Best Practices for Repairing & Preserving Concrete Streets and Roadways

Dan King, PhD, PE
deking@iastate.edu

IOWA STATE UNIVERSITY
Institute for Transportation

National Concrete Pavement Technology Center
Tech Center

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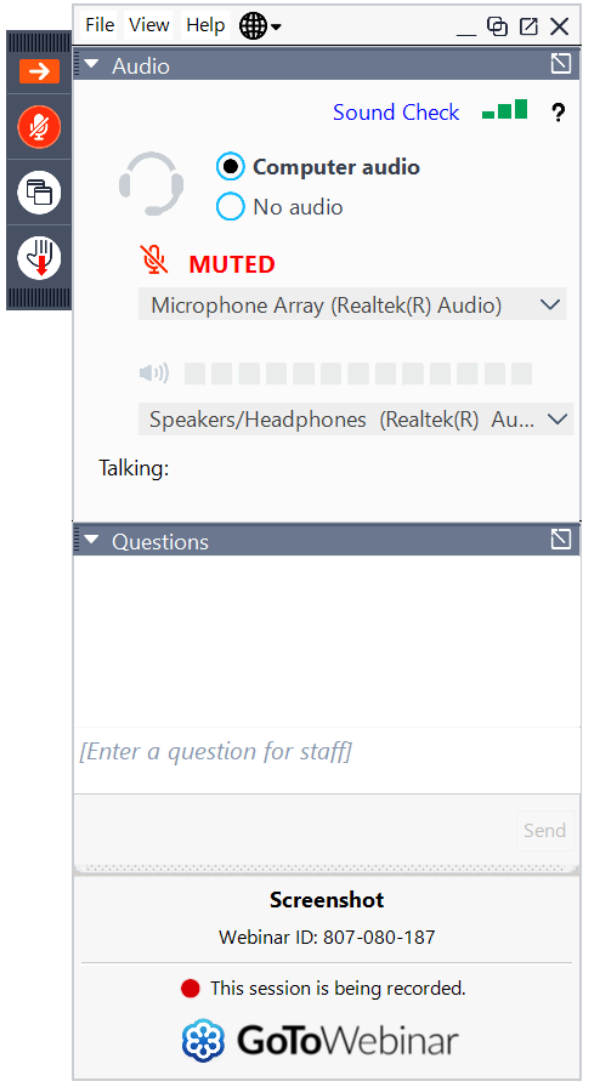

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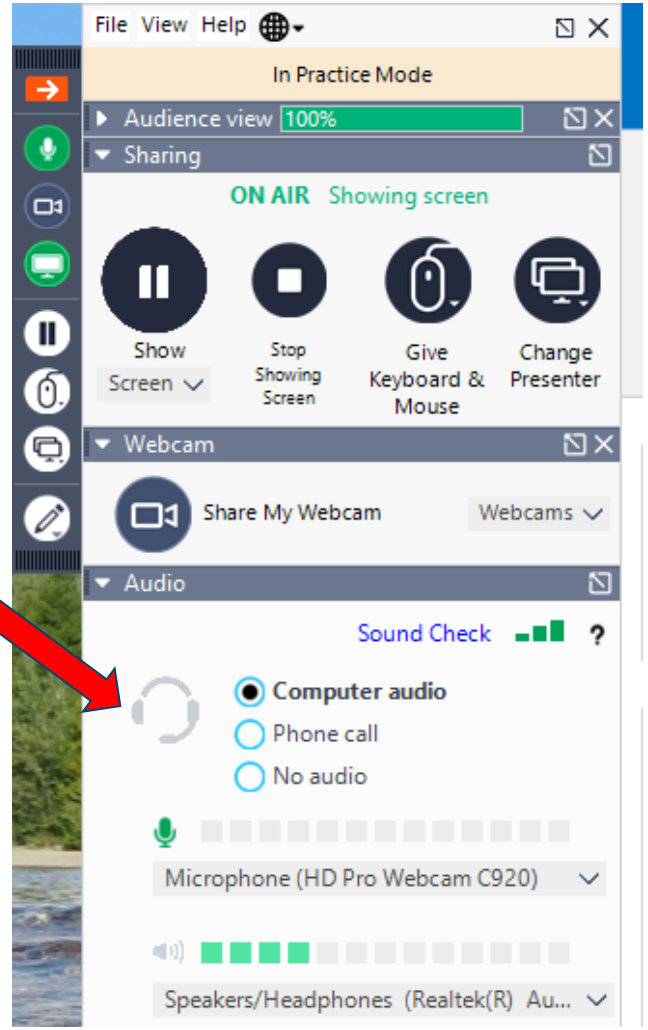

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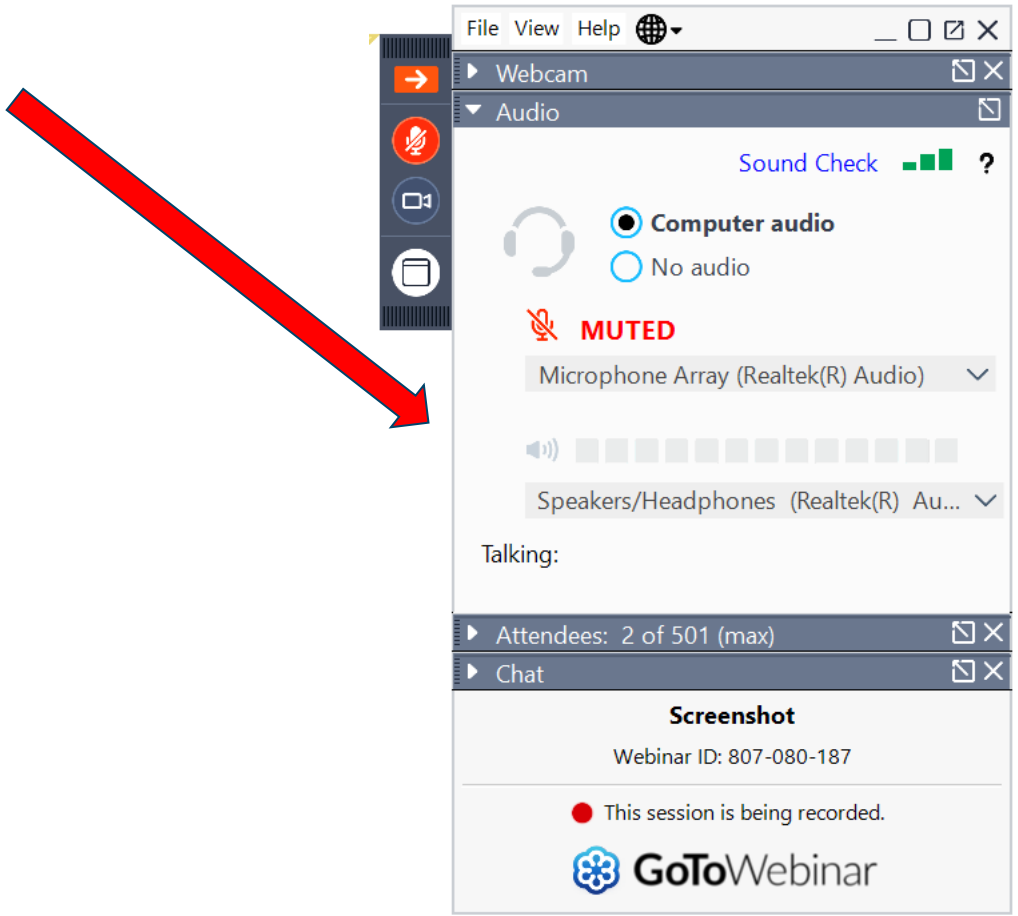

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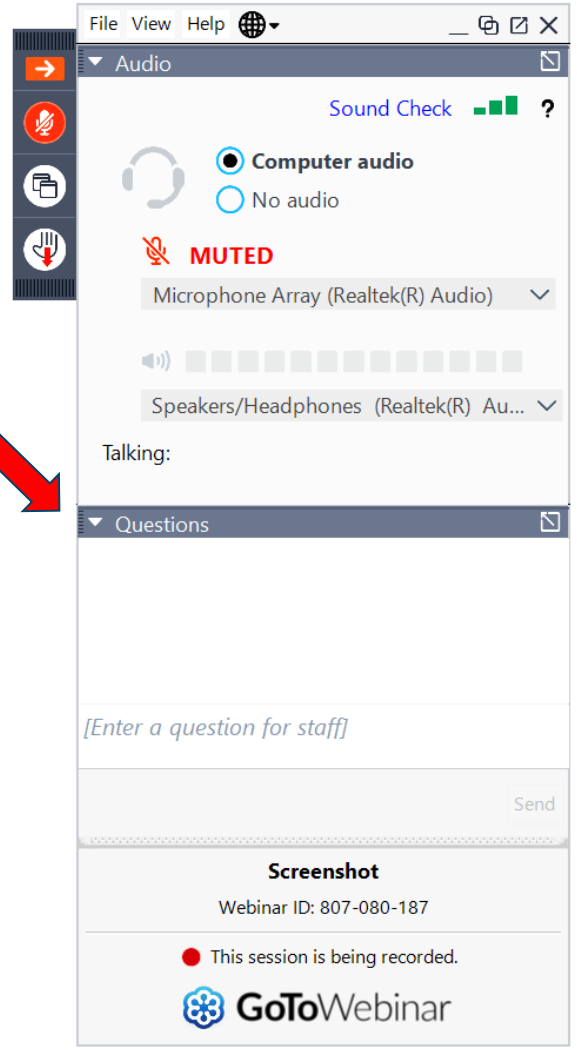
- Everyone is muted
- If you have questions, type them here
- We will compile all of the questions after the webinar is finished and post a full Q&A online
- A link to download a pdf of the slides is included under the “Handouts” tab
- PDHs will be sent out to all attendees after the webinar



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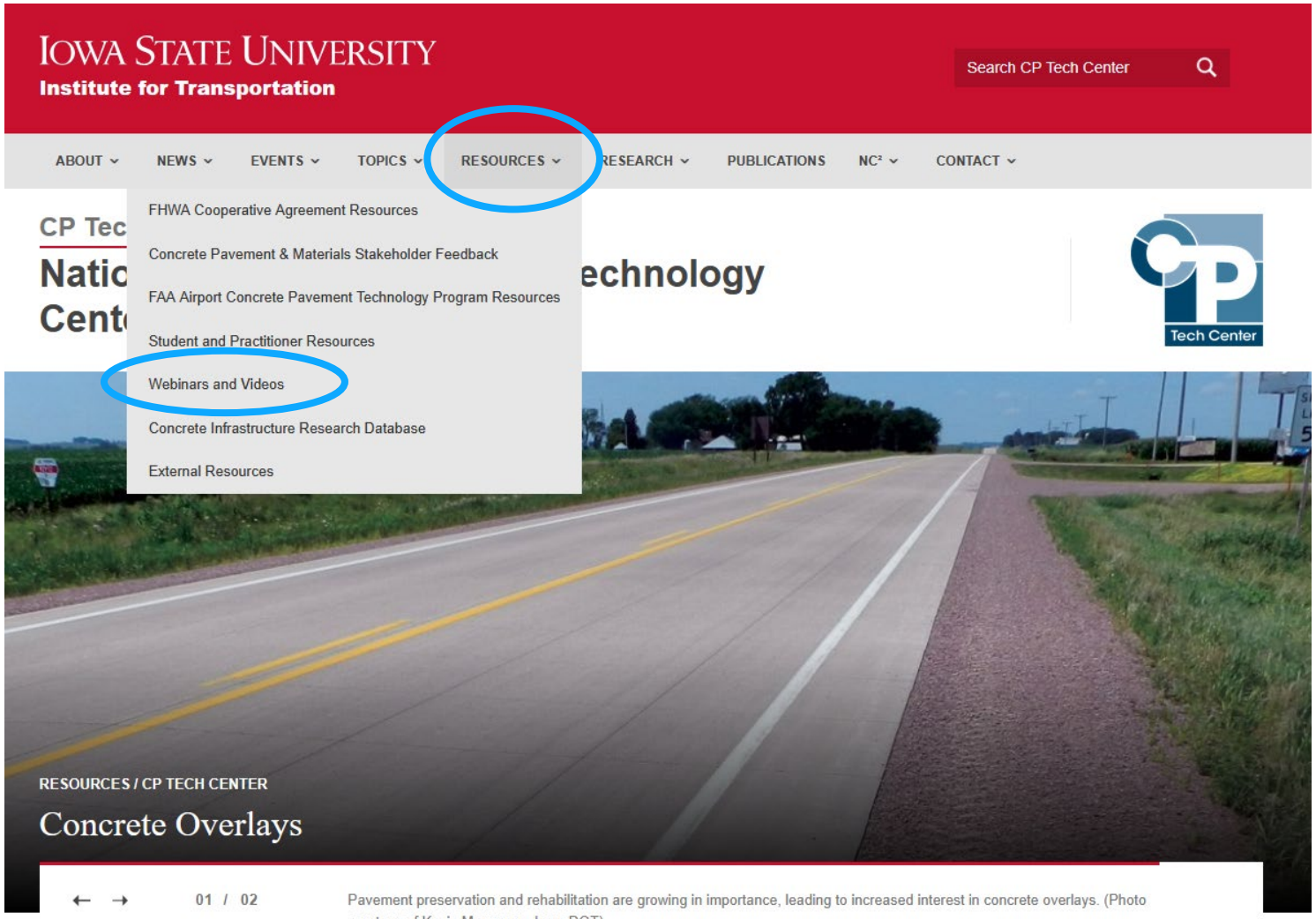

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VIDEO RESOURCES LIBRARY

The following multi-page table of past CP Tech Center webinars can be searched via the search bar by keyword, presenter, event, etc.—or navigated page-by-page from the bottom of the table.

