NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: Concrete Pavement Preservation

March 18, 2024

2:00 – 3:30 PM

PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

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Purpose Statement

This webinar will highlight available concrete preservation techniques and when they should be used. Presenters will share case studies of successful applications.

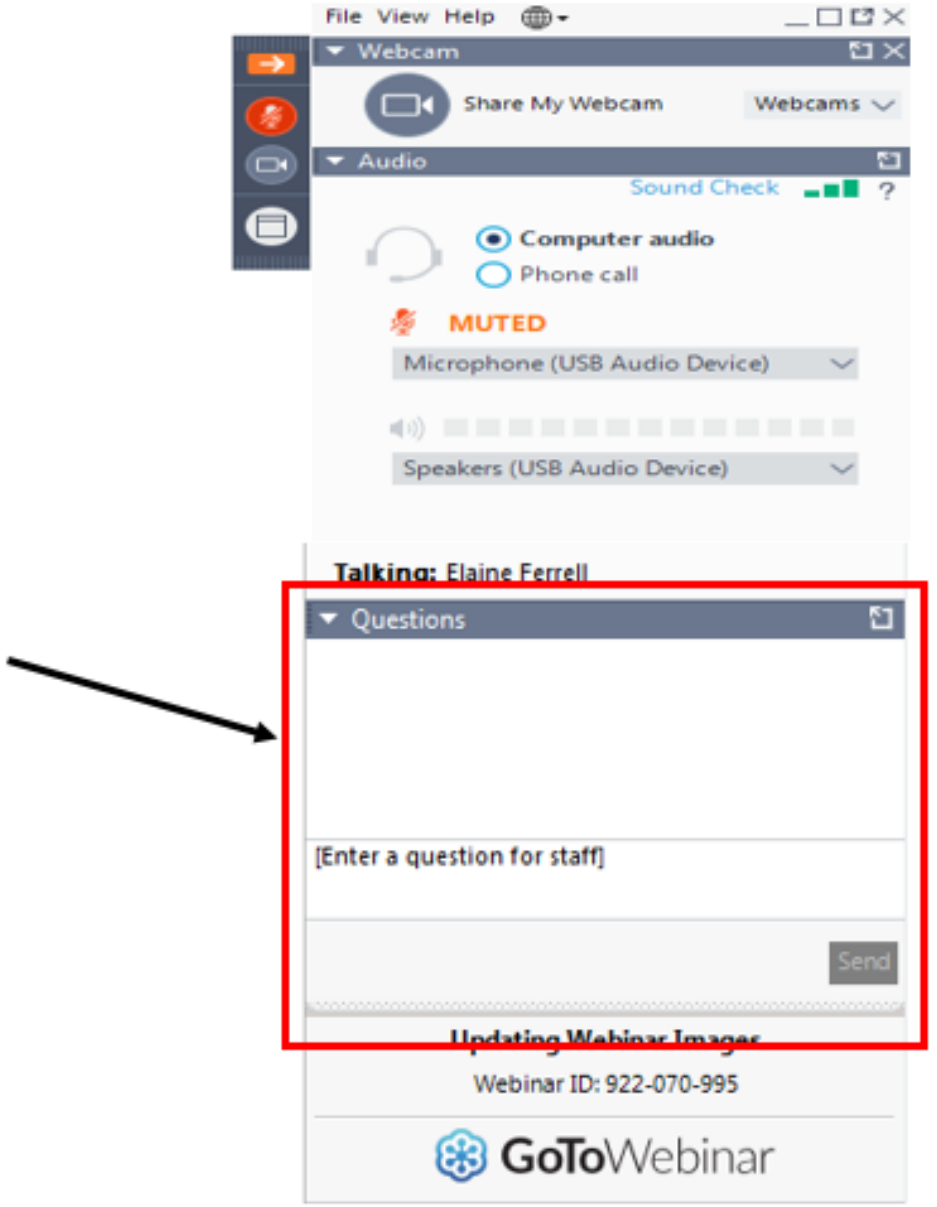
Learning Objectives

At the end of this webinar, you will be able to:

- Select appropriate preservation methods for a variety of concrete pavement distress mechanisms

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters

Dr. Peter C. Taylor

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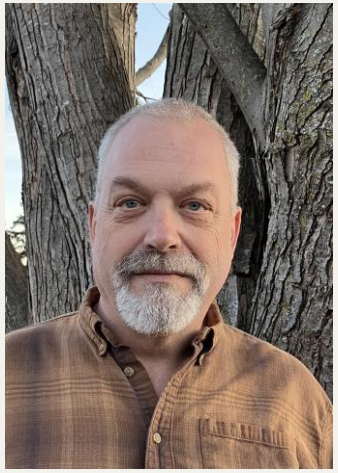
National Concrete Pavement Technology Center

Tech Center

Kurt Smith

ksmith@appliedpavement.com

applied pavement TECHNOLOGY



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DEPARTMENT OF TRANSPORTATION

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INDIANA DEPARTMENT OF TRANSPORTATION INDOT

NATIONAL ACADEMIES Sciences Engineering Medicine

Concrete Pavement Preservation Practices and Applications

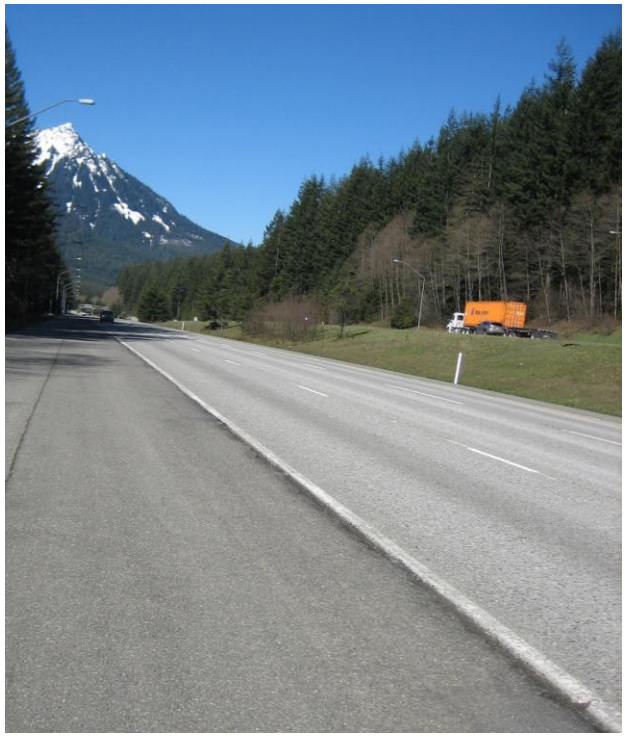
TRB Webinar:
Concrete Pavement Preservation

March 18, 2024

Kurt Smith
Applied Pavement Technology, Inc.

Outline

- Introduction to Pavement Preservation
- Treatments and Applications
- Selecting Treatments
- Closing Remarks



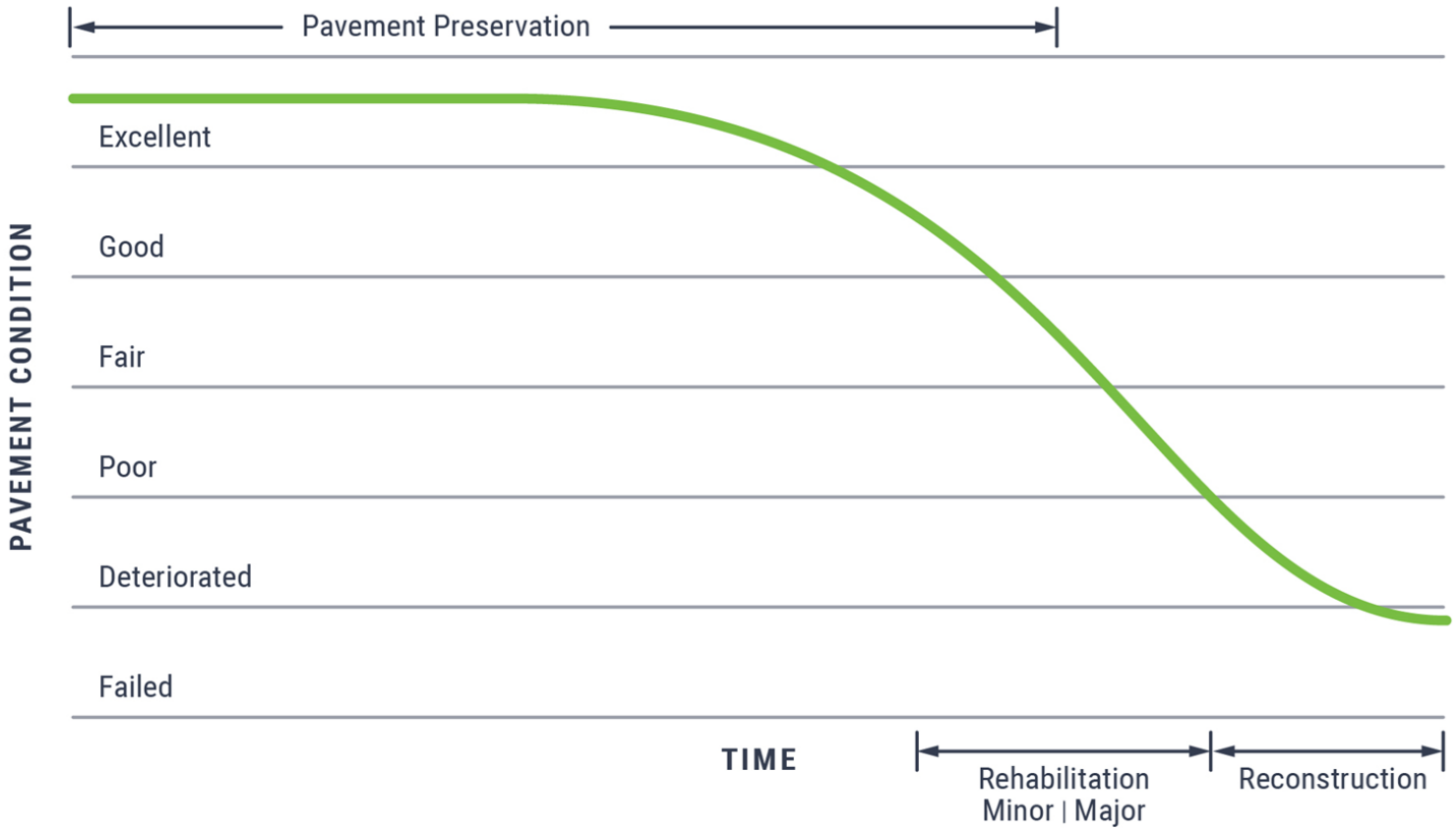
Introduction to Pavement Preservation

What Is Pavement Preservation?

- Proactive approach for managing pavement structures
- Focus on extending pavement life and maintaining or restoring functional condition
- Uses targeted solutions for existing pavement deficiencies

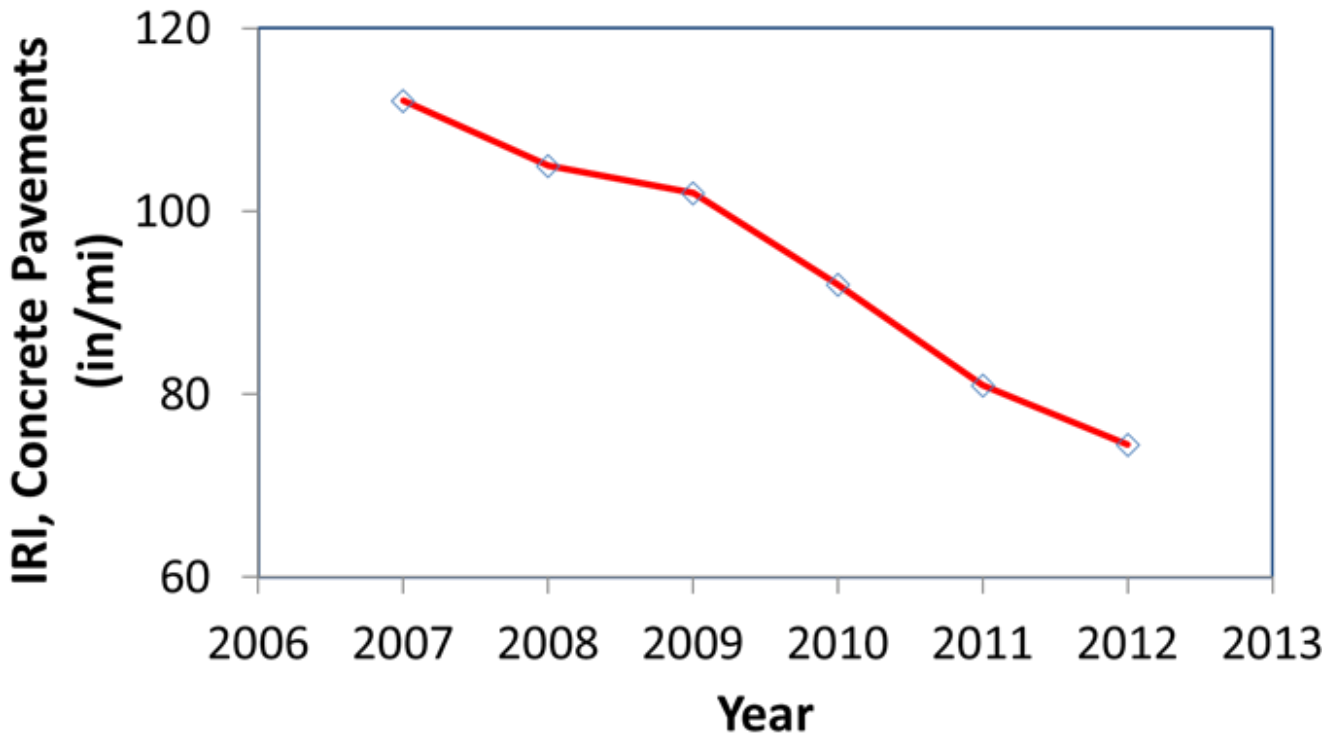
Favorable Characteristics for Preservation

