NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: Highly Modified Asphalt Development and Applications

May 2, 2024

12:00 – 1:30 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.

ENGINEERING
RCEP
REGISTERED CONTINUING EDUCATION PROGRAM

Purpose Statement

This webinar will describe the development of HiMA, including the applications at the National Center for Asphalt Technology. Presenters will discuss Florida Department of Transportation's (DOT) applications over the past decade and a more recent introduction and use by Utah DOT.

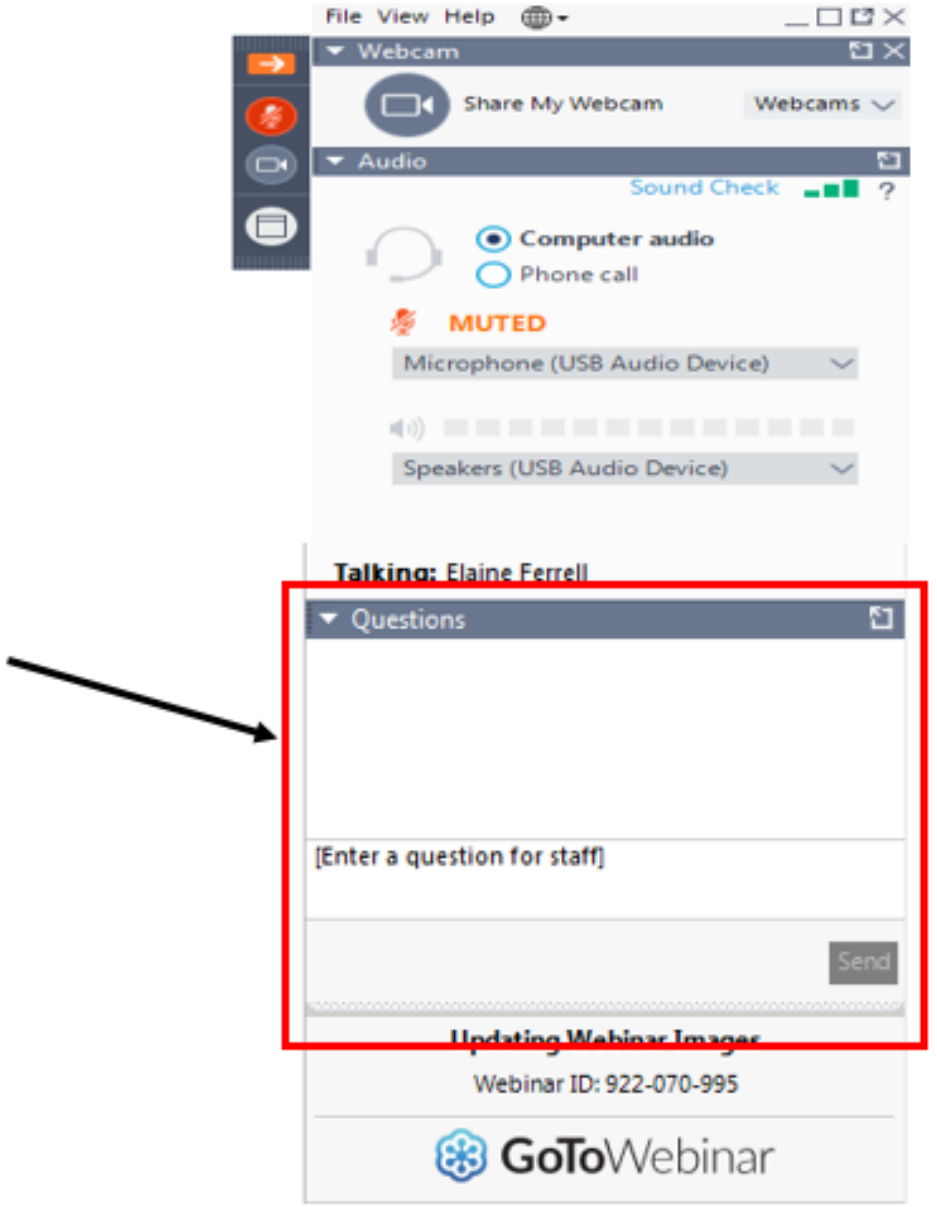
Learning Objectives

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

- Develop a specification assuring a HiMA binder
- Best utilize HiMA binders to provide more durable, rut resistant asphalt paving mixtures

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

Gary Fitts
gary.fitts@kraton.com

KRATON™

Dr. Robert Kluttz
bob.kluttz@kraton.com

KRATON™

Jim Musselman
jim.musselman@dot.state.fl.us

FDOT

Howard Anderson
handerson@utah.gov

UDOT Keeping Utah Moving

NATIONAL ACADEMIES *Sciences Engineering Medicine*

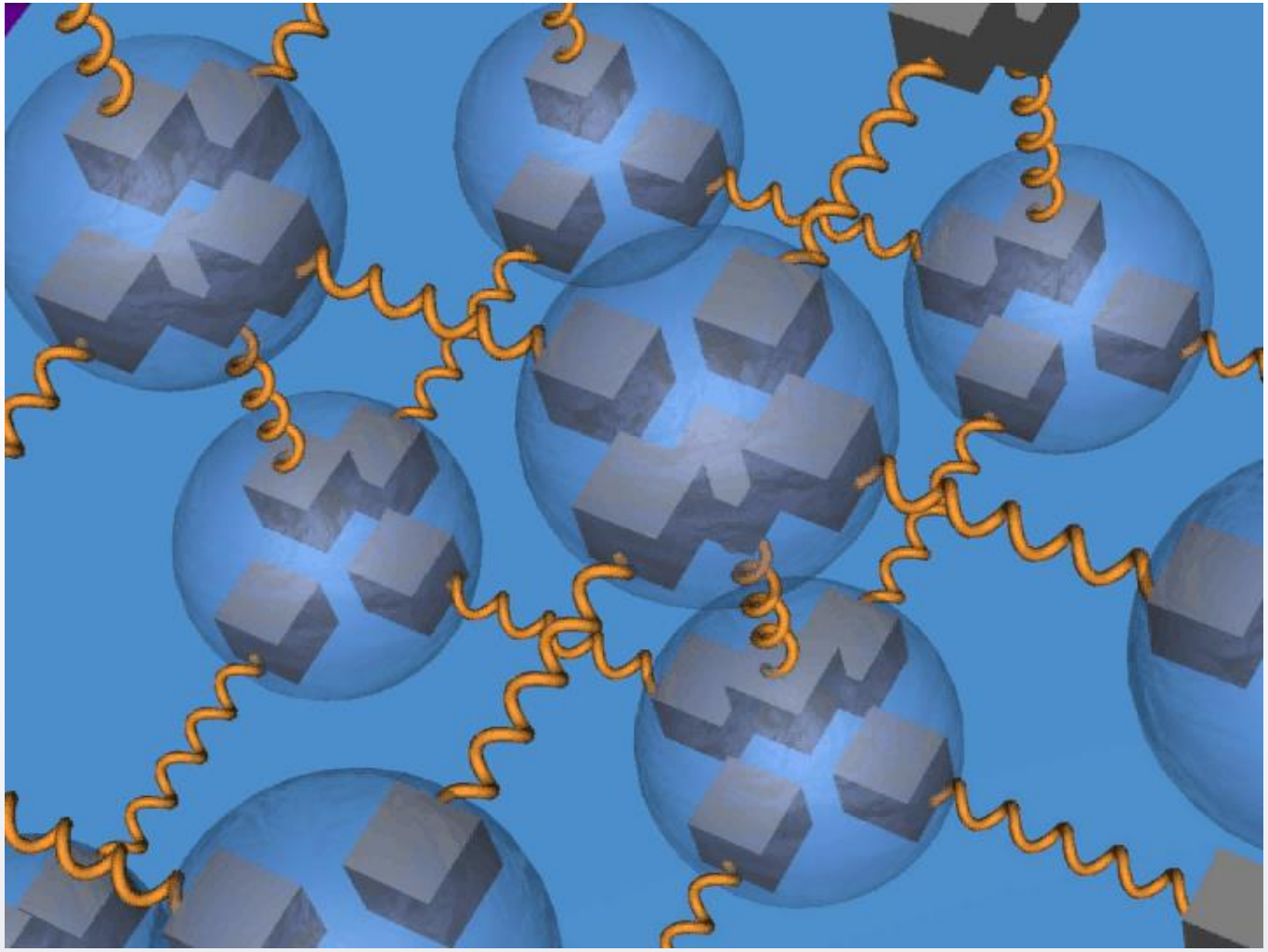
Highly Modified Asphalt- Development and Applications

Bob Kluttz
Kraton Corporation

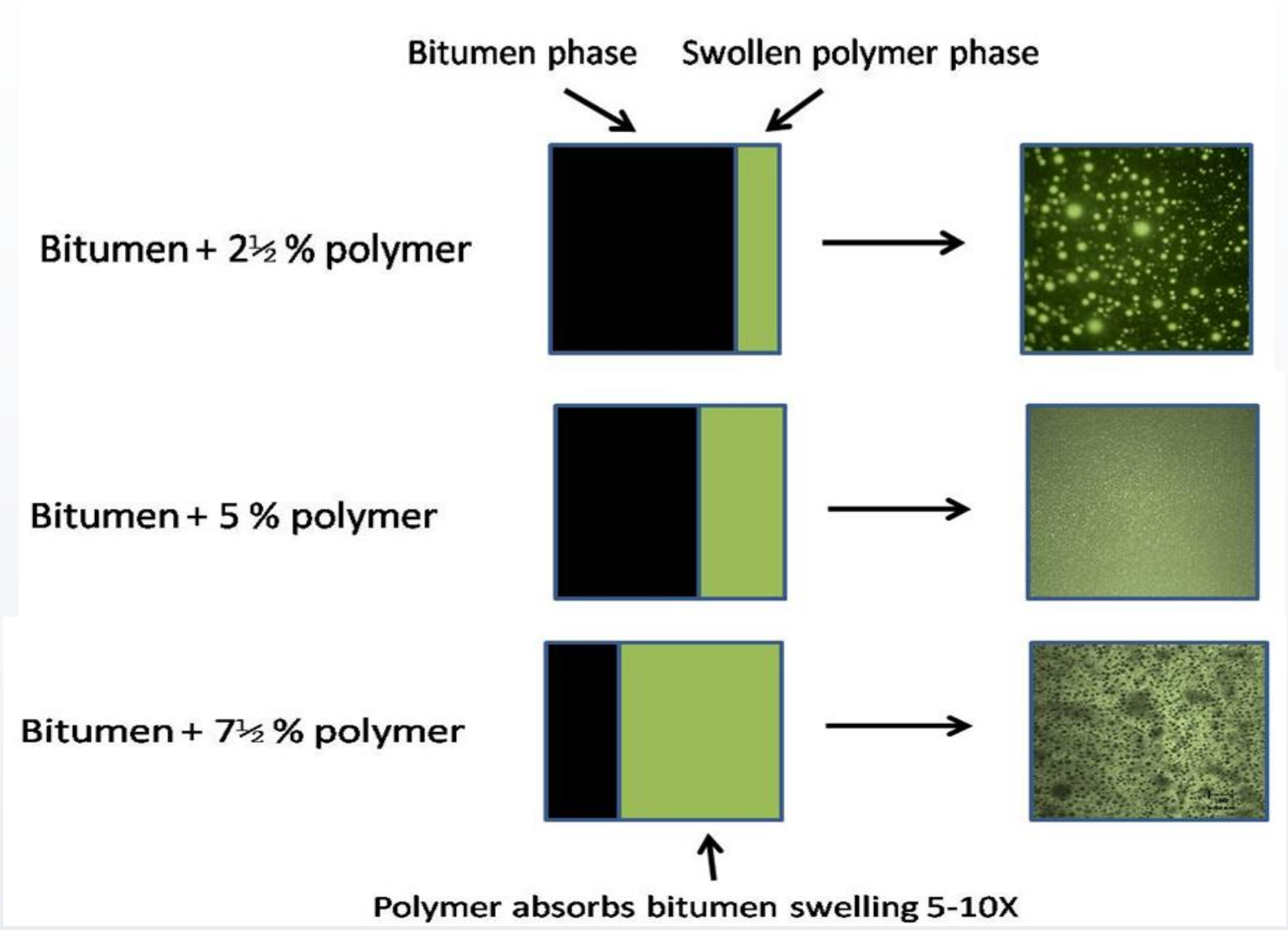
Outline

- What is highly modified asphalt, or HiMA?
- NCAT test track section performance
- Mixtures, Pavements

