WisDOT Research Updates

Steve Hefel and Tirupan Mandal
Bureau of Technical Services

2022 WAPA Annual Conference
Wisconsin Dells, WI

November 29th, 2022

Research Partners

NRRA
National Road Research Alliance

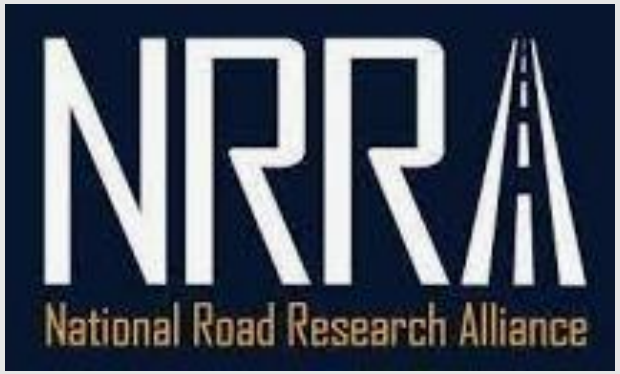
CAPRI
CONSORTIUM FOR ASPHALT
PAVEMENT RESEARCH AND IMPLEMENTATION

MnROAD
Safer, Smarter, Sustainable Pavements Through Innovative Research

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

WISCONSIN DEPARTMENT OF TRANSPORTATION

National Road Research Alliance (NRRA)



NRRA Research Updates

- Comprised of 14 agencies and more than 80 industries, associations, and academic institutions
- Research includes: **Flexible**, Geotechnical, Intelligent Construction, Preventive Maintenance, and Rigid
- http://www.dot.state.mn.us/mnroad/nrra/structure-teams/flexible/index.html

NRRA Research Updates

Current Flex Projects:

- MnROAD Reflective Cracking Challenge
- Recycled Binder Availability
- Reclamation and Recycling Techniques to Achieve Perpetual Pavements Characteristics
- Validation of Loose Mix Aging Procedures for Cracking Resistance Evaluation in Balanced Mix Design
- Perpetual Pavements in Wet-Freeze Climates

MnROAD Reflective Cracking Challenge

- Analyze the performance of HMA mixes in new construction and overlay applications at MnROAD.
- Constructed August 2022
- HMA lower layers, 200’ sawn joints, 200’ not sawn

- Control
- Control soft binder
- Control polymer binder
- Wet plastic
- Dry plastic
- Wet rubber
- Dry rubber
- Fiber with polymer x2
- SuperPave 5

Perpetual Pavements in Wet-Freeze Climates

- Analysis of the instrumentation data collected from the perpetual pavement sections to validate or update existing design criteria
- Laboratory testing to properly characterize HMA layers for PP design
- Comparison of conventional PP sections to PP sections built at MnROAD using recycling/reclamation techniques
- WisDOT I-94 project near Osseo will be part of the research done in 2023. 10” and 12” sections will be placed.
- Thinlay and Microsurfacing used in interstate applications

MnROAD and NCAT Research

MnROAD/NCAT Research Updates

- Wisconsin in pooled fund for Cracking Group Experiment and Pavement Preservation Group Experiment
- Test tracks and road sections in both Alabama and Minnesota
- https://eng.auburn.edu/research/centers/ncat/files/technical-reports/rep21-03.pdf

MnROAD/NCAT Research Updates

Cracking Group Study:

- Cracking Study in hot (AL) and cold (MN) climates
- IDEAL-CT method is a very good indicator for resistance to top-down cracking
- Long term aging was validated

Pavt Preservation Study:

- Effective in extending life
- Cost effectiveness varied by state

Others:

- High RAP, BMD, full depth rebuild, cold plant mix, friction, etc.

Consortium for Asphalt Pavement Research and Implementation (CAPRI)

CAPRI Research Updates

Pooled fund by 22 agencies

Consortium Goals

- Develop asphalt pavement research needs
- Provide technical guidance on current and evolving asphalt materials specifications
- Select and fund small-scale studies to address knowledge gaps or explore new topics
- Foster the implementation of useful research

https://eng.auburn.edu/research/centers/ncat/research/capri.html

CAPRI Research Updates

Subcommittees:

- Critical Issues
  - Choosing topics to research, BMD is top of list
- Technology Transfer
  - Developing website, short videos, webinars, workshops, etc
- Technology Evaluation
  - Evaluation of BMD tests, conducting synthesis, new tech
- Research Roadmap
  - Developing research database, starting with improving density, longitudinal joints, tack coat, and BMD.

