# CONCRETE PAVEMENT GUIDE

## PART 3: PRESERVATION STRATEGIES

## CHAPTER 320 – INDIVIDUAL SLAB REPLACEMENT

### 320.1 PURPOSE AND DESCRIPTION

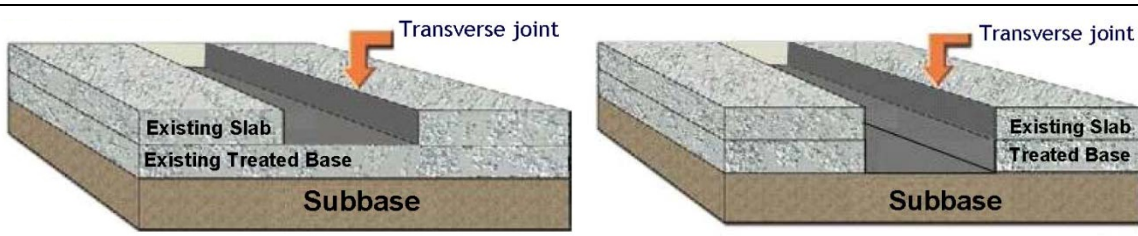
Individual slab replacement is a pavement preservation strategy for JPCP that improves the structural integrity and performance of existing concrete pavement. Slab replacement is not considered rehabilitation because it is not a new pavement structure designed for the long-term needs of the roadway.

Individual slab replacement is considered a limited-term fix with < 10 years of anticipated service life in truck traffic lanes. Even if a replaced slab lasts > 10 years, many surrounding slabs will likely continue to fail, indicating pavement rehabilitation strategies such as lane replacement should be considered. Performing successive slab replacement projects along the same route segment is inefficient pavement management that should be avoided.

Slab replacements patch isolated locations of failed pavement to minimize further deterioration and extend the life of the surrounding pavement. They are also effective for repairing distressed concrete pavement prior to an HMA or concrete overlay (see HDM Index 625.1).

Slab replacement involves the full-depth, full lane width removal of a severely deteriorated concrete slab and replacing it with an appropriate repair material that meets the design life and opening-time demands of the project.

Underlying base repair may also be required with slab replacement (see Figure 320-1). Slab and base replacement consists of removing the concrete pavement and underlying base and replacing both layers separately. New layers typically consist of portland cement concrete, rapid strength concrete, or HMA pavement and lean concrete base or concrete base, separated by a bond breaker.




**Slab Replacement** **Slab and Base Replacement**

**Figure 320-1: Slab and base removal**

### 320.1.1 Applications

Slab replacement should only be used to address severe deterioration of individual slabs in isolated areas when other strategies, including doing nothing, cannot extend the service life by at least 5 years or are not cost effective (refer to the Life-Cycle Cost Analysis Procedures Manual).

Slab replacement is appropriate when ≤ 10% slabs over the project or lane length meet the distress criteria in Table 320-3. When there is more extensive deterioration, the alternative with the lowest life cycle cost should be selected. Table 320-1 shows the slab replacement criteria used for concrete pavement strategy selection:

**Table 320-1 Concrete Pavement Strategy Selection**

| Slab Replacement Extent (per lane)[1] | Primary Concrete Pavement Strategy |
|---|---|
| ≤ 10% | Slab replacement[1] |
| 10 – 20% | Slab or lane replacement[2] (use LCCA to determine) |
| > 20% | Lane replacement[2] or CSOL[3] |

[1]Refer to Design Information Bulletin Number 81 "CAPM Guidelines"
[2]Refer to Ch. 400
[3]Refer to Ch. 410

The performance of slab replacements is dependent on appropriate application and the use of effective design and construction practices. The effectiveness of slab replacement depends on the timing of the repairs relative to the remaining pavement service life and identifying and repairing deterioration to the base (see Section 320.2.2).

Although not appropriate as a rehabilitation strategy by itself, slab replacement may be included as part of a rehabilitation project to address isolated locations within the project limits (see Table 320-2). These locations may include inside lanes where trucks are not legally permitted, ramps, shoulders, and truck lanes which are structurally adequate for at least 20 years and do not warrant rehabilitation.

**Table 320-2 Slab Replacement Project Category**

| Slab Replacement Category[1] | Anticipated Service Life | Project Type | Notes |
|---|---|---|---|
| Responsive Repair | 1 – 3 years | Maintenance (state forces)<br>Purchase order | For critical failures prior to a follow up project |
| Short Term | ≤ 5 years | HM<br>CAPM<br>2R or RRR | Routine preventive maintenance<br>Precursor to a follow up rehab project<br>Pre-overlay repairs |
| Extended Term | 5 – 10 years | CAPM<br>2R<br>RRR | For pre-overlay or repairs in adjacent lanes without 2R and RRR work. Expect follow up replacement of additional slabs during the anticipated service life. |

[1]Slab replacement category and anticipated service life vary based on existing distress type, severity, and extent (see Table 320-3), which should be used to choose the project type.

### 320.1.2 Limitations

It is important to recognize that slab replacement is not a suitable treatment for all pavements. Slab replacement does not address existing structural or material deficiencies, such as may be exhibited by pavement that is rapidly developing new cracking or is < 10 years old but with extensive cracking. These problems may be related to the concrete materials used or a lack of underlying support. Such problems require structural or functional enhancement, such as an overlay or lane replacement.

Similarly, slab replacement is not an effective strategy to combat other materials-related distress such as deterioration caused by alkali-silica reactivity (ASR), although it may be used as an interim measure until more extensive rehabilitation measures can be taken.

Slab replacement is not considered long-term pavement restoration and should not be used solely as a rehabilitation strategy. Slab replacement limitations include:

- Continued rapid deterioration of the remaining existing pavement.
- Limited service life. Slab replacements match the existing pavement thickness and are not designed for a 20-year life.
- Patches of different materials with construction joints that lower adjacent slab performance.

## 320.2 REPLACEMENT CRITERIA

### *320.2.1 Replacing Distressed Slabs*

Not all cracks, spalls, or other distress in concrete pavement require slab replacement. Some cracked panels may provide acceptable performance for an extended period of time without any repair depending on the traffic volume, vehicle loading, climate, underlying base conditions, and distress type, severity, and extent. Those same variables affect the anticipated service life of slab replacements. Slab and base replacement criteria based on existing pavement condition and anticipated service life are summarized in Table 320-3:

**Table 320-3: Slab Replacement Criteria**

| Distress (Type, Severity, Extent) | Replace Base[1] | Anticipated Service Life | | | Reference Figure |
|---|---|---|---|---|---|
| | | Responsive Repair (1–3 years) | Short-Term (≤ 5 years) | Extended-Term (5–10 years) | |
| *Corner cracks* | | | | | |
| With settlement > ¼” | Y | N | Y | Y | 320-6 |
| ≥ 2 regardless of settlement | | N | N | Y | |
| Corner cracks ≥ ¾” width | | N | N | Y | 320-2 |
| *Transverse and Longitudinal Cracks* | | | | | |
| Crack width ≥ ¾” | | N | Y | Y | 320-3 |
| Settlement > ¼” relative to slab or adjacent slabs | | N | Y | Y | |
| *3rd stage cracking*[1] | | N | Y | Y | |
| Crack width ≥ ¼” | | N | N | Y | |
| Crack width ≥ ¾” | | N | Y | Y | |
| Crack width ≥ ¾” with spalling, rocking, or missing concrete | | Low Priority[5] | Y | Y | 320-4<br>320-5 |
| Crack with settlement > ¼” relative to slab or adjacent slabs | Y | N | Y | Y | 320-5<br>320-6<br>320-7 |
| *Spalling* | | | | | |
| > 1 ft² and > 1/3 slab depth | | N | Y | Y | |
| > 2 ft² or > 2” wide over 75% crack length<br>Extent > 1-15% of pavement segment | Y | N | Y | Y | |

| Distress (Type, Severity, Extent) | Replace Base[1] | Anticipated Service Life | | | Reference Figure |
|---|---|---|---|---|---|
| | | Responsive Repair (1–3 years) | Short-Term (≤ 5 years) | Extended-Term (5–10 years) | |
| *Settlement*[3] | | | | | |
| > ¼" with cracking | Y | N | Y | Y | |
| ≥ ¾" relative to adjacent slabs regardless of cracking | | N | N | Y | |
| *Rocking slabs*[4] | Y | Low Priority[5] | Y | Y | |

Notes:
1. Since deteriorated base can extend beyond an individual slab into adjacent slabs, consider partial or complete replacement of adjacent slabs if distress includes: 3rd stage cracking with widths > ½", corner cracks with widths > ¼", or settlement. Refer to Section 320.2.2 for more information.
2. 3rd stage cracking is at least two interconnecting transverse, longitudinal, or corner cracks that divide a slab into ≥ 3 pieces.
3. Where the entire roadway or roadbed width has settled due to earth movement or hydraulic activity, consult with Geotechnical Services before implementing pavement strategies.
4. Rocking slabs move up and down relative to adjacent slabs when traversed by vehicles or trucks, a sign the slab is unstable and no longer supported by the base. Distress indicators of slab rocking include missing pieces, pumping fines, severe crack faulting or spalling, or slabs which have broken into > 6 pieces. If slab is intact, consider subsealing (see Ch. 300).
5. Low priority replacements can be included in projects with sufficient funding.

Rigid pavement distresses are described in more detail in the Automated Pavement Condition Survey Manual. Contact the Office of Pavement Management and Performance in the Division of Maintenance Pavement Program for more information.

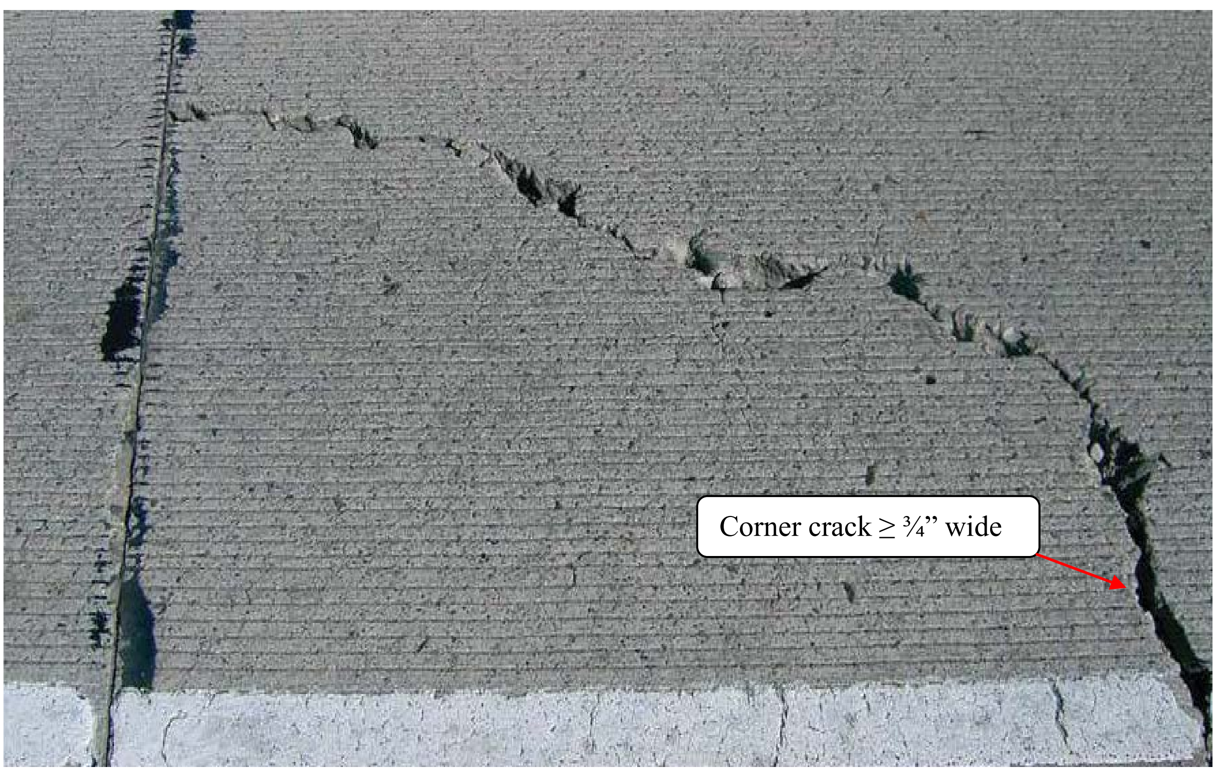



**Figure 320-2: Replace slab – severe corner crack ≥ 3/4" wide**

**Figure 320-3: Replace slab – transverse crack ≥ ¾" wide with spalling**

**Figure 320-4: Replace slab – 3rd stage cracking ≥ ¾" wide with minor spalling**

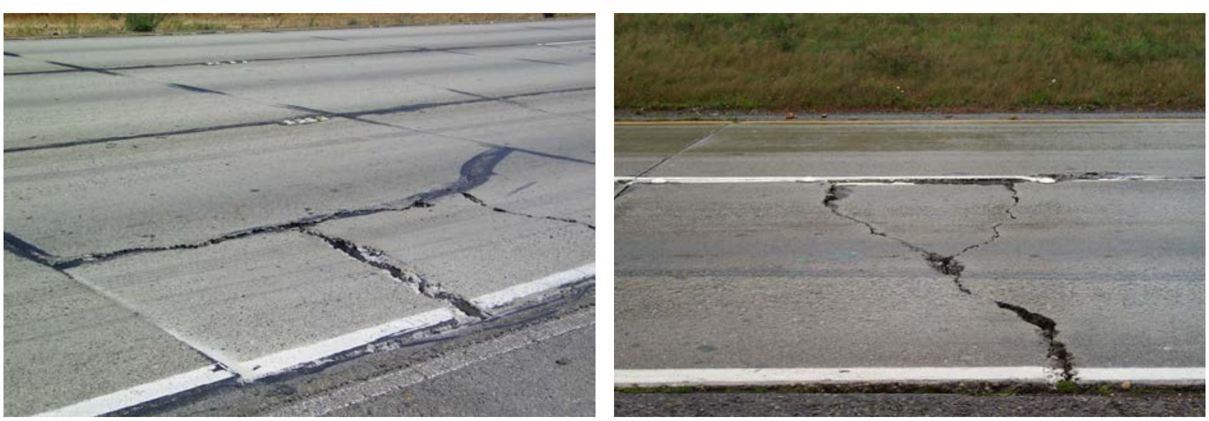


**Figure 320-5: Replace slab and base – 3rd stage cracking ≥ ¾" wide, settlement ≥ ¼", spalling**

### *320.2.2 Replacing Base*

The most appropriate type of slab repair must be determined based on the condition of the entire pavement structure to be repaired, including the need to remove and replace the existing base. Performing only slab replacement when the underlying base is deteriorated will lead to early slab replacement failure, sometimes in < 1 year, resulting in additional repairs and increased cost. Conversely, replacing good base unnecessarily will increase the construction time and cost.

