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ROAD MAP TRACK 7
Concrete Pavement Maintenance and Preservation

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Moving Advancements into Practice (MAP) Briefs describe innovative research and promising technologies that can be used now to enhance concrete paving practices. This MAP brief provides information relevant to Track 7 of the CP Road Map, Concrete Pavement Maintenance and Preservation.

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"Moving Advancements into Practice"
MAP Brief January-February 2012
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Full-Depth Repairs for Concrete Pavements

Introduction

A full-depth repair (FDR) is defined as a cast-in-place concrete repair that extends through the full thickness of the existing pavement.

FDRs are an effective method to extend the service life of a pavement when used in the correct repair applications. Typically, FDRs are appropriate for pavements with distresses that are material related or distresses that extend beyond the upper half of the pavement and affect ride or safety (figure 1). Distresses that are located in the upper half of the slab can be addressed with partial-depth repairs.

Specific types of distress include transverse cracking, corner breaks, longitudinal cracking, deteriorated joints, blowups, and punchouts. FDRs may also be used in conjunction with bonded or unbonded concrete overlays.

Project Selection

Concrete pavements with deterioration primarily surrounding joints or cracks are good candidates for FDRs, particularly if the deterioration is in a concentrated area and not throughout the length of the pavement. If the FDR repair area is greater than five to ten percent of the total pavement area, the effectiveness of a FDR is reduced. FDR can be used in jointed concrete, jointed reinforced concrete, and continuously reinforced concrete pavements.

Figure 1. Deteriorated pavement that is a good candidate for FDR

In pavements with severe material-related problems, such as high levels of D-cracking, or reactive aggregate, such as alkali-silica reaction, FDR will only provide temporary relief and the distresses will likely reoccur.

Materials and Design Considerations

Extensive subsurface deterioration is often prevalent near punchouts or at faulting along the longitudinal joint. Studies and investigations are recommended to determine the extent of the deterioration and to understand the magnitude of the project.

Material and design considerations vary between jointed concrete pavement (JCP)and continuously reinforced concrete pavement (CRCP).

Jointed Concrete Pavements

Accurate sizing of the repair is essential to a successful FDR. Sometimes the deterioration at the bottom of the slab may extend as much as 3 ft outside the visual deterioration on the surface when the pavement has a material-related distress (figure 2). The repair dimensions can be identified through coring and deflection tests.

For pavements with dowels, 6 ft is the recommended minimum repair length to reduce pumping or break-up of the slab. Full width replacements are preferred because they result in a more stable patch due to the well-defined boundaries.

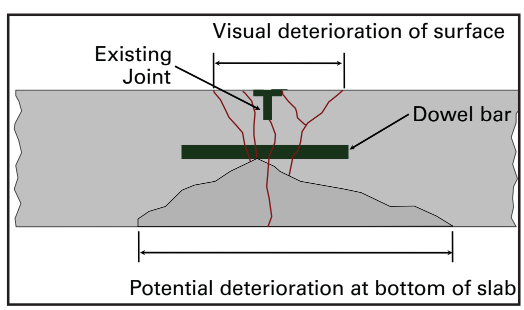

Figure 2. Deterioration beneath joint

In non-doweled pavements, the recommended minimum repair length is 6 to 10 ft. Other FDR recommendations include the following:

- Saw to full depth a minimum of 2 ft from any joints.
- Use straight-line sawcuts; form rectangles in-line with the jointing pattern.
- Connect patches to make one large patch if the patch is a utility cut. The cuts should be 6 to 12 in. beyond the limits of excavation and made after the trench has been backfilled.

Figure 3 shows recommended replacement boundaries based on the locations and lengths of cracks in relation to joints and lanes.

Continuously Reinforced Concrete Pavement

For CRCP, repair recommendations include the following:

- Minimum repair length of 6 ft is recommended if the reinforcing steel is tied; 4 ft is recommended if the steel is mechanically connected or welded.
- Repair boundaries should be no more than 18 in. from non-deteriorated cracks unless it is unavoidable due to the abundance of cracks. In that case, the repair should be no closer than 6 in.
- Repairs should span a full lane unless the repair can be accomplished in less than half of a lane.

Figure 4 shows recommended replacement boundaries based on the locations and lengths of cracks in CRCP.

