Concrete Pavement Preservation: Concrete Pavement Surface Restoration and Joint and Crack (Re-)Sealing

Presented by:
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Primary Source Material

Concrete Pavement Preservation and Preventive Maintenance (A Webinar Series)

• Part 1 – The Essentials: From Pavement Evaluation to Strategy Selection - March 15

• Part 2 – Partial- and Full-Depth Repair Methods – April 15

• Part 3 – Tips and Techniques for Specialized Repair and Construction Methods – September 27
  – Includes Slab Stabilization, Slab Jacking, Dowel Bar Retrofit, Cross-Stitching and Slot Stitching, Retrofit Edge Drains

• Part 4 – Pavement Maintenance and Preservation Using Concrete Overlays – October 25

• Part 5 – Concrete Pavement Surface Restoration and Joint/Crack (Re)Sealing – November 1
  – Includes Diamond Grinding and Grooving
Webinar Part 1 - Highlights

• What is Preventive Maintenance?
  – Planned strategy of cost effective treatments
  – Applied to structurally sound pavements with significant remaining life
  – Maintain or improve functional condition

• What is Pavement Preservation?
  – Network level, long-term strategy for enhancing pavement performance
  – Focus on extending pavement life and restoring functional condition
  – Goals accomplished with a collection of preventive maintenance treatments and a few minor rehabilitation and routine maintenance treatments
Webinar Part 1 - Highlights

- **Pavement Evaluation**
  - Determine causes of deterioration
  - Develop appropriate alternatives
  - Provides quantitative information for quantity estimates, LCCA
  - As-built info, distress surveys, NDT, sampling

- **Strategy Selection**
  - Treatment-Distress Matrix
  - Concurrent Treatment Sequencing

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**Distress-Treatment Matrix**

<table>
<thead>
<tr>
<th>Distress</th>
<th>Slab Stabilization</th>
<th>Slab Jacking</th>
<th>Partial-Depth Repair</th>
<th>Full-Depth Repair</th>
<th>Retrofitted Edge Drains</th>
<th>Dowel Bar Retrofit</th>
<th>Cross Stitching / Slot Stitching</th>
<th>Diamond Grinding</th>
<th>Diamond Grooving</th>
<th>Joint Resealing</th>
<th>Crack Sealing</th>
<th>Thin Concrete Overlay</th>
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<tbody>
<tr>
<td>Corner breaks</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
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<td>Bumps, settlements, heaves</td>
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</tr>
</tbody>
</table>

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Concurrent Treatment Sequencing

- Restored Concrete Pavement
  - Joint/Crack Resealing
  - Grooving
  - Diamond Grinding
  - Tied PCC Shoulders
  - Cross-Stitching
  - Dowel Bar Retrofit
  - Full-Depth Repair
  - Partial-Depth Repair
  - Retrofit Edge Drains
  - Slab Stabilization

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Distressed Concrete Pavement

- Not all projects will require every procedure, but the sequence should be maintained.
Slab Jacking
Slab Stabilization vs. Slab Jacking

- **Slab Stabilization:**
  - Pressure insertion of grout/polyurethane to **fill** void beneath slab

- **Slab Jacking:**
  - Pressure insertion of grout/polyurethane to **raise** slab (profile restoration)
Partial-Depth Repairs
Benefits

- Restores slab integrity
- Improves ride quality
- Extends the service life
- Restores a well-defined uniform joint sealant reservoir
Partial-Depth Repair Types

Fig. 5.1 on p. 5.2
Diamond Grinding and Grooving
Grinding vs. Grooving

• Diamond grinding
  – Removal of thin layer of concrete surface to restore smoothness and friction

• Diamond grooving
  – Creation of channels in concrete pavements to reduce hydroplaning potential
  – Typically performed in localized areas
Surface Comparison

Diamond Grinding

Diamond Grooving
Other Surface Textures

• Optimized Texture for City Streets (OTCS)
  – Similar to diamond grinding but reduced land heights/widths

• Next Generation Concrete Surface (NGCS)
  – Manufactured, low-noise surface consisting of flush grinding and grooving

• Cold Milling
  – Removal of concrete layer using carbide blades
Other Texture Comparisons

NGCS

Cold Milling

OTCS
Diamond Grinding
Diamond Grinding
Potential Performance Benefits

• Restored smoothness (by removing built-in roughness and joint/crack faulting)
• Improved friction
• Improved cross-slope
• Reduced noise
• Typical performance life: 14-17 years
# Diamond Grinding

## Effect on Roughness

Percent decrease in IRI (new pavement): 58% (avg)

<table>
<thead>
<tr>
<th>Test Area</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>59%</td>
<td>56%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>53%</td>
</tr>
<tr>
<td>3</td>
<td>64%</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>55%</td>
</tr>
</tbody>
</table>