- Few or limited structural problems
- No materials-related distress
- Pavements in overall relatively good condition
- Pavements subjected to all traffic levels



Benefits of Preservation

- Extended service life
- Improved performance
  - Smoothness
  - Safety
  - Noise
- Cost savings
- Enhanced sustainability



One agency's success with a concrete pavement preservation program

Examples of Effective Preservation

US 41, Chassel, MI (1958)

I-10, Ontario, CA (1947)

I-5, Olympia, WA (1969)

Treatments and Applications

Concrete Pavement Preservation Treatments

Primary Treatments:

- Partial-depth repairs
- Full-depth repairs
- Dowel bar retrofit
- Joint resealing
- Diamond grinding
- Crack sealing
- Diamond grooving

Additional Treatments:

- Cross stitching
- Slab stabilization
- Slab jacking
- Slot stitching
- Retrofitted edge drains

Workhorse Treatments

Partial-Depth Repairs

Full-Depth Repairs

Diamond Grinding

Dowel Bar Retrofit

Joint Resealing

Typical Applications

Concrete Pavement Deficiency	Possible Treatments
Transverse Cracking	Full-Depth Repair Dowel Bar Retrofit
Longitudinal Cracking	Cross Stitching Full-Depth Repair
Corner Break	Full-Depth Repair
Punchout (CRCP)	Full-Depth Repair
Joint Spalling/Deterioration	Partial-Depth Repair Full-Depth Repair Joint Resealing
Buckling/Blowups	Full-Depth Repair

Typical Applications (continued)

Concrete Pavement Deficiency	Possible Treatments
Pumping/Faulting	Slab Stabilization Dowel Bar Retrofit Diamond Grinding Joint Resealing
Joint Sealant Damage	Joint Resealing
Localized Settlements	Slab Jacking
Roughness	Diamond Grinding
Poor Friction	Diamond Grinding Diamond Grooving
Noise	Diamond Grinding Next Generation Concrete Surface

Selecting Treatments

Pavement Evaluation

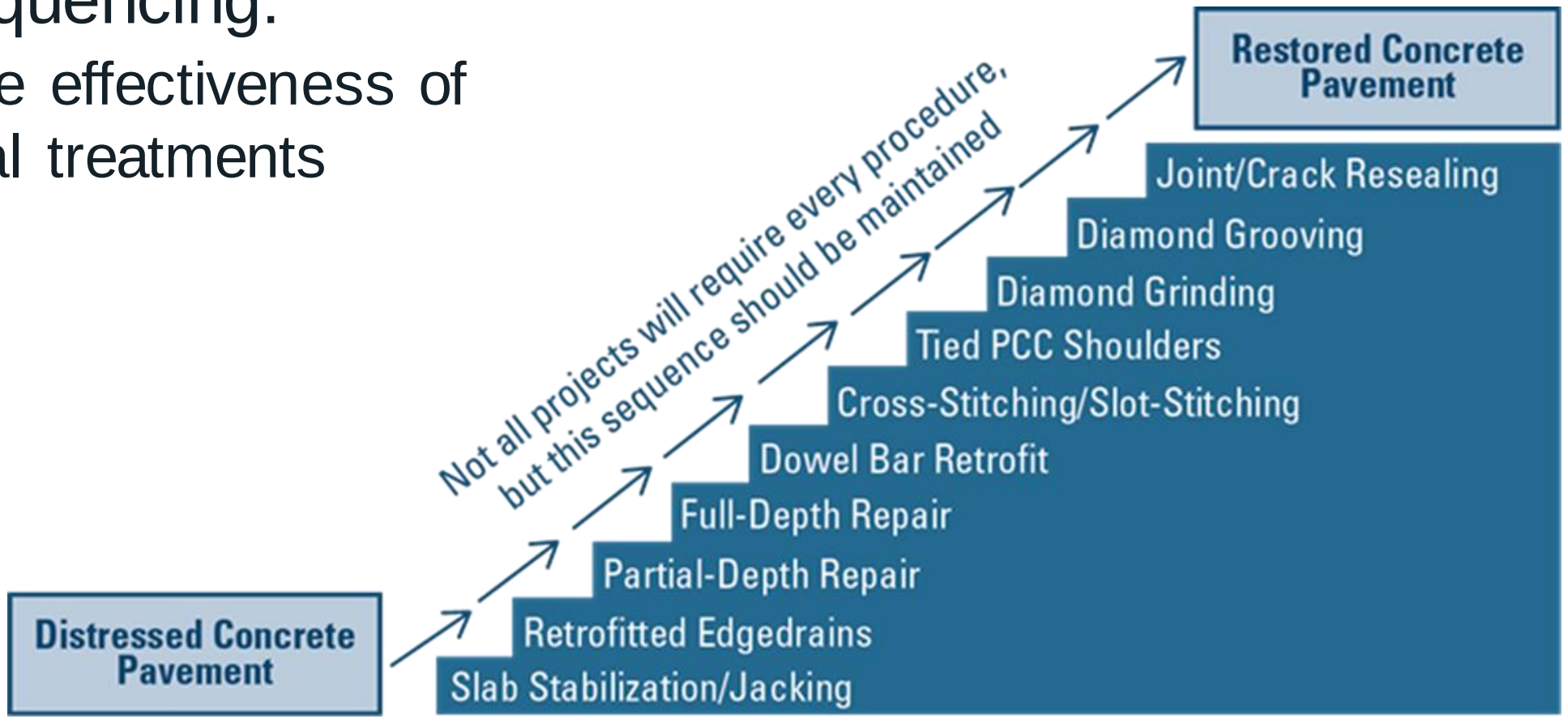
- Objectives
  - Determine causes of deterioration
  - Determine if pavement is not a candidate for preservation
  - Develop appropriate treatment alternatives
- Components
  - Pavement distress surveys
  - Nondestructive testing
  - Surface characteristics testing
  - Field sampling and testing

Selecting Treatments

- Treatments must:
  - Address deficiencies
  - Meet project constraints (e.g., traffic loadings, available lane closure times, maintenance of traffic options, geometrics)
  - Meet other agency decision factors (e.g., costs, performance life, safety, sustainability, network-level considerations)
- Multiple treatments often applied concurrently

Construction Sequencing

- For concurrent activities
- Proper sequencing:
  - » Maximize effectiveness of individual treatments



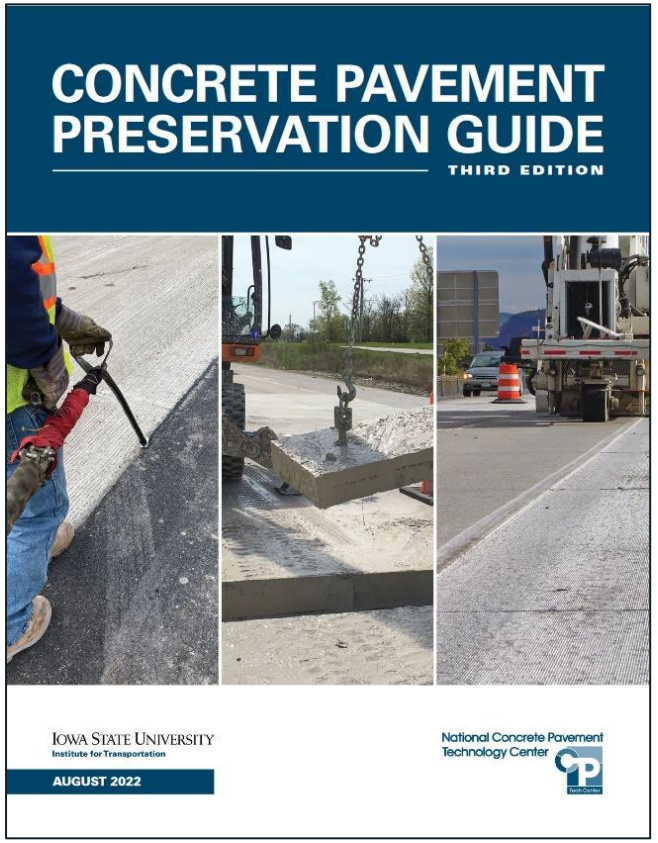
Closing Remarks

Closing Remarks

- Preservation: established approach for managing pavements
- Key benefits: improved performance, extended life, cost savings, sustainability
- Applications:
  - Pavements in fair-good condition
  - All traffic levels
- Achieved by: collection of treatments capable of targeting specific deficiencies
- Selected agency experiences highlighted in next presentations

More Information

- More information available from the National Concrete Pavement Technology Center:
  - Concrete Pavement Preservation Guide, 3rd Edition
  - https://cptechcenter.org/pavement-preservation/



Thank You!

Kurt Smith
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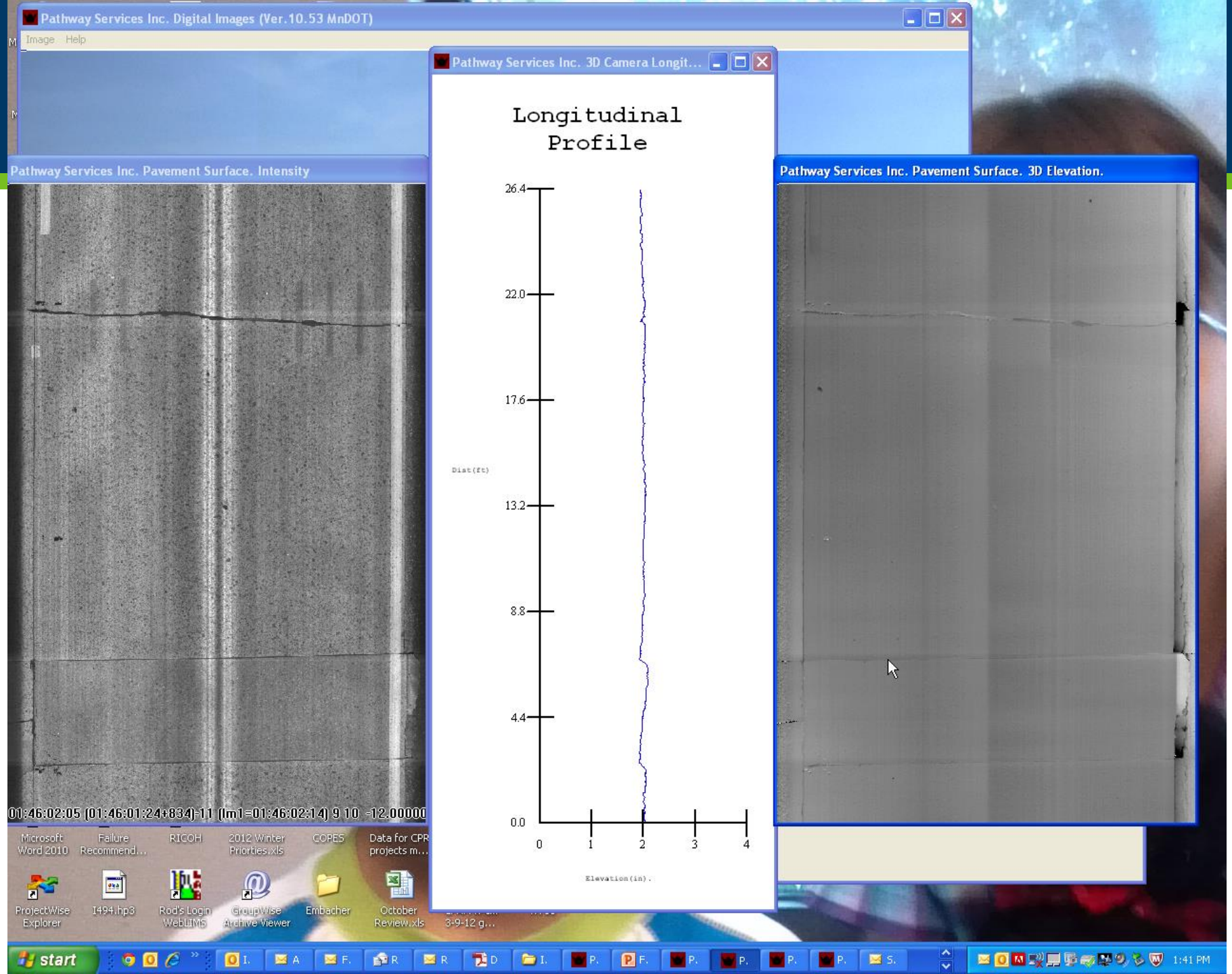
Mn/DOT Evaluation of Dowel Bar Anchoring in Full Depth Repairs