Search

Video	Title	Presenters	Event	Resources
	Not Your Grandfather's Concrete	Peter Taylor Matt Fonte	Concrete Pavement Technology Tuesday	Slides Q & A
	Pavement Design for Designers & Non-Designers and Why You Should Care	Eric Ferrebee Jim Mack	Concrete Pavement Technology Tuesday	Slides Q & A
	Performance Engineered Mixtures for PCC Pavements	Peter Taylor Christian Olmoz	New and Evolving Technologies Webinar	Slides Q & A

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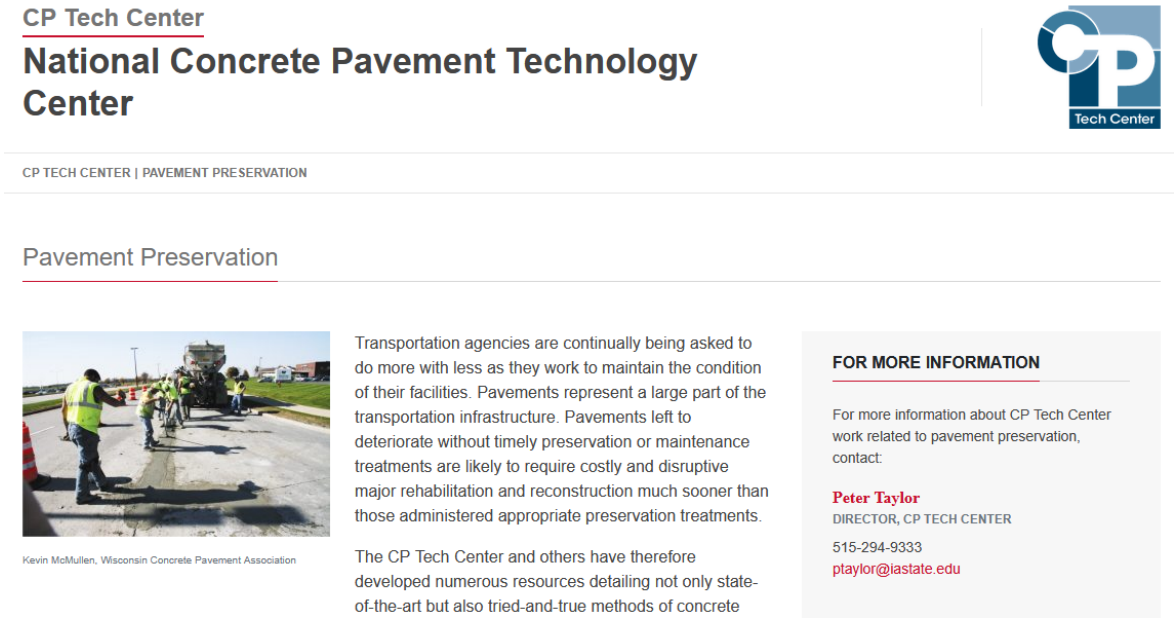
Acknowledgments & Additional Resources

- Thanks to Iowa DOT & ICPA for supporting this program

- Much more information is available at the Pavement Preservation topics page on the CP Tech Center website
  - **www.cptechcenter.org/pavement-preservation/**



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CP TECH CENTER | PAVEMENT PRESERVATION

Pavement Preservation

Kevin McMullen, Wisconsin Concrete Pavement Association

Transportation agencies are continually being asked to do more with less as they work to maintain the condition of their facilities. Pavements represent a large part of the transportation infrastructure. Pavements left to deteriorate without timely preservation or maintenance treatments are likely to require costly and disruptive major rehabilitation and reconstruction much sooner than those administered appropriate preservation treatments.

The CP Tech Center and others have therefore developed numerous resources detailing not only state-of-the-art but also tried-and-true methods of concrete

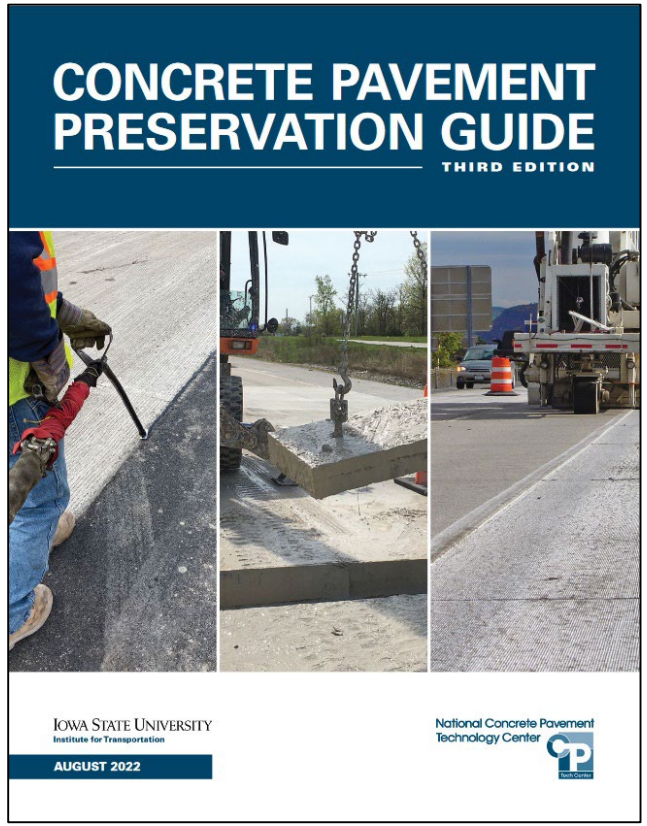
FOR MORE INFORMATION

For more information about CP Tech Center work related to pavement preservation, contact:

Peter Taylor
DIRECTOR, CP TECH CENTER
515-294-9333
ptaylor@iastate.edu

Acknowledgments & Additional Resources

- The *Concrete Pavement Preservation Guide* is the CP Tech Center's most comprehensive resource on this topic
- Special thanks:
  - Jerod Gross, Snyder & Associates
  - Lee Shepard, ICPA
  - Todd Hanson, Iowa DOT
  - Kurt Smith, APTech
  - Max Grogg, APTech
  - Prashant Ram, APTech
  - Kelly Smith, APTech
  - Dale Harrington



Audience Questions

- Use the QR code to join a Slido Q&A:

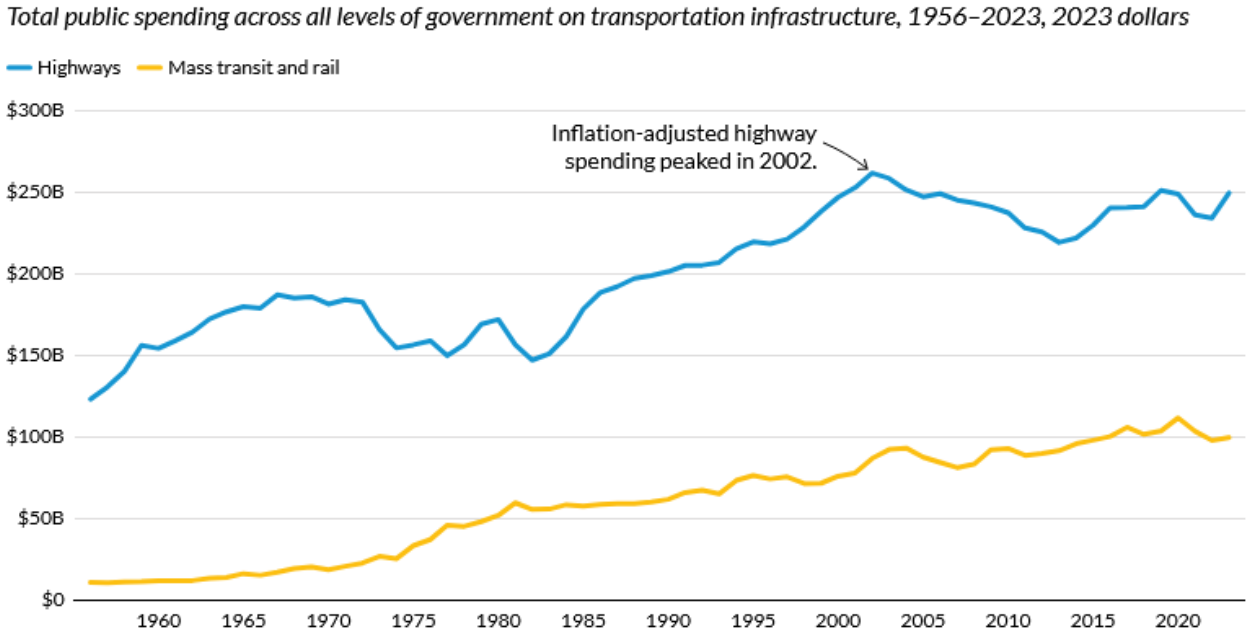
Today's Presentation

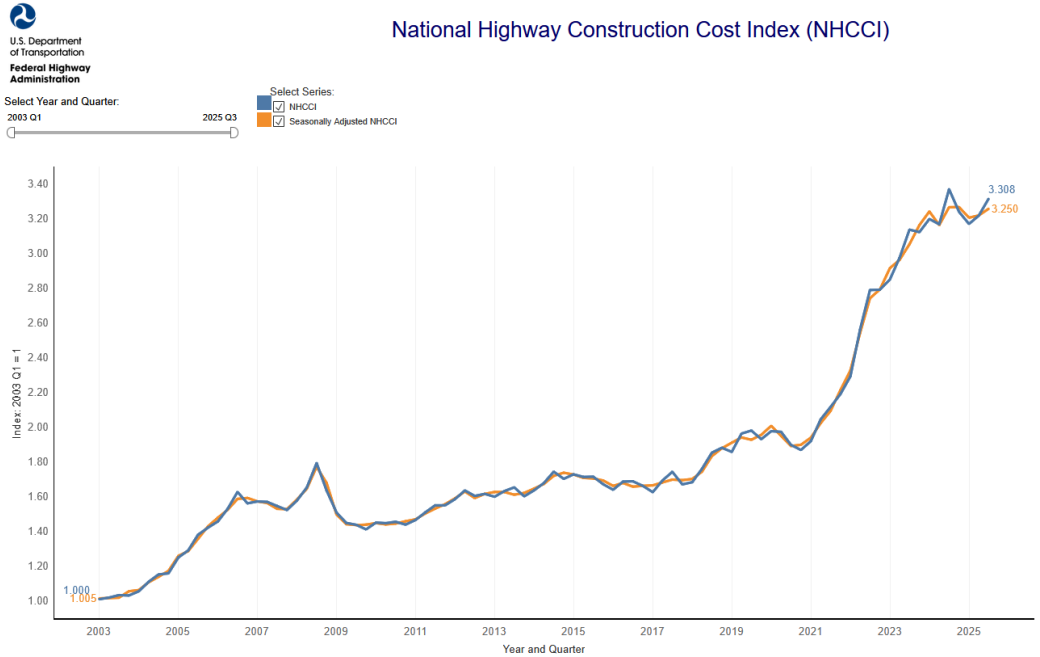
- Introduction
- Evaluating Potential Projects
- Preservation & Repair Treatments
- Putting Projects Together

Introduction

Today's Landscape

- Given trends in highway funding and spending, agencies must find cost effective ways to keep up with demands on their streets and roadways and maintain them in good condition





Sources: Urban Institute, FHWA

Pavement Preservation

- Concrete pavements stand out for their ability to fulfill long-term service life objectives and adapt to changing traffic loads
  - This ability can be leveraged even further with a more proactive approach to pavement preservation

I-10 near Ontario, California
Constructed 1947

Pictured 2017
270,000 vpd

Images: Southwest CPA

What is Pavement Preservation?

