Concrete Pavement Preservation

Timely and Effective Treatments for Preserving and Restoring the Condition of Concrete Pavements

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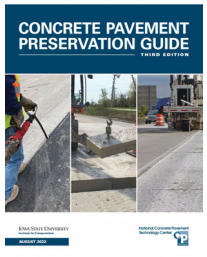
Outline

- Introduction: What is Pavement Preservation?
- Getting Started: Evaluating the Pavement
- Effective Preservation Treatments
- Strategy Selection

Acknowledgments & Further Information

- More information is available from the CP Tech Center:
  - https://cptechcenter.org/pavement-preservation/
- New in 2022: Concrete Pavement Preservation Guide, 3rd Edition



Introduction: What is Pavement Preservation?

What is Pavement Preservation?

- Proactive approach to managing pavement assets
- Focus on extending pavement life and maintaining or restoring functional condition
- Accomplished using a collection of preservation and rehabilitation treatments

A more recent definition:

Concrete pavement preservation is a strategy of extending concrete pavement service life for as long as possible by arresting, greatly diminishing, or avoiding pavement deterioration processes.

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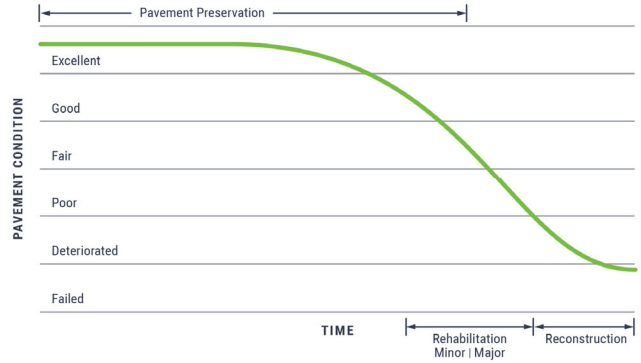
What is Pavement Preservation?



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What is Pavement Preservation?

- Keys to successful projects:
  - **Right pavement:** few/limited structural problems or materials-related distress
  - **Right time:** before significant structural issues
  - **Right treatment:** address the conditions with targeted treatments
  - **Right installation:** install the treatment effectively so the full benefits are achieved

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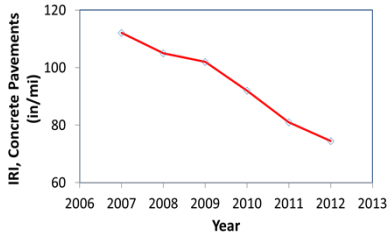
Concrete Pavement Preservation

- Benefits
  - User satisfaction
    - Smoothness
    - Safety
    - Fewer traffic disruptions
    - Reduced lane closure duration
  - Improved network conditions
  - Long-term cost savings
  - Enhanced sustainability

- Example benefits: Network-level smoothness data from KY after adoption of preservation program:



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Concrete Pavement Preservation

Primary Treatments:
- Crack sealing
- Diamond grinding
- Diamond grooving
- Dowel bar retrofit
- Full-depth repair
- Joint resealing
- Partial-depth repair

Additional Treatments:
- Concrete overlay
- Cross stitching
- Slab stabilization
- Slab jacking
- Slot stitching
- Retrofitted edge drains

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Concrete Pavement Preservation

- Typical performance of selected preservation treatments:

Treatment	Expected Performance (treatment life)
Slab stabilization	5 to 10 years
Partial-depth repairs	10 to 20+ years
Full-depth repairs	20+ years
Dowel bar retrofit	15 to 20+ years
Cross stitching	10 to 20+ years
Diamond grinding	15 to 25+ years
Joint resealing	8 to 16+ years

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Getting Started: Evaluating the Pavement

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Purposes of a Pavement Evaluation

- Provides qualitative information to:
  - Determine causes of deterioration
  - Determine if pavement is not a candidate for preservation
  - Develop appropriate treatment alternatives
- Provides quantitative information for:
  - Quantity estimates
  - Assessment of deterioration rates
  - Performing life-cycle cost analyses

