CHAPTER 210 — JOINTED PLAIN CONCRETE PAVEMENT (JPCP)

This Chapter discusses specific topics related to new JPCP design, including guidance for using related 2010 and 2015 Standard Plans and Standard Specifications. Refer to Part 4 for guidance on JPCP rehabilitation methods. General information about concrete pavement structure design and materials is contained in Chapter 120 and HDM Chapters 600 – 670. The Pavement Program website has additional technical pavement related information and links to other useful sites (http://www.dot.ca.gov/hq/maint/Pavement/Pavement_Program).

210.1 JPCP COMPONENTS

Jointed plain concrete pavement (JPCP) is unreinforced cast-in-place concrete pavement designed with dowelled transverse joints and tied longitudinal joints to control cracking as well as vertical and horizontal movement. Transverse and longitudinal joints are cut to a 1/8” width and not sealed except in desert and mountain climate regions. JPCP is typically constructed with the components shown in Figure 210-1:
Existing rigid pavement built in California prior to 2004 is generally non-doweled JPCP. Existing JPCP built prior to 1992 is typically untied.

This section contains a brief discussion of concrete, joints, tie bars, and dowel bars. Refer to Chapter 120 and HDM Chapters 600, 610, and 620 for more information about pavement structure design, materials, and other design considerations and requirements.

210.1.1  Concrete
Concrete consists of a combination of cementitious materials, coarse and fine-graded aggregate, water, and typically some property modifying admixtures. Concrete properties such as strength, durability, permeability, and abrasive wear resistance are materials dependent. Section 90 of the 2010 Standard Specifications defines the required chemical and physical concrete material properties for contractor developed mix designs, with some additional requirements for concrete pavements specified in Section 40. For more comprehensive information about concrete materials, refer to Chapter 120 and the Concrete Technology Manual.

Concrete pavement thickness is determined using standard design catalogs for new concrete pavement structures in HDM Index 623.1. The catalogs are based on mechanistic-empirical analysis principles considering climatic effects, applied traffic loads, and subgrade quality. To select the best materials and determine layer thicknesses, successful pavement structure designs must consider these and other engineering factors such as traffic control and estimated costs.

210.1.2  Joints
Concrete slabs will crack randomly from natural actions such as shrinkage or curling. Joints are vital JPCP design elements to control slab cracking and horizontal movement. Without joints, plain concrete pavements would be riddled with cracks within 1 or 2 years after placement. JPCP, if incorrectly placed or has poorly designed joints, will have premature cracking. JPCP joint types include longitudinal, transverse, construction, and intersection joints.

Longitudinal Joints
Longitudinal joints are necessary to control longitudinal cracking in JPCP. They are typically constructed at lane lines in multiples of 12’ (see Figure 210-2). Tie bars are typically placed at these joints to hold abutting slab faces in contact (see Section 210.1.4).

Transverse Joints
Transverse joints are constructed at right angles to longitudinal joints in new JPCP construction as seen in Figure 210-2. Historically, JPCP transverse joints were skewed and spaced at various intervals, including 15’ uniform spacing and staggered intervals of 18, 19, 12, and 13 feet or 12, 15, 13, and 14 feet. Beginning in 2013, 14’ uniform transverse joint spacing became standard.

Dowel bars handle the load transfer in new JPCP so skewed transverse joints are not necessary. Skewing also makes it difficult to place dowels along the transverse joint. Section 210.1.5 provides additional information on load transfer across transverse joints.

For lane/shoulder addition or reconstruction, the new transverse joints may not line up with the existing joint spacing in the adjacent lane. Revised Standard Plan RSP P18 shows 3 different cases of existing and new transverse joints alignment that may be encountered when reconstructing or adding concrete lane/shoulder adjacent to existing concrete pavement. To prevent crack migration from the existing transverse joints over to the new and weaker transverse joints, longitudinal isolation joints are needed.
Figure 210–2: Transverse and longitudinal joints

Isolation Joints
An isolation joint is a type of longitudinal joint that prevents existing transverse joints or cracks from migrating over to the newly placed JPCP. Isolation joints are generally used when matching the existing transverse joints is not practical. They are placed to separate dissimilar concrete pavement structure, and reduce compressive stresses that can cause uncontrolled cracking.