Determining when underlying base should be replaced is one of the more challenging aspects to engineering slab replacements since the base layer is not visible until construction. Coring and GPR can be used to investigate condition but have limitations including time, expense, and accuracy. The most efficient method for estimating base replacement during design is to use the surface distresses of the concrete slab to indicate base failure (see Table 320-3), considering that deteriorated base can extend beyond an individual slab into adjacent areas. Distress indicators include:

- Cracking with settlement > ¼"
- Rocking slabs (typically with pumping fines)
- Spalling > 2ft$^2$ total or > 2" wide over 75% of the crack length

Assuming base failure and replacement for all adjacent slabs is not practical, but adding 5% to the identified slab replacement quantity is a reasonable estimate without any other data. It should be possible to approximate the total estimate for base replacement within 25% of the final quantity, which will ultimately be determined during construction when slabs are removed and the base condition can be analyzed.

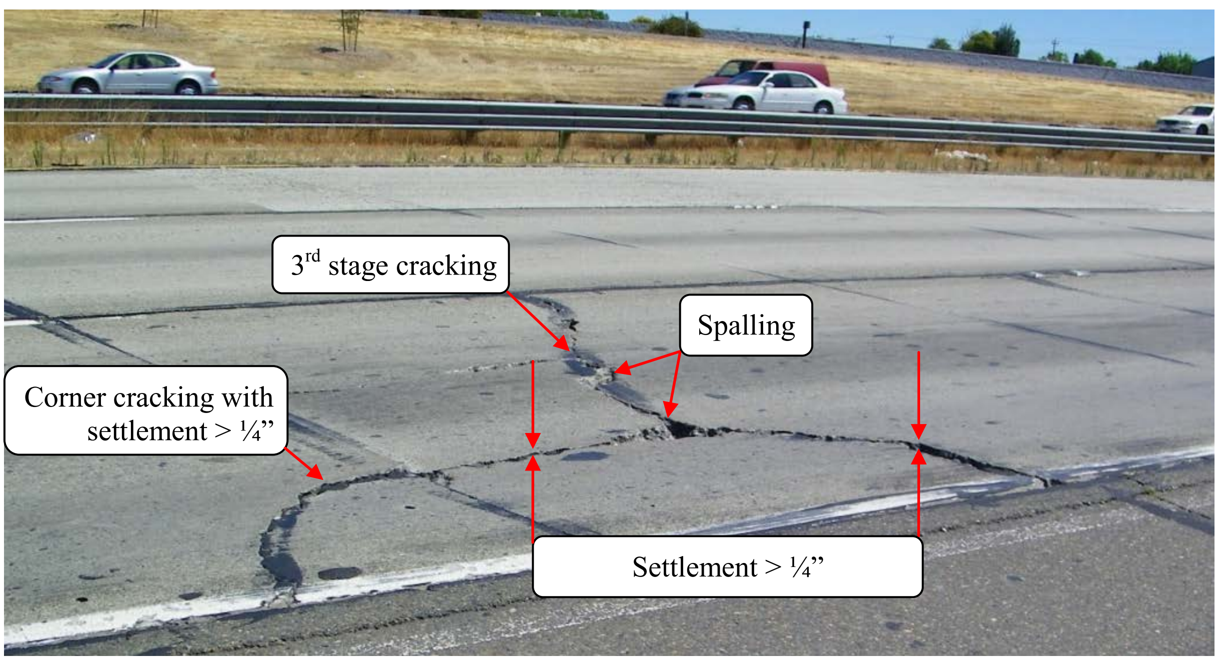



**Figure 320-6: Replace slabs and base – corner and 3rd stage cracking with settlement > ¼"**

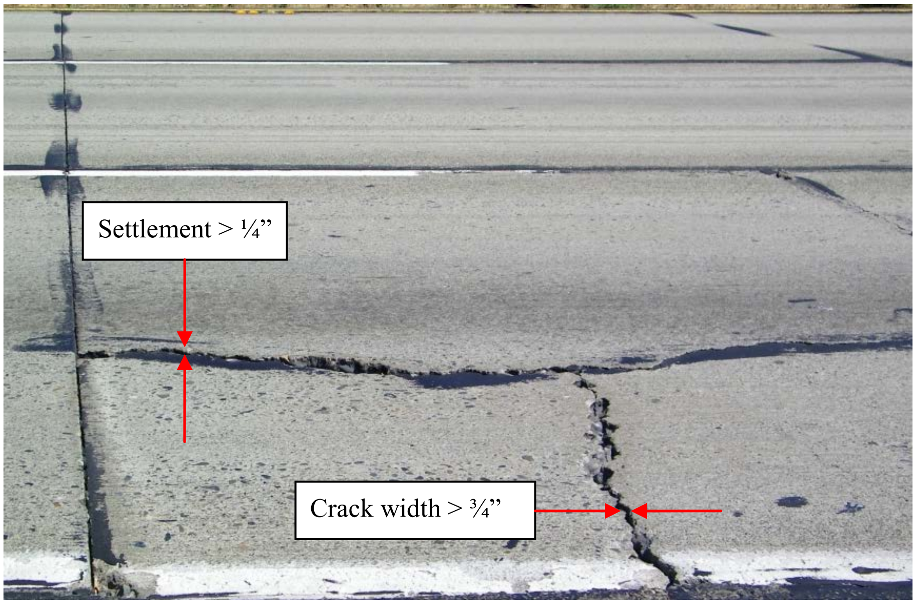



**Figure 320-7: Replace slab and base – 3rd stage cracking and settlement**

### *320.2.3 Other Repair Strategies*

Cracks, spalls, and other distresses which do not meet the slab replacement criteria in Table 320-3 should be repaired using another strategy (see Table 100-1) or left in-place, except for situations when continuous removal is more cost effective (see Section 320.4.2). Some cracks do not affect the functional pavement serviceability for supporting traffic loads (see Figure 320-8) or result from construction defects in the original pavement (see Figure 320-9).