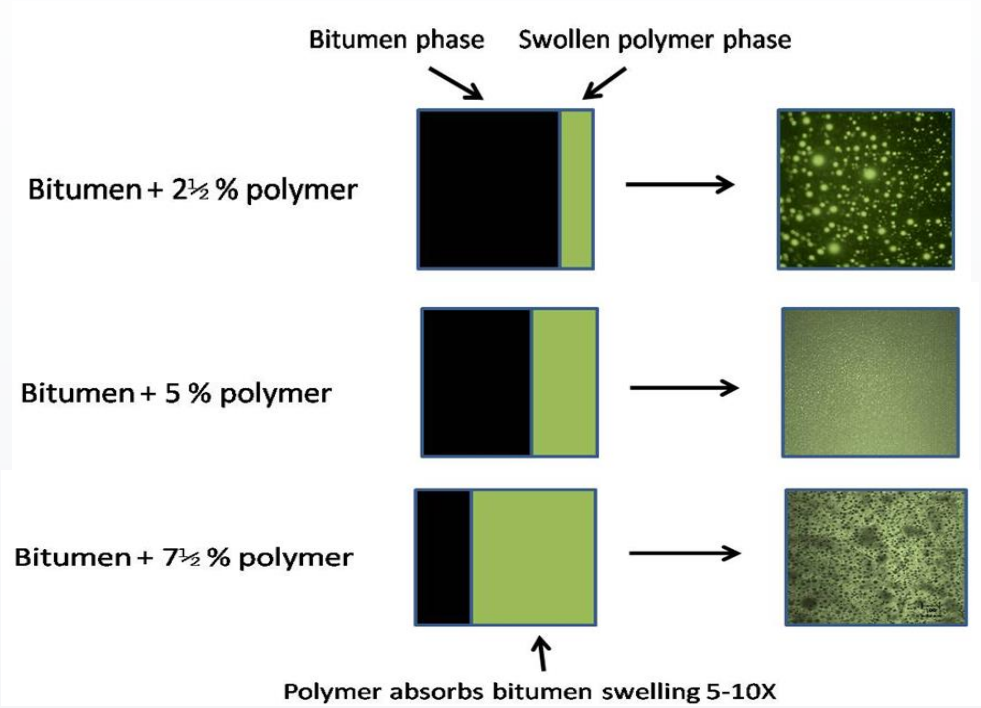
SBS in Bitumen



Phase Morphology

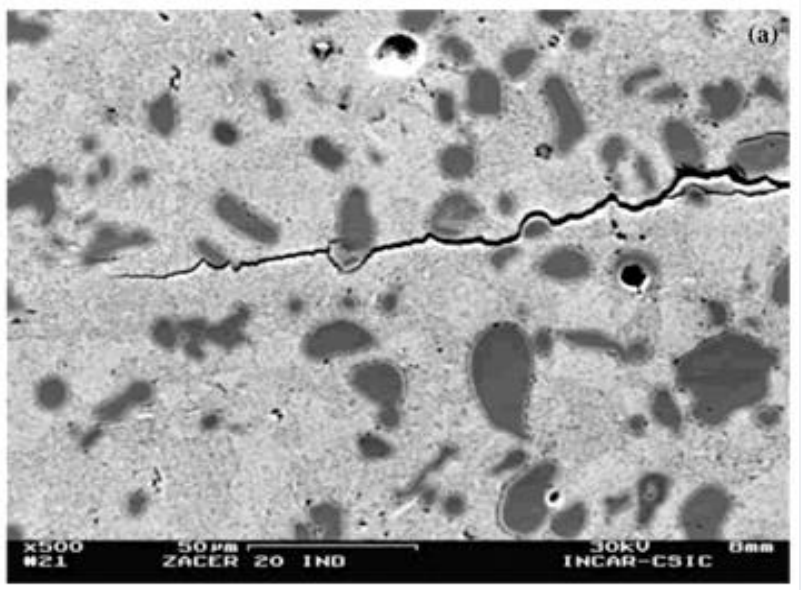


What Is Highly Modified Asphalt?



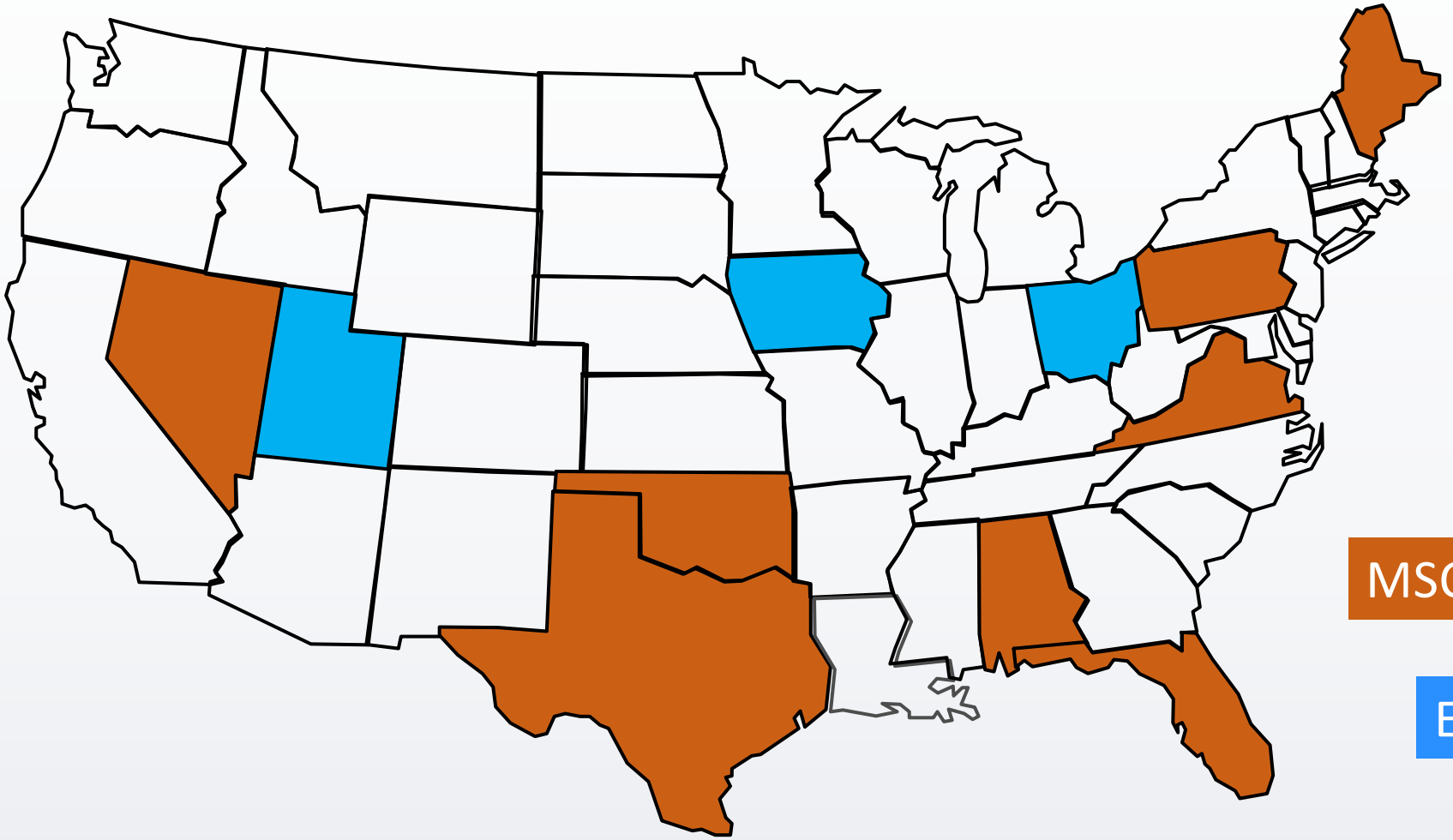
Over 5,000,000 tons in over 70 projects around the world have demonstrated **superior performance** at **reduced thickness**.

- Highly Modified Asphalt is exactly what it says, asphalt with more than double the normal amount of SBS polymer.
- This results in a much denser polymer network with up to 10X resistance to rutting **and** fatigue cracking.



Current HiMA Specifications-USA

Alaska



Hawai'i

MSCR $\%R_{3.2} \geq 90$*

$ER_{77°F} \geq 90$

MSCR @ 76°C, except for Alaska DOT&PF

Selected Job Stories

- 2009 - NCAT Test Track – numerous papers and reports
- 2010 - Port of Napier, NZ, loading facility, eliminated rutting problems
- 2012 – I-40 in Oklahoma – persistent rutting and cracking. Deep rehab using HiMA in 2012 maintained low (~50 in/mi) IRI ten years later, with no evidence of structural distress
- 2013 – New York City – > 50 blocks of 1st Avenue. 2023 most pavement still in "good" condition (ref. NYCDOT website). Exceeded NYCDOT expectations
- 2015 – US 90 Midway FL – led to routine specifying of FDOT "High Polymer" binder
- 2015 – AK DOT&PF projects in Anchorage and on Glenn Highway. Reduced rutting from studded tire abrasion by 30% increasing lifetime 50%.
  - https://www.fhwa.dot.gov/innovation/innovator/issue93/page_03.html
  - https://www.fhwa.dot.gov/pavement/tops/pubs/HiMA_Case_Study_Report-06_508v2.pdf

National Center for Asphalt Technology Test Track

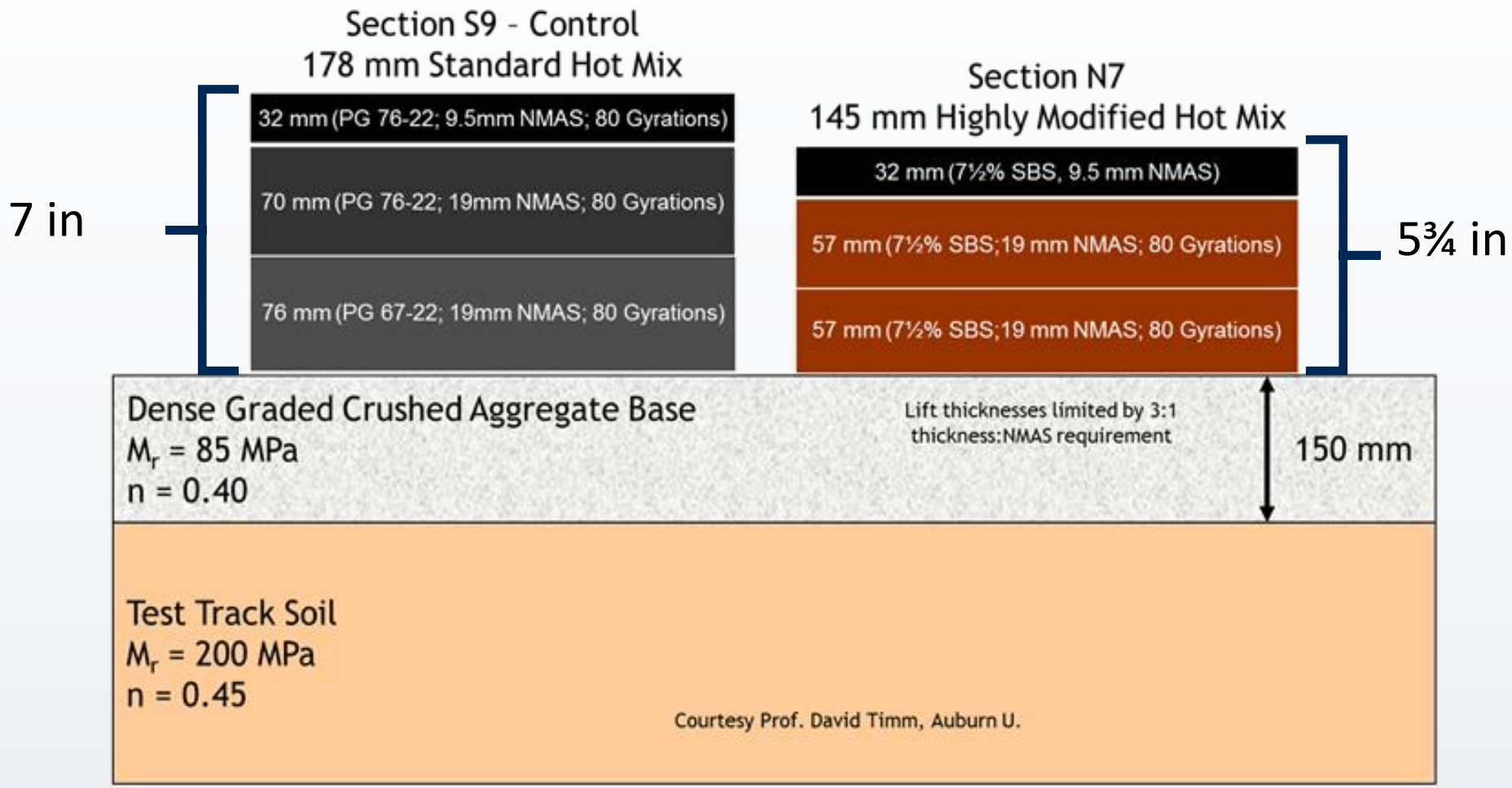
- 5 trucks, 16 h/day, 5 days/week
- Axle load: 18 kip
- Speed: 45 mph

National Center for Asphalt Technology Test Track

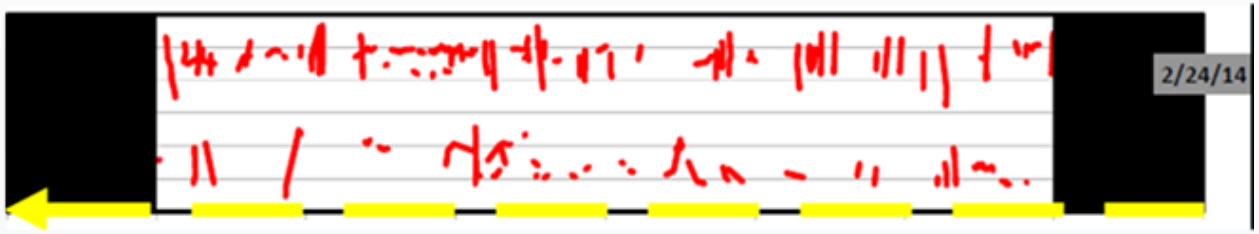
- Track loading cycle: ~ 2 years of trafficking equals about 10 million ESALs
- ESAL = Equivalent Single Axle Load = equivalent damage caused by 1 pass of 18,000 lb single axle load

- Highly Modified Asphalt (HiMA) project started in 2009 cycle
- Part of Performance Group study—6 sections including control
- Continued in 2012 cycle-Total 20 million ESALs