Source: 2003 ADOT Study

Expect higher decreases for older pavements (~70% average).
## Diamond Grinding

### Effect on Friction

Percent increase in friction (new, longitudinally tined pavement): 27%

<table>
<thead>
<tr>
<th>Test Area</th>
<th>Lane 1</th>
<th>Lane 2</th>
<th>Lane 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25%</td>
<td>15%</td>
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</tr>
<tr>
<td>2</td>
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<td></td>
<td>18%</td>
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<tr>
<td>3</td>
<td>41%</td>
<td>35%</td>
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</tr>
<tr>
<td>4</td>
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<td></td>
<td>26%</td>
</tr>
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</table>

Source: 2003 ADOT Study
Diamond Grinding

Other Advantages

• Can be done lane-at-a-time under a moving operation

• **Does not affect overhead clearances**

• No new materials introduced

• **Limited waste**

• Aesthetically blends patching and other irregularities into consistent surface
Diamond Grinding

Project Selection

- Structurally sound pavement
- Triggers:
  - Average faulting > 0.08 in (higher for JRCP)
  - IRI (Roughness) > 160 to 220 in/mi
  - Wheelpath wear > 0.25 to 0.40 in
  - Surface friction below agency standards
  - Excessive noise levels
- Consider hardness of aggregate
- Consider need for associated treatments (e.g., LTR)
- Recommended Evaluation Procedures:
  - Distress surveys
  - Roughness and/or friction testing
Diamond Grinding

Limitations

• Does not address structural or durability issues
• Hardness of aggregate affects costs, productivity, and performance life
• Roughness and deterioration will re-develop if causes are not addressed
  – Full- and partial-depth repairs
  – Dowel bar retrofit
  – Slab stabilization
  – Joint resealing?
Figure 9.15 on p. 9.14

- Diamond Grinding Equipment Schematic
  - Hydraulic Cylinder
  - Grinding Machine Frame
  - Leading Bogies
  - Subframe
  - Grinding Head
  - Trailing Bogies
  - Depth-Control Wheels
Diamond blades mounted in series on cutting head

- Cutting head width from 48 to 50 in [1,220 to 1,270 mm]
- Spacing of 50 to 60 blades per ft [164 to 197 blades per meter]
Diamond Grinding
Cutting Head and Blades

Figure 9.1 on p. 9.2
Diamond Grinding
Blade and Spacer Pairings

Figure 9.4 on p. 190
## Diamond Grinding

### Blade Spacing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Hard Agg</th>
<th>Soft Agg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groove Width</td>
<td>0.09 – 0.15 in</td>
<td>0.09 – 0.15 in</td>
<td>0.09 – 0.15 in</td>
</tr>
<tr>
<td>Land Area</td>
<td>0.07 – 0.13 in</td>
<td>0.07 – 0.11 in</td>
<td>0.09 – 0.13 in</td>
</tr>
<tr>
<td>Depth</td>
<td>0.04 – 0.12 in</td>
<td>0.04 – 0.12 in</td>
<td>0.04 – 0.12 in</td>
</tr>
<tr>
<td>No. of Blades</td>
<td>50 – 60/ft</td>
<td>53 – 60/ft</td>
<td>50 – 54/ft</td>
</tr>
</tbody>
</table>

Table 9.1 on p. 9.3
Diamond Grinding

Blade Spacing Effects

- Correct spacing critical to achieving proper texture
- Hard and large-sized aggregates require tighter blade spacing

52 blades/foot

60 blades/foot
Diamond Grinding
Construction Considerations

- Mobile single-lane closure
- Grind parallel to centerline
  - Max 2-in overlap (1 inch or less preferred)
  - Maintain cross-slope of adjoining passes
  - Limit holidays
- Slurry removal
Diamond Grinding

Grinding Process
Diamond Grinding
After First Pass of Grinding Machine
Diamond Grinding

Feather Pass at Curb and Gutter

Fig. 9.17 on p. 9.16
Diamond Grinding

Holidays

Fig. 9.16 on p. 9.15
Diamond Grinding

Slurry Handling

• Establish slurry handling schemes prior to project (on-site or off-site)

• On-Site
  – Deposit on foreslopes
  – Avoid wetland areas and natural streams or lakes

• Off-Site
  – On-board vacuums and water tankers
  – Deposit in settlement ponds
Diamond Grinding
Grinding Machine
Diamond Grinding
Trucks Collecting Slurry
Diamond Grinding
Finished Product
Diamond Grinding
Key Factors for Success

• Selection of proper candidate projects
• Proper design (blade spacing, transverse slope, and project layout)
• Conduct grinding parallel to the centerline
• Check that overlaps are within tolerances
• Monitor grinding depth
• Verify end product meets specification
  – Smoothness testing
  – Friction and/or texture measurements
Troubleshooting
What is wrong here?