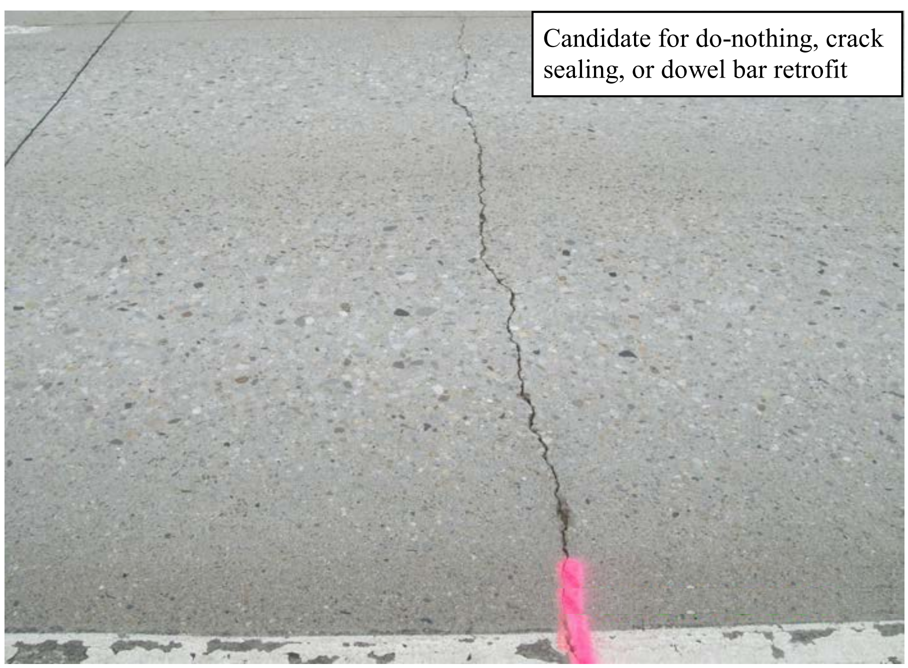



**Figure 320-8: No replacement – narrow transverse crack < ¾” with no settlement**

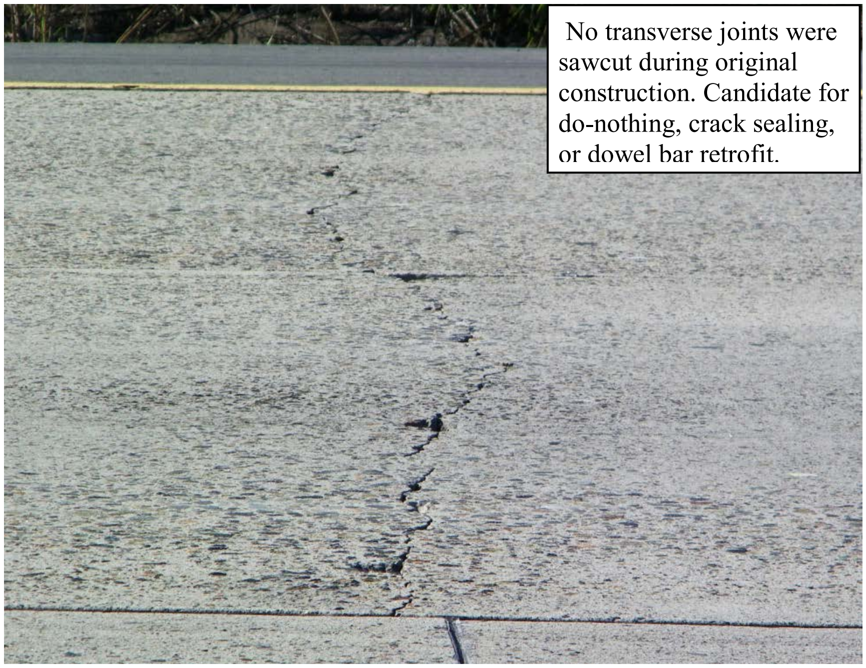



**Figure 320-9: No replacement – voluntary transverse crack < ¾" with minor spalling < 2ft$^2$**

## 320.3 MATERIALS

Slab replacement materials are selected based on a number of considerations, including strength, available curing time, prevailing climatic conditions, cost, equipment requirements, mixing and placing time, desired service life, and the size and depth of repairs. In addition, material-specific properties, such as strength gain, modulus of elasticity, bond strength, scaling resistance, sulfate resistance, abrasion resistance, shrinkage characteristics, coefficient of thermal expansion, and freeze-thaw durability can be considered in the selection process.

The district materials engineer should be consulted regarding desired material properties, unusual base and subgrade issues, and new potentially innovative technologies. The current state of practice in concrete pavement repair allows for virtually any opening time requirement using either conventional cementitious materials, rapid strength concrete (RSC), or precast concrete panels. However, RSC mixes and precast panels have higher costs, typically require special handling, are more difficult to construct, and are more likely to fail prematurely when not properly constructed. HMA is less expensive but is not recommended for extended-term slab replacements.

### *320.3.1 Base Replacement Materials*

Rapid strength concrete base (RSCB) or lean concrete base rapid setting (LCBRS) is used to replace existing base under individual slab replacements. RSCB is RSC that complies with Section 90-3 of the Standard Specifications, although it must be placed separately from the RSC pavement surface using a bond breaker. Using RSCB instead of LCBRS can simplify the slab replacement construction operation and add strength to the pavement structure.

### *320.3.2 Base Bond Breaker*

Base bond breaker is a material used to reduce friction between concrete pavement and base material that can lead to cracking. 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.

### *320.3.3 Cast-in-Place Cementitious Materials*

Cast-in-place cementitious RSC materials are most commonly used for slab replacement because of the need for high early strength before opening to traffic. Standard Specification Section 90-3 allows the contractor to design the concrete mix depending on available curing time. Generally, 4 types of concrete mixes are used for slab replacement:

**Table 320-4: Concrete Mix Types**

| Typical Curing Time (hours) | Concrete Mix Type |
|---|---|
| 2–4 | Specialty high early strength cement mixes. The cement may be portland, non-portland, or blended. |
| 4–6 | In addition to specialty cements, Type III portland cement with non-chloride accelerators and high-range water-reducing admixture may be used if shrinking and early age cracking requirements are met. |
| < 24 | Type II portland cement with non-chloride accelerators |
| ≥ 24 | Conventional Type II portland cement* |

*Note: preferred for lower cost and superior performance when strength can be attained before traffic opening.

The use of calcium chloride ($CaCl_2$) accelerators to achieve rapid strength is not allowed since they can double the rate of steel corrosion and concrete shrinkage, resulting in excessive slab cracking.

Although RSC repair materials can provide effective solutions for early opening to traffic, there are also associated performance concerns. For example, NCHRP Report 540 about early-opening-to-traffic (EOT) RSC mixtures noted that many such mixtures contain higher cement contents and multiple admixtures, which can lead to increased shrinkage, altered microstructure, and unexpected interactions(3). Furthermore, the study noted:

- Durable 6 to 8-hour and 20 to 24-hour EOT repairs can be constructed, but the 6 to 8-hour EOT rapid strength concrete materials are more prone to durability-related problems, heightening the risk of premature failure.
- Difficulty in achieving an adequate entrained air-void system was associated with EOT concrete, resulting in paste freeze-thaw deterioration and deicer scaling.
- Increasing cement contents do not necessarily increase concrete strength, and in fact may adversely affect the durability of the RSC mixture.
- Increased problems may result from interactions between the various mixture constituents. Extensive testing should be conducted on the actual job mixture during the mix design stage.

### *320.3.4 Precast Concrete*

The use of precast concrete panels for slab replacement is currently under development. It offers the potential of rapid construction using conventional cementitious materials that are cast and cured away from the construction site, which could produce longer lasting slab replacements for a higher initial construction cost. In 2012, precast concrete pavement was about 30% to 100% more expensive than RSC according to contract cost data. Because of their high cost, precast concrete panels are best used where:

1. Traffic handling and detour options preclude the use of cast-in-place mixes that cure in 8 hours or more.
2. The existing pavement is expected to be structurally adequate or sound for at least the next 20 years, such as for ramps and inside, HOV, HOT, or other lanes where trucks are not permitted.