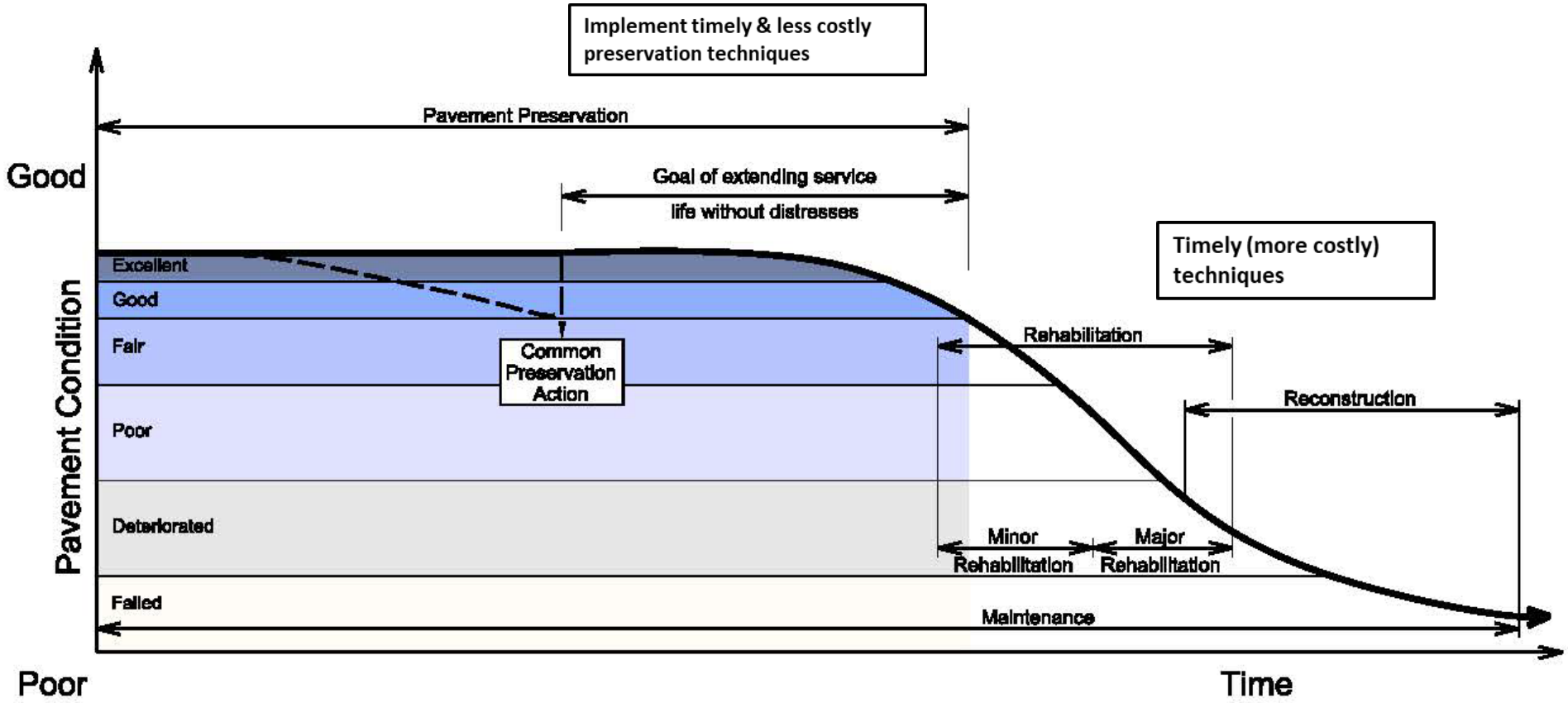
- A proactive approach to managing pavement assets
- Focused on extending pavement life and maintaining or restoring functional condition
- Accomplished using a collection of maintenance, preservation, rehabilitation, and repair treatments

From the Concrete Pavement Preservation Guide, 3rd Edition:

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?

- A look at pavement condition over time, and where these treatments and activities fit in:



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

Concrete Pavement Preservation Treatments

- Selected treatments, including typical performance:

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

Which of these treatments do you have experience with? (Select all that apply)

Evaluating Potential Projects

Treatment Strategy Selection Process

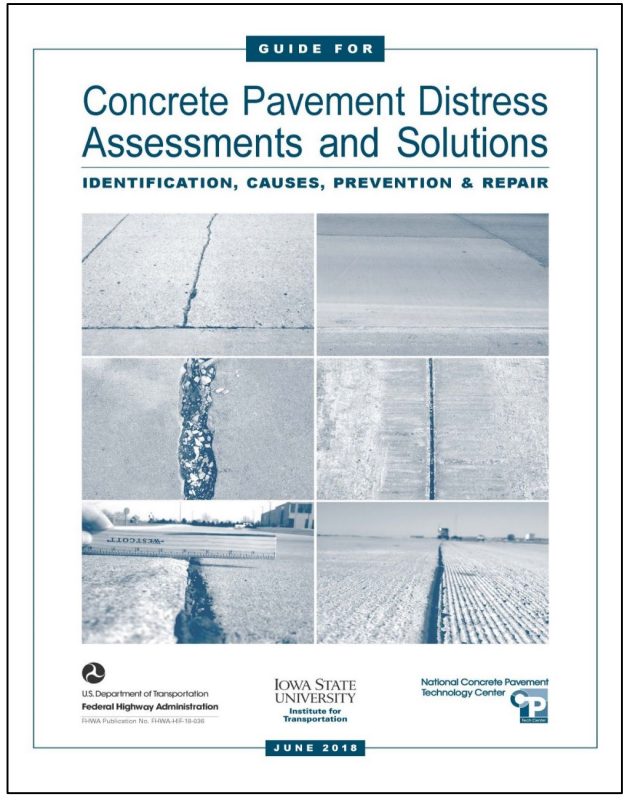
1. **Conduct pavement evaluation**
2. **Determine causes of distress**
3. **Identify treatments to address distresses**
4. *Identify constraints and key selection factors*
5. *Develop feasible treatment strategies*
6. *Assess cost effectiveness of alternative treatment strategies*
7. *Select preferred treatment strategy*

1. Conduct Pavement Evaluation

- How do we determine if preservation is right for a project and which treatments we should use?
  - Pavement condition data
  - Distress surveys
  - Drainage surveys
  - Testing and Sampling
    - Smoothness/roughness testing
    - Friction testing
    - Deflection testing
    - Cores

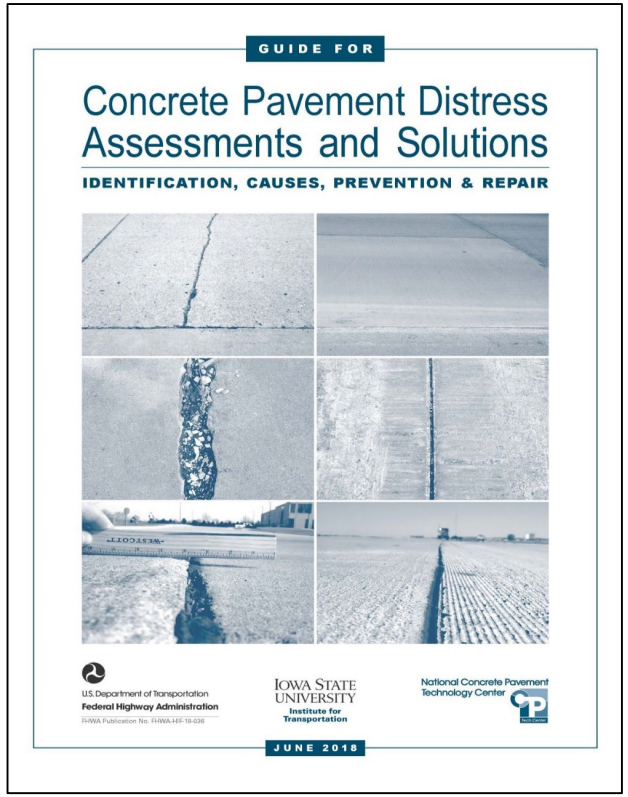
2. Determine Causes of Distress

- Use insight gained from survey information, testing data, and core samples to determine root causes for observed distresses and deficiencies
  - Structural
  - Functional
  - Materials
  - Drainage



3. Identify Treatments to Address Deficiencies

- Select treatments based on prevalence, severity, and causes of observed distresses



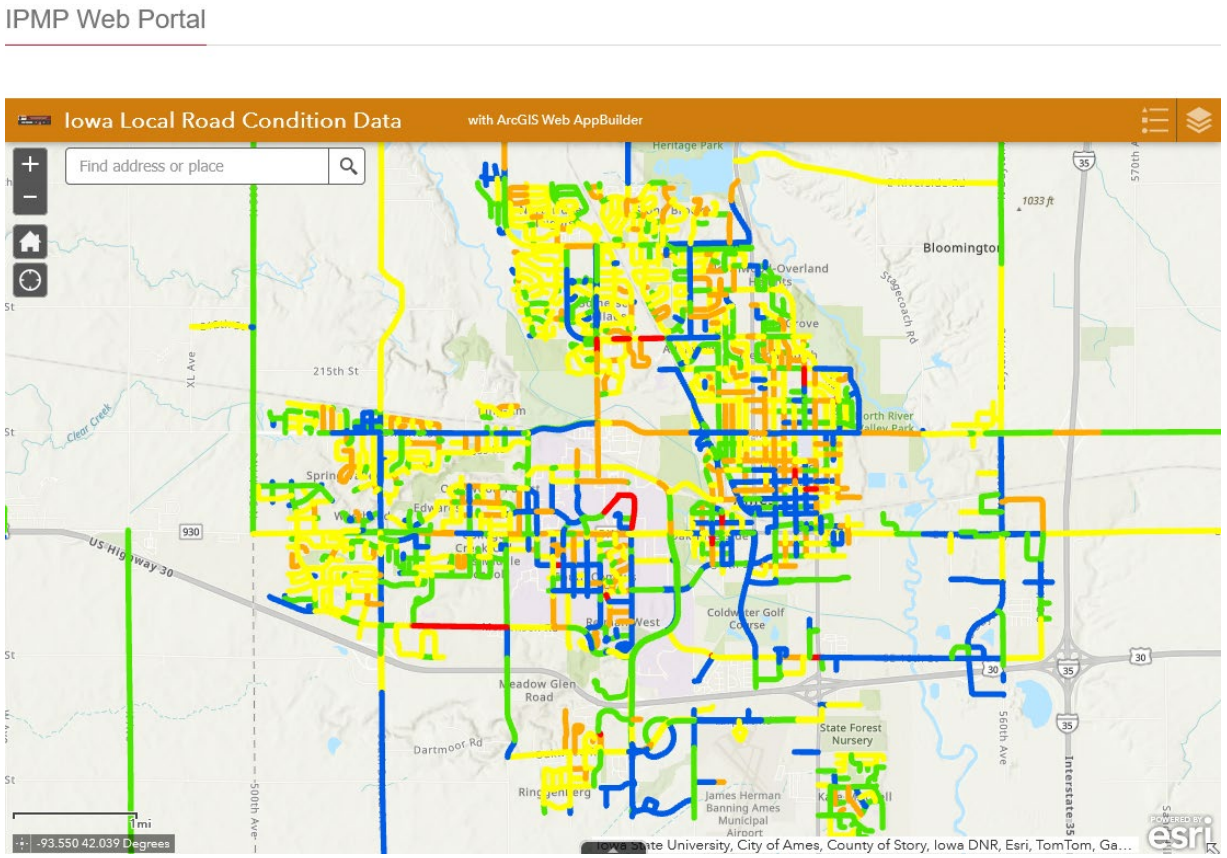
3. Identify Treatments to Address Deficiencies

