Concrete Pavement Preservation

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

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Tech Center

Outline

- Introduction
- Getting Started
- Preservation Treatments
- Local Project Examples

Acknowledgments & Further Information

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- Much more information is available from the CP Tech Center:
  - https://cptechcenter.org/pavement-preservation/

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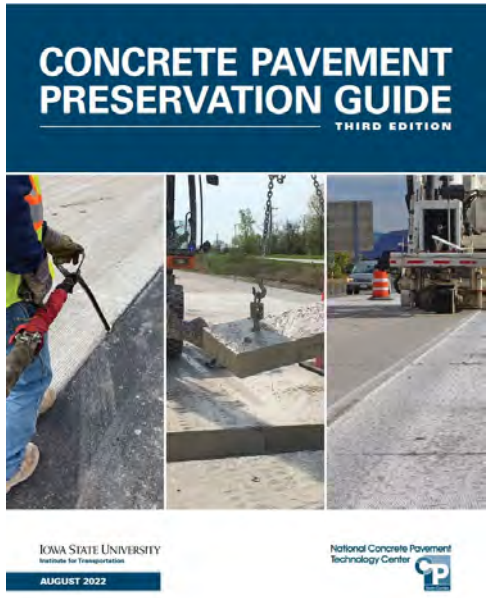


Introduction

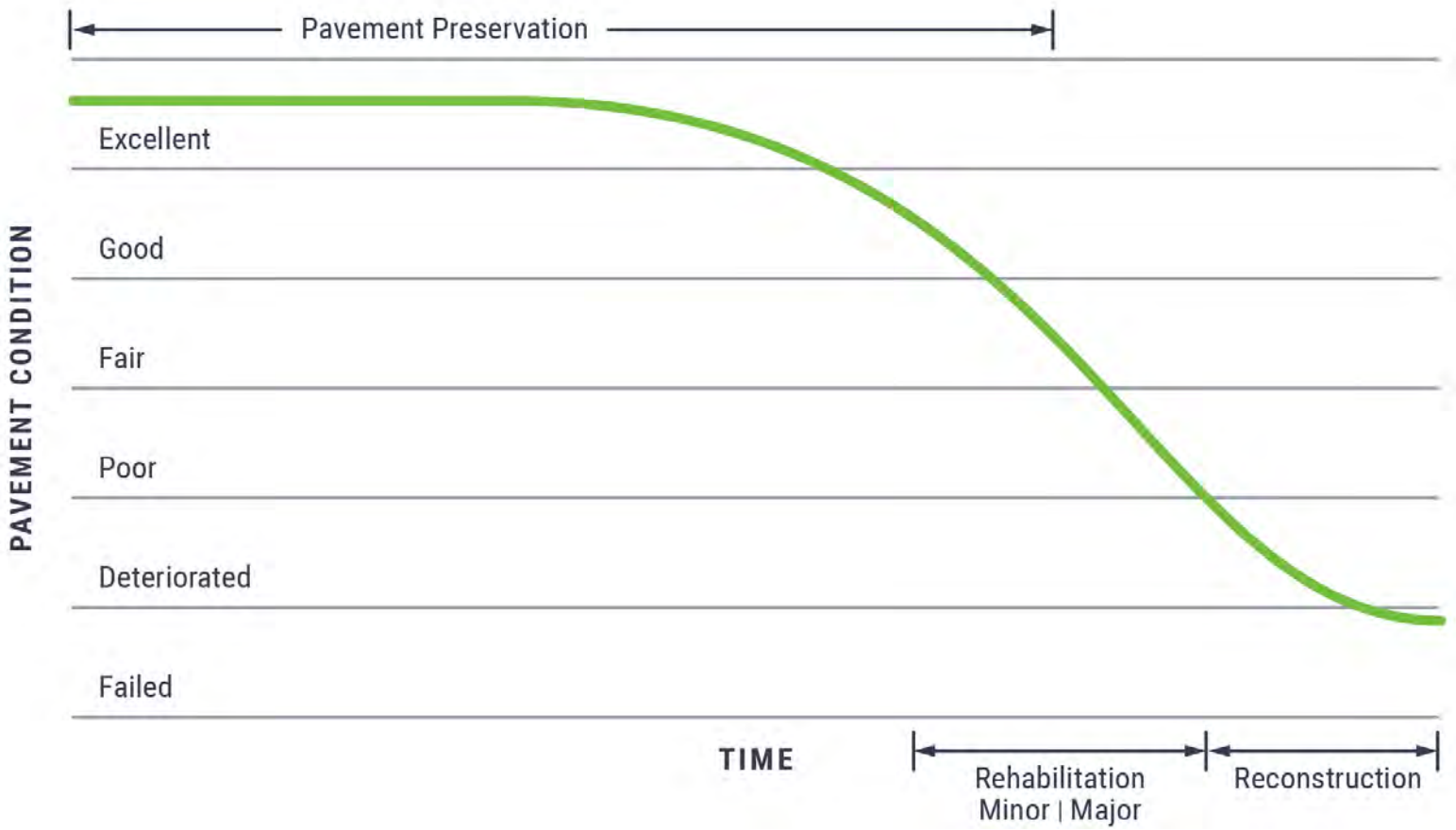
What is Pavement Preservation?

- 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.

What is Pavement Preservation?



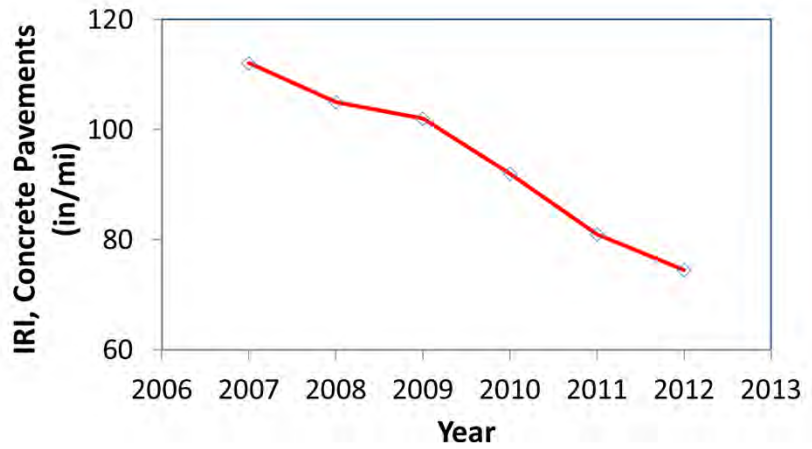
What is Pavement Preservation?