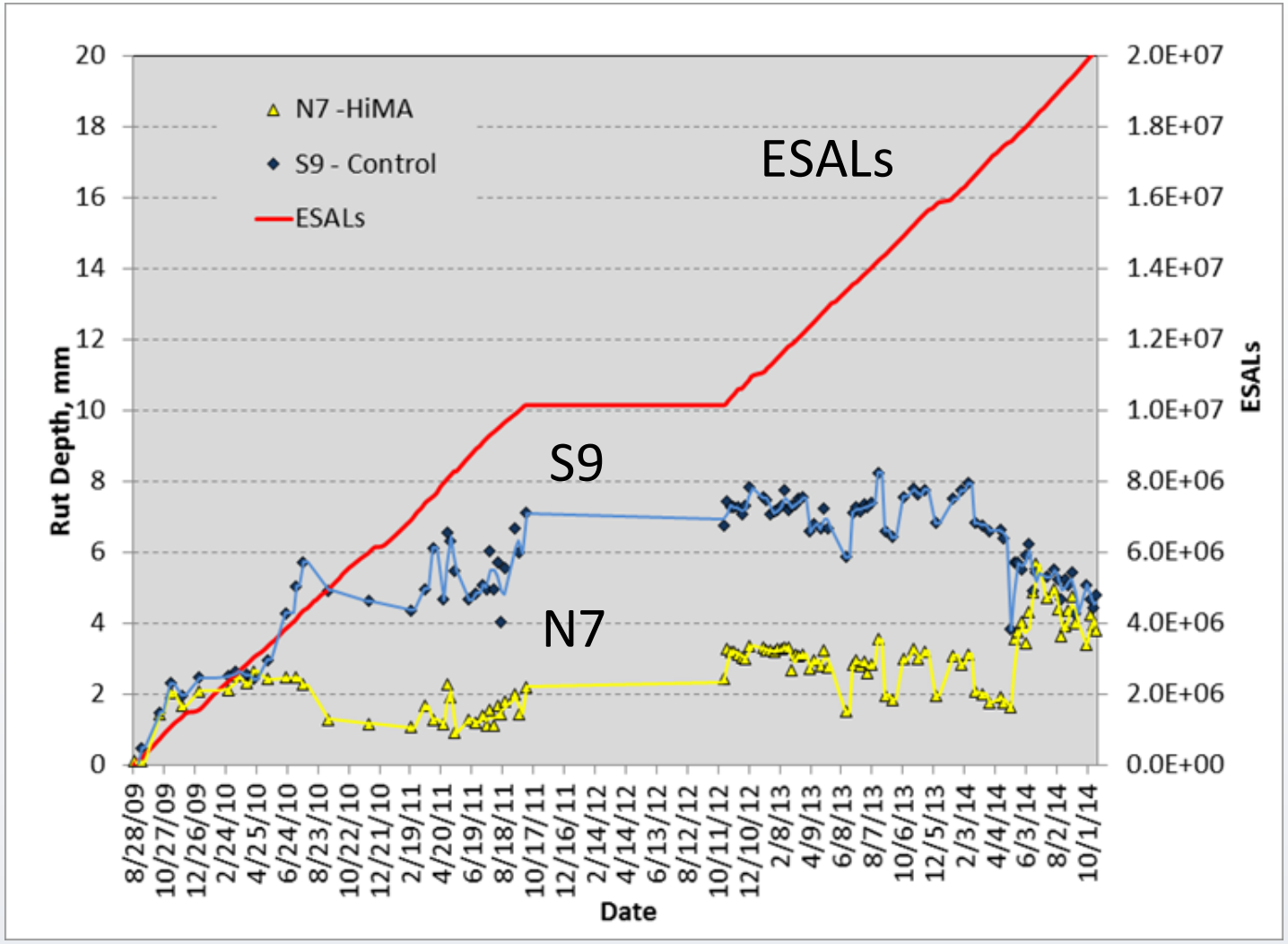
Control (S9) and HiMA (N7) Section Designs



Crack Maps after ~17 Million ESALs

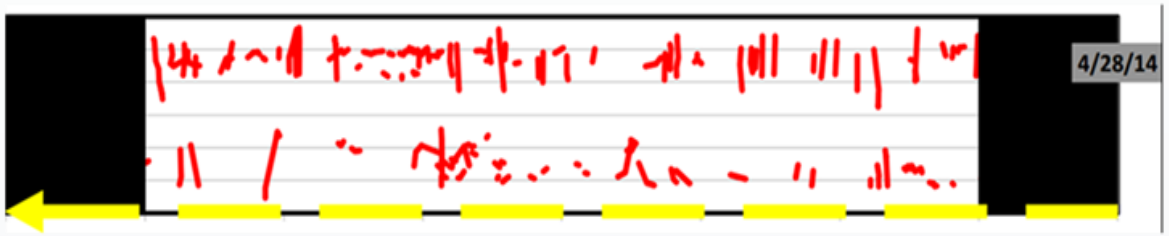
	3/14 Rutting	2/14 Crack Maps
S9	6.0 mm	 Lane - 9% Left wheel path - 12% Right wheel path - 21%
N7	1.6 mm	 Lane - 0% Left wheel path - 0% Right wheel path - 0%

Rutting after 20 Million ESALs



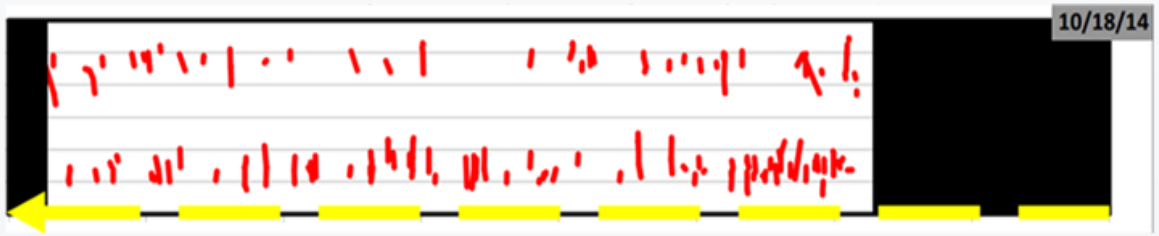
N7 Crack Map at 20 Million ESALs

S9



Lane - 10% Left wheel path - 13% Right wheel path - 21%

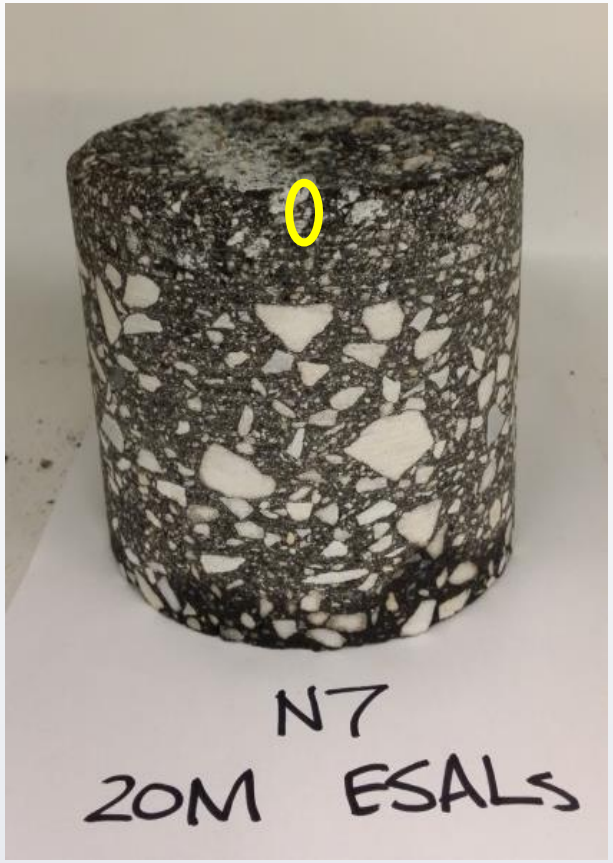
N7



Lane - 6% Left wheel path - 15% Right wheel path - 8%

N7 cracking was all hairline, superficial

S9 resurfaced at 17 million ESALs



HiMA Market Applications – Where Does it Add Value?

- Structural Applications
  - With a sound base, thinner pavements with lower upfront cost
  - Demonstrated in many field applications & Ohio University APLF
  - With weak base, much longer lifetime can be achieved
- Thin Overlays
  - Superior resistance to reflective cracking BUT requires finer, richer mix.
- Preservation Surfacing such as micro surfacing
- Open Grade Mixes for Reduced Raveling
- SAMI Layers
- High Stress Applications – ramps, intersections
- AASHTOWare® Pavement ME Design works for HiMA designs

Federal Highway Administration
Every Day Counts – 6 (EDC-6)
Targeted Overlay Pavement Solutions

- Asphalt Rubber Gap-Graded Mix
- Crack Attenuating Mix
- Enhanced Friction Overlays
- Highly Modified Asphalt
- High Performance Thin Overlays
- Open Graded Friction Course
- Stone Matrix Asphalt
- Ultra-Thin Bonded Wearing Course

Federal Highway Administration
Every Day Counts (EDC-6)
Targeted Overlay Pavement Solutions-Asphalt Technologies

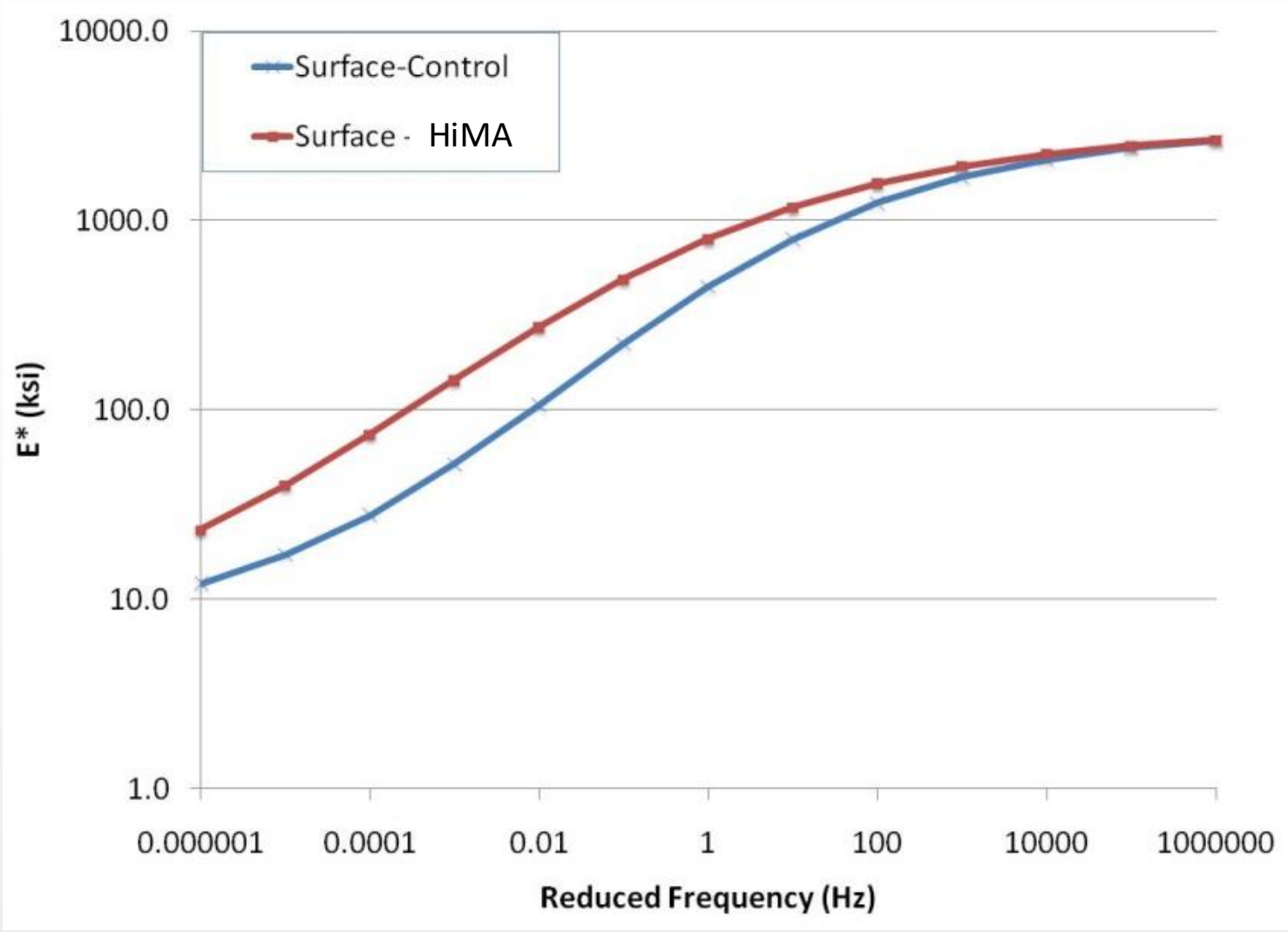
- Asphalt Rubber Gap-Graded Mix
- Crack Attenuating Mix
- Enhanced Friction Overlays
- Highly Modified Asphalt
- High Performance Thin Overlays
- Open Graded Friction Course
- Stone Matrix Asphalt
- Ultra-Thin Bonded Wearing Course

- In fact, HiMA can be applied to most of the TOPS applications.
- It's a multi-purpose tool.

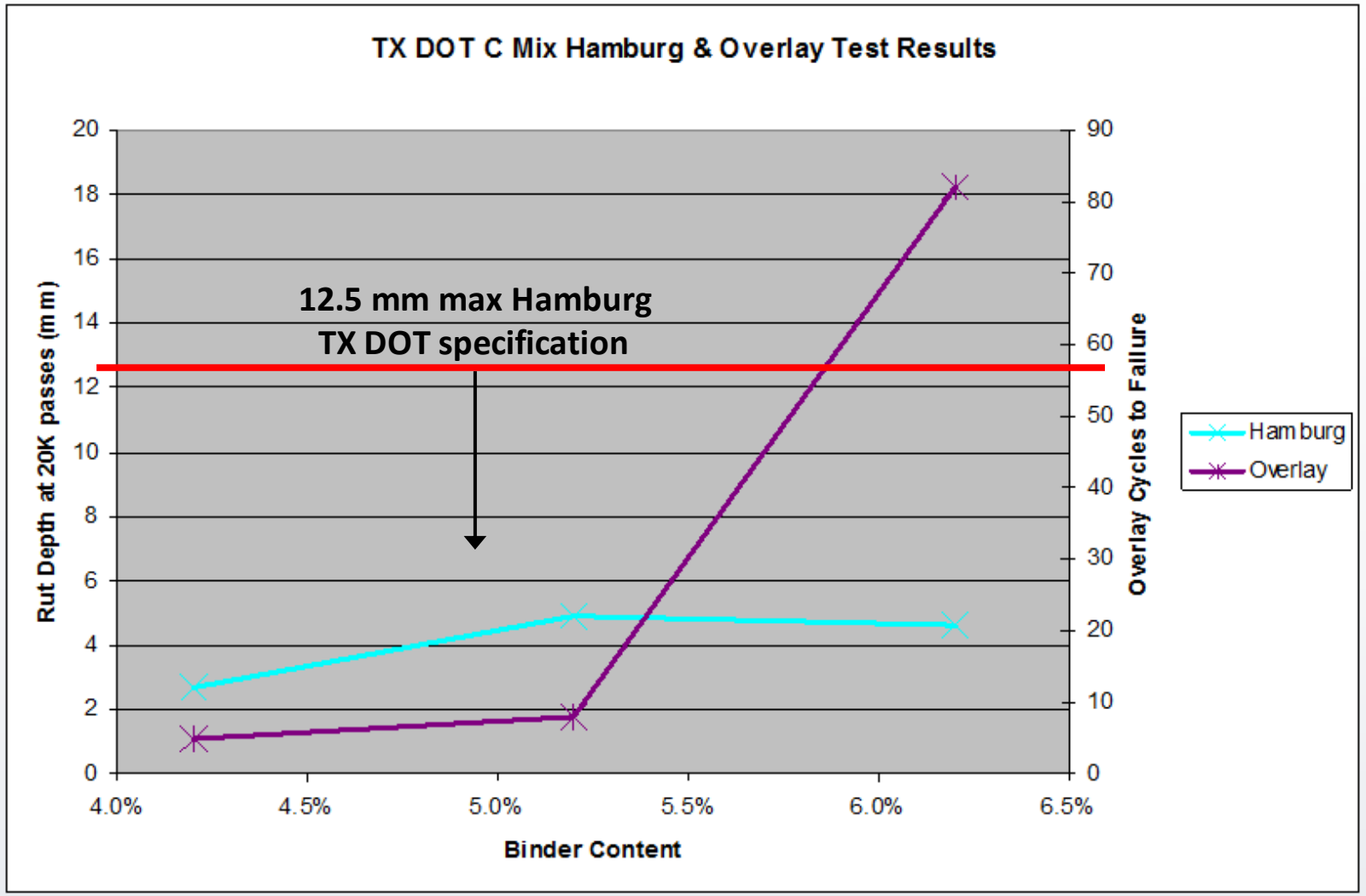
How Does HiMA Affect Mixture Characteristics and Pavement Performance?