Precast concrete slab replacement is currently considered experimental, so use on a project must be approved by the HQ Division of Maintenance Pavement Program. Please refer to HDM Topic 621 and contact the Pavement Program for the most current information.

### *320.3.5 Hot Mix Asphalt*

Using hot mix asphalt (HMA) materials for individual slab replacement is a nonstandard strategy that should only be considered in the following situations:

- As a responsive repair when deteriorated slabs need to be replaced before a project can be programmed or advertised (as determined by the district maintenance engineer or deputy district director of maintenance). If a project cannot be programmed and advertised within 5 years, concrete should be used to replace the slab, even for responsive repairs.
- As a short-term solution for a roadway that has a planned project to rehabilitate the lane within 10 years.
- When doing slab replacement repairs as part of an overlay project.

For better performing slab replacement with HMA, the best practice is to use a stiffer, more angular mix with a warm mix additive to aid compaction and cooling time. HMA is not recommended for extended-term repairs of concrete pavements because it can allow horizontal movement of adjacent slabs, provides no load transfer across transverse construction joints, and creates a patchwork of unsightly black and white surfaces.

Please consult with HQ Office of Concrete Pavement and Pavement Foundations regarding nonstandard special provision approval to use HMA for slab replacement.

## 320.4 DESIGN ISSUES

Design issues for slab replacement include dowel bar use, order of work, repair locations and boundaries, pavement smoothness, load transfer, design features, project plans and specifications, and cost estimating.

### *320.4.1 Order of Work*

The sequence of work for slab replacement is very important for isolated repairs whether done independently or as part of a comprehensive pavement project. The following order of applicable work is recommended for pavement construction:

1. Slab subsealing or jacking should be done before spall repair so any accidental spalling that occurs can be readily repaired (see Ch. 300).
2. Spall repairs should be done before or concurrently with isolated slab replacement in case adjustments to locations or boundaries are necessary as construction proceeds (see Ch. 310).
3. Repair existing edge drains. Cap off any edge drains that are plugged and repair pipes and outlets where existing edge drains are still functioning.

4. Repair or reconstruct shoulders. Depending on the extent of distress, existing shoulders with minimal distress should be fog sealed, milled and filled when localized surface distress or minimal shoulder drop-off is present, or reconstructed when severe cracking or severe shoulder drop-off is present (see HMA Pavement Guide).
5. Diamond grinding should follow spall repair, isolated slab replacement, and dowel bar retrofit to restore pavement surface smoothness and avoid intermittent grinding that unnecessarily reduces the concrete thickness (see Ch. 340).
6. Joint sealing or joint seal replacement should be completed as needed following other repair strategies (see Ch. 360).

### *320.4.2 Repair Locations and Boundaries*

Visual surveys are needed to identify individual slab replacement locations and estimate quantities during preliminary and final project design, and to verify locations and boundaries during construction. Identifying definitive repair boundaries is critical to completing a project quickly and ensuring good repair performance. Ensuring that all deterioration is included within the repair boundaries minimizes the need for additional, unplanned saw cutting and concrete removal work. Using the criteria in Section 320.2, project designers should also consult with the district maintenance engineer and area field personnel when selecting slabs for replacement. If existing spalls are deeper than 1/3 the slab thickness, slab replacement should be used as the repair strategy.

The pavement management system contains a visual record of every mainline concrete slab in the state, accessible online through the iVision software program at https://ivision.fugro.com/CaliforniaSH/#/Login. Visual and distress data are scheduled for collection biannually, so the available information can provide approximate pavement conditions but may not reflect the most current conditions, which should be verified with a field review to identify unrecorded or recent distress and potential failure mechanisms, such as issues with surrounding terrain or drainage conditions (see Section 110.2). It may be possible to effectively survey the traveled way from median and outside shoulder areas during non-peak daytime hours. Blank slab replacement field review forms are included in Appendix 320-1.

A follow-up field evaluation should be performed during PS&E or construction as close as possible to the scheduled repair work so any additional deterioration that developed since the latest estimate is repaired.

Engineering judgment, coring, and sounding techniques can be used to identify the extent of the deterioration beneath the surface and determine final repair boundaries. Refer to Standard Plan RSP P-8 and the criteria below regarding the sizing and layout of slab replacements:

- *Minimum length*: It is generally recommended that the entire panel length is replaced for 3rd stage cracking, settlement, or severely spalled cracks. Partial length slab replacement may be used on panels longer than 13’ when the damage (corner crack, joint spalls, etc.) is only on one side of the slab. A minimum repair length of 6.5’ is recommended to minimize rocking, pumping, and premature breakup of the slab.
- *Minimum width*: Always replace the full slab width between longitudinal joints because the boundaries are well defined and the repair is more stable.
- *Joints* (see Figure 320-10):

- Match the spacing and skew of transverse joints in the existing pavement for cast-in-place and HMA replacements, except any slab replacement ≥ 15’ long must have an intermediate transverse joint located at mid-panel to prevent uncontrolled cracking.
- When the transverse joints in adjacent lanes do not match, the longitudinal joints must have an isolation joint to separate the new and existing pavement, preventing the intermediate slab replacement joint from causing cracks in the adjacent lanes.

- *Adjacent joints/cracks*: A slab replacement joint should be at least 6.5’ from the nearest joint or crack to prevent the development of adjacent slab deterioration.
- *Adjacent base deterioration*: Deteriorated base can extend beyond an individual slab into adjacent slabs that will require partial or complete replacement to minimize additional failures. Consider replacing adjacent slabs outside the criteria given in Table 320-3 if distress includes 3rd stage cracking, crack widths > ½”, corner cracks with widths > ¼”, or settlement.

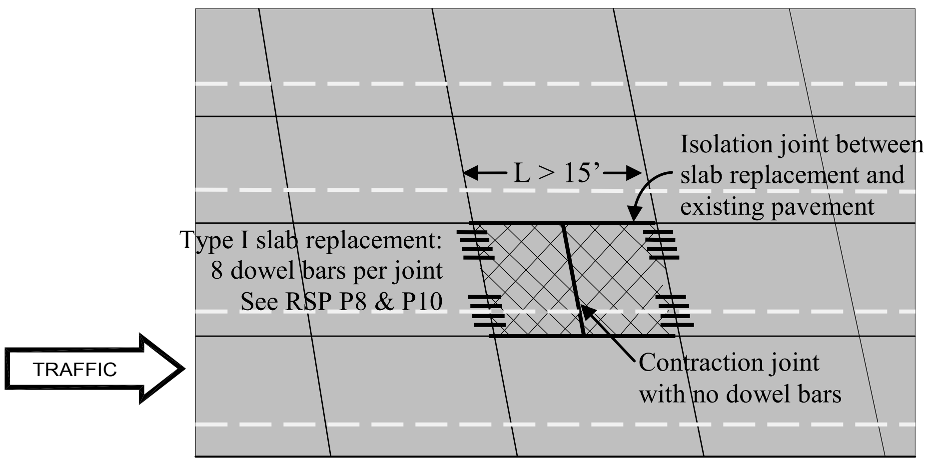



**Figure 320-10: Example joint and dowel requirements**

Because of the time and labor cost involved in preparing the transverse construction joints for slab replacement, it may be more cost effective to combine closely located replacement areas into one larger repair area, allowing a continuous concrete pour and potentially improving pavement performance. Figure 320-11 shows some examples of cost effective replacement area combinations.