DEPARTMENT OF TRANSPORTATION

Gordon “Gordy” Bruhn| Sr. Engineering Specialist

Winter 2024

I-90 Full Depth Repair Faulting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2
3
4
Elevation(in).
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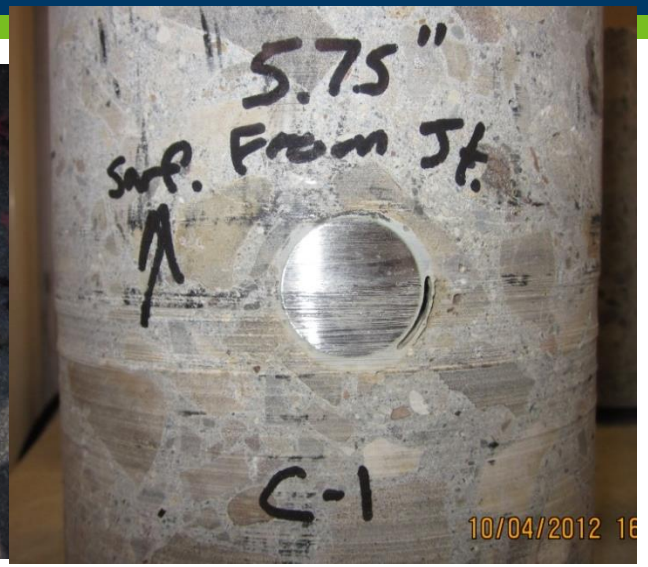
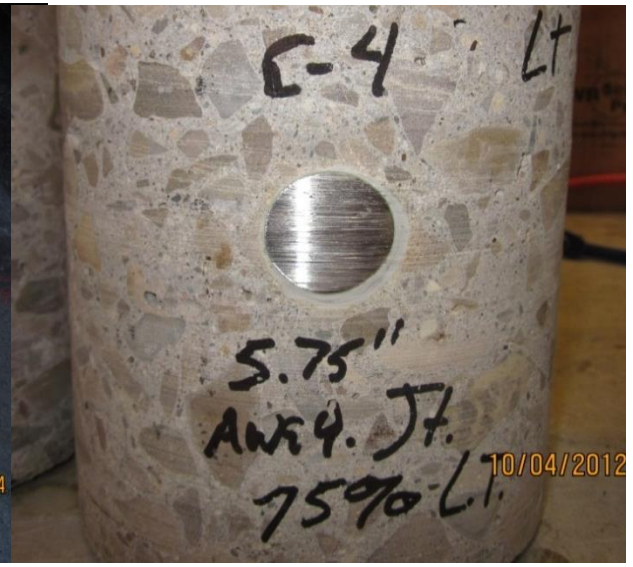
I-90 – Full Depth Repairs

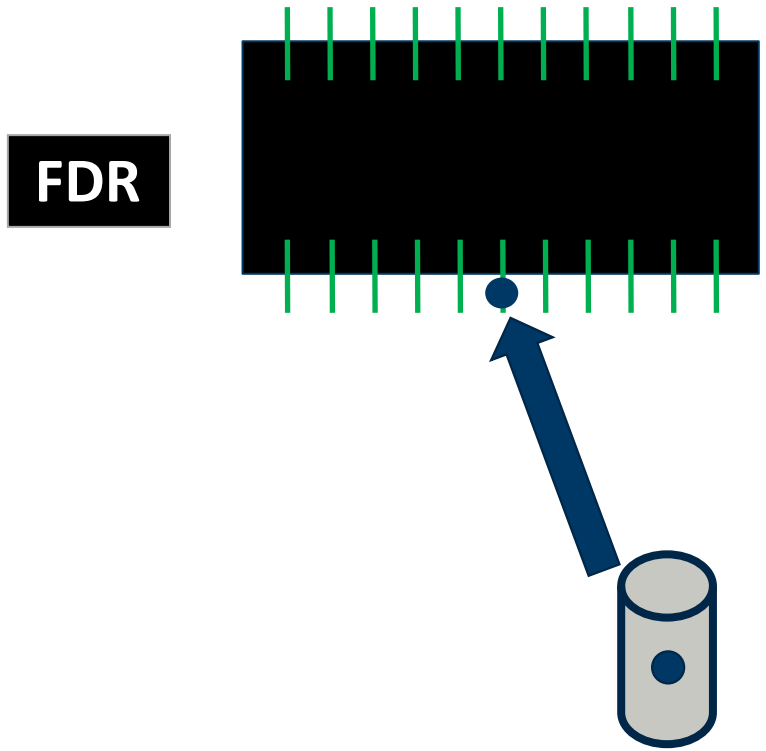




I-90 Investigation

- Full Scale Investigation of other CPR projects constructed between 2007 and 2012
- Was the switch from 11 dowels to 6 (3 per WP) or 8 (4 per WP) depending on traffic going too far? But it works for retrofit dowel projects…
- Where did the material go? We used more than we needed? Did it break down, was it durable?
- Is Spec constructible?
  - *Place the bonding agent into the drilled holes to completely fill the void.*

SOCKETED VOIDS AROUND DOWEL BARS



- Core over drill and grouted dowel bar on the in-place concrete.

I-35 South of the Twin Cities had loose Dowels

I-694 Cores showed Loose Dowels

MnROAD FDR Field Installation – Phase 2 – 8/15&16/13

- 1” and 1.25” diameter dowel bars
- All lanes diamond ground
- No grout, modified grout bag, grout capsule, epoxy (2 types)
- Controlled location
- FWD testing seasonally
- Coring
- Monitoring over time

MnROAD Mainline - Old Westbound

13 cells

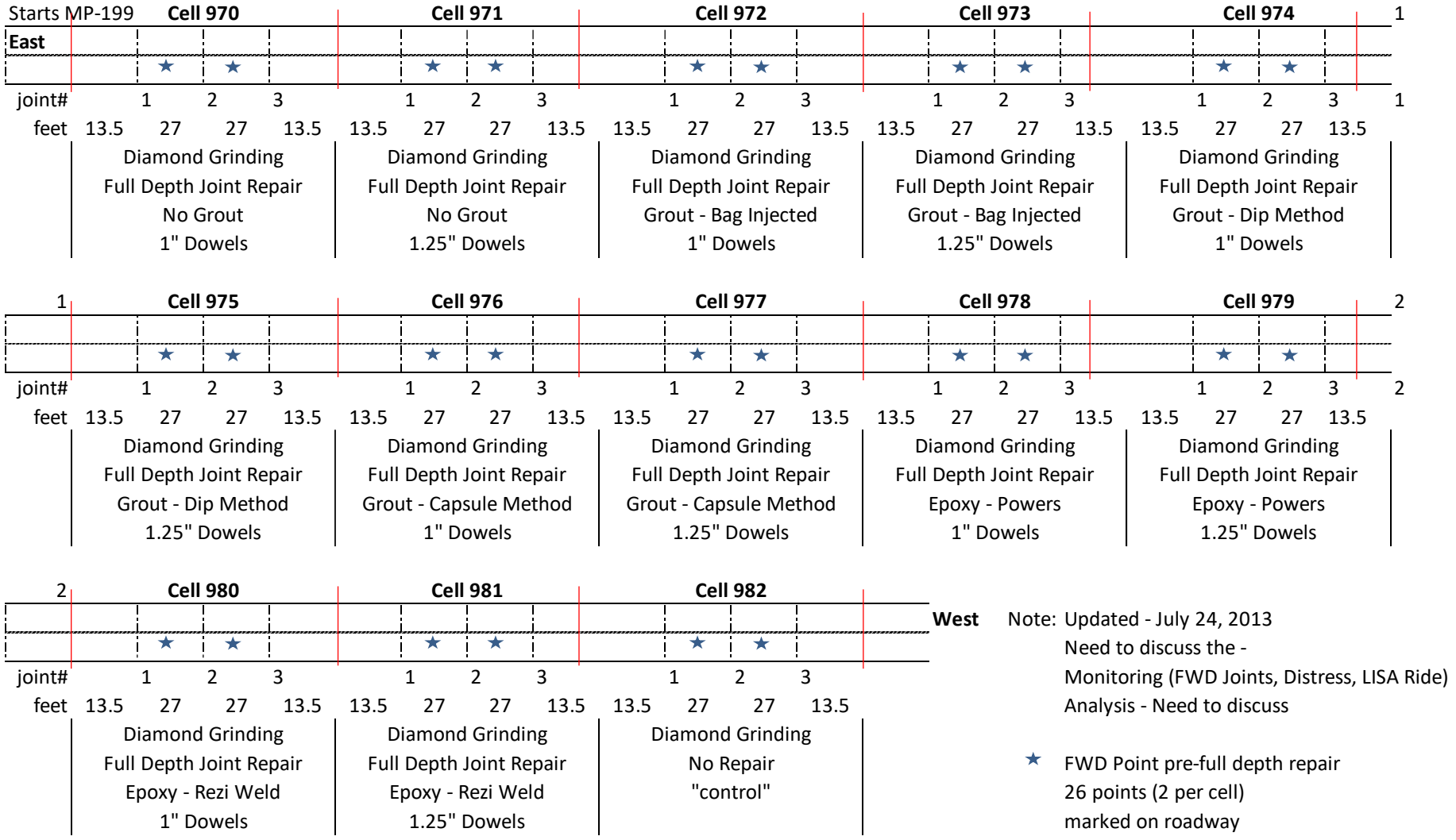
each cell has 3 joints = 81 feet long = both lanes

Interstate I-94 (By-Pass)

9” JRCP / 6” Class-6 Base / Clay (1973)

Estimated 140,000 Rigid ESAL/Year

28,500 ADT - 13% Trucks



Note: Updated - July 24, 2013

Need to discuss the -

Monitoring (FWD Joints, Distress, LISA Ride)

Analysis - Need to discuss

★ FWD Point pre-full depth repair

26 points (2 per cell)

marked on roadway

Modified Grout Bag with Extension Tube.

Grout Adhesive Using a Grout Capsule
Soak in Water for 2 min or Until Bubble Stop

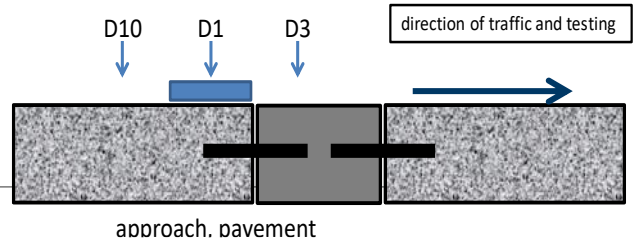
Fill Back of Drill Hole with Epoxy

Dowel Dipped in Adhesive (Grout or Epoxy) and Inserted in Drill Hole

Measuring Dowel Bar Effectiveness with FWD Testing

- Larson and Smith (2005) suggest that "doweled joints with LTE of 85 percent or less and/or a differential deflection greater than 5 mils in five years or less are unlikely to provide satisfactory long-term performance."
- Values reflect new construction – *I believe adaptive to performance of full depth repairs*

Source: Guide to Dowel Load Transfer Systems for Jointed Concrete Roadway Pavements (Sept 2011)



Average of LTE

Load Transfer Efficiency - Approach - Pavement

LTE (%)

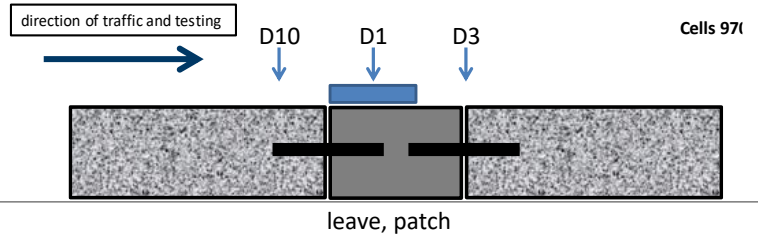
100
90
80
70
60
50
40
30
20
10
0

8/13/2013
9/13/2013
7/31/2014
11/7/2014

970 971 972 973 974 975 976 977 978 979 980 981 982

NG1 NG1.25 GB1 GB1.25 GD1 GD1.25 GC1 GC1.25 EP1 EP1.25 ER1 ER1.25 C

CELL



Average of LTE

Load Transfer Efficiency - Leave - Patch

LTE (%)

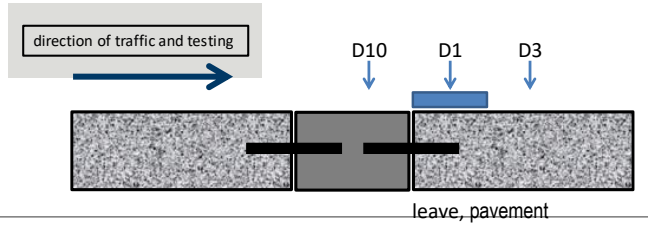
120
100
80
60
40
20
0

9/13/2013
7/31/2014
11/7/2014

NG1 NG1.25 GB1 GB1.25 GD1 GD1.25 GC1 GC1.25 EP1 EP1.25 ER1 ER1.25

MnROAD Mainline - Old Westbound Cell #

CELL



Average of LTE

Load Transfer Efficiency - Leave - Pavement

8/13/2013
9/13/2013
7/31/2014
11/7/2014

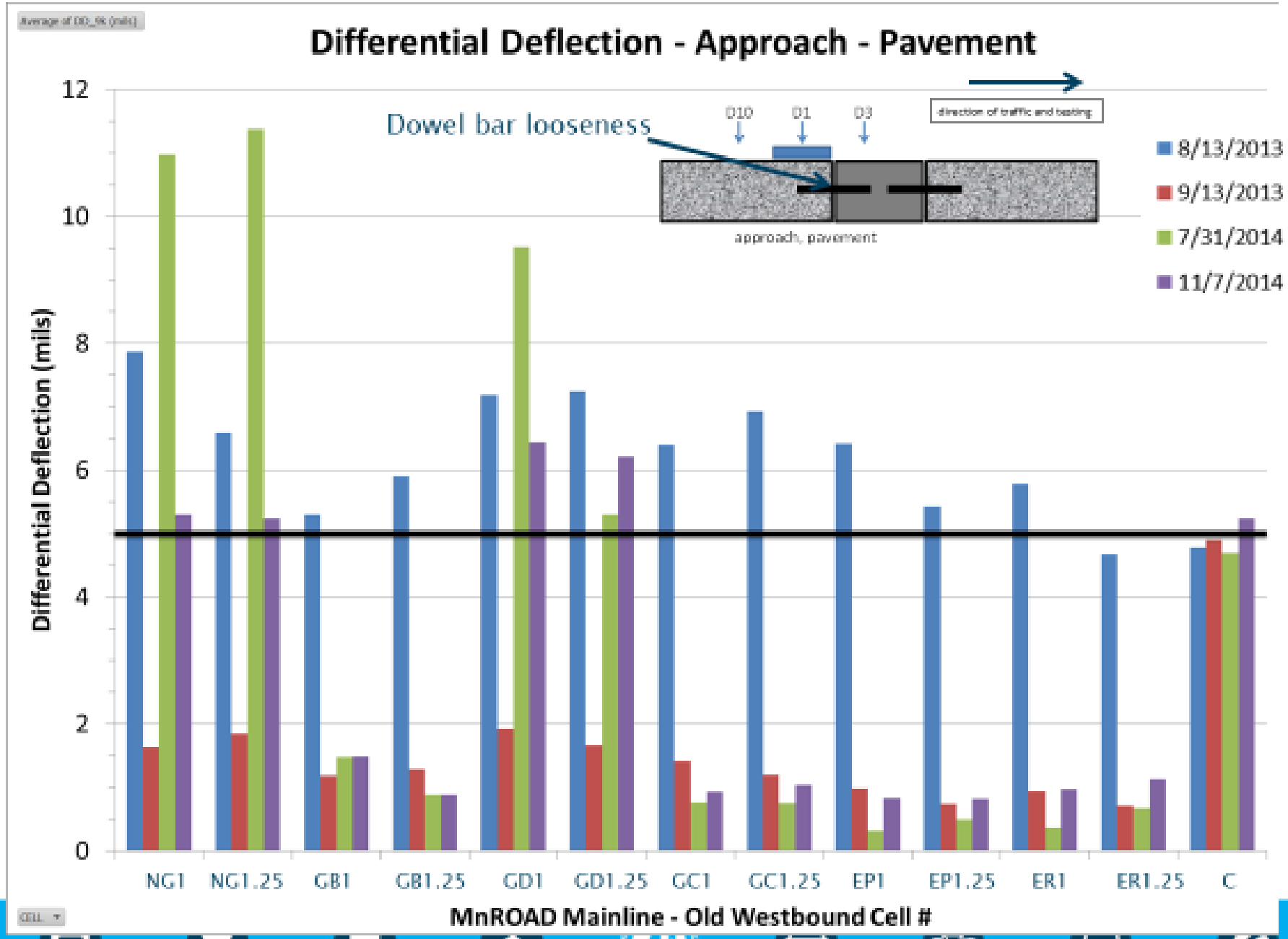
LTE (%)

