Long Life Concrete Pavement Joint Performance

Joint Rehabilitation

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Representing the National CP Tech Center

Driving Forces for Concrete Pavement Joint Repairs

For states experiencing concrete pavement joint deterioration in cold weather, there are cost-effective repair methods available which can mitigate the damage and restore the existing pavement and the investment.
Treatment Selection Process

1. Conduct pavement evaluation.
2. Determine joint distress causes.
3. Identify potential treatments.
4. Identify constraints.
5. Develop feasible treatment strategies.
6. Assess the life-cycle costs associated with treatment strategies.
7. Select preferred strategy.

Rehabilitation Strategies
**Partial-Depth Repairs**

**Introduction**

- **Definition**

  *Removal and replacement of small, shallow areas of deteriorated PCC at spalled or distressed joints.*

  - Distress limited to upper 1/2 of slab
  - Existing load transfer devices are functional
  - Cost $\approx$ $20$ to $30 / \text{ft}^2$
    - Cost on Major Quantities of Longitudinal can be $12 - $20
    - Cost on night work can be as high as $55 per square foot
Benefits

- Restores structural integrity
- Improves ride quality
- Extends the service life
- Restores a well-defined uniform joint sealant reservoir

Three Types of Partial Depth Repairs

Type 1 - Spots Repairs (SR) - Pay by Square Foot.
Type 2 - Long Joint/Crack Repairs (LJCR) - Pay by Linear foot
Type 3 - Bottom Half Repairs (BHR)
Good Candidate Projects

• Spalls caused by:
  - Incompressibles in joints
  - Localized areas of weak material
  - Joint deterioration

• Surface deterioration caused by:
  - Reinforcing steel too close to surface
  - Poor curing or finishing practices

• Recommended evaluation procedures:
  - Distress surveys
  - Sounding and cores from pavement

Poor Candidate Projects

• Spalls due to dowel bar misalignment

• Spalls at working cracks due to shrinkage, fatigue, or foundation movement

• Spalls due to D-cracking or reactive aggregate
Type 2 – Extended Length Repairs

• Longitudinal or transverse joints (Type 2A)
• Cracks (Type 2B) longer than 6 ft.

Type 2 – Extended Length Repairs

• Type 2A (Joints), the joint re-establishments typically by sawing
• Type 2B (cracks) the crack pressure relief is performed joint material in the crack itself.
• Removal of the existing pavement is usually by milling
Material Selection for Partial-Depth Repairs
Patch Material

- Material selection for partial-depth repairs depends on these factors:
  - Allowable lane closure time (strength of material)
  - Shrinkage Characteristics
  - Coefficient of Thermal Expansion
  - Ambient temperature
  - Cost
  - Size of repair
  - Estimated performance

Partial Depth Repair Mixes

<table>
<thead>
<tr>
<th></th>
<th>M-4WR Iowa Mix</th>
<th>3U18 Minnesota Mix</th>
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<tbody>
<tr>
<td>Cement</td>
<td>15.6% by volume</td>
<td>16.1% by volume</td>
</tr>
<tr>
<td>W/C</td>
<td>0.33 – 0.44</td>
<td>0.35</td>
</tr>
<tr>
<td>Coarse Agg. / Fin Agg.</td>
<td>50% Split 62% by volume</td>
<td>50% Split 59% by volume</td>
</tr>
<tr>
<td>WR</td>
<td>Type E</td>
<td>Type E</td>
</tr>
<tr>
<td>Coarse Aggregate</td>
<td>Pea Gravel (100% passing 1/2&quot;) or 3/8&quot; Chips</td>
<td>100% passing 3/8&quot; 55&quot;-95&quot; passing No. 4</td>
</tr>
<tr>
<td>Air</td>
<td>6% by volume</td>
<td>6.5% by volume</td>
</tr>
</tbody>
</table>
Bonding (Grout) Agent

- Sand-cement grouts have proven adequate when used as bonding agents with concrete repair materials.
  - 2 parts Type I cement
  - 1 part water (may be more or less to develop a creamy consistency)
  - 1 part sand

Construction Steps

1. Repair dimension selection
2. Concrete removal
3. Repair area preparation
4. Joint preparation
5. Bonding agent application
6. Patch material placement
7. Curing
8. Diamond grinding (optional)
9. Joint sealing
Repair Dimension Selection

**Recommendations**

- Min. Patch Length 12 in
- Min. Patch Width 4 in

Single areas less than (6 in) 150 mm long or (1.5 in) 40 mm wide are not normally patched.
Partial-Depth Repair

(TOP VIEW)

Boundary saw cuts min. 2 in. (50 mm) deep, 3 in. (76 mm) outside distressed area. Overlap cuts at corners and approx. 1 in. (25 mm) across joint.