- Keys to successful projects:
  - Target the right pavement for receiving preservation treatments
  - Target the right time in the life of the pavement for the preservation treatments
  - Install the treatment effectively so the full benefits are achieved

Concrete Pavement Preservation

- Benefits
  - User satisfaction
    - Smoothness
    - Safety
    - Fewer traffic disruptions
  - Long-term cost savings
  - Sustainability

- Network-level smoothness data from KY after adoption of a diamond grinding program:



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

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

Getting Started

Evaluating Pavement Condition

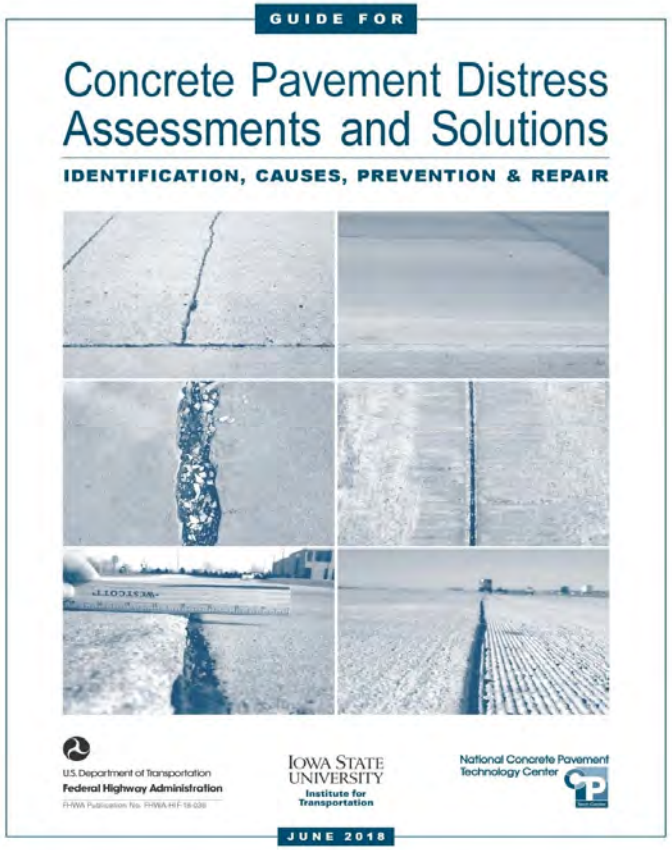
- How do we determine if preservation is right for a project and which preservation treatments we should use?
  - Qualitative methods
    - Identify deterioration/distresses
    - Determine causes
  - Quantitative methods
    - Quantity estimates
    - Deterioration rates
    - Life cycle cost analysis

Pavement Distress Survey

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

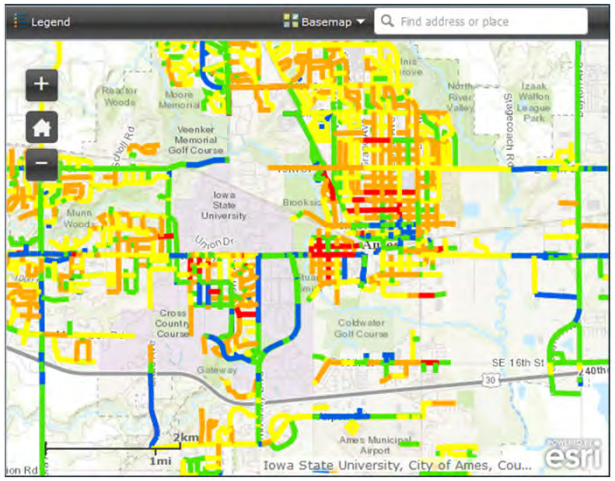
Pavement Distress Survey

- Document pavement condition
- Identify types of distress
- Group areas of similar performance
- Gain insight into causes of deterioration
- Identify additional testing needs
- Identify possible treatment alternatives
- Identify repair areas and quantities



Data Collection

- Automated pavement condition data can be used to identify candidates for preservation
- Allows for planning and programing of preservation activities at a network level



L Image: APTech

Data Collection

- Example of trigger values for planning preservation activities:

Performance Indicator	Trigger Value	Limit Value	Repair
Trans. Cracking	1.5-2.5% of slabs cracked	5-15% of slabs cracked	Partial, Full, Dowel Bar Repairs
Joint Deterioration	2.0-4.0% of joints	15-20% of joints	Partial-Depth Repair
Joint Faulting	1/8 inch	3/8 – 1/2 inches*	Dowel Bar Retrofit
Roughness	90 in/mi	170 in/mi*	Diamond Grinding

Testing and Sampling

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

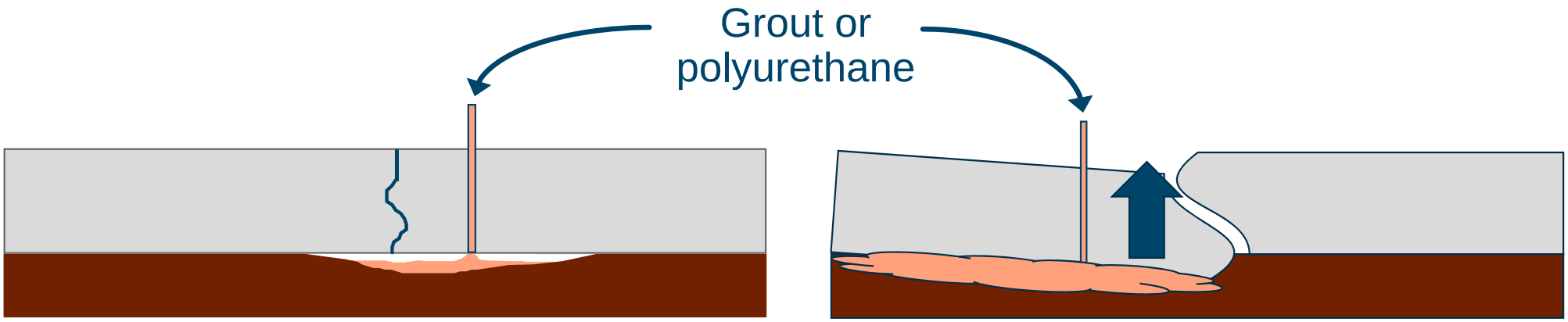
Testing and Sampling

- Field sampling may not always be necessary, but can provide valuable information
  - Uncertainty in condition, deterioration depth, thickness of older pavement layers

Preservation Treatments

Slab Stabilization and Slab Jacking

- Pressure insertion of polyurethane or grout to fill voids underneath slabs (stabilization) or to raise slabs (jacking)



