CHAPTER 620 – RIGID PAVEMENT

Topic 621 – Types of Rigid Pavements

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 2 to 7-foot intervals (see Figure 621.1). The continuous reinforcement in the pavement holds the cracks tightly together.

CRCP may be used in new construction, reconstruction, and rehabilitation as concrete overlays, lane replacement and widening, in all climate regions except High Mountain and High Desert. 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).

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). The initial cost of constructing JPCP is typically less than CRCP but CRCP can be more cost effective over the life of the pavement. JPCP is recommended for all truck routes, ramps, urban streets, pavements in High Mountain and High Desert climate regions and in other regions where there is not sufficient space or time to construct CRCP.

When JPCP is placed as a Concrete Overlay over Asphalt (COA) and the truck volume is low to medium (typically AADTT below 1000), the thickness of the concrete slabs can be thin (0.35 to 0.60 ft) and therefore need to be short (less than 8 ft). This special design will be called Short JPCP-COA or SJPCP-COA. The recommended slab length is 6 ft while the slab width should be 6 ft but the slab in the outer half-lane can be up to 8 ft to provide a widened lane with 1 to 2 ft into the shoulder.

Typically, SJPCP-COA technique requires partial-depth milling of the existing pavement surface to remove surface defects and enhance the adhesion potential of the asphalt. Other reasons for milling include matching geometric requirements such as bridge clearances and providing an even surface to achieve a uniform concrete overlay thickness if payment for concrete overrun is not the selected option.

A minimum of 0.25 ft of sound asphalt (in fair to good condition) is recommended before placing the concrete overlay. When the asphalt that remains after the milling operation is less than 0.25 ft or it is in poor condition, approval from the Caltrans Office of Concrete Pavements is required, unless one of the two following options are adopted:

- Add an asphalt overlay, 0.10 to 0.25 ft thick, on top of the existing asphalt surface, milled or not. The thickness of the asphalt overlay plus the remaining sound asphalt must be at least 0.25 ft. Either HMA Type A or RHMA-G can be used for constructing this overlay.
- Cold recycling (CR) of the existing asphalt pavement by using full-depth recycling with foamed asphalt (FDR-FA) or partial-depth recycling with emulsified or foamed asphalt (PDR-EA or PDR-FA). The performance of SJPCP-COA with a CR base has not been verified yet. Consequently, the implementation of this rehabilitation alternative with CR base also requires approval from the Caltrans Office of Concrete Pavements and should be closely monitored.

621.3 Precast Concrete Pavement (PCP)

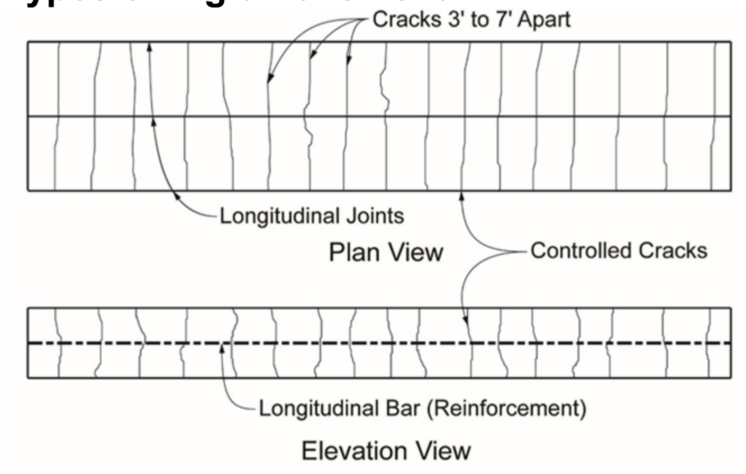
PCP uses panels that are precast off-site instead of cast in-place, which is the primary difference between PCP and JPCP. Figure 621.1 does not show PCP because after installing the panels the section views of PCP are same as JPCP. The precast panels are linked together with dowel bars and should have 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.

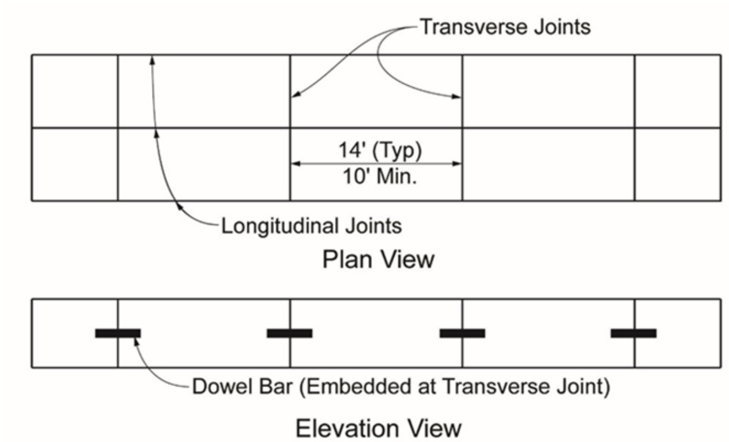
The primary disadvantage of PCP is the high cost of fabrication, transportation and installation. PCP also needs a leveling system at the base underneath the precast panels during construction to even out the loads on the slab and avoid uneven deflections or stresses that could lead to faulting, slab 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

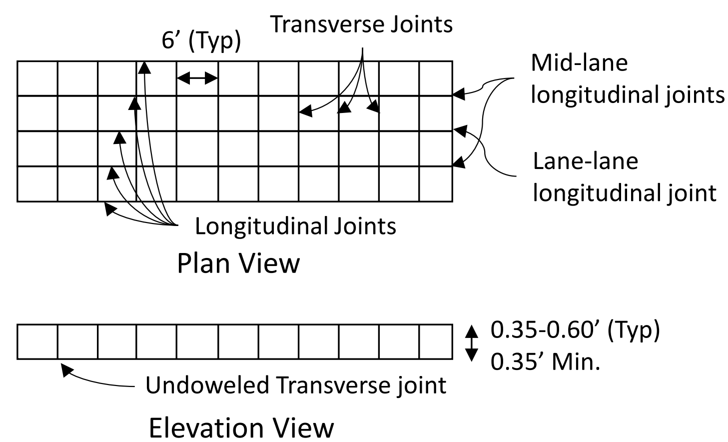
Types of Rigid Pavement



Continuously Reinforced Conrete Pavement (CRCP)



