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High-Speed Concrete Pavement Rehabilitation and Construction

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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. MAP Brief 7-2 provides information relevant to Track 7 of the CP Road Map, High-Speed Concrete Pavement Rehabilitation and Construction.

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MAP Brief 7-2 is available at: http://www.cproadmap.org/publications/ MAPbrief7-2.pdf

"Moving Advancements into Practice"
MAP Brief 7-2:
Describing promising technologies that can be used now to enhance concrete paving practices

Partial-Depth Repairs for Concrete Pavements

Introduction

Partial-depth repairs are defined as the removal and replacement of small areas of deteriorated (or spalled) concrete, typically in joints or cracks. The depth of deterioration can vary from a few millimeters to the full depth of the pavement. Once they begin, spalls tend to grow or propagate under repeated thermal stresses and traffic loading.

Partial-depth repairs restore structural integrity and improve ride quality. Repairs of partially deteriorated joint areas also restore a well-defined, uniform joint-sealant reservoir prior to joint resealing.

Partial-depth repairs have traditionally been used where joint or crack deterioration is in the top one-third of the slab and the existing load transfer devices (if any) are still functional. This approach has been used in most of the country, with the belief that if deterioration extends below the top one-third, then a full-depth repair is warranted.

However, by using new milling equipment and concrete mixtures, several cold-weather states have successfully demonstrated the use of partial-depth repair techniques in pavements where deteriorated areas are deeper than the top one-third but slightly less than the top one-half of the slab. Thus, partial-depth repairs can now be used for a greater number of deteriorated joint repairs.

This MAP brief discusses three different types of partial-depth repairs:

- Type 1 - Spot repair
- Type 2 - Long joint/crack repair
- Type 3 - Bottom half repair

Types 1 and 2 are standard partial-depth repairs (figure 1), and type 3 repairs are those developed for special repairs including the bottom half of the slab.

Type 1 - Spot Repairs

Spot repairs are appropriate in small, shallow areas, where joint or crack deterioration is located in the top one-half of the slab (figure 2). Spot repairs are at least 10 in. long, but less than 6 ft, and are typically used for pavements where the existing load transfer devices (if any) are still functional.

The most common method of removal for spot repairs is the saw and chip method, although milling is becoming more popular for some locations.

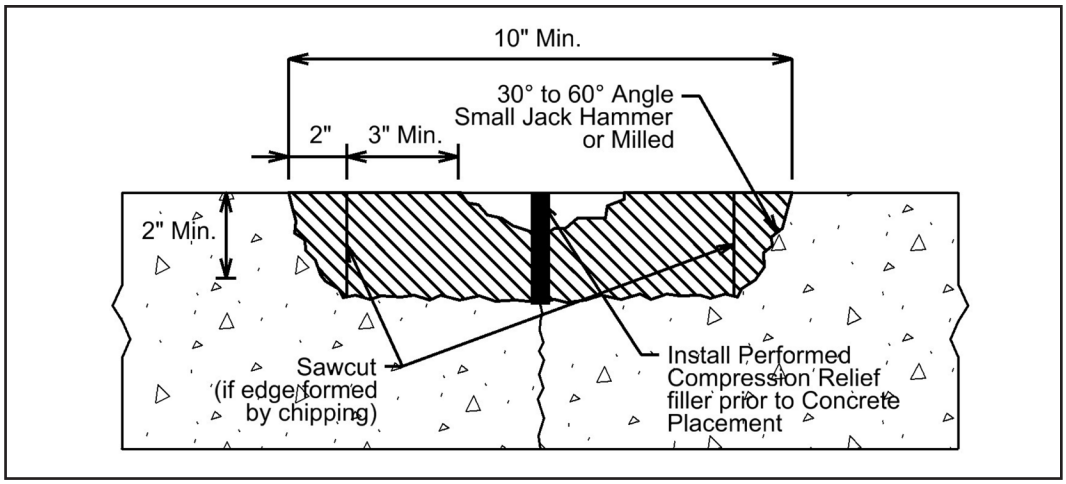

Figure 1. Typical (Type 1 and 2) partial-depth repair

Figure 2. Spot repair required

Figure 3. Longitudinal joint deterioration where Type 2 repair can be used

Type 2 - Long Joint/Crack Repairs

Long joint/crack repairs are partial-depth repairs in transverse and longitudinal joints or cracks longer than 6 ft and extending from one-third to one-half the depth of the concrete pavement (figure 3). Removal is usually by milling, and a small jackhammer is used for the remaining part of the patch where the mill cannot reach.

Both V-shaped and straight milling heads have been used to remove deteriorated pavement for long joint/crack repairs.

Type 3 – Bottom Half Repairs

As depicted in figure 4, sometimes one or more corners or the edge of a concrete pavement will deteriorate to the full depth for a short distance. Bottom half repairs are used for locations where the deterioration along the partial-depth repair exceeds T/2 in depth. This repair is for work performed in the bottom half of the pavement and its use should be limited to the edges or cross-joint locations that are not greater than 18 in. long.

Figure 4. Deteriorated pavement corner where Type 3 repair can be used. As shown in photo, tie rods are drilled at an angle into existing slab and then bent straight to tie the new patch with the existing pavement (strips of compressible material are positioned prior to placement of patch material).