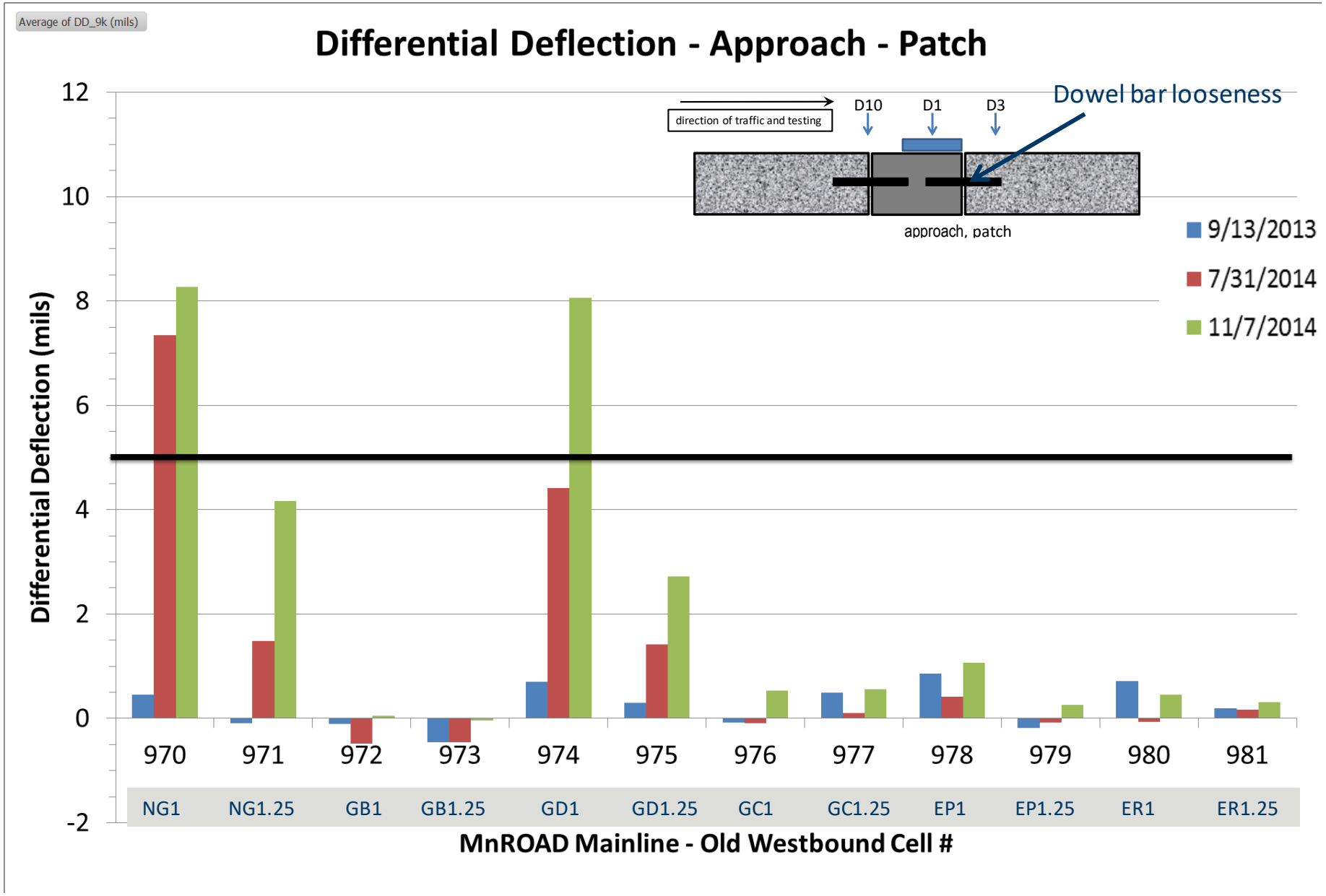
100
90
80
70
60
50
40
30
20
10
0

NG1 NG1.25 GB1 GB1.25 GD1 GD1.25 GC1 GC1.25 EP1 EP1.25 ER1 ER1.25 C

MnROAD Mainline - Old Westbound Cell #

CELL


Differential Deflection - Approach - Pavement
Dowel bar looseness
D10
D1
D3
direction of traffic and testing
approach, pavement
8/13/2013
9/13/2013
7/31/2014
11/7/2014
Differential Deflection (mils)
0
2
4
6
8
10
12
NG1
NG1.25
GB1
GB1.25
GD1
GD1.25
GC1
GC1.25
EP1
EP1.25
ER1
ER1.25
C
MnROAD Mainline - Old Westbound Cell #


Average of DD_9k (mils)
Differential Deflection - Approach - Patch
Dowel bar looseness
direction of traffic and testing
D10
D1
D3
approach, patch
9/13/2013
7/31/2014
11/7/2014
Differential Deflection (mils)
12
10
8
6
4
2
0
-2
970
971
972
973
974
975
976
977
978
979
980
981
NG1
NG1.25
GB1
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GD1
GD1.25
GC1
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EP1
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ER1
ER1.25
MnROAD Mainline - Old Westbound Cell #

Prescriptive or Performance with Anchoring Procedures?

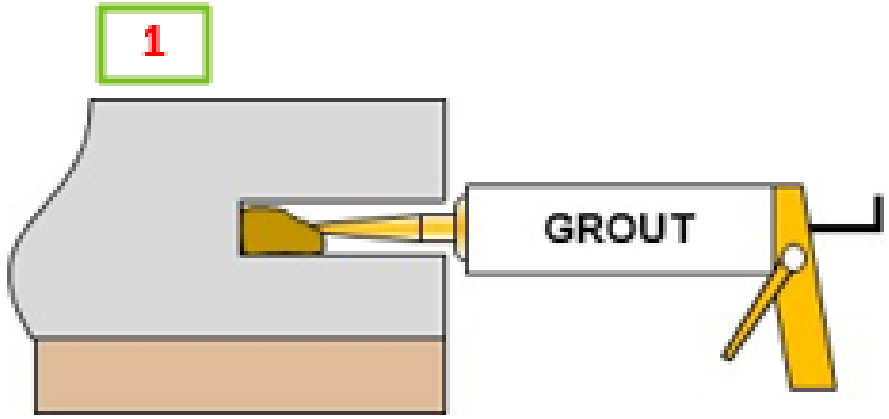
- Dowel Bar Anchoring Test Section
  - Complete FDR at least one (1) day prior to startup
  - Install 11 dowels in accordance with appropriate FDR
  - Cure the dowel bar anchoring adhesive at least 4 hours before coring.
  - DO NOT PLACE CONCRETE IN THE DOWEL BAR TEST SECTION.
  - Take (3) – 4” full depth cores centered on the dowel and 1 1/2" from the sawed vertical face.
- Dowel Bar Anchoring Assurance Coring
  - At the Engineer’s discretion, the Contractor will take additional cores to confirm consistent dowel bar anchoring.
  - For each 1500 Lineal Feet of FDR, the Engineer will randomly choose 2 separate repairs and mark 2 dowel bars for assurance coring.

Gang Drill…Bit size at least 1/8th Greater than Dowel Diameter

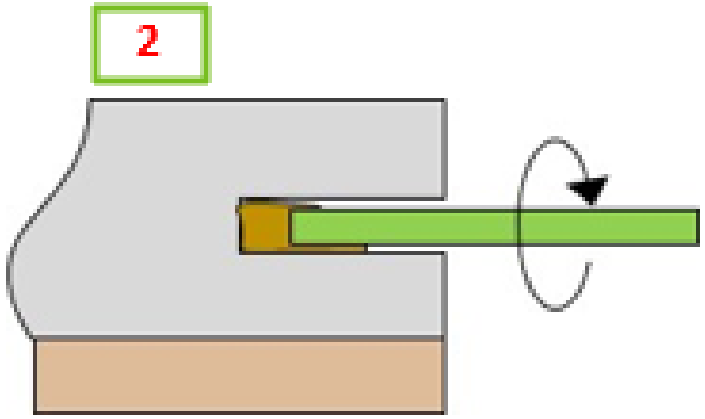
Compressed Air Cleaning
150 psi minimum

Menards Grout Bag

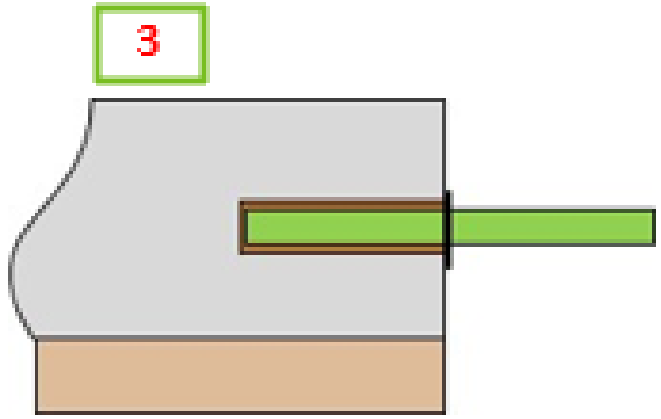
Grout or Epoxy Installation Method



- Inject grout to the back of the hole.



- Twist the Dowel bar while pushing it into the hole.



- Place grout retention disk to hold grout (optional).

See the list of the approved grouts / epoxy resins for more information.

The Contractor will take three 4-inch diameter full depth cores centered on the dowel and 1 inch from the sawed vertical face.

Type CD-LV Repairs

Dowel Bar Anchoring Test Section
Sawcut and Remove Test Section

Saw 1-foot outside original saw cut

Type CD-LV Repairs

Dowel Bar Anchoring Test Section
Evaluation of Adhesive Coverage

Acceptable – Grout Adhesive

Acceptable – Epoxy Adhesive

The concrete Engineer considers the anchoring method acceptable if no air voids are greater than ¼ inch in any direction.

Concrete Unit Recommendations

Once the method is approved by the Engineer, the Contractor can begin work and the Agency will require assurance coring to verify the Contractor continues to maintain acceptable adhesive coverage around the dowel bars.

Type CD-LV Repairs

Dowel Bar Anchoring Test Section
Evaluation of Adhesive Coverage

Unacceptable Grout Adhesive Coverage

Unacceptable Epoxy Adhesive Coverage

The concrete Engineer considers the anchoring method acceptable if no air voids are greater than ¼ inch in any direction.

If the Engineer determines the anchoring of the dowels is not acceptable, remove the first test section and install another test section at the Contractor's expense.

Concrete Unit Recommendations

If the Contractor switches installation crew members, the Inspector needs to verify they are still following the approved process. If the Contractor deviates, the work is unauthorized until they comply with the demonstrated process.

Experience has shown the dip and stick method for anchoring dowel bars results in insufficient adhesive coverage.