Jointed Plain Concrete Pavement (JPCP)



Short JPCP - Concrete Overlay over Asphalt (SJPCP-COA)

Topic 622 – Engineering Requirements

622.1 Engineering Properties

Various types of Portland cement are used with Type II with Type II/V being most common. Type 1L gaining quickly. 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 catalog found in this chapter are presented in Table 622.2. The design catalog is 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 conventional Portland cement concrete pavement to be opened to traffic as early as 3 days and strength 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 the Rigid Pavement Design Catalog

Property	Values
Unit weight	147 lb/ft^3
Poisson's ratio	0.20
Coefficient of thermal expansion	4.8×10^{-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 shortwave absorptivity	0.85
Cement type	Type II Portland cement
Cementitious material content	24 lb/ft^3 (600 lb/yd^3)
Water to cementitious material ratio	0.42
Curing method	Curing compound
PCC zero-stress temperature (internally calculated)	105 °F
Ultimate shrinkage (internally calculated)	646 microstrains
Reversible shrinkage (% of ultimate shrinkage)	50%
Time to develop ultimate shrinkage	35 days
Modulus of rupture or flexural strength (28 days)	637 psi

Table 622.2

Concrete Pavement Performance Factors

Factor	Value
General	
Design Life	Determined per Topic 612 (40 years for JPCP and CRCP; 20 years for SJPCP-COA)
Reliability	95%
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	0.15 inch max
SJPCP-COA only	
Longitudinal cracking at end of design life	10% of slabs 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 is typically 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 by minimizing distortion of asphalt at the joint. It can also be used as a transition between structure approach slabs and asphalt pavement.

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 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 622.5 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:

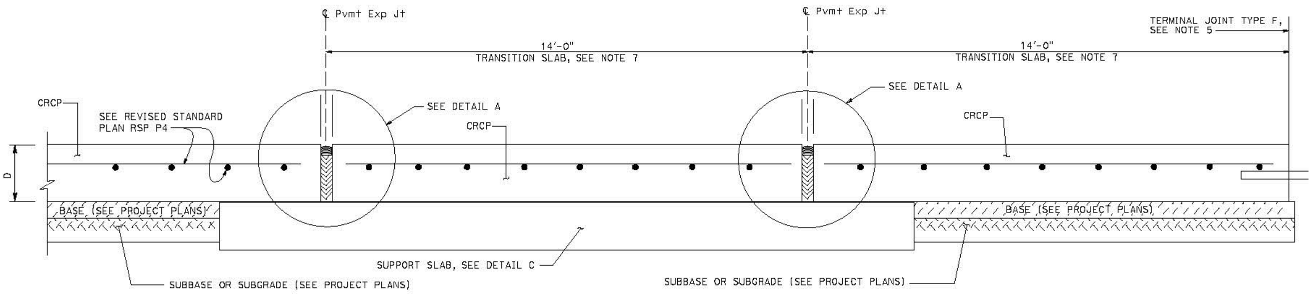
(a) Terminal Joints – Terminal joints are used in CRCP to transition to another pavement type or to a structure approach slab. It is found at the beginning and end of all CRCP. Its function is to isolate CRCP and adjacent pavement types or approach slab to prevent damage and faulting at the transverse 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 622.5)

Figure 622.5

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, except SJPCP-COA.
- Transverse joints in JPCP in all desert and mountain climate regions, except SJPCP-COA.

(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. *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 joints in JPCP, except for SJPCP-COA.
- All transverse construction joints.
- 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. Grinding on new pavement may be required to achieve smoothness requirements.

622.10 Pavement Smoothness

Pavement smoothness, which is also referred to as ride quality, is an important surface characteristic. Smoother pavements provide the following benefits:

- Improved ride quality.
- Extended pavement life.
- Reduced highway travel user costs, such as fuel usage and vehicle maintenance costs.
- Lower pavement maintenance costs and fewer 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 meet an IRI target. For additional information, see the pavement smoothness page on the Department Pavement website.

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

Topic 623 includes the procedure for determining the minimum concrete pavement thicknesses of the traveled way for new construction, widening, reconstruction and overlay projects. New Construction involves a design with a new alignment. Widening involves the construction of additional lanes to improve traffic flow and increase capacity on an existing highway. Reconstruction is the replacement of the entire existing pavement structure by an equivalent or increased new pavement structure along an existing alignment. Overlay is when a concrete pavement is placed directly on an existing pavement like SJPCP-COA. Refer to Topic 603 for more details about types of pavement projects.

For pavement structures at locations other than the traveled way, such as shoulders and parking lots, see Topic 626.

623.1 Catalog

The Caltrans Rigid Pavement Design Catalog is based on a comprehensive database created from runs of version 2.5.5 of the AASHTOWare Pavement Mechanistic-Empirical Design (PMED) software covering different combinations of concrete pavement types, local design factors, and design features expected in the Caltrans road network.

The rigid pavement design is based on the following factors:

- Pavement type (JPCP, CRCP, or SJPCP-COA).
- Performance factors (Table 622.2):
    - Distress type and limit, specific to each type of pavement.
    - Design life, specific to each type of pavement.
    - Design reliability, fixed to 95% for Caltrans pavement design.
- Local design factors:

- Climate region. Caltrans considers nine climate regions for pavement design and management: North Coast (NC), Central Coast (CC), South Coast (SC), Low Mountain (LM), High Mountain (HM), South Mountain (SM), Inland Valley (IV), Desert (DE), and High Desert (HD). Climate is discussed in Topic 615.
- Traffic characteristics:
  - Initial AADTT of the design lane. This value results from applying directional and lane distribution factors to the two-way AADTT.
  - WIM spectra. Caltrans considers five different truck traffic groups for pavement design and management: WIM-1, WIM-2, WIM-3, WIM-4, and WIM-5. The five WIM spectra span the truck traffic characteristics that exist on the Caltrans road network, with WIM-1 being the lightest and WIM-5 being the heaviest.
  - Traffic linear growth rate (AADTT equivalent linear yearly growth). This factor is fixed to 3% when using the collection of Tables 623.1A through 623.1F.
  - Refer to Topic 613 for more details about traffic considerations.
- Subgrade soil. Soil types for existing subgrade shall be classified according to the Unified Soil Classification System (USCS). If more than one soil type are present in the subgrade, then the user should choose the more conservative design based on the less stable soil. Subgrade is discussed in Topic 614.