An isolation joint is required for:
1. Lane or shoulder addition and reconstruction where:
   a. New and existing transverse joints do not align
   b. New and existing transverse joints align and tie bars are not required.
2. Interior lane replacement where joints do not align between new and existing

When adding a new lane where an asphalt shoulder is removed, the abutting concrete slab edge should be saw cut to remove any surface roughness and protruding pockets of concrete at the isolation joint. Preformed bituminous expansion joint filler material is used to fill the isolation joint from the top of the base layer to the bottom of the reservoir. The joint is sealed at the surface with liquid sealant or preformed compression joint seal material to prevent infiltration of incompressible materials and moisture. The joint filler and seal material should be placed continuously from one edge of the slab to the other to the dimensions shown in Detail “A” on 2010 Revised Standard Plan RSP P18.

Construction Joints
A construction joint is either a:
1. Transverse joint that joins together consecutive slabs constructed at different times
2. Longitudinal joint constructed between lanes paved in 2 separate passes.

For longitudinal construction joints in non-doweled JPCP, tie bars usually connect adjacent slabs together. Transverse construction joints for doweled pavement should coincide with the standard 14’ joint spacing.

Intersection Joints
Occasionally, state highways serve as local streets that require special joint layout considerations. Manholes, drainage inlets, curbs, gutters and other existing features need to be identified and considered for special construction details. Each intersection will require a custom joint layout that should be included as part of the construction details shown on the project plans. Joint design recommendations include:

- Maintaining perpendicular joints to simplify intersection construction. Skewed transverse or longitudinal joints should be minimized as much as possible in the intersection.
- Maintain lane widths and keep concrete panels as square as possible (1:1 to 1:1.25 ratio).
Avoid triangular shaped panels and angles < 60°.
Consider slab lengths as they approach the intersection if there is a transition from an alternating to constant transverse joint pattern.
Design the joint layout considering traffic lane closure restrictions.

Field adjustments may be needed, but jointing plan details will provide clear guidance, help the contractor bid the project, and minimize disagreements or confusion during construction. Placement of new features such as traffic loop detectors that may affect daily production during construction should also be indicated.

210.1.3 Base Bond Breaker
Base bond breaker materials reduce friction between concrete pavement and rigid base material that can lead to cracking. For JPCP placed over LCB, SSP 36-2 allows the contractor to select asphalt binder, curing compound, or geosynthetic base bond breaker materials. The bond breaker allows the pavement structure layers to move independently, reducing reflective cracking and providing flexibility for slab curling due to temperature differences between the top and bottom of the pavement surface (see Section 120.1.1 for more information).

210.1.4 Tie Bars
Tie bars used in JPCP construction are 30” long deformed metal bars, placed at mid slab depth, perpendicular to the longitudinal construction and contraction joints. Tie bars are placed a minimum of 15” from a transverse joint and at 28” spacing thereafter (see Figure 210-3). Tie bars are typically used at longitudinal joints to hold abutting concrete faces in tight contact. Tie bars can also be used in transverse construction joints of non-doweled JPCP shoulders.