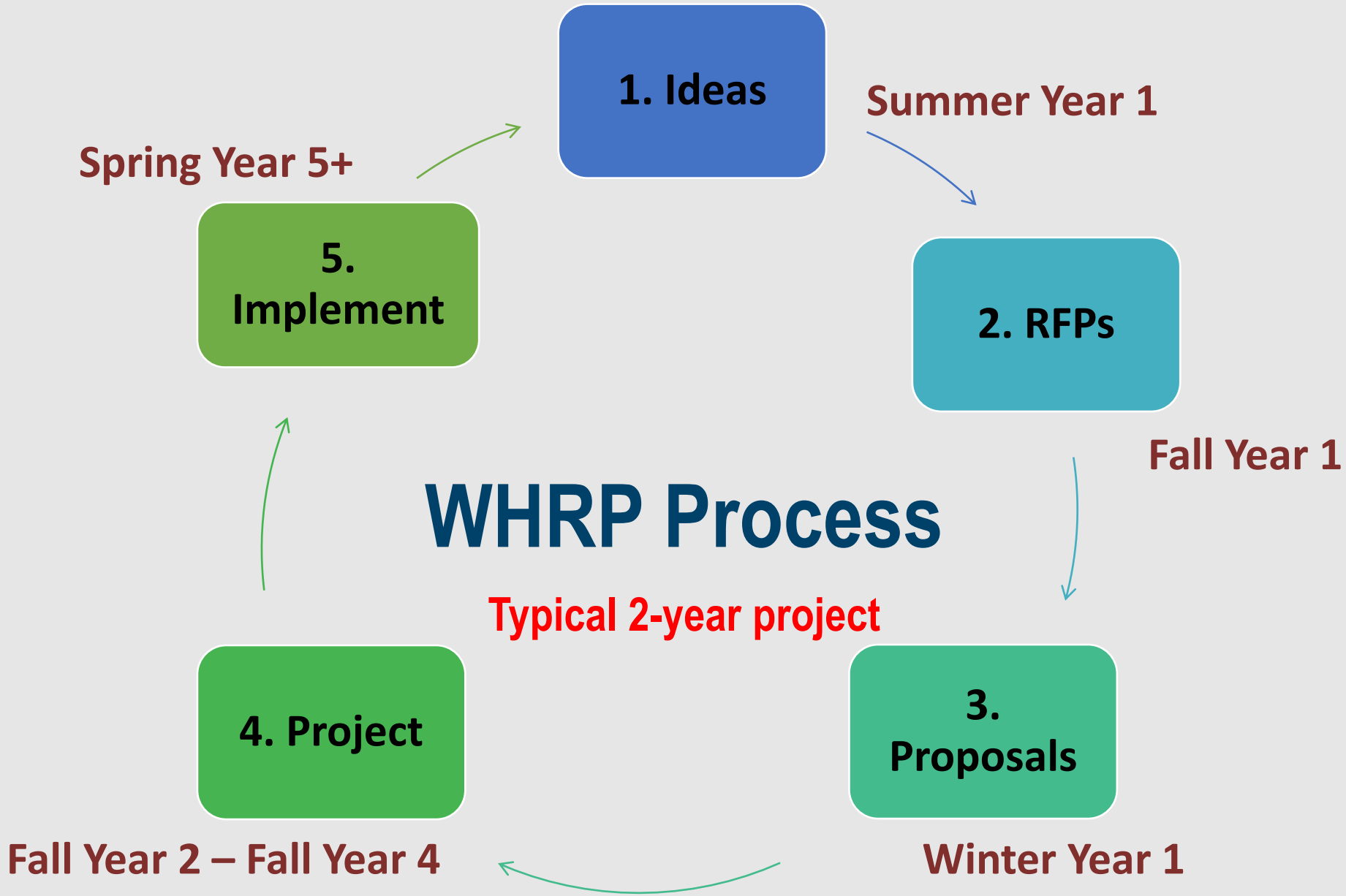
Wisconsin Highway Research Program (WHRP)

WHRP Overview

- Established in 1998 by the Wisconsin Department of Transportation (WisDOT) in collaboration with the University of Wisconsin-Madison
- WHRP budget in FFY 2022 -- $985,000
- Primary research areas:
  - **Flexible Pavements ◄**
  - Rigid Pavements
  - Structures
  - Geotechnics
- http://wisconsindot.gov/Pages/about-wisdot/research/whrp.aspx

Technical Oversight Committee

- Steve Hefel – DOT
- Tirupan Mandal – DOT
- Erik Lyngdal – DOT
- Dan Kopacz – DOT
- Matthew Bertucci – DOT
- Devin Harings – DOT
- Hani Titi – UW Milwaukee
- Danny Xiao – UW Platteville
- James Pforr – FHWA
- Deborah Schwerman – WAPA
- Derek Frederixon – Mathy Construction
- Stacy Glidden – Walbec Group
- Carl Johnson – Stark Asphalt
- Dan Swiertz - Asphalt Materials, Inc.
- Erv Dukatz – Flyereld Consulting, LCC
- Albert Kilger – Behnke Materials Engineering


1. Ideas
Summer Year 1
2. RFPs
Fall Year 1
3. Proposals
Winter Year 1
4. Project
Fall Year 2 – Fall Year 4
5. Implement
Spring Year 5+
WHRP Process
Typical 2-year project

WHRP Completed Projects Last 5 Years

Year Completed	Project ID	Title	Major Takeaway
2018	16-02	Asphaltic Binder Extraction Protocol for Determining Amount & PG Characteristics of Asphaltic Mixtures	Auto Extractor and Ignition Test
2018	17-04	Field Aging and Oil Modification Study	Short- & Long-Term Aging
2018	16-06	Regressing Air Voids for Balanced HMA Mix Design Study	Adding Binder Improves Balance
2018	15-05	Evaluation of WisDOT Quality Management Program (QMP) Activities and Impacts on Pavement Performance	Improved PWL Program
2019	17-06	Investigation of Tack Coat Materials on Tracking Performance	Tack Coat Bonding Properties
2019	18-06	Enhanced Moisture Sensitivity Study	HWTD and MiST