- Pavement design features:
  - Base type, with options specific to each type of pavement.
  - Base thickness, user-input only for SJPCP-COA.
  - Subbase type, user-input only for SJPCP-COA.
  - Shoulder type, with options specific to each type of pavement.

The JPCP thickness reported by the Rigid Pavement Design Catalog is exclusively based on slab transverse cracking. The sections included in the following tables have been verified for faulting and IRI.

The CRCP thickness reported by the Rigid Pavement Design Catalog is not based on the *PMED* CRCP punchout model. Instead, it is based on the corresponding JPCP thickness for the same performance factors, local design factors, and design features, assuming 10 punchouts per mile is equivalent to 10% transverse cracking. The CRCP design assumes 0.7% longitudinal steel reinforcement following Caltrans Standard Plan P4 (2019 revision).

The SJPCP-COA thickness reported by the Rigid Pavement Design Catalog is exclusively based on slab longitudinal cracking. *PMED* does not model SJPCP-COA faulting and IRI.

In addition to the concrete properties shown in Table 622.1 and the performance factors shown in Table 622.2, the Rigid Pavement Design Catalog is based on a number of *PMED* modeling assumptions. The assumptions are summarized in Tables 623.1A and 623.1B for JPCP and SJPCP-COA designs, respectively.

Table 623.1A

Assumptions Adopted in *PMED* for JPCP Design

Factor	Value (1)
Transverse joint spacing	14 ft
Slab-base bonding	Debonded
Lane-shoulder load transfer efficiency	Function of shoulder type: • Untied concrete: 0% • Tied concrete: 50%
Widened slab width	14 ft
Permanent curl/warp	-10°F
Cracking calibration coefficients (2)	C4 = 0.52; C5 = -2.17
Cracking reliability, standard error formula (2)	3.5522 * Cracking(%)^0.3415 + 0.75
Provision for grinding (3)	0.06 ft
Minimum slab thickness	0.65 ft
Transverse joints	Doweled
Dowels diameter (ϕ) (4)	Function of slab thickness (Caltrans Standard Plan P10): • ≤0.65 ft thickness: ϕ = 1 in. • 0.70-0.85 ft thickness: ϕ = 1.25 in. • ≥0.90 ft thickness: ϕ = 1.5 in.
Initial IRI	Function of project type: • New or reconstruction: 67.5 in./mile • Widening or lane replacement: 75 in./mile
Hot mix asphalt base	*PMED* default asphalt concrete with PG 64-10 binder. Erodibility Class 2 (very erosion resistant material) adopted for the faulting calculation.
Lean concrete base	*PMED* default chemically stabilized material with 2 million psi resilient modulus. Erodibility Class 2 (very erosion resistant material) adopted for the faulting calculation.

(1) The rationale for the selection of the different values can be found in the UCPRC Tech Memo UCPRC-TM-2021-03 available at eScholarship web site.
(2) PMED defaults, 2006 National calibration.
(3) Two blanket grinding operations.
(4) The dowel diameter does not have any effect on *PMED* predicted JPCP cracking and, consequently, on the thickness determined by the Rigid Pavement Design Catalog. The dowel diameter has a large impact on *PMED* predicted faulting and IRI.

Table 623.1B

Assumptions Adopted in *PMED* for SJPCP-COA Design

Factor	Value [(1)]
Slab size	6×6 ft
Slab-base bonding	Bonded
Permanent curl/warp	-10°F
Cracking calibration coefficients [(2)]	C4 = 0.40; C5 = -2.21
Cracking reliability, standard error formula [(2)]	3.5522 * Cracking(%)^0.4315 + 0.5
Provision for grinding [(3)]	0.03 ft
Minimum slab thickness	0.33 ft
Maximum slab thickness	0.60 ft
Transverse joints	Undoweled
Load transfer efficiency of transverse joints	70%
Hot mix asphalt base	*PMED* default asphalt concrete with PG 64-10 binder
Cold recycling base	*PMED* default asphalt concrete with PG 64-40 binder

(1) The rationale for the selection of the different values can be found in the UCPRC Tech Memo UCPRC-TM-2021-02 available at eScholarship web site.
(2) PMED defaults, 2016 National calibration.
(3) One blanket grinding operation.

Tables 623.1C(a) through (i) contain the minimum thickness for concrete pavement surface layers, base, and subbase of the traveled way for all types of projects. The concrete thickness in the tables includes a provision for future grinding (sacrificial thickness) of 0.06 ft. The concrete thickness is rounded to the nearest 0.05 feet. Each table contains different combinations of base and shoulder types. The tables are categorized by climate regions and Weigh In-Motion (WIM) spectra. The catalog is categorized by climate regions and Weigh In-Motion (WIM) spectra, as follows:

- Table 623.1C(a): Group I climate and WIM 1-2
- Table 623.1C(b): Group I climate and WIM 3
- Table 623.1C(c): Group I climate and WIM 4-5
- Table 623.1C(d): Group II climate and WIM 1-2

- Table 623.1C(e): Group II climate and WIM 3
- Table 623.1C(f): Group II climate and WIM 4-5
- Table 623.1C(g): Group III climate and WIM 1-2
- Table 623.1C(h): Group III climate and WIM 3
- Table 623.1C(i): Group III climate and WIM 4-5

The climate groups for JPCP and CRCP design are defined as follows:

- Group I: SC and NC
- Group II: CC, LM, SM, HM, and HD
- Group III: IV and DE

Two base types are included in the JPCP and CRCP tables: HMA (hot mix asphalt) and LCB (lean concrete base). See Table 623.4 for further base requirements.

The JPCP and CRCP design tables consider any of the following subgrades:

- Type I: Coarse-grained soils SC, SP, SM, SW, GC, GP, GM, and GW (USCS)
- Type II: Fine-grained soils CL, MH, and ML (USCS)
- Type III: Fine-grained soil CH (USCS) stabilized with lime or cement

Type I includes subgrades made of coarse-grained soils that are primarily sand (S) and gravel (G), regardless of whether they are well (W) or poorly (P) graded or have silt (M) or clay (C) in them. Type II includes subgrades made of fine-grained soils with low (L) and high (H) plasticity. Finally, Type III includes subgrades made of fine-grained soil CH (clay with high plasticity). The Type III subgrades must be stabilized with lime or cement for JPCP or CRCP construction.