Material Selection for Partial-Depth Repairs

Material selection for partial-depth repairs depends on these factors:

- Allowable lane closure time
- Ambient temperature
- Cost
- Size of repair
- Estimated performance

High-quality portland cement concrete is generally accepted as the most appropriate material for the repair of existing concrete pavements.

A mix developed by the Minnesota DOT, called 3U18, has been very successful for more than 30 years. This mix results in an 18± hour opening strength of 2,500 psi. Earlier opening times can be achieved with appropriate admixtures. Mixing is done either by hand, ready mix, or mobile concrete mixers. This mix can also be bought in 50 lb bags for small projects.

Cementitious 3U18 Recommended for Use in Partial-Depth Repairs

- 850 lbs Type I Cement
- 295 lbs of water
- 1,328 lbs of coarse aggregate (100% passing 3/8 in. sieve)
- 1,328 lbs of sand (55% passing #4 sieve)
- Target W/C of 0.35
- Type E Water Reducing and Accelerator
- 6.5% air

A wide variety of rapid-setting and high-early-strength proprietary materials have been developed for partial-depth repairs. The materials are easy to place, achieve exceptional early strength, and have been approved for use by a number of highway agencies. They are more expensive but prove useful when traffic requires 5 hours or less opening strength. These and other products are discussed in the Concrete Pavement Preservation Workshop Reference Manual (2008).

Construction Steps for Partial-Depth Repairs

Construction steps for partial-depth repairs are as follows.

1. Determine repair boundaries

The repair area is identified by sounding the deteriorated pavement using a chain, ball peen hammer, or steel pipe. Next, the boundaries for sawing or milling are marked on the pavement. The repair should extend 2 to 4 in. beyond the visible distressed area.

2. Concrete Removal

There are two common methods for removing deteriorated concrete prior to a partial-depth repair: 1) sawing and chipping with a jackhammer and 2) milling.

Sawing and chipping with a jackhammer

The most common method for partial-depth spot repairs is the saw and chip method (typically for Type 1 repairs), where a 2 in. saw cut is used to define the boundary area for the patch and a small (less than 35 lb) jackhammer is used to remove the outside edge of the saw cut in order to eliminate a smooth face and remove the rest of the existing concrete. These patches are either square or rectangular (figure 5).

Milling

Cold milling is another option for removing deteriorated concrete (typically for Type 2 repairs). Milling produces a very rough, irregular surface that promotes a high degree of mechanical interlock between the repair material and the existing slab (figure 6).

3. Repair Area Preparation

Sandblasting, and compressed airblasting are normally sufficient for obtaining an adequately clean surface.

4. Joint Preparation

The most frequent failure of partial-depth repairs at joints occurs due to restrained movement, which results in excessive compressive stresses in the repair material. Partial-depth repairs placed directly against transverse joints and cracks may fail due to compressive forces created when the slabs expand and insufficient room is provided for thermal expansion.

Figure 5. Type 1 repair—sawing and chipping (a strip of compressible material is positioned prior to placement of patch material)

Figure 6. Type 2 repair—milling (a strip of compressible material is positioned prior to placement of patch material)

To prevent pavement failure at joints or cracks, a strip of polystyrene or polyethylene compressible material is typically placed in the joint to act as a bond breaker (figure 7). This prevents any of the patch material from entering the joint or crack and preventing movement of the joint. The bond breaker (or at least the upper portion) is normally removed before the joint is sealed. As noted, the compressible material is positioned prior to placement of the patch material.

5. Bonding Agent Application

After the surface of the existing concrete has been cleaned, and just prior to placement of the repair material, the surface should be coated with a cement grout (figure 8) to ensure complete bonding of the repair material to the surrounding concrete. The grout should coat all vertical and horizontal surfaces, should be mixed to the consistency of thick cream, and should be placed immediately before the repair material so the grout does not set.

Successful grout recipes used by many states, including Minnesota consist of the following:

Figure 7. Cutting excess compressible material used as bond breaker in longitudinal crack

Figure 8. Placement of cement grout as bonding agent (a strip of compressible material is positioned prior to placement of patch material)

- 2 parts Type I cement
- 1 part water
- 1 part sand

6. Patch Material Placement

General patch material placement guidelines are as follows:

- Batch in small quantities.
- Overfill the patch area by approximately 1/8 in.
- Consolidate the patch material using vibrators or vibrating screeds. Smaller patches are consolidated using small spud vibrators or by hand rodding and tamping.
- Troweling toward the edge is recommended. The surface of the repair should be textured to match that of the surrounding slab as much as possible.
- It is important to work the material away from the center of the patch and towards the edges to promote bonding.

After the patch material has been placed, the edges of the repair should be sealed with grout to help prevent moisture infiltration and the joint re-established by sawing (figure 9).

7. Curing

The most effective curing procedure in hot weather is to apply a white-pigmented curing compound as soon as water has evaporated from the repair surface. Some agencies require curing compound to be applied at 1.5 to 2 times the normal application rate to prevent shrinkage cracks in the repairs.

8. Joint Sealing

The final step in the process is sealing the joint. This helps ensure that incompressibles don't cause additional spalls to occur.

Figure 9. Edge sealing using sand-cement grout after placement of patch material