CALIFORNIA
DEPARTMENT OF TRANSPORTATION

manual change transmittal

TITLE	APPROVED BY	NO.
HIGHWAY DESIGN MANUAL SEVENTH EDITION – CHANGE 12/31/20	JANICE BENTON, Chief	Date Issued: 12/28/20 Page 1 of 2
SUBJECT AREA Table of Contents; List of Figures; List of Tables; Chapters: 60, 80, 100, 300, 620, 900; and Index	ISSUING UNIT DIVISION OF DESIGN	
SUPERCEDES SEE BELOW FOR SPECIFIC PAGE NUMBERS	DISTRIBUTION **ALL HOLDERS OF THE 7TH EDITION, HIGHWAY DESIGN MANUAL**	

The Table of Contents; List of Figures; List of Tables; Chapters: 60, 80, 100, 300, 620, 900; and the Index of the Seventh 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: https://dot.ca.gov/programs/design/manual-highway-design-manual-hdm. Changes include updates related to design period, tapered edge, grading catch point, rigid concrete design, and landscape architecture-roadsides. Also, included are clarification language, typographical corrections, reference corrections, and updates to figures and tables.

These changes are effective December 31, 2020 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 https://dot.ca.gov/programs/design/manual-highway-design-manual-hdm.

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

Index 103.2 — **Design Period, Page 100-6**
The design period has been updated at the request of FHWA to not allow less than a 20-year period for the Interstate System. Resurfacing, Restoration, and Rehabilitation (3R), safety and operational projects continue to use current ADT for the design period.

Index 302.3 — **Tapered Edge, Page 300-7**
The tapered edge subject has been updated with various refinements.

Index 304.1 — **Side Slope Standards, Page 300-18**
The uniform catch point guidance of at least 18 feet from the edge of the shoulder has been adjusted from an underlined to a permissive standard. Also, the reference to light grading has been removed.

Chapter 620 — **Chapter 620 – Rigid Pavement, Entire Chapter**
Rigid pavement guidance has been modified to clarify some language and update some design practices mostly related to terminal joints in Continuously Reinforced Concrete Pavement (CRCP).

Index 904.5 **Locating Trees, Page 900-10**
Language added to clarify that large tree planting guidance for conventional highways applies where the freeway or expressway intersects a conventional highway or local facility.

Index 904.6 **Locating Plants in Conformance with Sight Distances, Page 900-10**
Sight distance requirements are clarified including horizontal sight distance on roadway curvatures.

Index 904.9 **Plant Establishment, Page 900-13**
Correction is provided for plant establishment period as a separate contract or for part of a highway construction project.

Enclosures available on the Department Design website at: https://dot.ca.gov/programs/design/manual-highway-design-manual-hdm.

CHAPTER 60 – NOMENCLATURE

Unless indicated otherwise in this manual, wherever the following abbreviations, terms, or phrases are used, their intent and meaning shall be as identified in this Chapter.

Topic 61 – Abbreviations

Index 61.1 – Official Names

AASHTO	American Association of State Highway and Transportation Officials
Caltrans or Department	California Department of Transportation
CFR	Code of Federal Regulations
CTC or Commission	California Transportation Commission
DES	Division of Engineering Services
District	Department of Transportation Districts
DOT	U.S. Department of Transportation
DOD	Division of Design
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
GS	Geotechnical Services
METS	Office of Materials Engineering and Testing Services
OAP	Office of Asphalt Pavements
OCP	Office of Concrete Pavements
PP	Pavement Program
PS&E	Plans, Specifications, and Estimate
PUC	Public Utilities Commission
SD	Structure Design
SHOPP	State Highway Operation and Protection Plan
STIP	State Transportation Improvement Program

Topic 62 – Definitions

62.1 Geometric Cross Section

(1) Lane.

a) Auxiliary Lane--The portion of the roadway for weaving, truck climbing, speed change, or for other purposes supplementary to through movement.

b) Lane Numbering--On a multilane roadway, the lanes available for through travel in the same direction are numbered from left to right when facing in the direction of travel.

c) Multiple Lanes--Freeways and conventional highways are sometimes defined by the number of through lanes in both directions. Thus an 8-lane freeway has 4 through lanes in each direction. Likewise, a 4-lane conventional highway has 2 through lanes in each direction. Lanes that are not equally distributed to each direction would otherwise be described as appropriate.

d) Median Lane--A speed change lane within the median to accommodate left turning vehicles.

e) Speed Change Lane--An auxiliary lane, including tapered areas, primarily for the acceleration or deceleration of vehicles when entering or leaving the through lanes.

f) Traffic Lane/Vehicle Lane--The portion of the traveled way for the movement of a single line of vehicles, both motor vehicle and bicycle.

(2) *Bikeways.*

a) Class I Bikeway (Bike Path). Provides a completely separated facility for the exclusive use of bicycles and pedestrians with crossflow by vehicles minimized.

b) Class II Bikeway (Bike Lane). Provides a striped lane for one-way bike travel on a street or highway.

c) Class III Bikeway (Bike Route). Provides for shared use with pedestrian or motor vehicle traffic.

d) Class IV Bikeway (Separated Bikeway). Provides for the exclusive use of bicycles and includes a separation (e.g., grade separation, flexible posts, inflexible physical barrier, or on-street parking) required between the separated bikeway and the through vehicular traffic.

(3) *Maintenance Vehicle Pullout (MVP).* Paved areas, or appropriate all weather surfaces, adjacent to the shoulder for field personnel to park off the traveled way and access the work site.

(4) *Median.* The portion of a divided highway separating the traveled ways in opposite directions.

(5) *Outer Separation.* The portion of an arterial highway between the traveled ways of a roadway and a frontage street or road.

(6) *Roadbed.* That portion of the roadway extending from curb line to curb line or shoulder line to shoulder line. Divided highways are considered to have two roadbeds.

(7) *Roadside.* A general term denoting the area adjoining the outer edge of the roadbed to the right of way line. Extensive areas between the roadbeds of a divided highway may also be considered roadside.

(8) *Roadway.* That portion of the highway included between the outside lines of the sidewalks, or curbs and gutters, or side ditches including also the appertaining structures, and all slopes, ditches, channels, waterways, and other features necessary for proper drainage and protection.

(9) *Shoulder.* The portion of the roadway contiguous with the traveled way for the accommodation of stopped vehicles, for emergency use, for errant vehicle recovery, and for lateral support of base and surface courses. The shoulder may accommodate on-street parking as well as bicyclists and pedestrians, see the guidance in this manual as well as DIB 82.

(10) *Sidewalk.* A surfaced pedestrian way contiguous to a roadbed used by the public where the need for which is created primarily by the local land use. See DIB 82 for further guidance.

Table 82.1A

Boldface Standards (Cont.)

612.5	Pavement Design Life for Pavement Roadway Rehabilitation Projects[(1), (2)]
Topic 613	Traffic Considerations
Index 613.5	Shoulder Traffic Loading Considerations[(1), (2)]
613.5	Depth of Shoulder Pavement Structural Section[(1), (2)]
CHAPTER 620	RIGID PAVEMENT
Topic 622	Engineering Requirements
Index 622.5	Transition Panels, Terminal Joints and End Anchors[(1), (2)]
Index 622.7	Dowel Bars and Tie Bars[(1) (2)]
Topic 625	Engineering Procedures for Pavement Rehabilitation
Index 625.2	Rigid Pavement Rehabilitation Strategies[(1), (2)]
Topic 626	Other Considerations
Index 626.2	Shoulder[(1), (2)]
626.2	Tied Rigid Shoulders or Widened Slab Standards[(1), (2)]
626.2	Tied Rigid Shoulders or Widened Slab at Ramps and Gore Standard[(1), (2)]
CHAPTER 630	FLEXIBLE PAVEMENT
Topic 635	Engineering Procedures for Flexible Pavement Rehabilitation
Index 635.2	Limits of Paving on Resurfacing Projects[(1), (2)]
CHAPTER 700	MISCELLANEOUS STANDARDS
Topic 701	Fences

Design exception approval of Boldface Standards for nonfreeway facilities, including local streets and roads at interchanges, 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.

Table 82.1A

Boldface Standards (Cont.)

Index 701.2	Fences on Freeways and Expressways[1]
CHAPTER 900	LANDSCAPE ARCHITECTURE
Topic 904	Planting Design
Index 904.9	Plant Establishment
Topic 905	Irrigation Design
Index 905.2	Water Supply
Topic 912	Roadside Site Design
Index 912.1	Freeway Ramp Design
Topic 913	Safety Roadside Rest Areas
Index 913.5	Public Pay Telephone
CHAPTER 1000	BICYCLE TRANSPORTATION DESIGN
Topic 1003	Design Criteria
Index 1003.1	Class I Bikeway Widths[1]
1003.1	Class I Bikeway Shoulder Width[1]
1003.1	Class I Bikeway Horizontal Clearance[1]
1003.1	Class I Bikeway Structure Width[1]
1003.1	Class I Bikeway Vertical Clearance[1]
1003.1	Class I Bikeway Minimum Separation From Edge of Traveled Way[1]
1003.1	Physical Barriers Adjacent to Class I Bikeways[1]
1003.1	Class I Bikeway in Freeway Medians[1]
1003.1	Class I Bikeway Design Speeds[1]
1003.1	Stopping Sight Distance

Design exception approval of Boldface Standards for nonfreeway facilities, including local streets and roads at interchanges, 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.

Table 82.1B

Underlined Standards (Cont.)

208.6	Minimum width of Walkway of Pedestrian Overcrossings
208.6	Minimum Vertical Clearance of Pedestrian Undercrossings
208.6	Class I Bikeways Exclusive Use
208.10	Protective Screening on Overcrossings
208.10	Bicycle Railing Locations
Topic 210	Earth Retaining Systems
Index 210.6	Cable Railing
CHAPTER 300	GEOMETRIC CROSS SECTION
Topic 301	Traveled Way Standards
Index 301.2	Class II Bikeway Lane Width
301.3	Algebraic Differences of Cross Slopes at Various Locations
Topic 303	Curbs, Dikes, and Side Gutters
303.1	Use of Curb with Posted Speeds of 40 mph and Greater
303.3	Dike Selection
303.4	Bulbout Design
Topic 304	Side Slopes
Index 304.1	Side Slopes 4:1 or Flatter
Topic 305	Median Standards
Index 305.1	Median Width Freeways and Expressways – Urban
305.1	Median Width Freeways and Expressways – Rural
305.1	Median Width Conventional Highways – Urban and Rural Main Streets
305.1	Median Width Conventional Highways – Climbing or Passing Lanes
305.2	Median Cross Slopes
Topic 309	Clearances
Index 309.1	Clear Recovery Zone – 4:1 or Flatter Apply on All Highways
309.1	Clear Recovery Zone – Necessary Highway Features

Table 82.1B

Underlined Standards (Cont.)

309.1	Clear Recovery Zone – Discretionary Fixed Objects
309.1	Safety Shaped Barriers at Retaining, Pier, or Abutment Walls
309.1	High Speed Rail Clearance
309.5	Structures Across or Adjacent to Railroads – Vertical Clearance
Topic 310	Frontage Roads
Index 310.2	Outer Separation – Urban and Mountainous Areas
310.2	Outer Separation – Rural Areas
CHAPTER 400	INTERSECTIONS AT GRADE
Topic 403	Principles of Channelization
Index 403.3	Angle of Intersection
403.6	Optional Right-Turn Lanes
403.6	Right-Turn-Only Lane and Bike Lane
Topic 404	Design Vehicles and Related Definitions
Index 404.4	STAA Design Vehicles on the National Network, Terminal Access, California Legal, and Advisory routes
404.4	California Legal Design Vehicle Accommodation
404.4	45-Foot Bus and Motorhome Design Vehicle
Topic 405	Intersection Design Standards
Index 405.1	Corner Sight Distance – No Sight Obstruction in Clear Sight Triangle
405.1	Corner Sight Distance – Driver Set Back
405.1	Corner Sight Distance –Minimum Corner Sight Distance and Table
405.1	Corner Sight Distance at Signalized Public Road Intersections
405.1	Corner Sight Distance at Private Road Intersections
405.1	Decision Sight Distance at Intersections
405.3	Curve Radius for Free Right-Turn with Pedestrian Crossing
405.4	Pedestrian Refuge by Area Place Type
405.5	Emergency Openings and Sight Distance

Table 82.1C

Decision Requiring Other Approvals (Cont.)

701.2	Locked Gates - Used by Other Public Agencies or by Non-Utility Entities – FHWA Approval Required on Interstates
Topic 706	Roadside Management and Vegetation Control
Index 706.2	Vegetation Control
CHAPTER 800	HIGHWAY DRAINAGE DESIGN
Topic 805	Preliminary Plans
Index 805.1	Requires FHWA Approval
805.2	Bridge Preliminary Report
805.4	Unusual Hydraulic Structures
805.5	Levees and Dams Formed by Highway Fills
805.6	Geotechnical
Topic 808	Selected Computer Programs
Index 808.1	Table 808.1
CHAPTER 820	CROSS DRAINAGE
Topic 829	Other Considerations
Index 829.9	Dams
CHAPTER 830	TRANSPORTATION FACILITY DRAINAGE
Topic 837	Inlet Design
Index 837.2	Inlet Types
CHAPTER 850	PHYSICAL STANDARDS
Topic 853	Pipe Liners and Linings for Culvert Rehabilitation
Index 853.4	Alternative Pipe Liner Materials
CHAPTER 870	CHANNEL AND SHORE PROTECTION – EROSION CONTROL
Topic 872	Planning and Location Studies
Index 872.3	Site Consideration
Topic 873	Design Concepts
Index 873.1	Introduction
873.3	Armor Protection

*Authority to approve deviations from this “Decision Requirement” is delegated to the District Director.

Table 82.1C

Decision Requiring Other Approvals (Cont.)

CHAPTER 900	LANDSCAPE ARCHITECTURE - ROADSIDES
Topic 904	Planting Design
Index 904.1	Planting Design General
Index 904.3	Plant Selection
Topic 905	Irrigation Design
Index 905.1	Irrigation Design General
Index 905.4	Irrigation System Equipment
CHAPTER 910	LANDSCAPE ARCHITECTURE – ROADSIDE SITES
Topic 912	Roadside Sites Design
Index 912.1	Roadside Sites Layout
Index 912.3	Site Furnishings
Topic 913	Safety Roadside Rest Areas
Index 913.4	Safety Roadside Rest Area Buildings and Structures
Index 913.5	Safety Roadside Rest Area Utilities and Facilities
Topic 914	Vista Points
Index 914.3	Vista Point Amenities
Topic 915	Park & Ride Facilities
Index 915.1	Park & Ride Facilities General
CHAPTER 1000	BICYCLE TRANSPORTATION DESIGN
Topic 1003	Miscellaneous Criteria
Index 1003.5	Bicycle Path at Railroad Crossings
CHAPTER 1100	HIGHWAY TRAFFIC NOISE ABATEMENT
Topic 1101	General Requirements
Index 1101.2	Objective – Extraordinary Abatement

*Authority to approve deviations from this “Decision Requirement” is delegated to the District Director.

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:

ADT (2015) = 9800	D = 60 %
ADT (2035) = 20 000	T = 12 %
DHV = 3000	V = 70 mph
ESAL = 4 500 000	TI_{20} = 11.0

CLIMATE REGION = Desert

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 typically be based on estimated traffic 20 years after completion of construction. For new facilities and reconstruction projects on the Interstate System a minimum 20-year design period is required. With justification, for projects other than on the Interstate System, design periods less 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.

Safety, Resurfacing, Restoration, and Rehabilitation (RRR), and operational improvement projects should be designed on the basis of current ADT, including projects on the Interstate System.

Complimentary to the design period, various components of a project (e.g., drainage facilities, structures, pavement structure, etc.) have a design life that may differ from the design period. For pavement design life requirements, see Topic 612.

Topic 104 – Control of Access

104.1 General Policy

Control of access is achieved by acquiring rights of access to the highway from abutting property owners and by permitting ingress and egress only at locations determined by the State.

On freeways, direct access from private property to the highway is prohibited without exception. Abutting ownerships are served by frontage roads or streets connected to interchanges.

104.2 Access Openings

See Index 205.1 for the definition and criteria for location of access openings. The number of access openings on highways with access control should be held to a minimum. (Private property access openings on freeways are not allowed.) Parcels which have access to another public road or street as well as frontage on the expressway are not allowed access to the expressway. In some instances, parcels fronting only on the expressway may be given access to another public road or street by constructing suitable connections if such access can be provided at reasonable cost.

With the exception of extensive highway frontages, access openings to an expressway are limited to one opening per parcel. Wherever possible, one opening should serve two or more parcels. In the case of a large highway frontage under one ownership, the cost of limiting access to one opening may be prohibitive, or the property may be divided by a natural barrier such as a stream or ridge, making it necessary to provide an additional opening. In the latter case, it may be preferable to connect the physically separated portions with a low-cost structure or road rather than permit two openings.

104.3 Frontage Roads

(1) General Policy.

(a) Purpose--Frontage roads are provided on freeways and expressways to:

- Control access to the through lanes, thus increasing safety for traffic.
- Provide access to abutting land ownerships.
- Provide or restore continuity of the local street or road systems.
- Provide for bicycle and pedestrian traffic that might otherwise need to use the freeway.

(b) Economic Considerations--In general, a frontage road is justified on freeways and expressways if the costs of constructing the frontage road are less than the costs of providing access by other means. Right of way considerations often are a determining factor. Thus, a frontage road would be justified if the investment in construction and extra right of way is less than either the severance damages or the costs of acquiring the affected property in its entirety. Frontage roads may be required to connect parts of a severed property or to serve a landlocked parcel resulting from right of way acquisition.