Depending on the quality of the subgrade, a class 2 aggregate subbase should be provided for construction purposes, as specified in Table 623.5. Alternatively, the subgrade should be stabilized lime, cement, asphalt emulsion, or another stabilizer that is appropriate for the subgrade material.

Table 623.1C(a)

Group I Climate (SC and NC) and WIM 1-2

	Minimum Thickness of Concrete Surface Layer (ft)							
	Widened Slab			Tied Concrete Shoulder			Untied Shoulder	
AADTT [1]	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA
100	0.65	0.65		0.65	0.65		0.70	0.65
200	0.65	0.65		0.65	0.65		0.70	0.70
500	0.65	0.65		0.70	0.70		0.75	0.75
1,000	0.70	0.65	0.75	0.75	0.70	0.75	0.80	0.80
2,000	0.70	0.70	0.75	0.80	0.75	0.75	0.80	0.80
4,000	0.75	0.75	0.75	0.80	0.80	0.75	0.85	0.85
8,000	0.80	0.75	0.75	0.85	0.80	0.80	0.90	0.90
12,000	0.80	0.80	0.80	0.85	0.85	0.80	0.90	0.95
16,000	0.80	0.80	0.80	0.85	0.85	0.85	0.95	0.95
20,000	0.80	0.85	0.80	0.90	0.90	0.85	0.95	0.95

[1] Initial (year 1) AADTT of the design lane.

Table 623.1C(b)

Group I Climate (SC and NC) and WIM 3

	Minimum Thickness of Concrete Surface Layer (ft)							
	Widened Slab			Tied Concrete Shoulder			Untied Shoulder	
AADTT [1]	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA
100	0.65	0.65		0.65	0.65		0.70	0.65
200	0.65	0.65		0.65	0.65		0.70	0.70
500	0.65	0.65		0.70	0.70		0.75	0.75
1,000	0.70	0.65	0.75	0.75	0.70	0.75	0.80	0.80
2,000	0.70	0.70	0.75	0.75	0.75	0.75	0.80	0.80
4,000	0.75	0.70	0.75	0.80	0.80	0.75	0.85	0.90
8,000	0.80	0.80	0.75	0.80	0.85	0.80	0.90	0.95
12,000	0.80	0.80	0.80	0.85	0.90	0.85	0.95	0.95
16,000	0.80	0.85	0.80	0.90	0.90	0.85	0.95	1.00
20,000	0.85	0.90	0.85	0.90	0.95	0.90	1.00	1.00

[1] Initial (year 1) AADTT of the design lane.

Table 623.1C(c)

Group I Climate (SC and NC) and WIM 4-5

	Minimum Thickness of Concrete Surface Layer (ft)							
	Widened Slab			Tied Concrete Shoulder			Untied Shoulder	
AADTT (1)	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA
100	0.65	0.65		0.65	0.65		0.70	0.65
200	0.65	0.65		0.65	0.65		0.70	0.70
500	0.65	0.65		0.70	0.70		0.75	0.75
1,000	0.70	0.65	0.75	0.75	0.70	0.75	0.80	0.80
2,000	0.70	0.70	0.75	0.75	0.75	0.75	0.80	0.85
4,000	0.75	0.75	0.75	0.80	0.80	0.80	0.85	0.90
8,000	0.80	0.80	0.80	0.85	0.85	0.85	0.90	0.95
12,000	0.80	0.85	0.80	0.85	0.90	0.85	0.95	1.00
16,000	0.85	0.90	0.85	0.90	0.95	0.90	1.00	1.00
20,000	0.85	0.90	0.85	0.90	0.95	0.90	1.00	1.05

(1) Initial (year 1) AADTT of the design lane.

Table 623.1C(d)

Group II Climate (CC, LM, SM, HM, and HD) and WIM 1-2

	Minimum Thickness of Concrete Surface Layer (ft)							
	Widened Slab			Tied Concrete Shoulder			Untied Shoulder	
AADTT (1)	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA
100	0.65	0.65		0.65	0.65		0.70	0.65
200	0.65	0.65		0.70	0.65		0.75	0.70
500	0.65	0.65		0.75	0.70		0.80	0.75
1,000	0.70	0.70	0.75	0.75	0.75	0.75	0.80	0.80
2,000	0.75	0.70	0.75	0.80	0.75	0.75	0.85	0.85
4,000	0.75	0.75	0.75	0.80	0.80	0.80	0.90	0.90
8,000	0.80	0.80	0.80	0.85	0.85	0.80	0.90	0.95
12,000	0.80	0.85	0.80	0.85	0.90	0.85	0.95	0.95
16,000	0.85	0.85	0.85	0.90	0.90	0.85	0.95	1.00
20,000	0.85	0.90	0.85	0.90	0.95	0.90	1.00	1.00

(1) Initial (year 1) AADTT of the design lane.

Table 623.1C(e)

Group II Climate (CC, LM, SM, HM, and HD) and WIM 3

	Minimum Thickness of Concrete Surface Layer (ft)							
	Widened Slab			Tied Concrete Shoulder			Untied Shoulder	
AADTT [1]	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA
100	0.65	0.65		0.65	0.65		0.70	0.65
200	0.65	0.65		0.70	0.65		0.75	0.70
500	0.65	0.65		0.70	0.70		0.80	0.75
1,000	0.70	0.65	0.75	0.75	0.70	0.75	0.80	0.80
2,000	0.75	0.70	0.75	0.80	0.75	0.75	0.85	0.85
4,000	0.75	0.75	0.75	0.80	0.80	0.80	0.90	0.90
8,000	0.80	0.85	0.80	0.85	0.90	0.85	0.95	1.00
12,000	0.85	0.90	0.85	0.90	0.95	0.90	0.95	1.00
16,000	0.85	0.90	0.85	0.90	0.95	0.90	1.00	1.05
20,000	0.90	0.95	0.90	0.95	1.00	0.90	1.00	1.05

(1) Initial (year 1) AADTT of the design lane.