WHRP Active/Recently Completed Projects

Year Completed	Project ID	Title	Major Takeaway
2020	19-05	Rubber Asphalt Study for Wisconsin	Use of GTR in WI
2021	19-04	Recycled Asphalt Binder Study	Use of Recycled Asphalt Mixes
2021	**20-04**	**Balanced Mixture Design Implementation Support**	**Benchmarking & Pilot Spec**
2021	**21-05**	**Material Specifications for Longitudinal Joint Construction, Remediation and Maintenance**	**Alternative methods during and post construction**
2022	**20-03**	**Expansion of AASHTOWare ME Design Inputs**	**Updated PMED Inputs for HMA**
Active	**21-04**	**Interlayer Mixture Design**	**Alternative test method for IMDs**
Active	**22-04**	**Balanced Mixture Design Pilot and Field Test Sections**	**Field Sections & Repeatability**
Active	**23-01**	**Benchmarking Delta Tc (ΔTc) for Wisconsin Materials**	**Use of ΔTc in WI**

WHRP 20-04: *Balanced Mixture Design Implementation Support*

Project Team:

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

Objective:

- Evaluate performance-based methodologies for asphalt mixture design
- Develop preliminary balanced mixture design (BMD) specifications

WHRP 20-04: *Balanced Mixture Design Implementation Support*

Mix ID	Traffic Level	NMAS	Primary Aggregate Type	PG Grade	RAP (%)	RAS (%)	Air Voids (%)
A	SMA	12.5	Carbonate	58V-28	0	3	4.5
B	HT	12.5	Gravel	58S-28	10	0	3.0
C	HT	12.5	Carbonate	58S-28	16	0	3.0
D	HT	12.5	Carbonate	58S-28	15	0	3.0
E	MT	9.5	Gravel	58S-28	30	0	3.0
F	MT	9.5	Gravel	52S-34	35	0	3.0
G	MT	9.5	Carbonate	58S-28	31	0	3.0
H	MT	9.5	Carbonate	58S-28	30	0	3.0
I	MT	12.5	Granite	58S-28	14	2	3.0
J	MT	12.5	Gravel	58S-28	38	0	3.0
K	MT	12.5	Carbonate	58S-28	26	0	3.0
L	MT	12.5	Carbonate	58S-28	10.1	3.4	3.0
M	MT	12.5	Quartz	58S-28	18	3	3.0
N	LT	9.5	Gravel	58S-28	32	0	3.0
O	LT	12.5	Granite	58S-28	20	2	3.0
P	LT	12.5	Gravel	58S-28	29	0	3.0
Q	LT	12.5	Carbonate	58S-28	29	0	3.0
R	LT	12.5	Quartz	58S-28	21	3	3.0

Mix Designs in the Benchmarking Experiment

WHRP

WHRP 20-04: *Balanced Mixture Design Implementation Support*

Suggested Preliminary Performance Test Criteria

Traffic Level	HWTT*		IDEAL-CT#	DCT#
	CRD_{20k} (mm)	SN (passes)	CT_{Index}	G_f (J/m^2)
SMA Mix	≤ 6.0	≥ 2,000	≥ 80	≥ 400
HT Mix			≥ 40	≥ 300
MT Mix	≤ 7.0			
LT Mix	≤ 8.0			

* *test conducted on short-term aged specimens.*

\# *test conducted on long-term aged specimens.*

WHRP 21-05: *Material Specifications for Longitudinal Joint Construction, Remediation and Maintenance*

Project Team:

WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

bitumix solutions

Objective:

- Identify and compare materials, processes, and experiences to improve longitudinal joint performance during and after construction
- Recommend best practices for selected materials and processes relative to Wisconsin standard practice
- Summarize quality assurance requirements for each selected alternative

WISCONSIN DEPARTMENT OF TRANSPORTATION

WHRP

WHRP 21-05: *Material Specifications for Longitudinal Joint Construction, Remediation and Maintenance*

Recommended Joint Improvement Practices and Materials

Construction & Design (CD)			*Supplemental Methods & Materials During Construction (MDC)*			*Supplemental Methods & Materials Post-Construction and/or Low Joint Density Remedial/Repair (MPC)*[1]		
Item	*Coding*	*Minimum Agency Count*[0]	*Item*	*Coding*	*Minimum Agency Count*[0]	*Item*	*Coding*	*Minimum Agency Count*[0]
Echelon and/or Tandem Paving	CD-2	12 (24%)	Void Reducing Asphalt Membrane (aka Longitudinal Joint Seal)	MDC-4	16 (32%)	Penetrating Asphalt Emulsion	MPC-1	6 (12%)
Specific Joint Geometry Selection Vertical Butt Joint **Tapered Joint (inc. Notched Wedge)** Milled and/or Cut-Back Joint	CD-1	23 (46%)	**Coating Cold Joint Face with Asphalt Emulsion** – "Tack" (inc. single application, double application, etc.)	MDC-2	46 (92%)	Asphalt Emulsion Fog Seal	MPC-3	3 (6%)
Joint Density Measurement	CD-6	33 (66%)	Joint Adhesive and/or Hot Applied Asphaltic Coating Applied to Cold Joint Face	MDC-3	14 (28%)	Specialty Fog Seal – Not Necessarily Asphalt-Containing (Inc. Rejuvenating Fog Seal, Bio-Based, etc.)	MPC-4	2 (4%)
			Joint Reheaters (Infrared or Other)	MDC-1	4 (8%)	Micro-surfacing, fixed width/specialized	MPC-6	1 (2%)

[0]Count is Agencies that specify or have known recent or sustained experience via specification, provision, or change order of (for) line item; since not all information is public, the count is expressed as a "Minimum" count.