(c) Access Openings--Direct access to the through lanes is allowable on expressways. When the number of access openings on one side of the expressway exceeds three in 1,600 feet, a frontage road should be provided (see Index 104.2).

(2) New Alignment. Frontage roads generally are not provided on freeways or expressways on new alignment since the abutting property owners never had legal right of access to the new facility. They may be provided, however, on the basis of considerations mentioned in (1) above.

(3) Existing Alignment. Where a freeway or expressway is developed parallel to an existing highway or local street, all or part of the existing roadway often is retained as a frontage road. In such cases, if access to remainders of land on the side of the freeway or expressway right of way opposite the old road cannot be provided by other means, a frontage road must be constructed to serve the landlocked remainders or the remainders must be purchased outright. The decision whether to provide access or purchase should be based on considerations of cost, right of way impacts, street system continuity and similar factors (see (1) above).

(4) Railroad Crossings. Frontage roads on one or both sides of a freeway or expressway on new alignment, owing to safety and cost considerations, frequently are terminated at the railroad right of way. When terminating a frontage road at the railroad crossing, bicycle and pedestrian traffic still needs to have reasonable access through the community.

Any new railroad grade crossings and grade separations, and any relocations or alterations of existing crossings must be cleared with the railroad and approved by the PUC.

(5) *Frontage Roads Financed by Others.* Frontage roads which are not a State responsibility under this policy may be built by the State upon request of a local political subdivision, a private agency, or an individual. Such a project must be covered by an agreement under which the State is reimbursed for all construction, right of way, and engineering costs involved.

104.4 Protection of Access Rights

For proper control of acquired access rights, fencing or other approved barriers shall be installed on all controlled access highways except as provided in Index 701.2(3)(e).

104.5 Relation of Access Opening to a Median Opening

<u>Access openings should not be placed within 300 feet of a median opening unless the access opening is directly opposite the median opening.</u>

Details on access openings are given under Index 205.1.

104.6 Maintaining Local Community Access

When planning and designing a new freeway or expressway, the designer needs to consider the impacts of an access controlled facility on the local community. Closing non-expressway local road connections may negatively impact access for pedestrians, bicyclists and equestrians. A new facility may inadvertently sever local non-motorized access creating long out of direction travel. Designers need to coordinate with local agencies for access needs across an access controlled facility.

104.7 Cross References

(a) Access Control at Intersections at Grade (see Index 405.6).

(b) Access Control at Interchanges (see Index 504.8).

Topic 105 – Pedestrian Facilities

105.1 General Policy

The California Vehicle Code Section 21949 has stated a policy for the Department to provide safe and convenient travel for pedestrians. Conventional highways can be used by pedestrians. Although the Department will work to provide safe and convenient pedestrian travel on these highways, not all of these highways will contain sidewalks and walkways. Connections between different modes of travel should be considered when designing highway facilities, as all people may become pedestrians when transferring to a transit based facility. Pedestrian use near transit facilities should be considered during the planning phase of transportation improvement projects. See DIB 82 for accessibility guidance of pedestrian facilities. See also Topics 115 and 116 for guidance regarding designing for bicycle traffic.

- 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 away from traffic in the same plane as the traveled way. This design permits the snow plowing crew to remove snow from the lanes and the shoulders with the least number of passes.
- For 2-lane roads with 4-foot shoulders, see Index 307.2.
- If shoulders are Portland cement concrete and the District plans to convert shoulders into through lanes within the 20 years following construction, then shoulders are to be built in the plane of the traveled way and to lane standards for width and structural section. (See Index 603.4).
- Deciding to construct pedestrian facilities and elements, where none exist, is an important consideration. Shoulders are not required to be designed as accessible pedestrian routes although it is legal for a pedestrian to traverse along a highway. In urban, rural main street areas, or near schools and bus stops with pedestrians present, pedestrian facilities should be constructed. In rural areas where few or no pedestrians exist, it would not be reasonable or cost effective to construct pedestrian facilities. This determination should involve the local agency and must be consistent with the design guidance provided in Topic 105 and in Design Information Bulletin 82, "Pedestrian Accessibility Guidelines for Highway Projects" for people with disabilities.

Shoulder slopes for superelevated curves are discussed in Index 202.2.

See Index 307.2 for shoulder slopes on 2-lane roads with 4-foot shoulders.

302.3 Tapered Edge

The tapered edge is a sloped edge that is placed at the edge of the paved roadbed to provide a smooth reentry for vehicles that leave the roadway. Its design is based on research performed by the FHWA.

The tapered edge should be placed on all pavement edges either during new construction or on overlay projects irrespective of pavement types and is most useful:

- On undivided roadways.
- On roadways with unpaved shoulders.
- On roadways with Class II Bikeways.

The tapered edge is not to be placed on roadways:

- Next to curbs, dikes, guardrails, barriers, walls, and landscape paving.
- Where there is not enough room to place the tapered edge without reducing the existing lane width.

- Within 3 feet of driveways or intersections.
- Where pavement overlay thickness is less than 0.15 foot.

Tapered edge is optional when the distance between consecutive minor roads or driveways is less than 30 feet. See the Standard Plans for design and construction details regarding tapered edge.

Topic 303 – Curbs, Dikes, and Side Gutters

303.1 General Policy

Curb (including curb with gutter pan), dike, and side gutter all serve specific purposes in the design of the roadway cross section. Curb is primarily used for channelization, access control, separation between pedestrians and vehicles, and to enhance delineation. Dike is specifically intended for drainage and erosion control where stormwater runoff cannot be cost effectively conveyed beyond the pavement by other means. Curb with gutter pan serves the purpose of both curb and dike. Side gutters are intended to prevent runoff from a cut slope on the high side of a superelevated roadway from running across the pavement and is discussed further in Index 834.3.

Aside from their positive aspects in performing certain functions, curbs and dikes can have undesirable effects. In general, curbs and dikes should present the least potential obstruction, yet perform their intended function. As operating speeds increase, lower curb and dike height is desirable. Curbs and dikes are not considered traffic barriers.

On urban conventional highways where right of way is costly and/or difficult to acquire, it is appropriate to consider the use of a "closed" highway cross section with curb, or curb with gutter pan. There are also some situations where curb is appropriate in freeway settings. The following criteria describe typical situations where curb or curb with gutter pan may be appropriate:

(a) Where needed for channelization, delineation, or other means of improving traffic flow and safety.

(b) At ramp connections with local streets for the delineation of pedestrian walkways and continuity of construction at a local facility.

(c) As a replacement of existing curb with gutter pan and sidewalk.

(d) On frontage roads on the side adjacent to the freeway to deter vehicular damage to the freeway fence.

(e) When appropriate to conform to local arterial street standards.

(f) Where it may be necessary to solve or mitigate operational deficiencies through control or restriction of access of traffic movements to abutting properties or traveled ways.

(g) In freeway entrance ramp gore areas (at the inlet nose) when the gore cross slope exceeds standards.

(h) At separation islands between a freeway and a collector-distributor to provide a positive separation between mainline traffic and collector-distributor traffic.

(i) Where sidewalk is appropriate.

metal dike insert are shown in the structure approach plans provided by the Division of Engineering Services, (DES).

(7) *Bridges and Grade Separation Structures.* When both roadbeds of a curbed divided highway are carried across a single structure, the median curbs on the structure should be in the same location as on adjacent roadways.

(8) *Approach Nose.* The approach nose of islands should also be designed utilizing a parabolic flare, as discussed in Index 405.4.

303.6 Curbs and Dikes on Frontage Roads and Streets

Continuous curbs or dikes are not necessarily required on all frontage roads. Where curbs or dikes are necessary for drainage control or other reasons, they should be consistent with the guidelines established in this topic and placed as shown on Figure 307.4B. Local curb standards should be used when requested by local authorities for roads and streets that will be relinquished to them.

Topic 304 – Side Slopes

304.1 Side Slope Standards

Slopes should be designed as flat as is reasonable. For new construction, widening, or where slopes are otherwise being modified, embankment (fill) slopes should be 4:1 or flatter. Factors affecting slope design are as follows:

(a) *Safety.* Flatter slopes provide better recovery for errant vehicles that may run off the road. A cross slope of 6:1 or flatter is suggested for high speed roadways whenever it is achievable. Cross slopes of 10:1 are desirable.

Embankment slopes 4:1 or flatter are recoverable for vehicles. Drivers who encroach on recoverable slopes can generally stop or slow down enough to return to the traveled way safely. See Index 309.1(2) for information on clear recovery zones.

A slope which is between 3:1 and 4:1 is considered traversable, but not recoverable. Since a high percentage of vehicles will reach the toe of these slopes, the recovery area should be extended beyond the toe of slope. The AASHTO Roadside Design Guide should be consulted for methods of determining the preferred extent of the runout area.

Embankment slopes steeper than 3:1 should be avoided when accessible by traffic. District Traffic, and the AASHTO Roadside Design Guide should be consulted for methods of determining the preferred treatment.

Regardless of slope steepness, it is desirable to round the top of slopes so an encroaching user remains in contact with the ground. Likewise, the toe of slopes should be rounded to prevent users from nosing into the ground.

(b) *Erosion Control.* Slope designs steeper than 4:1 must be approved by the District Landscape Architect in order to assure compliance with the regulations affecting Stormwater Pollution contained in the Federal Clean Water Act (see Index 82.4). Slope steepness and length are two of the most important factors affecting the erodibility of a slope. Slopes should be designed as flat as possible to prevent erosion. However, since there are other factors such as soil type, climate, and exposure to the sun, District Landscape Architecture and the District Stormwater Coordinator must be contacted for erosion control requirements. See Topic 906.

A Storm Water Data Report (SWDR) documents project information and considerations pertaining to Storm Water Best Management Practices (BMPs) and Erosion Control methods. The SWDR is prepared and signed by key personnel (including the District Landscape Architect) at the completion of each phase of a project. By signing the SWDR, the District Landscape Architect approves compliance with the proposed slope designs.

(c) *Structural Integrity.* Slopes steeper than 2:1 require approval of District Maintenance. The Geotechnical Design Report (See Topic 113) will recommend a minimum slope required to prevent slope failure due to soil cohesiveness, loading, slip planes and other global stability type failures. There are other important issues found in the Geotechnical Design Report affecting slope design such as the consistency of the soil likely to be exposed in cuts, identification of the presence of ground water, and recommendations for rock fall.

(d) *Economics.* Economic factors such as purchasing right of way, imported borrow, and environmental impacts frequently play a role in the decision of slope length and steepness. In some cases, the cost of stabilizing, planting, and maintaining steep slopes may exceed the cost of additional grading and right of way to provide a flatter slope.

(e) *Aesthetics.* Flat, gentle, and smooth, well transitioned slopes are visually more satisfying than steep, obvious cuts and fills. In addition, flatter slopes are more easily revegetated, which helps visually integrate the transportation improvement within its surrounding environment. Contact the District Landscape Architect when preparing a contour grading plan.

Where normal slopes catch in a distance less than 18 feet from the edge of the shoulder, a uniform catch point, at least 18 feet from the edge of the shoulder, should be used. This is done not only to improve errant vehicle recovery and aesthetics, but also to reduce grading costs. Uniform slopes wider than 18 feet can be constructed with large production equipment thereby reducing earthwork costs.

Transition slopes should be provided between adjoining cuts and fills. Such slopes should intersect the ground at the uniform catch point line.

In areas where heavy snowfall can be expected, consideration should be given to snow removal problems and snow storage in slope design. It is considered advisable to use flatter slopes in cuts on the southerly side of the roadway where this will provide additional exposure of the pavement to the sun.

CHAPTER 620 – RIGID PAVEMENT

Topic 621 – Types of Rigid Pavements

Index 621.1 – Continuously Reinforced Concrete Pavement (CRCP)

CRCP uses reinforcement rather than transverse joints for crack control. Longitudinal joints are still used. Transverse random cracks are expected in the slab, usually at 3 to 7-foot intervals (see Figure 621.1). The continuous reinforcement in the pavement holds the cracks tightly together.

CRCP can be used for concrete pavement new construction and concrete overlays for TI ≥ 13.0 in all climate regions except High Mountain and High Desert. It can also be used for widening and replacement of existing lanes where there is adequate space to construct.

CRCP may cost more initially than other types of cast in place pavement due to the added cost of the reinforcement, but can be more cost-effective over the life of the pavement on high volume routes due to improved long-term performance and reduced maintenance.

Because there are no sawn transverse joints, CRCP should provide better ride quality and less maintenance than Jointed Plain Concrete Pavement (JPCP).

Additional CRCP guidance can be found in the "Concrete Pavement Guide" on the Department's Pavement website.

621.2 Jointed Plain Concrete Pavement (JPCP)

JPCP is the most common type of rigid pavement used by the Department. JPCP uses longitudinal and transverse joints to control where cracking occurs in the slabs (see Figure 621.1), and does not contain reinforcement other than tie bars and dowel bars (see Index 622.4). Initially JPCP is cheaper to construct than CRCP but CRCP is cost effective over the life of the pavement. JPCP is recommended for lower volume truck routes (TI < 13.0), ramps, urban streets, pavements in High Mountain and High Desert climate regions and on widened and rehabilitated pavements where there is not sufficient space to construct CRCP.

Additional guidance for JPCP can be found in the "Guide for Design and Construction of New Jointed Plain Concrete Pavements" on the Department Pavement website.

621.3 Precast Concrete Pavement (PCP)

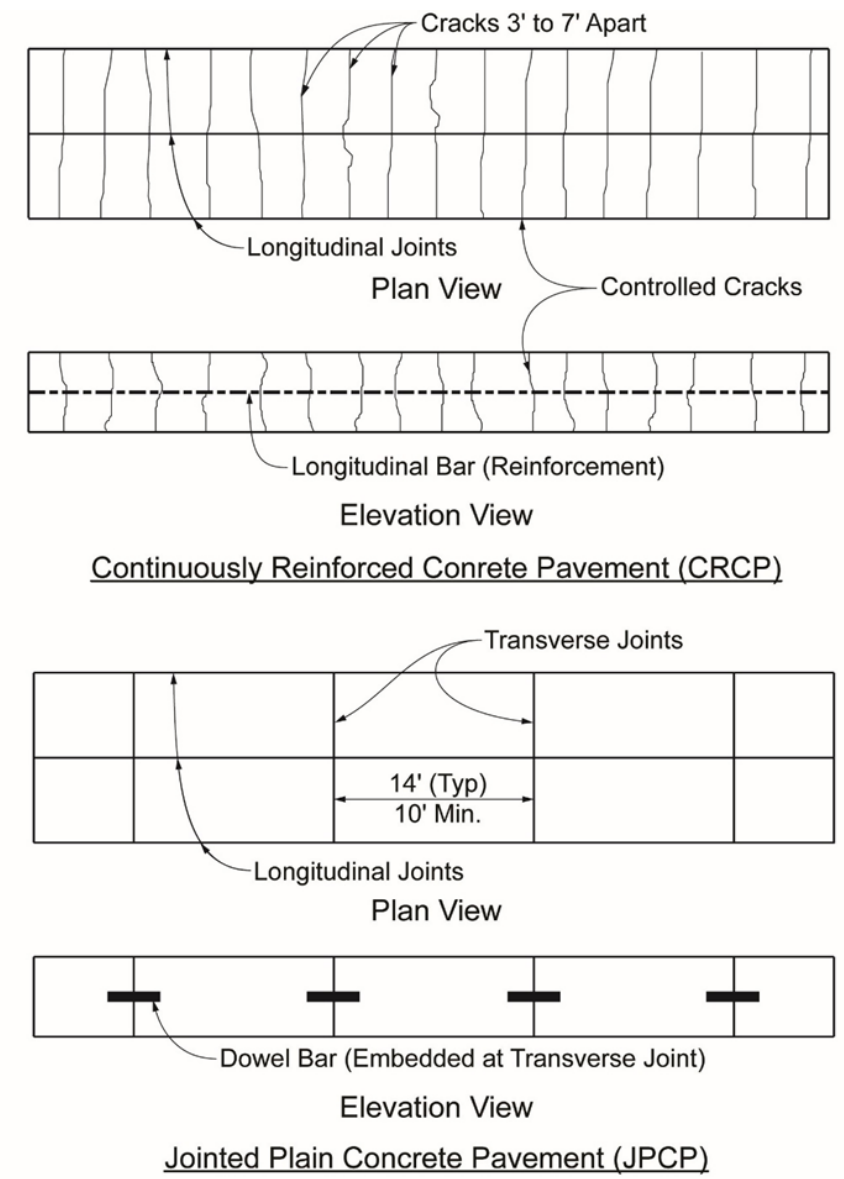
PCP uses panels that are precast off-site instead of cast in-place, which is basically the only difference between PCP and JPCP. Figure 621.1 does not show PCP because after installing the panels the section views of PCP are same as JPCP. The precast panels are linked together with dowel bars and should have tied bars like JPCP, at least in the outer or inner lanes. PCP offers the following advantages:

- Improved concrete mixing and curing as they are controlled in a precast yard.
- Shorter lane closure times than using conventional concrete for JPCP, which is beneficial when there are short construction windows.

The primary disadvantage of PCP is the high cost of fabrication, transportation and installation. PCP also needs a leveling system at the base underneath the precast panels during construction to even out the loads on the slab and avoid uneven deflections or stresses that could lead to faulting, slab settlement, and/or premature cracking. Although PCP is not currently included in the Standard Specs and Plans, it has been used since 2010 in California and should be considered.

Figure 621.1

Types of Rigid Pavement



Topic 622 – Engineering Requirements

622.1 Engineering Properties

The predominant type of concrete used in California for rigid pavement is made of Type II Portland cement. Other types of hydraulic cement are sometimes used for special considerations such as rapid strength concrete (RSC), which can be made of Type III Portland cement, Calcium Sulfoaluminate (CSA) cement, or other proprietary rapid setting cements.