Table 623.1C(f)

Group II Climate (CC, LM, SM, HM, and HD) and WIM 4-5

	Minimum Thickness of Concrete Surface Layer (ft)							
	Widened Slab			Tied Concrete Shoulder			Untied Shoulder	
AADTT [1]	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA
100	0.65	0.65		0.65	0.65		0.70	0.65
200	0.65	0.65		0.70	0.65		0.75	0.70
500	0.65	0.65		0.70	0.70		0.80	0.75
1,000	0.70	0.70	0.75	0.75	0.75	0.75	0.80	0.80
2,000	0.75	0.70	0.75	0.80	0.80	0.75	0.85	0.90
4,000	0.80	0.80	0.75	0.80	0.85	0.80	0.90	0.95
8,000	0.80	0.85	0.85	0.85	0.90	0.85	0.95	1.00
12,000	0.85	0.90	0.85	0.90	0.95	0.90	1.00	1.05
16,000	0.90	0.95	0.90	0.95	1.00	0.90	1.05	1.05
20,000	0.90	0.95	0.90	0.95	1.00	0.95	1.05	1.10

(1) Initial (year 1) AADTT of the design lane.

Table 623.1C(g)

Group III Climate (IV and DE) and WIM 1-2

	Minimum Thickness of Concrete Surface Layer (ft)							
	Widened Slab			Tied Concrete Shoulder			Untied Shoulder	
AADTT [(1)]	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA
100	0.65	0.65		0.65	0.65		0.70	0.65
200	0.65	0.65		0.65	0.65		0.70	0.70
500	0.65	0.65		0.70	0.70		0.75	0.75
1,000	0.70	0.65	0.75	0.75	0.70	0.75	0.80	0.80
2,000	0.70	0.70	0.75	0.80	0.75	0.75	0.85	0.85
4,000	0.75	0.75	0.75	0.80	0.80	0.80	0.90	0.90
8,000	0.80	0.80	0.80	0.85	0.85	0.85	0.95	0.95
12,000	0.80	0.85	0.80	0.90	0.90	0.85	0.95	1.00
16,000	0.85	0.90	0.85	0.90	0.95	0.90	1.00	1.00
20,000	0.85	0.90	0.85	0.90	0.95	0.90	1.00	1.05

(1) Initial (year 1) AADTT of the design lane.

Table 623.1C(h)

Group III Climate (IV and DE) and WIM 3

	Minimum Thickness of Concrete Surface Layer (ft)							
	Widened Slab			Tied Concrete Shoulder			Untied Shoulder	
AADTT [(1)]	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA
100	0.65	0.65		0.65	0.65		0.70	0.65
200	0.65	0.65		0.65	0.65		0.70	0.70
500	0.65	0.65		0.70	0.70		0.75	0.75
1,000	0.70	0.65	0.75	0.75	0.70	0.75	0.80	0.85
2,000	0.70	0.70	0.75	0.80	0.80	0.75	0.85	0.90
4,000	0.75	0.80	0.80	0.80	0.85	0.80	0.90	0.95
8,000	0.80	0.85	0.85	0.90	0.90	0.85	0.95	1.00
12,000	0.85	0.90	0.85	0.90	0.95	0.90	1.00	1.05
16,000	0.90	0.95	0.90	0.95	1.00	0.90	1.05	1.05
20,000	0.90	0.95	0.90	0.95	1.00	0.95	1.05	1.10

(1) Initial (year 1) AADTT of the design lane.

Table 623.1C(i)

Group III Climate (IV and DE) and WIM 4-5

	Minimum Thickness of Concrete Surface Layer (ft)							
	Widened Slab			Tied Concrete Shoulder			Untied Shoulder	
AADTT [1]	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA
100	0.65	0.65		0.65	0.65		0.70	0.65
200	0.65	0.65		0.65	0.65		0.70	0.70
500	0.65	0.65		0.70	0.70		0.80	0.80
1,000	0.70	0.70	0.75	0.75	0.75	0.75	0.80	0.85
2,000	0.75	0.75	0.75	0.80	0.80	0.80	0.90	0.90
4,000	0.80	0.85	0.80	0.85	0.90	0.85	0.95	0.95
8,000	0.85	0.90	0.85	0.90	0.95	0.90	1.00	1.05
12,000	0.90	0.95	0.90	0.95	1.00	0.90	1.05	1.05
16,000	0.90	0.95	0.90	0.95	1.00	0.95	1.05	1.10
20,000	0.95	1.00	0.90	1.00	1.05	0.95	1.10	1.10

(1) Initial (year 1) AADTT of the design lane.

Table 623.1D

Requirements for JPCP and CRCP Bases

Base	Material	Minimum Thickness
HMA [1] [2]	Hot mix asphalt, type A Standard Specifications Section 39	0.25 ft
LCB [3] [4] [5]	Lean concrete base Standard Specifications Section 28	0.35 ft

(1) If an asphalt treated permeable base (ATPB) is needed to perpetuate an existing treated permeable layer, place the ATPB between the concrete 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.

(2) The HMA binder grade may be either PG 64-10 or PG 64-16, regardless of the climate zone. Other PG grades may be used to prevent rutting associated to construction traffic, in case considerable construction traffic is expected. Refer to Topic 632 for more details regarding asphalt binder selection.

(3) Use only with JPCP.

(4) 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.

(5) Place an interlayer between the concrete surface layer (JPCP) and the LCB in all cases.

Table 623.1E

Requirements for JPCP and CRCP Subbases

Subgrade Soil (USCS)	Subgrade Type	Minimum Class 2 Aggregate Subbase Thickness
GW	Type I	Subbase not required
GP	Type I	Subbase not required
GM	Type I	Subbase not required
GC	Type I	0.35 ft
SW	Type I	0.35 ft
SP	Type I	0.35 ft
SM	Type I	0.35 ft
SC	Type I	0.35 ft
ML	Type II	0.50 ft
CL	Type II	0.50 ft
MH	Type II	0.75 ft
CH	Type III	Requires stabilization

Tables 623.1F(a) through (d) provide the minimum concrete thickness for SJPCP-COA traveled way. The concrete thickness in the tables includes a provision for future grinding (sacrificial thickness) of 0.03 ft. The concrete thickness is rounded to the nearest 0.05 feet. Each table contains different combinations of base type and thickness and subbase type. The tables are categorized by subgrade type and climate region:

- Table 623.1F(a): Type I subgrade and Group I climate
- Table 623.1F(b): Type I subgrade and Group II climate
- Table 623.1F(c): Type II subgrade and Group I climate
- Table 623.1F(d): Type II subgrade and Group II climate

The climate groups for SJPCP-COA design are defined as follows:

- Group I: CC and NC
- Group II: SM, DE, HD, IV, LM, SC, and HM

Two base types are included in the SJPCP-COA tables: HMA (hot mix asphalt) and CR (cold recycling). The CR alternative includes full-depth recycling with foamed asphalt (FDR-FA) and partial-depth recycling with emulsified or foamed asphalt (PDR-EA or PDR-FA).