Repair Materials

The primary design consideration in material selection is the available lane closure time. Early opening requirements may dictate the need for high early-strength mixes. However, these mixes may have a higher cost and sometimes require special handling procedures to minimize shrinkage and micro-cracking. State highway practices recommend a range between 2,000–3,000 psi (Van Dam et al. 2005). Using the most conventional mix is generally the best approach.

The regional climate of the repair site is another major consideration. High temperatures may preclude the use of fast-setting materials. Conducting a laboratory test using the repair materials is necessary to ensure that the opening strength requirements are met. To maintain durability, 5.0 to 7.5 percent entrained air is required in cold weather regions.

For load transfer on thicker JCP pavements (8 in. or greater), smooth dowel bars are recommended for best performance. 1.5 in. bars are the most effective for load transfer (ACPA 1995) unless the pavement is less than 10 in. thick, in which case 1.25 in. bars may be acceptable. Typically, bars are set 12 in. apart with 4 to 5 bars per wheel path (figure 5).

In CRCP, it is important to maintain the continuity of reinforcement through the FDR; however, a method that does not maintain the continuity of the reinforcement has been utilized for the full-depth repair of a single lane in a multi-lane CRCP (FHWA 2012). The reinforcing in the new pavement should match the existing in grade, quality, and number. New bars should be cut so the ends are 2 in. from the joint face and either tied, mechanically connected, or welded to the existing reinforcement. Use of chairs is recommended during placement to ensure the steel is not bent during the concrete placement.

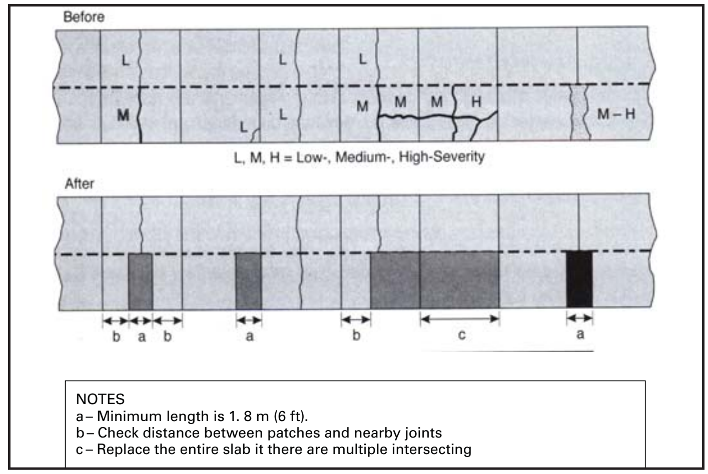

Figure 3. FDR boundaries for JCP (ACPA 2006)