Table 622.1 shows the concrete engineering properties that were used to develop the rigid pavement design catalog in this chapter. The values are based on Department specifications and experience with materials used in California.

622.2 Performance Factors

The end-of-design life performance factors used to develop concrete pavement structure design catalogs found in this chapter are presented in Table 622.2. The design catalogs are intended to ensure that concrete pavements are engineered to meet or exceed the performance factors in Table 622.2 (i.e., the pavement structure will last longer before reaching these thresholds).

622.3 Types of Concrete

(1) *Portland Cement Concrete (PCC).* Portland cement concrete is the most common concrete used. It is composed of Portland cement, supplementary cementitious materials, aggregate, water and sometimes chemical admixtures. It is typically produced by weighing materials in batches that are charged into a rotary drum mixer. For pavements, the mixer is usually stationary and the concrete is loaded into dump trucks for delivery. The concrete is normally placed and consolidated using a paving machine which incorporates internal vibrators, grade control and the screed among other things. Initial setting of the concrete is normally about 4 to 6 hours; however, accelerators can be added to make the time much shorter. Strength gain allows the pavement to be opened to traffic as early as 3 days and continues to increase for an extended period. Portland cement concrete is designed to resist environmentally induced degradation for over 100 years. Typical use for Portland cement concrete is new pavement, widening, reconstruction and rehabilitation.

Table 622.1

Concrete Properties Used in Developing Rigid Pavement Design Catalog

Property	Values
Transverse joint spacing	14 ft
Initial IRI immediately after construction	63 in/mile max
Reliability	90%
Unit weight	150 lb/ft^3
Poisson's ratio	0.20
Coefficient of thermal expansion	5.5 x 10^{-6}/ °F
Thermal conductivity	$1.25 \frac{\text{Btu}}{\text{hr-ft-}°F}$
Heat capacity	$0.28 \frac{\text{Btu}}{\text{lbm-}°F}$
Permanent curl/warp effective temperature difference	Top of slab is 10 °F cooler than bottom of slab
Surface layer/base interface	Unbonded
Surface shortwave absorptivity	0.85
Cement type	Type II Portland Cement
Cement material content (cement + flyash)	24 lb/ft^3
Water: cementitious material ratio	0.42
PCC zero-stress temperature	100.9 °F
Ultimate shrinkage at 40% relative humidity	537 microstrain
Reversible shrinkage (% of ultimate shrinkage)	50%
Time to develop ultimate shrinkage	35 days
Modulus of rupture or flexural strength (28 days)	625 psi
Dowel bar diameter	1.5 in (1.25 in for rigid pavement thickness < 0.70 ft)

Table 622.2

Concrete Pavement Performance Factors

Factor	Value
General	
Design Life	Determined per Topic 612
Terminal IRI [1] at end of design life	170 in/mile max
JPCP only	
Transverse cracking at end of design life	10% of slabs max
Average joint faulting at end of design life	0.10 inch max
CRCP only	
Punchouts at end of design life	10 per mile max

NOTE:

[1]The International Roughness Index (IRI) is a nationally recognized method for measuring the smoothness of pavements.

(2) *Rapid Strength Concrete (RSC).* Rapid strength concrete is used in cases where rapid construction (typically 3 days or less) and accelerated opening to traffic is the most important consideration. RSC is either highly accelerated Portland cement concrete without supplementary cementitious materials or concrete made with a proprietary hydraulic cement which sets and gains strength extremely fast. It is produced either by weighing batches that are charged into a rotary drum mixer truck and then accelerated with chemicals at the pavement site or by volumetric proportioning and continuous mixing at the pavement site. The concrete is typically placed into forms or an excavated area and consolidated using hand held vibrators. Finishing is normally done with a roller screed and hand tools. The final finish is typically rougher than Portland cement concrete and grinding to achieve smoothness may be needed. Strength gain allows the pavement to be opened to traffic in hours where it continues to gain strength for several days. Rapid strength concrete is designed for rapid return to service. Because these products are relatively new to pavements, their long-term durability (40 or more years) has yet to be substantiated. Typical use for rapid strength concrete is JPCP replacement, punch-out repair, reconstruction or widening in locations where traffic cannot be diverted for at least 3 days.

(3) *Roller Compacted Concrete (RCC).* Roller compacted concrete is Portland cement concrete that is produced with water content diminished to the point that it must be consolidated with a vibratory roller, similar to asphalt pavement. The initial finish looks similar to an HMA surface. It is typically produced by volumetric proportioning and continuous mixing in a stationary plant and the concrete is loaded into dump trucks for delivery. The concrete is placed and shaped by a paving machine similar to an asphalt paving machine in lifts up to 0.80 ft. The concrete is compacted by a 10 ton vibratory roller. It is not as smooth as pavement placed with concrete paving machines. Strength gain allows the pavement to be opened to light traffic in 24 hours and heavy traffic (trucks) in 3 days. It will continue to gain strength for an extended period. Roller compacted concrete is designed to resist environmentally induced degradation for over 100 years.

Roller compacted concrete is only used on State highways for shoulders and temporary detours.

622.4 Pavement Joints

(1) *Construction.* Construction joints are joints between sections of concrete slabs that result when concrete is placed at different times. Construction joints can be transverse or longitudinal and are constructed in all types of concrete pavements. Except for precast pavement, the joint is formed by placing a metal or wooden header board that is set vertical to the surface and at right angle or parallel to the centerline and it is of sufficient length and height so that it conforms to the cross section of the pavement.

For CRCP, construction joints allow for some paving breaks in the continuous concrete paving operation. On a subsequent paving day the joints are used to extend the pavement in-kind. Transverse construction joints typically include additional longitudinal reinforcement to keep construction cracks from widening. Holes are drilled in the header board to allow the longitudinal reinforcing bars to pass through the header board.

For JPCP, construction joints occur at planned transverse joints and longitudinal joints. They are typically placed by the contractor to facilitate their paving operation. Details and instructions for how to place construction joints in JPCP are found in the Standard Plans and Standard Specifications. Tie bars are typically used at longitudinal construction joints to connect the adjoining slabs together so that the construction joint will be tightly closed. Dowel bars are used at transverse construction joints to provide load transfer.

(2) *Contraction.* Longitudinal and transverse contraction joints (also known as weakened plane joints) are sawed into new pavement to control the location and geometry of shrinkage, curling, and thermal cracking.

CRCP is constructed without transverse contraction joints. Transverse cracks are allowed to form but are held tightly together with continuous reinforcing steel.

JPCP contains contraction joints that create a weakened line across the slab to control the location of the expected natural cracks. The concrete is supposed to crack at the contraction joints and not elsewhere in the slabs. The Standard Plans show the typical spacing details for transverse contraction joints. For special situations, such as intersections and ramps, spacing layout will be needed. See HDM Index 626.3 for special consideration when engineering a rigid pavement intersection.

(3) *Isolation.* Isolation joints are used to separate dissimilar pavements/structures in order to reduce compressive stresses that could cause cracking. Examples of dissimilar pavements/structures include different joint patterns, different types of concrete pavement (e.g., CRCP/JPCP), structure foundations, drainage inlets, drainage inlet depressions, manholes and manhole frame and cover. Isolation joints keep cracks from propagating through the joint and are sealed to prevent water/dirt infiltration. Isolation joints are most commonly placed along pavement longitudinal joints. Because of different arrangements for structure foundations, drainage inlets, drainage inlet depressions, and utility frames and covers, isolation joints are necessary to provide isolation to relieve stresses in the abutting faces of dissimilar pavements/structures.

(4) *Expansion.* Expansion joints are used in CRCP as part of the expansion terminal joint system where there is a need to allow for a large expansion, greater than one half inch, between approach slabs and other types of pavements. They are typically placed in the transverse direction. Like isolation joints, expansion joints are sealed to prevent water and dirt infiltration. For CRCP, expansion joints are typically used where CRCP abuts up to bridges, structure approach slabs or other types of rigid pavements, including an existing CRCP. Expansion joints are typically not used with JPCP.

Typical joint spacing patterns can be found in the Standard Plans. In some cases such as intersections and parking lots, joint spacing patterns need to be engineered and included on project construction details. See Topic 626 for further details.

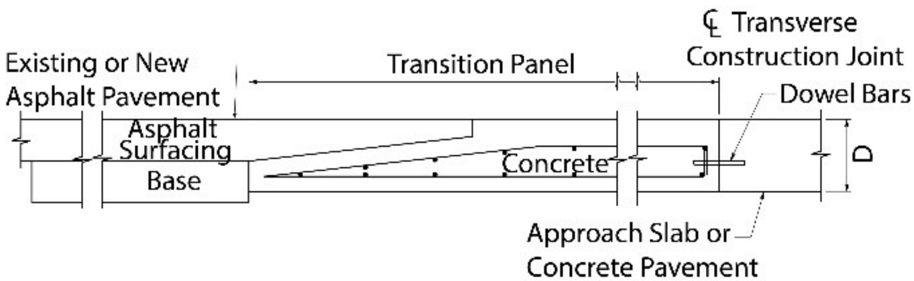
622.5 Transition Panels, Terminal Joints and End Anchors

Transition panels and end anchors are used at transverse joints to minimize deterioration or faulting of the joint where rigid pavement abuts to flexible pavement, a different type of rigid pavement, or a structure approach. The following types of transition joints and anchors should be used where applicable:

(1) *Concrete Pavement Transition Panel.* The concrete pavement transition panel is used to provide a smooth transition between concrete and asphalt pavements (see Figure 622.5A) by minimizing distortion of asphalt at the joint. It can also be used as a transition between structure approach slabs and asphalt pavement.

Figure 622.5A

Concrete Pavement to Asphalt Pavement Transition Panel



The transition panel is a 12-foot long reinforced concrete panel placed between the existing or new asphalt pavement and the concrete pavement or approach slab. It is not always possible to build this panel due to short construction windows and limited space. Where building this panel is not possible, a JPCP End Anchor or CRCP terminal joint type A or C should be used.

(a) End Anchor - Use when JPCP abuts to asphalt or composite pavement and Concrete Pavement Transition Panel is not used. Also recommended where JPCP abuts to structure approach slabs. Consists of a 14-foot long end panel which varies in thickness from the designed thickness to 2 feet. Base type and thickness under the end anchor is the same as base under JPCP.

(2) *Continuously Reinforced Concrete Pavement*. **For CRCP, expansion terminal joint systems (ETJS) shall be used at all transitions to or from structure approach slabs, whereas terminal joint type G shall be used at all transitions with another pavement as shown in Table 622.5.** Where a construction joint is not used to connect two segments of CRCP, a terminal joint G must be used, which includes an expansion joint. As indicated in Table 622.5, use an expansion terminal joint system (ETJS) or a terminal joint type G to accommodate and minimize the movement of the end of a CRCP section when it encounters a structure approach slab, abutment, or another pavement. The Standard Plans include a variety of details for these transitions.

Table 622.5

Use of Terminal Joints and Expansion Joints in CRCP

Type	Structure Approach Slab or Abutment	New or Existing JPCP or Existing CRCP
Terminal Joint Type G	No	Yes
Expansion Terminal Joint System (ETJS) (1)	Yes	No

NOTE:

(1) Includes a Terminal Joint Type F.

Depending on the CRCP terminal type to be used, Figure 622.5B shows the schematic diagrams of Expansion Terminal Joint System between CRCP and existing structure approach slab.

The following types of joints and anchors are used for CRCP:

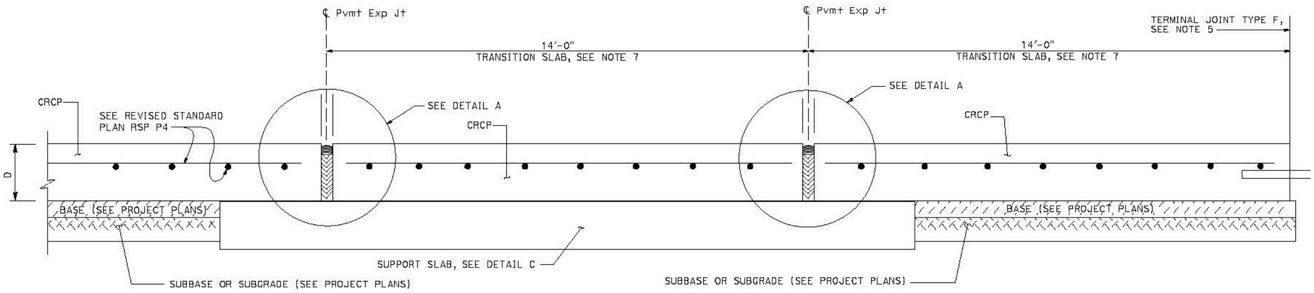
(a) Terminal Joints – Terminal joints are used in CRCP to transition to another pavement type or to a structure approach slab. It is found at the beginning and end of all CRCP. Its function is to isolate CRCP and adjacent pavement types or approach slab to prevent damage and faulting at the transverse joint. The following are terminal joint types for CRCP:

- Terminal Joint Type (A) - Use when constructing new CRCP next to existing asphalt pavement and if a concrete pavement transition panel is not viable.
- Terminal Joint Type (B) - Use when the newly constructed CRCP terminates at future pavement construction. CRCP at the terminus will be supported with a reinforced concrete support slab and backfilled with backing material and later removed when the new pavement will be constructed.
- Terminal Joint Type (C) - Use when the newly constructed CRCP terminates at a proposed temporary asphalt pavement construction for traffic staging. CRCP at the terminus will be supported with a reinforced concrete support slab.
- Terminal Joint Type (F) - Use when constructing new CRCP next to a structure approach slab.
- Terminal Joint Type (G) - Use when constructing new CRCP next to new or existing JPCP, PCP, or existing CRCP.

(b) Expansion Terminal Joint System (ETJS) - ETJS is a series of two 14-ft reinforced slabs with two full depth, full width transverse expansion joints designed to absorb the pavement expansion without damaging adjacent structures. These two expansion joints are placed on a 24-ft long support slab to provide load transfer (see Figure 622.5B).

Figure 622.5B

Expansion Terminal Joint System Between CRCP and Structure Approach Slab



NO SCALE

(3) *Jointed Plain Concrete Pavement.* The following types of transition joints and anchors are used only for JPCP:

(a) Terminal Joint Type 1 – Use when constructing new JPCP next to existing concrete pavement or structure approach slab. It consists of a transverse construction joint with dowel bars drilled and bonded to existing concrete.

(b) Terminal Joint Type 2 – Use when constructing new JPCP next to new structure approach slabs or concrete to asphalt transition panel. It consists of a transverse construction joint with dowel bars placed at the joint of new concrete pavement or structure approach slabs and the new concrete.

622.6 Joint Seals

(1) *General.* Joint and crack seals are used to protect wide joints (joints 3/8 inch or wider) from infiltration of surface moisture and intrusion of incompressible materials. Infiltration of surface moisture and intrusion of incompressible materials into joints is minimized when a narrow joint is used.

(2) *New Construction, Widening, and Reconstruction.* Joints are not sealed or filled for new construction, widening, or for reconstruction except for the following conditions:

- isolation joints,
- expansion joints,
- longitudinal construction joints in all desert and mountain climate regions, and
- transverse joints in JPCP in all desert and mountain climate regions.

(3) *Preservation and Rehabilitation.* To be effective, existing joint seals should be replaced every 10 to 15 years depending on the type used. As part of preservation or rehabilitation strategies, existing joint seals should be replaced when the pavement is ground, replaced or dowel bar retrofitted. Previously unsealed joints should be reviewed to determine if joint sealing is warranted. The condition of the existing joints and joint seals should be reviewed with the District Maintenance or District Materials Engineer to determine if joint seal replacement is warranted.

(4) *Selection of Joint Seal Material.* Various products are available for sealing joints with each one differing in cost and service life. The type of joint sealant is selected based on the following criteria:

- Project environment.

  In mountain and high desert climate regions where chains are used during winter storms, joint sealants that use backer rods are not recommended. Severe climate conditions (such as in the mountains or deserts) will require more durable sealants and/or more frequent replacement.

- Type of roadway.

  Interstate or State highway, and corresponding traffic characteristics including traffic volumes and percentage of truck traffic.

- Condition of existing reservoir.

  If the sides of in-place joint faces are variable in condition, do not use preformed compression seal.

- Expected performance.

  If suitable for intended use and site conditions, the sealant with the longest service life is preferred.

  The joint sealant selected should match the type of existing joint sealant being left in place.

- Cost effectiveness.

  Life cycle cost analysis (LCCA) is used to select the appropriate sealant type.

  Joint sealants should not last longer than the pavement being sealed.

622.7 Dowel Bars and Tie Bars

(1) Dowel bars are smooth round bars that act as load transfer devices across pavement joints.

Dowel bars shall be placed within the traveled way pavement structure at the following joints:

- **All transverse terminal joints in CRCP at new and existing JPCP or structure approach slabs.**
- **All transverse contraction and construction joints in JPCP.**
- **All transverse construction joints in PCP.**
- **All transverse transition joints regardless of concrete pavement type where concrete pavement abuts to structure approach slabs or other concrete pavement type.**

Dowel bars should not be used on shoulders except within the limits of widened slabs and for tied concrete shoulders that are engineered to be converted to a future lane in conformance with Index 613.5(2). When dowel bars are used, they must meet the same requirements as the traveled way.

For JPCP slab replacements, the placement of dowel bars is determined on a project-by-project basis based on proposed design life, condition or remaining service life of adjacent slabs, whether original pavement was constructed doweled or undoweled, and other pertinent factors. Details for doweling slab replacements for JPCP can be found in the Standard Plans.

In limited situations, dowel bars are placed across longitudinal joints. See Standard Plans for further details.

