- Provide adequate information based on foundation investigation.
- Locate overhead and underground utilities.
- Review drainage and show any modifications on the plans.
- Determine and specify architectural treatment.
- Determine the need for special design, and coordinate with the Office of Structures Design during the early stages of design.

1102.6 Noise Barrier Aesthetics

1 General. A landscaped earth berm or a combination wall and berm tend to minimize the apparent noise barrier height and are an aesthetically acceptable alternative among noise barrier options; however, these alternatives are not always suitable for many sites due to limited space.

Some additional cost to enhance the aesthetic quality of the noise barrier is usually warranted. Early community involvement toward proposing aesthetic treatment improvements on noise barriers is recommended to accommodate contextual considerations. However, accountability for designs that significantly increase the cost of the noise barrier should be a topic for discussion early in the design process.

Soundwalls should not be designed with abrupt beginnings or ends. Generally, the ends of the soundwall should be tapered or stepped if the height of the soundwall exceeds 6 feet. See Standard Plans for further details. Consult the District Landscape Architect regarding the design of tapers or stepped ends, aesthetic treatment, highway planting and landscaping adjacent to noise barriers.

2 Aesthetic Treatment. Standard aesthetic treatments have been developed by the DES Office of Structure Design for the various alternative materials.

When treatment that is not a standard aesthetic treatment is proposed for noise barriers, contact the District Landscape Architect for selection of the most appropriate treatment. The District Traffic Engineer or designee should be consulted in these instances to ensure that the
(3) Planting Near Noise Barriers. The use of plants in conjunction with noise barriers can help to combat graffiti and promote public acceptance of the noise barrier. When landscaping is to be placed adjacent to the soundwall, which will eventually screen a substantial portion of the wall, only minimal aesthetic treatment is justified.

See Index 902.3 and the Project Development Procedures Manual for additional information.

(4) Transparent Barriers. Noise barriers may impact viewsheds where consideration of transparent barriers may be warranted. A list of pre-qualified transparent barrier systems is available on the Authorized Materials List at: http://www.dot.ca.gov/aml/.

1102.7 Maintenance Consideration in Noise Barrier Design

(1) General. Noise barriers placed within the area between the shoulder and right of way line complicate the ongoing maintenance operations. When there is a substantial distance behind the noise barriers and in front of the right of way line, special consideration is required. If the adjoining land is occupied with streets, roads, parks, or other large parcels, an effort should be made during the right of way negotiations to have the abutting property owners maintain the area. In this case, the chain link fence at the right of way line would not be required. Maintenance by others may not be practical if a number of small individual properties abut the noise barrier.

(2) Access Requirements. Access to the back side of the noise barrier must be provided if the area is to be maintained by the Department. In subdivided areas, access can be via local streets, when available. If access is not available via local streets, access gates or openings are essential at intervals along the noise barrier. Access may be provided via offsets in the barrier. Offset barriers must be overlapped a minimum of 2.5 to 3 times the offset distance in order to maintain the integrity of the sound attenuation of the main barrier. Location of the access openings must be coordinated with the District maintenance office.

(3) Noise Barrier Material. The alternative materials selected for the noise barrier should be appropriate for the environment in which it is placed. For walls that are located at or near the edge of shoulder, the portion of the noise barrier located above the safety-shape concrete barrier should be capable of withstanding the force of an occasional vehicle which may ride up above the top of the safety barrier.

1102.8 Emergency Access Considerations in Noise Barrier Design

(1) General. In addition to access gates being constructed in noise barriers to satisfy the Department’s maintenance needs, they may also be constructed to provide a means to access the freeway in the event of a catastrophic event which makes the freeway impassable for emergency vehicles. These gates are not intended to be used as an alternate means of emergency access to adjacent neighborhoods. Access to those areas should be planned and provided from the local street system. Small openings may also be provided in the noise barrier which would allow a fire hose to be passed through it. Local emergency response agencies should be contacted early in the design process to determine the need for emergency access gates and fire hose openings.

(2) Emergency Access Gate Requirements. Access gates in noise barriers should be kept to a minimum and should be at least 1,000 feet apart. Locations of access should be coordinated with the District maintenance office. Only one opening should be provided at locations where there is a need for access openings to serve both the emergency response agency and the Department’s maintenance forces. Gates should be designed to comply with the soundwall details developed by the Office of Structures Design.

(3) Fire Hose Access Openings. When there is no other means of providing fire protection to the freeway, small openings for fire hoses may be provided. Fire hose access should be located as close as possible to the fire hydrants on the local street system. Where possible, fire hose
access should be combined with emergency or maintenance access openings. The Office of Structures Design should be requested to design fire hose access openings.

### 1102.9 Drainage Openings in Noise Barrier

Drainage through noise barriers is sometimes required for various site conditions. Depending on the size and spacing, small, unshielded openings at ground level can be provided in the barriers to allow drainage and not adversely impact the noise attenuation of the barrier. The following sizes of unshielded openings at ground level are allowed for this purpose:

(a) Openings of 8" x 8" or smaller, if the openings are spaced at least 10 feet on center.

(b) Openings of 8" x 16" or smaller, if the openings are spaced at least 20 feet on center, and the noise receiver is at least 10 feet from the nearest opening.

The location and size of the drainage openings need to be designed based on the hydraulics of the area. The design should take into consideration possible erosion problems that may occur at the drainage openings.

Where drainage requirements dictate openings that do not conform to the above limitations, shielding of the opening will be necessary to uphold the noise attenuation of the barrier. The shielding designed must consider the hydraulic characteristics of the site. When shielding is determined to be necessary, consultation with the District Hydraulics Unit and the District Traffic Safety Engineer or designee is recommended, as well as the Division of Environmental Analysis.
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