November 2017
Publication no. cmr 17-013-TB5

Partial Depth Repair

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TECH BRIEF

*This document is a brief technical summary of the MoDOT case study **Partial Depth Repair Case Study for Minnesota and Other Leading States** which is included in a larger report, **Concrete Repair Best Practices: A Series of Case Studies**, Publication no. cmr 17-013, November 2017.*

Introduction

Partial depth repair (PDR) is a well-established technique applied to an existing concrete pavement that has spalls along joints and cracks. Nevertheless, there have been a number of failures of PDRs over the years on projects across the country. This Tech Brief focuses on PDR in Minnesota but also includes information from Missouri, Utah, Washington, Georgia, and California. These States' specifications and acceptance procedures have evolved over many years into a reliable and cost-effective process that has generally produced good long-term performance of PDR.

Pre-Construction Partial Depth Repair Considerations

Minnesota and the other States typically perform PDR to provide a long-term repair to localized concrete spalling and deterioration at transverse joints, longitudinal joints, and cracks. The key question that should be asked first is how long the agency wants the PDR to last. This Tech Brief focuses on the longer term PDR requirements (e.g., 10+ years). Two key pre-construction aspects are described.

Appropriate Existing Condition for PDR

MnDOT does the coring to determine if a pavement is a good candidate for a CPR project. If it is a CPR candidate, then the cores are used to estimate PDR/FDR quantities. If MnDOT finds the lower portion of the PCCP is unsound they will then skew the repairs more towards FDRs. Georgia only uses PDR if the spalling is less than 4 inches deep into the slab; otherwise, a full depth repair (FDR) is used. Missouri repairs joint and crack spalling and high steel for jointed reinforced concrete pavement

(JRCP). Missouri also checks to see if the slab is deteriorated < ½ thickness; otherwise, FDR is specified.

California utilizes PDR for spall repair to restore localized surface deterioration in joints, cracks, or miscellaneous areas within the upper 1/3 of the concrete slab depth. Spall repair is commonly used to repair isolated spalling between 6 inches and 6 feet long caused by incompressible material in joints or cracks, localized areas of weak material from poor consolidation, curing, finishing practices, and joint inserts. California makes clear that deterioration beyond 1/3 slab thickness should be full depth repaired. A contractor comment covering several States is that the State marked repair areas are very often not sufficient to cover all of the deterioration, and this creates problems.

A strong consensus among States and contractors was that PDRs work well with typically good service life when they are applied to the appropriate distress and pavement conditions.

Marking of PDR Boundaries

MnDOT sounds the pavement and marks a rectangular area to be repaired. The Contractors remove the deteriorated concrete pavement with a combination of milling and light weight pneumatic chipping hammers. The agency then checks the removed area for further unsound concrete. If unsound pavement is found the inspection staff will mark/paint the areas that need additional work/pavement removals.

Georgia sounds each joint with a visual defect to help establish boundaries. The pavement surfaces along the sides of each joint are struck with a hammer, chain drag, or similar tool to detect unsound concrete that sounds flat or hollow. Georgia marks the limits of defective areas by a rectangle 2 inches beyond the outer limits of unsound concrete. Missouri selects the repair boundary that is 1 to 2 inches beyond the visible surface deterioration. Washington uses both visual and sounding techniques. A rectangular boundary is sawed at least 3 inches beyond the deterioration. Utah utilizes visual and sounding and then saws the boundaries 6 inches beyond the deterioration to ensure sound concrete. California determines the unsound concrete by sounding (dull, hollow sound) using a hammer, steel rod, or dragging chain. At least 2 inches are required beyond the unsound limits, but 5 inches are required beyond the edge of visible spalling.

The PDR size and shape must be tailored to the slab deterioration. Minimum PDRs are in the order of 12x12x2 inches deep and maximums 3 to 4 feet for cementitious materials. Hot applied elastomeric materials should have much more restrictive requirements.

Partial Depth Repair Specifications

Following is a summary of the State specifications and other documents.