(2) *Tie Bars*. Tie bars are deformed bars (i.e., rebar) or connectors that are used to hold the faces of abutting rigid slabs in contact. Tie bars are typically placed across longitudinal joints. **Tie bars shall be placed at longitudinal joints except at the following locations:**

- Adjacent concrete pavement when the spacing of transverse joints of adjacent slabs is not the same.
- Roller compacted concrete.
- Do not tie more than 50 feet width of JPCP together to preclude random longitudinal cracks from occurring due to the pavement acting as one large rigid slab. In order to maintain some load transfer across the longitudinal joint, the Standard Plans include details for placing dowel bars in the longitudinal joint within the travelled way for this situation.
- Individual slab replacements.

Further details regarding tie bars can be found in the Standard Plans.

622.8 Base Interlayer

When concrete pavement is placed on a concrete base without an engineered interlayer (a.k.a. bond breaker) uncontrolled cracking can occur. In areas of bonding, the pavement and base act as a monolithic mass causing sawn joints to be ineffective due to insufficient depth. This causes cracks to occur in the pavement surface in unexpected areas. To prevent bonding and subsequent crack formation, use a base interlayer between concrete pavement and concrete bases, including lean concrete base, cement treated permeable base, and cement treated base.

Several methods are available for using an interlayer including sufficient application of wax curing compound, geosynthetic, or asphalt binder. When using rapid strength concrete, plastic sheeting or paper may also be suitable alternatives. Asphalt pavement interlayers can be used but it is more efficient to use asphalt base for construction than require two separate products. The Standard Specifications and Standard Special Provisions provide the options for the Contractor to select but the designer should specify them on the plans if a specific interlayer is to be used. For design, the engineer needs to identify on the typical sections when the interlayer is to be installed.

622.9 Texturing

Longitudinal tining is the typical texturing for new pavements. Grooving is typically done to rehabilitate existing pavement texture or to improve surface friction. Grinding is typically done to restore a smooth riding surface on existing pavements or for individual slab replacements.

622.10 Pavement Smoothness

Pavement smoothness, which is also referred to as ride quality, is an important surface texture characteristic that affects both long-term pavement performance as well as ride quality. Smoother pavements have lower dynamic loads and provide the following benefits:

- Improved ride quality;
- Extended pavement life;
- Reduced highway travel user costs, such as gas usage and wear and tear; and
- Lower pavement maintenance costs and less work zone activities.

Pavement smoothness, or ride quality, is measured in terms of the International Roughness Index (IRI). For new construction, reconstruction or widening/lane replacement projects, the concrete pavement is engineered and built to have an IRI. For additional information, see the pavement smoothness page on the Department Pavement website.

Topic 623 – Engineering Procedure for New, Widening, and Reconstruction Projects

623.1 Catalog

Tables 623.1B through M contain the minimum thickness for concrete pavement surface layers, base, and subbase of the traveled way for all types of projects. All JPCP structures shown are doweled. The tables are categorized by subgrade soil type and climate regions. Figure 623.1 is used to determine which table to use to select the traveled way pavement structure. For pavement structure types at other locations such as shoulders and parking lots, see Topic 626.

The steps for selecting the appropriate concrete pavement structure are as follows:

(1) *Determine the Soil Type for the Existing Subgrade*. Soil types for existing subgrade are categorized into Types I, II, and III as shown in Table 623.1A. Soils are classified by the Unified Soil Classification System (USCS). If a soil can be classified in more than one type in Table 623.1A, then the engineer should choose the more conservative design based on the less stable soil. Subgrade is discussed in Topic 614.

(2) *Determine Climate Region*. Find the location of the project on the Pavement Climate Map. The Pavement Climate Map is discussed in Topic 615.

(3) *Select the Appropriate Table (Tables 623.1B through M).* Select the table that applies to the project based on subgrade soil type, and climate region. Use Figure 623.1 to determine which table applies to the project.

(4) *Determine Whether Pavement Has Lateral Support Along Both Longitudinal Joints*. The pavement is considered to have lateral support if any of the following exist:

   - longitudinal joints are tied to an adjacent lane or shoulder,
   - tied rigid shoulders are present, or
   - a widened slab is present.

If lateral support is provided along only one longitudinal joint, then the pavement is considered to have no lateral support. As shown in Tables 623.1B through M, pavement thicknesses are reduced slightly for slabs engineered with lateral support along both longitudinal joints.

(5) *Select Pavement Structure*. Using the Traffic Index provided or calculated from the traffic projections, select the desired pavement structure from the list of alternatives provided.

Note that although the pavement structures listed for each Traffic Index are considered to be acceptable for the climate, soil conditions, and design life desired, they should not be considered as equal designs. Some designs will perform better than others, have lower maintenance/repair costs, and/or lower construction life-cycle costs. For these reasons, the rigid pavement structures in these tables cannot be used as substitutes for the pavement structures shown in approved contract plans.

Figure 623.1

Rigid Pavement Catalog Decision Tree

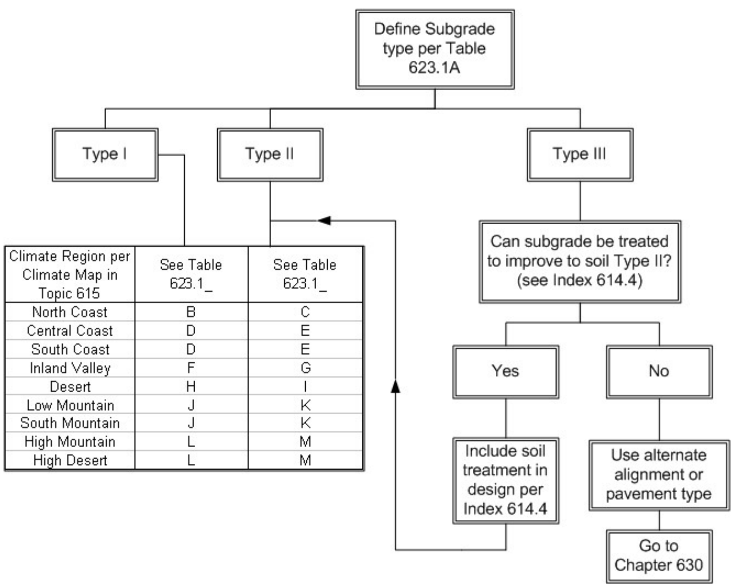


Table 623.1A

Relationship Between Subgrade Type(1)

Subgrade Type(2)	Unified Soil Classification System (USCS)
I	SC, SP, SM, SW, GC, GP, GM, GW
II	CH (PI ≤ 12), CL, MH, ML
III	CH (PI > 12)

NOTES:
(1) See Topic 614 for further discussion on subgrade and USCS.
(2) Choose more conservative soil type (i.e., use soil with a lower subgrade type) if native soil can be classified by more than one type.

Legend
PI = Plasticity Index

Table 623.1B

Rigid Pavement Catalog (North Coast, Type I Subgrade Soil)(1), (2), (3), (4), (5)

	Rigid Pavement Structural Depth					
TI	With Lateral Support (ft)			Without Lateral Support (ft)		
≤ 9			0.70 JPCP 0.50 AB			0.70 JPCP 0.50 AB
9.5 to 10			0.75 JPCP 0.60 AB			0.75 JPCP 0.60 AB
10.5 to 11	0.70 JPCP 0.35 LCB	0.70 JPCP 0.25 HMA-A	0.75 JPCP 0.70 AB	0.75 JPCP 0.35 LCB	0.75 JPCP 0.25 HMA-A	0.80 JPCP 0.70 AB
11.5 to 12	0.75 JPCP 0.35 LCB	0.75 JPCP 0.25 HMA-A	0.75 CRCP 0.25 HMA-A	0.80 JPCP 0.35 LCB	0.80 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A
12.5 to 13	0.80 JPCP 0.35 LCB	0.80 JPCP 0.25 HMA-A	0.75 CRCP 0.25 HMA-A	0.85 JPCP 0.35 LCB	0.85 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A
13.5 to 14	0.80 JPCP 0.35 LCB	0.80 JPCP 0.25 HMA-A	0.75 CRCP 0.25 HMA-A	0.90 JPCP 0.35 LCB	0.85 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A
14.5 to 15	0.85 JPCP 0.35 LCB	0.85 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A	0.95 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A
15.5 to 16	0.90 JPCP 0.35 LCB	0.90 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A	1.00 JPCP 0.35 LCB	1.00 JPCP 0.25 HMA-A	0.90 CRCP 0.25 HMA-A
16.5 to 17	0.95 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A	1.05 JPCP 0.35 LCB	1.05 JPCP 0.25 HMA-A	0.95 CRCP 0.25 HMA-A
> 17	1.00 JPCP 0.35 LCB	1.00 JPCP 0.25 HMA-A	0.90 CRCP 0.25 HMA-A	1.10 JPCP 0.35 LCB	1.10 JPCP 0.25 HMA-A	1.00 CRCP 0.25 HMA-A

NOTES:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.

(2) Includes 0.03 ft sacrificial wearing course for future grinding of JPCP/CRCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP = Jointed Plain Concrete Pavement
CRCP = Continuously Reinforced Concrete Pavement
LCB = Lean Concrete Base
HMA-A = Hot Mix Asphalt (Type A)
ATPB = Asphalt Treated Permeable Base
AB = Class 2 Aggregate Base
TI = Traffic Index

Table 623.1C

Rigid Pavement Catalog (North Coast, Type II Subgrade Soil) (1), (2), (3), (4), (5)

	Rigid Pavement Structural Depth					
TI	With Lateral Support (ft)			Without Lateral Support (ft)		
< 9			0.70 JPCP 1.00 AB			0.70 JPCP 1.00 AB
9.5 to 10			0.75 JPCP 1.00 AB			0.75 JPCP 1.00 AB
10.5 to 11	0.70 JPCP 0.35 LCB 0.60 AS	0.70 JPCP 0.25 HMA-A 0.60 AS	0.75 JPCP 1.30 AB	0.75 JPCP 0.35 LCB 0.60 AS	0.75 JPCP 0.25 HMA-A 0.60 AS	0.80 JPCP 1.30 AB
11.5 to 12	0.75 JPCP 0.35 LCB 0.60 AS	0.75 JPCP 0.25 HMA-A 0.60 AS	0.75 CRCP 0.25 HMA-A 0.60 AS	0.80 JPCP 0.35 LCB 0.60 AS	0.80 JPCP 0.25 HMA-A 0.60 AS	0.80 CRCP 0.25 HMA-A 0.60 AS
12.5 to 13	0.80 JPCP 0.35 LCB 0.70 AS	0.80 JPCP 0.25 HMA-A 0.70 AS	0.75 CRCP 0.25 HMA-A 0.70 AS	0.85 JPCP 0.35 LCB 0.70 AS	0.85 JPCP 0.25 HMA-A 0.70 AS	0.80 CRCP 0.25 HMA-A 0.70 AS
13.5 to 14	0.80 JPCP 0.35 LCB 0.70 AS	0.80 JPCP 0.25 HMA-A 0.70 AS	0.75 CRCP 0.25 HMA-A 0.70 AS	0.90 JPCP 0.35 LCB 0.70 AS	0.85 JPCP 0.25 HMA-A 0.70 AS	0.80 CRCP 0.25 HMA-A 0.70 AS
14.5 to 15	0.85 JPCP 0.35 LCB 0.70 AS	0.85 JPCP 0.25 HMA-A 0.70 AS	0.80 CRCP 0.25 HMA-A 0.70 AS	0.95 JPC 0.35 LCB 0.70 AS	0.95 JPCP 0.25 HMA-A 0.70 AS	0.85 CRCP 0.25 HMA-A 0.70 AS
15.5 to 16	0.90 JPCP 0.35 LCB 0.70 AS	0.90 JPCP 0.25 HMA-A 0.70 AS	0.85 CRCP 0.25 HMA-A 0.70 AS	1.00 JPCP 0.35 LCB 0.70 AS	1.00 JPCP 0.25 HMA-A 0.70 AS	0.90 CRCP 0.25 HMA-A 0.70 AS
16.5 to 17	0.95 JPCP 0.35 LCB 0.70 AS	0.95 JPCP 0.25 HMA-A 0.70 AS	0.85 CRCP 0.25 HMA-A 0.70 AS	1.05 JPCP 0.35 LCB 0.70 AS	1.05 JPCP 0.25 HMA-A 0.70 AS	0.95 CRCP 0.25 HMA-A 0.70 AS
> 17	1.00 JPCP 0.35 LCB 0.70 AS	1.00 JPCP 0.25 HMA-A 0.70 AS	0.90 CRCP 0.25 HMA-A 0.70 AS	1.10 JPCP 0.35 LCB 0.70 AS	1.10 JPCP 0.25 HMA-A 0.70 AS	1.00 CRCP 0.25 HMA-A 0.70 AS

NOTES:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.

(2) Includes 0.03 ft sacrificial wearing course for future grinding of JPCP/CRCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP = Jointed Plain Concrete Pavement
CRCP = Continuously Reinforced Concrete Pavement
LCB = Lean Concrete Base
HMA-A = Hot Mix Asphalt (Type A)
ATPB = Asphalt Treated Permeable Base
AB = Class 2 Aggregate Base
AS = Class 2 Aggregate Subbase
TI = Traffic Index

Table 623.1D

Rigid Pavement Catalog (South Coast/Central Coast, Type I Subgrade Soil) (1), (2), (3), (4), (5)

	Rigid Pavement Structural Depth					
TI	With Lateral Support (ft)			Without Lateral Support (ft)		
≤ 9			0.70 JPCP 0.50 AB			0.75 JPCP 0.50 AB
9.5 to 10			0.75 JPCP 0.60 AB			0.80 JPCP 0.60 AB
10.5 to 11	0.75 JPCP 0.35 LCB	0.75 JPCP 0.25 HMA-A	0.80 JPCP 0.70 AB	0.80 JPCP 0.35 LCB	0.80 JPCP 0.25 HMA-A	0.85 JPCP 0.70 AB
11.5 to 12	0.80 JPCP 0.35 LCB	0.80 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A	0.85 JPCP 0.35 LCB	0.85 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A
12.5 to 13	0.85 JPCP 0.35 LCB	0.85 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A	0.90 JPCP 0.35 LCB	0.90 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A
13.5 to 14	0.85 JPCP 0.35 LCB	0.85 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A	0.95 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A	0.90 CRCP 0.25 HMA-A
14.5 to 15	0.90 JPCP 0.35 LCB	0.90 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A	1.00 JPCP 0.35 LCB	1.00 JPCP 0.25 HMA-A	0.95 CRCP 0.25 HMA-A
15.5 to 16	0.95 JPCP 0.35 LCB	0.90 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A	1.05 JPCP 0.35 LCB	1.05 JPCP 0.25 HMA-A	0.95 CRCP 0.25 HMA-A
16.5 to 17	1.00 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A	0.90 CRCP 0.25 HMA-A	1.10 JPCP 0.35 LCB	1.10 JPCP 0.25 HMA-A	1.00 CRCP 0.25 HMA-A
> 17	1.05 JPCP 0.35 LCB	1.05 JPCP 0.25 HMA-A	0.95 CRCP 0.25 HMA-A	1.15 JPCP 0.35 LCB	1.15 JPCP 0.25 HMA-A	1.00 CRCP 0.25 HMA-A

NOTES:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.

(2) Includes 0.03 ft sacrificial wearing course for future grinding of JPCP/CRCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP = Jointed Plain Concrete Pavement
CRCP = Continuously Reinforced Concrete Pavement
LCB = Lean Concrete Base
HMA-A = Hot Mix Asphalt (Type A)
ATPB = Asphalt Treated Permeable Base
AB = Class 2 Aggregate Base
TI = Traffic Index

Table 623.1E
Rigid Pavement Catalog (South Coast/Central Coast, Type II Subgrade Soil) (1), (2), (3), (4), (5)

TI	Rigid Pavement Structural Depth: With Lateral Support (ft)			Without Lateral Support (ft)		
≤ 9			0.70 JPCP 1.00 AB			0.75 JPCP 1.00 AB
9.5 to 10			0.75 JPCP 1.00 AB			0.80 JPCP 1.00 AB
10.5 to 11	0.75 JPCP 0.35 LCB 0.60 AS	0.75 JPCP 0.25 HMA-A 0.60 AS	0.80 JPCP 1.30 AB	0.80 JPCP 0.35 LCB 0.60 AS	0.80 JPCP 0.25 HMA-A 0.60 AS	0.85 JPCP 1.30 AB
11.5 to 12	0.80 JPCP 0.35 LCB 0.60 AS	0.80 JPCP 0.25 HMA-A 0.60 AS	0.80 CRCP 0.25 HMA-A 0.60 AS	0.85 JPCP 0.35 LCB 0.60 AS	0.85 JPCP 0.25 HMA-A 0.60 AS	0.80 CRCP 0.25 HMA-A 0.60 AS
12.5 to 13	0.85 JPCP 0.35 LCB 0.70 AS	0.85 JPCP 0.25 HMA-A 0.70 AS	0.80 CRCP 0.25 HMA-A 0.70 AS	0.90 JPCP 0.35 LCB 0.70 AS	0.90 JPCP 0.25 HMA-A 0.70 AS	0.85 CRCP 0.25 HMA-A 0.70 AS
13.5 to 14	0.85 JPCP 0.35 LCB 0.70 AS	0.85 JPCP 0.25 HMA-A 0.70 AS	0.80 CRCP 0.25 HMA-A 0.70 AS	0.95 JPCP 0.35 LCB 0.70 AS	0.95 JPCP 0.25 HMA-A 0.70 AS	0.90 CRCP 0.25 HMA-A 0.70 AS
14.5 to 15	0.90 JPCP 0.35 LCB 0.70 AS	0.90 JPCP 0.25 HMA-A 0.70 AS	0.85 CRCP 0.25 HMA-A 0.70 AS	1.00 JPCP 0.35 LCB 0.70 AS	1.00 JPCP 0.25 HMA-A 0.70 AS	0.95 CRCP 0.25 HMA-A 0.70 AS
15.5 to 16	0.95 JPCP 0.35 LCB 0.70 AS	0.90 JPCP 0.25 HMA-A 0.70 AS	0.85 CRCP 0.25 HMA-A 0.70 AS	1.05 JPCP 0.35 LCB 0.70 AS	1.05 JPCP 0.25 HMA-A 0.70 AS	0.95 CRCP 0.25 HMA-A 0.70 AS
16.5 to 17	1.00 JPCP 0.35 LCB 0.70 AS	0.95 JPCP 0.25 HMA-A 0.70 AS	0.90 CRCP 0.25 HMA-A 0.70 AS	1.10 JPC 0.35 LCB 0.70 AS	1.10 JPCP 0.25 HMA-A 0.70 AS	1.00 CRCP 0.25 HMA-A 0.70 AS
> 17	1.05 JPCP 0.35 LCB 0.70 AS	1.05 JPCP 0.25 HMA-A 0.70 AS	0.95 CRCP 0.25 HMA-A 0.70 AS	1.15 JPCP 0.35 LCB 0.70 AS	1.15 JPCP 0.25 HMA-A 0.70 AS	1.00 CRCP 0.25 HMA-A 0.70 AS

NOTES:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.