- Layer Mechanical Properties (Modulus, or Stiffness)
- Cracking Resistance
- Rutting Resistance
- Cracking Versus Rutting
- Structural Integrity
- For OGFC-greater resistance to raveling

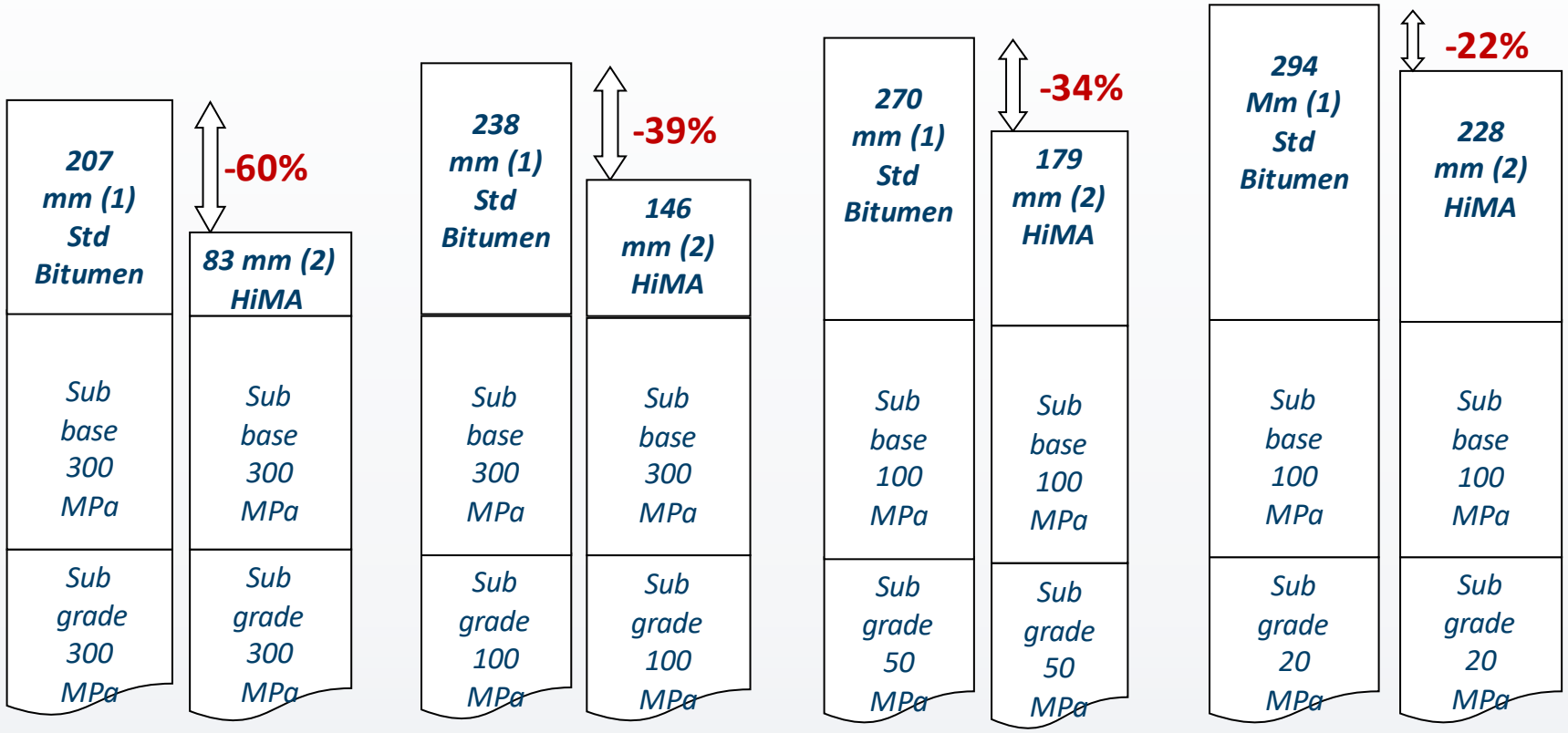
Dynamic Modulus Testing Results – 9.5 mm NMAS Mixtures



TxDOT Mixtures – “Type C” (Dense-graded), Item 341



Thickness Reduction Capability



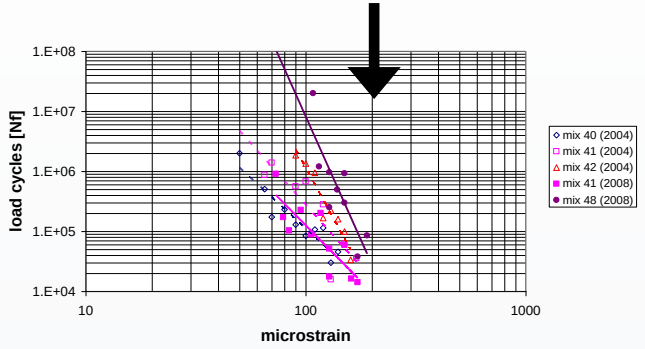
Stiff support → **Soft support**

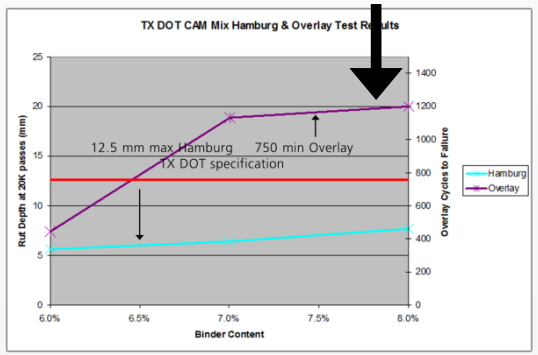
(1) Thickness determined by asphalt strain criterion
(2) Thickness determined by subgrade strain criterion

HiMA = Highly Modified Asphalt

Waterproof Bridge Deck Mix

- Seals concrete to prevent damage from salt, deicing chemicals to deck
- Key distress—fatigue cracking, water permeation
- Solution—very rich fine mix with <2% voids.
- Lower cost & far better workability than alternatives.





SECTION 555 - BRIDGE DECK WATERPROOF SURFACE COURSE

555.01 DESCRIPTION

This Section describes the requirements for constructing bridge deck waterproof surface course (BDWSC).

555.02 MATERIALS

555.02.01 Materials

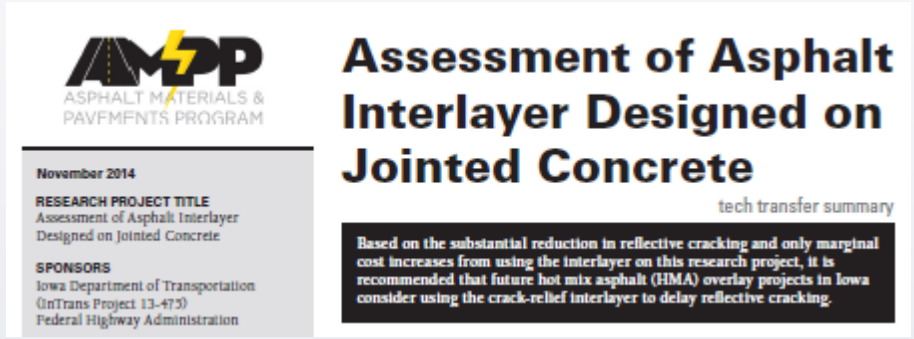
Provide materials as specified:

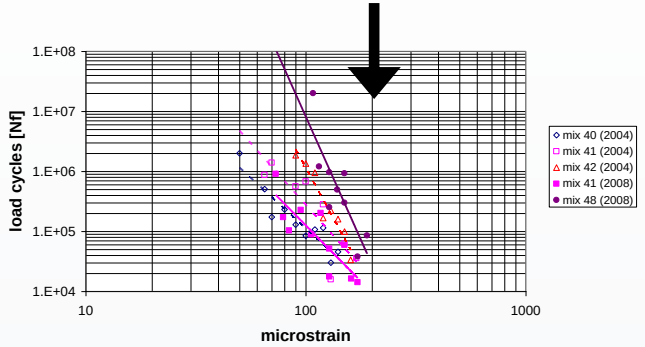
Tack Coat 64-22, PG 64-22 ..... 902.01.01
Tack Coat:
Cut-Back Asphalt, Grade RC-70 ..... 902.01.02
Emulsified Asphalt, Grade RS-1, SS-1, SS-1h, Grade CSS-1 or CSS-1h 902.01.03
Joint Sealer, Hot Poured 914.02
Polymerized Joint Adhesive 914.03

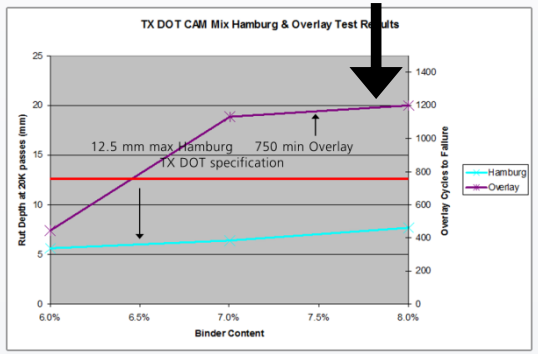
Crack Resistant Interlayer

- High strain environment.
- Key distress—reflective cracking.
- Solution—very rich fine mix with high binder content/low voids.
- Lower cost than thick structural layer or geotextile plus leveling course.

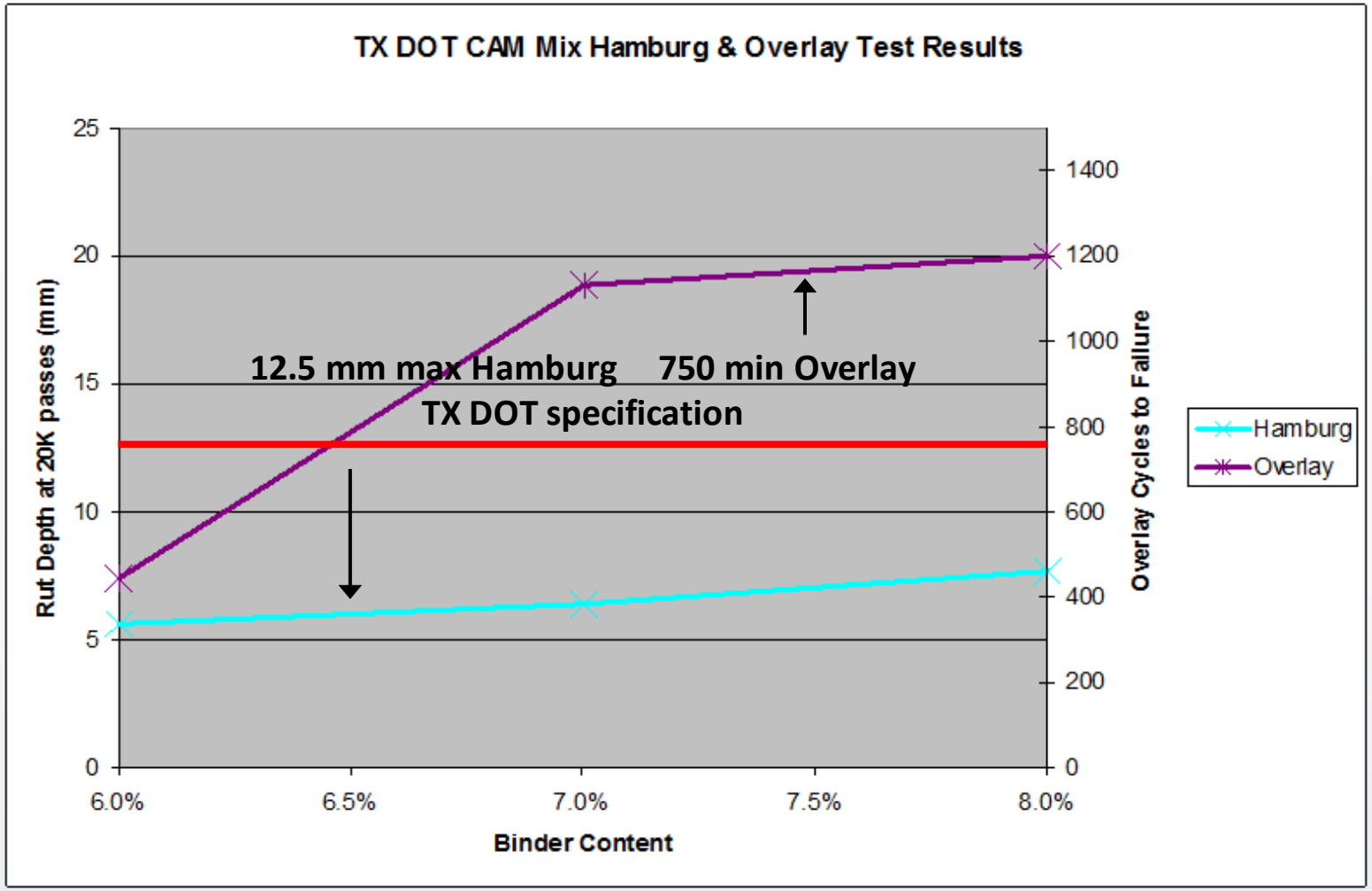
OKLAHOMA DOT Section 411(j), RIL







TxDOT Crack Attenuating Mixture (CAM), Item 3000



PMA Producer's Perspective

- Polymer Handling
- Blending
- Storage & Pumping
- Transport

- Generally, production and terminal storage of HiMA binders are like conventional PMA binders.