Good Probability of Improving Joint Performance
May Improve Joint Performance
Not Widely Practical for WisDOT
Bold Items = Current WisDOT Spec.

WHRP 20-03: *Expansion of AASHTOWare ME Design Inputs*

Project Team:

ARA

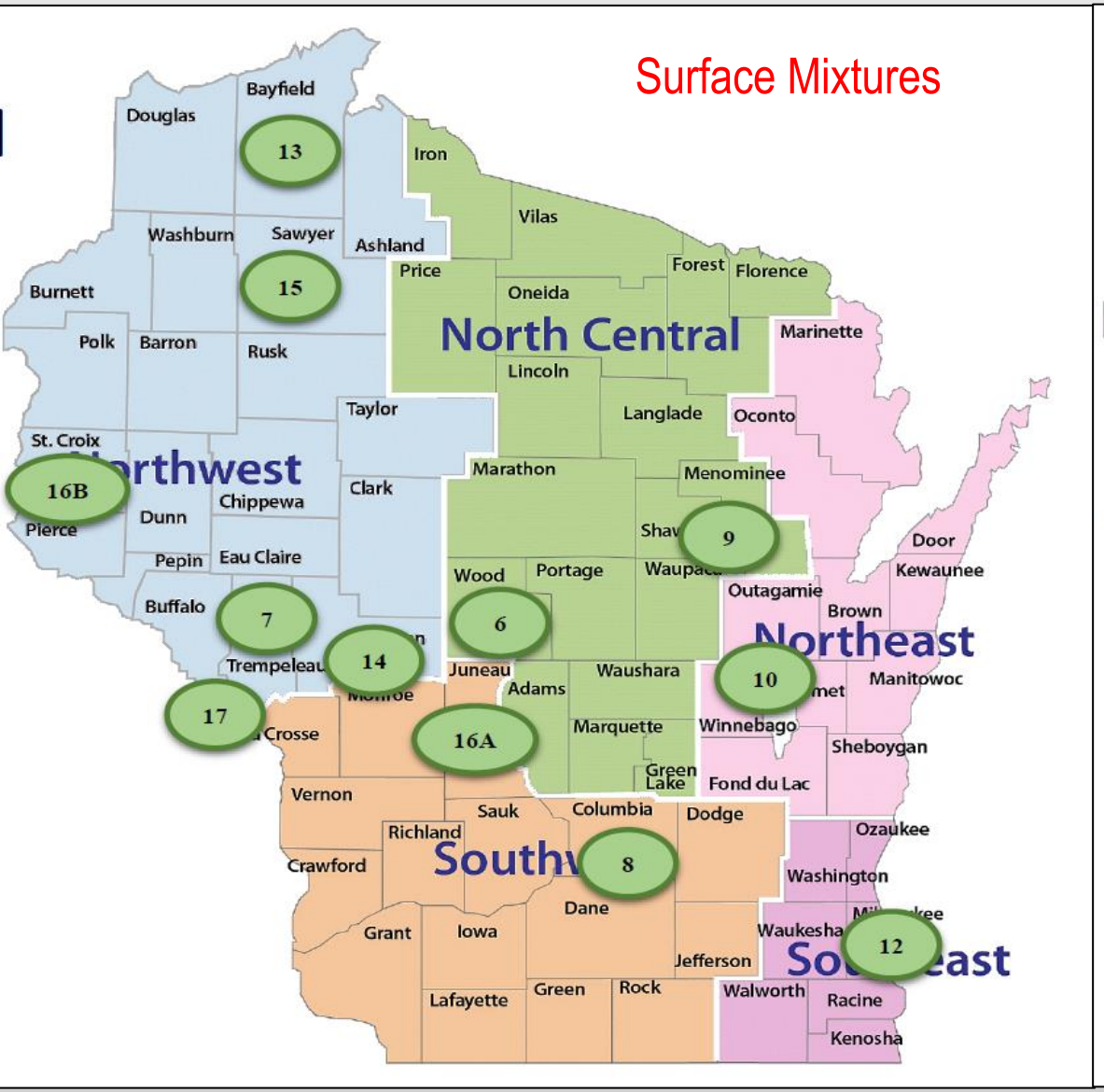
ADVANCED ASPHALT TECHNOLOGIES

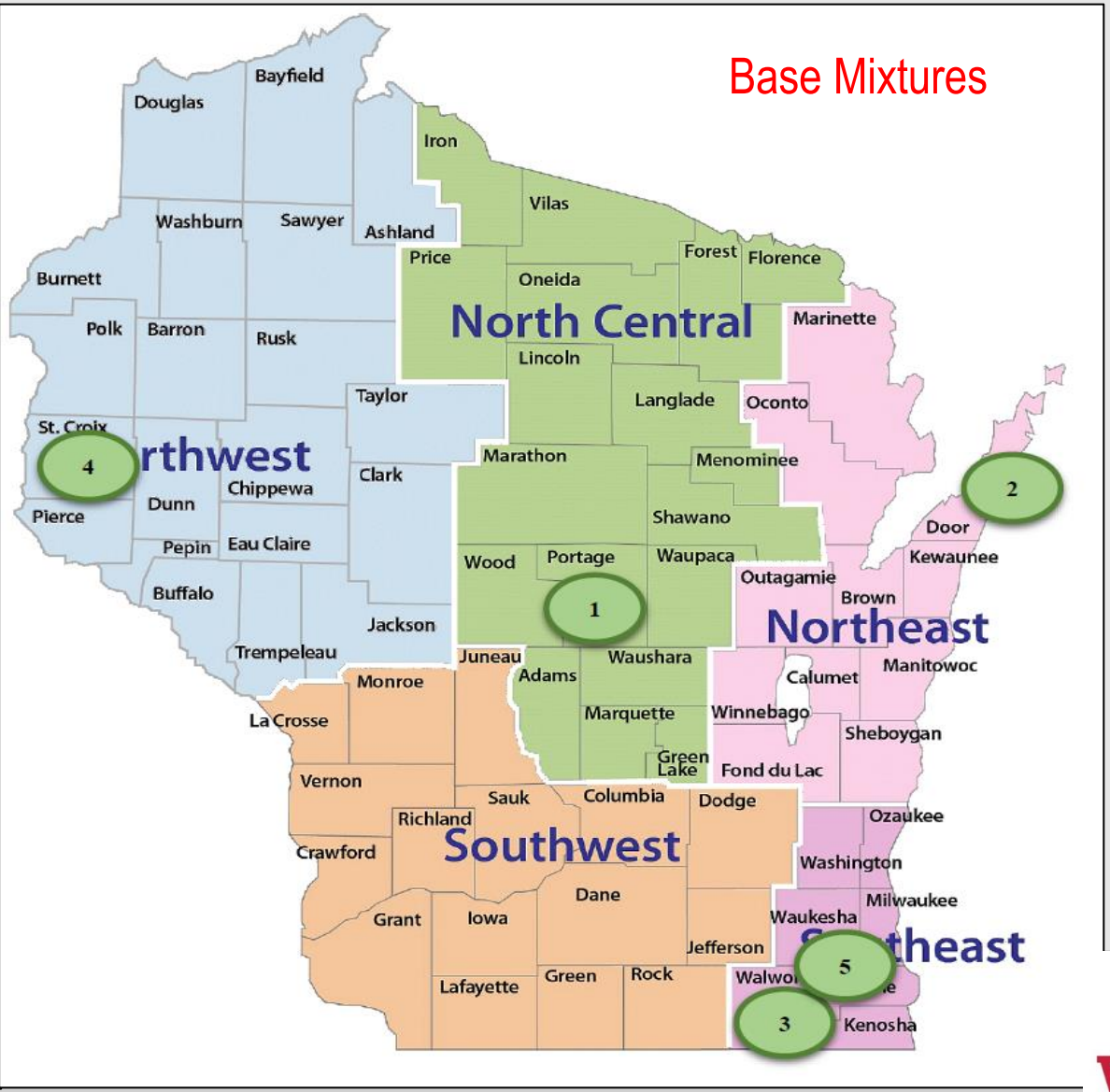
Objective:

- Expand the asphalt mix properties library for using in the Pavement ME Design software in Wisconsin
- Provide updated structural layer coefficients for the different asphalt mixtures included in the Wisconsin's materials library

WHRP 20-03: *Expansion of AASHTOWare ME Design Inputs*

Mixtures selected for this study represents a higher tonnage of surface and base mixtures placed in Wisconsin over the past 3 years





WHRP

WHRP 20-03: *Expansion of AASHTOWare ME Design Inputs*

Mixture Identification			Dynamic Modulus	Repeated Load Plastic Deformation	Creep Compliance	Tensile Strain at Failure	Bending Beam Fatigue
003	Base	PG58-28S; 3MT	√			√	
057	Base	PG58-28S; 3LT	√	√		√	√