Unground Areas (“Holidays”)
Troubleshooting
What is wrong here?

Poor Vertical Match Between Passes
Diamond Grooving
Diamond Grooving

- Cutting parallel grooves into the pavement using diamond saw blades
- Longitudinal (more common) or transverse
- Benefits
  - Reduced hydroplaning potential
  - Reduced wet-weather crashes
  - Reductions in splash and spray
Diamond Grooving
Effect on Friction

Fig. 9.4 on p. 9.6
Diamond Grooving

Project Selection

- High incidence of wet-weather crashes
- Generally performed at localized areas
- Pavements should be structurally and functionally sound
Diamond Grooving
Orientation

- **Longitudinal**
  - Decreased hydroplaning potential
  - Improved curve tracking
  - Easier to conduct under traffic
  - Lateral “squirm” of vehicles

- **Transverse**
  - Most direct channel for water drainage
  - Significant braking traction
  - Difficult to conduct under traffic
  - Noise may be an issue
  - Common for bridge decks and airports
Diamond Grooving
Design Considerations

- Groove entire lane area (but allow for small areas with surface irregularities)
- Use recommended blade spacing

**Saw blade thickness:**
- Minimum Depth: 0.125 in [3.2 mm]
- Maximum Depth: 0.25 in [6.4 mm]

**Diagram:**

- Minimum Depth: 0.125 in [3.2 mm]
- Maximum Depth: 0.25 in [6.4 mm]

Fig. 9.5 on p. 9.6
Diamond Grooving
Construction Considerations

• Groove dimensions
• Direction of grooving
• Disposal of slurry
• Procedures similar to diamond grinding
Diamond Grooving Equipment

- Head width: 1 to 6 ft [0.3 to 1.8 m]
- Blade spacing: 0.75 in [19 mm]
- Vacuum system to collect slurry
Diamond Grooving
Longitudinal Grooving
Diamond Grooving

Transverse Grooving

Bridge Deck

Airport
Diamond Grooving
Key Factors for Success

• Selection of proper candidate projects
• Proper selection of groove dimensions
• Selection of grooving direction
NGCS
NGCS Description

- Manufactured concrete pavement surface
- Uses conventional grinding equipment in two-phase operation:
  - Flush grinding
  - Grooving
  - Can also use single-pass equipment.
- Combines smoothness of diamond grinding and hydroplaning reduction of grooving into a low-noise surface
- New and rehabilitated pavements
NGCS Equipment Head Comparisons

NGCS Head (first pass)  Conventional Diamond Grinding Head
NGCS
Construction

Flush Grind

Grooved
NGCS
Future

• NGCS continues to be evaluated by a growing number of highway agencies
• Projects in at least 9 states
• Benefits of low noise but also increased smoothness, improved lateral stability, and reduction in hydroplaning potential
Joint Resealing and Crack Sealing
Joint Resealing & Crack Sealing

- Definition

Placement of an approved sealant material in an existing joint or crack to reduce moisture infiltration and prevent intrusion of incompressibles.
PCC Pavement Deterioration

Influence of Moisture Infiltration

Cracks/Joints + Moisture Infiltration → Base/Subbase Softening → Transverse Joint Faulting
PCC Pavement Deterioration

Influence of Moisture Infiltration

Cracks + Moisture Infiltration

→ Breakdown of Existing Cracks

Deteriorated Cracks
PCC Pavement Deterioration
Influence of Incompressibles

Cracks/Joints + Incompressible Material

Joint Spalling

Blow-Ups
Joint Resealing
Guidelines and Project Selection

• Reseal when existing sealant no longer functional
• Pavement not severely deteriorated
• In conjunction with other preservation activities

If joints were originally sealed, continue to keep those joints sealed
## Joint Sealing Materials

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Specs</th>
<th>Description</th>
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<tbody>
<tr>
<td>Polymerized/Rubberized Asphalt</td>
<td>ASTM D6690, Type I-IV (AASHTO M324)</td>
<td>Thermoplastic I: Mod climates II-III: Most climates IV: Very cold climates</td>
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<tr>
<td>Silicone</td>
<td>ASTM D5893, Type NS or SL</td>
<td>Thermosetting NS: Non-sag SL: Self leveling</td>
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<tr>
<td>Polysulfides, polyurethane</td>
<td>Fed Spec SS-S-200E, type M or H</td>
<td>Thermosetting</td>
</tr>
<tr>
<td>Preformed Polychloroprene</td>
<td>ASTM D2628</td>
<td>Polychloroprene</td>
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<tr>
<td>Backer Rod</td>
<td>ASTM D5249</td>
<td>For hot- or cold-applied sealants</td>
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</table>