Mix Production/Paving

- Follow best practice recommendations provided by supplier and maintain open communications!
- Ideal binder storage temperature 320°-330°F, agitation
  - Mix discharge temperature ~ 320-340°F
  - **Do not overheat the binder during storage!**
- Avoid dilution/contamination in storage tanks
- More viscous at pumping temperatures, adjust accordingly
- Chemical warm mix additives okay
- Avoid long-term storage when possible. Cool down if holding for an extended period of time.
- Produce, deliver and handle the mix and paving operation so that the mix temperature behind the paver screed is at least 300°F.
- Complete rolling for densification before the mix temperature drops to 220°F.

Contractor's Guide for HiMA

Everything You Always Wanted to Know About Paving with HP

(But Were Afraid to Ask)

Available Languages—
English, Metric

Thank you!

Questions and comments after the third presenter

Legal Disclaimer

All information set forth herein is for informational purposes only. Kraton Corporation, on behalf of itself and its affiliates ("KRATON"), believes the information set forth herein to be true and accurate. Any recommendations, presentations, statements or suggestions that may be made are without any warranty or guarantee whatsoever, and shall establish no legal duty on the part of KRATON. The product(s) shown herein may not be available in all geographies where KRATON is represented.

The legal responsibilities of KRATON with respect to the products described herein are limited to those set forth in KRATON's Conditions of Sale or any effective sales contract. KRATON does not warrant that the products described herein are suitable for any particular uses or applications. Users of KRATON's products must rely on their own independent judgment, and must conduct their own studies, registrations, and other related activities, to establish the suitability of any materials or KRATON products selected for any intended purpose, and the safety and efficacy of their end products incorporating any KRATON products for any application. Physical properties obtained may vary depending on certain conditions, and the results obtained will ultimately depend on actual circumstances and in no event KRATON guarantees the achievement of any specific results. Customer is responsible for ensuring that workplace safety and disposal practices are in compliance with applicable laws.

Nothing set forth herein shall be construed as a recommendation to use any Kraton product in any specific application or in conflict with any existing intellectual property rights. KRATON reserves the right to withdraw any product from commercial availability and to make any changes to its products. **KRATON expressly disclaims any and all liability for any damages or injuries arising out of any activities relating to the use of any information set forth in this publication, or the use of any KRATON products.**

*KRATON and the Kraton logo are either trademarks or registered trademarks of KRATON.

KRATON™

Florida Department of
TRANSPORTATION

FDOT's History with High Polymer Asphalt Mixtures

Jim Musselman
State Asphalt Materials Engineer

Overview

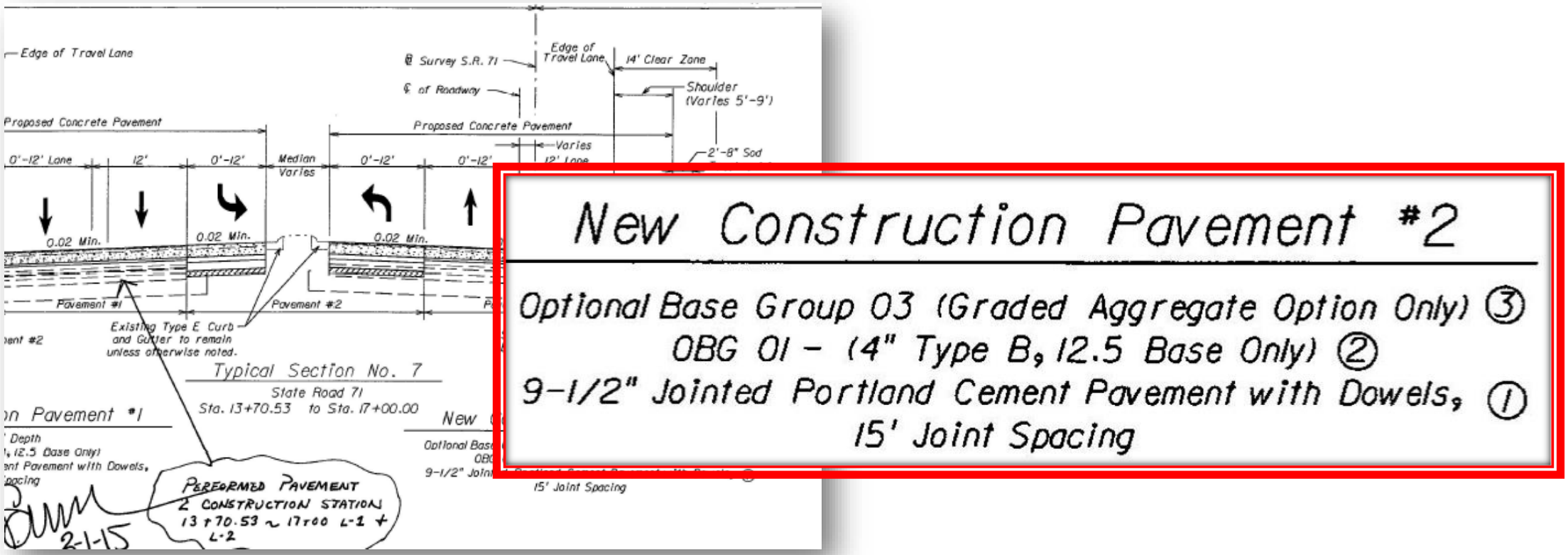
- Why did FDOT move towards high polymer mixtures
- Early projects
- Background research
- High polymer applications in Florida
- Projects

Why did FDOT move towards high polymer binders?

- 2013: SR-71 Marianna, Jackson County, Florida
- Multiple truck stops; repeated asphalt pavement failures

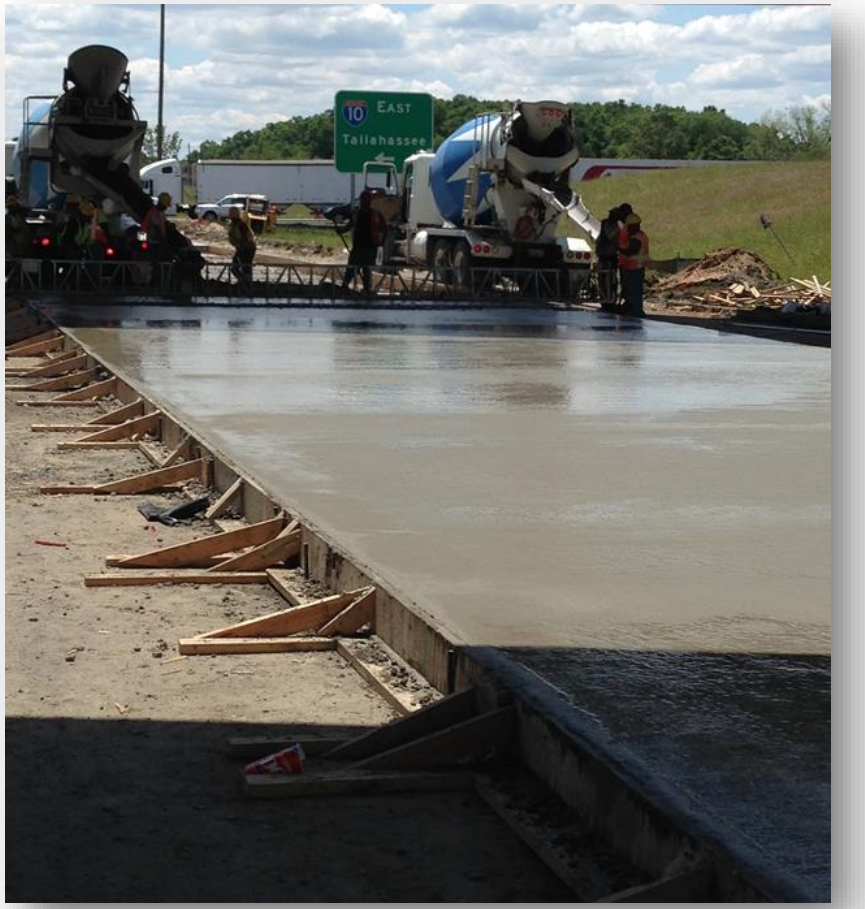
SR-71 Jackson County

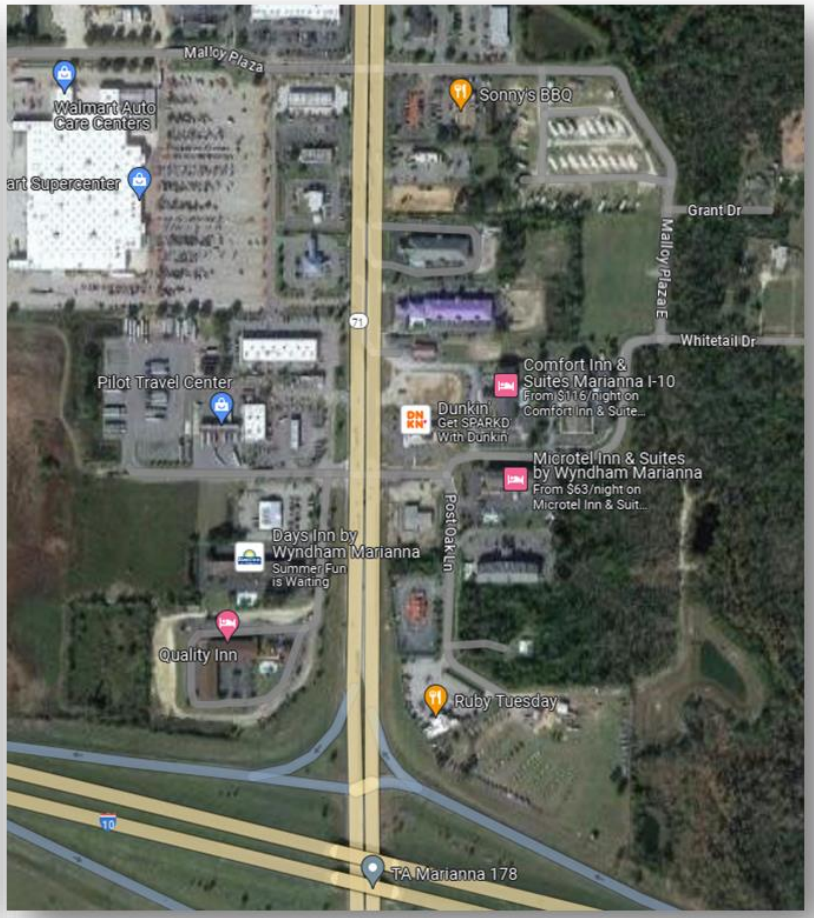
- District opted to rehabilitate project with PCC



SR-71 Jackson County

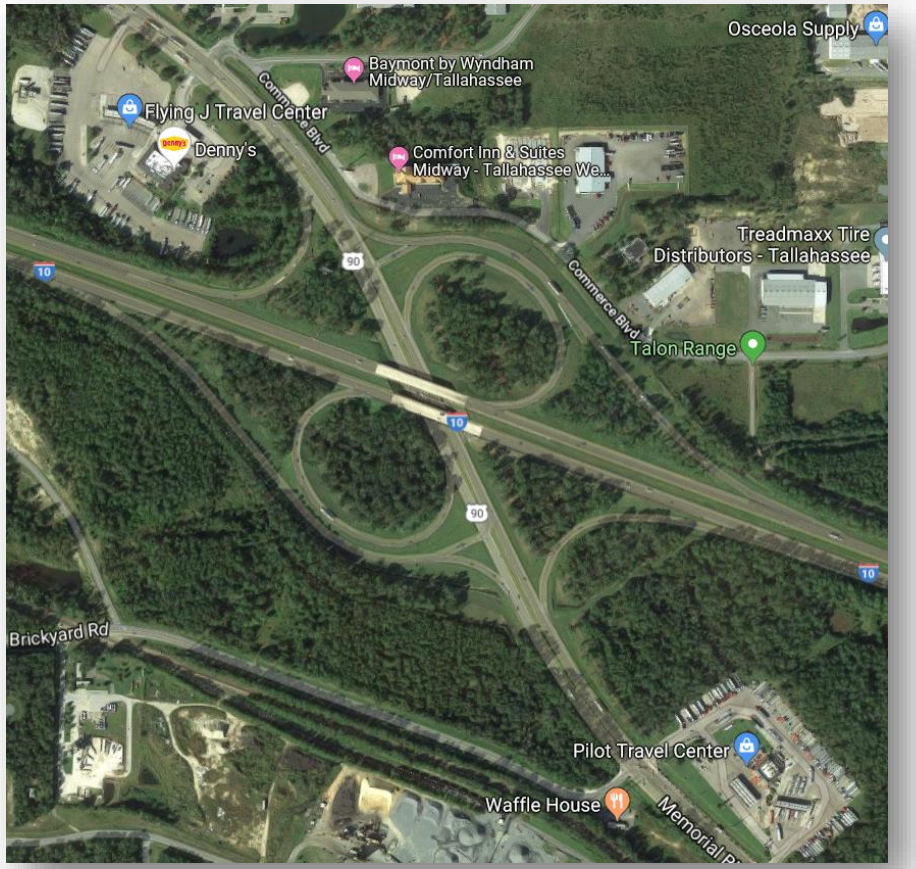
Work Began: August 2013
Work Ended: December 2014