State	Specification/Document
MN	MnDOT 2302 SP MnDOT 2302 SP and 3105
CA	Section 41-1: Spall Repair (Polyester Concrete) Section 41-4: Spall repair (fast-setting concrete for pre-overlay repair, anticipated life <5 years) CA "Concrete Pavement Guide"
GA	GA 451, 435
MS	MoDOT 613.20. Standard Drawing 613 (Sht. #2)
WA	WSDOT 5-01 Cement Concrete Pavement Rehabilitation
UT	UDOT 2751 Partial Depth (Cementitious) UDOT 2751S (Hot Applied Proprietary Flexible Material)

Removal of PCC in PDR Area

The most common procedure to remove deteriorated concrete is to saw the boundaries of a rectangular area and then use light chipping hammers to remove the concrete. Today, several States—Minnesota (who pioneered this procedure), Missouri, California, and others—either specify or allow milling of the area for a PDR. Minnesota began using this innovative approach to more quickly and cost-effectively remove deteriorated concrete starting in the 1980s and has used this procedure ever since. The concrete is removed primarily by milling followed up with minor removals by chipping hammers <35 lbs as needed. Milling machines used for concrete removal are equipped with a device for stopping at preset depths to prevent damage to the dowel bars. The maximum partial depth thickness is recommended to be 1/3 of slab thickness. A thickness of 1/2 slab thickness can be used for areas with material-related issues. The area is cleaned by sandblasting and air blasting, which by all accounts is critical to strong bonding. A minimum of 2 inches or more of depth is generally recommended.

Forming Joint in PDR

All States reestablish the existing crack that runs through or alongside the PDR and consider this a critical step to avoid future PDR failure. Minnesota reestablishes the existing crack with wax coated cardboard and/or expansion material. Reestablished joints are then sawed and hot pour sealed. Missouri maintains the existing joint and crack with ≥ ¼-inch fiber board or other material before placing the concrete patch material. Missouri maintains the existing joint with ≥ ¼-in fiber board or other material before placing concrete patch material. California uses either closed-cell foam or rigid foam material insert which is stable in the presence of the freshly mixed polyester concrete. Georgia places a 0.25-inch-wide piece of closed cell polyethylene foam shaped to fit the saw cut in the joints bordering the repair areas. Polyethylene foam must be supported in a straight line. Washington forms the new joint to the same width as the existing joint or crack. Compressible joint material is placed into existing joint 1 inch below the depth of repair.

A Utah contractor stated that there is always a foam/fiber insert problem of maintaining a straight up and down material that goes deep enough through the patch material. The insert just does not stand up and slumps or bends over and creates a very poor or no joint at all. This contractor prefers to green saw the joint on all their projects. MnDOT allows green sawing if the repair depth remains above the dowels. This is a much more reliable methodology to getting a proper joint. If placing patches in cool weather, the joint should be sawed thicker (full depth of the repair material) so that it will not close up in the hot summer and spall the repair.

PDR Material

States use both conventional concrete and proprietary early opening rapid set materials. In general, conventional concrete has performed better with fewer PDR failures. However, some proprietary materials have also performed well, have much higher cost, and provide the early opening advantage. Several types of materials are described in the PDR case study report. Just a couple of special interest are briefly described here.

California repairs spalls using polyester concrete for spall repairs and retrofit dowel bars. It has a high molecular weight methacrylate (HMWM) bonding agent. Contractors indicate that polyester concrete does a great job and holds up well. A contractor states that the polyester concrete often outlasts the surrounding original concrete slab.

Utah participated in a Strategic Highway Research Program (SHRP) H-106 study on PDR where several material types were installed on I-15 in 1991 and monitored for 7 years. These PDRs were properly installed by experienced contractors. The Utah jointed plain concrete pavement (JPCP) was sound concrete with no underlying deterioration at the joints, and spalling was in the upper one-half of the slab. Results showed most of the repair materials performed exceptionally well with a 100 percent survival rate (Type III PCC, Set 45, Five Star HP, MC-64, Sika Printo 11, and PERCOL FL).

This same experiment was repeated in three other States, with similar results for Arizona and South Carolina (both had no underlying concrete deterioration). Results from Pennsylvania, however, showed a much lower PDR survival rate (35 to 80 percent) at 7 years, believed to be caused by the more extensive deterioration of the existing pavement.