- Treatment-distress matrix:

Distress	Slab Stab	Slab Jack	PDR	FDR	DBR	Cross/Slot Stitch	Grinding	Grooving	Retrofit Drains	Joint Reseal	Crack Seal	PCC Overlay
Corner breaks				✓							✓[a]	✓
Linear cracking				✓		✓[a, b]					✓[a]	✓
Punchouts				✓								✓
D-cracking				✓[c]								
Alkali-agg reaction (AAR)				✓[c]								
Map cracking, crazing, scaling			✓									
Jt seal damage										✓		
Joint spalling			✓	✓								
Blowup				✓								
Pumping	✓				✓	✓			✓			✓
Faulting		✓			✓		✓		✓			
Bumps/heaves/ settlements		✓		✓			✓					
Polishing/low friction							✓	✓				✓

3. Identify Treatments to Address Deficiencies

- Pavement condition data can be obtained from the Iowa Pavement Management Program (IPMP)



3. Identify Treatments to Address Deficiencies

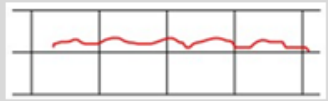
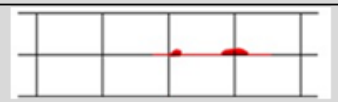
- Data-driven approaches in pavement management systems:

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

Have you used pavement condition data collected by Iowa DOT or the IPMP to develop a repair or preservation project?

3. Identify Treatments to Address Deficiencies

- Appendix 9-6 of the Iowa DOT construction manual:

Defect	Orientation	Location	Description	Transverse JT, D or UnD	Recommended Repair	Example
Uncontrolled Crack	Longitudinal	Relatively parallel to & within 1 ft. of JT. May cross or end at long.JT	Full-Depth	Either	Saw/route & seal the crack or cross-stitch the crack Epoxy sawed joint if uncracked	
Uncontrolled Crack	Longitudinal	Relatively parallel to & within wheel path, 1-5 ft. from JT	Full-Depth, hairline, or spalled	Either	Remove and replace panel or cross-stitch crack	
Uncontrolled Crack	Longitudinal	Relatively parallel to & >5 ft. from a longitudinal JT or edge	Full-Depth	Either	Cross-stitch crack	
Spalled sawcut or uncontrolled crack	Longitudinal	Anywhere	Spalled	Either	Partial-Depth Repair	
Uncontrolled Crack	Diagonal	Anywhere	Full-Depth	Either	Full-Depth Repair	
Uncontrolled Crack	Multiple per panel	Anywhere	Two or more full depth cracks dividing panel into 3 or more pieces	Either	Remove and replace panel	

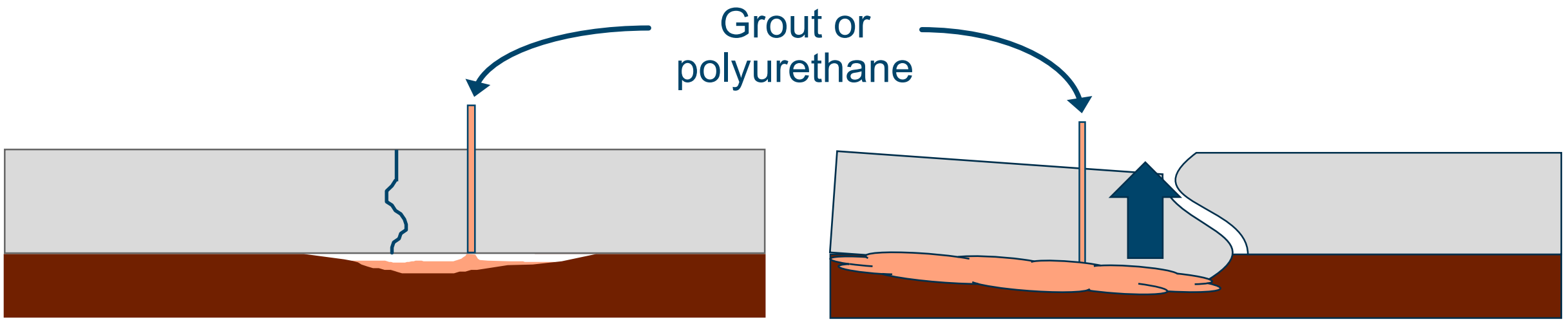
Full-Depth repair per Specification 2529
Partial-Depth repair per Specification 2530
Cross-stitch repair per Construction Manual 9.27
Repairs should be made without use of Calcium Chloride unless early opening to traffic is necessary.

a LTR = load-transfer restoration (if faulted less than 1/2"); 3 dowel bars per wheel path grouted into slots sawed across the crack. Slots must be parallel to each other and the longitudinal joint. Backfill with non-shrink, cement-based grout. Diamond grind if faulting is severe.