US-90: Midway, Gadsden County

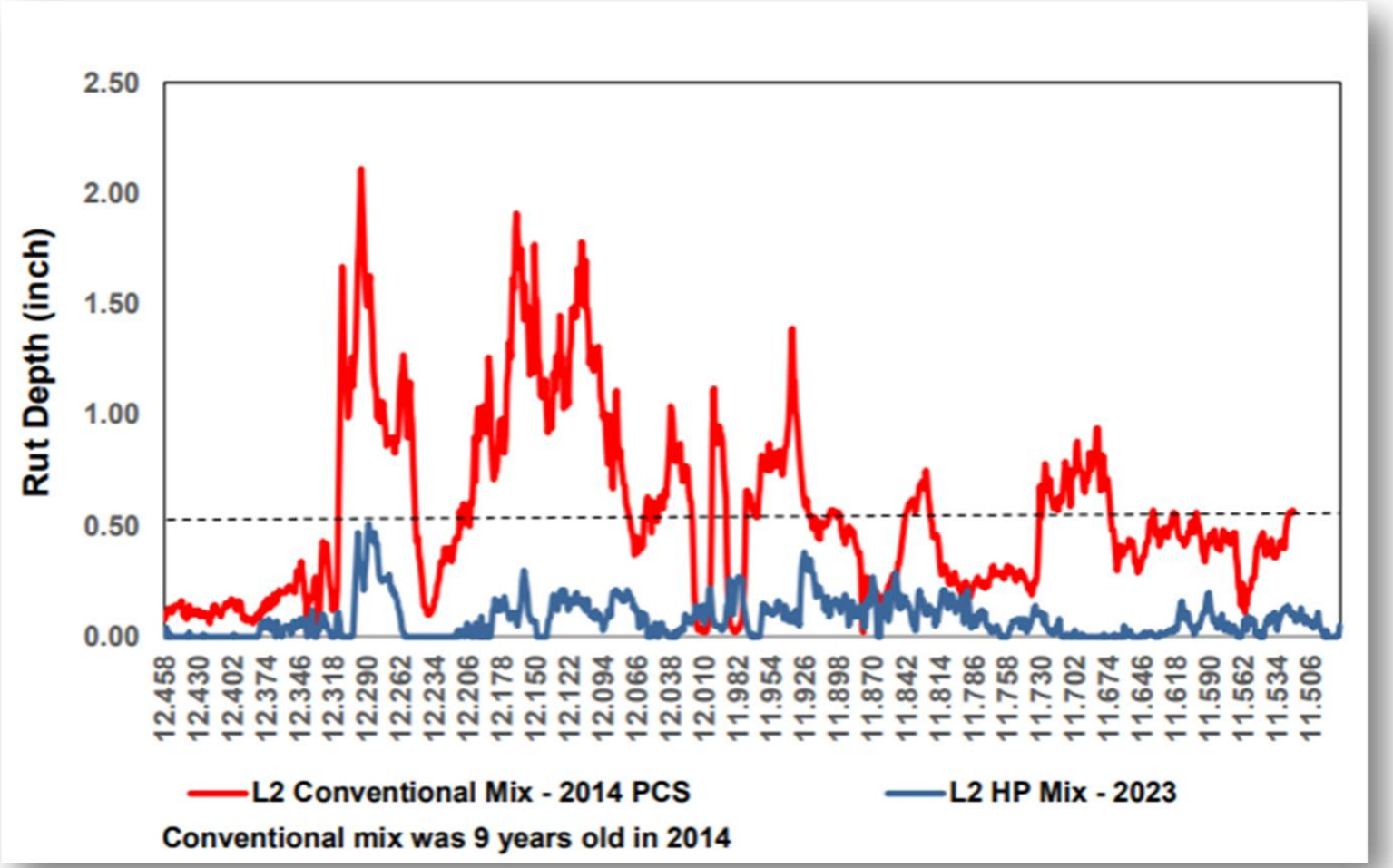
- 2015: Similar scenario as SR-71



US-90 Gadsden County

- Originally programmed to be reconstructed with concrete pavement
- Westbound travel lanes at the I-10 interchange
  - Between two truck stops
  - Rutting up to two inches
- Concerned with potential traffic interruptions
  - District opted to resurface with a high polymer mixture
- Maintenance Contract: Milled and resurfaced top 2.5” with a single lift of dense-graded friction course containing high polymer binder
  - August 2015
- Concrete reconstruction cancelled

US-90 Gadsden County Rutting Data

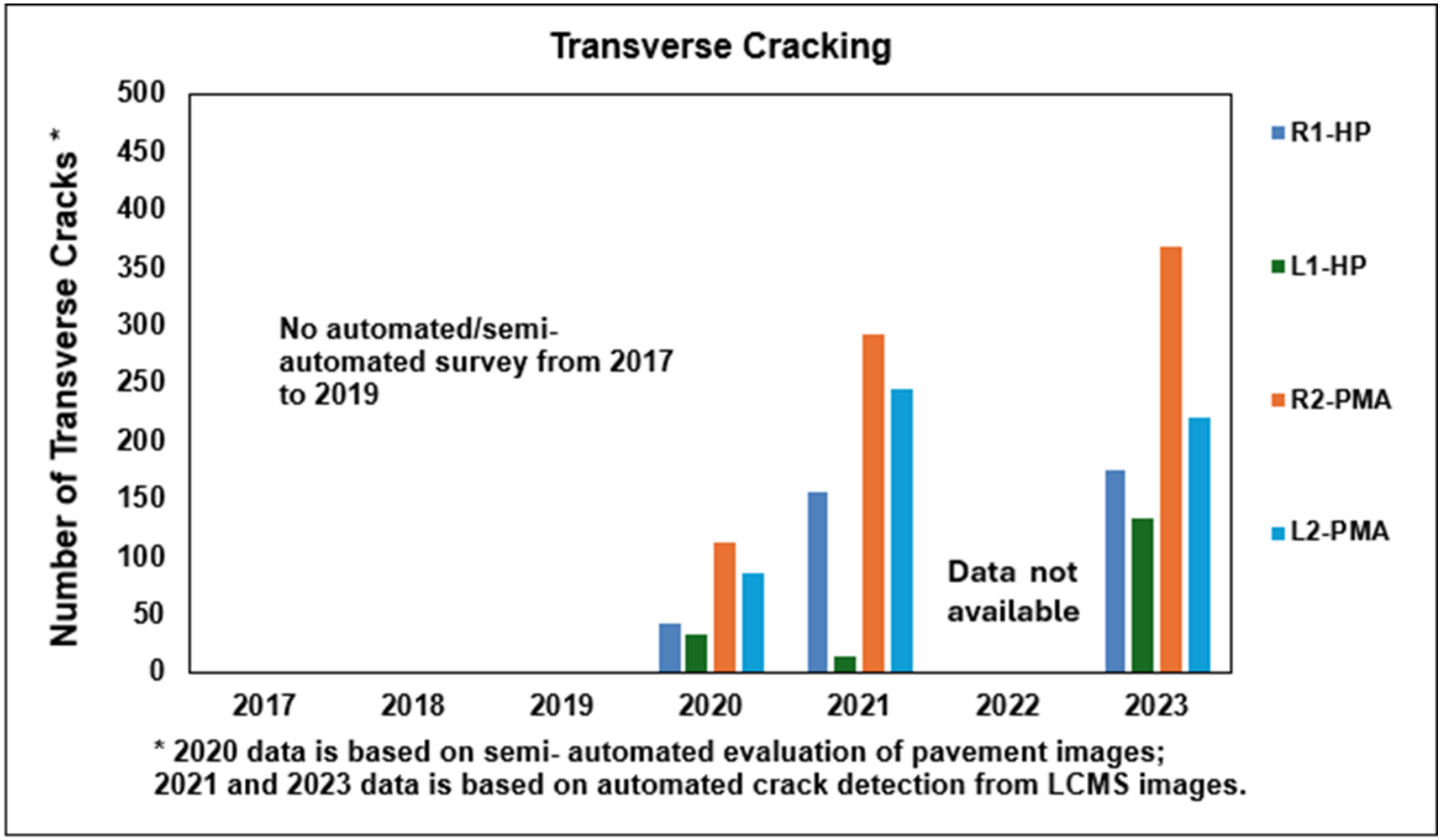


US-41 Tampa, Hillsborough County

- Project has underlying jointed PCC slabs with 20-ft spacing
  - Severe reflective cracking from joints
- Milled off existing asphalt
- Joints and cracks were cleaned and sealed prior to placing mix
- Placed 2.0 inches of asphalt over concrete pavement
  - Inside travel lanes contain 2.0” of high polymer mix
  - Outside travel lanes contain 2.0” of polymer-modified PG 76-22 mix
- Project was paved in May 2016

US-41 (Nebraska Avenue) – Hillsborough County

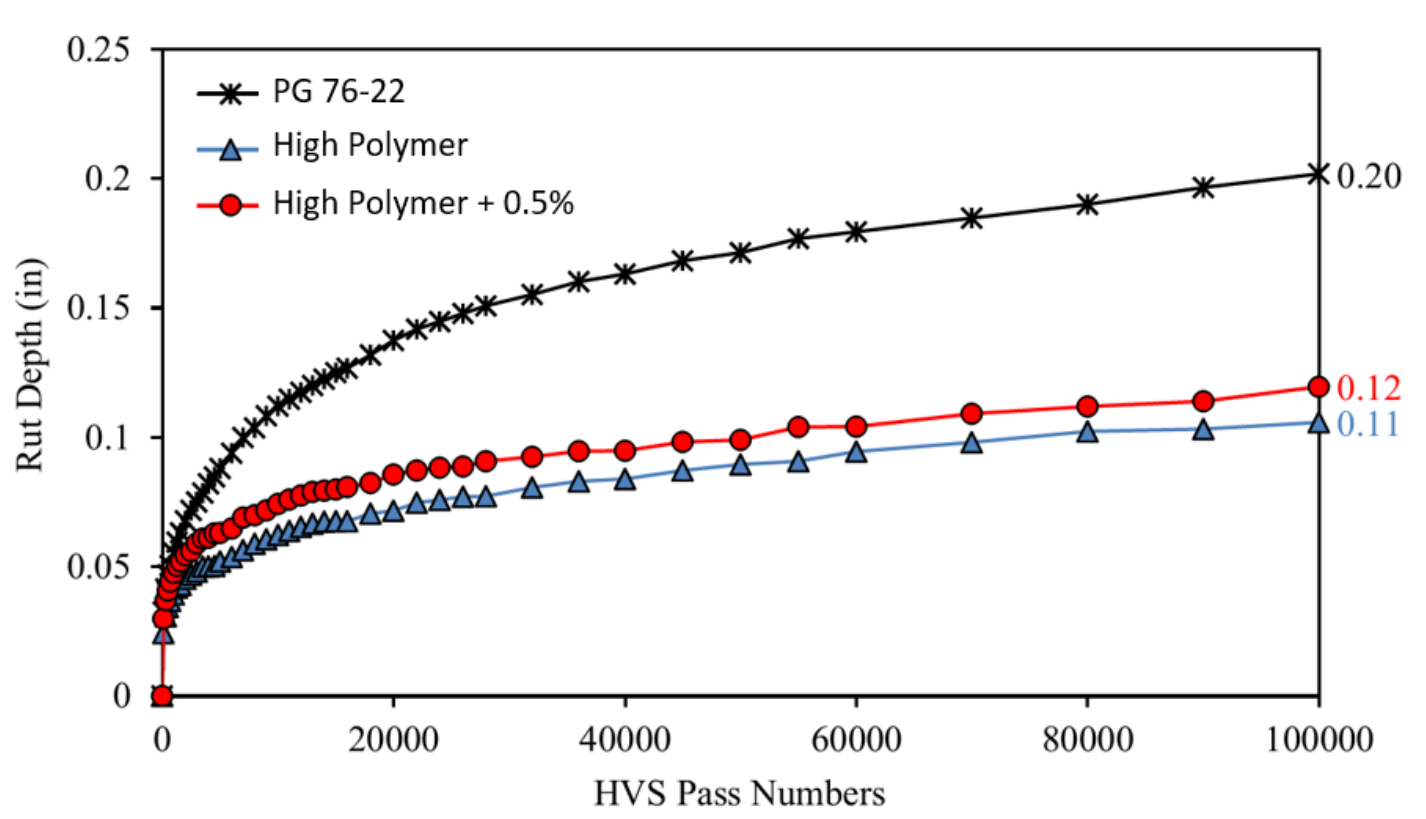
US-41 Cracking Data



HIGH POLYMER RESEARCH

FDOT High Polymer Research (Rutting)

- High polymer binder vs. polymer modified PG 76-22 binder



FDOT Heavy Vehicle Simulator

FDOT High Polymer Research (OGFC Durability)

- Evaluation of FC-5 (OGFC) with High Polymer Binder to Reduce Raveling
  - Texas A&M Transportation Institute
- The objective of this research was to determine if the use of high polymer binder in OGFC mixtures (in lieu of PG 76-22 binder) will increase the performance/longevity of OGFC mixtures.
- The research indicated high polymer binder significantly improved the performance of FDOT's OGFC mixtures and was cost-effective.

FDOT High Polymer Research (Structural Support)

- Determine the Structural Coefficient for Asphalt Mixes Containing High Polymer Binder
  - University of Nevada Reno
- The objective of this project was to determine the additional structural value high polymer mixtures compared to asphalt mixtures containing PG 76-22 binder.
- The research showed there is roughly a 20% increase in structural capacity for high polymer binder mixtures.