The asphalt base thickness is defined as follows:

- HMA alternative: The thickness of sound asphalt that remains after milling (if milling is conducted) plus any HMA or rubberized gap-graded hot mix asphalt (RHMA-G) overlay that may be added to improve the asphalt base structural capacity and/or surface condition.
- CR alternative:
  - For FDR-FA: The thickness of the full-depth recycling.
  - For PDR-EA or PDR-FA: The thickness of sound asphalt that remains after milling plus the thickness of the partial-depth recycling.

The SJPCP-COA design tables consider the following subbasses:

- Cement-treated base (CTB)
- Lean concrete base (LCB)
- Others (aggregate base, asphalt treated permeable base, etc.)

The SJPCP-COA design tables consider the following subgrades:

- Type I: Coarse-grained soils SC, SP, SM, SW, GC, GP, GM, and GW (USCS)
- Type II: Fine-grained soils CL, MH, and ML (USCS)
- Type III: Fine-grained soil CH (USCS) stabilized with lime or cement; these subgrades can be assimilated into Type I subgrades to determine the concrete thickness
- Type III: Fine-grained soil CH (USCS) unstabilized and without drainage issues; these subgrades can be assimilated into Type II subgrades to determine the concrete thickness

The “Not applicable” (N.A.) concrete thickness in Tables 623.6A through D indicates that the required concrete thickness is over 0.60 ft and, consequently, standard JPCP rather than SJPCP-COA design should be considered.

Table 623.1F(a)

Type I Subgrade and Group I Climate (CC and NC)

AADTT [1]	Subbase	Minimum Thickness of Concrete Surface Layer (ft) HMA Base HMA 0.25 ft	HMA 0.35 ft	HMA 0.45 ft	CR Base CR 0.25 ft	CR 0.35 ft	CR 0.45 ft
50	CTB, LCB	0.35	0.35	0.35	0.40	0.35	0.35
	Others	0.35	0.35	0.35	0.45	0.40	0.35
100	CTB, LCB	0.40	0.35	0.35	0.45	0.40	0.35
	Others	0.40	0.35	0.35	0.45	0.40	0.35
200	CTB, LCB	0.40	0.35	0.35	0.45	0.45	0.40
	Others	0.45	0.35	0.35	0.50	0.45	0.40
500	CTB, LCB	0.45	0.35	0.35	0.50	0.45	0.45
	Others	0.45	0.40	0.35	0.50	0.50	0.45
1,000	CTB, LCB	0.50	0.40	0.35	0.55	0.50	0.45
	Others	0.50	0.45	0.35	0.55	0.50	0.50
2,000	CTB, LCB	0.50	0.45	0.35	0.55	0.55	0.50
	Others	0.50	0.45	0.35	0.55	0.55	0.50

(1) Initial (year 1) AADTT of the design lane.

Table 623.1F(b)

Type I Subgrade and Group II Climate (SM, DE, HD, IV, LM, SC, and HM)

AADTT [1]	Subbase	Minimum Thickness of Concrete Surface Layer (ft) HMA Base HMA 0.25 ft	HMA 0.35 ft	HMA 0.45 ft	CR Base CR 0.25 ft	CR 0.35 ft	CR 0.45 ft
50	CTB, LCB	0.40	0.35	0.35	0.45	0.40	0.40
	Others	0.40	0.40	0.35	0.45	0.40	0.40
100	CTB, LCB	0.45	0.40	0.35	0.45	0.45	0.40
	Others	0.45	0.40	0.35	0.45	0.45	0.40
200	CTB, LCB	0.45	0.45	0.35	0.50	0.45	0.45
	Others	0.45	0.45	0.40	0.50	0.45	0.45
500	CTB, LCB	0.50	0.45	0.40	0.50	0.50	0.50
	Others	0.50	0.50	0.45	0.55	0.50	0.50
1,000	CTB, LCB	0.55	0.50	0.45	0.55	0.55	0.50
	Others	0.55	0.50	0.50	0.55	0.55	0.50
2,000	CTB, LCB	0.55	0.50	0.50	0.60	0.55	0.55
	Others	0.55	0.55	0.50	0.60	0.55	0.55

(1) Initial (year 1) AADTT of the design lane.

Table 623.1F(c)

Type II Subgrade and Group I Climate (CC and NC)

		Minimum Thickness of Concrete Surface Layer (ft)					
		HMA Base			CR Base		
AADTT (1)	Subbase	HMA 0.25 ft	HMA 0.35 ft	HMA 0.45 ft	CR 0.25 ft	CR 0.35 ft	CR 0.45 ft
50	CTB, LCB	0.50	0.40	0.35	0.50	0.50	0.45
	Others	0.50	0.45	0.35	0.55	0.50	0.50
100	CTB, LCB	0.50	0.45	0.35	0.55	0.50	0.45
	Others	0.50	0.45	0.35	0.55	0.55	0.50
200	CTB, LCB	0.55	0.45	0.35	0.55	0.55	0.50
	Others	0.55	0.50	0.40	0.60	0.55	0.55
500	CTB, LCB	0.55	0.50	0.40	0.60	0.55	0.55
	Others	0.60	0.55	0.45	0.60	0.60	0.55
1,000	CTB, LCB	0.60	0.55	0.45	N.A.	0.60	0.55
	Others	0.60	0.55	0.50	N.A.	0.60	0.60
2,000	CTB, LCB	0.60	0.55	0.50	N.A.	N.A.	0.60
	Others	N.A.	0.60	0.55	N.A.	N.A.	0.60

(2) Initial (year 1) AADTT of the design lane.