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Key Pavement Evaluation Components

- Pavement Distress & Drainage Surveys
- Nondestructive Testing
- Surface Characteristics Testing
- Field Sampling and Testing

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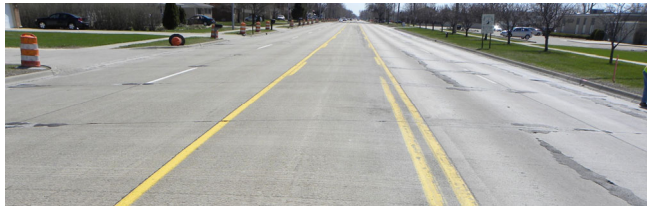
Pavement Distress Survey

- Provides fundamental information on pavement performance
- General indicator of pavement deficiencies and needs
- Identifies needs for additional field testing



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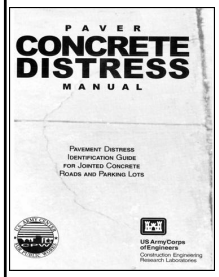
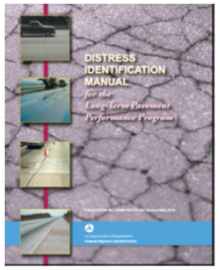
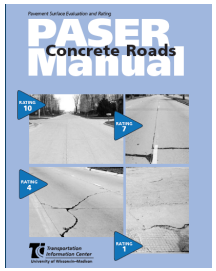
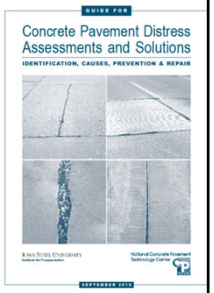
Pavement Distress Survey: Example Manuals









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Pavement Distress Surveys

- Manual data collection methods

- Automated data collection methods

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Example Distress Trigger Values

Performance Indicator	Typical Trigger Value	Typical Limit Value	Possible Treatments
Transverse Cracking	1.5-2.5% of slabs cracked	5-15% of slabs cracked	• Full-depth repair • Dowel bar retrofit
Joint Deterioration	2.0-4.0% of joints	15-20% of joints	• Partial-depth repairs • Full-depth repairs
Joint Faulting	1/8 inch	3/8 – 1/2 inches	• Dowel bar retrofit • Diamond grinding • Slab stabilization
Roughness	90 in/mi	170 in/mi	• Diamond grinding

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Testing and Sampling

- More detailed information may also need to be collected on-site to inform treatment selection and strategy
- Nondestructive testing can provide many kinds of information
  - Layer thicknesses, material properties
  - Load transfer
  - Location of voids, rebar
  - Smoothness, friction, noise




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Testing and Sampling

- Field sampling not routinely needed on most preservation projects
- In some cases, may be required to provide information on:
  - Layer type, thickness, and properties
  - Depth of deterioration
  - Underlying support layer conditions


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Effective Preservation Treatments

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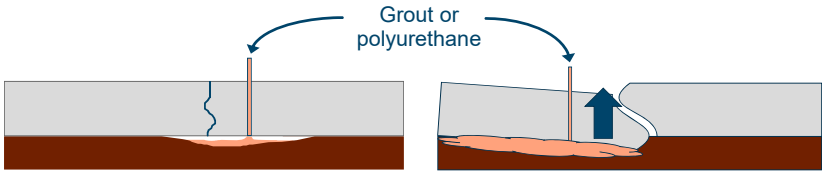
Slab Stabilization and Slab Jacking

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

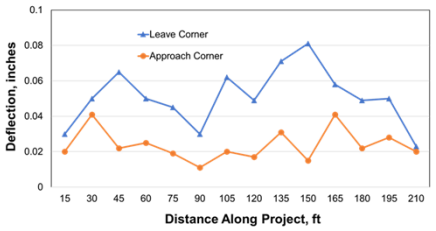


Slab Stabilization

- Addresses issues such as loss of support and pumping/erosion of subbase before they result in significant distresses like faulting or cracking