Slab Stabilization

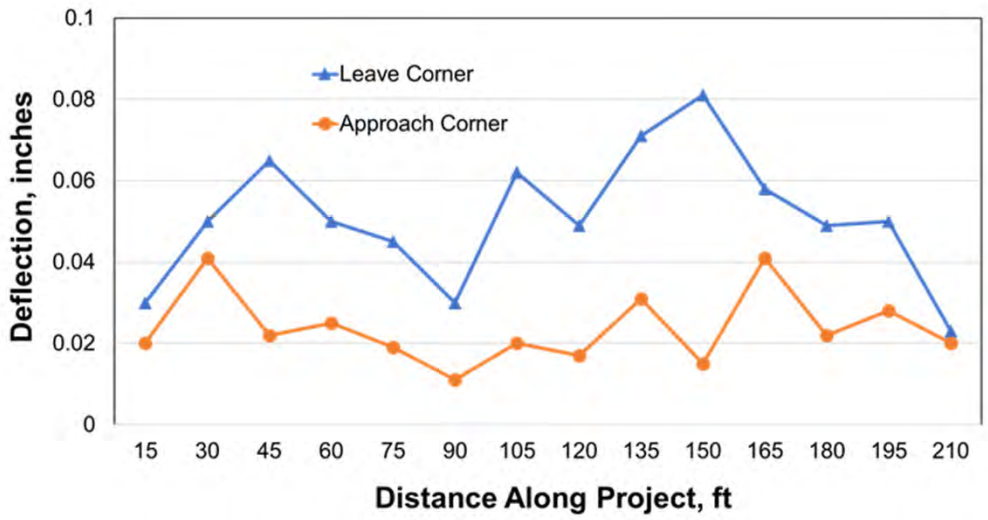
Slab Jacking

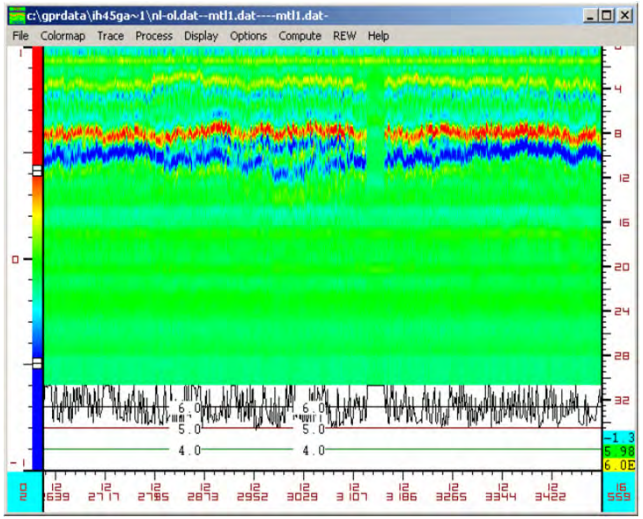
Slab Stabilization

- 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



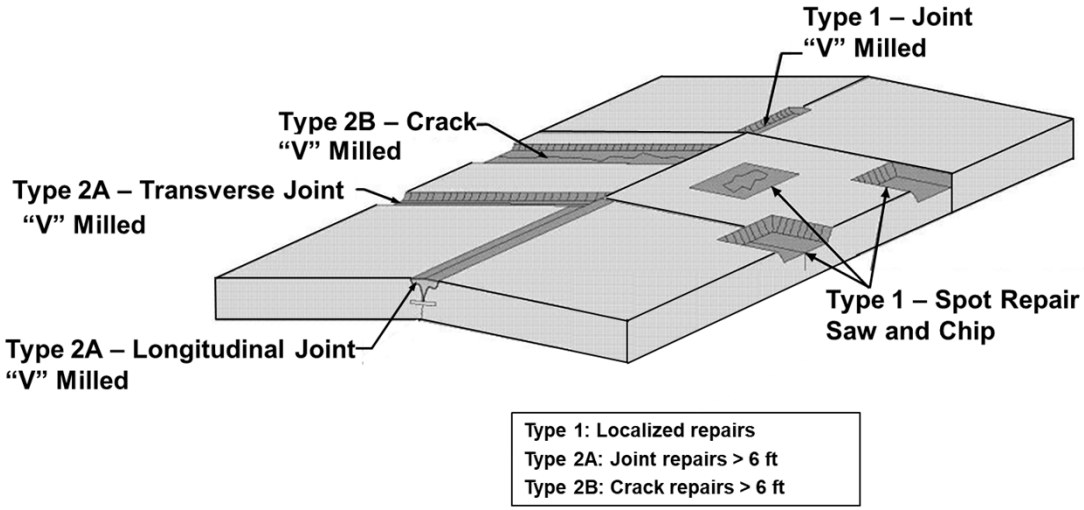


Slab Jacking

- 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



Partial-Depth Repairs

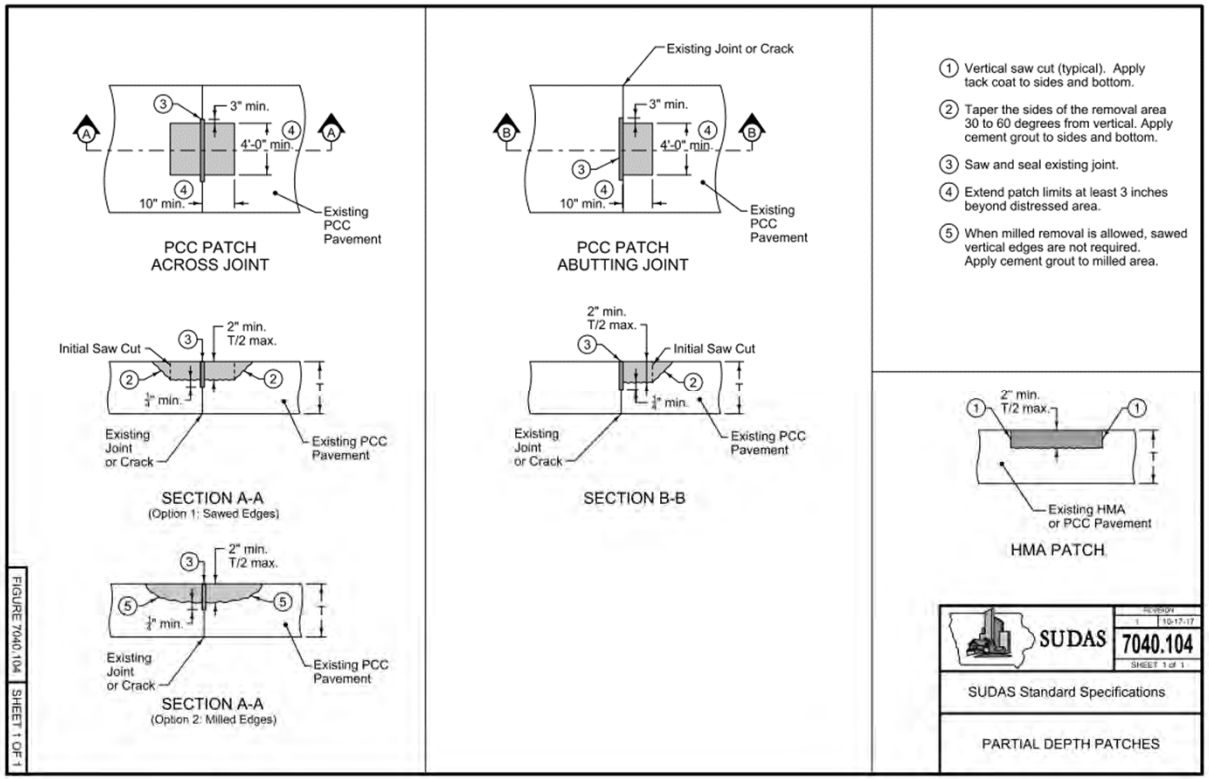
- What makes a good candidate for PDR?
  - Spalling caused by incompressible materials
  - Joint deterioration caused by de-icing chemicals
  - Surface deterioration tied to poor curing or finishing