Preservation & Repair 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

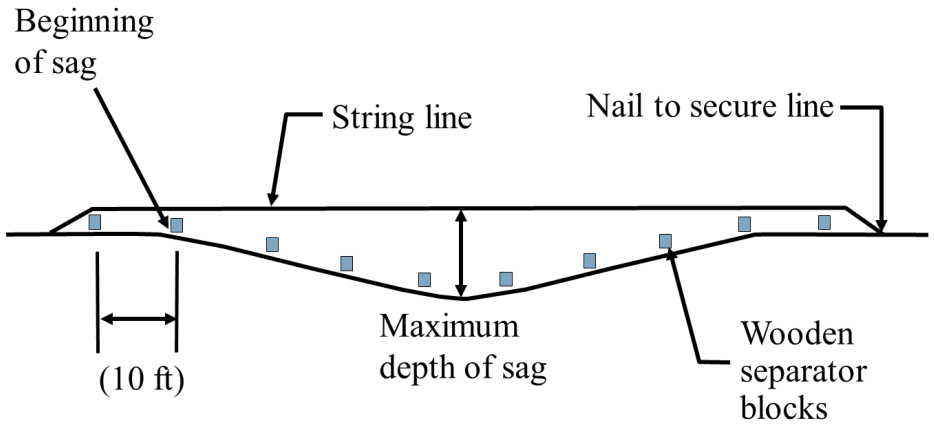
Slab Jacking

Slab Stabilization

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

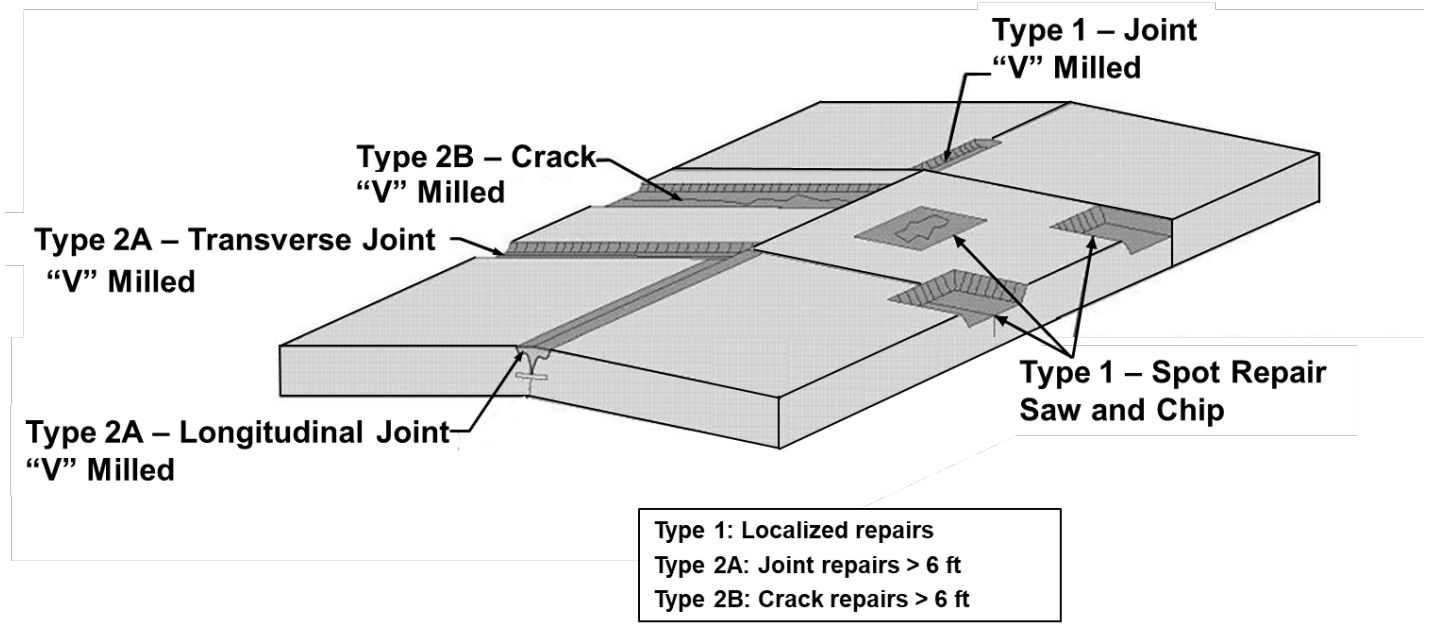
Slab Jacking

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



Partial-Depth Repairs

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

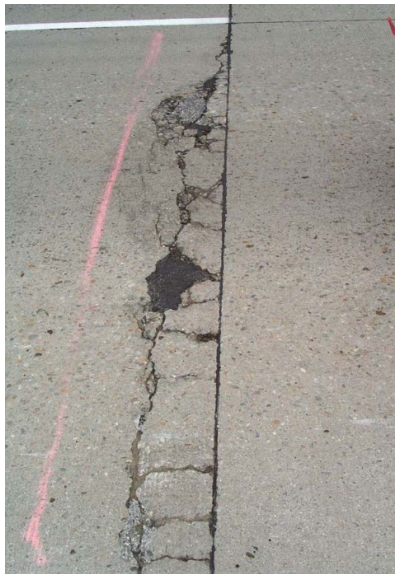


Partial-Depth Repairs

- 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

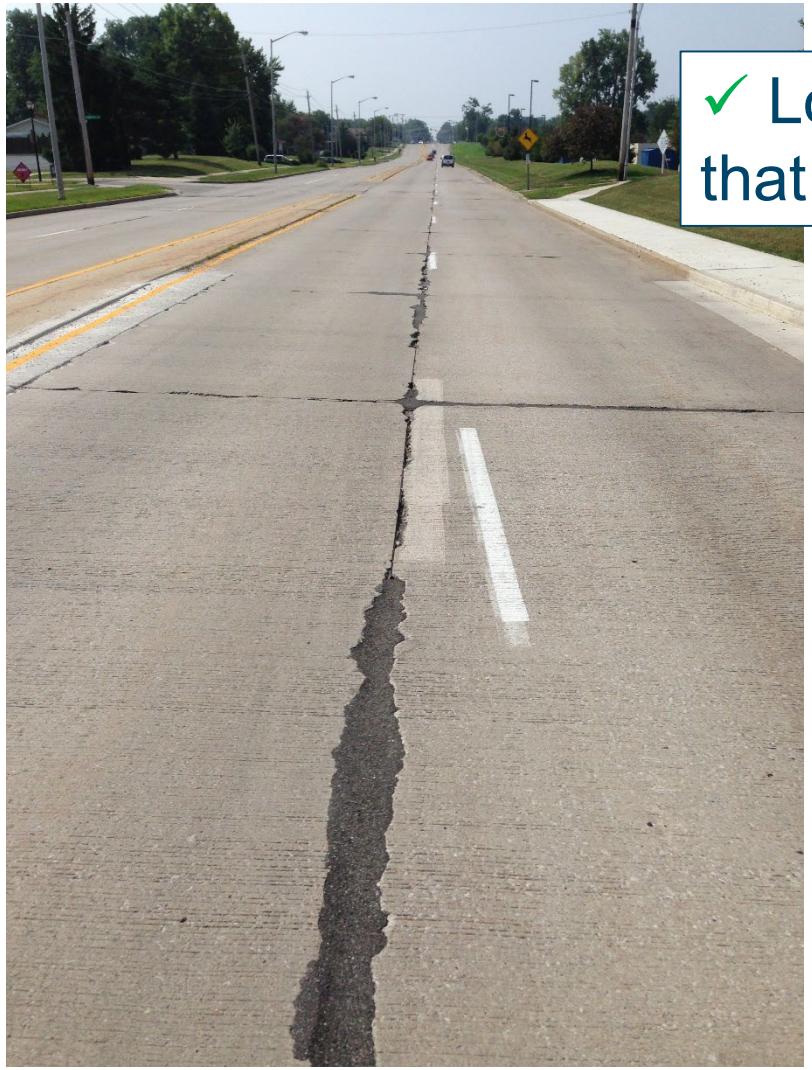
- When is PDR not the right solution?
  - Deterioration greater than 1/2 slab thickness
  - Spalling due to working cracks, dowel bar misalignment, etc.
  - Joint deterioration caused by D-cracking or reactive aggregates
    - In this case, PDR is at best a stopgap measure



Good Candidate for PDR?

Do you think this project is a good candidate for PDR? (1/3)

Good Candidate for PDR?



✓ Looks like shallow spalling that could be addressed by PDR

Good Candidate for PDR?

Do you think this project is a good candidate for PDR? (2/3)

Good Candidate for PDR?

X We can see the dowel bar, so deterioration exceeds 1/2 depth

Good Candidate for PDR?

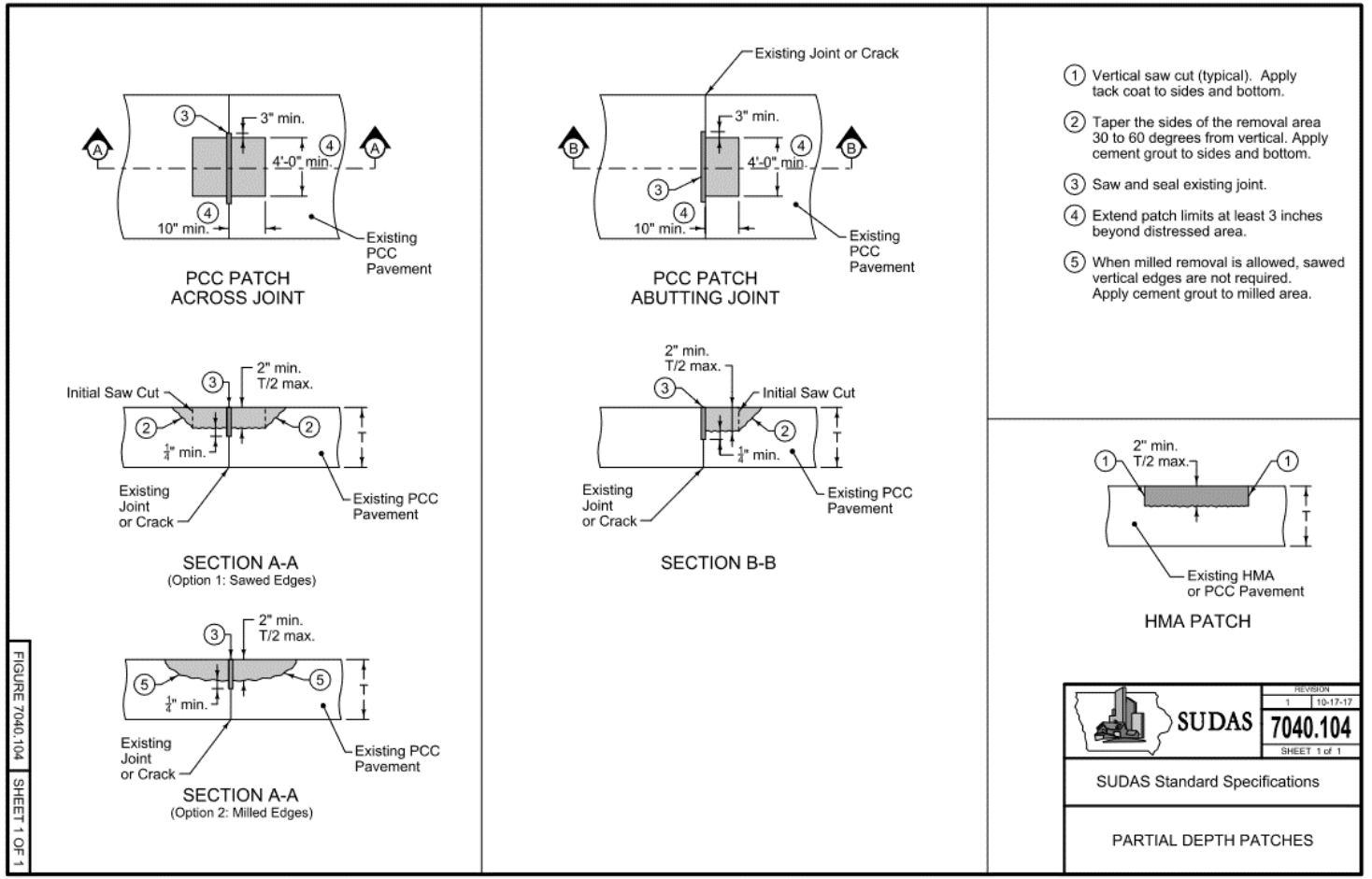
Do you think this project is a good candidate for PDR?

Good Candidate for PDR?

?? The deterioration doesn't look deeper than 1/2 depth, but it looks pretty extensive – we might want to take a core to check

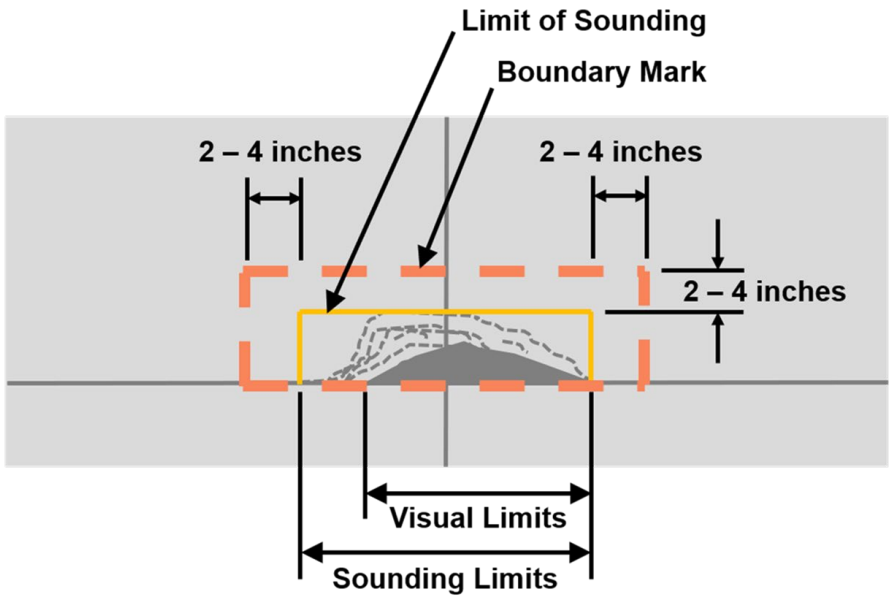
Partial-Depth Repairs

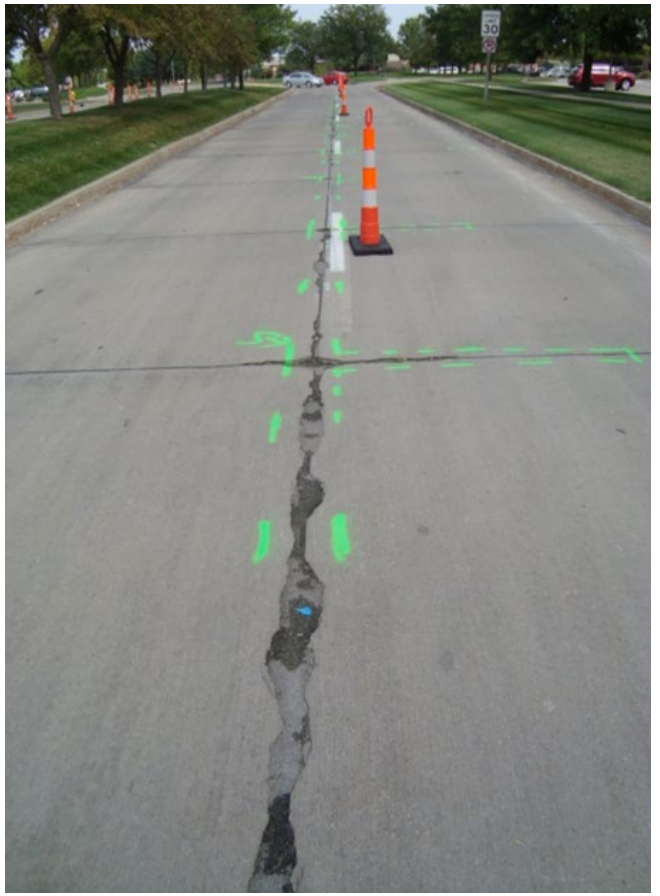
- SUDAS 7040.3.03 & Iowa DOT 2530:



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





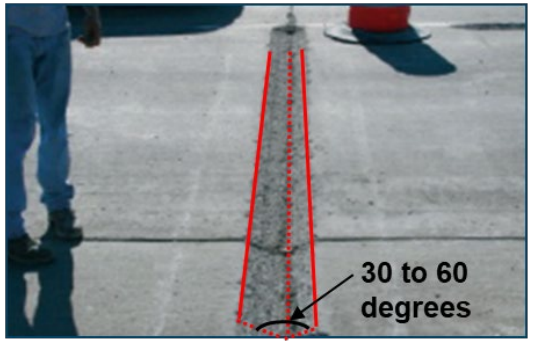
Partial-Depth Repairs

- Pavement removal approaches
  - 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
  - Standard or high early strength PCC
  - Other types of rapid-setting cements
  - Polymer-based materials
  - Bituminous materials

Not recommended for transverse joints

Partial-Depth Repairs

- Construction process
  - Establish a clean, roughened surface (sandblasting)
  - 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 sawing) and seal joints
  - Must saw through the full depth of the patch

If you have worked on partial-depth repair projects, which method have you found to be most common to re-establish joints or cracks?