Final Thoughts

- **In my opinion …**
  - ***"Full Depth Repairs are an excellent technique for concrete pavement preservation – just remember it is sometimes the simple things that can cause the biggest problems."***
  - ***"Proper project selection and Contractor Workmanship are the keys to success!"***

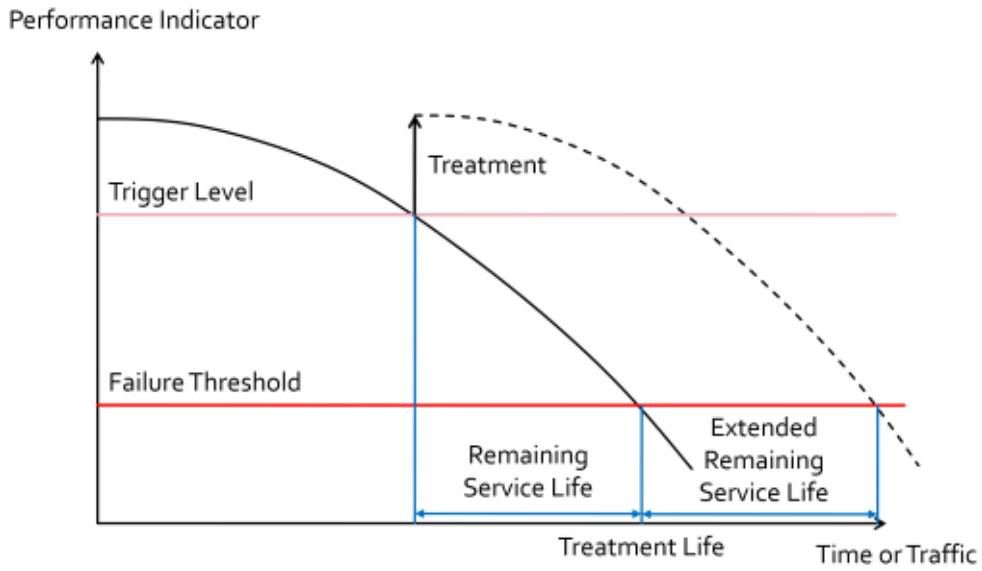
Use of Preservation Techniques Indiana

Tommy E. Nantung PhD PE

INDOT Division of Research and Development

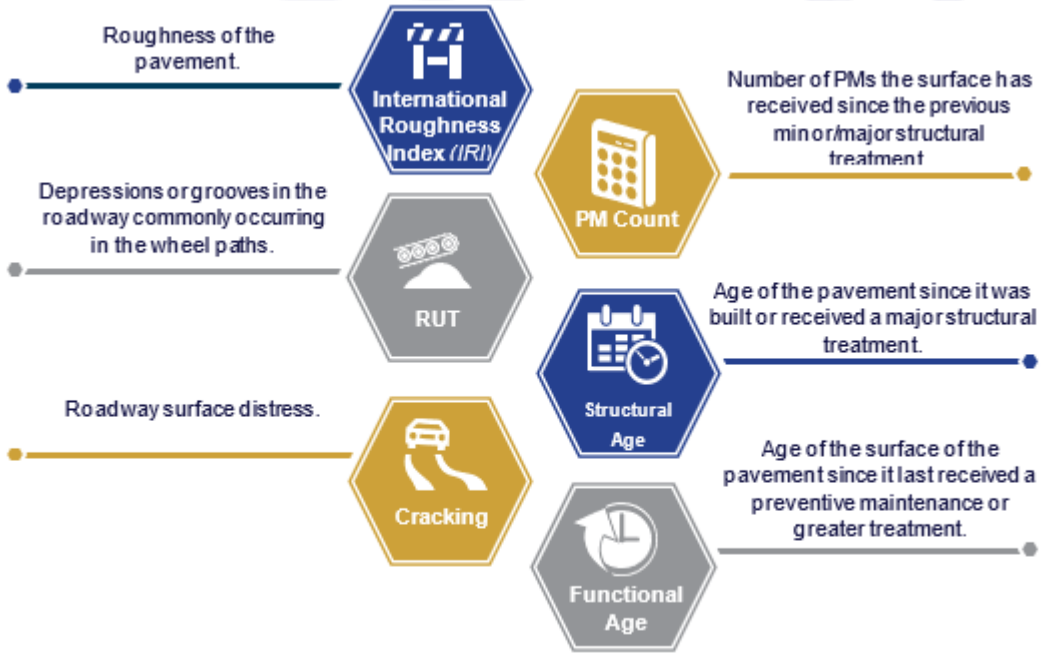
Preservation Topics

- Concept of Concrete Pavement Preservation
- Selecting Timing, Candidates, and Treatments
  - When, Where, How
- Feature Treatments
  - Diamond Grinding and Grooving
  - Joint Deterioration Partial Depth Patching
  - Slab Jacking



INDOT Major Principle of Preservation

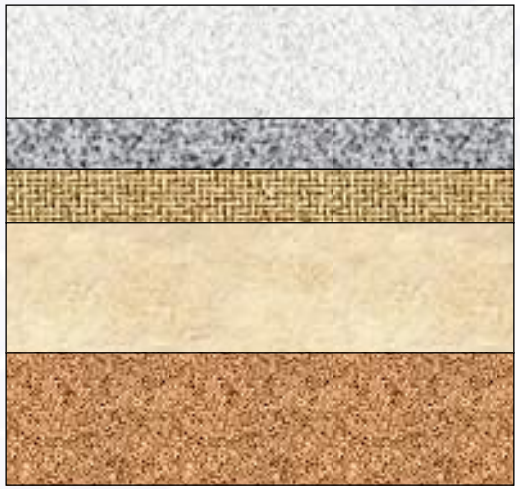
- To preserve the pavement structure while maintaining the surface function
- Selection of candidates
  - Pavement is structurally sound
  - Structural age
  - Functional age
  - Accommodate future traffic
- Treatment selection
  - Probability of success
  - Cost and effectiveness
  - Durability and future maintenance



NextLevel INDIANA

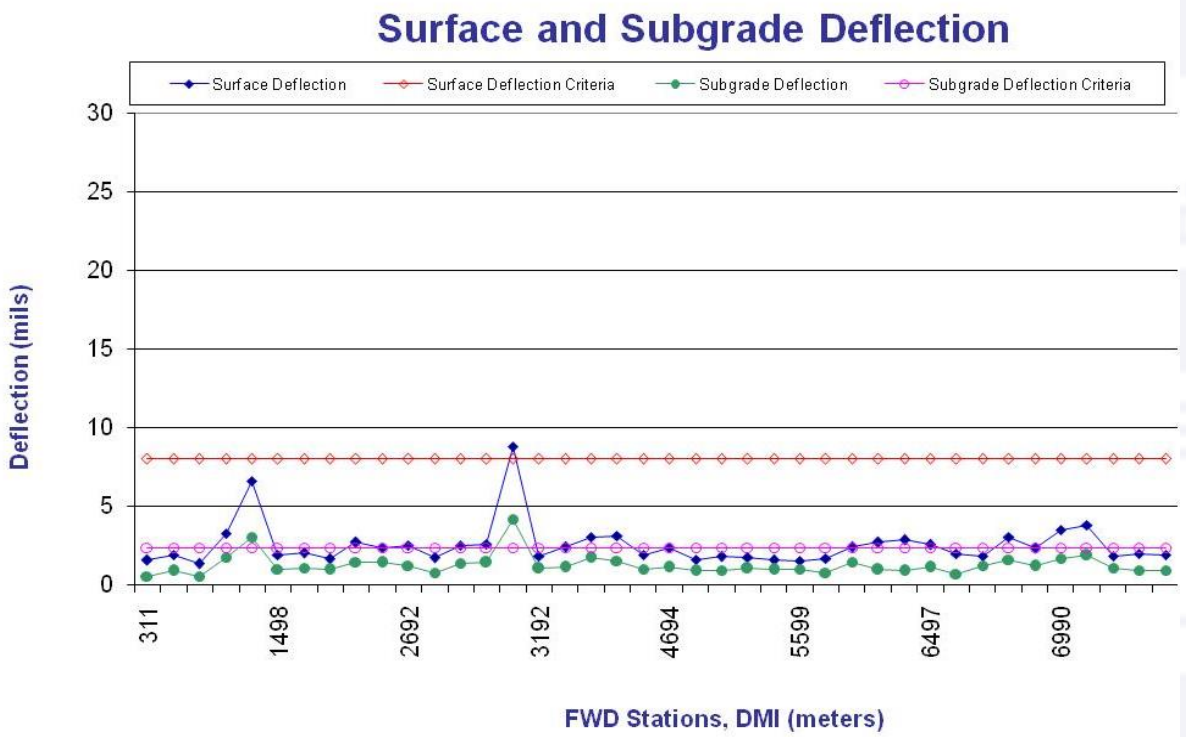
Preservation Case 1

- I-80/I-94 Borman Express way
  - Year built: 1999 to 2005
  - IRI Average: 107 in./mile
  - Designed: 1998
  - Design ESALs: 600 millions
  - AADT: 180,643 veh./day
  - AADTT: 54,009 trucks/day
  - The largest truck traffic in the world, 80% trucks at night



Preservation Case 1: Existing Structure

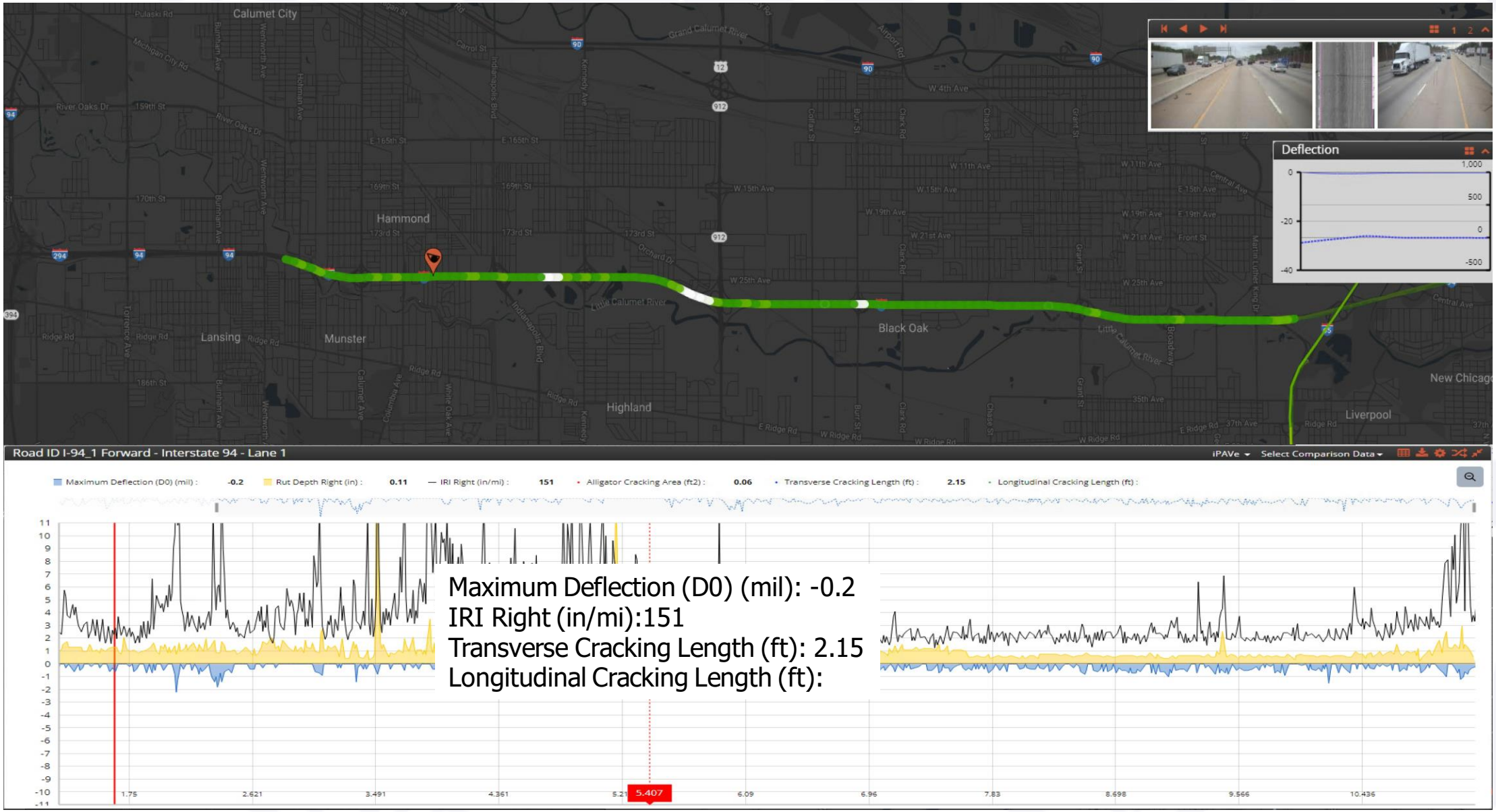
FWD Station	In-Situ CBR (%)	In-situ Structural Number	Dynamic K-value of Concrete Pavement Support(pci)
311	7.00	7.61	1000.00
399	7.00	7.00	698.88
692	7.00	8.63	1000.00
1292	5.71	7.54	270.30
1396	3.56	5.35	172.70
1498	7.00	8.97	447.14
1592	7.00	8.02	585.62
2095	7.00	9.91	450.74
2500	7.00	7.50	341.14
2588	7.00	8.84	274.78
2692	7.00	7.40	459.52
2802	7.00	8.36	813.50
2895	7.00	7.73	415.86
2999	7.00	8.25	343.58
3092	2.60	4.90	121.28
3192	7.00	9.50	430.48
3683	7.00	7.52	485.76
4011	5.85	7.95	242.06
4099	7.00	7.04	336.90
4192	7.00	8.46	517.12
4694	7.00	7.57	464.56



In-Situ	Average		Standard Deviation	
Elastic Modulus of Concrete	1,842,058	psi	775,578	psi
Structural Number	8.05		1.29	
Modulus of Resilience of Subgrade Soil	14,870	psi	5,424	psi
CBR of Subgrade Soil	6.70	%	0.91	%
Dynamic K-value of Pavement support	482	pci	208	pci

NextLevel INDIANA

Preservation Case 1: Candidate



Maximum Deflection (D0) (mil): -0.2
IRI Right (in/mi):151
Transverse Cracking Length (ft): 2.15
Longitudinal Cracking Length (ft):