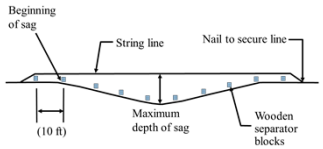
Slab Stabilization

- Loss of support can be identified from deflection testing, GPR, or visual observation



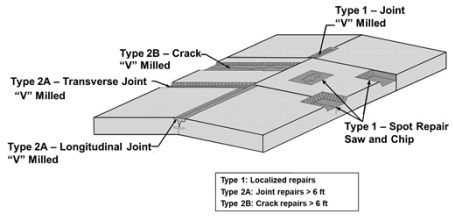
Slab Jacking

- Best for addressing localized areas of settlement
  - Fill areas, culverts, bridge approaches
  - Not a method for addressing joint faulting



Partial-Depth Repairs

- Removal & replacement of shallow areas of deteriorated concrete
  - Depth up to 1/2 of slab thickness
- Frequently used to address joint spalling and deterioration



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Partial-Depth Repairs

- Good candidates
  - Spalling caused by incompressibles
  - Joint deterioration caused by de-icing chemicals
  - Surface deterioration tied to poor curing or finishing

- Poor candidates
  - Deterioration > 1/2 slab thick
  - Spalling due to working cracks or dowel misalignment.
  - Materials-related distress spalling

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Partial-Depth Repairs

- Pavement removal
  - Saw and patch
  - Chip and patch
  - Mill and patch

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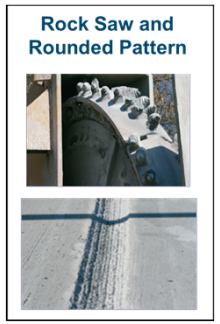
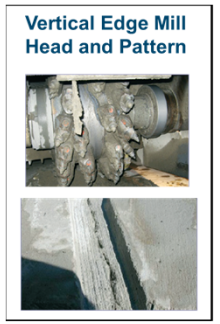
Partial-Depth Repairs

- Milling options:





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Partial-Depth Repairs

- Can provide effective performance provided:
  - Properly sized (all deteriorated materials removed)
  - Durable materials
  - Properly installed (very sensitive to construction process)

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Full-Depth Repairs

- Tried and true method of concrete pavement repair
- Extends to the full depth of the existing slab
  - Cast-in-place
  - Precast
- Applicable for:
  - Jointed concrete pavements
  - Continuously reinforced concrete pavements
  - Utility cuts

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Full-Depth Repairs

- Best for addressing intermittent structural deterioration
- Maintain serviceability or prepare pavement for overlay

Table 6.1. Candidate JPCP/JRCP distresses addressed by FDRs

Distress type	Distress severity levels that could trigger FDR
Transverse cracking	Medium, high
Longitudinal cracking	Medium, high
Corner break	Low, medium, high
Spalling of joints	Medium,[1] high
Blowup	Low, medium, high
D-cracking (at joints or cracks)[2]	Medium,[1] high
Reactive aggregate spalling[2]	Medium,[1] high
Deterioration adjacent to existing repair	Medium,[1] high
Deterioration of existing repairs	Medium,[1] high

Table 6.2. Candidate CRCP distresses addressed by FDRs

Distress type	Distress severity levels that could trigger FDR
Punchout	Low, medium, high
Deteriorated transverse cracks[1]	Medium, high
Longitudinal cracking	Medium, high
Blowup	Low, medium, high
Construction joint distress	Medium, high
Localized distress	Medium,[2] high
D-cracking (at cracks)[3]	High
Deterioration adjacent to existing repair	Medium,[2] high
Deterioration of existing repair	Medium,[2] high

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Full-Depth Repairs

- Design and materials considerations
  - Repair location and boundaries
  - Opening time demands
  - Repair material selection
    - Standard PCC mix
    - High-early strength PCC mix
    - Mixes with other rapid-setting cements
  - Opening strength requirements