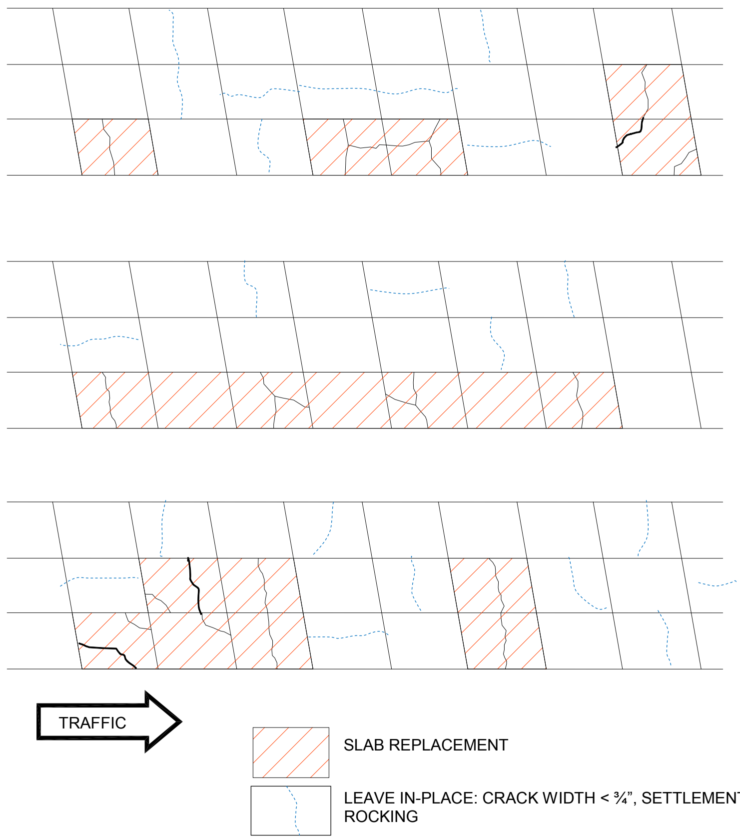



**Figure 320-11: Example slab replacement repair areas**

### *320.4.3 Dowel Bar Use*

Load transfer is the ability of a joint or crack to transfer a portion of an applied traffic load from one side to the other (see Section 120.3.2). Since saw cutting around the slab replacement perimeter results in a smooth vertical surface with no aggregate interlock, dowel bars are recommended for extended term repairs ≥ 5 years to restore load transfer at transverse construction joints (refer to Type I in Revised Standard Plan RSP P-8). Restoring load transfer helps minimize differential vertical movement that can cause spalling, rocking, pumping, faulting, and premature failure of the replacement or adjacent slabs.

Dowel bars should be installed using the drill and bond method unless the construction window is too short to allow the operation (see 2010 Standard Specification Section 41-10). As an alternative, dowel bars may be installed from the pavement surface after slab replacement using the dowel bar retrofit method (see Ch. 330). Dowel bar retrofit is not preferred for slab replacements due to increased cost and failure potential.

Dowel bars are not necessary in transverse contraction joints saw cut between newly placed slabs because aggregate interlock is expected to provide adequate load transfer throughout the anticipated service life of the slab replacement. Recent data gathered statewide indicated dowels can potentially reduce 3rd stage cracking in replaced RSC slabs, but placing dowels in contraction joints of RSC with moderate shrinkage can cause excessive slab curling stresses.

### *320.4.4 Pavement Smoothness*

Achieving a smooth surface is a challenge with slab replacement work. Consider including diamond grinding to correct smoothness issues associated with poor construction practice and workmanship if the existing pavement meets the criteria in Chapter 340 and HDM Topics 622 and 624.

## 320.5 PLANS, SPECIFICATIONS, AND ESTIMATING

### *320.5.1 Plans*

A complete set of slab replacement plans requires these sheets:

1. Title sheet showing limits of project
2. Typical cross sections showing existing pavement widths and thicknesses
3. Quantity sheets specifying the type and amount of work.
    - Locations of slab replacement and other work should be tabulated in the quantity tables rather than shown on layout sheets, even if layout sheets are provided for other work. Include the following note: "Locations shown for individual slab replacement and replacing underlying base in quantity tables are approximate. Final locations will be determined by the Engineer."
4. Construction details for unique items of work not addressed on other plan sheets
5. Standard plans listed in Table 320-5:

**Table 320-5: Standard Plans for Individual Slab Replacement**

| Design Feature | Plan | Comments |
|---|---|---|
| Individual Slab Replacement with Rapid Strength Concrete | P8 | Details for 2 types of RSC slab replacements:<br>• Type I uses drill and bond dowel bars at transverse construction joints for extended term repairs (5-10 years).<br>• Type II without dowels for short term repairs (≤ 5 years) or for crack, seat, and overlay projects. |
| Joint Sealing | P20 | Use when existing joint seals need to be replaced. |
| Dowel Bar Details | P10 | Use for Type I slab replacements with dowel bars |

### *320.5.2 Specifications*

Standard Specifications, Standard Special Provisions (SSPs), and additional information on nSSP's for individual slab replacement work are listed in Table 320-6:

**Table 320-6: Specifications for Individual Slab Replacement**

| Item Code | Description | 2010 and 2015 Standards | Special Provisions | Comments |
|---|---|---|---|---|
| 411105 | Individual Slab Replacement (RSC) | 41-9<br>90-3 | | For standard slab replacement work. Includes payment for base bond breaker. |
| Nonstandard | Individual Slab Replacement (precast concrete) | | nSSP* | Use with approval for precast concrete. Include nonstandard construction details. |
| Nonstandard | Individual Slab Replacement (HMA) | 39 | nSSP* | Use with approval for HMA. Include nonstandard construction details. |
| Not used | Base Bond Breaker | | 36-2 | Should be included for all individual slab replacement work. Specifies bond breaker materials and placement. |

| Item Code | Description | 2010 and 2015 Standards | Special Provisions | Comments |
|---|---|---|---|---|
| 280200 | Replace Base | | SSP 28-15 | Should be included for all slab replacement work. |
| Nonstandard | Lean Concrete Base (3/8") | | nSSP* | Use for individual slab replacement with precast concrete. |
| 410096 | Drill and Bond (Dowel Bar) | 41-10 | | Use for each bar at construction joints of Type I RSC slab replacements. |
| Various | Replace Joint Seal | 41-5 | | Use when existing joint seals need to be replaced because of slab repair. Match the existing joint seal material. |

*nSSPs must be approved by the HQ Division of Maintenance Pavement Program. Contact the Office of Concrete Pavement and Pavement Foundations.

Existing base removal specifications are in SSP 28-15 "Replace Base," which also includes payment for the RSCB or LCBRS replacement material and placement. SSP 28-15 must be used together with the appropriate materials specifications in SSP 28-3 for RSCB or 28-4 for LCBRS.