Saw cut approx. 2 in. (51 mm) away from joint for protecting opposite face. Saw cut skimming opposite joint to provide clean vertical face.

Concrete Removal

Jackhammering

- Removal begins at center and extends outward
- Remove top 1/3 but no more
- Care not to fracture sound concrete
- Removal near joints should be done w/10-15 lb. hammer to avoid damage

Operate hammer no greater than 35°
Partial-Depth Repair

Compressible Insert

3 in. min. Spall Patch

1 in.

Need for Compressible Insert

Point Bearing Popout & Breakage

Joint Closure Debonding

Expansion

Expansion
Milling Machine-V Head for Partial Depth Patch

- Weight – 9 Tons
- Little dust
- Removal rate 8 ft. / minute

Skid Steer for Milling Partial Depths

- Best suited for corner spalls and random cracks, it can maneuver better than the larger mills.
- Skid Steers weigh about 8000 pounds and can have removal rates of 2 – 3 feet per minute.
- Light weight skid steers can cause spalling at edges, but most minor spalls will be patched with concrete mix.
- It is easy to lift the front end off the ground during milling, but can be done with minor spalling.
Type 1 – Joint Mill and Removal

- Milling along the joint or crack
- Milling perpendicular to the joint or crack

Type 2 – Joint Mill & Removal
Type 2 – Crack Mill and Removal

Rounded Milling (Type 1 & 2)

Type 2B Crack Milling

Sweeping Milled Area
Repair Area Preparation

- Surface of the repair area must be clean.

  Sounding with hammer

  Sandblasting to remove loose debris

  Air Blasting for final cleaning

Bonding Agent Application

- Cleaning the surface of the existing concrete
- Just prior to placement of the repair material, coat the surface with a sand-cement grout to ensure complete bonding of the repair material
- Mixed to the creamy consistency
- Placed immediately before the repair material, so the grout doesn’t set

  Cement grout of Type 2A – Joint Repair

  Cement grout of Type 3 – Bottom Half Repair
Placement of Compression Relief

- To prevent failure, a strip of polystyrene or polyethylene (wax board) compressible material is placed in the joint.
- Has the ability to maintain its rigidity for the concrete placement.
- Place a foot on the cardboard during concrete vibration, so it does not float.

Concrete placement for Type 1 repair using waxed cardboard

Type 2B – Crack Repair

Screeding and Finishing

- Screed the repair surface on each side of the compression relief.
- At least two passes should be made to ensure a smooth repair surface.
- Paint a sand-cement grout (the same grout as used for bonding.
- At the edges of the repair to impede delamination of the patch.

Placement of grout at edge of partial-depth repair
Sawing Relief Joints

- Type 1 and Type 2A joints have been successfully sawed to create compression relief.
- Tooling of the joint can be done to help create a weak plane during concrete placement.
- Joint reservoir shall be wider than the crack under the repair.

Completed Repairs

- Completed Type 1 crack repair
- Completed Type 2A joint repair
- Completed Type 2B crack repair
- Completed Type 3 repair
Curing

P.D.P. Have large surface areas in relation to their volumes (which can lead to rapid moisture loss)

- Prevent moisture loss
- White-pigmented curing compound commonly used (some require 1.5 to 2 times normal rate)
- Opening to traffic
  - Mix / temperature dependent
  - Common values: 2,000 to 3,000 psi

Opening to Traffic

- Partial depth repair in upper half of pavement
- When bonded to existing pavement little or no tension in the patch
- Can open to traffic earlier (1,600 – 1,800 psi)
Examples of Long Lasting Partial Depth Repairs

20 year old Type 2A longitudinal and transverse partial depth repairs in Hopkins, MN

Close up of partial depth patch in Hopkins, MN done in 1991 and picture taken 2011

Full-Depth Repairs
Full-Depth Repair

• Purpose
  - Restore structure
  - Restore ride
• Used for
  - Joint/crack deterioration
    ➢ Spalling (also below surface)
    ➢ Cracking
  - Broken slabs
  - Corner breaks

Remove and Replace Concrete

Full-Depth Repair – KEY POINTS

• Prior to paving, test the concrete mixture for strength, strength gain and durability properties at the range of air temperature it will be placed in on the project

• Lay out patches and estimate material quantities as accurately

• Provide load transfer between all full-depth patches and the surrounding pavement.