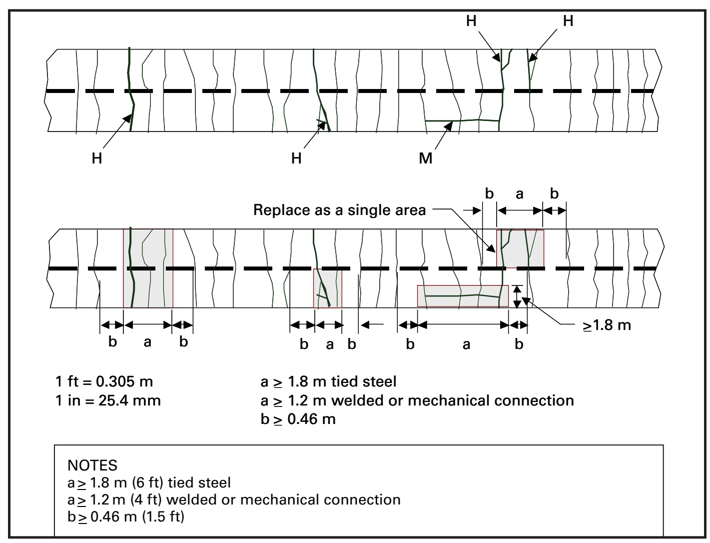

Figure 4. FDR boundaries for CRCP

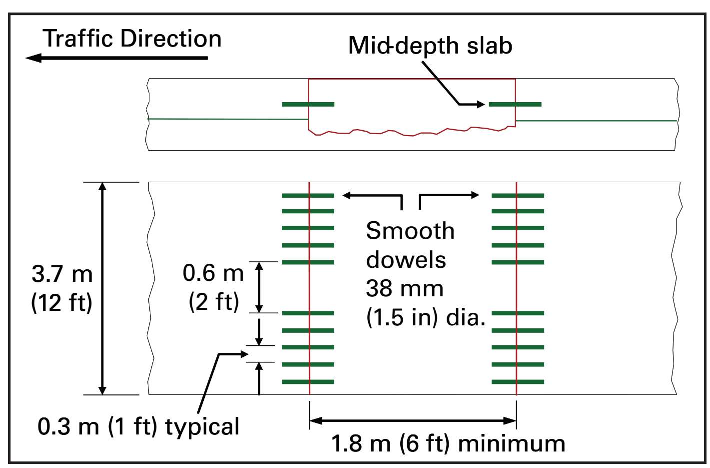

Figure 5. Example dowel bar layout for JCP

Construction Procedures

Typically, full-depth repairs are made with on-site concrete poured panels. However, when the pavement must be opened in a short timeframe or in congested areas such as intersections, precast concrete panel systems have been used. Advancements in the use of precast concrete have been made in recent years (FHWA 2007; FHWA 2010).

Concrete Removal

For JCP, either the breakup and cleanout method (figure 6) or the lift-out method (figure 7) is acceptable for concrete removal. For the breakup and cleanout method, large drop hammers or large jackhammers should not be used because they may cause damage to adjacent pavement. In either method, protection of adjacent pavement is critical.

On exceedingly hot days, pressure relief cuts may be needed within the repair boundaries to prevent spalling of the adjacent surface during concrete removal. If a wheel saw is used, it should not penetrate more than 0.5 in. into the subbase.

For CRCP, the deteriorated pavement must be carefully removed to ensure the remaining reinforcing is not damaged. If the reinforcing is bent, it must be straightened. If more than 10 percent of the bars are seriously damaged or corroded, or if three or more adjacent bars are broken, the repair area should be expanded another lap distance.

Repair Area Preparation

All disturbed subbase and subgrade materials should be removed and replaced with similar material or concrete. Excessive moisture should be allowed to dry. If standing water is present, a lateral drain should be installed through the shoulder.

Due to the difficulty of compacting granular material with hand vibrators in confined areas, adequate compaction is difficult to achieve. In these situations, replacing disturbed aggregate with concrete is recommended, with recognition of the fact that such repairs may be keyed into the base and thermal movements of the slab may be restricted.

Restoration of Load Transfer

Joints for FDR areas should match the existing pavement whenever possible. If a new joint is being created as part of the FDR area, there are two types of sawed transverse joints that can be used: rough-faced and smooth-faced.

A rough-faced joint can be used, with aggregate interlock providing load transfer. For new, smooth-faced transverse joints, steel tie bars are used to hold the slabs together. Smooth-faced joints with dowels are located at the existing pavement transverse joints and are typically used when the entire panel is replaced. See figure 8 for a detailed illustration of load transfer for FDRs.

If the full-depth sawn areas are open to traffic during construction, traffic loadings should be minimized to limit subgrade disturbance from lack of load transfer between panels for pavements with dowel joints.

Jointed Concrete Pavements

For JCP, dowel embedment procedures are critical because they are often the cause of spalling and faulting due to movement in the dowels. Ensure that dowel holes are dry and free of debris. Place non-shrink grout or epoxy resin in the dowel holes. Insert the dowels with a slight twisting motion to ensure uniform coating of the bars and anchoring of the material. A grout retention disk may be placed over the dowel