Partial-Depth Repairs

- Can provide effective performance provided:
  - Proper sizing to address the full extent of deterioration
  - Construction with durable materials
  - Proper installation

Partial-Depth Repairs

- Troubleshooting
  - Failure to properly re-establish the joint or crack can lead to debonding and rapid deterioration
  - If sawing, make sure to saw on time and all the way through

Partial-Depth Repairs

- Troubleshooting
  - Make sure to mix patching materials properly, especially when using something other than standard PCC

Full-Depth Repairs

- Tried and true method of concrete pavement repair
- Extends to the full depth of the existing slab
- Applicable for both repairs and utility cuts

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

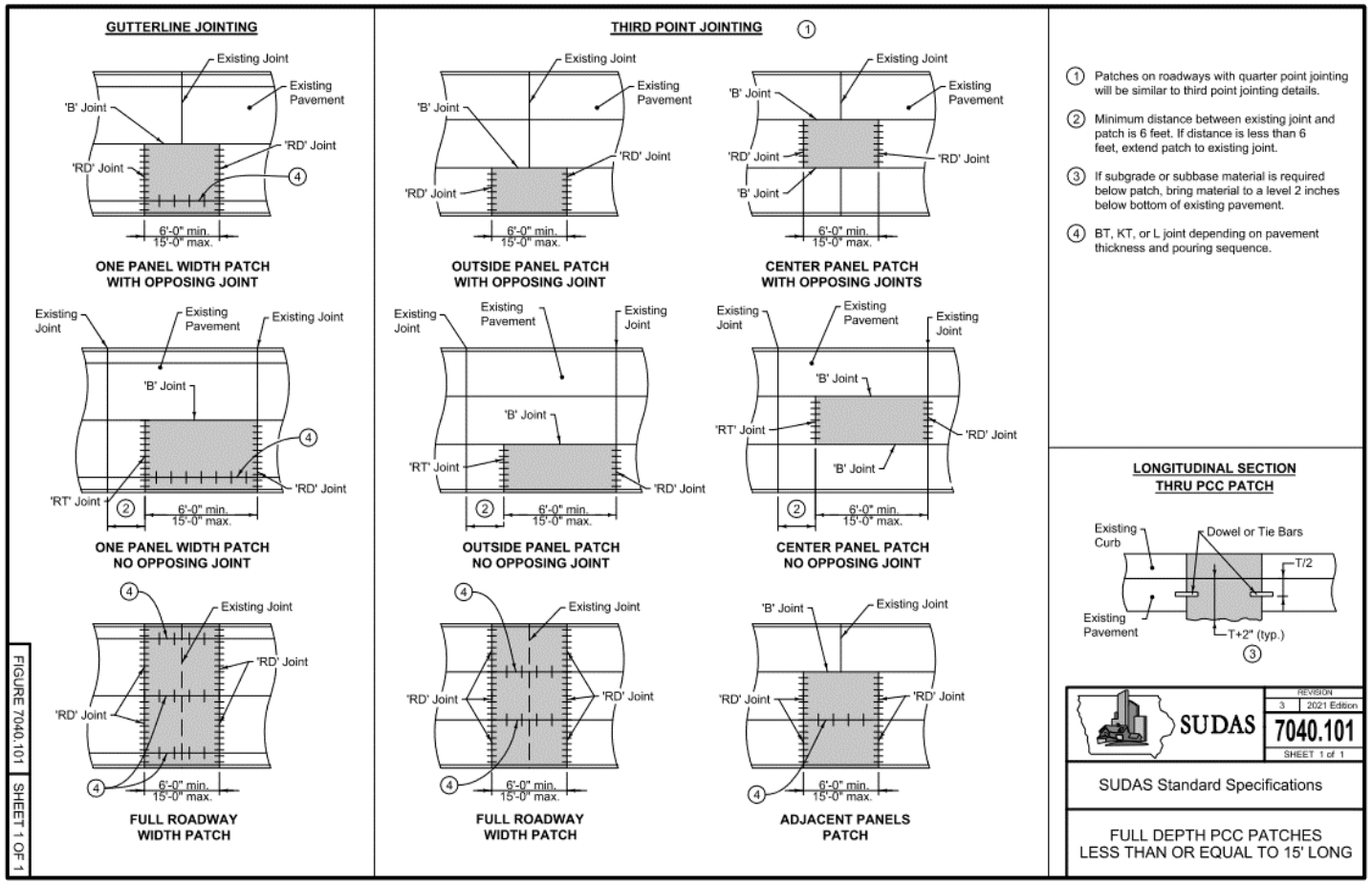
Distress type	Distress severity levels that could trigger FDR
Transverse cracking	Medium, high
Longitudinal cracking	Medium, high
Corner break	Low, medium, high
Spalling of joints	Medium,[1] high
Blowup	Low, medium, high
D-cracking (at joints or cracks)[2]	Medium,[1] high
Reactive aggregate spalling[2]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

Full-Depth Repairs

- SUDAS 7040.3.02 & Iowa DOT 2529:



Full-Depth Repairs

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

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

Full-Depth Repairs

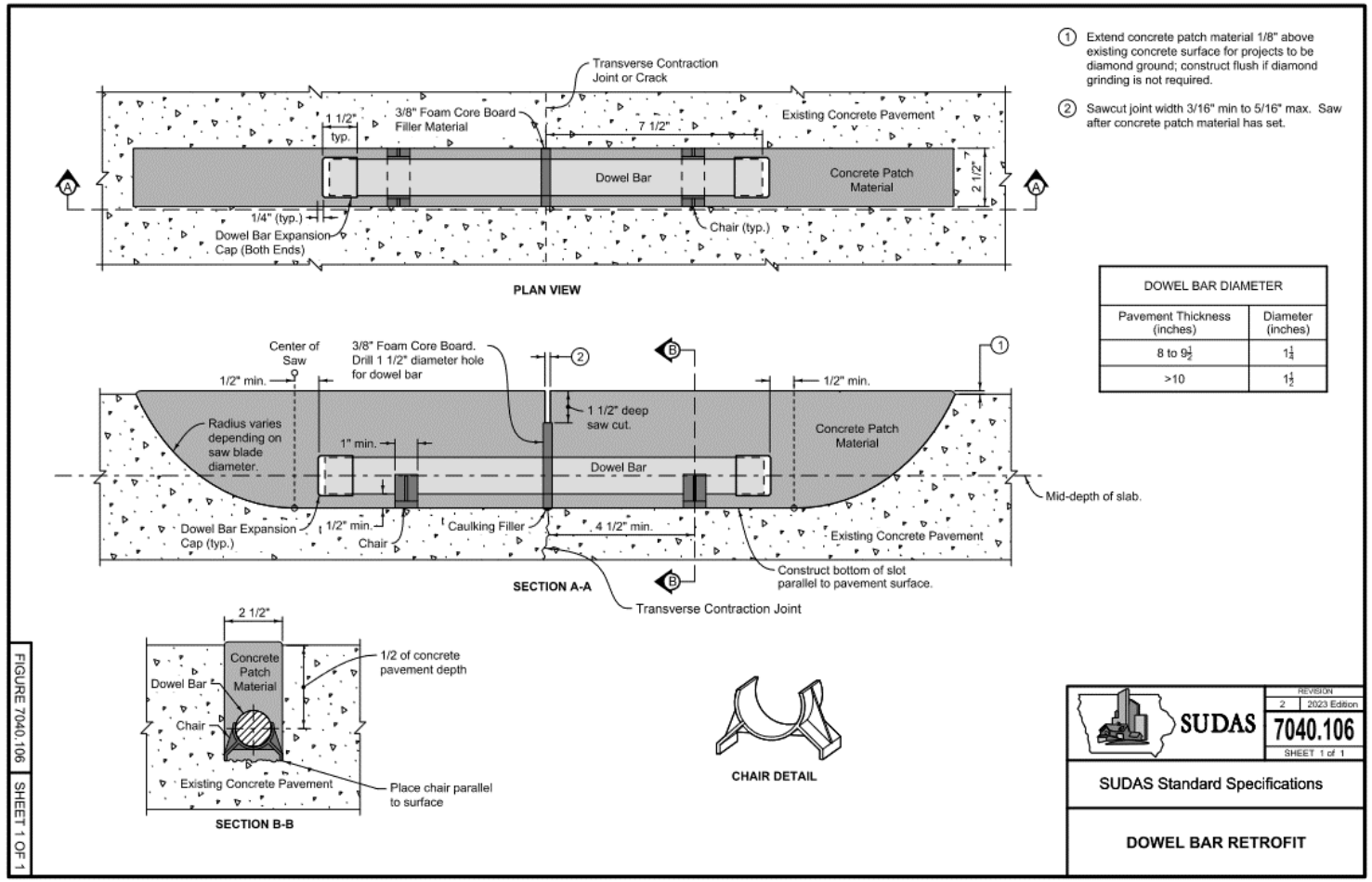
- Done well, full-depth repairs are capable of an extended treatment life of 20+ years
  - Restore load transfer to doweled pavements
  - Use durable repair materials
  - Ensure proper placement, finishing, and curing

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

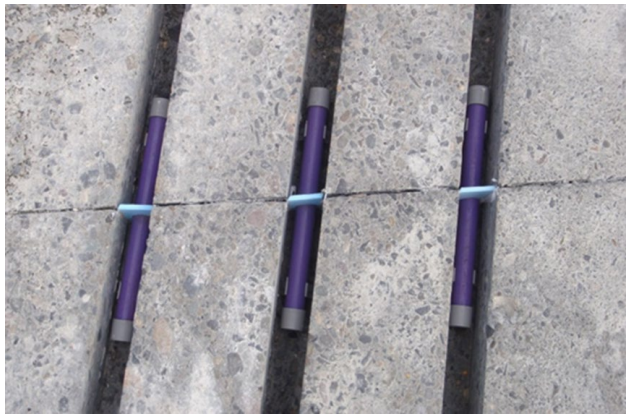
Dowel Bar Retrofit

- SUDAS 7040.3.10:



Dowel Bar Retrofit

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

In the city or cities that you work in, how prevalent do you feel that faulted, un-doweled pavements are?

Cross Stitching and Slot Stitching

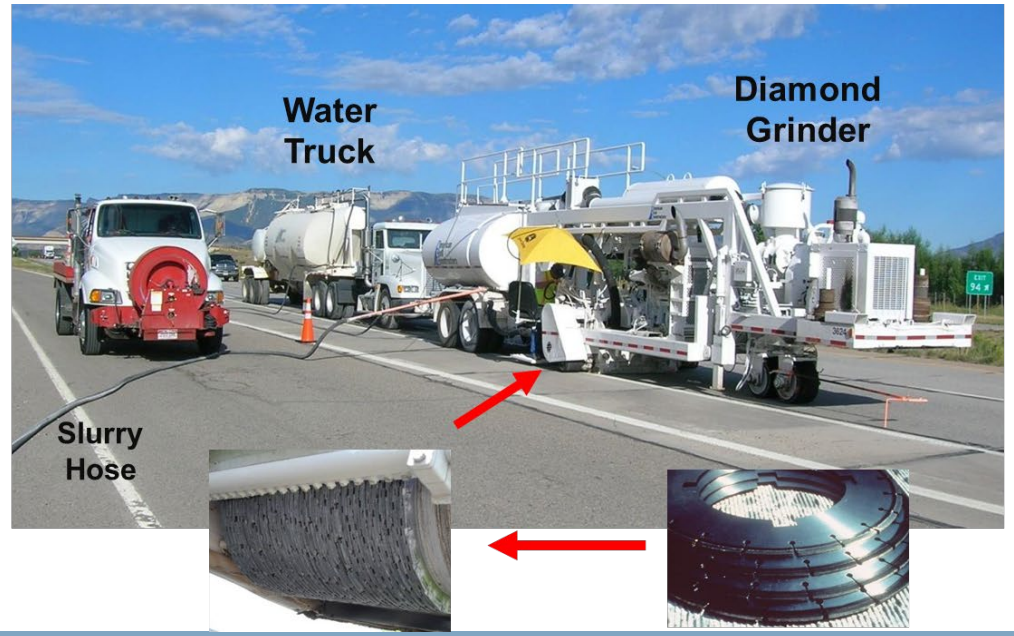
- Repair methods for longitudinal cracks and joints

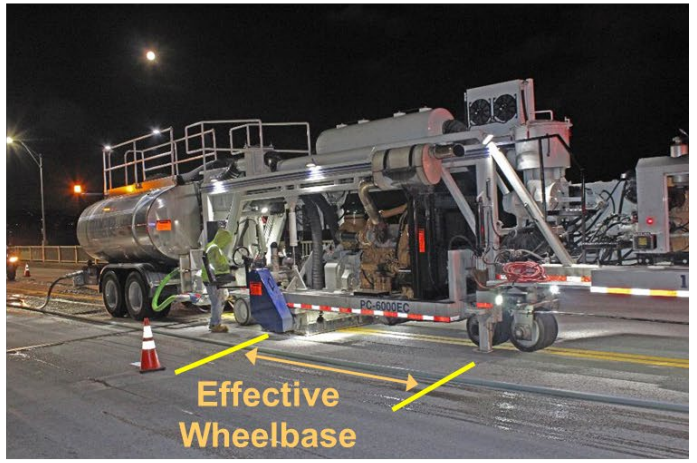
Diamond Grinding (and Grooving)

- 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 collection and removal is required in urban areas
  - Providing a slurry disposal site can help the contractor!