Table 623.1F(d)

Type II Subgrade and Group II Climate (SM, DE, HD, IV, LM, SC, and HM)

		Minimum Thickness of Concrete Surface Layer (ft)					
		HMA Base			CR Base		
AADTT (1)	Subbase	HMA 0.25 ft	HMA 0.35 ft	HMA 0.45 ft	CR 0.25 ft	CR 0.35 ft	CR 0.45 ft
50	CTB, LCB	0.50	0.45	0.40	0.55	0.50	0.45
	Others	0.50	0.50	0.45	0.55	0.55	0.50
100	CTB, LCB	0.55	0.50	0.45	0.55	0.55	0.50
	Others	0.55	0.50	0.50	0.55	0.55	0.55
200	CTB, LCB	0.55	0.50	0.50	0.60	0.55	0.55
	Others	0.55	0.55	0.50	0.60	0.60	0.55
500	CTB, LCB	0.60	0.55	0.50	0.60	0.60	0.55
	Others	0.60	0.60	0.55	N.A.	0.60	0.60
1,000	CTB, LCB	0.60	0.60	0.55	N.A.	0.60	0.60
	Others	N.A.	0.60	0.60	N.A.	N.A.	0.60
2,000	CTB, LCB	N.A.	0.60	0.60	N.A.	N.A.	0.60
	Others	N.A.	N.A.	0.60	N.A.	N.A.	N.A.

(2) Initial (year 1) AADTT of the design lane.

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 per mile.

(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.

(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.

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. This analysis should account for the future costs of the pavement that is not replaced. If CAPM has lower life cycle cost, pursue the project as a CAPM project.

625.2 Rigid Pavement Rehabilitation Strategies

(1) Strategies. Some rehabilitation strategies 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 catalog found in Index 623.1. Attention should be given to maintaining existing drainage patterns underneath the surface layer, (see Chapter 650 for further guidance).

(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 for Overlay. Existing pavement distresses should be repaired before overlaying the pavement. 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.

(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 listed in Chapter 610. The Materials Report should discuss any historical problems observed in the performance of rigid and flexible 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.

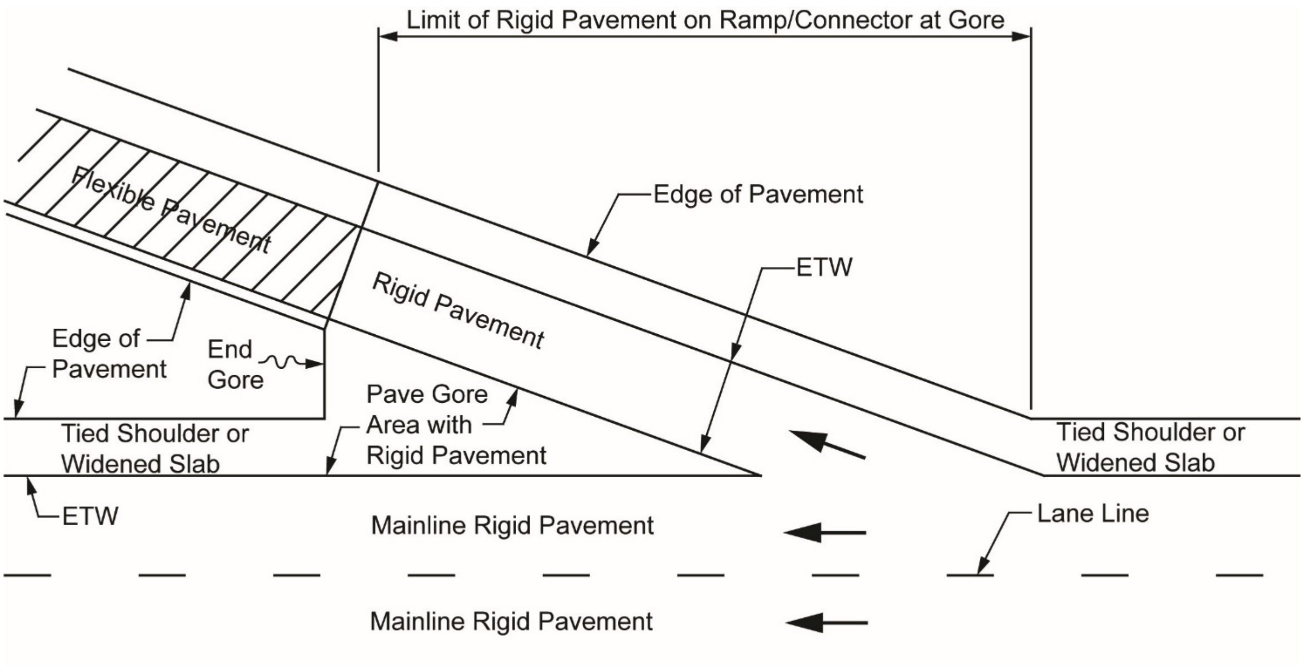
(2) Ramps and Connectors. If tied rigid shoulders or widened slabs are used on the mainline, then the ramp or connector gore area (including ramp traveled way adjacent to the gore area) should also be constructed with rigid pavement (see Figure 626.1). This will minimize deterioration of the joint between 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.

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.