093	Surface	PG58-28H; 4HT	√		√		
119	Base	PG58-28S; 3HT	√			√	√
121	Surface	PG58-28V; 4SMA	√	√	√		
127	Surface	PG58-34S; 4MT	√		√		
165	Surface	PG58-28S; 4HT	√		√		
208	Surface	PG58-28S; 4LT	√	√	√		
236	Surface	PG58-28S; 4MT	√	√	√		
251	Surface	PG58-28V; 4HT	√	√			
258	Surface	PG58-28S; 4MT	√	√	√		
319	Surface	PG58-28H; 4MT	√	√	√		
1020	Surface	PG58-34V; 4SMA	√	√	√		
1060	Base	PG58-28H; 3HT	√	√		√	√
1166	Base	PG58-28S; 2HT	√			√	√
7130	Surface	PG58-34V; 5MT	√	√			
8357	Surface	PG58-34S; 4LT	√		√		

- *17 Mixes* for Dynamic Modulus (AASHTO T378-17)
- *10 Mixes* for Creep Compliance (AASHTO T322-07)
- *11 Mixes* for Repeated Load Plastic Deformation (NCHRP 9-30A)
- *4 Mixes* for Bending Beam Fatigue (AASHTO T321-17)
- *5 Mixes* for Tensile Strength at Failure (NCHRP 9-06)

WHRP

WHRP 20-03: *Expansion of AASHTOWare ME Design Inputs*

Conclusions:

- Input level 1 properties are different relative to the global input level 3 default properties that are included in the Pavement ME Design software