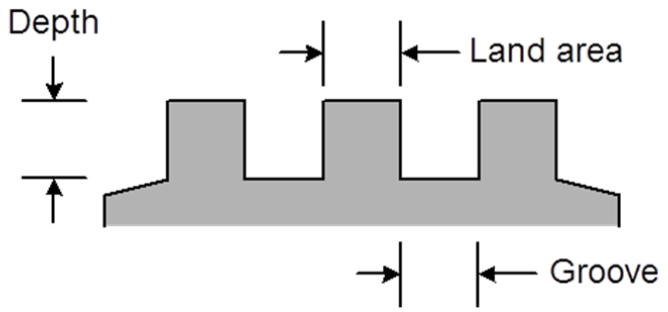




Diamond Grinding

- 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%
  - Grinding must be combined with DBR to truly correct faulting and to ensure the smoothness benefits are long-lasting

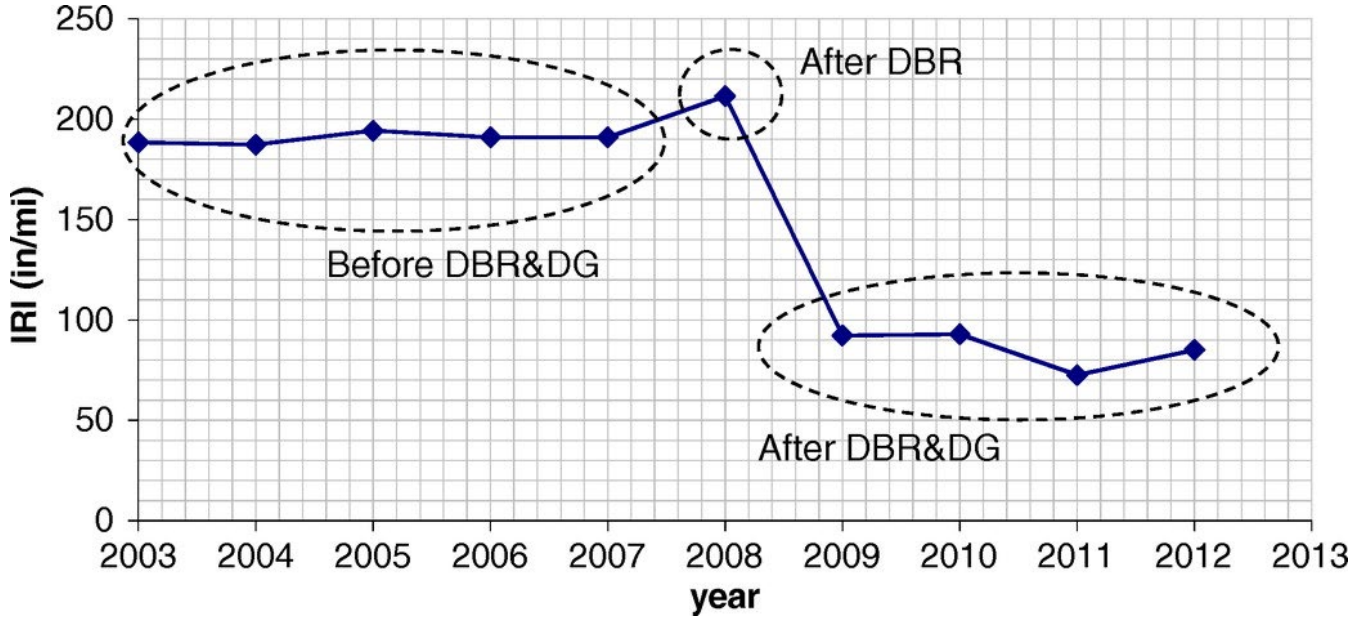


Image: TXDOT, Chen and Hong (2014)

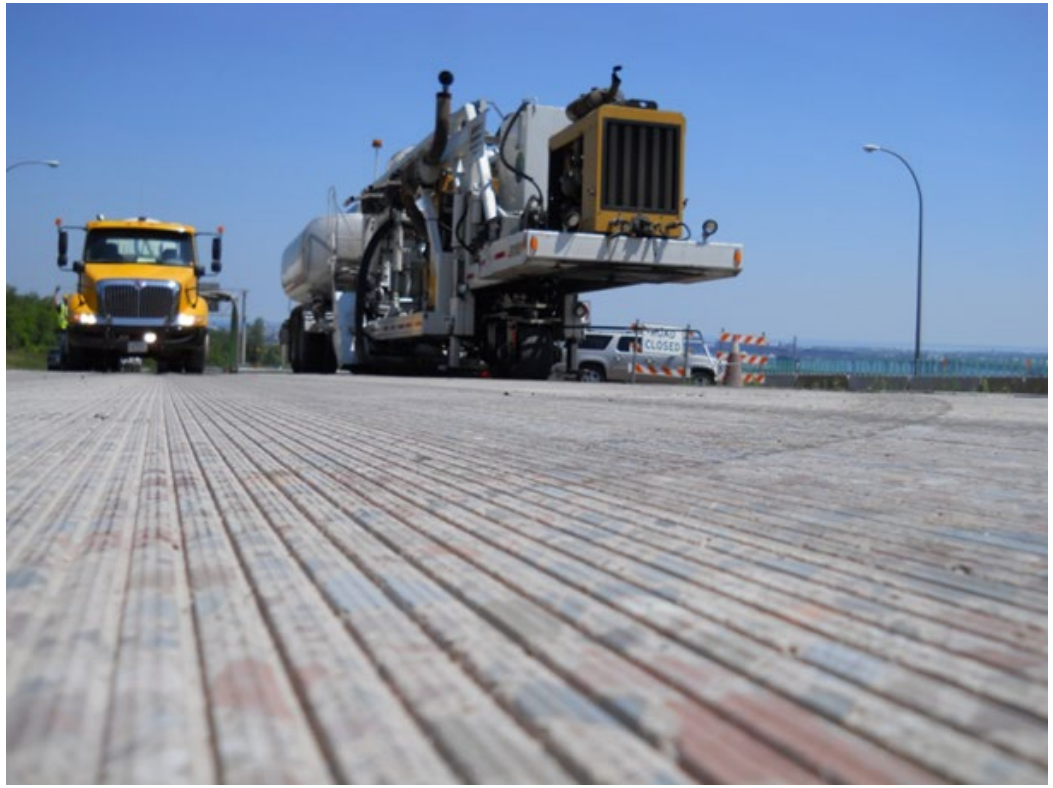
Diamond Grinding

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

Image: Snyder and Associates

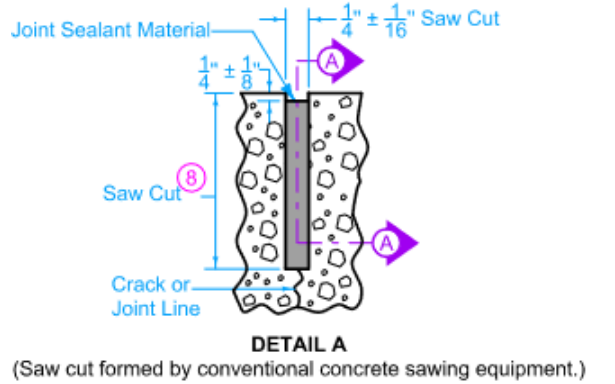
Next Generation Concrete Surface (NGCS)

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

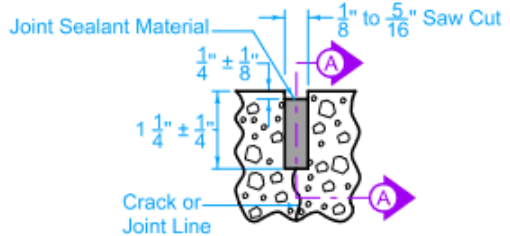


Joint Re-sealing and Crack Sealing

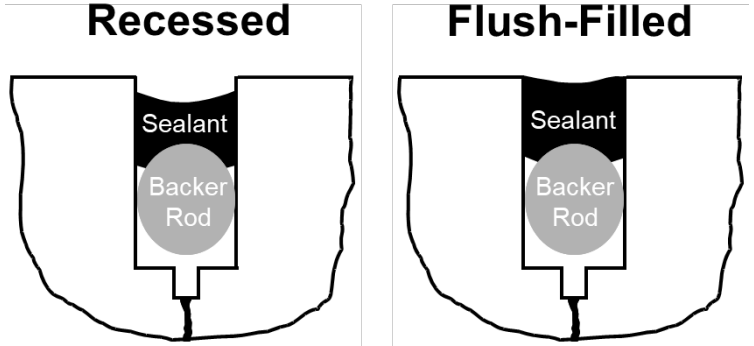
- Goals
  - Reduce infiltration of moisture and deicing chemicals
  - Prevent intrusion of incompressible materials
- Variety of materials may be used for sealing
  - For re-sealing, usually hot-poured asphalt
- “Sealing” vs “Filling”



DETAIL A
(Saw cut formed by conventional concrete sawing equipment.)



DETAIL B
(Saw cut formed by approved early concrete sawing equipment.)



Joint Re-sealing and Crack Sealing

- Treatment life: 8 to 16+ years
- We do not recommend using backer rod in our climate:

Putting Projects Together

Treatment Strategy Selection Process

1. *Conduct pavement evaluation*
2. *Determine causes of distress*
3. *Identify treatments to address distresses*
4. **Identify constraints and key selection factors**
5. **Develop feasible treatment strategies**
6. **Assess cost effectiveness of alternative treatment strategies**
7. **Select preferred treatment strategy**

4. Identify Constraints and Key Selection Factors

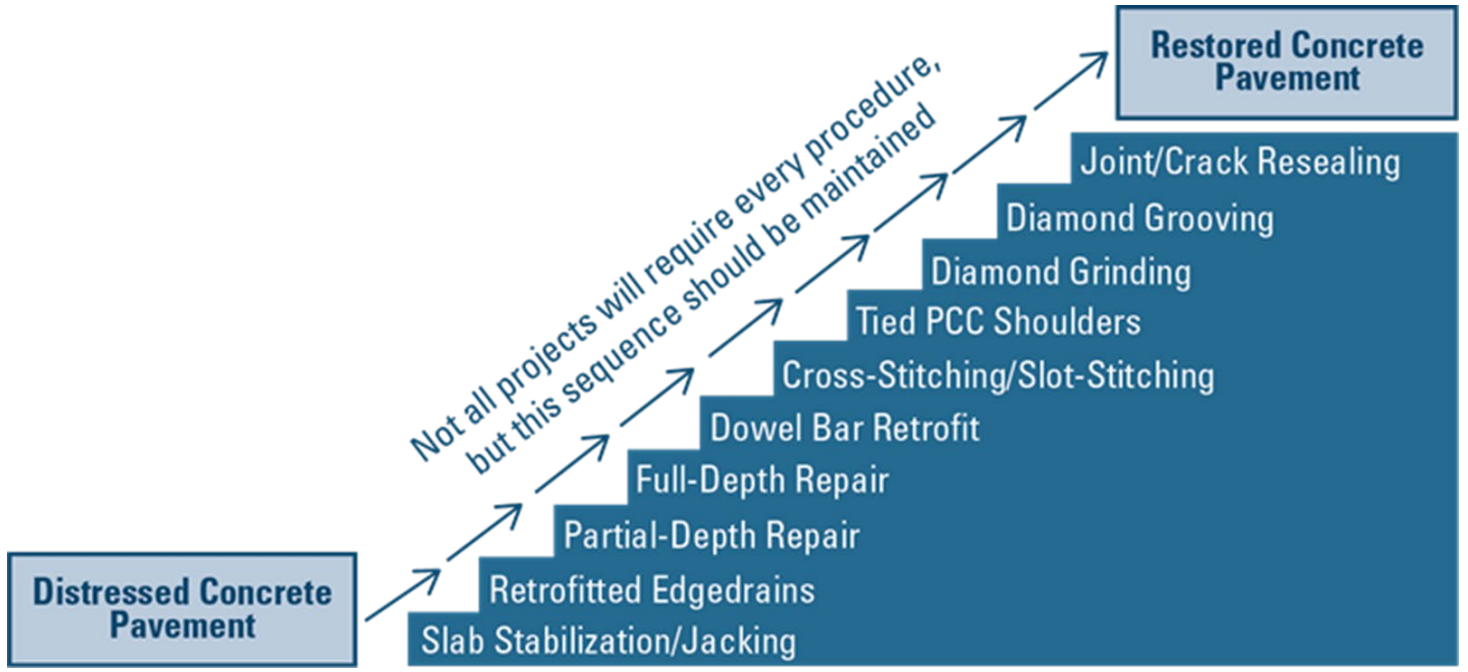
- Consider other factors that might influence the selection process:
  - Traffic levels
  - Lane closure options
  - Future maintenance requirements or construction plans
  - Geometry
  - Funding