Partial-Depth Repairs

- When is PDR not the right solution?
  - Deterioration greater than 1/2 slab thickness
  - Spalling due to working cracks, dowel bar misalignment, etc.
  - Joint deterioration caused by D-cracking or reactive aggregates
    - In this case, PDR is at best a stopgap measure

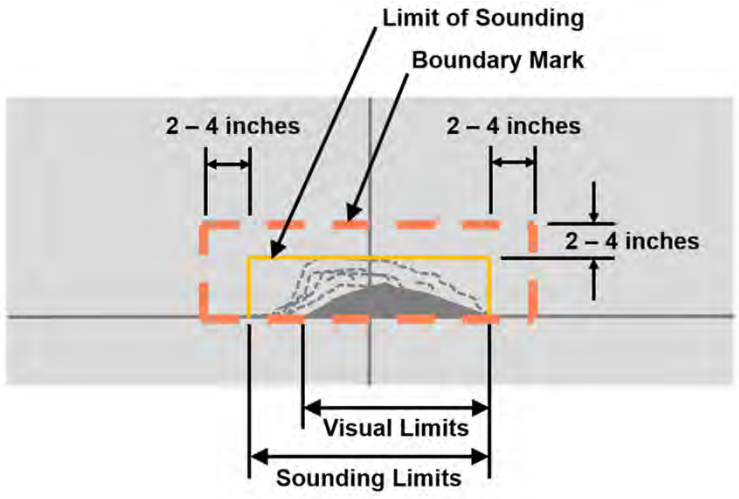
Partial-Depth Repairs

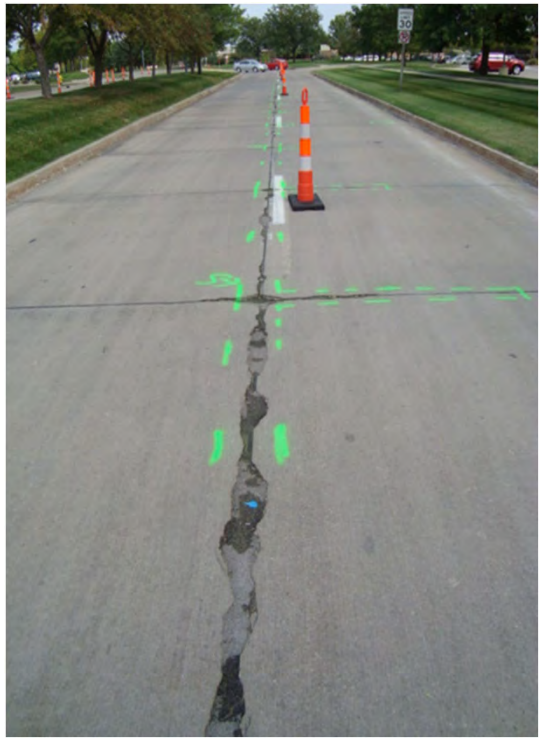
- SUDAS 7040.3.03 & Iowa DOT 2530:



Partial-Depth Repairs

- Repair boundaries
  - Determine extent of deterioration by sounding
  - Extend 3 inches outside of unsound areas
  - Combine spalls if closer than 24 inches





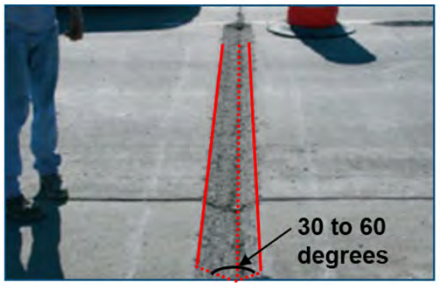
Partial-Depth Repairs

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

Partial-Depth Repairs

- Milling options:

"V" Shape Milling Head and Pattern



Rock Saw and Rounded Pattern

Vertical Edge Mill Head and Pattern

Partial-Depth Repairs

- Select repair materials based on curing time, placement conditions, size and depth of repair, performance requirements
  - Conventional or high early strength PCC
  - Other types of rapid-setting cements
  - Polymer-based materials
  - Bituminous materials

Partial-Depth Repairs

- Construction process
  - Establish a clean, roughened surface
  - Prepare compressible joint re-former for patches at joints
    - Joints can also be re-established by sawing

Partial-Depth Repairs

- Apply bonding agent (cement or epoxy grout) to patch area
  - Ensure the bonding agent doesn’t set or dry out
- Place, finish, and cure the repair material
  - Grout edges of the patch
- Re-saw joints (if not using joint re-former) and seal joints
  - Must saw through the full depth of the patch

Partial-Depth Repairs

- Treatment life: 10 to 20+ years
  - Very sensitive to the construction process – patches can last a long time, but failures can occur quickly!