- The **selection variables are dependent on** the mixture property which includes RAP/RAS content, asphalt grade, and Fine Aggregate Angularity (FAA) or N_{Design} used for mixture design

- A catalog of asphalt binders and mixtures was created (.XML files) for use in flexible pavement design

WHRP 21-04: *Interlayer Mixture Design*

Project Team:

ADVANCED ASPHALT TECHNOLOGIES

Objective:

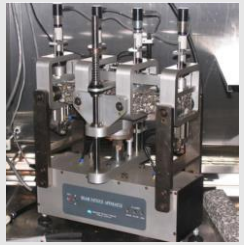
- Develop an alternative method for accepting interlayer mixture designs without the bending beam fatigue test

WHRP 21-04: *Interlayer Mixture Design*

TABLE 460-2 MIXTURE REQUIREMENTS

Mixture type	Interlayer
LA Wear (AASHTO T96) 500 revolutions(max % loss)	13 40
Soundness (AASHTO T104) (sodium sulfate, max % loss)	12
Freeze/Thaw (AASHTO T103) (specified counties, max % loss)	15
Fractured Faces (ASTM 5821) (one face/2 face, % by count)	75/60
Flat & Elongated (ASTM D4791) (max %, by weight)	5 (5:1 ratio)
Fine Aggregate Angularity (AASHTO T304, method A, min)	45
Sand Equivalency (AASHTO T176, min)	40
Clay Lumps and Friable Particle in Aggregate (AASHTO T112)	<= 1%
Plasticity Index of Material Added to Mix Design as Mineral Filler (AASHTO T89/90)	<= 4
Gyrations for Ndes	50
Air Voids, %Va (%Gmm Ndes)	2.0 (98.0)
Dust to Binder Ratio (% passing 0.075mm/Pbe)	0.8 - 1.6
Voids filled with Binder (VFB or VFA, %)	70 - 95
Flexural Beam Fatigue Test, average cycles (AASHTO T321) [1]	>100,000

- Per WisDOT **STSP 460-070**
  - Flexural beam fatigue test (per AASHTO T32)
    > 100,000



- Ongoing project
  - Expected completion:
    December 2022

WHRP 22-04: *Balanced Mixture Design Pilot and Field Test Sections*

Project Team:

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

Objective:

- Statistically analyze the variance of performance test data during construction
- Assess the long-term field performance of balance mix design pavements

WHRP 22-04: *Balanced Mixture Design Pilot and Field Test Sections*

- **Test Sections have been constructed this year**
  - Six mixes expected to have various performance

HWTT Corrected Rut Depth	IDEAL CT Index (after 6-hours @ 135°C aging)	
	> 65	< 35
> 7.0 mm	①	③
< 3.5 mm	②	④
V-grade binder	⑤	⑥

WHRP 22-04: *Balanced Mixture Design Pilot and Field Test Sections*

- **Test variability on other projects**
  - Testing 10 consecutive sublots
  - Determine the consistency and changes due to mix changes

- Ongoing project
  - Expected completion: November 2023

WHRP 23-01: *Benchmarking Delta Tc (ΔTc) for Wisconsin Materials*

Project Team:

Rutgers The State University of New Jersey

abatech consulting engineers

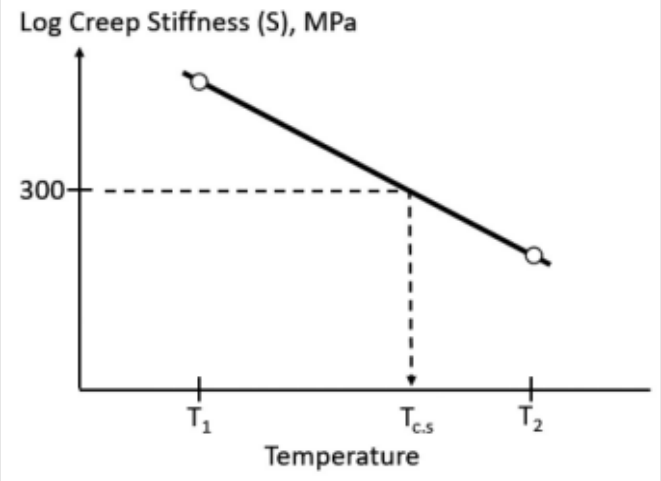
Objective:

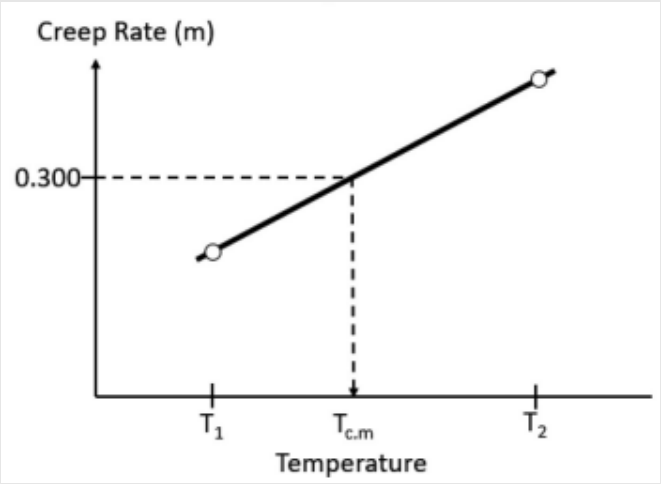
- Evaluate the use of the ΔTc parameter to help predict the non-load-related cracking susceptibility of Wisconsin asphalt mixtures, including recycled asphalt binders and rejuvenators
- Use past research to standardize, validate, and recommend an aging procedure prior to measurement of ΔTc