![Figure 210–3: Tie bars](image)

Tie bars are recommended at longitudinal construction joints for lane and shoulder additions or reconstruction, but are not recommended where isolation joints are required. Based on prior experience, tied JPCP lanes are limited to a 50’ maximum width (see Revised Standard Plan RSP P18). When more lanes are tied together, concrete slabs tend to crack longitudinally. Tied slabs act collectively as one slab and friction between the base and the slabs is high enough to restrain movement and cause cracking. When more than 3 lanes and a shoulder or 4 lanes are being tied together, tie bars should be omitted at one of the longitudinal joints, preferably an inside lane without heavy vehicle traffic. Dowel bars are sometimes used for limited load transfer across untied longitudinal joints.
Revised Standard Plan RSP P18 provides lane schematics showing dowel and tie bar use at longitudinal joints and longitudinal isolation joint construction. The plan does not show all possible project conditions, so where project design scenarios differ, show the location of the untied longitudinal joint on a typical cross section or construction detail.

Where tie bars are installed at pavement transitions and the new concrete thickness is greater than the existing thickness, tie bars should be placed within the middle third of each slab (see Figure 210-4).

![Figure 210-4: Example tie bar placement](image)

Recommended tie bar placement depth ranges, measured in inches from the pavement surface, are shown in Table 210-1:

<table>
<thead>
<tr>
<th>New Concrete (inches)</th>
<th>Existing Concrete (inches)</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>3.0 – 5.4</td>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>3.3 – 5.4</td>
<td>3.3 – 6.0</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>3.7 – 5.4</td>
<td>3.7 – 6.0</td>
<td>3.7 – 6.6</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>4.0 – 5.4</td>
<td>4.0 – 6.0</td>
<td>4.0 – 6.6</td>
<td>4.0 – 7.4</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>4.3 – 5.4</td>
<td>4.3 – 6.0</td>
<td>4.3 – 6.6</td>
<td>4.3 – 7.4</td>
<td>4.3 – 8.0</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>4.7 – 5.4</td>
<td>4.7 – 6.0</td>
<td>4.7 – 6.6</td>
<td>4.7 – 7.4</td>
<td>4.7 – 8.0</td>
<td></td>
</tr>
</tbody>
</table>

210.1.5 Load Transfer and Dowel Bars

Load transfer is the ability of a joint to transfer an applied traffic load from one side of the joint to the other. Dowel bars are smooth, round metal bars that allow load transfer across joints. Ideally, load transfer is achieved through 3 mechanisms:

1. Mechanical load transfer devices such as dowel bars
2. Aggregate interlock across abutting edges of concrete
3. Friction between the concrete pavement surface and base

In new JPCP pavement, dowels are placed on center at 1’ intervals along the transverse joint, with a 6” offset at longitudinal joints (see Figure 210-5 and Revised Standard Plan RSP P10). Dowel bars are not required for concrete shoulders placed or reconstructed next to a widened slab (see Revised Standard Plan RSP P3B).
All dowel bars must be treated or epoxy coated, but Section 40 of the Standard Specifications allows the contractor to select the dowel bar materials with restrictions in more corrosive environments. Stainless steel bars are used in marine environments and in mountainous climates dowels are epoxy coated to prevent corrosion from exposure to deicing chlorides.

Refer to Section 120.3.2 for more information about load transfer and dowel bars.

210.2 OTHER JPCP CONSIDERATIONS

210.2.1 Widening

Longitudinal isolation joints are used when placing dowelled pavement next to non-doweled pavement, or where the spacing pattern of transverse joints is different. Dowelled rigid pavement will have a repeated interval spacing pattern, so matching the existing spacing is problematic. An isolation joint prevents cracks in the new lane or shoulder from adjacent existing transverse joints where joint spacing does not match.

2010 Revised Standard Plans RSP P3A and RSP P3B detail JPCP widening and indicate lane lines must be placed at longitudinal joints. For situations where the isolated longitudinal construction joint at the widening does not match the proposed lane lines, a small tied strip of variable width is used to line up the dimensions. If the width between the lane line and construction joint is > 3'-3", a longitudinal contraction joint is placed at the proposed lane line. For widths ≤ 3'-3", no longitudinal contraction joint is used.

When a lane addition occurs next to an existing lane, the existing adjacent lane should be ground smooth for the full width prior to new lane construction. Grinding the existing pavement will provide a level surface for the slip-form paving machine, resulting in construction of a smoother lane.