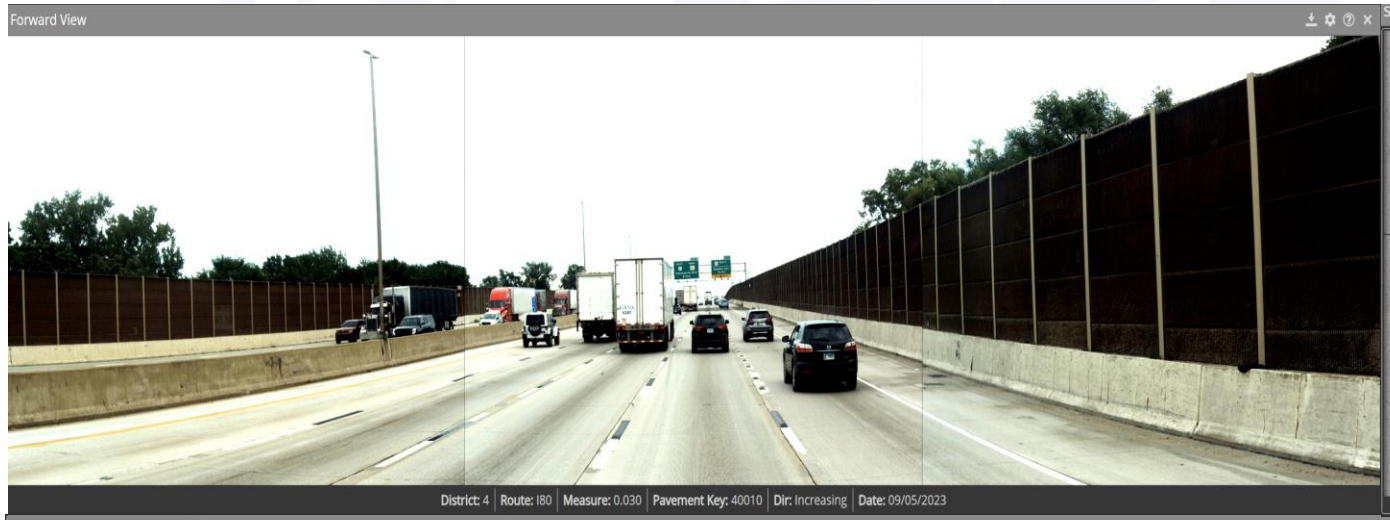
Picture From: ARRB

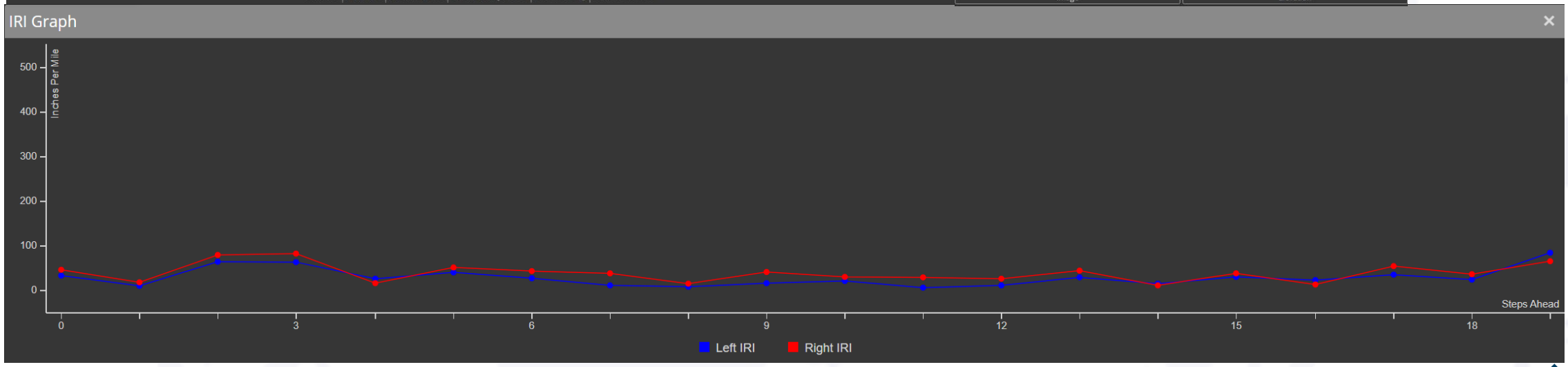
Preservation Case 1: : Before Treatment

Preservation Case 1: After Treatment

Picture From: Google Map

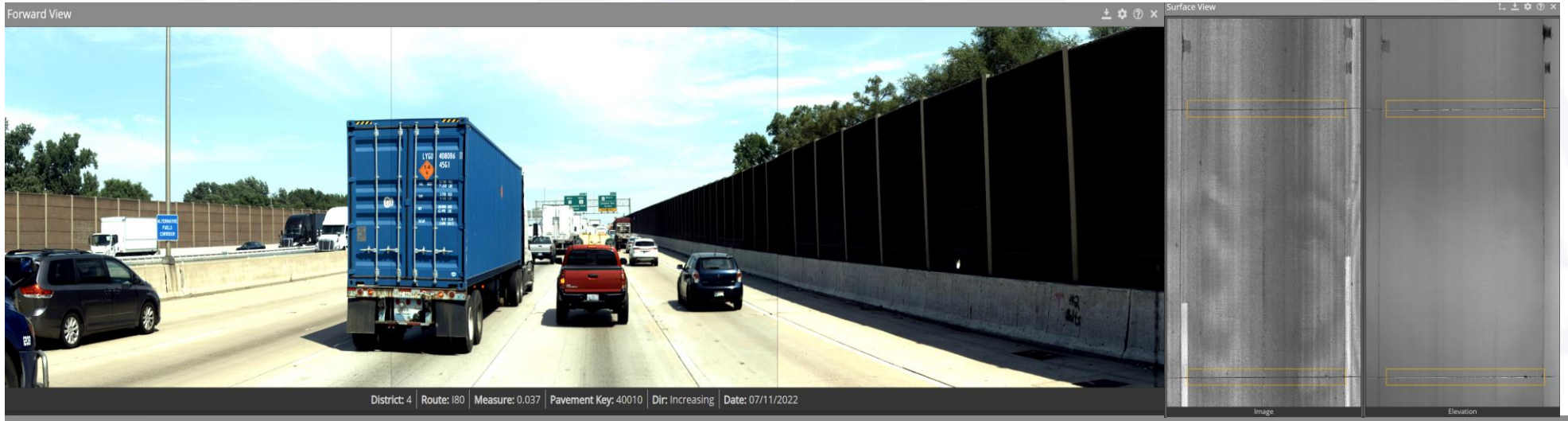
Preservation Case 1: Review in September 2023

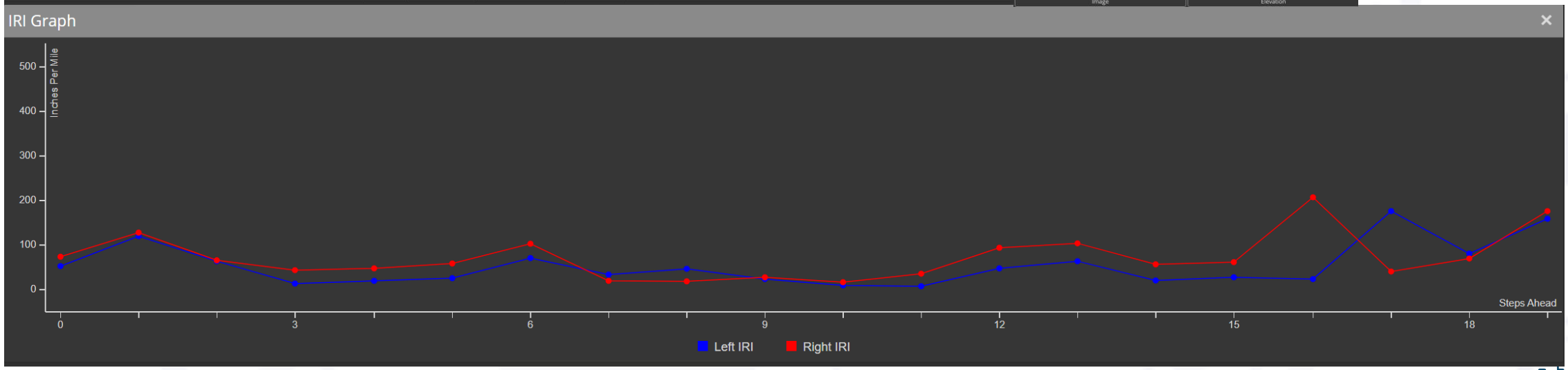




NextLevel INDIANA

Preservation Case 1: Before Treatment, July 2022

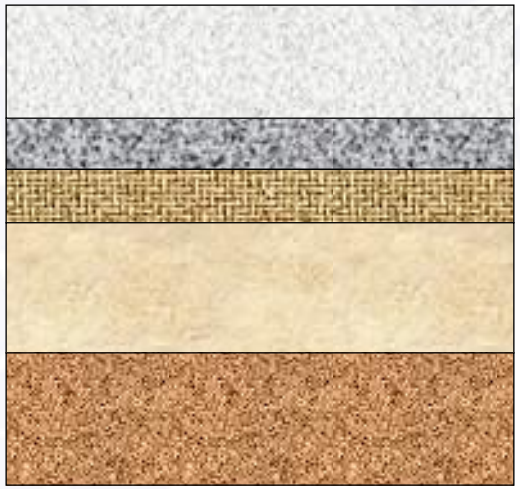




NextLevel INDIANA

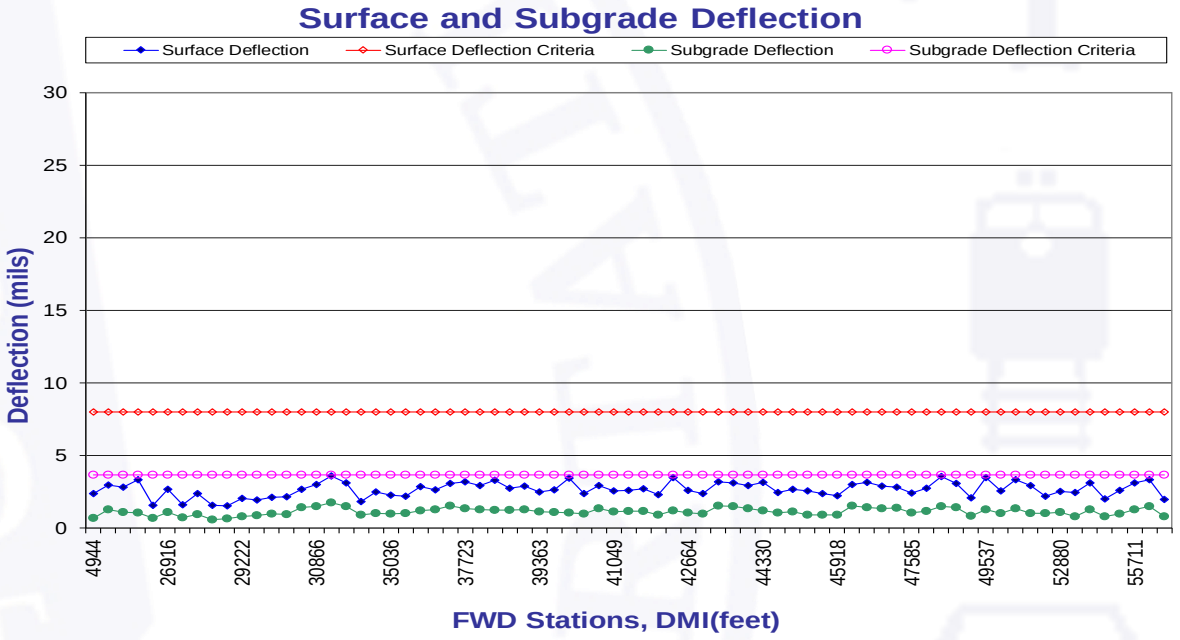
Preservation Case 2

- I-465 Indianapolis Loop
  - Year built: 1964
  - Rehabilitation: 1993
  - IRI Average: 107 in./mile
  - Patching: October 2016
  - AADT: 116,021 veh./day
  - AADTT: 32,616 trucks/day
  - Longitudinal joint deteriorations due to deicing salt