Full-Depth Repairs

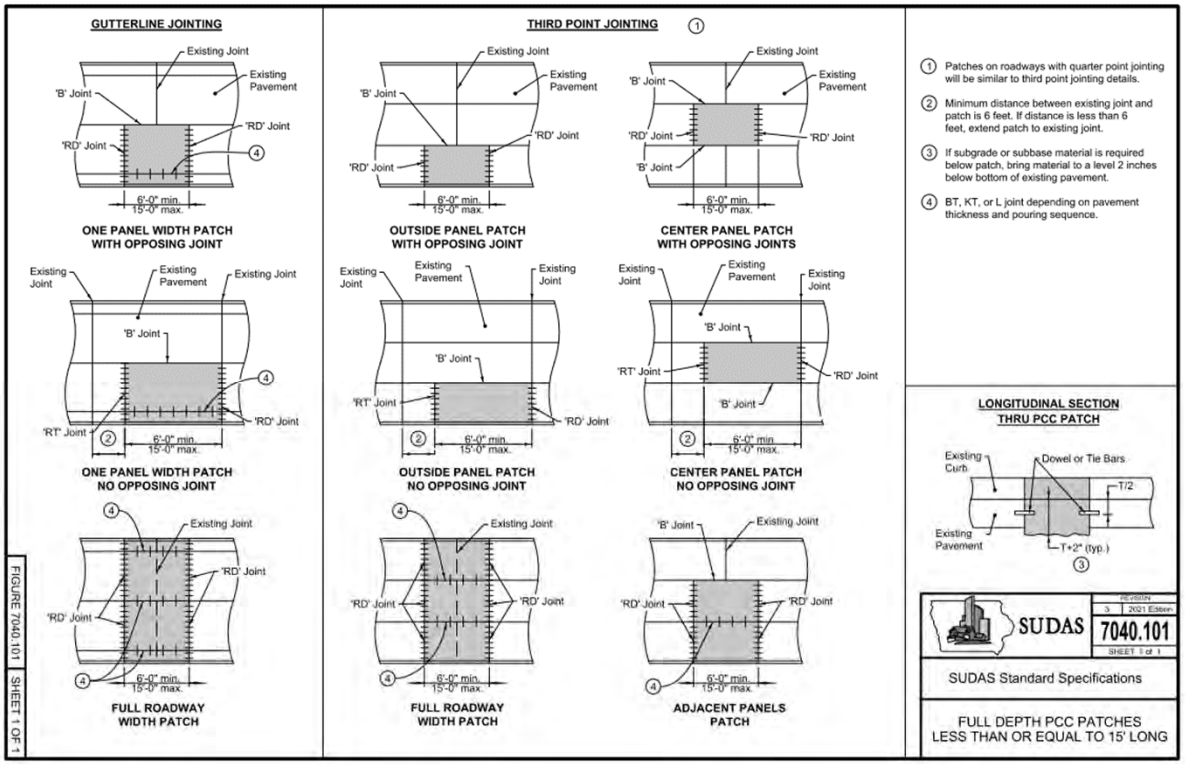
- Tried and true method of concrete pavement repair
- Best for addressing intermittent structural distresses

Candidate JCP Distresses
Transverse Cracking (M, H)
Longitudinal Cracking (M, H)
Corner Breaks (L, M, H)
Spalling (M, H)
Blowups (L, M, H)
D-Cracking or ASR Deterioration*

** Stopgap measure*

Full-Depth Repairs

- SUDAS 7040.3.02 & Iowa DOT 2529:



Full-Depth Repairs

- Capable of extended treatment life of 20+ years
  - Make sure to restore load transfer in doweled pavements
  - Consider the potential tradeoff between using high early strength PCC mixes and the longevity of the repair
  - Cure!

High Early Strength Mixes for Patching

- Class M mix (Iowa DOT IM 529 & section 2529)
  - About 30-40% higher Portland cement content
  - Minimal-to-no use of SCMs
  - Include calcium chloride for overnight opening (5-10 hours)
  - Sacrifices some durability for opening strength in < 24 hours

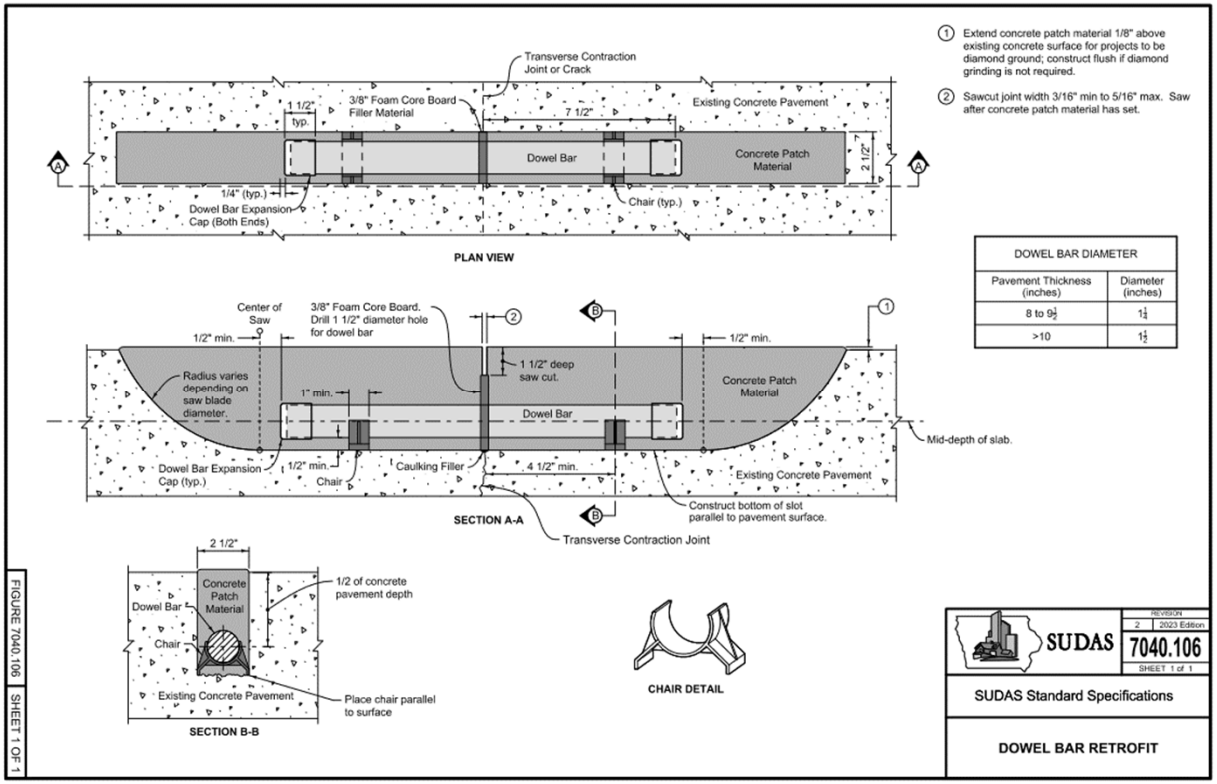
- Mixes with other types of rapid setting cements (e.g. CSA cement)
  - Combines high early strength with excellent long-term durability
  - Potential for improved patch performance
  - May be logistically challenging to use
  - Expensive

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

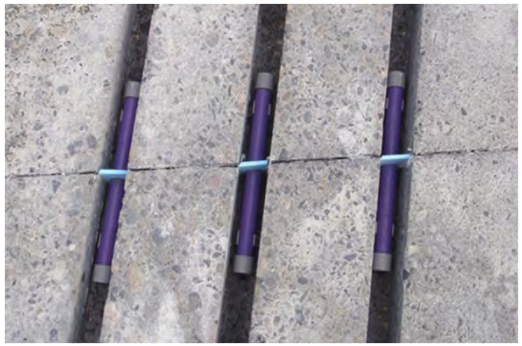
Dowel Bar Retrofit

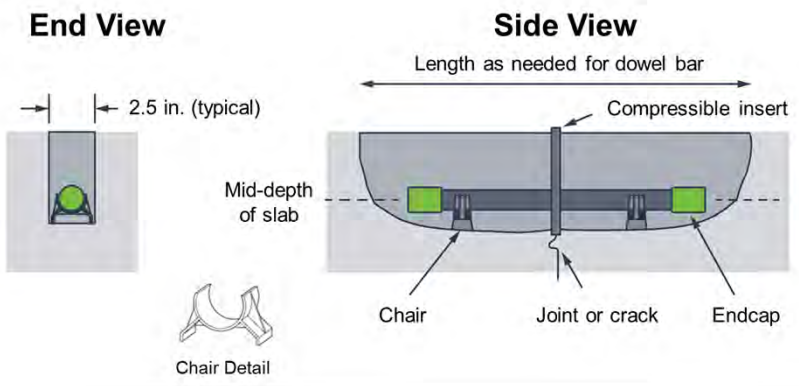
- SUDAS 7040.3.10:



Dowel Bar Retrofit

- Slot cutting
- Slot preparation
- Dowel bar placement
  - Chairs and compressible insert
- Placement of patching material
- Re-saw joint/crack





Dowel Bar Retrofit

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

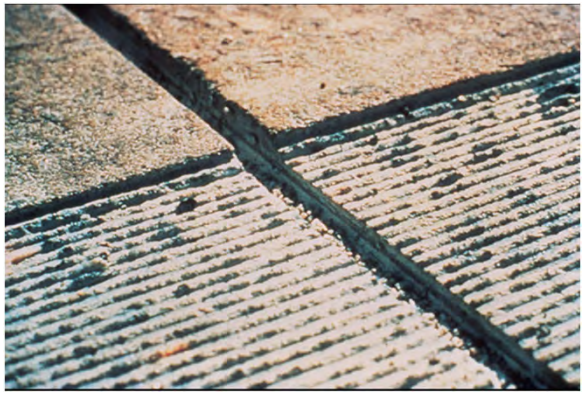
Image: City of Dubuque

Cross Stitching and Slot Stitching

- Repair methods for longitudinal cracks and joints

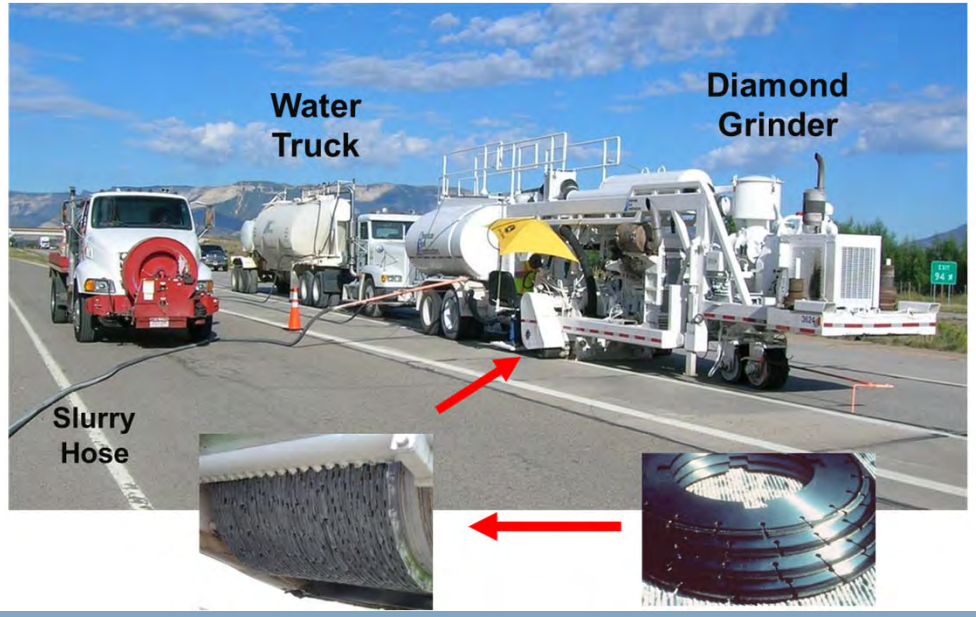
Diamond Grinding (and Grooving)

- 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



Diamond Grinding

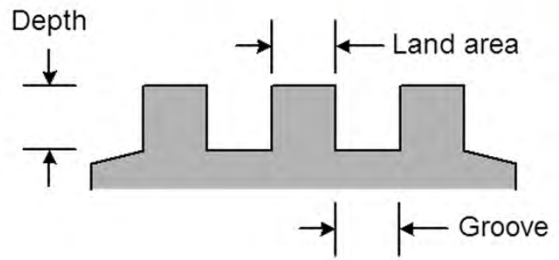
- Can be constructed under mobile single lane closures
- Typical 4 ft grinding head (3 passes/lane)
- Slurry removal process in urban areas



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



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

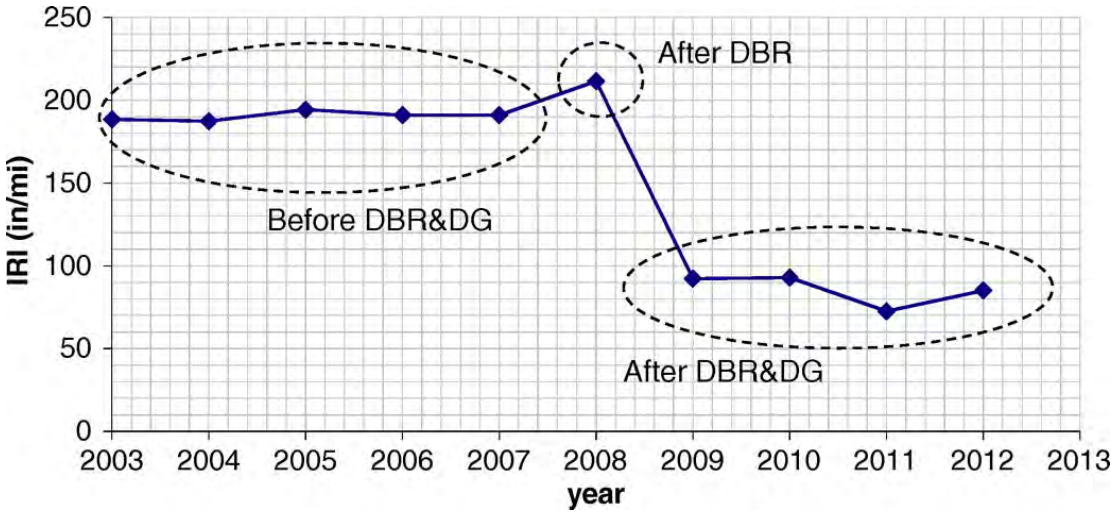


Image: TXDOT, Chen and Hong (2014)