210.2.2 Widened Lanes with HMA Shoulders

2010 Revised Standard Plan RSP P3B shows a widened lane with HMA or JPCP shoulders. Widened lanes are not tied to rigid or flexible shoulders, but are striped to a 12’ traffic lane width to keep the wheel path away from slab edges where critical loading stress occurs. This reduces fatigue damage and improves JPCP performance. Studies have shown that the loading impact for a widened lane with HMA shoulders is comparable to a standard width slab with tied shoulders, although widened lanes with HMA shoulders are not preferred due to potential issues with curling and warping, as well as different material behavior from thermal movement (see Section 210.2.4).
210.2.3  Narrow Shoulders
A longitudinal joint should not be used if the shoulder is less than 4’ wide. The shoulder should be paved as part of the outside or inside panel and delineated by an edge stripe. If a rigid shoulder is added, tying the shoulder with tie bars is essential to hold the shoulder to the lane and provide edge support.

210.2.4  Pavement Transitions
When end panel pavement transitions are to different pavement materials within the same lane (rigid to flexible or flexible to rigid), refer to 2010 Revised Standard Plan RSP P30. When the surface changes from flexible to rigid, special design consideration should be given to the impact loading at the transverse joint. An alternative to the reinforced concrete pavement transition is to thicken the concrete at the transition to existing AC, similar to what is shown on the pavement end anchor detail.

Placing flexible lane or shoulders next to concrete lanes is undesirable due to differential thermal movement. The softer AC tends to shove and deform. Occasionally, this produces a noticeable bump or joint separation at the interface.

Expansion joints are not used with JPCP. Using doweled JPCP and shorter panel lengths eliminates the need for pavement pressure relief, even with longer continuous runs of JPCP on steep grades. Often bridges, overpasses, approach slabs, and other roadway features break up the continuous runs and provide an expansion joint on approach or sleeper slab to account for thermal movement.

210.2.5  Concrete Barrier in Concrete Medians
Concrete barrier can be placed directly on concrete pavement, with a monolithic concrete foundation, or on compacted base material (see Standard Plan A76A). When concrete barrier is placed on concrete pavement, full contact friction develops at the surface interface as the concrete hardens. Friction limits the ability of the pavement slab to expand and contract with temperature changes, increasing longitudinal cracking potential if the barrier is placed over a longitudinal joint. Placing a bond breaker at the interface will allow JPCP slab movement (see Figure 210-6a). Another alternative is to align the concrete barrier so the entire width is placed on the same slab and no bond breaker is needed (see Figure 210-6b). For new alignments or concrete median widening where the finished grade of each roadbed is within 1.5”, the pavement can be placed narrower to accommodate the concrete barrier. The barrier can be placed together with a naturally formed monolithic concrete foundation in the gap, separated from the pavement by an isolation joint (see Figure 210-6c).

![Diagram of concrete barrier placement alternatives](image)

(a) Over longitudinal joint   (b) Along longitudinal joint   (c) Isolated concrete foundation

Figure 210–6: Concrete barrier placement alternatives
210.2.6 Concrete Pavement Over Culverts

Adequate cover provides support for traffic loads between the pavement surface and the culvert. Culverts and concrete pavement structures should be designed to withstand roadway traffic loading using the minimum cover for various pipe thicknesses and diameters shown in HDM Tables 856.3A through 856.3P. Standard Plan D88 has a table with minimum cover for construction loads on culverts. Figure 210-7 shows a rigid pavement constructed over an existing cross-drain culvert with inadequate cover:

![Concrete pavement structure with inadequate cover](image)

**Figure 210–7: Concrete pavement structure with inadequate cover**

210.2.7 Stage Construction

There are various construction issues that influence the constructability of the concrete pavement and should be taken into consideration. Creating means for consistent construction materials and methods will help create a smooth and long lasting pavement. Strategies include:

- Provide sufficient work area for required equipment and access for consistent product delivery and paver speed.
- Distance to batch plant should be taken into consideration. If one is not close to the project site, a staging area should be provided for contractor’s use.
- Provide a minimum of 2.5’ clearance width between pavement placement and barriers and hinge points to ensure good control of paving operation and smoothness.
- Minimize the number of stages and setups to provide consistent paving operations.