(2) Includes 0.03 ft sacrificial wearing course for future grinding of JPCP/CRCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP = Jointed Plain Concrete Pavement
CRCP = Continuously Reinforced Concrete Pavement
LCB = Lean Concrete Base
HMA-A = Hot Mix Asphalt (Type A)
ATPB = Asphalt Treated Permeable Base
AB = Class 2 Aggregate Base
AS = Class 2 Aggregate Subbase
TI = Traffic Index

Table 623.1F

Rigid Pavement Catalog (Inland Valley, Type I Subgrade Soil) (1), (2), (3), (4), (5)

	Rigid Pavement Structural Depth					
TI	With Lateral Support (ft)			Without Lateral Support (ft)		
< 9			0.75 JPCP 0.50 AB			0.80 JPCP 0.50 AB
9.5 to 10			0.80 JPCP 0.60 AB			0.90 JPCP 0.60 AB
10.5 to 11	0.75 JPCP 0.35 LCB	0.75 JPCP 0.25 HMA-A	0.85 JPCP 0.70 AB	0.85 JPCP 0.35 LCB	0.90 JPCP 0.25 HMA-A	0.95 JPCP 0.70 AB
11.5 to 12	0.85 JPCP 0.35 LCB	0.85 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A	0.95 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A
12.5 to 13	0.85 JPCP 0.35 LCB	0.90 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A	1.00 JPCP 0.35 LCB	1.00 JPCP 0.25 HMA-A	0.90 CRCP 0.25 HMA-A
13.5 to 14	0.95 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A	1.05 JPCP 0.35 LCB	1.05 JPCP 0.25 HMA-A	0.95 CRCP 0.25 HMA-A
14.5 to 15	1.00 JPCP 0.35 LCB	1.00 JPCP 0.25 HMA-A	0.90 CRCP 0.25 HMA-A	1.15 JPCP 0.35 LCB	1.15 JPCP 0.25 HMA-A	1.00 CRCP 0.25 HMA-A
15.5 to 16	1.05 JPCP 0.35 LCB	1.05 JPCP 0.25 HMA-A	0.95 CRCP 0.25 HMA-A	1.20 JPCP 0.35 LCB	1.20 JPCP 0.25 HMA-A	1.05 CRCP 0.25 HMA-A
16.5 to 17	1.10 JPCP 0.35 LCB	1.10 JPCP 0.25 HMA-A	0.95 CRCP 0.25 HMA-A	1.25 JPCP 0.35 LCB	1.25 JPCP 0.25 HMA-A	1.10 CRCP 0.25 HMA-A
> 17	1.15 JPCP 0.35 LCB	1.15 JPCP 0.25 HMA-A	1.00 CRCP 0.25 HMA-A	1.30 JPCP 0.35 LCB	1.30 JPCP 0.25 HMA-A	1.10 CRCP 0.25 HMA-A

NOTES:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.

(2) Includes 0.03 ft sacrificial wearing course for future grinding of JPCP/CRCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP = Jointed Plain Concrete Pavement
CRCP = Continuously Reinforced Concrete Pavement
LCB = Lean Concrete Base
HMA-A = Hot Mix Asphalt (Type A)
ATPB = Asphalt Treated Permeable Base
AB = Class 2 Aggregate Base
TI = Traffic Index

Table 623.1G

Rigid Pavement Catalog (Inland Valley, Type II Subgrade Soil)[(1), (2), (3), (4), (5)]

	Rigid Pavement Structural Depth					
TI	With Lateral Support (ft)			Without Lateral Support (ft)		
≤ 9			0.75 JPCP 1.00 AB			0.80 JPCP 1.00 AB
9.5 to 10			0.80 JPCP 1.00 AB			0.90 JPCP 1.00 AB
10.5 to 11	0.75 JPCP 0.35 LCB 0.60 AS	0.75 JPCP 0.25 HMA-A 0.60 AS	0.85 JPCP 1.30 AB	0.85 JPCP 0.35 LCB 0.60 AS	0.90 JPCP 0.25 HMA-A 0.60 AS	0.95 JPCP 1.30 AB
11.5 to 12	0.85 JPCP 0.35 LCB 0.60 AS	0.85 JPCP 0.25 HMA-A 0.60 AS	0.80 CRCP 0.25 HMA-A 0.60 AS	0.95 JPCP 0.35 LCB 0.60 AS	0.95 JPCP 0.25 HMA-A 0.60 AS	0.85 CRCP 0.25 HMA-A 0.60 AS
12.5 to 13	0.85 JPCP 0.35 LCB 0.70 AS	0.90 JPCP 0.25 HMA-A 0.70 AS	0.80 CRCP 0.25 HMA-A 0.70 AS	1.00 JPCP 0.35 LCB 0.70 AS	1.00 JPCP 0.25 HMA-A 0.70 AS	0.90 CRCP 0.25 HMA-A 0.70 AS
13.5 to 14	0.95 JPCP 0.35 LCB 0.70 AS	0.95 JPCP 0.25 HMA-A 0.70 AS	0.85 CRCP 0.25 HMA-A 0.70 AS	1.05 JPCP 0.35 LCB 0.70 AS	1.05 JPCP 0.25 HMA-A 0.70 AS	0.95 CRCP 0.25 HMA-A 0.70 AS
14.5 to 15	1.00 JPCP 0.35 LCB 0.70 AS	1.00 JPCP 0.25 HMA-A 0.70 AS	0.90 CRCP 0.25 HMA-A 0.70 AS	1.15 JPCP 0.35 LCB 0.70 AS	1.15 JPCP 0.25 HMA-A 0.70 AS	1.00 CRCP 0.25 HMA-A 0.70 AS
15.5 to 16	1.05 JPCP 0.35 LCB 0.70 AS	1.05 JPCP 0.25 HMA-A 0.70 AS	0.95 CRCP 0.25 HMA-A 0.70 AS	1.20 JPCP 0.35 LCB 0.70 AS	1.20 JPCP 0.25 HMA-A 0.70 AS	1.05 CRCP 0.25 HMA-A 0.70 AS
16.5 to 17	1.10 JPCP 0.35 LCB 0.70 AS	1.10 JPCP 0.25 HMA-A 0.70 AS	0.95 CRCP 0.25 HMA-A 0.70 AS	1.25 JPCP 0.35 LCB 0.70 AS	1.25 JPCP 0.25 HMA-A 0.70 AS	1.10 CRCP 0.25 HMA-A 0.70 AS
> 17	1.15 JPCP 0.35 LCB 0.70 AS	1.15 JPCP 0.25 HMA-A 0.70 AS	1.00 CRCP 0.25 HMA-A 0.70 AS	1.30 JPCP 0.35 LCB 0.70 AS	1.30 JPCP 0.25 HMA-A 0.70 AS	1.10 CRCP 0.25 HMA-A 0.70 AS

NOTES:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.

(2) Includes 0.03 ft sacrificial wearing course for future grinding of JPCP/CRCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP = Jointed Plain Concrete Pavement
CRCP = Continuously Reinforced Concrete Pavement
LCB = Lean Concrete Base
HMA-A = Hot Mix Asphalt (Type A)
ATPB = Asphalt Treated Permeable Base
AB = Class 2 Aggregate Base
AS = Class 2 Aggregate Subbase
TI = Traffic Index

Table 623.1H

Rigid Pavement Catalog (Desert, Type I Subgrade Soil) (1), (2), (3), (4), (5)

	Rigid Pavement Structural Depth					
TI	With Lateral Support (ft)			Without Lateral Support (ft)		
< 9	0.70 JPCP 0.35 LCB	0.70 JPCP 0.25 HMA-A	0.75 JPCP 0.50 AB	0.75 JPCP 0.35 LCB	0.75 JPCP 0.25 HMA-A	0.80 JPCP 0.50 AB
9.5 to 10	0.75 JPCP 0.35 LCB	0.75 JPCP 0.25 HMA-A	0.80 JPCP 0.60 AB	0.80 JPC 0.35 LCB	0.85 JPCP 0.25 HMA-A	0.90 JPCP 0.60 AB
10.5 to 11	0.80 JPCP 0.35 LCB	0.80 JPCP 0.25 HMA-A	0.85 JPCP 0.70 AB	0.85 JPCP 0.35 LCB	0.90 JPCP 0.25 HMA-A	0.95 JPCP 0.70 AB
11.5 to 12	0.85 JPCP 0.35 LCB	0.85 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A	0.90 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A
12.5 to 13	0.95 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A	1.05 JPCP 0.35 LCB	1.05 JPCP 0.25 HMA-A	0.95 CRCP 0.25 HMA-A
13.5 to 14	1.00 JPCP 0.35 LCB	1.00 JPCP 0.25 HMA-A	0.90 CRCP 0.25 HMA-A	1.15 JPCP 0.35 LCB	1.15 JPCP 0.25 HMA-A	1.05 CRCP 0.25 HMA-A
14.5 to 15	1.05 JPC 0.35 LCB	1.05 JPCP 0.25 HMA-A	0.95 CRCP 0.25 HMA-A	1.20 JPCP 0.35 LCB	1.20 JPCP 0.25 HMA-A	1.10 CRCP 0.25 HMA-A
15.5 to 16	1.10 JPCP 0.35 LCB	1.10 JPCP 0.25 HMA-A	1.00 CRCP 0.25 HMA-A	1.25 JPCP 0.35 LCB	1.25 JPCP 0.25 HMA-A	1.10 CRCP 0.25 HMA-A
16.5 to 17	1.15 JPCP 0.35 LCB	1.15 JPCP 0.25 HMA-A	1.05 CRCP 0.25 HMA-A	1.30 JPCP 0.35 LCB	1.30 JPCP 0.25 HMA-A	1.10 CRCP 0.25 HMA-A
> 17	1.20 JPCP 0.35 LCB	1.20 JPCP 0.25 HMA-A	1.10 CRCP 0.25 HMA-A	1.30 JPCP 0.35 LCB	1.30 JPCP 0.25 HMA-A	1.10 CRCP 0.25 HMA-A

NOTES:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.

(2) Includes 0.03 ft sacrificial wearing course for future grinding of JPCP/CRCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP = Jointed Plain Concrete Pavement
CRCP = Continuously Reinforced Concrete Pavement
LCB = Lean Concrete Base
HMA-A = Hot Mix Asphalt (Type A)
ATPB = Asphalt Treated Permeable Base
AB = Class 2 Aggregate Base
TI = Traffic Index

Table 623.1I

Rigid Pavement Catalog (Desert, Type II Subgrade Soil) (1), (2), (3), (4), (5)

	Rigid Pavement Structural Depth					
TI	With Lateral Support (ft)			Without Lateral Support (ft)		
< 9	0.70 JPCP 0.35 LCB 0.50 AS	0.70 JPCP 0.25 HMA-A 0.50 AS	0.75 JPCP 1.00 AB	0.75 JPCP 0.35 LCB 0.60 AS	0.75 JPCP 0.25 HMA-A 0.60 AS	0.80 JPCP 1.00 AB
9.5 to 10	0.75 JPCP 0.35 LCB 0.50 AS	0.75 JPCP 0.25 HMA-A 0.50 AS	0.80 JPCP 1.00 AB	0.80 JPCP 0.35 LCB 0.60 AS	0.85 JPCP 0.25 HMA-A 0.60 AS	0.90 JPCP 1.00 AB
10.5 to 11	0.80 JPCP 0.35 LCB 0.60 AS	0.80 JPCP 0.25 HMA-A 0.60 AS	0.85 JPCP 1.30 AB	0.85 JPCP 0.35 LCB 0.60 AS	0.90 JPCP 0.25 HMA-A 0.60 AS	0.95 JPCP 1.30 AB
11.5 to 12	0.85 JPCP 0.35 LCB 0.60 AS	0.85 JPCP 0.25 HMA-A 0.60 AS	0.80 CRCP 0.25 HMA-A 0.60 AS	0.90 JPCP 0.35 LCB 0.60 AS	0.95 JPCP 0.25 HMA-A 0.60 AS	0.85 CRCP 0.25 HMA-A 0.60 AS
12.5 to 13	0.95 JPCP 0.35 LCB 0.70 AS	0.95 JPCP 0.25 HMA-A 0.70 AS	0.85 CRCP 0.25 HMA-A 0.70 AS	1.05 JPCP 0.35 LCB 0.70 AS	1.05 JPCP 0.25 HMA-A 0.70 AS	0.95 CRCP 0.25 HMA-A 0.70 AS
13.5 to 14	1.00 JPCP 0.35 LCB 0.70 AS	1.00 JPCP 0.25 HMA-A 0.70 AS	0.90 CRCP 0.25 HMA-A 0.70 AS	1.15 JPCP 0.35 LCB 0.70 AS	1.15 JPCP 0.25 HMA-A 0.70 AS	1.05 CRCP 0.25 HMA-A 0.70 AS
14.5 to 15	1.05 JPCP 0.35 LCB 0.70 AS	1.05 JPCP 0.25 HMA-A 0.70 AS	0.95 CRCP 0.25 HMA-A 0.70 AS	1.20 JPCP 0.35 LCB 0.70 AS	1.20 JPCP 0.25 HMA-A 0.70 AS	1.10 CRCP 0.25 HMA-A 0.70 AS
15.5 to 16	1.10 JPCP 0.35 LCB 0.70 AS	1.10 JPCP 0.25 HMA-A 0.70 AS	1.00 CRCP 0.25 HMA-A 0.70 AS	1.25 JPCP 0.35 LCB 0.70 AS	1.25 JPCP 0.25 HMA-A 0.70 AS	1.10 CRCP 0.25 HMA-A 0.70 AS
16.5 to 17	1.15 JPCP 0.35 LCB 0.70 AS	1.15 JPCP 0.25 HMA-A 0.70 AS	1.05 CRCP 0.25 HMA-A 0.70 AS	1.30 JPCP 0.35 LCB 0.70 AS	1.30 JPCP 0.25 HMA-A 0.70 AS	1.10 CRCP 0.25 HMA-A 0.70 AS
> 17	1.20 JPCP 0.35 LCB 0.70 AS	1.20 JPCP 0.25 HMA-A 0.70 AS	1.10 CRCP 0.25 HMA-A 0.70 AS	1.30 JPCP 0.35 LCB 0.70 AS	1.30 JPCP 0.25 HMA-A 0.70 AS	1.10 CRCP 0.25 HMA-A 0.70 AS

NOTES:

(1) Thicknesses shown are for doweled JPCP only. Not valid for nondoweled JPCP.

(2) Includes 0.03 ft sacrificial wearing course for future grinding of JPCP/CRCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP = Jointed Plain Concrete Pavement
CRCP = Continuously Reinforced Concrete Pavement
LCB = Lean Concrete Base
HMA-A = Hot Mix Asphalt (Type A)
ATPB = Asphalt Treated Permeable Base
AB = Class 2 Aggregate Base
AS = Class 2 Aggregate Subbase
TI = Traffic Index

Table 623.1J

Rigid Pavement Catalog (Low Mountain/South Mountain, Type I Subgrade Soil) (1), (2), (3), (4), (5)

	Rigid Pavement Structural Depth					
TI	With Lateral Support (ft)			Without Lateral Support (ft)		
≤ 9			0.75 JPCP 0.50 AB			0.75 JPCP 0.50 AB
9.5 to 10			0.75 JPCP 0.60 AB			0.85 JPCP 0.60 AB
10.5 to 11	0.75 JPCP 0.35 LCB	0.75 JPCP 0.25 HMA-A	0.80 JPCP 0.70 AB	0.85 JPCP 0.35 LCB	0.85 JPCP 0.25 HMA-A	0.90 JPCP 0.70 AB
11.5 to 12	0.80 JPCP 0.35 LCB	0.85 JPCP 0.25 HMA-A	0.80 CRCP 0.25 HMA-A	0.90 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A
12.5 to 13	0.90 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A	1.00 JPCP 0.35 LCB	1.05 JPCP 0.25 HMA-A	0.90 CRCP 0.25 HMA-A
13.5 to 14	0.95 JPCP 0.35 LCB	1.00 JPCP 0.25 HMA-A	0.85 CRCP 0.25 HMA-A	1.05 JPCP 0.35 LCB	1.10 JPCP 0.25 HMA-A	0.95 CRCP 0.25 HMA-A
14.5 to 15	1.00 JPCP 0.35 LCB	1.05 JPCP 0.25 HMA-A	0.90 CRCP 0.25 HMA-A	1.15 JPCP 0.35 LCB	1.20 JPCP 0.25 HMA-A	1.05 CRCP 0.25 HMA-A
15.5 to 16	1.05 JPCP 0.35 LCB	1.10 JPCP 0.25 HMA-A	0.95 CRCP 0.25 HMA-A	1.20 JPCP 0.35 LCB	1.25 JPCP 0.25 HMA-A	1.10 CRCP 0.25 HMA-A
16.5 to 17	1.10 JPCP 0.35 LCB	1.15 JPCP 0.25 HMA-A	1.00 CRCP 0.25 HMA-A	1.25 JPCP 0.35 LCB	1.30 JPCP 0.25 HMA-A	1.10 CRCP 0.25 HMA-A
> 17	1.15 JPCP 0.35 LCB	1.20 JPCP 0.25 HMA-A	1.00 CRCP 0.25 HMA-A	1.30 JPCP 0.35 LCB	1.35 JPCP 0.25 HMA-A	1.10 CRCP 0.25 HMA-A

NOTES:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.