Figure 6. Concrete removal using a backhoe

Figure 7. Concrete removal using the lift-out method

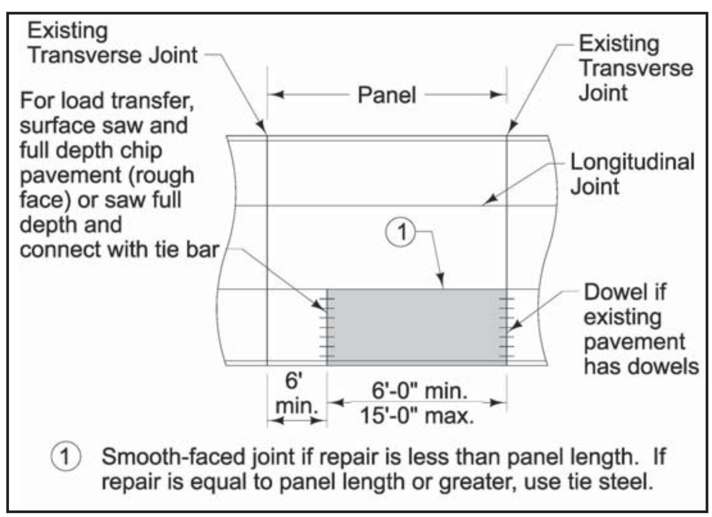

Figure 8. Top view of FDR repair

and against the slab to hold the grout or epoxy in place. See figures 9 and 10 for detail on dowel bar placement.

Prior to placement of the concrete, protruding dowels should be lightly greased to prevent concrete from bonding to the bar and to allow movement of the slab.

Continuously Reinforced Concrete Pavements

CRCP FDRs should have rough faces and continuous reinforcement to allow load transfer. The increased surface area of a rough face allows aggregate interlock, which helps transfer the load from the existing pavement through the repair.

For CRCP, correct splicing is critical for load transfer. Maintain a minimum of 3 in. concrete cover and 2.5 in. edge clearance. Figure 11 shows steel layout for continuously reinforced concrete pavement full-depth repair.

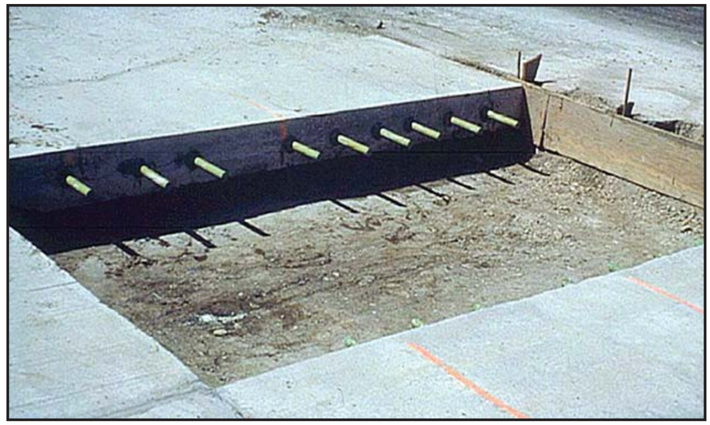

Figure 9. Example of a JCP FDR with smooth-faced joint

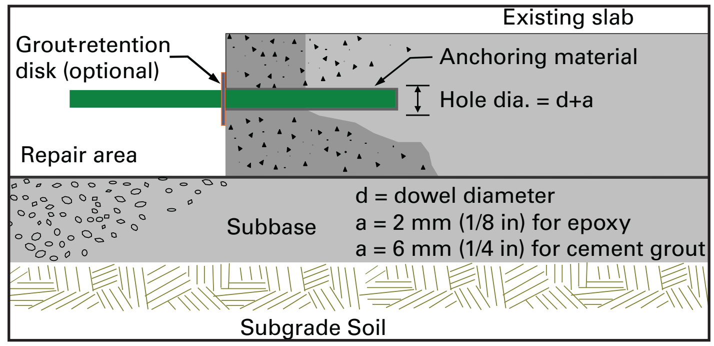

Figure 10. Example of dowel bar placement

Figure 11. Example of CRCP FDR

Concrete Placement and Finishing

Ensure concrete is well vibrated at the edges and not overfinished. Ambient temperatures should be between 4°C and 32°C (40°F and 90°F) when placing concrete (ACPA 2006). Joints should be sawed as soon as possible without damaging the concrete.

Curing

Moisture retention and temperature are critical during the curing process for strength development of the concrete. Fast-setting concrete is particularly sensitive; therefore, in projects with early opening time, insulation blankets may be required, particularly in cold weather. When repairs are made in cold weather, the difference in the temperature of the patch and the air temperature should not exceed 40°F to prevent thermal shock of the patch.

Quality Control

Quality control is essential for a successful FDR. Quality should be emphasized from the beginning of the project, during specification development and design through materials checks, equipment inspections, and weather requirements.

Primary Source

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