210.3 Plans, Specifications, and Estimating

The Standard Plans, Standard Specifications, and Standard Special Provisions (SSPs) are contractual documents that are components of the project design package. Standard Specification Section 40 contains concrete pavement specifications and Section 40-4 is for specific JPCP requirements, with various Standard Special Provisions (SSPs) used for associated work (see Section 210.3.2).

JPCP pavement structure limits for each type of concrete material should be accurately shown on the project typical sections, layouts, and construction details. Pavement on project plans and details must be identified as JPCP instead of previously used terms PCC or PCCP to match current standard plans, specifications, and bid items. JPCP is included as an abbreviation on Standard Plan A10A. If the pavement is non-doweled, it should be referred to on the plans and specifications as “JPCP (Non- Doweled)” and for sections where rapid strength concrete (RSC) is required, it should be referenced as JPCP (RSC). Non-standards pay items should be used to match the names shown on the plans.
The project engineer should assess all the individual features and determine if additional construction details, SSP edits, or nonstandard special provisions are needed to construct the project. Transitions to ramps, intersections, drainage features, and bridge approaches (clearance issues) are some elements that may require additional contract plan details. When unique or complicated pavement issues arise and a recommendation from Headquarters is desired, contact the Office of Concrete Pavement and Pavement Foundations in Headquarters Division of Maintenance for assistance.

210.3.1 Standard Plans


<table>
<thead>
<tr>
<th>RSP Plan Sheet</th>
<th>Standard Plan Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Jointed Plain Concrete Pavement – New Construction</td>
<td>Use for new construction with tied JPCP shoulder.</td>
</tr>
<tr>
<td>P2</td>
<td>Jointed Plain Concrete Pavement – Widened Lane New Construction</td>
<td>Use for new construction widened lane with flexible shoulder or untied JPCP.</td>
</tr>
<tr>
<td>P3A</td>
<td>Jointed Plain Concrete Pavement – Lane &amp; Shoulder Addition / Replacement</td>
<td>Use for lane &amp; shoulder addition.</td>
</tr>
<tr>
<td>P3B</td>
<td>Jointed Plain Concrete Pavement – Widen Lane &amp; Shoulder Addition or Replacement</td>
<td>Use for widen lane &amp; shoulder addition.</td>
</tr>
<tr>
<td>P10</td>
<td>Concrete Pavement – Dowel Bar Details</td>
<td>Shows orientation, tolerance and dowel bar layout. Use with P1, P2, P3A, &amp; P3B.</td>
</tr>
<tr>
<td>P12</td>
<td>Concrete Pavement – Dowel Bar Basket Details</td>
<td>Baskets are always allowed with dowels. Use with P1, P2, P3A, &amp; P3B.</td>
</tr>
<tr>
<td>P15</td>
<td>Concrete Pavement – Tie Bar Details</td>
<td>Shows orientation, tolerance and tie bar layout. Use with P1, P2, P3A, &amp; P3B.</td>
</tr>
<tr>
<td>P17</td>
<td>Concrete Pavement – Tie Bar Basket Details</td>
<td>Baskets are always allowed with tie bars. Use with P1, P2, P3A, &amp; P3B.</td>
</tr>
<tr>
<td>P18</td>
<td>Concrete Pavement – Lane Schematics and Isolation Joint Details</td>
<td>Shows general cases where isolation joints are to be located. Use standard plan for all concrete applications.</td>
</tr>
<tr>
<td>P20</td>
<td>Concrete Pavement – Joint Seals</td>
<td>Use joint seals for all locations where needed. Refer to Ch. 360.</td>
</tr>
<tr>
<td>P30</td>
<td>Concrete Pavement – End Panel Pavement Transitions</td>
<td>Use where concrete paving lane abuts to existing pavement at transverse joint. Use with P1, P2, P3A, &amp; P3B.</td>
</tr>
<tr>
<td>P33</td>
<td>Concrete Pavement – Lane Drop Details No. 1</td>
<td>Use for projects when lane drops are included in jointed plain concrete pavement areas.</td>
</tr>
<tr>
<td>P34</td>
<td>Concrete Pavement – Lane Drop Details No. 2</td>
<td>Use for projects when lane drops are included in jointed plain areas.</td>
</tr>
<tr>
<td>P35</td>
<td>Concrete Pavement – Ramp Gore Area Details</td>
<td>Uses when ramps or gore areas are found in concrete pavement areas.</td>
</tr>
<tr>
<td>P45</td>
<td>Concrete Pavement – Drainage Inlet Details No. 1</td>
<td>Use for projects with shoulder drainage inlets with aprons. Isolation joint is constructed around drainage inlet.</td>
</tr>
<tr>
<td>P46</td>
<td>Concrete Pavement – Drainage Inlet Details No. 2</td>
<td>Use for projects with shoulder drainage inlets with aprons. Isolation joint is constructed around concrete apron of the inlet.</td>
</tr>
</tbody>
</table>
210.3.2 Standard Special Provisions (SSPs)