(2) Includes 0.03 ft sacrificial wearing course for future grinding of JPCP/CRCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP = Jointed Plain Concrete Pavement
CRCP = Continuously Reinforced Concrete Pavement
LCB = Lean Concrete Base
HMA-A = Hot Mix Asphalt (Type A)
ATPB = Asphalt Treated Permeable Base
AB = Class 2 Aggregate Base
TI = Traffic Index

Table 623.1K
Rigid Pavement Catalog (Low Mountain/South Mountain, Type II Subgrade Soil) (1), (2), (3), (4), (5)

TI	Rigid Pavement Structural Depth: With Lateral Support (ft)			Rigid Pavement Structural Depth: Without Lateral Support (ft)		
≤ 9			0.75 JPCP 1.00 AB			0.75 JPCP 1.00 AB
9.5 to 10			0.75 JPCP 1.00 AB			0.85 JPCP 1.00 AB
10.5 to 11	0.75 JPCP 0.35 LCB 0.60 AS	0.75 JPCP 0.25 HMA-A 0.60 AS	0.80 JPCP 1.30 AB	0.85 JPCP 0.35 LCB 0.60 AS	0.85 JPCP 0.25 HMA-A 0.60 AS	0.90 JPCP 1.30 AB
11.5 to 12	0.80 JPCP 0.35 LCB 0.60 AS	0.85 JPCP 0.25 HMA-A 0.60 AS	0.80 CRCP 0.25 HMA-A 0.60 AS	0.90 JPCP 0.35 LCB 0.60 AS	0.95 JPCP 0.25 HMA-A 0.60 AS	0.85 CRCP 0.25 HMA-A 0.60 AS
12.5 to 13	0.90 JPCP 0.35 LCB 0.70 AS	0.95 JPCP 0.25 HMA-A 0.70 AS	0.85 CRCP 0.25 HMA-A 0.70 AS	1.00 JPCP 0.35 LCB 0.70 AS	1.05 JPCP 0.25 HMA-A 0.70 AS	0.90 CRCP 0.25 HMA-A 0.70 AS
13.5 to 14	0.95 JPCP 0.35 LCB 0.70 AS	1.00 JPCP 0.25 HMA-A 0.70 AS	0.85 CRCP 0.25 HMA-A 0.70 AS	1.05 JPCP 0.35 LCB 0.70 AS	1.10 JPCP 0.25 HMA-A 0.70 AS	0.95 CRCP 0.25 HMA-A 0.70 AS
14.5 to 15	1.00 JPCP 0.35 LCB 0.70 AS	1.05 JPCP 0.25 HMA-A 0.70 AS	0.90 CRCP 0.25 HMA-A 0.70 AS	1.15 JPCP 0.35 LCB 0.70 AS	1.20 JPCP 0.25 HMA-A 0.70 AS	1.05 CRCP 0.25 HMA-A 0.70 AS
15.5 to 16	1.05 JPCP 0.35 LCB 0.70 AS	1.10 JPCP 0.25 HMA-A 0.70 AS	0.95 CRCP 0.25 HMA-A 0.70 AS	1.20 JPCP 0.35 LCB 0.70 AS	1.25 JPCP 0.25 HMA-A 0.70 AS	1.10 CRCP 0.25 HMA-A 0.70 AS
16.5 to 17	1.10 JPCP 0.35 LCB 0.70 AS	1.15 JPCP 0.25 HMA-A 0.70 AS	1.00 CRCP 0.25 HMA-A 0.70 AS	1.25 JPCP 0.35 LCB 0.70 AS	1.30 JPCP 0.25 HMA-A 0.70 AS	1.10 CRCP 0.25 HMA-A 0.70 AS
> 17	1.15 JPCP 0.35 LCB 0.70 AS	1.20 JPCP 0.25 HMA-A 0.70 AS	1.00 CRCP 0.25 HMA-A 0.70 AS	1.30 JPCP 0.35 LCB 0.70 AS	1.35 JPCP 0.25 HMA-A 0.70 AS	1.10 CRCP 0.25 HMA-A 0.70 AS

NOTES:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.

(2) Includes 0.03 ft sacrificial wearing course for future grinding of JPCP/CRCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP =	Jointed Plain Concrete Pavement	ATPB =	Asphalt Treated Permeable Base
CRCP =	Continuously Reinforced Concrete Pavement	AB =	Class 2 Aggregate Base
LCB =	Lean Concrete Base	AS =	Class 2 Aggregate Subbase
HMA-A =	Hot Mix Asphalt (Type A)	TI =	Traffic Index

Table 623.1L

Rigid Pavement Catalog (High Mountain/High Desert, Type I Subgrade Soil) (1), (2), (3), (4), (5)

	Rigid Pavement Structural Depth					
TI	With Lateral Support (ft)			Without Lateral Support (ft)		
≤ 9			0.85 JPCP 0.50 AB			0.90 JPCP 0.50 AB
9.5 to 10			0.90 JPCP 0.60 AB			0.95 JPCP 0.60 AB
10.5 to 11	0.90 JPCP 0.35 LCB	0.90 JPCP 0.25 HMA-A	0.95 JPCP 0.70 AB	0.95 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A	1.00 JPCP 0.70 AB
11.5 to 12	0.95 JPCP 0.35 LCB	0.95 JPCP 0.25 HMA-A		1.05 JPCP 0.35 LCB	1.05 JPCP 0.25 HMA-A	
12.5 to 13	1.00 JPCP 0.35 LCB	1.05 JPCP 0.25 HMA-A		1.10 JPCP 0.35 LCB	1.15 JPCP 0.25 HMA-A	
13.5 to 14	1.05 JPCP 0.35 LCB	1.10 JPCP 0.25 HMA-A		1.15 JPCP 0.35 LCB	1.20 JPCP 0.25 HMA-A	
14.5 to 15	1.10 JPCP 0.35 LCB	1.15 JPCP 0.25 HMA-A		1.20 JPCP 0.35 LCB	1.25 JPCP 0.25 HMA-A	
15.5 to 16	1.15 JPCP 0.35 LCB	1.20 JPCP 0.25 HMA-A		1.25 JPC 0.35 LCB	1.30 JPCP 0.25 HMA-A	
16.5 to 17	1.20 JPCP 0.35 LCB	1.25 JPCP 0.25 HMA-A		1.30 JPCP 0.35 LCB	1.35 JPCP 0.25 HMA-A	
> 17	1.25 JPCP 0.35 LCB	1.25 JPCP 0.25 HMA-A		1.35 JPCP 0.35 LCB	1.35 JPCP 0.25 HMA-A	

NOTES:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.

(2) Includes 0.15 ft sacrificial wearing course for future grinding of JPCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP = Jointed Plain Concrete Pavement
CRCP = Continuously Reinforced Concrete Pavement
LCB = Lean Concrete Base
HMA-A = Hot Mix Asphalt (Type A)
ATPB = Asphalt Treated Permeable Base
AB = Class 2 Aggregate Base
TI = Traffic Index

Table 623.1M
Rigid Pavement Catalog (High Mountain/High Desert, Type II Subgrade Soil) (1), (2), (3), (4), (5)

TI	Rigid Pavement Structural Depth: With Lateral Support (ft)			Without Lateral Support (ft)		
≤ 9			0.85 JPCP 1.00 AB			0.90 JPCP 1.00 AB
9.5 to 10			0.90 JPCP 1.00 AB			0.95 JPCP 1.00 AB
10.5 to 11	0.90 JPCP 0.35 LCB 0.60 AS	0.90 JPCP 0.25 HMA-A 0.60 AS	0.95 JPCP 1.30 AB	0.95 JPCP 0.35 LCB 0.60 AS	0.95 JPCP 0.25 HMA-A 0.60 AS	1.00 JPCP 1.30 AB
11.5 to 12	0.95 JPCP 0.35 LCB 0.60 AS	0.95 JPCP 0.25 HMA-A 0.60 AS		1.05 JPCP 0.35 LCB 0.60 AS	1.05 JPCP 0.25 HMA-A 0.60 AS	
12.5 to 13	1.00 JPCP 0.35 LCB 0.70 AS	1.05 JPCP 0.25 HMA-A 0.70 AS		1.10 JPCP 0.35 LCB 0.70 AS	1.15 JPCP 0.25 HMA-A 0.70 AS	
13.5 to 14	1.05 JPCP 0.35 LCB 0.70 AS	1.10 JPCP 0.25 HMA-A 0.70 AS		1.15 JPCP 0.35 LCB 0.70 AS	1.20 JPCP 0.25 HMA-A 0.70 AS	
14.5 to 15	1.10 JPCP 0.35 LCB 0.70 AS	1.15 JPCP 0.25 HMA-A 0.70 AS		1.20 JPCP 0.35 LCB 0.70 AS	1.25 JPCP 0.25 HMA-A 0.70 AS	
15.5 to 16	1.15 JPCP 0.35 LCB 0.70 AS	1.20 JPCP 0.25 HMA-A 0.70 AS		1.25 JPCP 0.35 LCB 0.70 AS	1.30 JPCP 0.23 HMA-A 0.70 AS	
16.5 to 17	1.20 JPCP 0.35 LCB 0.70 AS	1.25 JPCP 0.25 HMA-A 0.70 AS		1.30 JPCP 0.35 LCB 0.70 AS	1.35 JPCP 0.25 HMA-A 0.70 AS	
> 17	1.25 JPCP 0.35 LCB 0.70 AS	1.25 JPCP 0.25 HMA-A 0.70 AS		1.35 JPCP 0.35 LCB 0.70 AS	1.35 JPCP 0.25 HMA-A 0.70 AS	

NOTES:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.

(2) Includes 0.15 ft sacrificial wearing course for future grinding of JPCP.

(3) Portland cement concrete may be substituted for LCB when justified for constructability or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.

(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

(5) Place an interlayer between JPCP and LCB in all cases

LEGEND:

JPCP = Jointed Plain Concrete Pavement
CRCP = Continuously Reinforced Concrete Pavement
LCB = Lean Concrete Base
HMA-A = Hot Mix Asphalt (Type A)
ATPB = Asphalt Treated Permeable Base
AB = Class 2 Aggregate Base
AS = Class 2 Aggregate Subbase
TI = Traffic Index

Topic 624 – Engineering Procedures for Pavement Preservation

624.1 Preventive Maintenance

Examples of rigid pavement preventive maintenance strategies include the following or combinations of the following:

- Seal random cracks.
- Joint seal, repair/replace existing joint seals.
- Dowel bar retrofit.
- Grinding or grooving to maintain ride quality and/or restore surface texture.
- Special surface treatments (such as methacrylate, hardeners, and others).

Rigid pavement preventive maintenance strategies are discussed further in the Concrete Pavement Guide.

624.2 Capital Pavement Maintenance (CAPM)

A CAPM project is warranted if any of the following criteria is met:

(1) Continuously Reinforced Concrete Pavement

- Number of punchouts with high severity cracking is between 1 and 10 percent.

(2) Jointed Plain Concrete Pavement

Number of slabs with 3rd stage cracking between 1 and 10 percent of a given travel lane-mile. Note, 3rd stage cracking is any slab with two or more intersecting cracks of at least ¾ inch in width.

- Combination of corner, longitudinal, and traverse cracking and/or spalling between 1 and 15 percent of travel lane-miles. Note, corner, longitudinal, or transverse cracks that are at least ¾ inch in width. Also note, spalling is regarded as a joint or crack which spalls at least 6 inches wide as measured from centerline of joint or spall.

(3) All Concrete Pavements

- International Roughness Index (IRI) is more than 170 with no or minor distress.
- Faulting greater than ¼ inch.

CAPM strategies include the following or combinations of the following:

(a) Individual slab replacement (for JPCP) and punchout repair (for CRCP). The use of rapid strength concrete in the replacement of concrete slabs should be considered to minimize traffic impacts and open the facility to traffic in a minimal amount of time. Individual slab replacements and punchout repair may include replacing existing cement treated base or lean concrete base with rapid setting concrete lean concrete base or rapid strength concrete. For further information (including information on rapid strength concrete) see the Concrete Pavement Guide on the Department Pavement website.

(b) Spall repair. Spall repair is a corrective maintenance treatment that replaces loss of concrete, typically around joints or cracks, with polyester or fast-setting concrete. Depending on the existing pavement condition, spall repairs can be used as the primary project treatment or in combination with other preventive, corrective, or rehabilitation strategies. Typical cases when spall repair may be needed include repair of spalled joints and cracks on individual slab replacement projects, as a pre-overlay repair of a distress pavement surface, or prior to grinding or joint sealing projects.

(c) Grinding to correct faulting or poor ride. To improve ride quality, diamond grind the concrete pavement to correct ride smoothness to an acceptable level. If the existing pavement has an IRI > 170 inches per mile, restore ride quality to an IRI that is 40 percent improvement. If individual slab replacement is part of the project, diamond grind the concrete pavement after slab replacement is completed. The pavement must maintain an IRI of less than 170 inches per mile throughout its service life.

(d) Asphalt overlay strategies for CAPM in Index 635.2 may also apply to concrete pavement where appropriate.

The roadway rehabilitation requirements for overlays (see Index 625.1(2)) and preparation of existing pavement surface (Index 625.1(3)) apply to CAPM projects. Additional information regarding CAPM policies can be found in PDPM Appendix H and Design Information Bulletin (DIB) 81 “Capital Preventive Maintenance Guidelines.” Additional details for scoping and designing these strategies can be found in the Concrete Pavement Guide. Both DIB 81 and the Concrete Pavement Guide can be found on the Department Pavement website.

Topic 625 – Engineering Procedures for Pavement Rehabilitation

625.1 Rehabilitation Warrants

A rehabilitation project is warranted if any of the following criteria is met:

Jointed Plain Concrete Pavement

- Number of slabs with 3rd stage cracking between 1 and 10 percent of a given travel lane-mile. Note, 3rd stage cracking is any slab with two or more intersecting cracks of ¾ inch in width.
- Combination of corner, longitudinal, and traverse cracking and/or spalling exceeding 15 percent of given travel lane-miles. Note, corner, longitudinal, or transverse cracks are at least ¾ inch in width. Also note, spalling is regarded as a joint or crack which spalls at least 6 inches wide as measured from centerline of joint or spall.

  When the number of slabs that warrant slab replacement per the above criteria is between 10 and 20 percent, perform a life cycle cost analysis per Topic 619 comparing roadway rehabilitation to CAPM. If CAPM has lower life cycle cost, pursue the project as a CAPM project.

625.2 Rigid Pavement Rehabilitation Strategies

(1) Strategies. An overview of rigid pavement strategies for rehabilitation is discussed in the “Concrete Pavement Guide,” which can be found on the Department Pavement website.

Some rehabilitation strategies discussed in the guide include the following or combinations of the following:

(a) Concrete overlay. To determine the thickness of the rigid layer, use the rigid layer thicknesses for new pavement found in Index 623.1. Include a 0.10 foot minimum asphalt interlayer between the concrete overlay and the existing concrete pavement. The interlayer may need to be thicker if it is used temporarily for traffic handling.

(b) Lane replacement. Lane replacements are engineered using the catalogs found in Index 623.1. Attention should be given to maintaining existing drainage patterns underneath the surface layer, (see Chapter 650 for further guidance). For further information see the Concrete Pavement Guide located on the Department Pavement website.

(c) Crack, seat, and asphalt overlay. Thicknesses should be engineered using Caltrans mechanistic-empirical method (CalME). See Index 635.2 for further details. Thicknesses for a 20-year and 40-year design life using this strategy have been provided in Table 625.2 for cost estimating purposes in planning documents when calculations are not available.

For crack, seat, and asphalt overlay projects, a nonstructural wearing course may be placed in addition to (but not as a substitute for) the thickness found in Table 625.2 for 20-year design life. A nonstructural wearing course is required for a 40-year design life. Once a rigid pavement has been cracked, seated, and

overlaid with asphalt pavement it is considered to be a composite pavement and subsequent preservation and rehabilitation strategies are determined in accordance with the guidelines found in Chapter 640.

(d) Asphalt overlay (without crack and seat). If the existing rigid pavement (JPCP) will not be cracked and seated, for a 20-year design life, add an additional 0.10 foot HMA to the minimum standard thicknesses of HMA surface course layer given in Table 625.2. Since the maximum thickness for RHMA-G is 0.20 foot (see Index 631.3), no additional thickness is needed if RHMA-G is used for the overlay. For 40-year design life, if the existing pavement cannot be cracked and seated it will need to be removed or rubberized. The section should be designed as a flexible pavement per Index 633.1(3) or Caltrans mechanistic-empirical method (CalME) in Chapter 630.

(2) *Overlay Limits*. **On overlay projects, the entire traveled way and paved shoulder shall be overlaid.** Not only does this help provide a smoother finished surface, it also benefits bicyclists and pedestrians when they need to use the shoulder.