• Use durable materials, a well-graded mix design, and a proper curing regimen for a long-lasting repair.
**Key Points**

**Selecting Repair Boundaries**

**Potential Extent of Deterioration at Joint**

Visual deterioration of surface

Existing Joint

4' to 6' Typical Repair

Can be 3 ft.

Potential deterioration at bottom of slab

(Particularly for MRD)

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**Key Points**

**Load Transfer Design**

**Recommendations**

Traffic Direction

Mid-depth slab

3.7 m (12 ft)

0.6 m (2 ft)

0.3 m (1 ft) typical

1.8 m (6 ft) minimum

Smooth dowels 38 mm (1.5 in) dia.

(> 10")

(< 10")

3.7 m (12 ft)

0.6 m (2 ft)

0.3 m (1 ft) typical

1.8 m (6 ft) minimum
**Key Points**

**Repair Materials**

- PCC mixes – Type 1-C mix (sometime accelerators)
- Rapid set cement (RSC) – 2 to 6 hrs.
- Regulated set portland cement (RSPC) – Initial set 2 to 30 min.
- Proprietary materials <4 hrs. opening (not recommended)
- Minimum opening strength 2000 to 2500 psi (most states)

**Key Points**

**Full-Depth Repair – Load Transfer**

1. Inject Grout to Back of Hole
2. Twist one turn while pushing in dowel
3. Place grout retention disk to hold in grout (optional)
### Full-Depth Repair - Opening

<table>
<thead>
<tr>
<th>Slab Thickness (in.)</th>
<th>Strength for Opening to Traffic (psi)</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Repair Length &lt; 10 ft</td>
<td>Slab Replacements</td>
</tr>
<tr>
<td></td>
<td>Comp</td>
<td>Flex</td>
</tr>
<tr>
<td>6</td>
<td>3000</td>
<td>490</td>
</tr>
<tr>
<td>7</td>
<td>2400</td>
<td>370</td>
</tr>
<tr>
<td>8</td>
<td>2150</td>
<td>340</td>
</tr>
<tr>
<td>9</td>
<td>2000</td>
<td>275</td>
</tr>
<tr>
<td>10+</td>
<td>2000</td>
<td>250</td>
</tr>
</tbody>
</table>

### Joint Resealing
Trapped Moisture?

- The longitudinal joints do not open up as much because of the tie bars.
- Rehabilitation of existing pavement- Seal saw-cuts for both longitudinal and transverse joints if no outlet available

Joint and Crack Filling or Resealing
Joint Resealing

• Purpose
  – Protect rehabilitated pavement
  – Prevent infiltration of water and incompressible

• Used for:
  – Replace ineffective sealant
  – Minimize moisture infiltration
  – Minimize incompressible infiltration

Joint Resealing – KEY POINTS

• Saw sealant reservoirs to the specified dimensions.

• Immediately follow sawing with a power washer to clean the slurry from both sides of the sealant reservoir.

• Sandblast both sides of the sealant reservoir if dried slurry remains after power washing.

• Place sealants in accordance with the specifications set by the manufacturer.
Joint and Crack Resealing

Backer Rod
Concrete Overlays

Unbonded Overlays of Concrete Pavements

- Existing pavement serves as a subbase which must provide uniform support
- Because of this, unbonded overlays can be placed on pavements that are in poor condition
- Does not require extensive pre-overlay repairs to the existing pavement
Unbonded Overlays of Concrete Pavements

- Milling operation will remove a large portion of unsound concrete
- Mill the existing pavement full width and to a depth that removes the majority of deteriorated concrete

Unbonded Overlays of Concrete Pavements

- Removal of remaining loose material and leveling deteriorated joints areas with flowable mortar
  - Partial Depth; flowable mortar
  - Full Depth; Concrete
Unbonded Overlays of Concrete Pavements

- Placement of a separation layer (HMA or geotextile)
- Construction of an unbonded overlay

Unbonded Overlays Primary Keys

The keys to constructing successful unbonded overlays are:

- Minimal pre-overlay repairs
- Separator layer is important to isolate unbonded overlay from underlying pavement.
- If the separation layer is geotextile fabric heavy wrinkles in the fabric should be eliminated.
- Shorter joint spacing helps minimize curling and warping stresses; transverse joints should be placed at 6’ c/c or less.
Draining Interlayer

Curb Removed

Curb Not Removed

Questions?

National CP Tech Center
http://www.cptechcenter.org

Remember ...