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Full-Depth Repairs

- Construction steps:
  1. Sawing of repair boundaries
  2. Concrete removal
  3. Repair area preparation
  4. Restoration of load transfer
  5. Treatment of longitudinal joint
  6. Concrete placement and finishing
  7. Curing

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Full-Depth Repairs

- Done well, full-depth repairs are capable of an extended treatment life of 20+ years
  - Restore load transfer to doweled pavements
  - Use durable repair materials
  - Ensure proper placement, finishing, and curing

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Full-Depth Repairs

- Precast panels may also be used for full-depth repairs
- Several systems are available with similar installation steps:

Dowel bars drilled in existing slab

Dowel bars fabricated in precast panel

Precast panel using full dowel bar retrofit installation

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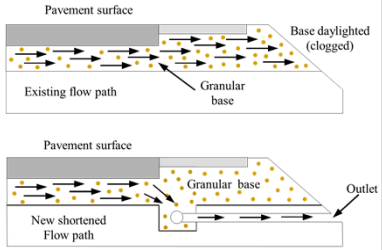
Retrofitted Edge Drains

- Remove surface infiltration water from beneath pavements
  - Shortens drainage path
  - Gets water out more quickly
- Alleviate moisture issues on pavements with inadequate drainage
- Delay or slow the development of moisture-related distresses



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Dowel Bar Retrofit

- Installation of dowel bars across transverse joints or cracks
- Improves load transfer, reduces deflections, and corrects and prevents faulting
- Typical repair: 3 to 4 bars in each wheel path

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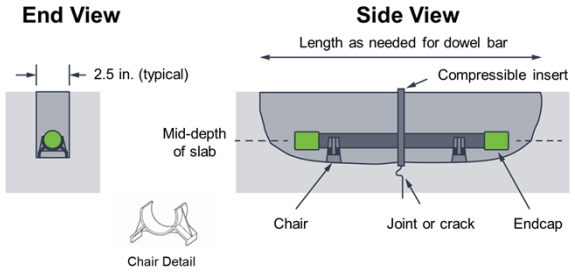
Dowel Bar Retrofit



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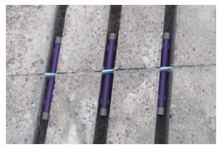
Dowel Bar Retrofit

- Construction steps:
  1. Slot cutting
  2. Slot preparation
  3. Dowel bar placement
  4. Placement of patching material
  5. Re-saw joint/crack



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Dowel Bar Retrofit

- Treatment life: 15 to 20+ years
- Usually combined with diamond grinding to restore and improve pavement smoothness

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Cross Stitching and Slot Stitching

- Repair methods for longitudinal cracks and joints



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Diamond Grinding (and Grooving)

- Diamond grinding
  - Removal of a thin layer of the concrete surface
  - Improves pavement smoothness, surface texture, and noise
- Diamond grooving
  - Creation of channels to reduce potential for hydroplaning


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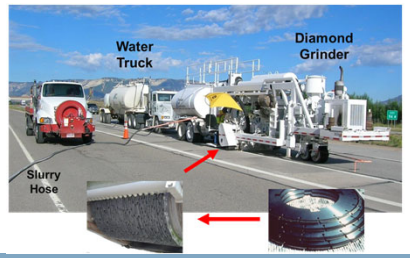
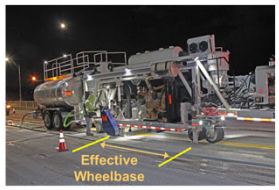
Diamond Grinding

- Can be constructed under mobile single lane closures
- Typical 4 ft grinding head (3 passes/lane)
- Slurry collection and removal process in urban areas





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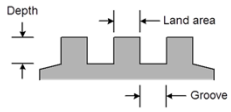
Diamond Grinding

- Blade design:

Parameter	Range	Hard Agg	Soft Agg
Groove Width	0.09 – 0.15 in	0.09 – 0.15 in	0.09 – 0.15 in
Land Area	0.07 – 0.13 in	0.07 – 0.11 in	0.09 – 0.13 in
Depth	0.04 – 0.12 in	0.04 – 0.12 in	0.04 – 0.12 in
No. of Blades	50 – 60/ft	53 – 60/ ft	50 – 54/ft



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Diamond Grinding

- Feathering adjacent to curb using a smaller grinding machine:

Diamond Grinding

- Typically reduces pavement roughness by 15-60%
  - DBR is necessary to truly correct faulting and to ensure the smoothness benefits are long-lasting

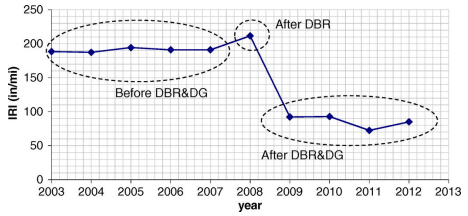


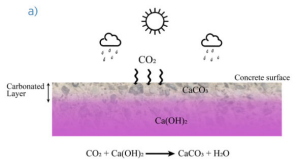
Image: TXDOT, Chen and Hong (2014)

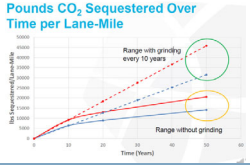
Diamond Grinding

- Combines well with other preservation treatments
  - Smooths patch areas and other irregularities into a consistent surface

Diamond Grinding

- Can have a significant impact on sustainability and life cycle impacts of the pavement
  - Restores pavement condition and pavement smoothness without new using new paving materials
  - Smooth roads improve fuel efficiency and reduce emissions
  - Grinding exposes new surface area to sequester CO_2

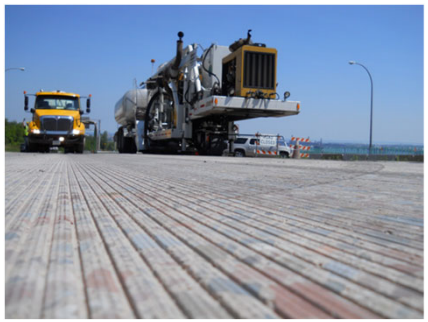




Images: MIT, NCE

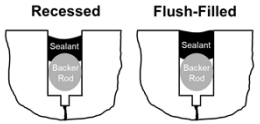
Next Generation Concrete Surface (NGCS)

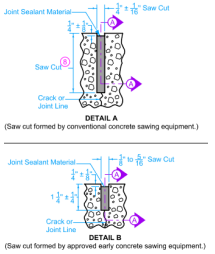
- Ultra low-noise surface consisting of flush grinding and grooving



Joint Re-sealing and Crack Sealing

- Goals
  - Reduce infiltration of moisture and deicing chemicals
  - Prevent intrusion of incompressible materials
- Variety of materials may be used for sealing
  - For re-sealing, usually hot-poured asphalt or silicone sealant
- "Sealing" vs "Filling"





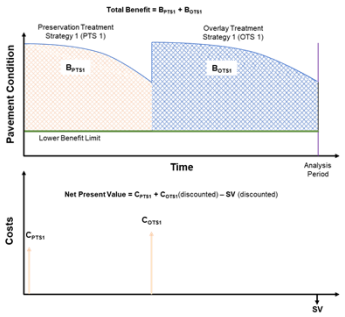
Joint Re-sealing and Crack Sealing

- Treatment life: 8 to 16+ years
- Caution with use of backer rod & hot pour in cold climates:

Strategy Selection

Strategy Selection

- Variety of methods for informing choice of treatment strategies
  - Economic
    - Benefit-cost ratio analysis (BCR)
    - Life-cycle cost analysis (LCCA)
  - Sustainability
    - Life-cycle assessment (LCA)
    - Sustainability rating systems



Strategy Selection

- Construction sequencing
  - Preservation activities can be applied concurrently
  - Proper sequencing is important to maximize the effectiveness of the individual treatments