High Polymer Binder Usage in Florida

- Used to address:
  - Severe rutting
  - Bottom-up fatigue (alligator) cracking
  - Raveling (in OGFC mixtures)
  - Also used to address reflective cracking in some instances
- Approximately 3 - 5% of mix placed on FDOT's system annually

TYPICAL APPLICATIONS

Rutting

- Only 0.3% of FDOT's system is deficient due to rutting.
- However, rutting is a significant safety concern
- Traffic volumes are increasing

High Volume Intersection / Interchanges

Inspection Stations/Toll Facilities

Bottom-up Fatigue Cracking

- Like rutting, there is a low percentage of this type of distress in Florida
- However, this is an expensive repair, especially when geometrically constrained by curb or guard rail

Bottom-up Cracking at Bridge Approaches

Open-Graded Friction Courses

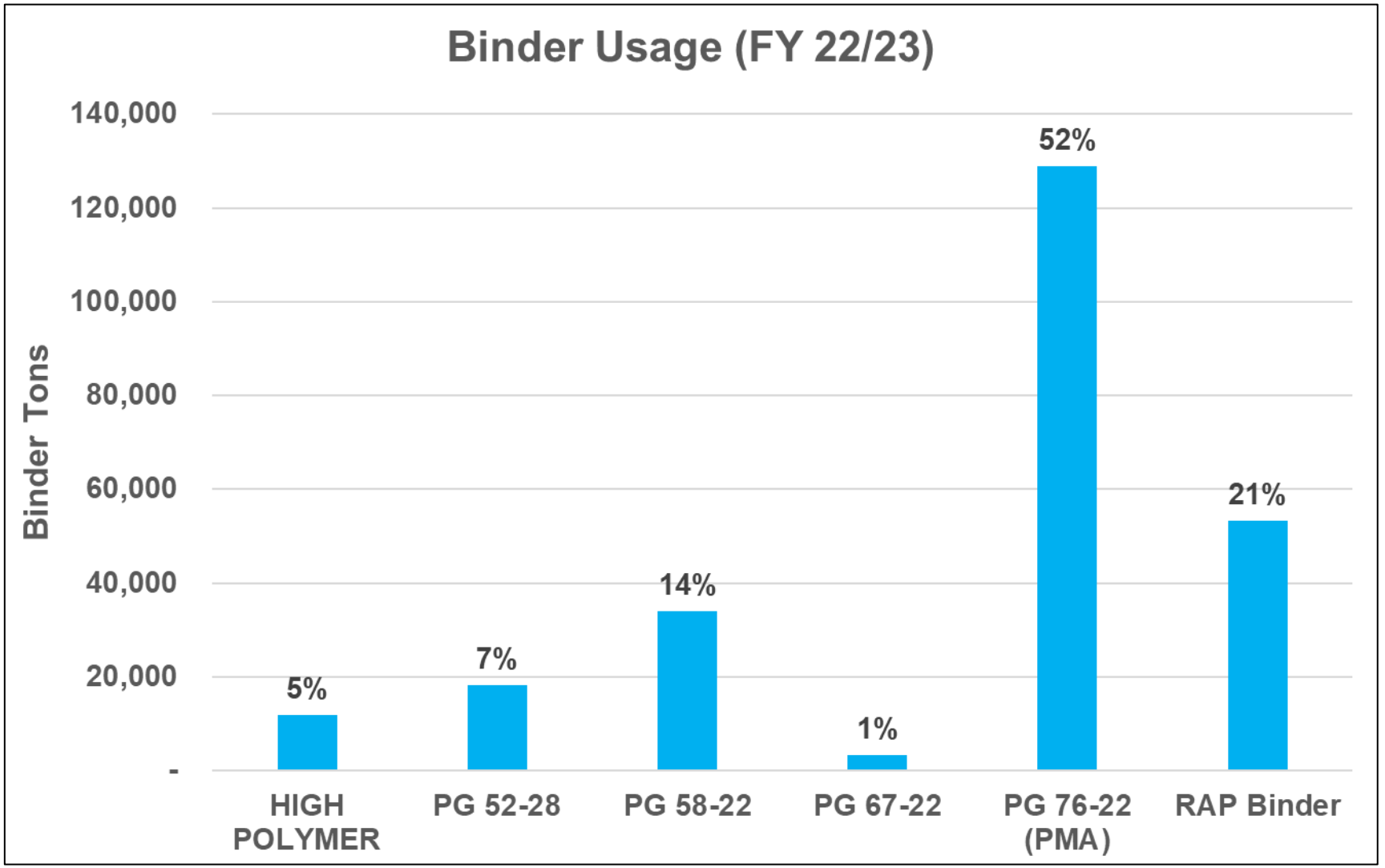
- Half of the Department's 45,000 lane miles are paved with OGFC
  - Around 500,000 tons of OGFC every year
- Includes high speed signalized intersections and other locations with repetitive turning and stopping movements.

Open-Graded Friction Courses

Usage of High Polymer

- Placed high polymer mixtures on over 100 projects to date
- Placed over one million tons of high polymer mix in Florida

Binder Usage



Summary

- FDOT has had excellent performance with high polymer binders
- Minimal constructability problems
- Used to address rutting, raveling, fatigue and reflective cracking
  - Focus on preventing premature failures
- High polymer mixtures are expensive and are used where they add the most value

THANK YOU!

Jim.Musselman@dot.state.fl.us

TRB Webinar UDOT HiMod Asphalt Experience

Howard Anderson, P.E.
UDOT State Asphalt Engineer
May 2, 2024

Acknowledgments:
Lonnie Marchant and other RME's
Dave Johnson, Asphalt Institute
Clark Allen, Lead Technician
Bob Kluttz, ETG Mtg's, 2015 SR-191 Project

Asphalt Binder Grading (viscoelastic material)

- AC Grading System, units of 100 poises. Each one double the Absolute viscosity taken at 140 F.
- AC 2.5
- AC 5
- AC 10
- AC 20
- (AC 30) In-between grade
- AC 40

- SHRP PG Grading System, attempted the same thing using a constant DSR G* modulus, each grade increasing in 6 C increments.
- PG 58 (close to AC 10)
- PG 64 (close to AC 20)
- PG 70
- PG 76

UDOT Binder Specification

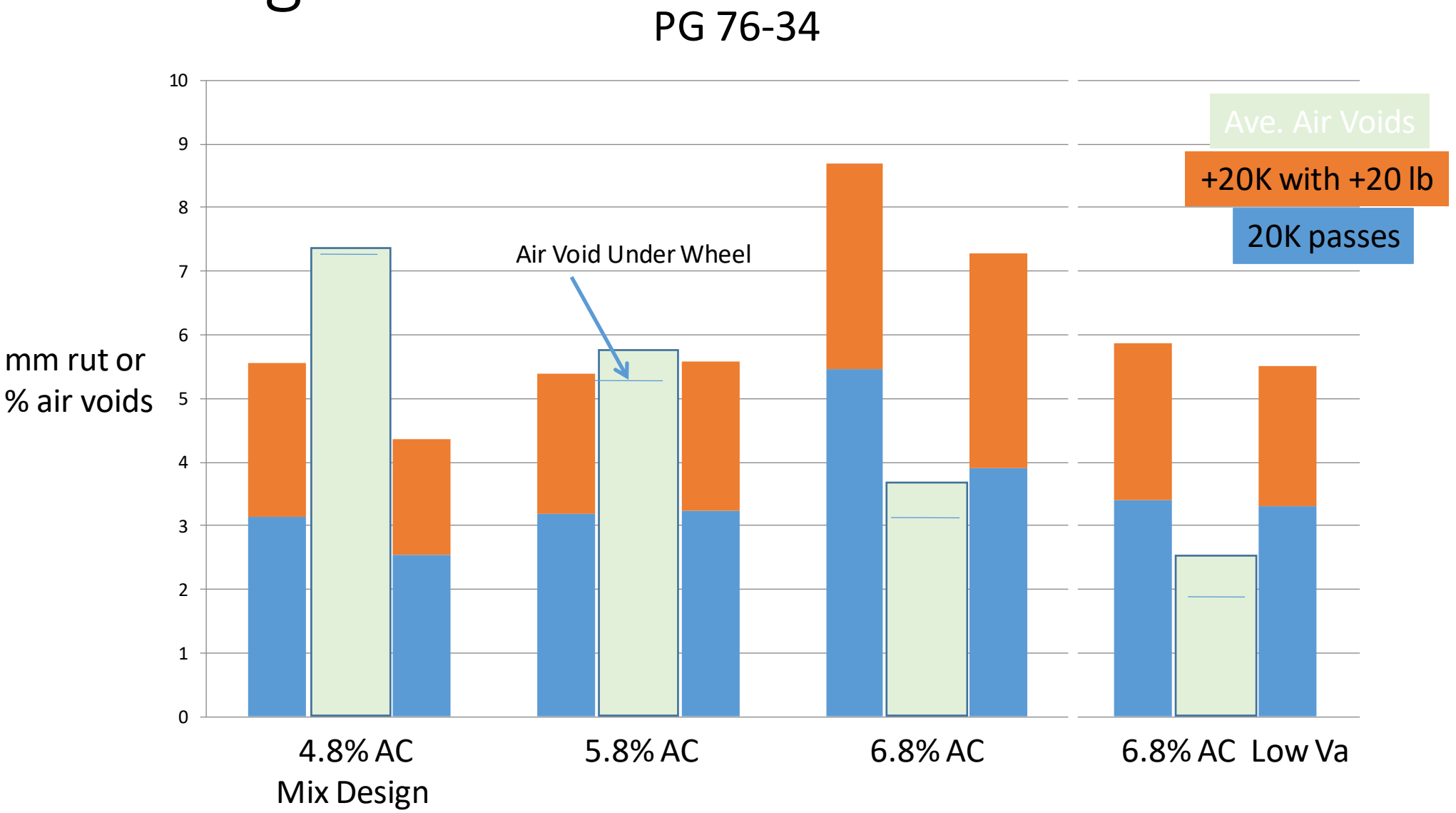
Table 10

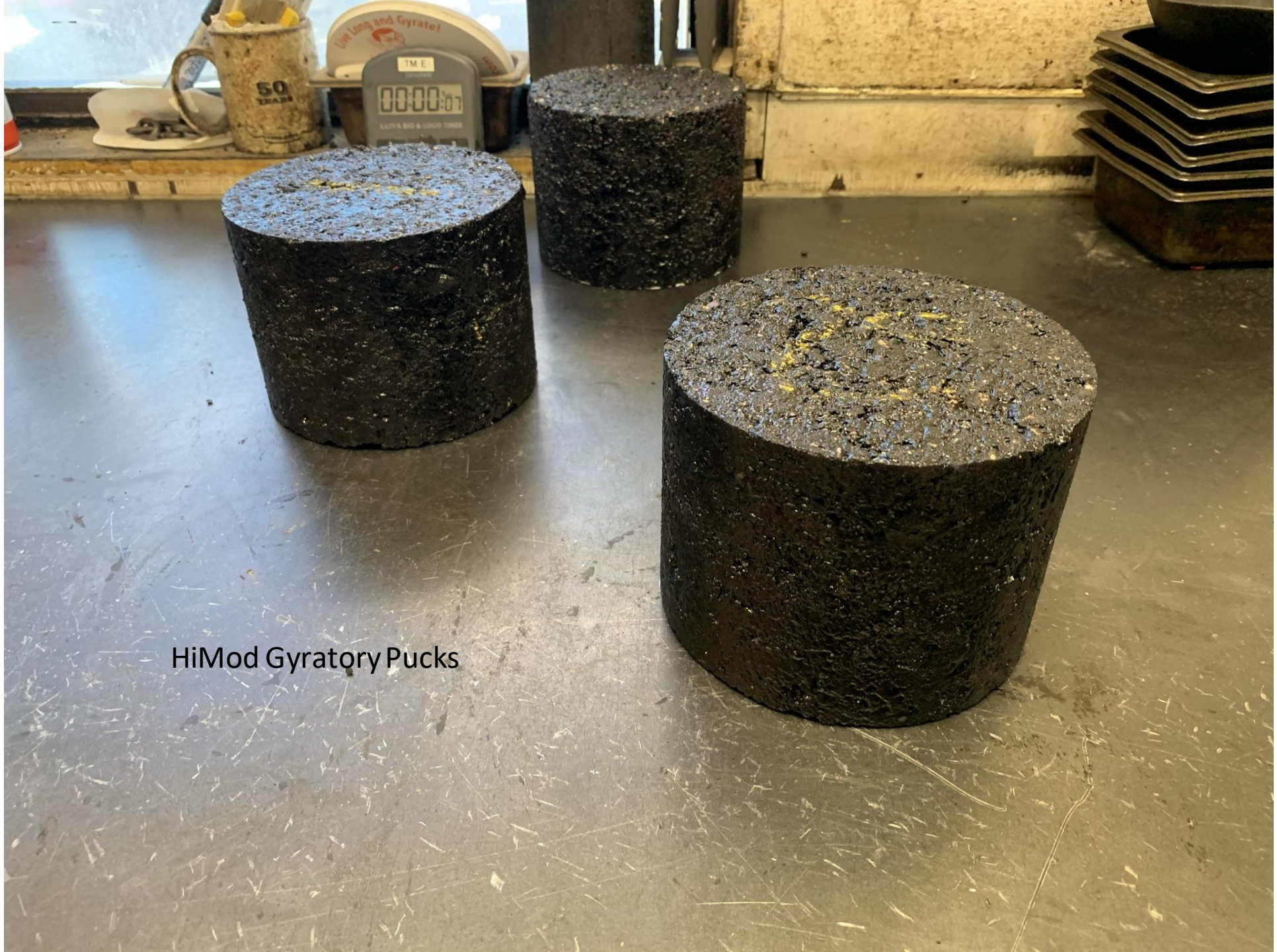
PG76-34 Highly Modified		
Original Binder		
Dynamic Shear Rheometer, AASHTO T 315	@ 76° C, G*, kPa	1.30 Min.
	@ 76° C, phase angle, degrees	70. 0 Max.
Rotational Viscometer, AASHTO T 316	@ 135° C, Pa.s	3 Max.
Flash Point, AASHTO T 48	°C	260 Min.
RTFO Residue, AASHTO T 240		
Dynamic Shear Rheometer, AASHTO T 315	@ 76° C, G*/sinδ, kPa	2.20 Min.
Elastic Recovery, AASHTO T 301 mod (a)	%	90 Min.
PAV Residue, 20 hours, 2.10 MPa, 100 °C, AASHTO R 28		
Dynamic Shear Rheometer, AASHTO T 315	@ 25° C, kPa	5,000 Max.
Bending Beam Rheometer, AASHTO T 313	@ -24° C, S, MPa	300 Max. 150 Min.
	@ -24° C, m-value	0.300 Min.
Delta Tc from additional BBR test, ASTM D7643	@ -30° C	-1.0 Min.

(a) Modify paragraph 4.5 as follows: Stop the ductilometer after 20 cm has been reached and within 2 seconds. Sever the specimen at its center with a pair of scissors.