Standard Specification Section 41-9 and SSP 36-2 allow the contractor to select various bond breaker materials such as polyethylene film, curing paper, or geosynthetics for RSCB or LCBRS. Payment for base bond breaker is included in bid item #411105 for individual slab replacement.

When individual slab replacement and other pavement repairs are included in a project, include order of work provisions when applicable (see Section 320.4.1 for recommendations).

The cost current standard specifications, special provisions, and plans are available through the Office Engineer Office of Construction Contract Standards website: http://oe.dot.ca.gov.OCCS.html.

### *320.5.3 Precast Concrete Pavement Issues*

The use of precast concrete systems for slab replacement introduces some unique issues. Whereas cast-in-place systems typically require placing and curing new material in a hole created by the removal of broken slabs, precast systems are built off site using prebuilt forms. Since existing pavement thicknesses vary, establishing exact dimensions for each precast replacement slab during casting or at the site by saw cutting is very expensive and time consuming. To avoid unnecessary construction costs, use the following design features in precast panel system project plans:

1. The construction details developed for use statewide allow for adequate sizing so panels can be trimmed, either to re-establish the original longitudinal joint location between adjacent precast replacements or to customize installations adjacent to gutters. In general, the goal is to cut the hole to fit the precast slab rather than cutting or casting the precast slab to fit the hole.
2. Joints: use perpendicular transverse joints for new precast slabs rather than matching existing skewed joints.
3. Thickness: design the precast panels ½" thinner than the existing concrete thickness. To establish the existing pavement thickness, check ground penetrating radar data from the pavement management system, as-built plans, or consider coring.
4. Length: give Contractor flexibility to select the length of the panel to use for the slab replacement. Precast panel details should require a minimum 8' length panel that extends at

least 0.10’ beyond the slab replacement limits. Any existing concrete slab left in place must be at least 6’ long.

5. Width: construct the precast slab 0.15’ wider on each side to address potential variability in the existing slab width.
6. Curves: for locations on curves, precast concrete panel plans must show the existing centerline radius information (from as-built data) for trapezoidal construction details.

Precast concrete pavement is an experimental product. Until standard plans, specifications, and guidance are adopted, contact the HQ Division of Maintenance Pavement Program for approval and assistance regarding precast concrete pavement use.

### *320.5.4 Cost Estimating*

It is critical to make a reasonable estimate in the Project Report (PR) or Project Scope Summary Report (PSSR) when programming project funding for slab replacement. Estimates should be based on locations and boundaries identified from APCS, iVision, and field reviews, but reasonably conservative to avoid underestimation, account for invisible deterioration below the pavement surface, and anticipate additional deterioration prior to construction. The slab failure rate over several years at the project location can be used as an indicator of how many additional slabs may fail prior to construction completion. Approximately 15-20% additional slab replacement is typically reasonable. If better information is not available when preparing the cost estimate, assume 20% of the slab replacements will also require base replacement.

For the engineer’s estimate at PS&E, any previous quantity estimates should be updated to reflect existing distress levels. Quantities should be based on current pavement condition data from the pavement management system and verified with a field review as close to PS&E as possible, using the criteria in Section 320.2. The updated estimate should also account for future deterioration likely to occur prior to scheduled project construction, which can be predicted using deterioration rates established from historical pavement condition data or percentage rates based on engineering judgment. Generally, adding 5% to the slab replacement quantity to account for unforeseen locations and additional deterioration is reasonable. While estimates should be conservative to avoid underestimation, overestimating the final estimate for PS&E can lead to slabs that are in good condition being replaced with potentially poorer performing replacements in order to match the estimated quantity.

Accurate quantity estimates should be within 75 to 125% of the actual amount repaired during construction. Slab and base replacement quantities will fluctuate during construction because field conditions change and the actual base condition is unknown until the concrete surface is removed.

Unit Costs

Unit prices for slab replacement vary from project to project in different areas of the state. District construction personnel have unique knowledge and should be consulted about constructability issues that can affect cost such as: traffic handling and closure windows, equipment mobilization, haul routes, delivery times, and availability of rapid strength concrete plant production and scheduling.

Initial construction costs can be estimated using historical contract cost data for all contracted bid items and other information available on the Division of Design cost estimating website at http://www.dot.ca.gov/hq/oppd/costest/costest.htm. Currently, Item 411105 is used for Individual Slab Replacement (RSC), but cost data may be limited. Previously, Items 401000 or 401108 were used for slab replacement. If historical cost data for an item is limited or not reasonable for the project conditions, adjust the unit cost estimate for differences in available data. For approximate estimates of cast-in-place RSC or precast slab replacement, the multipliers in Table 320-7 for Item 401000 "Concrete Pavement" or Item 401050 "Jointed Plain Concrete Pavement" can be used:

**Table 320-7: Slab Replacement Unit Cost Estimation**

| Construction Window (hours) | Cast-In-Place RSC Multiplier | Precast Multiplier |
|---|---|---|
| 6 – 8 | 3 – 5x | 5 - 8x |
| 12 – 24 | 2x | 3x |
| > 24 | 1x | 1.5x |

Additional Bid Items

A successful slab replacement project may also require additional pavement bid items for replacing base, spall repair, repairing asphalt concrete shoulders or ramps, sealing cracks, and replacing existing joint seals. Replacing the entire joint seal along the slab replacement and sealing cracks will reduce future slab failures by preventing intrusion of incompressible materials and surface water. For joint seals, use the bid item that matches the existing seal material. Reseal both longitudinal and transverse repair joints according to 2010 Standard Specification Section 41-5 using asphalt rubber, silicone, or preformed compression seal material. For more detailed information on joint sealing, refer to Chapter 360.

Bid items for typical slab replacement pavement work are shown in Table 320-8:

**Table 320-8: Typical Individual Slab Replacement Pavement Work Bid Items**

| 2010 and 2015 Standards | | | Prior Standards (for estimating unit costs only) | |
|---|---|---|---|---|
| Item Code | Description | Unit | Item Code | Description |
| 280200 | Replace Base | CY | --- | Previously included in other bid items |
| 410096 | Drill and Bond (Dowel Bar) | EA | 406050 | Dowel Bar (Drill and Bond) |
| 411105 | Individual Slab Replacement (RSC) | CY | 401108 | Replace Concrete Pavement (RSC) |
| 410120 | Spall Repair (Polyester Concrete) | SQYD | 413113 | Repair Spalled Joints (Polyester Grout) |
| 410121 | Spall Repair (Fast-setting Concrete) | SQYD | 413112 | Repair Spalled Joints (Fast-setting Grout) |
| | | | 413111 | Repair Spalled Joints |
| 414222 - 414224 | Replace Joint Seal (Preformed Compression) - *3 size ranges* | LF | 413114 | Replace Joint Seal (Existing Concrete Pavement) |
| 414221 | Replace Joint Seal (Silicone) | LF | 414119 | Replace Concrete Pavement Joint (Silicone) |
| 414220 | Replace Joint Seal (Asphalt Rubber) | LF | 414120 | Replace Concrete Pavement Joint (Asphalt Rubber) |
| Nonstandard | Seal Cracks | LF | 414105 | Seal Random Cracks |
| | | | 414111 | Rout and Seal Random Cracks |

### *320.5.5 Production Rates*

Slab replacement production rates are dependent on lane closure restrictions, location, and the replacement materials used. Longer construction windows are more cost effective and yield greater production, as do replacements in outer lanes compared to center lanes. If slab replacement locations are more than a mile apart, re-mobilization may be required, greatly reducing production rates. If locations are in a confined area that does not accommodate large equipment, time-consuming maneuvering, hand-working, or special equipment may be required.