Preservation Case 2: Candidate – FWD Test

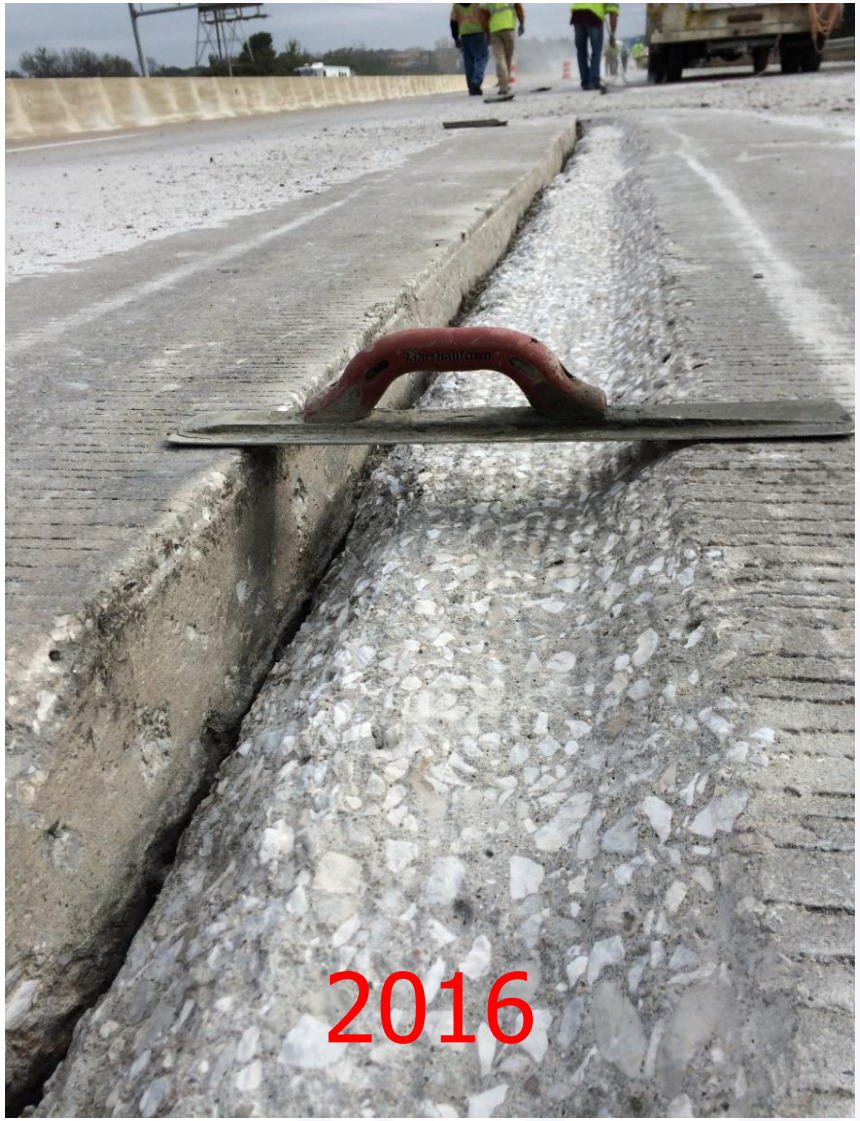
FWD Station (ft)	Latitude	Longitude	Surface Deflection	In-Situ CBR	In-situ Structural Number
4944	39.8786448	-86.2687644	2.40	7.00	6.55
24294	39.9281325	-86.2616815	2.98	7.00	7.08
25292	39.9272716	-86.2582332	2.82	7.00	7.04
26315	39.9264455	-86.2549167	3.35	7.00	6.22
26617	39.9261527	-86.2537942	1.59	7.00	8.50
26916	39.9258840	-86.2527729	2.66	7.00	7.37
27946	39.9249853	-86.2492464	1.63	7.00	8.65
28261	39.9247148	-86.2482165	2.39	7.00	7.41
28579	39.9244540	-86.2471404	1.59	7.00	8.16
28897	39.9241694	-86.2460685	1.53	7.00	8.74
29222	39.9238892	-86.2449793	2.05	7.00	7.90
29514	39.9236612	-86.2439827	1.94	7.00	8.20
29826	39.9234886	-86.2429201	2.11	7.00	8.18
30196	39.9233709	-86.2415666	2.17	7.00	7.86
30580	39.9233753	-86.2402168	2.68	6.99	8.44
30866	39.9233936	-86.2391883	3.00	7.00	7.39
31184	39.9234208	-86.2380526	3.59	6.47	6.95
31538	39.9234319	-86.2367992	3.13	7.00	7.21
31830	39.9234519	-86.2357223	1.84	7.00	8.60
34773	39.9236210	-86.2252695	2.50	7.00	7.36
35036	39.9236526	-86.2243146	2.28	7.00	7.66
36502	39.9237507	-86.2190565	2.21	7.00	7.95
36771	39.9237676	-86.2181295	2.88	7.00	7.04
37106	39.9237841	-86.2169369	2.64	7.00	7.69
37447	39.9238166	-86.2157240	3.09	7.00	7.35



In-Situ	Average	Standard Deviation
Elastic Modulus of Concrete (psi)	2,881,457	1,281,034
Structural Number	7.35	0.56
Modulus of Resilient of Subgrade Soil (psi)	15,588	3,940
CBR of Subgrade Soil (%)	6.99	0.06
Dynamic K-value of Pavement Support (pci)	541	220

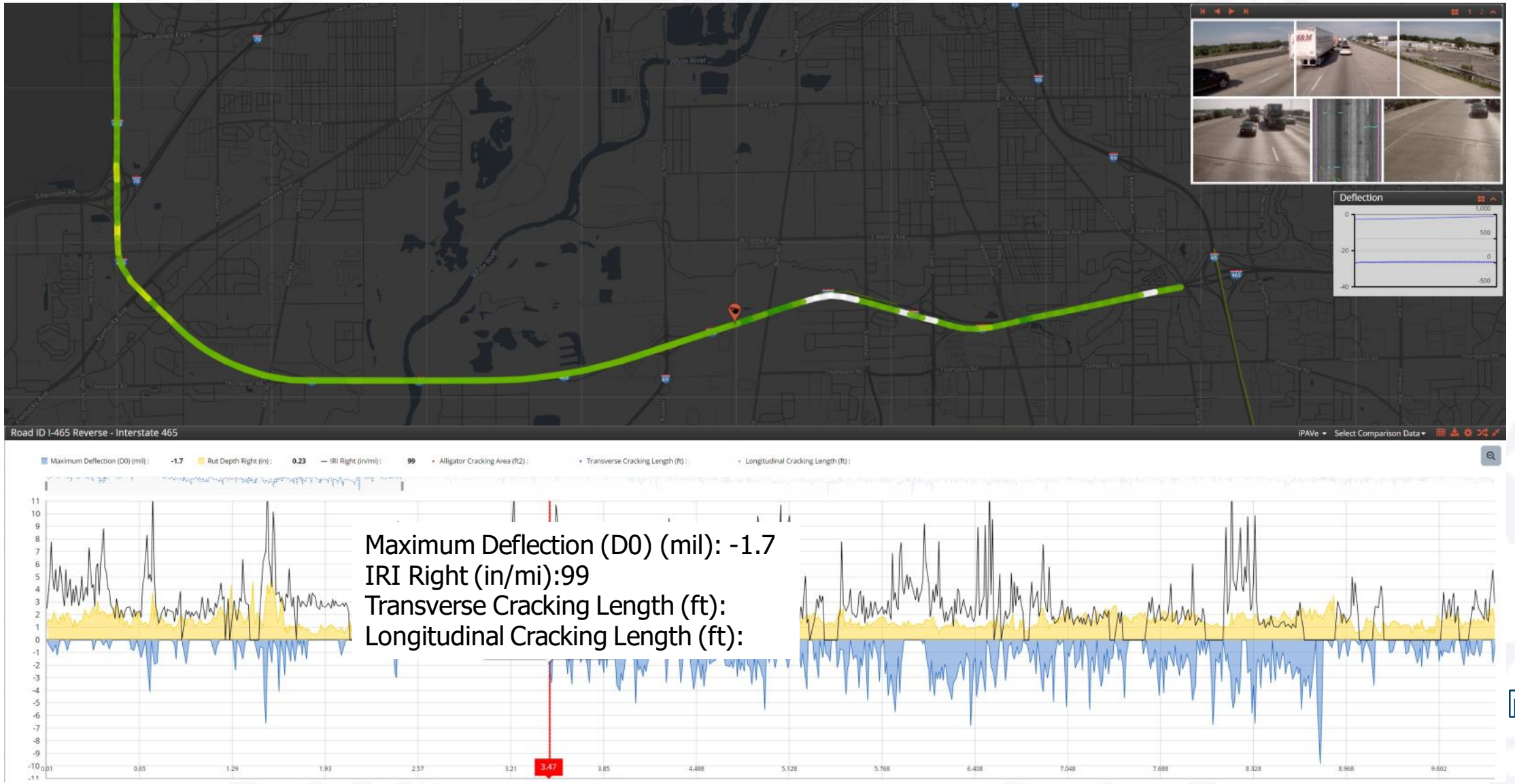
NextLevel INDIANA

Preservation Case 2: Candidate



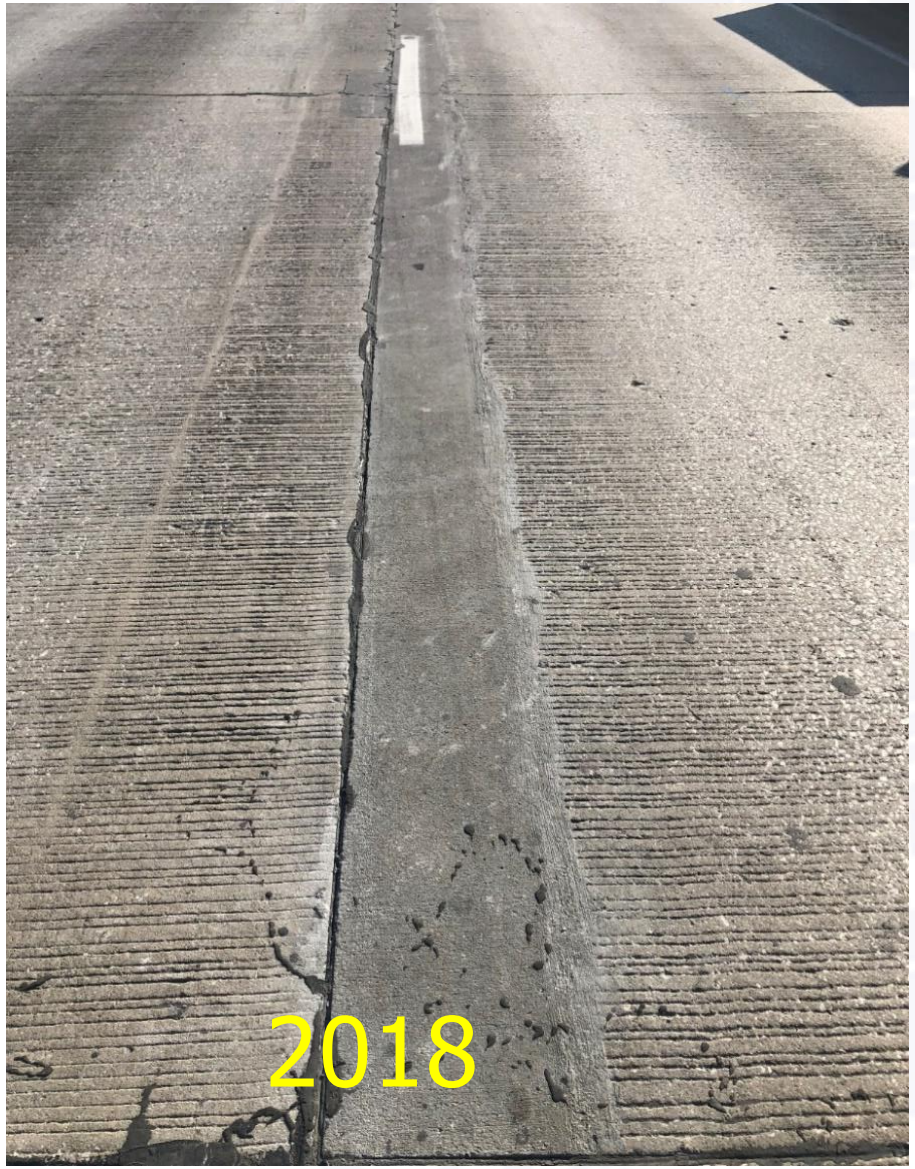
NextLevel INDIANA

Preservation Case 2: Candidate



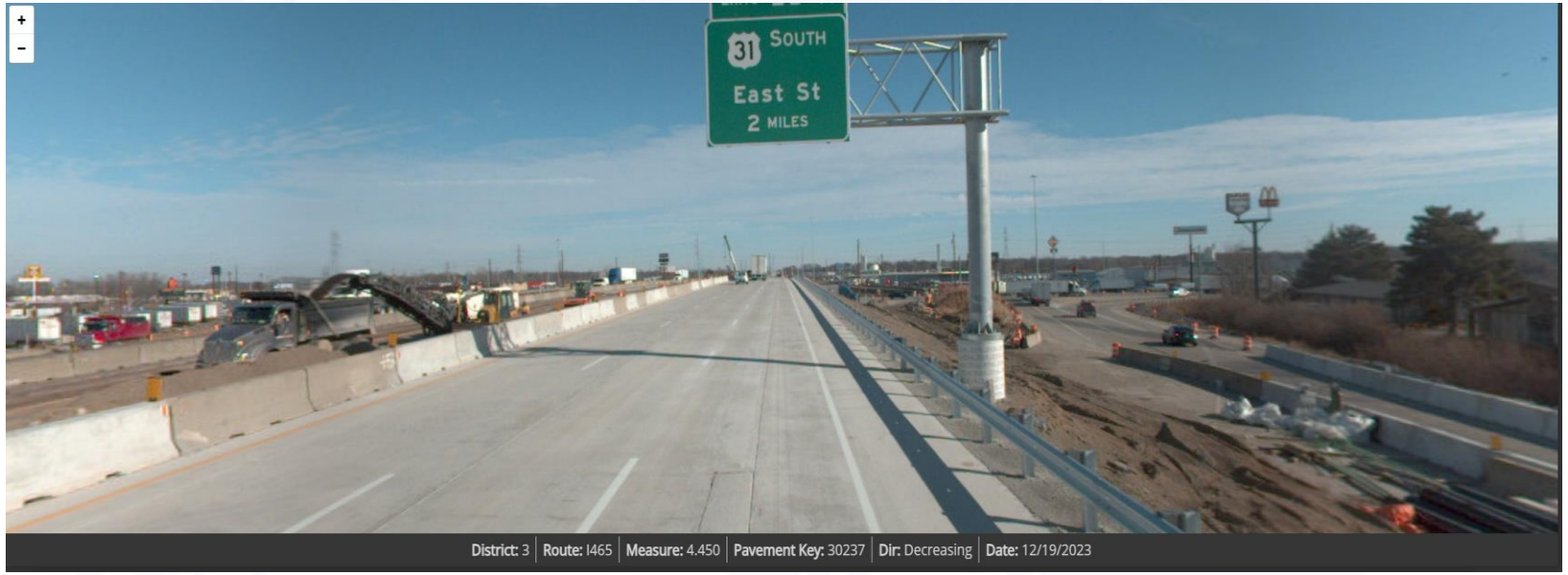
Picture From: ARRB 2022

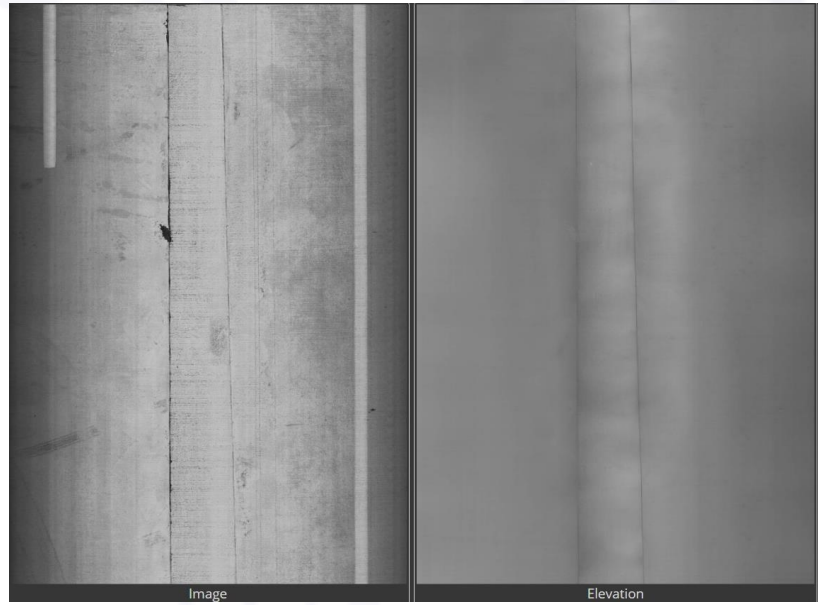
Preservation Case 2: Candidate – FWD Test