Diamond Grinding

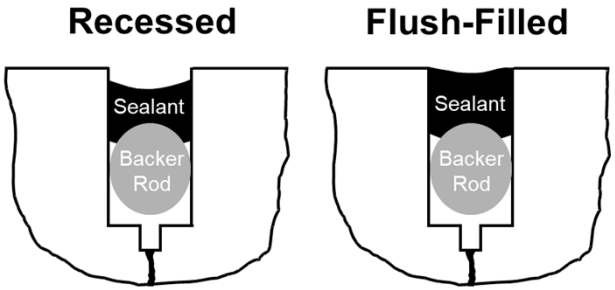
- Combines well with other preservation treatments
  - Smooths patching and other irregularities into a consistent surface
- Can have a significant impact on sustainability of the pavement
  - Restoration of pavement smoothness without new using new paving materials
  - Smooth roads improve fuel efficiency and reduce emissions
  - Grinding exposes new concrete to sequester additional CO_2

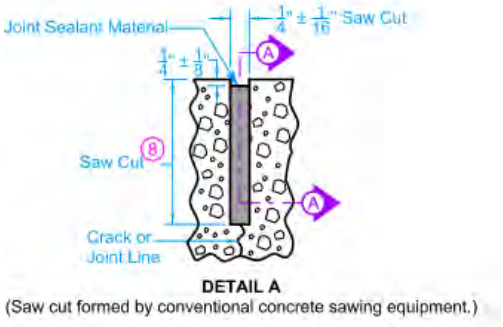
Next Generation Concrete Surface (NGCS)

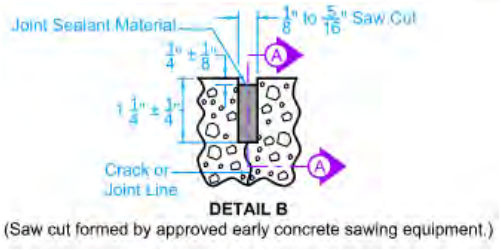
- Ultra low-noise surface consisting of flush grinding and grooving

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”





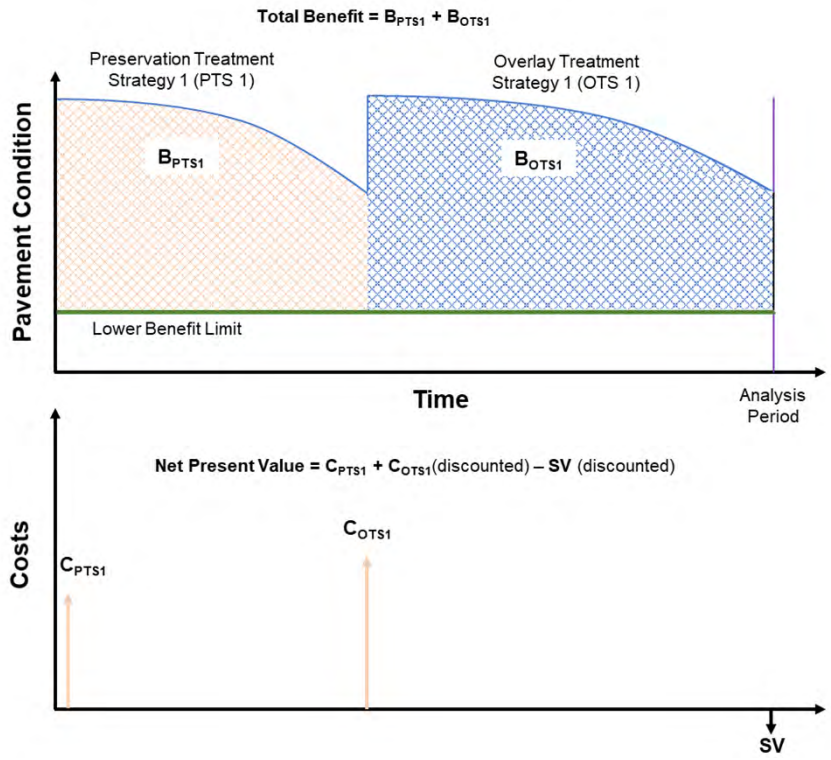


Joint Re-sealing and Crack Sealing

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

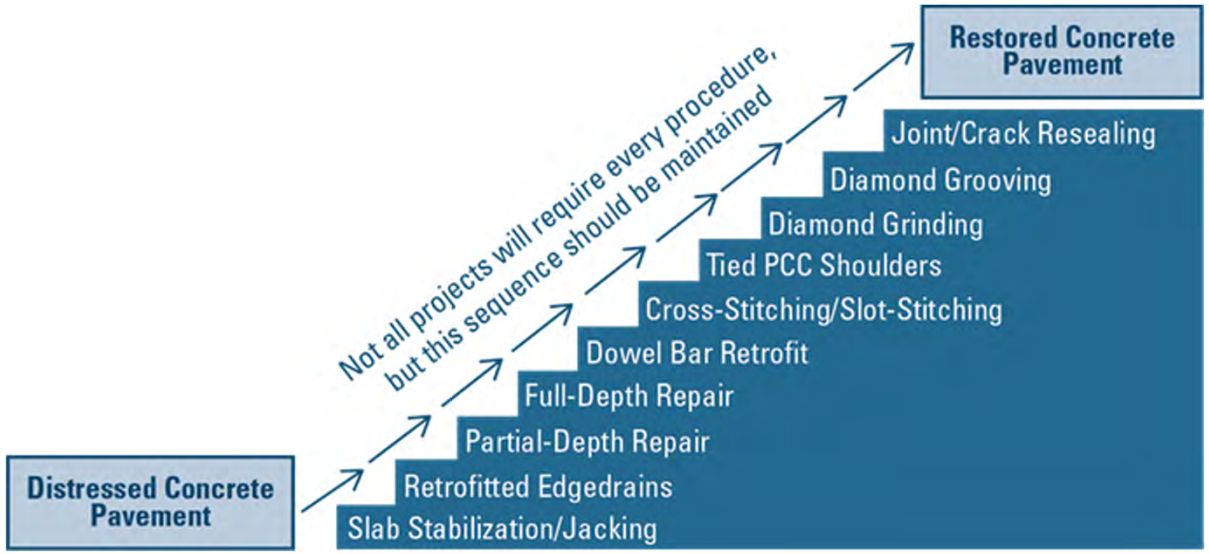
Strategy Selection

- 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



Local Project Examples

Bowling Street, Cedar Rapids

Background

- 2-mile corridor, 8,000 vpd
- Paving for Progress
- 1979 construction (no dowels)
- Transverse joint faulting
- Safety improvements needed (4 to 3 lane conversion, RR crossing)

Pavement evaluation

- FWD testing
  - Confirmed areas of load transfer inefficiency
  - Confirmed candidate for dowel bar retrofit
- Coring
  - Confirmed deterioration was limited to surface

Bowling Street, Cedar Rapids

Preservation Strategies

- Dowel bar retrofit
  - Did not install in bike lanes
- Cross stitching
- Partial-depth repairs
- Full-depth repairs
- Diamond grinding
- Joint refilling

Bowling Street, Cedar Rapids

- Several preservation treatments
- 4 lane corridor allowed for effective construction staging
- Treatments were properly identified during the design process
- Pre-arranged location for diamond grinding slurry