Hamburg
Slab strips
from under
the wheel

Hamburg Test





HiMod Gyratory Pucks

Property	Mix Design Requirement	Mix Design Value
Asphalt Binder	PG 76-34	PG 76-34
Gyrations	50	50
NMAS Crushed Aggregates	12.5 mm 100%	12.5 mm 100%
Asphalt Content		6.0% (5.33% Virgin, 0.67% RAP Binder)
Air Voids	1.0-1.5%	1.0% (0.1% at 75 gyrations)
Voids in Mineral Aggregate	15.0-17.0	15.3
Voids Filled with Asphalt	90.0-95-0%	93.3%
Drain Down	0.3% max	0.0%
RAP	15% max	15%
Hamburg Depth (note bath temperature increased from 50 to 54°C for second 20,000 passes) Slab Void target 4 %	7.0 mm max after 20,000 passes	3.9 mm
	10.0 mm max after 40,000 passes	6.1 mm


Staker Beck Street
CHECK-IN STATION
IF CHANGING MATERIAL OR JOB YOU MUST CHECK-IN AT THE SCALE BEFORE YOU LOAD
YOU CAN CONTACT THE SCALE BY USING THE PHONE ON THE PLATFORM OR BY CB CHANNEL


DO NOT
ENTER
HAMM


UTAH
UDOT
Wendover Port of Entry


CAT


Welcome to Utah
We all Buckle up
Join us

Wendover I-80 POE: Core Density Results

Density Target: 96.0%, Lower Limit: 94%

Core	Total Thickness	Top Half Density	Bottom Half Density
1	6.27 inches	97.9%	98.0%
2	6.27 inches	97.8%	94.4%
3	6.1 Inches	97.2%	92.8%
4	6.1 Inches	97.3%	97.6%

Highly Modified, High Density, Low Air Void Installations in Utah

Project Description	Pavement Description	Design Thickness	Construction Year	HiMod Tonnage	Observed Density
Wendover	Port of Entry off I-80	6 Inches	2021	450	+97%
I-15 near Parish Lane	Overlay of PCC both NB and SB	3 Inches	2022 and 2023	2,216 NB 1,258 SB	+96.5%
SR-196; MP 24 to 80 F-0196(7)24	13-mile Overlay	1.5 Inches	2023	15,506	+96%
SR 173; 4800 W. to Bangerter Highway F-0173(42)4	Overlay	1.5 Inches	2023	5,001	+96%
I-80, I-15, I-215 Bridge Decks	7 Bridge Decks, Contractor Change Ordered	3-4 Inches	2023	unknown	+96%


I-15 Near Parish Lane


SR -196

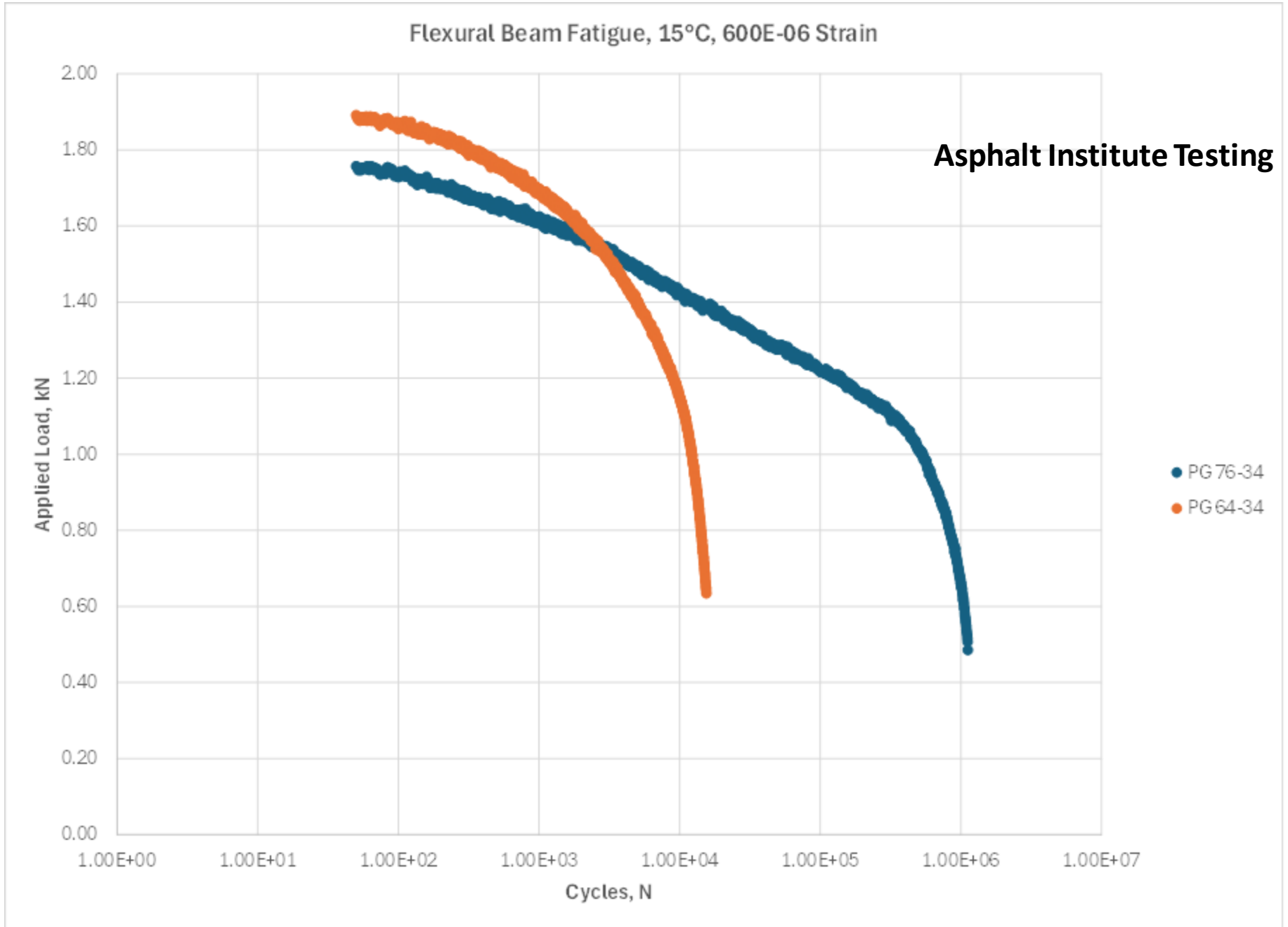
I-15 Bridge Deck


SR-173

IDEAL-CT Test Results:

HiMod, High Density Plant Mix Installed on I-215 Bridge Decks, 6.25% total binder, 15% RAP

Puck No.	IDEAL-CT 4% Voids		IDEAL-CT 7% Voids
1	389.4		362.3
2	246.2		476.2
3	217.7		
4	219.8		
5	171.9		
Average:	249		419



Asphalt Institute Testing

HiMod High Density or Low Air Void Projects in Utah coming up

Project Description	Pavement Description	Design Thickness	Construction Year	HiMod Tonnage	Has Thick Lift?
US 6 Interchange F-0006(230)174	High Traffic Interchange	5 inches	2024	4,123	Yes, 5 inch
I-80 MP 41 to 50 F-I80-2(82)41	9-mile Overlay	1.5 inches	2024	38,932	No
I-215 Ramps; State, Fashion F-R299(458)	Overlay of Concrete	3 inches	2024	1,673	No
US 40 East of Duchesne	10-mile Overlay	2 inches	2024	18,000 (estimate)	No
US 6 Tucker to Soldier Summit F-0006(245)204	7-mile mill and Overlay truck lane Overlay entire road	4 inches – truck lane Plus 2-inch to Truck lane and rest of road	2024	52,666	Yes, 4 inch
I-80: Near Airport Entrance Bridge Preservation F-R299(270)	Overlay of 19 bridge decks	3 inches	2024	4,603	No
SR-276 and SR-95 F-R499(457)	45 -Mile Overlay	2 Inches	2024	84,764	No
SR-261 and SR-276 Near Bluff	Overlay	2 inches	2024-2025	204,728	No
US-191: Dry Valley to Hatch Wash F-0191(206)89	Overlay	2 inches	2024	16,969	No
SR-171; 700 W. to State Street F-0171(72)9	Overlay	1.5 inches	2024	4,752	No
SR-190; Pavement Preservation F-0190(29)2	Overlay	1.5 inches	2024	11,105	No
US-89: Passing Lanes near Buckskin Wash S-0089(572)35	Overlay	2 inches	2024	17,906	Yes, 5 inch
US-89, SR-204 to SR-134	SMA changing to HiMod	2 inches	2024	11,500	No
SR 35 F-0035(13)0	Overlay	1.5 inch	2024	14,000 (estimate)	No
I-215 Reconstruction	Rubblize PCC Pavement and Overlay	5.5 inches	2025	In design	Yes, 4 inch
			Total:	**485,721**	


Questions?
Good Roads Cost Less:
• Perpetual pavements are sustainable and better for the environment

Today's presenters

Gary Fitts
gary.fitts@kraton.com

KRATON™

Dr. Robert Kluttz
bob.kluttz@kraton.com

KRATON™

Jim Musselman
jim.musselman@dot.state.fl.us

FDOT

Howard Anderson
handerson@utah.gov

UDOT Keeping Utah Moving

NATIONAL ACADEMIES *Sciences Engineering Medicine*

Upcoming events for you

June 23-26, 2024

2nd International Roadside Safety Conference

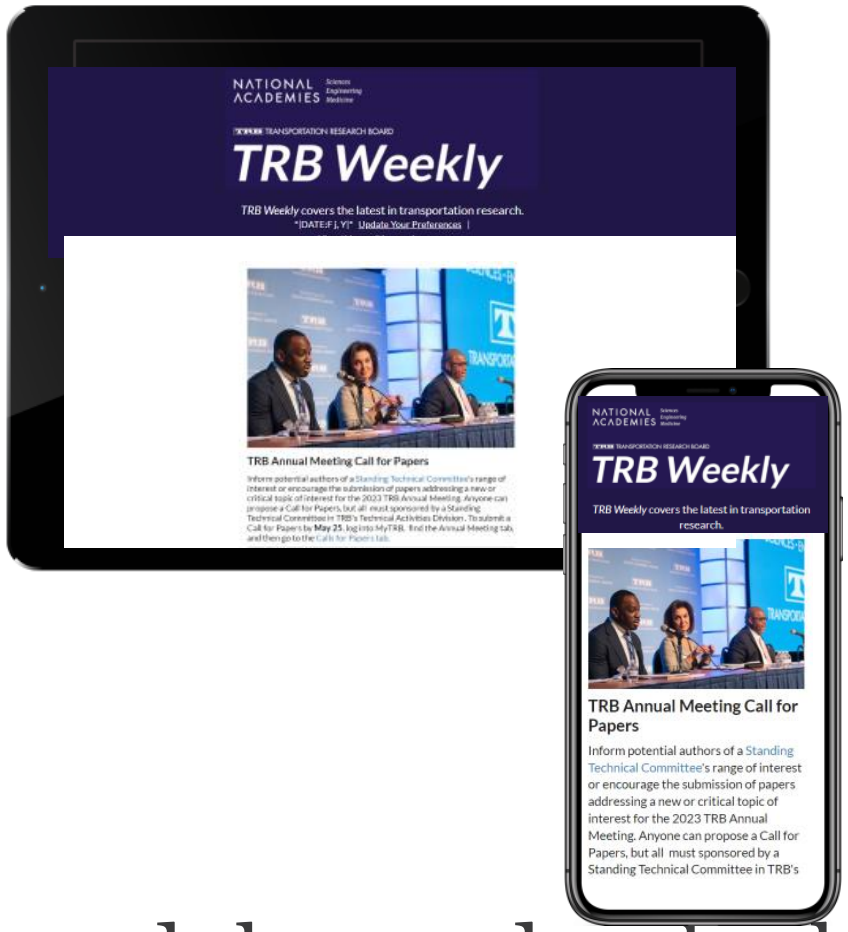
https://www.nationalacademies.org/trb/events

Subscribe to *TRB Weekly*

If your agency, university, or organization perform transportation research, you and your colleagues need the *TRB Weekly* newsletter in your inboxes!

Each Tuesday, we announce the latest:

- RFPs
- TRB's many industry-focused webinars and events
- 3-5 new TRB reports each week
- Top research across the industry



Spread the word and subscribe!
https://bit.ly/ResubscribeTRBWeekly

Discover new TRB Webinars weekly

Set your preferred topics to get the latest listed webinars and those coming up soon every Wednesday, curated especially for you!

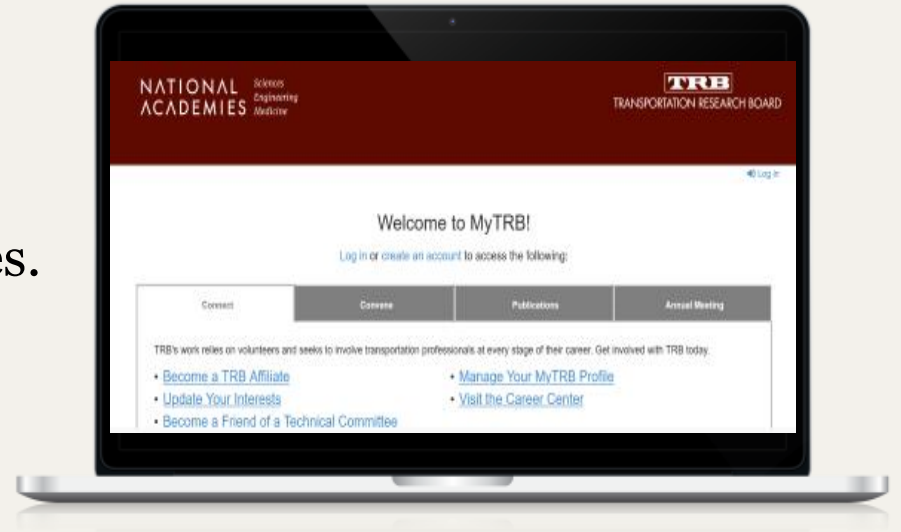
https://mailchi.mp/nas.edu/trbwebinars

And follow #TRBwebinar on social media

NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

Get involved



TRB mobilizes expertise, experience, and knowledge to anticipate and solve complex transportation-related challenges.

TRB's mission is accomplished through the hard work and dedication of more than **8,000 volunteers**.

https://www.nationalacademies.org/trb/get-involved

We want to hear from you

- **Take our survey**
- **Tell us how you use TRB Webinars in your work at trbwebinar@nas.edu**

NATIONAL ACADEMIES Sciences Engineering Medicine