Design and Construction of Highway Pavement Joint Systems

Troubleshooting Joint Design and Construction Issues

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Troubleshooting?

- Raveling or spalling is occurring due to sawing too soon or equipment problems.
- Early-age cracking is occurring due to sawing too late, insufficient joint depth, excessive joint spacing, excessive warping, excessive curling, too many lanes tied together, too much edge restraint, excessive slab/subbase bonding or restraint, misalignment of dowel bars, paving in cold weather, or paving in hot/dry weather.
- Sealant not adhering to joint.
- Sealant picks up or pulls out when opened to traffic.
- Sealant gelling in melting chamber (melter).
- Sealant cracking or debonding.
- Voids or bubbles in cured sealant.
- Etc…
- ... see ACPA literature or IMCP
Pavement Preservation Philosophy

Keeping good roads in good condition!
M&R Types vs. Condition/Time

- Pavement Preservation
- Preventive Maintenance
- Rehabilitation
- Minor Rehabilitation
- Major Rehabilitation
- Maintenance
- Reconstruction
Benefits of Pavement Preservation

- Higher customer satisfaction
- Improved pavement condition
- Cost savings
- Increased safety
- Reduced environmental impact
Good Candidate Projects

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

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

- Recommended evaluation procedures:
  - Distress surveys
  - Sounding
Partial-Depth Repair Process

(TOP VIEW)

3 in. min (75 mm) Compressible insert

(SIDE VIEW)

3 in. min (75 mm) Compressible insert

3 in. min (75 mm) Spall

Sawcut

Existing joint

Remove delaminated material

Patch

Compressible insert
Sizing of Repair

- Greater than 3 inches beyond spall
- Combine spalls if closer than 24 inches
- Cementitious:
  - 4 inch x 10 inch
  - 2 inch depth
- Proprietary:
  - Refer to instructions

Diagram:
- 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. (50 mm) away from joint for protecting opposite face.
- Saw cut skimming opposite joint to provide clean vertical face.
Concrete Removal

Methods

- Saw and Patch
  - Saw perimeter and light jackhammer breakout
- Chip and Patch
  - Light jackhammer breakout (no sawing)
- Mill and Patch
  - Removal of deteriorated concrete through cold milling
Use of Cold Milling Heads for Concrete Removal

<table>
<thead>
<tr>
<th>“V” Shape Milling Head and Pattern</th>
<th>Rock Saw and Rounded Pattern</th>
<th>Vertical Edge Mill Head and Pattern</th>
</tr>
</thead>
</table>

30 to 60 degrees
Material Selection Factors

- Allowable lane closure time
- Ambient temperature
- Material and placement cost
- Material properties (shrinkage, CTE, bond strength)
- Compatibility between repair material and existing pavement
- Size and depth of repair
- Performance capabilities
Repair Material Selection

- Repair materials for partial-depth repairs are generally classified cementitious, polymeric, or bituminous.

- Concrete mixes along with a wide variety of rapid-setting and high-early-strength proprietary materials have been developed.

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

- Concrete mix requires use of small-sized, coarse aggregate, usually less than 1/2 in.
Bonding Agent

- Intended to enhance bond between repair material and existing pavement.
  - Can reduce bond if not installed properly
- Required for many cementitious repair materials.
  - Some agencies allow clean, SSD surface in lieu of bonding agent
- Manufacturer’s instructions should be consulted for proprietary mixes
Joint Preparation

Plan View

Profile View

- joint
- bond breaker
- patch
- pavement
- scoring

3 in

1 in

3 in
Curing

- Prevent moisture loss
- White-pigmented curing compound commonly used
- Opening to traffic
  - Mix- /temperature-dependent
  - Common values: 1600 to 1800 psi
Re-establish Joint/Crack

- Type 1 and Type 2A joints have been successfully sawed.
- Fresh concrete can also be tooled prior to sawing.
- Joint reservoir must be wider than the crack under the repair.

Tooling of the joint

Sawing following tooling of the joint
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
GUIDE FOR
PARTIAL-DEPTH REPAIR OF
CONCRETE PAVEMENTS

April 2012

IOWA STATE UNIVERSITY
Institute for Transportation

Load Transfer Restoration
(Dowel Bar Retrofit, Cross-Stitching, and Slot Stitching)
Typical Causes of Poor Load Transfer

- Absence of load transfer devices
- Failed load transfer devices
- Poor aggregate interlock
- Poor pavement drainage
- Erodible base
Schematic of Dowel Bar Retrofit Installation

END VIEW

SIDE VIEW

As required

Compressible insert

Mid-depth of slab

Chair

Joint or crack

End cap

Varies
Dowel Layout

Centerline

24 in (600 mm)

2 groups of 3 bars on 12-in (300-mm) centers

Direction of Travel

12 to 18 in (300 to 450 mm)
Slot Creation
Slot Sawcuts
Dowel Bar Placement
Patching Material Placement
Consolidation and Finishing
Final Steps

- Diamond grinding
- Joint sealing
Cross Stitching

Definition

*Grouting of tiebars in holes drilled across nonworking longitudinal joints and cracks at an angle to the pavement surface*

Used to strengthen nonworking longitudinal joints and nonworking longitudinal cracks (in relatively good condition)
Cross Stitching
Applications and Benefits

- Prevent slab migration and to maintain aggregate interlock
- Mitigate the effects of tie bars omitted during construction
- Tying roadway lanes or shoulders that are separating
- Tying centerline longitudinal joints that are starting to fault
Cross Stitching Schematic

Top View

Cross-stitch Holes (Typ.)
(Alternate sides of crack)

Transverse Joint

Note A  24 in. min.