(3) *Preparation of Existing Pavement.* <u>Existing pavement distresses should be repaired before overlaying the pavement</u>. Cracks 3/8 inch or wider should be sealed; loose pavement removed and patched; spalls repaired; and broken slabs or punchouts replaced. Existing thermoplastic traffic striping and above grade pavement markers should be removed. This applies to both lanes and adjacent shoulders (flexible and rigid). The Materials Report should include a reminder of these preparations. Crack sealants should be placed ¼ inch below grade to allow for expansion (i.e., recess fill) and to alleviate a potential bump if an overlay is placed. For information and criteria for slab replacements, see the Concrete Pavement Guide located on the Department Pavement website.

(4) *Selection.* The selection of the appropriate strategy should be based upon life-cycle cost analysis, load transfer efficiency of the joints, materials testing, ride quality, safety, maintainability, constructability, visual inspection of pavement distress, and other factors

Table 625.2

Thicknesses for Crack, Seat, and Flexible Overlay

20-year (1)	TI <12.0	0.35′ HMA GPI or RPI 0.10′ HMA (LC)	0.35′ HMA GPI or RPI 0.10′ HMA (LC)	0.20′ RHMA-G RPI 0.10′ HMA (LC)
	TI ≥12.0	0.40′ HMA GPI or RPI 0.15′ HMA (LC)	0.20′ RHMA-G RPI 0.15′ HMA (LC)	0.20′ RHMA-G 0.15′ HMA GPI or RPI 0.10′ HMA (LC)
40-year	TI ≥15.0	0.10′ HMA-O or RHMA-O 0.20′ HMA (PM) 0.50′ HMA GPI or RPI 0.10′ HMA (LC)		0.10′ RHMA-O 0.20′ RHMA-G 0.50′ HMA GPI or RPI 0.10′ HMA (LC)
	TI 12 - 15	0.10′ HMA-O or RHMA-O 0.20′ HMA (PM) 0.35′ HMA GPI or RPI 0.10′ HMA (LC)		0.10′ RHMA-O 0.20′ RHMA-G 0.35′ HMA GPI or RPI 0.10′ HMA (LC)

NOTE:

(1) If the existing rigid pavement is not cracked and seated, add minimum of 0.10 foot HMA over the GPI layer.

Legend:

HMA = Hot Mix Asphalt
HMA (LC) = Hot Mix Asphalt Leveling Course
HMA (PM) = Hot Mix Asphalt Modified Binder
RHMA-G = Rubberized Hot Mix Asphalt (Gap Graded)
GPI = Geosynthetic Pavement Interlayer
RPI = Rubberized Pavement Interlayer

listed in Chapter 610. The Materials Report should discuss any historical problems observed in the performance of rigid pavement constructed with aggregates found near the proposed project and subjected to similar physical and environmental conditions.

(5) *Smoothness.* For rehabilitation projects, restore the ride quality to the IRI specified on the concrete pavement specifications. Additional information on smoothness can be found on the pavement smoothness page on the Department Pavement website.

Topic 626 – Other Considerations

626.1 Traveled Way

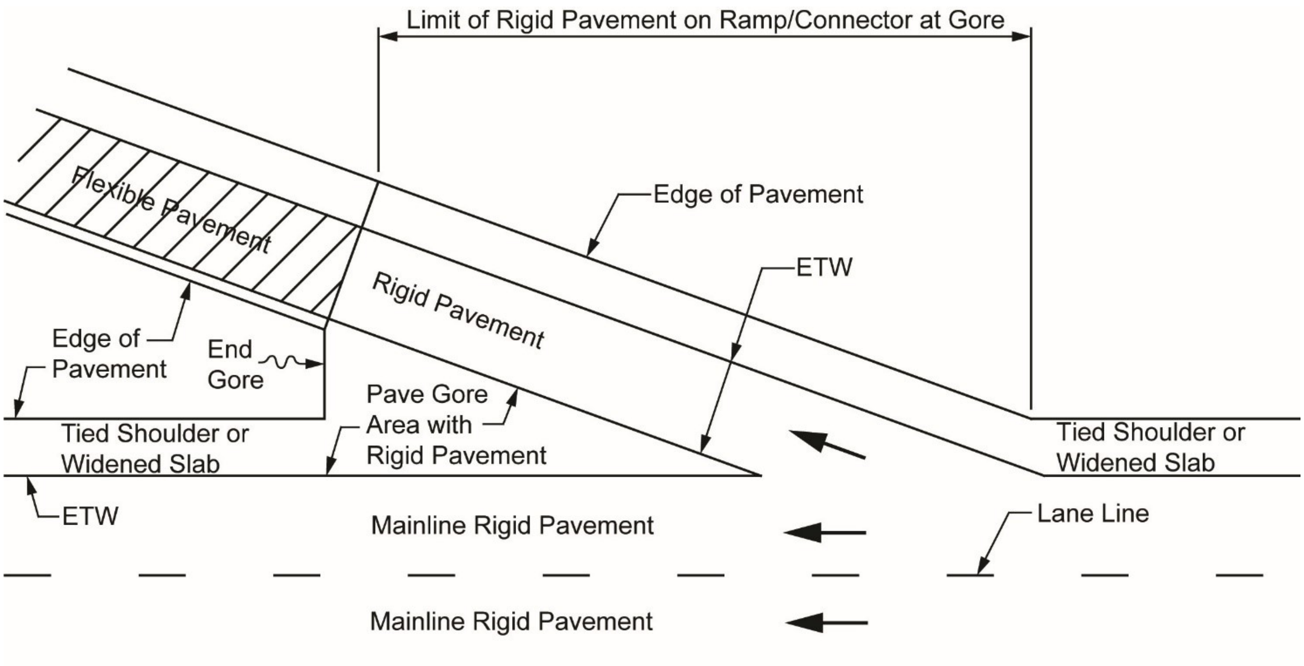
(1) *Mainline.* No additional considerations.

(2) *Ramps and Connectors.* If tied rigid shoulders or widened slabs are used on the mainline, then the ramp or connector gore area (including ramp traveled way adjacent to the gore area) should also be constructed with rigid pavement (see Figure 626.1). This will minimize deterioration of the joint between the flexible and rigid pavement. When the ramp or connector traveled way is rigid pavement, utilize the same base and thickness for the gore area as that to be used under the ramp shoulders, especially when concrete shoulders are utilized on the mainline. Note that in order to optimize constructability, any concrete pavement structure used for mainline concrete shoulders should still be perpetuated through the gore area. If the base is Treated Permeable Base (TPB) under the ramp's traveled way and shoulder, TPB should still be utilized in the ramp gore areas as well.

(3) *Ramp Termini.* Rigid pavement is sometimes placed at ramp termini instead of flexible pavement where there is projected heavy truck traffic (as defined in Index 613.5(1)(c)) to preclude pavement failure such as rutting or shoving from vehicular braking, turning movements, and oil dripping from vehicles. Once a design TI is selected for the ramp in accordance with Index 613.5, follow the requirements in Index 623.1 to engineer the rigid pavement structure for the ramp termini. The length of rigid pavement to be placed at the termini will depend on the geometric alignment of the ramp, ramp grades, and the length of queues of stopped traffic. The rigid pavement should extend to the first set of signal loops on signalized intersections. A length of 150 feet should be considered the minimum on unsignalized intersections. Special care should be taken to assure skid resistance in conformance with current standard specifications in the braking area, especially where oil drippage is concentrated. End anchors or transitions should be used at flexible/rigid pavement joints. The Department Pavement website has additional information and training for engineering pavement for intersections and rigid ramp termini.

Figure 626.1

Preferred Limits of Rigid Pavement at Flexible Pavement Ramp or Connector Gore Area



NOTES:

(1) Not all details shown.

(2) Off ramp shown. Same conditions apply for on ramps.

626.2 Shoulder

The types of shoulders that are used for rigid pavements can be categorized into the following three types:

(1) Tied Concrete Shoulders. These are shoulders that are built with rigid pavement that are tied to the adjacent lane with tie bars. These shoulders provide lateral support to the adjacent lane, which improves the long-term performance of the adjacent lane, reducing the need for maintenance or repair of the lane. To obtain the maximum benefit, these shoulders should be built monolithically with the adjacent lane (i.e., no construction joints). This will create aggregate interlock between the lane and shoulder, which provides increased lateral support.

The pavement structure for the tied rigid shoulder should match the pavement structure of the adjacent traffic lane at the edge of traveled way. Special delineation of concrete shoulders may be required to deter the use of the shoulder as a traveled lane. District Traffic Operations should be consulted to determine the potential need for anything more than the standard edge stripe.

The locations to use tied concrete shoulders is discussed under Selection Criteria of this Index. Tied concrete shoulders are also the most adaptable to future widening and conversion to a lane. Where there is an identified documented plan (such as Regional Transportation Plan, Metropolitan Transportation Plan and Interregional Transportation

Plan) to convert the shoulder into a traffic lane within the next 20 years, the shoulder may be built to the same geometric and pavement standards as the lane. See Index 613.5(2) for criteria and requirements.

(2) *Widened Slab.* Widened slabs involve constructing the concrete panel for the lane adjacent to the shoulder 14-feet wide on the outside and 13-feet wide on the inside in lieu of the prescribed lane width. The additional width becomes part of the shoulder width and provides lateral support to the adjacent lane. Widened slabs are most useful in areas where lateral support is desired but future widening is not anticipated.

(3) *Untied Shoulders.* Untied shoulders are shoulders that are not tied to the adjacent lane and do not provide lateral support to the adjacent lane. All new construction, reconstruction and rehabilitation shall not have untied shoulders unless a widened lane is constructed.

(4) *Selection Criteria.* Shoulders should be constructed of the same material as the traveled way pavement (in order to facilitate construction, improve pavement performance, and reduce maintenance cost). Shoulders adjacent to rigid pavement traffic lanes can be rigid with the following conditions:

(a) Tied concrete shoulders shall be used for:

- **rigid pavements constructed in the High Mountain and High Desert climate regions (see climate map in Topic 615).**
- **paved buffers between rigid High-Occupancy Vehicle (HOV) lanes and rigid mixed flow lanes. Same for High-Occupancy Toll (HOT) lanes.**
- **rigid ramps to and from truck inspection stations.**

(b) Either tied concrete shoulders or widened slabs shall be used for:

- **continuously reinforced concrete pavement.**
- **horizontal radii 300 feet or less.**
- **truck and bus only lanes.**
- **desert climate regions. Where widened slabs are used, the remaining shoulder width shall also be concrete pavement.**

Where tied concrete shoulders or widened slabs are used, they shall continue through ramp and gore areas (see Figure 626.2A). Paving the gore area and adjacent ramp with concrete is preferred (see Figure 626.1).

The shoulder pavement structure selected must meet or exceed the pavement design life standards in Topic 612 and meet requirements for shoulders in Index 613.5(2). Table 626.2 and Figure 626.2B show rigid pavement shoulder design thicknesses for widened slabs and untied shoulders which meet these requirements. For untied concrete shoulders and portions of shoulders built within widened lane, use the thicknesses in Table 626.2.

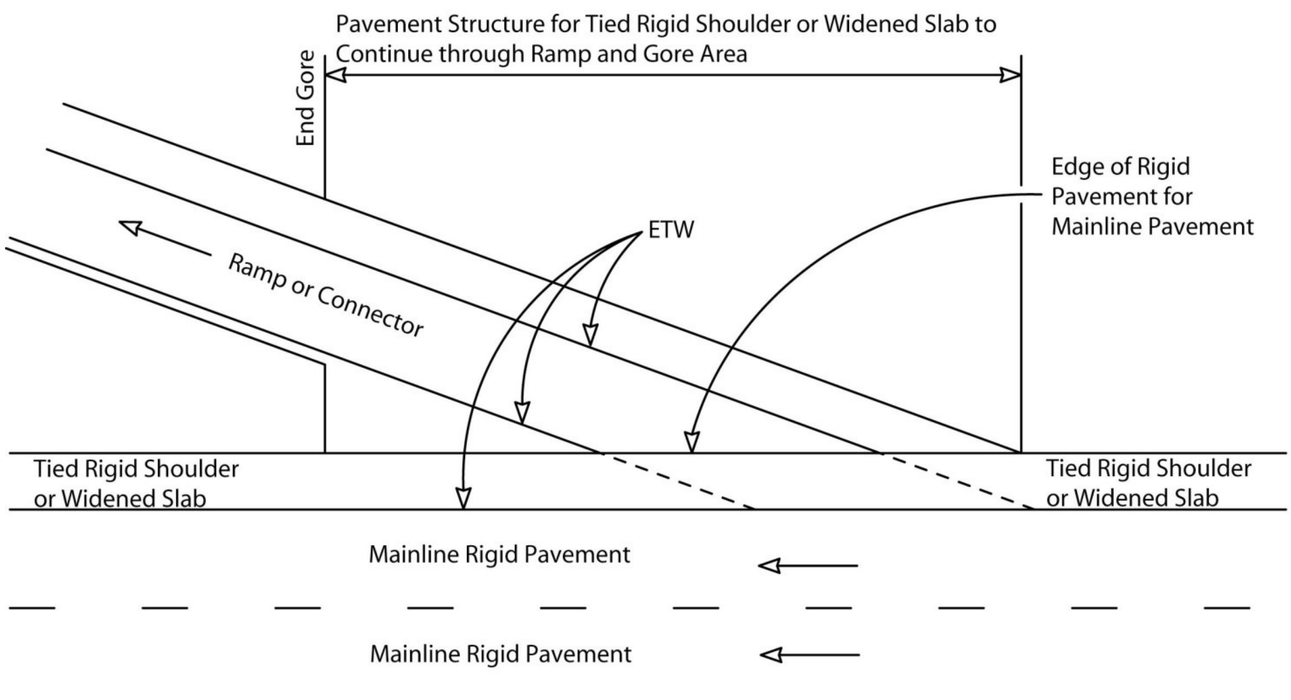
Table 626.2

Shoulder Concrete Pavement Designs ("S" Dimension)

Climate Region	S (Based on TI ≤ 9, unsupported edge)
North Coast	0.70
South Coast / Central Coast	0.75
Inland Valley	0.80
Desert	0.80
Low Mountain / South Mountain	0.75
High Mountain / High Desert	0.90

Figure 626.2A

Rigid Shoulders Through Ramp and Gore Areas

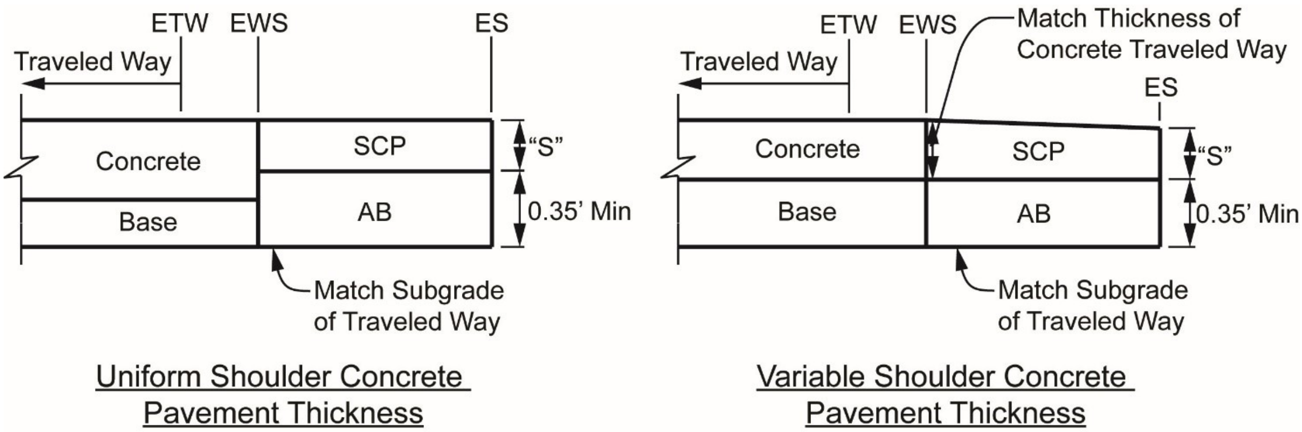


NOTES:

(1) Not all details shown.
(2) Off ramp shown. Same conditions apply for on ramps.

Figure 626.2B

Widened Slab Shoulder with Concrete Remainder Designs



NOTES:

No Scale
"S" = Shoulder Concrete Pavement thickness dimension
SCP = Shoulder Concrete Pavement
AB = Aggregate Base
TI = Traffic Index
ETW = Edge of traveled way
EWS = Edge of widened slab
ES = Edge of shoulder

626.3 Intersections

Standard joint spacing patterns found in the Standard Plans do not apply to intersections. Special paving details for intersections need to be included in the project plans. Special consideration needs to be given to the following features when engineering a rigid pavement intersection:

- Intersection limits.
- Joint types and joint spacing.
- Joint patterns.
- Slab dimensions.
- Pavement joints at utilities.
- Dowel bar and tie bar placement.

Additional information and training is available on the Department Pavement website.

626.4 Roadside Facilities

(1) *Safety Roadside Rest Areas and Vista Points.* If rigid pavement is selected for some site-specific reason(s), the pavement structures used should be sufficient to handle projected loads at most roadside facilities. To select the pavement structure, determine the Traffic Index either from traffic studies and projections developed for the project or the values

found in Table 613.5B, whichever is greater. Then select the appropriate pavement structure from the catalog in Index 623.1. Treated bases such as lean concrete base and hot mix asphalt base should not be used for Traffic Indices less than 12.

Joint spacing patterns found in the Standard Plans do not apply to parking areas. Joint patterns should be engineered as square as possible. Relative slab dimensions should be approximately 1:1 to 1:1.25, transverse-to-longitudinal. Transverse and longitudinal joints should be perpendicular to each other. Joints should be doweled in two directions. Special attention should be given to joint patterns around utility covers and manholes.