RSC is typically the most efficient material for slab replacement production. Precast concrete panels are hindered by a complicated installation process that may be unfamiliar to many contractors, while

HMA must be placed in multiple lifts that need to cool before overlaying. If the base needs replacing, production will be reduced by up to 20 minutes per slab.

When determining the number of working days, preproduction lead time also must be considered:

- For RSC, allow 20 working days for mix design verification and trial slab construction.
- Precast concrete pavement is fabricated at a plant, which requires at least 30 days lead time for forming, pouring, and curing. If the contractor proposes modifications to the precast plans, an additional 30 working days could be required to review shop drawings.
- For HMA, allow 25 days for job mix formula verification.

Table 320-9 contains an estimated range of production rates based on replacement material:

**Table 320-9: Estimating Individual Slab Replacement Working Days**

| Replacement Material | Preproduction Lead Time (working days) | Estimated Production Range (slabs/ 8-hr shift) |
|---|---|---|
| RSC | 20 | 20 – 32 |
| Precast concrete panels | 30 – 60 | 16 – 28 |
| HMA (2" lifts) | 25 | 15 – 25 |

## 320.6 OTHER CONSIDERATIONS

### *320.6.1 Traffic Control and Safety*

Proper traffic control must be placed and maintained on all slab replacement projects for the safety of the traveling public and construction personnel. Providing the maximum construction window is important to reduce worker safety risk, decrease construction cost, and improve slab replacement performance. Longer performing repairs reduce the need for future maintenance and construction activities, increasing safety and life-cycle cost effectiveness.

Considering the project location, size, and scope of work, weekend closures should be used wherever possible, particularly for slab replacement in the far inside or outside lanes. Often, even roadways in high traffic volume areas do not require all lanes during the weekend.

Due to typical traffic demand, a temporary nighttime closure may be necessary to complete slab replacement work, particularly for inner lanes where slab replacement may require closure of multiple lanes at once. Although concrete work can be done in lane closure windows as small as 5 hours, longer windows of 8 to 12 hours provides contractors more time to mobilize, work, and cure concrete, increasing performance and lowering bid costs. Night closures are the least desirable traffic handling alternative due to extended traffic impacts and adverse effects on construction quality, workmanship, production rates, and performance.

Refer to Section 120.3.4 for more detailed information about traffic handling alternatives.

### *320.6.2 Resident Engineer File*

Provide the resident engineer with the criteria and field notes used to select slabs and underlying base for replacement. See Appendix 320-2 for an example Resident Engineer Note.

For precast concrete slabs, include as-built plans showing the centerline curve radii. During construction, volumetric mixing trucks should be available as a contingency to provide material for failed base or removals that are considerably deeper than expected.

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8. Correa, A. L. and B. Wong. 2003. *Concrete Pavement Rehabilitation—Guide for Full-Depth Repairs*. FHWA-RC Atlanta 1/10-03 (5M). Federal Highway Administration, Atlanta, GA.

9. Yu, H. T., J. Mallela, and M. I. Darter. 2006. *Highway Concrete Technology Development and Testing Volume IV: Field Evaluation of SHRP C-206 Test Sites (Early Opening of Full-Depth Pavement Repairs)*. Report FHWA-RD-02-085. Federal Highway Administration, Washington, DC.

# APPENDIX 320-1: Individual Slab Replacement Forms

## Distress Map

**CO-RTE-PM:** **Direction:** **Page:**

**Panel No.:** **Date:**

**Lane**

___

**Lane**

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___ft ___ft ___ft ___ft ___ft ___ft ___ft

**Comments:** ______________________________

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**Panel No.:**

**Lane**

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**Lane**

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___ft ___ft ___ft ___ft ___ft ___ft ___ft

**Comments:** ______________________________

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# APPENDIX 320-1: Individual Slab Replacement Forms

## Field Data Summary Form

**CO-RTE-PM:** ______________________ **Date:** _______________

**Direction:** ______________

| Lane | Panel No. | Cracking | | Faulting | Pumping | Other | Photo | Comment |
|---|---|---|---|---|---|---|---|---|
| | | Type | Severity | inch | (y/n) | Distress | no. | |
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**Cracking type:**

TC = transverse; LC = longitudinal; CB = corner break
SS = Shattered Slab (3rd Stage with intersecting cracks)

**Other distress type:** ASR = Alkali-silica reactivity; R = Rutting

**Transverse Cracking**

| Associated Distress | Severity | | |
|---|---|---|---|
| | Low (L) | Medium (M) | High (H) |
| **Crack width (in)** | < ¼ | ¼ – ¾ | > ¾ |
| **Faulting (in)** | < ¼ | ¼ – 1 | > 1 |
| **Spall area ($ft^2$)** | < 1 | 1 – 2 | > 2 |

**Longitudinal and Corner Cracking**

| Associated Distress | Severity | | |
|---|---|---|---|
| | Low (L) | Medium (M) | High (H) |
| **Crack width (in)** | < ¼ | ¼ – ¾ | > ¾ |
| **Faulting (in)** | < ¼ | ¼ – 1 | > 1 |
| **Spall area ($ft^2$)** | < 1 | 1 – 2 | > 2 |

# APPENDIX 320-1: Individual Slab Replacement Forms

## Slab Replacement Summary Form

**CO-RTE-PM:** ____________________ **Date:** ____________________

**Direction:** ____________

| Lane | Panel | Cracking | | Faulting | Pumping | Material | Replace (y/n) | | Repair size (ft) | | Dowel | Jt. Seal | Grind | Photo | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Type | Severity | inch | (y/n) | Distress | Slab | Base | Width | Length | (y/n) | (y/n) | (y/n) | no. | |
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**Cracking type:**

TC= transverse; LC = longitudinal; CC = corner

SS = Shattered Slab (3rd Stage intersecting cracks)

**Other distress types:** ASR = Alkali-silica reactivity
R = Rutting

**Associated Distress:**

| | Transverse Crack | | | Longitudinal & Corner Crack | | |
|---|---|---|---|---|---|---|
| | Severity | | | Severity | | |
| | Low (L) | Med (M) | High (H) | Low(L) | Med (M) | High (H) |
| **Crack width** | < ¼ | ¼ – ¾ | > ¾ | < ¼ | ¼ – ¾ | > ¾ |
| **Faulting (in)** | < ¼ | ¼ – 1 | > 1 | < ¼ | ¼ – 1 | > 1 |
| **Spall area ($ft^2$)** | < 1 | 1 – 2 | > 2 | < 1 | 1 – 2 | > 2 |

# APPENDIX 320-1: Individual Slab Replacement Forms

**Slab Replacement Map**

| Direction: | | | | | | | | | Direction: | | | | | | | CO-RTE-PM:___________ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lane | | | | | | | | Lane | | | | | | | |
| | S | 4 | 3 | 2 | 1 | H | S | CENTER DIVIDER | S | H | 1 | 2 | 3 | 4 | S | Notes |
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S = Shoulder H = HOV Lane