5. Develop Feasible Treatment Strategies

- Strategy: a treatment or combination of treatments needed to address all of the deficiencies on a project

5. Develop Feasible Treatment Strategies

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



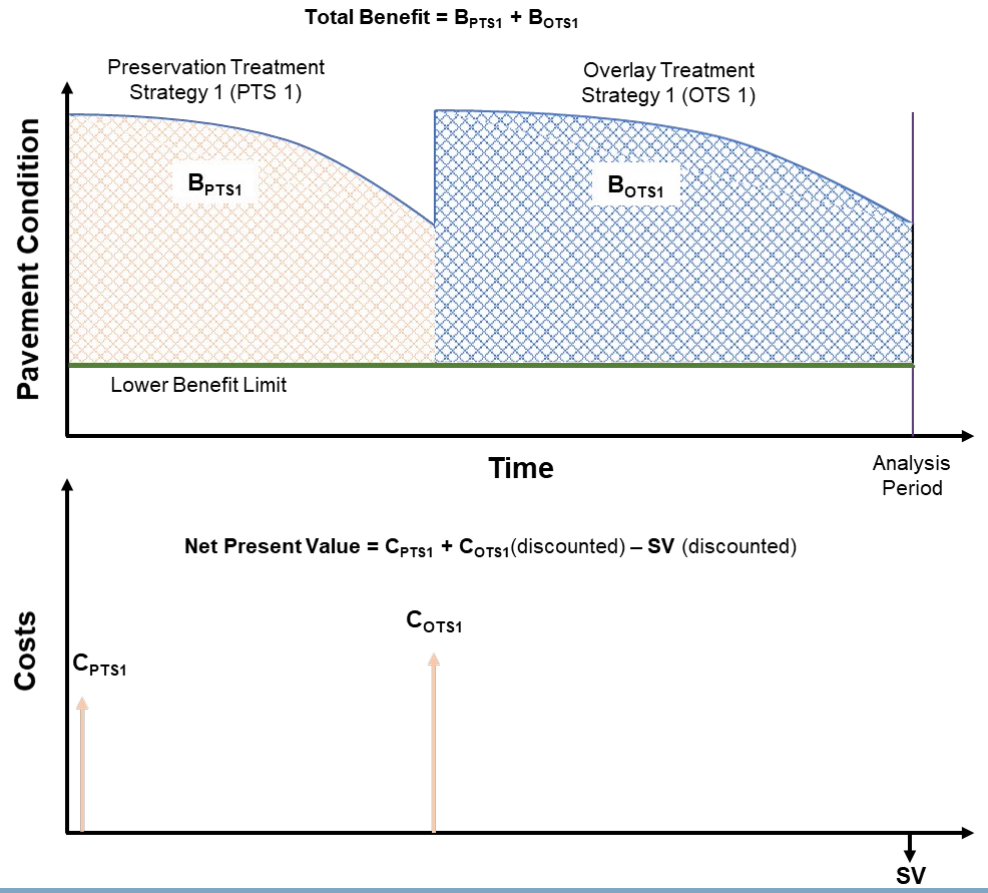
5. Develop Feasible Treatment Strategies

- Don’t forget that you can package these treatments with major improvements to other aspects of streets and roads
  - Pedestrian safety features
  - Bike lanes
  - Lane conversions

Image: Snyder and Associates

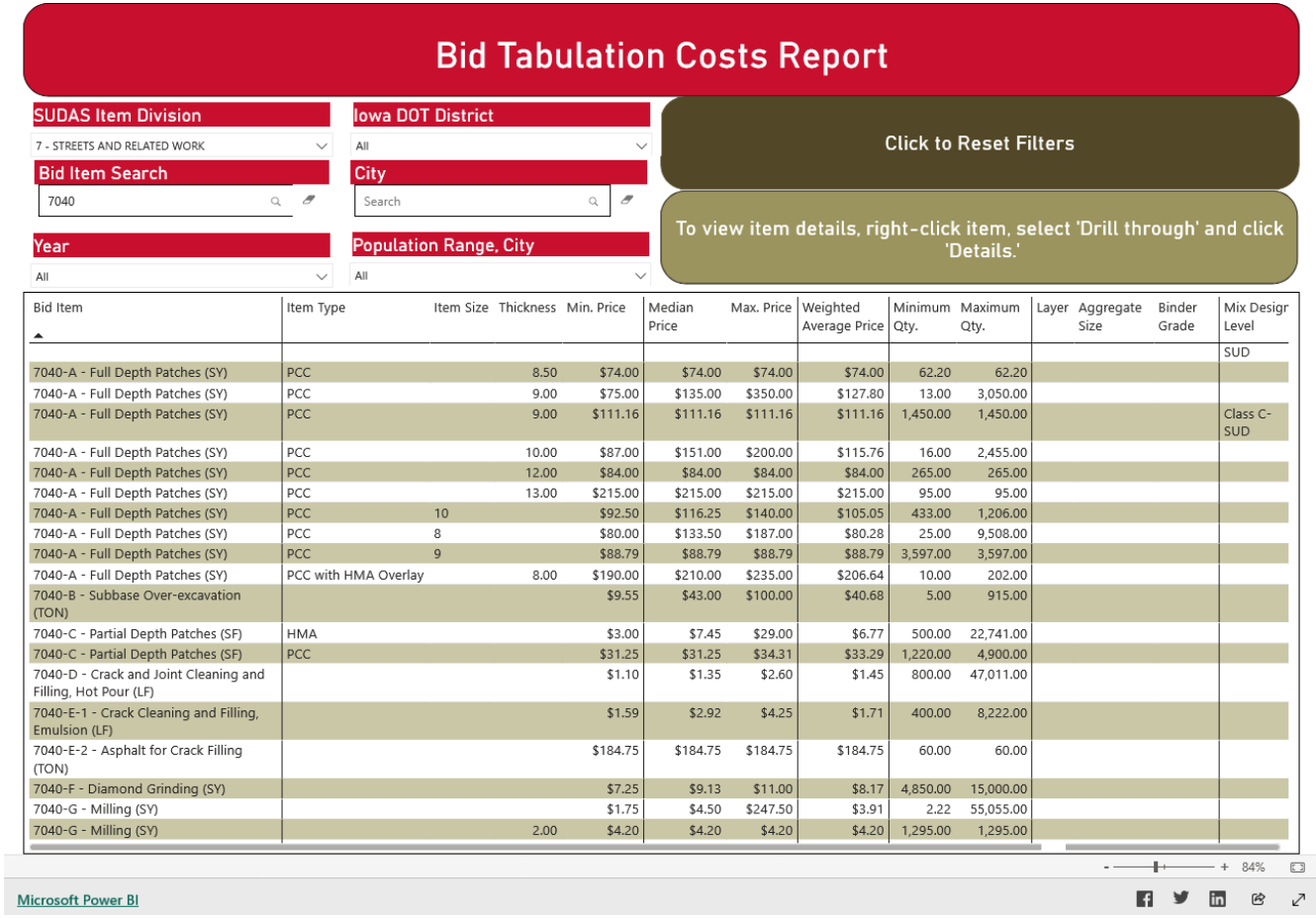
6. Assess Cost Effectiveness of Strategies

- Various methods for informing choice of treatment strategies:
  - Benefit-cost ratio analysis (BCR)
  - Life-cycle cost analysis (LCCA)
- Can be employed on both the project- and network-level



6. Assess Cost Effectiveness of Strategies

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



Bid Tabulation Costs Report

SUDAS Item Division: 7 - STREETS AND RELATED WORK
Iowa DOT District: All
Bid Item Search: 7040
City: Search
Year: All
Population Range, City: All

Click to Reset Filters

To view item details, right-click item, select 'Drill through' and click 'Details.'

Bid Item	Item Type	Item Size	Thickness	Min. Price	Median Price	Max. Price	Weighted Average Price	Minimum Qty.	Maximum Qty.	Layer	Aggregate Size	Binder Grade	Mix Desigr Level
													SUD
7040-A - Full Depth Patches (SY)	PCC		8.50	$74.00	$74.00	$74.00	$74.00	62.20	62.20				
7040-A - Full Depth Patches (SY)	PCC		9.00	$75.00	$135.00	$350.00	$127.80	13.00	3,050.00				
7040-A - Full Depth Patches (SY)	PCC		9.00	$111.16	$111.16	$111.16	$111.16	1,450.00	1,450.00				Class C-SUD
7040-A - Full Depth Patches (SY)	PCC		10.00	$87.00	$151.00	$200.00	$115.76	16.00	2,455.00				
7040-A - Full Depth Patches (SY)	PCC		12.00	$84.00	$84.00	$84.00	$84.00	265.00	265.00				
7040-A - Full Depth Patches (SY)	PCC		13.00	$215.00	$215.00	$215.00	$215.00	95.00	95.00				
7040-A - Full Depth Patches (SY)	PCC	10		$92.50	$116.25	$140.00	$105.05	433.00	1,206.00				
7040-A - Full Depth Patches (SY)	PCC	8		$80.00	$133.50	$187.00	$80.28	25.00	9,508.00				
7040-A - Full Depth Patches (SY)	PCC	9		$88.79	$88.79	$88.79	$88.79	3,597.00	3,597.00				
7040-A - Full Depth Patches (SY)	PCC with HMA Overlay		8.00	$190.00	$210.00	$235.00	$206.64	10.00	202.00				
7040-B - Subbase Over-excavation (TON)				$9.55	$43.00	$100.00	$40.68	5.00	915.00				
7040-C - Partial Depth Patches (SF)	HMA			$3.00	$7.45	$29.00	$6.77	500.00	22,741.00				
7040-C - Partial Depth Patches (SF)	PCC			$31.25	$31.25	$34.31	$33.29	1,220.00	4,900.00				
7040-D - Crack and Joint Cleaning and Filling, Hot Pour (LF)				$1.10	$1.35	$2.60	$1.45	800.00	47,011.00				
7040-E-1 - Crack Cleaning and Filling, Emulsion (LF)				$1.59	$2.92	$4.25	$1.71	400.00	8,222.00				
7040-E-2 - Asphalt for Crack Filling (TON)				$184.75	$184.75	$184.75	$184.75	60.00	60.00				
7040-F - Diamond Grinding (SY)				$7.25	$9.13	$11.00	$8.17	4,850.00	15,000.00				
7040-G - Milling (SY)				$1.75	$4.50	$247.50	$3.91	2.22	55,055.00				
7040-G - Milling (SY)			2.00	$4.20	$4.20	$4.20	$4.20	1,295.00	1,295.00				

84%

Microsoft Power BI

7. Select Preferred Treatment Strategy

- Partial depth repair, dowel bar retrofit, and diamond grinding combined effectively on the same project:

National Concrete Pavement Technology Center

Tech Center

Iowa State University

Institute for Transportation