Table 10.1 on p. 213
## Desirable Sealant Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
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<tbody>
<tr>
<td>Durability</td>
<td>Resistance to traffic, moisture, sunshine, and climatic variation</td>
</tr>
<tr>
<td>Extensibility</td>
<td>Deformation without rupturing</td>
</tr>
<tr>
<td>Resilience</td>
<td>Recovery from deformation and resistance to stone intrusion</td>
</tr>
<tr>
<td>Adhesiveness</td>
<td>Resistance to debonding at joint/crack wall during elongation</td>
</tr>
<tr>
<td>Cohesiveness</td>
<td>Resistance to internal rupture during elongation</td>
</tr>
</tbody>
</table>
Sealant Material Selection Factors

- Climatic conditions
- Joint/crack characteristics and spacing/density
- Traffic level and percent trucks
- Material availability and cost

Tool for estimating joint movement: http://apps.acpapa.org/apps/
Backer Rod

• Purpose:
  – Achieves shape factor
  – Prevents 3-sided adhesion

• Use closed-cell products

• Must be compatible with sealant type

• Diameter ~25% greater than joint width

• Use with caution in some cases
Example Joint Reservoir

Shape Factor = \( W:D \)

Fig. 10.4 on p. 216
## Joint Reservoir Design

### Recommended Shape Factors

<table>
<thead>
<tr>
<th>Sealant Material Type</th>
<th>Typical Shape Factor (W:D)</th>
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<tbody>
<tr>
<td>Rubberized Asphalt</td>
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<td>Silicone</td>
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<tr>
<td>Polysulfide and Polyurethane</td>
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</table>

Table 10.2 on p. 217
Joint Reservoir Design
Sealant Configurations

Recessed

Flush-Filled

Overbanded

See ACPA “Joint Noise Estimator” tool at: apps.acpa.org

Fig. 10.7 on p. 218
Construction: Joint Resealing

Procedures

1. Old sealant removal
2. Joint refacing
3. Joint reservoir cleaning
4. Backer rod installation
5. New sealant installation
Construction: Joint Resealing

Sealant Removal

Joint Plow

Joint Sawing
Construction: Joint Resealing

Joint Refacing
Construction: Joint Resealing

Cleaning the Joint

Air blasting

Water blasting

Sandblasting

Goal: clean, dry surface with newly exposed concrete (enhanced bond)
Construction: Joint Resealing

Backer Rod Installation
Construction: Joint Resealing

Installed Backer Rod
Construction: Joint Resealing

Sealant Installation

Hot-Poured Sealant

Silicone Sealant
Longitudinal Joint Resealing
Construction: Joint Resealing

Longitudinal PCC/PCC Joints

- Lane/lane or lane/shoulder joint
- Tied non-working joint
- Shape factor not needed
- Hot-applied thermoplastic sealant
Construction: Joint Resealing

Longitudinal PCC/HMA Joints

- Very difficult joint to seal
  - Vertical movements
  - Horizontal movements
- Major entry point for water infiltration
- Joint reservoir:
  - Minimum width and depth of 0.75 in [19mm]
  - No backer rod required
- Hot-applied and silicone sealants
- Some agencies simply overband
Construction: Joint Resealing

Sawed Longitudinal PCC/HMA Joint
Construction: Joint Resealing
Sealed Longitudinal PCC/HMA Joints
Key Factors For Success
Joint Resealing

• Selection of candidate projects
• Selection of proper material
• Proper reservoir design and joint shape factor
• Proper reservoir preparation
• Proper sealant application techniques
• Monitor opening to traffic
Troubleshooting
What is wrong here?

Too Much Applied Sealant
Troubleshooting

What is wrong here?

Dirt on Refaced Surfaces
Crack Sealing
Guidelines for Sealing Cracks

• Leave tight, narrow cracks alone
• Seal working transverse cracks
• Can seal cracks \( \leq 0.5 \text{ in} \ [13 \text{ mm}] \) wide
• Use special crack sawing blades
• Same general *joint* resealing procedures apply to *crack* sealing
Construction: Crack Sealing

Procedure

1. Crack sawing
2. Cleaning
3. Backer rod installation
4. Sealant installation
Construction: Crack Sealing

Crack Sawing
Construction: Crack Sealing

Sawed Crack
Construction: Crack Sealing

Completed Crack Seal
Closure

• A complete surface restoration strategy may encompass many techniques
  – Spall repair, grinding, grooving, joint resealing, etc.

• Strategy varies with individual project needs (surface defects, friction and hydroplaning issues, etc.)

• Surface restoration is an effective component of pavement preservation programs.
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Primary Source Material

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