Utah now uses a proprietary elastomeric material (Utah Spec Section 02751S), hot-applied flexible polymer modified patch material. These materials have been found to reliably remain in the hole over time, but the downside is that they settle under repeated loading causing a permanent deformation creating roughness within 2 to 7 years. These PDRs then have to be topped off to reduce roughness. If the JPCP will be diamond ground in the future, special precautions must be taken as described by Utah and the manufacturer, and the PDR must be limited to small repairs.

Washington has used rapid strength prepackaged cementitious repair materials in the past (with some poor performance) but is now transitioning to polymer concrete products looking for improved performance. Washington has looked at several polymer type products, utilizing either epoxy or polyester resin binders. The benefits of polymer concrete over cementitious repair products include fast cure times, improved bond strength, greater elongation properties, and no wet or special curing requirements. These benefits should result in faster return to traffic times and fewer repair failures.

Inspection/Acceptance

The inspection and acceptance process for PDR focuses on observations and testing:

- Proper marking and then milling or saw cutting boundaries and locations.
- Removal of deteriorated material but not damaging underlying material.
- Cleaning of the repair area. Sandblast is highly recommended.
- Sealing off the existing joint to prevent repair material from infiltrating.
- Applying bonding material where applicable.
- Curing the PDR surface.
- Forming of the joint through the repair. <u>This is critical for transverse joints</u>.
- Placement repair material placed.
- Time to open to traffic.
- 30-day warranty period (Minnesota).
- Georgia and some other States require the removal and replacement of the PDR if cracked.
- Check delamination of PDR from existing concrete through testing. Minnesota, Missouri, Utah, and Washington test for bonding of PDR using chains or other devices. Georgia occasionally tests for bonding of the PDR. Removal and replacement of the PDR is required if debonding is indicated.

Incentive/Disincentive

None of the States use incentives/disincentives for PDR. Minnesota, however, has a 30-day warranty and chain/sound all PDRs for bond. They feel if a PDR is going to lose bond, it often happens very quickly, and the 30-day warranty will very often catch this occurrence. Missouri and Utah also agreed that a short-term warranty may be a valuable idea for PDR. It is conceivable that an incentive/disincentive specification for bonding of PDRs could be developed. Bonding of the PDR requires that attention be paid to every step in the process of producing a good PDR.

Performance & Survival of PDR

The overall the performance of PDR shows that this technique has been highly variable, both within and between States. If properly installed using the procedures established in Minnesota and the other States surveyed, and placed by knowledgeable contractors, a PDR typically lasts 10 to 15 years or more dependent on levels of traffic and location within the traveled lane. However, many times something goes wrong and the PDR ends up with a short life of < 5 years. If a PDR is placed in a situation where there is surrounding concrete deterioration, then it will not last long, and an FDR should have been placed. Basically, everything has to go properly or the PDR will fail early.

Summary of PDR

To be successful and perform 10+ years, a PDR must meet the following requirements:

- Sound concrete surrounding the PDR.
- Proper milling and removal or sawing and removal of deteriorated material must occur.
- Cleaning (sandblasting) of the repair area.
- Placement of an effective bonding agent only if required by manufacturer.
- Sealing of existing joint within the PDR is absolutely required and forming of the joint/crack either through or at the edge of the PDR so that a clear joint is available.
- PDR material must be durable, bond well, and not shrink significantly.
- Inspection is in part observational and must be monitored sufficiently. Inspection is also testing for bonding between the PDR and concrete slab is an effective and needed acceptance procedure.
- Warranties (e.g., 30 days) are believed to be an effective approach to quality PDRs.

PDR has produced a significant increase in life of spalled JPCP and JRCP in the States interviewed whenever the PDR location and selection is proper, the specifications are followed, materials are durable, and inspection/acceptance procedures are followed. However, everything must go right.

Training

The points described in this Tech Brief indicate the importance of just-in-time training for State and contractor personnel prior to start of work. Lack of training was a major concern for PDR for all of the States and contractors included in the survey, because if anything goes wrong, the PDR is likely to fail early.

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Funding—This study was sponsored by the U.S. Federal Highway Administration.

TRT Terms/Keywords— Continuously reinforced concrete pavements; Maintenance practices; Pavement distress; Pavement maintenance; Repairing

Availability—This Tech Brief is available from the MoDOT Innovation Library at http://www.modot.org/services/or/byDate.htm