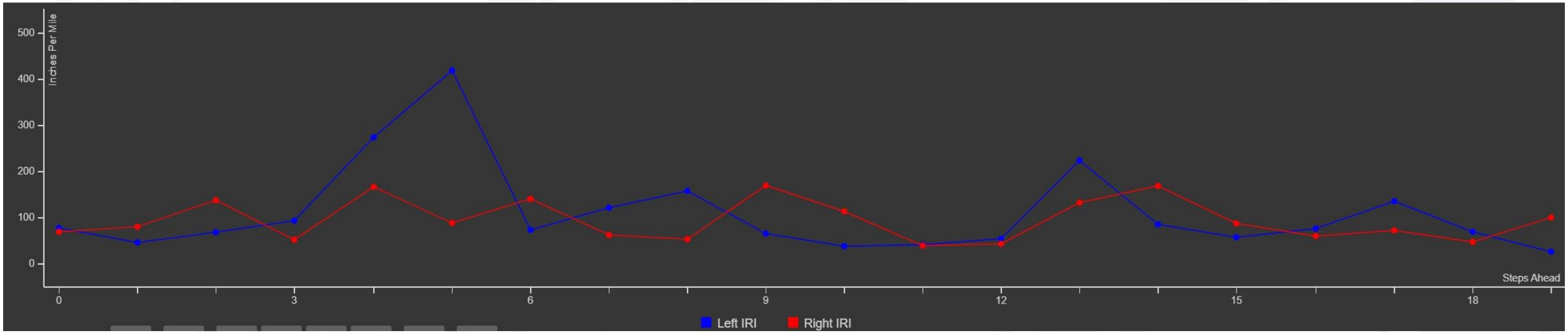


Joint patching works well and becomes a common practice

Preservation Case 2: Review in December 2023



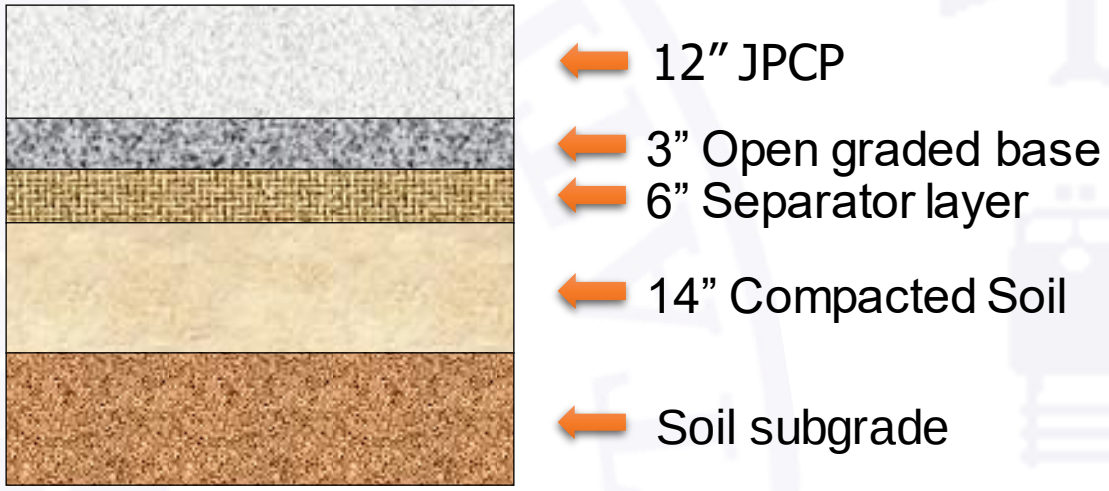




Picture From: PathWeb 2023

Preservation Case 3

- I-74 Shelbyville, Indiana
  - Year built: 1964
  - Rehabilitation: 1999
  - IRI Average: 126 in./mile
  - Slab Jacking: May 2022
  - AADT: 32,208 veh./day
  - AADTT: 8,981 trucks/day
  - Lane faulting to be lifted with foam

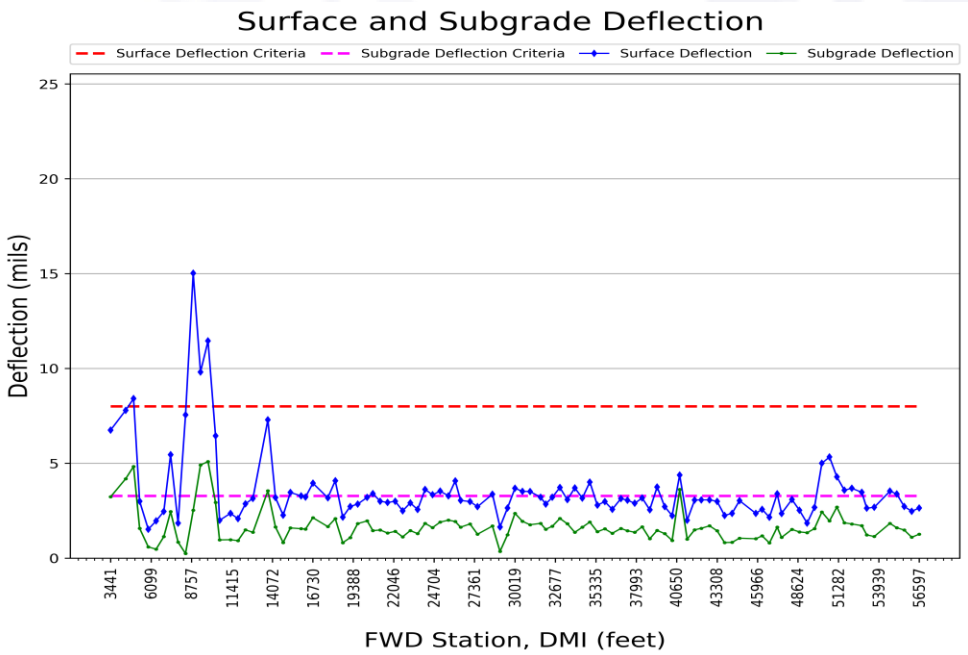


Preservation Case 3: Existing Structure

Workmanship and patient are the keys to success

Preservation Case 3: Candidate – FWD Test

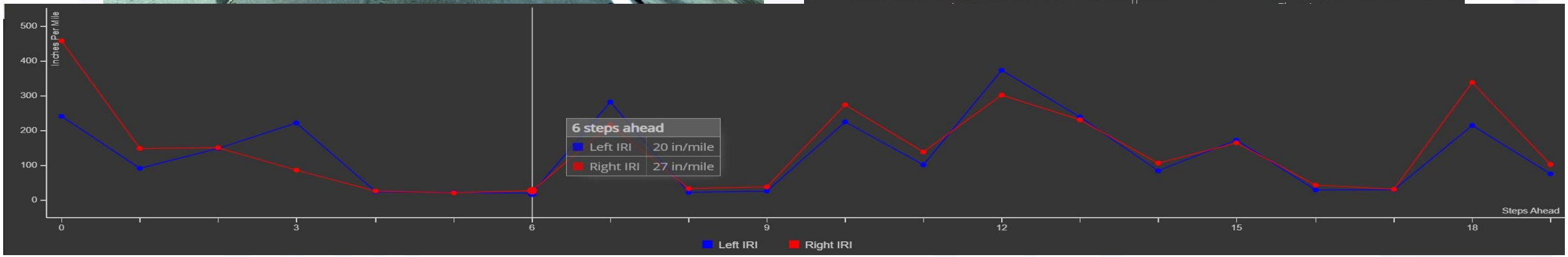
FWD Station (ft)	Latitude	Longitude	Surface Deflection	In-Situ CBR	In-situ Structural Number
3442	39.5441017	-85.7629312	6.75	3.10	7.19
4429	39.5424643	-85.7602269	7.79	2.36	7.12
4951	39.5415745	-85.7587498	8.41	2.17	6.96
5348	39.5409056	-85.7576616	3.00	6.90	9.45
5919	39.5398703	-85.7560732	1.52	7.00	11.20
6434	39.5389355	-85.7547412	1.96	7.00	9.44
6939	39.5379717	-85.7534201	2.46	7.00	9.96
7385	39.5371197	-85.7523099	5.45	4.08	7.59
7877	39.5361417	-85.7510588	1.84	7.00	10.95
8366	39.5351918	-85.7498495	7.55	7.00	5.55
8871	39.5342298	-85.7485944	15.02	7.00	4.18
9350	39.5332730	-85.7473596	9.81	2.04	6.43
9846	39.5323057	-85.7461365	11.45	1.96	5.91
10338	39.5313401	-85.7448968	6.45	3.41	7.20
10604	39.5308173	-85.7442365	1.99	7.00	10.83
11319	39.5294562	-85.7424149	2.36	7.00	9.81
11814	39.5285731	-85.7410701	2.08	7.00	10.42
12303	39.5277714	-85.7396629	2.86	6.40	9.96
12799	39.5270493	-85.7381903	3.15	7.00	9.02
13780	39.5256031	-85.7351978	7.29	2.82	7.05
14278	39.5248812	-85.7337590	3.19	6.20	9.38
14783	39.5241214	-85.7322067	2.26	7.00	9.66
15259	39.5234241	-85.7308078	3.46	6.29	8.89
15965	39.5223851	-85.7286889	3.28	6.45	9.12
16257	39.5219531	-85.7278308	3.22	6.54	9.19
16739	39.5211736	-85.7264067	3.95	4.82	8.84



In-Situ	Average	Standard Deviation
Elastic Modulus of Concrete (psi)	1,485,222	925,121
Structural Number	9.45	0.99
Modulus of Resilient of Subgrade Soil (psi)	10,901	4,644
CBR of Subgrade Soil (%)	6.08	1.15
Dynamic K-value of Pavement Support (pci)	484	258

NextLevel INDIANA

Preservation Case 3: Review in October 2023



Picture From: PathWeb 2023

Preservation Case 3: Review in October 2023

Picture From: Google Map

Preservation Case 3: Equipment and Skill

Better equipment and better skill give significantly better results

Conclusions

- Pavement preservation for Jointed Plain Concrete Pavement (JPCP) works and effective
- The most important things
  - Attention to details
  - Proper treatment types
  - Workmanship, patient, and have a plan B
  - Readiness of the construction crew to execute the preservation technique
- Selection of candidates
  - Select the item(s) that will be preserved and do non-destructive testing
  - The more structural items to be preserved, the more the challenges in the field

Today's presenters

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Kurt Smith

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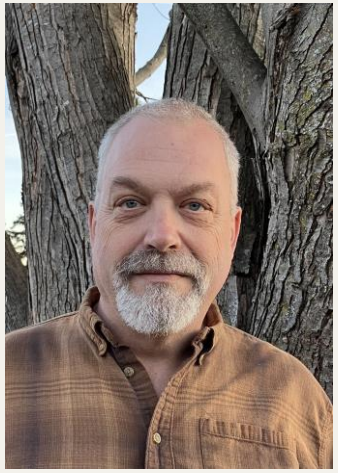
applied pavement TECHNOLOGY



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INDIANA DEPARTMENT OF TRANSPORTATION INDOT

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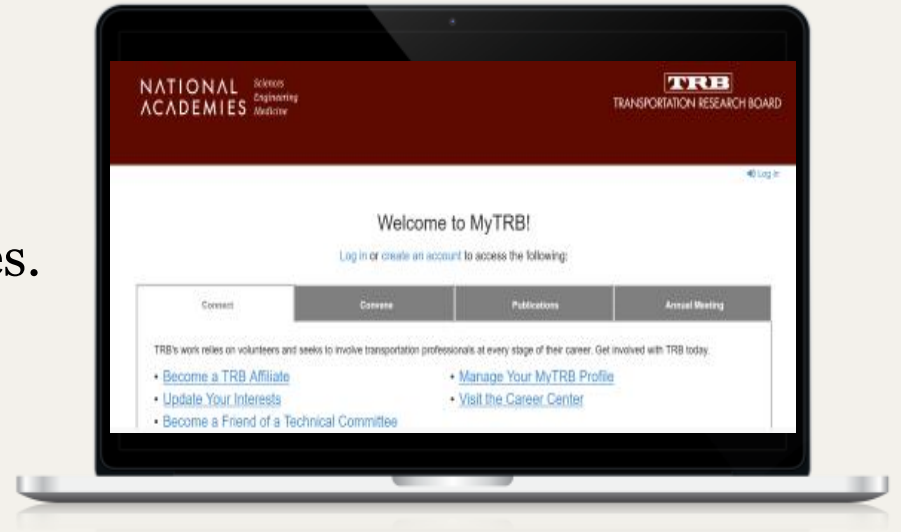

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