Use guidelines for intersections in Index 626.3 for further information.

(2) *Bicycle Facilities.* For bicycle facilities independent of the vehicular roadway use local standards where available and where local agencies will be maintaining the facility. Otherwise, for stand-alone bike paths, use the following thicknesses:

- 0.35 foot minor concrete and 0.50 foot aggregate base for bike paths not available to maintenance vehicles, or
- 0.50 foot minor concrete and 0.50 foot aggregate base for bike paths accessible to maintenance vehicles.

Place longitudinal joints at centerline for 2-way bikeways and no more than 8 feet for one way bikeways. Transverse joints should be placed such that the transverse slab dimension relative to longitudinal dimension is between 1:1 and 1:1.25. Construction is similar to sidewalks or pathways so dowel bars and tie bars should not be used.

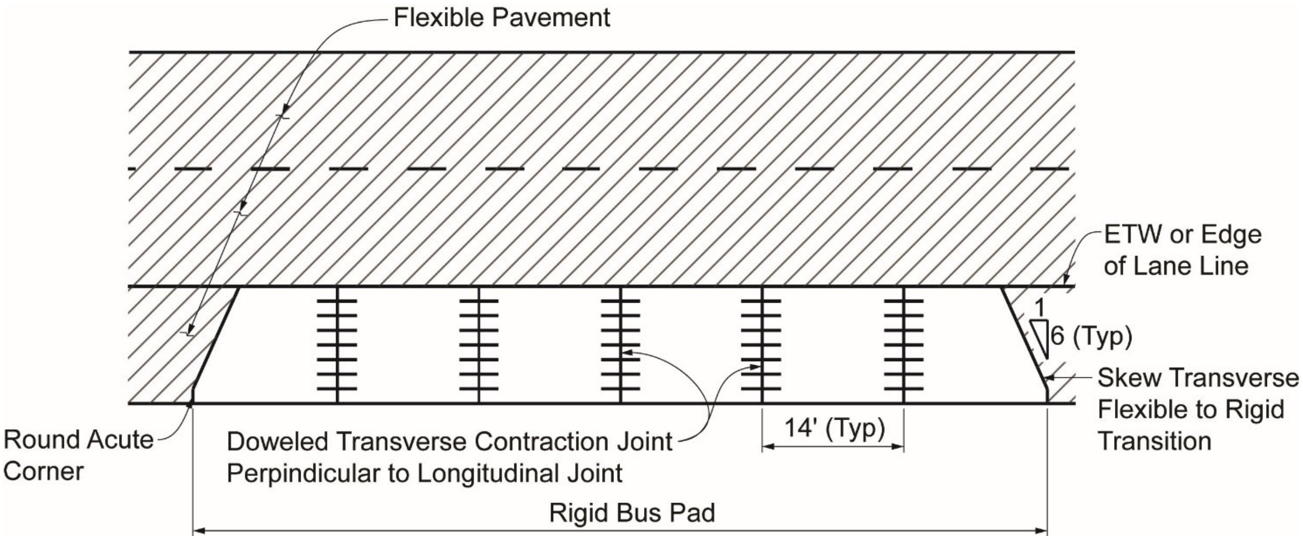
(3) *Bus Pads.* Bus pads are subjected to similar stresses as intersections; however, it is not practical to engineer rigid bus pads according to the Traffic Index, or according to bus counts. The minimum pavement structure for bus pads should be 0.85 foot JPCP with dowel bars at transverse joints on top of 0.5 foot lean aggregate subbase. Type III soil should be treated in accordance with Index 614.4. Where local standards are more conservative than the pavement structures mentioned above, local standards should govern.

Relative slab dimensions for bus pads should be approximately 1:1 to 1:1.25, transverse-to-longitudinal. The width of the bus pad should be no less than the width of the bus plus 4 feet. If the bus pad extends into the traveled way, the rigid bus pad should extend for the full width of the lane occupied by buses. The minimum length of the bus pad should be 1.5 times the length of the bus(es) that will use the pad at any given time. This will provide some leeway for variations in where the bus stops. Additional length of rigid pavement should be considered for approaches and departures from the bus pad since these locations may be subjected to the same stresses from buses as the pad. A 115-foot length of bus pad (which is approximately 250 percent to 300 percent times the length of typical 40-foot buses) should provide sufficient length for bus approach and departure. The decision whether to use rigid pavement for bus approach and departure to/from bus pads is the responsibility of the District.

A JPCP end anchor is not required, but may improve long-term performance at the flexible-to-rigid pavement transition. Doweled transverse joints should be perpendicular to the longitudinal joint at maximum 14 feet spacing, but consider skewing (at 1:6 typical) entrance/exit transverse flexible-to-rigid transitions, note that since acute corners can fail prematurely, acute corners should be reinforced or rounded (see Figure 626.4). Special care should be taken to assure skid resistance in conformance with current Standard Specifications in the braking area, especially where oil drippage is concentrated.

Figure 626.4

Rigid Bus Pad



NOTES:

(1) Not all details shown.

CHAPTER 900 – LANDSCAPE ARCHITECTURE – ROADSIDES

Topic 901 – Landscape Architecture General

Index 901.1 – Landscape Architecture Program

The Landscape Architecture Program is responsible for the development of policies, programs, procedures, standards, and guidance for all aspects of the California Highway System Roadside Program including planting, irrigation, permanent erosion control, mainstreet livability, structure aesthetics, roadside safety features, and landform grading.

The Landscape Architecture Program also serves as the coordinator for Safety Roadside Rest Areas, Vista Points, Scenic Highways, Classified Landscaped Freeways, Blue Star Memorial Highways and Landscape Administration Facilities such as Transportation Art, Gateway Monuments, and Community Identification.

Guidance in the Chapter 900 series is the responsibility of the Landscape Architecture Program and represents minimum standards.

901.2 Landscape Architecture Design Standards

Design roadsides to maximize sustainability and livability benefits through context-sensitive design solutions. Sustainable design solutions are those that consider balanced and long-term benefits to social, economic, and ecological well-being.

Sustainable landscape architecture designs:

- improve safety for workers and travelers
- improve the quality of the public realm
- conserve water and natural resources
- sequester carbon and improve ecosystem resiliency
- address fire safety
- preserve or improve visual quality and aesthetics
- reduce unnecessary maintenance activities
- employ cost-effective solutions
- consider life-cycle costs and benefits.

Attention should be given to the following considerations:

(1) *Worker Safety.* Design roadsides for the safety of highway workers and the public by considering the following:

  - Site new roadside features outside of the clear recovery zone and away from gore areas and driver decision points.

- Provide access for workers including maintenance vehicle pullouts, maintenance access roads and gates.
- Design solutions that facilitate the use of mechanical equipment to reduce worker activities on foot including the use of new technology.
- Select design solutions that eliminate maintenance activities.
- Relocate existing roadside elements to accessible areas outside the clear recovery zone or to protected locations.

Incorporate the above design considerations when designing roadsides. For example, provide access gates from local streets and frontage roads for maintenance personnel; coordinate with District Maintenance managers for preferred access points. Provide paved maintenance vehicle pullout areas away from traffic on high-volume highways where access cannot be made from local streets and roads. Consider providing maintenance access roads to the center of loop areas or other open, flat areas. Pave narrow areas and areas beyond freeway gore entrances and exits to reduce the need for maintenance. See Index 504.2(2) for contrasting surface treatment guidance.

(2) *Maintainability.* Field observations with maintenance personnel should be performed during project development, Pre-PID through PS&E. Ongoing communication between designers, landscape specialists, landscape maintenance personnel, and construction inspectors will ensure that maintenance concerns are addressed.

Design roadsides to minimize routine and ongoing roadside maintenance and to accommodate:

- graffiti control and removal.
- homeless encampment removal.
- mowing and weeding.
- litter, debris, and/or dead vegetation removal.
- exotic or "volunteer" vegetation control.
- pesticide and/or fertilizer application.
- pruning or removal of vegetation.
- irrigation and waterline break repair.
- irrigation scheduling for water budgeting.
- replacement of plants and repairs to inert materials.
- maintenance requirements of permanent stormwater pollution prevention treatment BMPs.

(3) *Livability.* Livability describes the degree to which the built environment improves human quality of life. Designs that improve livability are those that consider how the public realm and roadside can support travel and local community goals. Livable transportation systems connect people to opportunity and promote public health and safety, ecological quality, economic development, community vitality, social equity and interaction, multimodal travel, sense of place, and human health.

Create a state highway public realm through designs that improve community visual quality, provide inviting public spaces, and encourage active transportation. Encourage and support Landscape Architecture Administered Facilities such as Transportation Art, Gateway

In areas subject to frost and snow, plantings should not be located where they will cast shade and create patches of ice on vehicle and pedestrian thoroughfares.

Without exception, locate plants to maintain visibility to legal off-premise and on-premise outdoor advertising displays. Typical visibility viewsheds are as shown in the Encroachment Permits Manual 509.4.

(1) Maintenance Considerations. Consider the safety of maintenance workers and the traveling public when locating plants. Evaluate the mature size, form, and characteristics of the species, and long-term maintenance requirements.

Locate plants so that pruning will not be required.

Groundcover should be located so it will not extend onto shoulder backing, into drainage channels, or through fencing.

Minimize worker exposure to traffic and reduce the need for shoulder or lane closures. Locate vegetation away from shoulder, gore, 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.

Refer to the Maintenance Manual and Roadside Vegetation Management Handbook for additional considerations.

904.5 Locating Trees

Trees must be located to not visually restrict existing roadside signs and signals.

Locate trees to maintain a minimum vertical clearance of 17 feet from the pavement to the lower foliage of overhanging branches over the traveled way and shoulder. Locate trees to maintain a minimum vertical clearance of 8 feet from sidewalks or walkways to the lower foliage of overhanging branches for pedestrian passage.

For sidewalks and pedestrian plazas, design tree wells with a minimum of 2 feet from the tree trunk to the edge of the tree well to protect pavement from tree root displacement. Include root barriers to protect the pavement surrounding the tree well. Allow for an appropriate soil volume when designing tree wells.

Without exception, do not plant large trees over gas lines or under overhead utilities and/or structures. Coordinate with local utility provider or District Utility Engineering for guidance.

(1) Large Trees. Large trees are defined as plants which at maturity have trunks 4 inches or greater in diameter, measured 4 feet above the ground. Examples of large tree species are Coast Redwood (*Sequoia sempervirens*), Coast Live Oak (*Quercus agrifolia*), and Deodar Cedar (*Cedrus deodara*).

(2) Small trees. Small trees are defined as smaller trees or plants usually considered shrubs but trained in tree form that will develop up to a 4-inch diameter trunk at maturity. Examples of small trees are Crape Myrtle (*Lagerstroemia indica*), and Bottlebrush (*Callistemon sp.*) trained in standard form.

(3) Clear Recovery Zone (CRZ). Locate trees to be outside the CRZ. The CRZ provides an area for errant vehicles the opportunity to regain control. Refer to Index 309.1(2) for additional information and requirements of the CRZ.

Setbacks are measured from the edge of traveled way to the face of tree trunk. Situate trees to accommodate the anticipated mature tree size.

(a) Freeways and Expressways. On freeways and expressways, including interchange areas, there should be 40 feet or more of clearance between the edge of traveled way and large trees; but, a minimum clearance of 30 feet must be provided where trees may become a fixed object to errant vehicles. However, large trees may be planted within the 30-foot limit if they cannot be reached by an errant vehicle. For example, on cut slopes above a retaining wall, in areas shielded behind concrete barriers, metal beam guardrail, thrie beam, etc. which has been placed for reasons other than tree planting. Additionally, exceptions to the 30-foot setback may also be considered on cut slopes which are 2:1 or steeper The minimum tree setback in these cases should be 25 feet from the edge of traveled way.

Special considerations should be given to providing additional clearance in potential recovery areas. Setback distances greater than 30 feet should be provided at locations such as on the outside of horizontal curves and near ramp gores.

Large trees should not be planted in unprotected areas of freeway medians or expressway medians except for separated roadways with medians of sufficient width to meet the plant setback requirements for tree planting.

Where freeway or expressway right of way intersects a conventional highway or local facility, follow conventional highway requirements for large tree placement.

(b) Conventional Highways. When locating large trees on conventional highways comply with the requirements in Table 904.5.

904.6 Locating Plants in Conformance with Sight Distances

Sight distance requirements restrict the height of plants or the horizontal distance of plants from the traveled way. Low growing plants may be planted if the requirements for sight distance are met as discussed in Topic 201 – Sight Distance. Refer to Index 405.1(2) for corner sight distance requirements at intersections and driveways. Locate plants to maintain sight distance.

Sight distance limits are measured from the edge of traveled way to the outside edge of the mature growth. Locate plants to meet sight distance requirements when the plant reaches mature size. Preserve views of pedestrians and bicyclists at intersections and other conflict points.

Proposed mature planting should maintain sight distance required by the design speed of the facility, including planting along geometric curvature for horizontal sight distance. In cases where, due to geometric restrictions, the existing freeway facility does not provide optimum sight distance, no further reduction should be caused by planting.

When locating plantings at interchanges, provide ramp and collector-distributor road sight distance equal to or greater than that required by the design speed criteria. At points within an interchange area where ramp connections or channelization are provided, keep plantings clear of the shoulders and sight line shown in Figure 504.3I, Location of Ramp Intersections on the Crossroads.

Ensure clear recovery and sight distances are retained for vehicles, bicycles and pedestrians on the inside of curves in interchange loops, in median areas, on the ends of ramps, and on cut slopes. Generally, in interchange areas, a 50-foot horizontal clearance from the edge of traveled way, within the loops, is considered the sight distance plant setback for plants that grow above a 2-foot height.

environment. This period is used for identification and resolution of problems, and to minimize long-term maintenance requirements.

When planting is installed as a separate contract provide a three-year plant establishment period. When planting is installed as part of a highway construction project provide a one-year plant establishment period.

Projects with less than 5,000 square feet of planting or irrigation should have a plant establishment period of at least six months.

Mitigation planting may require longer plant establishment periods. Refer to specific permit requirements.

Topic 905 – Irrigation Design

905.1 Irrigation Design General

Irrigation systems should be designed to conserve water, minimize maintenance, minimize worker exposure to traffic, and sustain the planting. The design should be simple and efficient.

Irrigation systems that use recycled, non-potable, or untreated water must comply with State and local regulations.

Permanent irrigation systems are to be designed for automatic operation.

Review the entire irrigation design with the District Water Manager, District Landscape Specialist, and Maintenance Landscape Supervisor.

905.2 Water Supply

Use recycled or non-potable water for permanent irrigation systems. Designers should be familiar with the provisions of the California Streets and Highways Code, Section 92.3.

When the irrigation system is being installed as part of a separate contract install the water supply connection with the parent highway construction project.

Temporary irrigation systems may use potable water.

Coordinate water connections with the local water purveyor, follow water purveyor requirements for MWELO requirements, water meters, and cross contamination requirements.

905.3 Irrigation Conduit

Irrigation conduits should be provided on highway construction projects under new roadways and ramps, and on new bridge structures when future irrigated planting is anticipated. Extend existing conduits, as needed, on highway construction projects when widening or modifying roadways and ramps or modifying bridge structures.

Irrigation conduit consists of a conduit with a water supply line and sprinkler control conduit with a pull tape.

Coordinate with the District Landscape Architect to determine irrigation conduit needs, sizes, and locations.

(1) *Conventional Highways, Freeways, and Expressways.* Consider the following when sizing and locating irrigation conduits under roadways or ramps:

- Irrigation conduit consists of a minimum size of 8-inch diameter conduit, with a 3-inch water supply line and a 2-inch diameter sprinkler control conduit with pull tape. Consider sizing conduits and water supply lines larger when using nonpotable water.
- Irrigation conduits are typically spaced 1,000 feet apart on freeways. Consider using undercrossings for alternative crossing opportunities.
- Keep drainage facilities and irrigation conduit separate.

(2) *Bridge Structures.* Coordinate with Structures for location and placement of irrigation conduit in new bridge structures.

Consider the following when designing irrigation conduits for bridge structures:

- Generally, locate the irrigation conduit on the side of the bridge closest to the water source.
- Consider the maximum water demand and number or irrigation controller stations. The water supply line should be a minimum 3-inch diameter and conduit for the sprinkler control conduit should be a minimum 2-inch diameter and contain a pull wire.
- Ductile iron pipe is required for potable water supply line for pipes 4-inch diameter or larger because of its superior strength and flexible joints.

905.4 Irrigation System Equipment

Use standard, commercially available irrigation components. Nonstandard features may be used to address unique site conditions.

Select “smart” irrigation equipment and controllers to minimize worker exposure and conserve water.

Consider security measures, such as locking cabinets, enclosures and valve boxes.

When selecting irrigation components, consider water quality, such as sediment, salinity, and increased particulate content often found in recycled, and non-potable water sources. Include an appropriate filtration system when the recycled water quality contains undesirable suspended particles.

Place irrigation components that require regular maintenance as far from traffic as possible, outside the clear recovery zone, or behind safety devices. Place irrigation components in areas easily accessible by maintenance forces.

Consider potential damage from pedestrians or vehicles when locating irrigation equipment. Minimize exposure to traffic and reduce the need for shoulder or lane closures, irrigation equipment must be located far away from shoulder areas, gore areas, driver decision points, and narrow island areas between ramps and the traveled way.

Review the proposed location of backflow preventers and irrigation controllers in the field with the District Maintenance Supervisor and the District Water Manager.

(1) *Backflow Preventer Assembly.* The use of a reduced pressure principle backflow device is required for permanent irrigation systems using potable water. Include an enclosure with backflow preventer assemblies.

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