Kiwanis Avenue, Sioux Falls

Background

- 2-mile corridor
- 14,000 – 18,000 vpd
- 1991-1994 construction (no dowels)
- 8” – 10” PCC
- Joint deterioration & transverse joint faulting

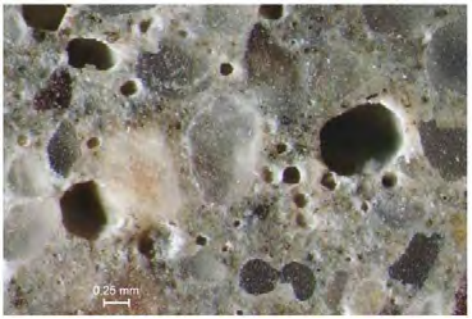
Pavement study

- Cores showed distress limited to upper ½

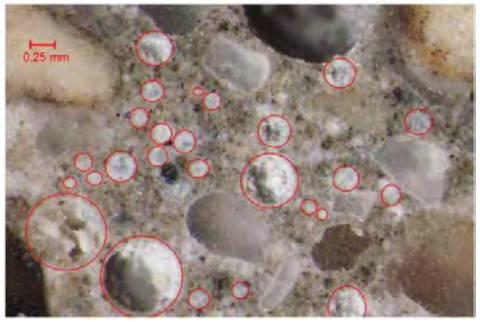
Kiwanis Avenue, Sioux Falls

Pavement study

- FWD analysis
- Petrography
  - Lower air content & presence of long-term saturation



Normal entrained air voids



Entrained air voids filled with ettringite

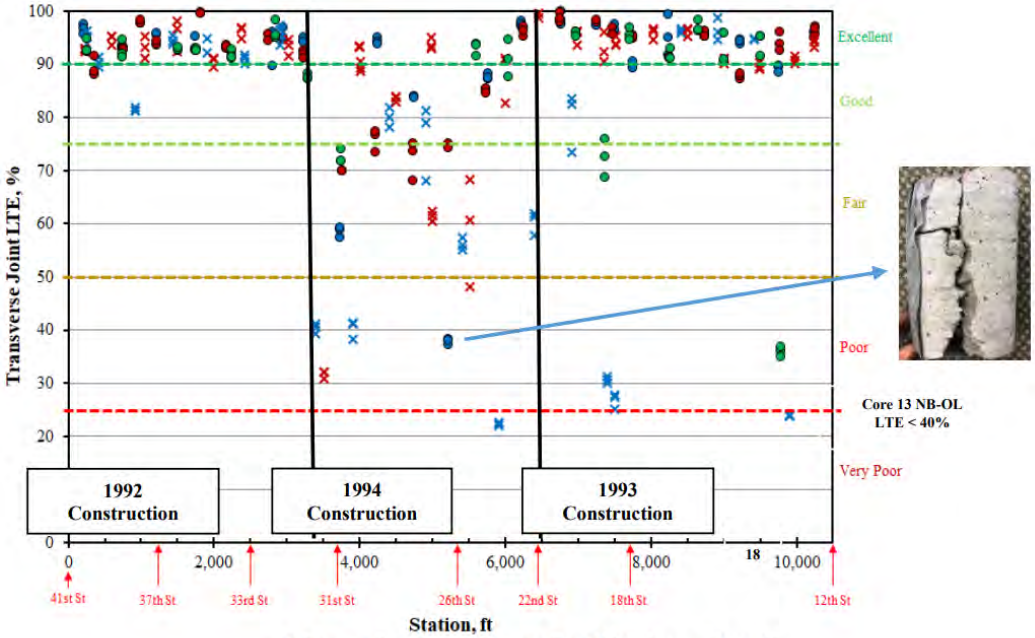


Figure 6 – Load Transfer Efficiency Profile

FWD analysis by Applied Pavement Technology, Inc.
Petrography performed by American Engineering Testing, Inc.

Kiwanis Avenue, Sioux Falls

Preservation Strategies

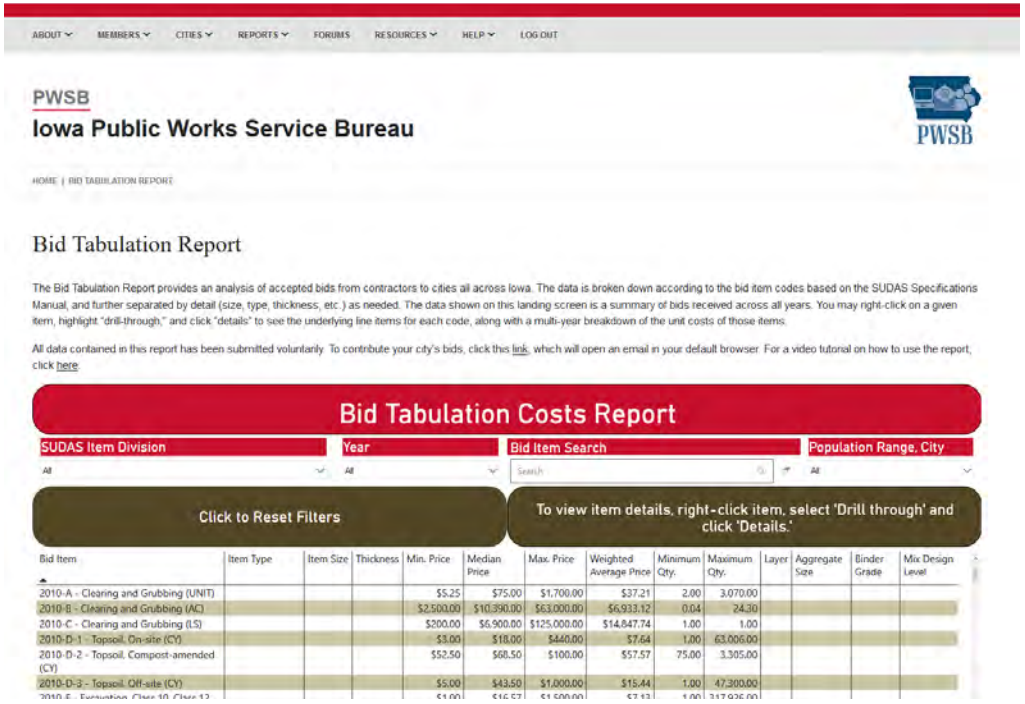
- Full-depth repairs
  - Accelerated mixes in intersections
- Partial-depth repairs
  - 3U58M mixture
- Diamond grinding
  - Re-sounding of PDRs after grinding
- Joint re-filling

Kiwanis Avenue, Sioux Falls

- Improved pedestrian access and signal crossings
- Improved PCI from 73 to 90

Typical Treatment Costs

- Iowa Public Works Service Bureau
  - Bid Tabulation Report
  - Preservation treatments are in the 7040 range of bid items

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