Table 210-3 lists some JPCP related SSPs for use with the 2010 Standard Specifications.

<table>
<thead>
<tr>
<th>SSP</th>
<th>Title</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>36-2</td>
<td>Bond Breaker</td>
<td>Use for base bond breaker between concrete pavement and concrete bases.</td>
</tr>
<tr>
<td>39-1.01</td>
<td>HMA (Type A)</td>
<td>Use for projects with HMA Type A, HMA Type B, HMA-O, RHMA-G, RHMA-O, or RHMA-O-HB.</td>
</tr>
<tr>
<td>40-1</td>
<td>Jointed Plain Concrete Pavement</td>
<td>Use for concrete pavement. Edit for stainless steel bars if tie or dowel bars are placed within 1,000 feet of marine environment or other salt water body.</td>
</tr>
<tr>
<td>41-5</td>
<td>Joint seal</td>
<td>Use if the climate region requires joint seal.</td>
</tr>
<tr>
<td>41-10</td>
<td>Drill and bond bars</td>
<td>Use if the method of tying the dowel and/or tie bars details is with drill and bond.</td>
</tr>
</tbody>
</table>

210.3.3 Cost Estimating

JPCP is paid by volume, calculated based on the width, thickness, and length shown on the project plans. The quantity of JPCP is measured and paid for by the cubic yard of concrete including furnishing and placing the dowel bars, dowel baskets, tie bars and saw cutting.

Unit cost estimates for JPCP volume are typically based on historical bid prices which can be found in the Contract Cost database accessible on the intranet at [http://sv08data.dot.ca.gov/contractcost/](http://sv08data.dot.ca.gov/contractcost/). Contract cost data unit prices by year are also published online through the Office of Engineer website at [http://www.dot.ca.gov/hq/esc/oe/awards/](http://www.dot.ca.gov/hq/esc/oe/awards/). Unit costs estimates should be adjusted based on project location, quantity of concrete, availability of materials used in the concrete mix, proximity of batch plants to construction site, and construction constraints such as lane closure windows and environmental restrictions.

Other items of work involved in the construction of concrete pavements may include base bond breaker, seal pavement joints, seal isolation joints, drill and bond bars, remove concrete and grinding existing concrete. These items of work are paid for separately and should be identified in the Project Initiation Document (PID) and Project Report (PR).