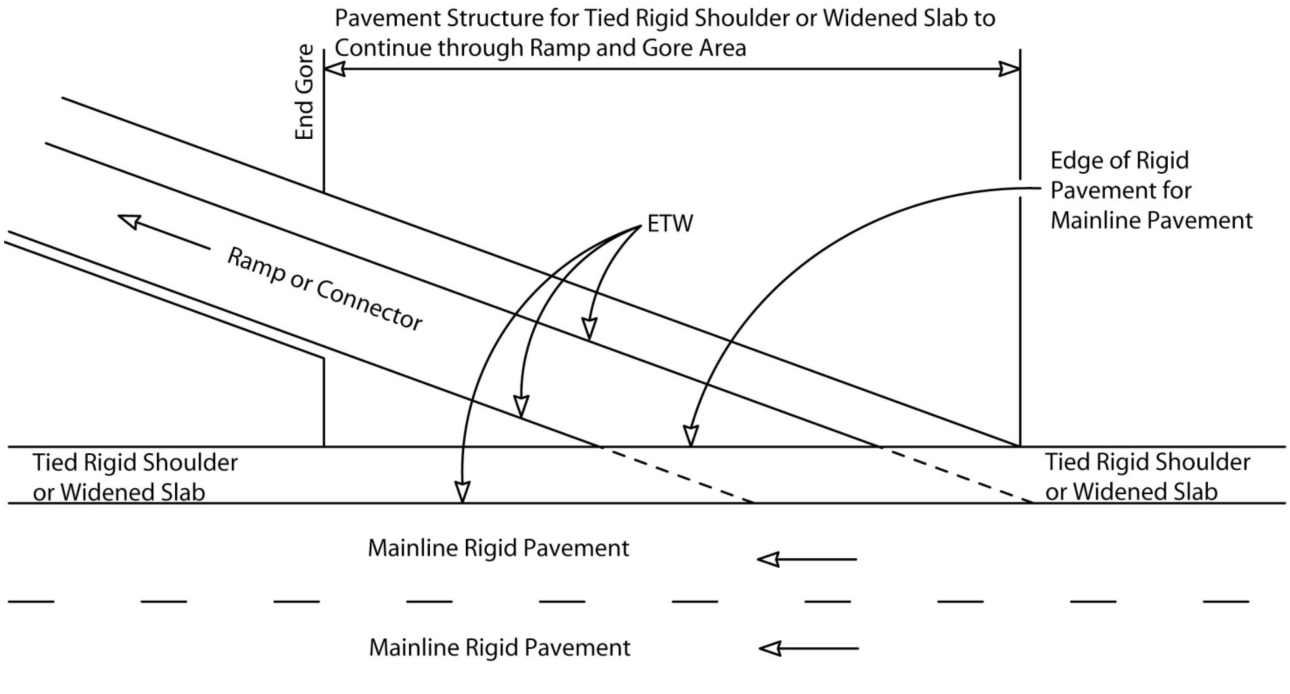
Table 626.2

Shoulder Concrete Pavement Designs (“S” Dimension)

Climate Region	S(ft) (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

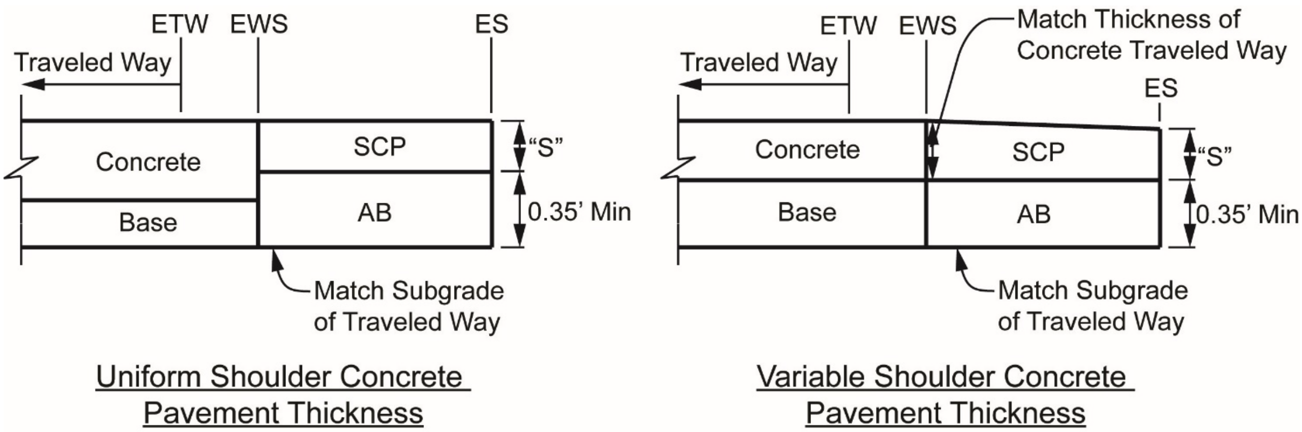


NOTES:

(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.

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.

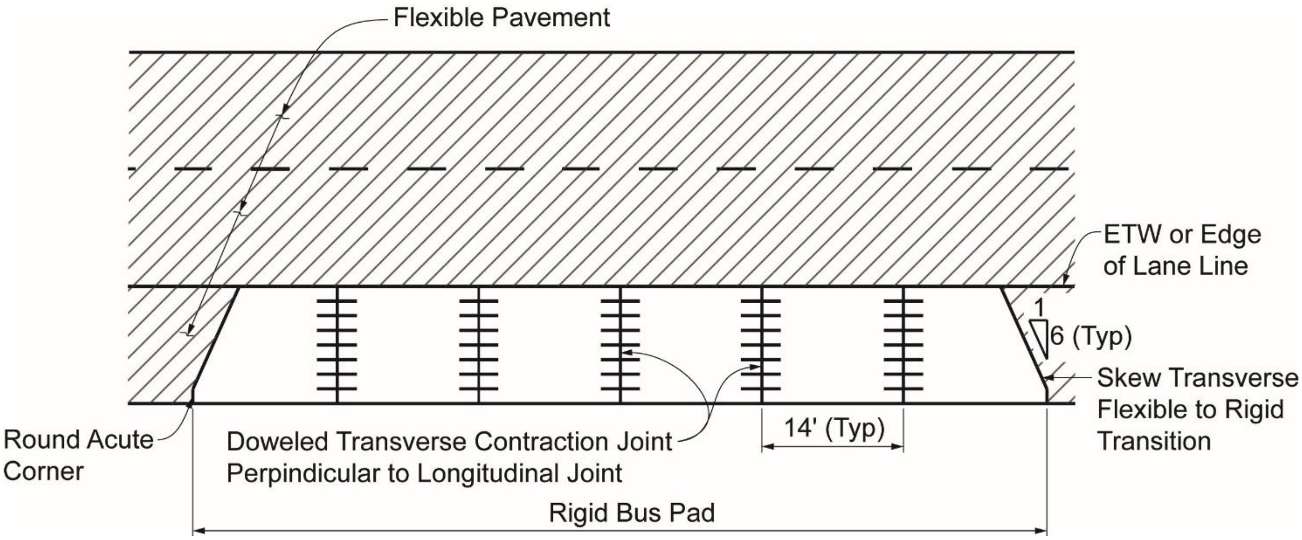
(3) Bus Pads. Bus pads are subjected to similar stresses as intersections; however, it is not practical to engineer rigid bus pads according to the Traffic Index, or according to bus counts. The minimum pavement structure for bus pads should be 0.85 foot JPCP with dowel bars at transverse joints on top of 0.5 foot aggregate base. 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.