Cross-sectional View

See Note B and table 8.5

See table 8.5

35° - 45°

1 in. (typ.)

Note C
## Cross Stitching
### Bar Dimensions, Angles, and Locations

<table>
<thead>
<tr>
<th>Angle</th>
<th>Slab Thickness, mm (in)</th>
<th>Distance from Crack to Hole, mm (in)</th>
<th>Length of Bar, mm (in)</th>
<th>Diameter of Bar, mm (in)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>200 (8)</td>
<td>225 (9)</td>
<td>250 (10)</td>
<td>275 (11)</td>
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<tr>
<td>35°</td>
<td>145 (5.75)</td>
<td>165 (6.50)</td>
<td>180 (7.25)</td>
<td>195 (7.75)</td>
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<tr>
<td>40°</td>
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<td>—</td>
<td>—</td>
<td>165 (6.50)</td>
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<td>45°</td>
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<td></td>
<td>240 (9.50)</td>
<td>275 (11.00)</td>
<td>315 (12.50)</td>
<td>365 (14.50)</td>
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<tr>
<td>40°</td>
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<td>—</td>
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<td>19 (0.75)</td>
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</table>
Cross Stitching
Drilling Holes
Cross Stitching
Inserting Epoxy
Cross Stitching
Bar Insertion
Slot Stitching
Applications and Benefits

- Hold together adjoining concrete slabs
- Maintain aggregate interlock
- Provide reinforcement/strength to the longitudinal joint or crack
Slot Stitching Schematic
Slot Stitching

Finished Crack
Full-Depth Repairs
Introduction

Definition

*Cast-in-place concrete repairs that extend the full-depth of the existing slab*

- Benefits
  - Restore rideability
  - Restore structural integrity
Load Transfer Design

Example Layout

Traffic Direction

Mid-depth slab

3 – 5 dowels/wheel path (typical)

Smooth dowels
38 mm (1.5 in) dia.

0.6 m (2 ft)

0.3 m (1 ft) typical

3.7 m (12 ft)

1.8 m (6 ft) minimum
Restoration of Load Transfer
Drilling Recommendations

- Dowel holes drilled at mid-depth of existing slab at specified spacings
- Dowel holes drilled slightly larger than dowel diameter
- Use gang drills for better alignment and increased productivity
Restoration of Load Transfer
Cleaning Holes (Air Blasting)
Restoration of Load Transfer
Injecting Anchoring Material
Restoration of Load Transfer
Dowel Bar Placement

1. Inject Grout to Back of Hole

2. Twist one turn while pushing in dowel

3. Place grout retention disk to hold in grout
Restoration of Load Transfer

Schematic of Dowel Bar Installation

Grout-retention disk (optional)

Existing slab

Hole dia. = d + a

Anchoring material

Repair area

Subbase

d = dowel diameter

a = 2 mm (1/8 in) for epoxy

a = 6 mm (1/4 in) for cement grout

Subgrade Soil
Restoration of Load Transfer Area
Prepared with Dowels in Place
Key Factors For Success (JCP)

- Selection of proper candidate projects
- Properly sized repairs
- Good material removal practices
- Properly prepared repair area
- Effective restoration of load transfer
- Selection of appropriate repair material
- Proper material placement, finishing, and curing
Pavement Preservation
Source Material

Precast Concrete Repairs
Precast Concrete Slabs

Prefabricated panels used for repair or reconstruction of roadway pavements

Advantages:

- Better quality concrete
- Improved curing
- Minimal weather impacts
- Rapid opening
- Prevent early-age construction failures

A number of systems are available
Jointed Precast Concrete Pavement Systems (JPrCP)
Load Transfer System Options
Repair Panel Leveling Options

Embedded Leveling Bolt - Generic

Precision Grade-Supported

Shim Supported (with grout injection)

Urethane or Grout Injection
Matching Pavement Surface Geometry

Slab shape depends on geometry of pavement surface

Single Plane
Slopes of opposite sides are equal

Warped Plane
Slopes of opposite sides are unequal

Source: The Fort Miller Co., Inc.
Many Uses

- Tappan Zee Bridge Toll Plaza
- New York City Intersection
- Santa Monica, California Bus Pad
- LaGuardia Airport (New York)
Acknowledgment

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