WHRP 23-01: *Benchmarking Delta Tc (ΔTc) for Wisconsin Materials*

Objective (Contd.):

- Compare the bench marking study results against ΔTc thresholds recommended by past researchers to determine the risk of early non-load related cracking in Wisconsin
- Recommend a plan for implementing ΔTc as a preferred performance measure for cracking susceptibility into WisDOT specifications





- ❑ Ongoing project
  - Expected completion: November 2024

Principal Investigators, TOC Members, and Consultants for WHRP

Wisconsin DOT Internal Research

CIR Field Tests

- Part of NCHRP 9-62 Project
- CIR Tests:
  - Long-Pin Shear Field Test
    - Surfacing
  - Short-Pin Raveling Field Test
    - Trafficking
- Properties Measured:
  - Blow Count
  - Torque Value

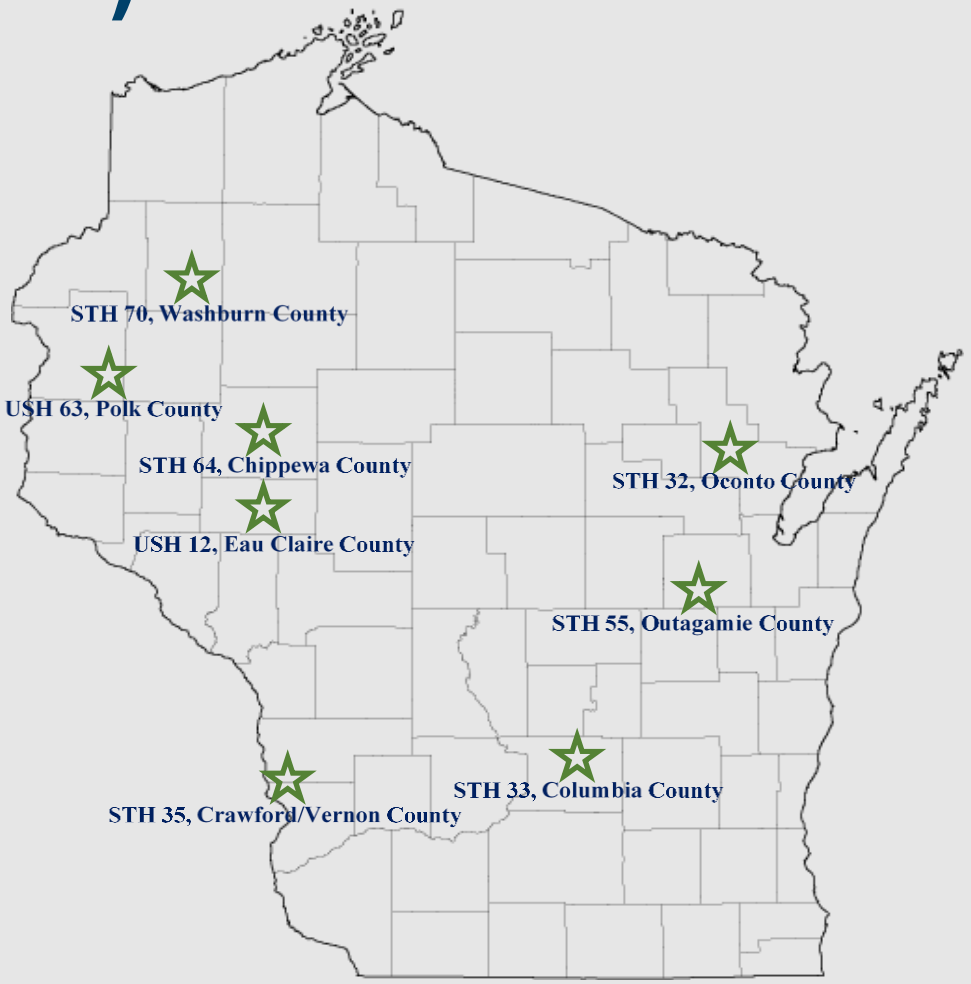
Long Pins

Short Pins

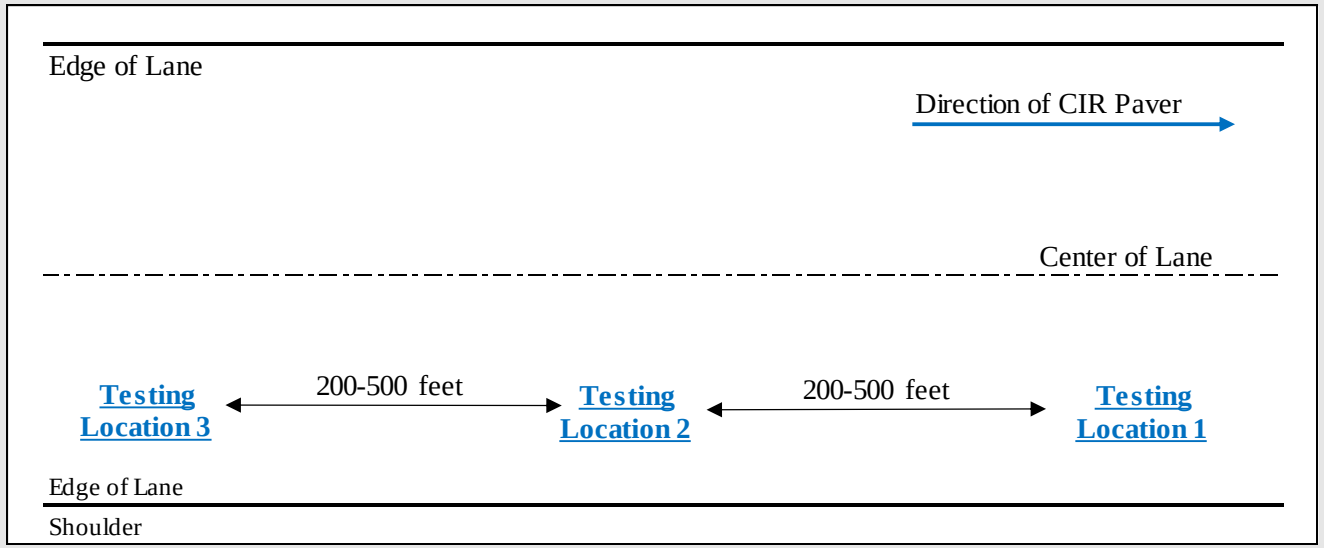
Pavement Unit Research on Cold In-place Recycled (CIR)

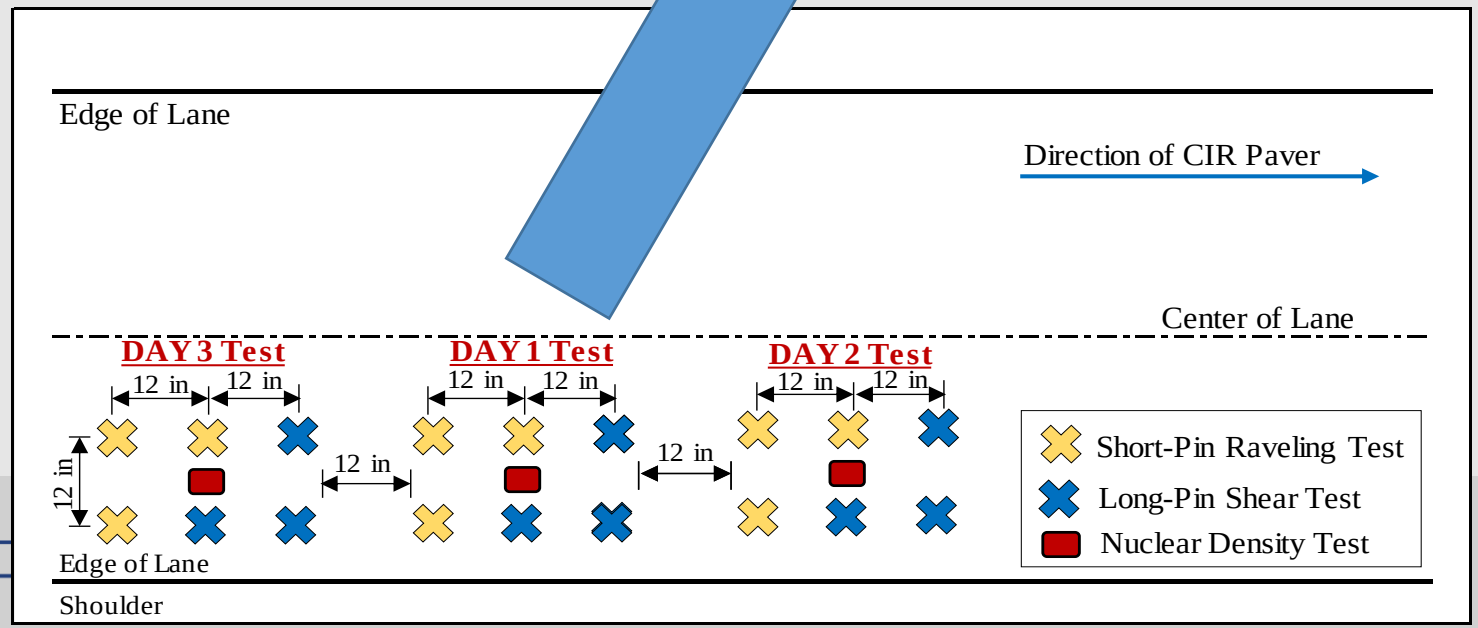
Project ID	Roadway	County	Foamed AC* (%)	Target Density (pcf)	NMAS	Truck%	Length (mi)
8130-01-70	STH 70	Washburn	1.9	132.9	3/4”	20.2	6.3
6040-00-73	STH 33	Columbia	1.7-2.0	140.1	3/4”	19.6	9.4
9190-26-71	STH 32	Oconto	2.1	134.4	3/4”	10.2	7.6
7080-03-75	USH 12	Eau Claire	2.0-2.5	120.6	3/4”	11.5	10.7
5160-07-71	STH 35	Crawford/ Vernon	2.0	129.1	3/8”	16.7	11.8
6560-08-71	STH 55	Outagamie	2.1	130.6	1/2"	16.1	2.1
1550-04-72	USH 63	Polk	2.0	128.1	1/2"	9.5	7.0
8190-00-72	STH 64	Chippewa	1.6	130.8	3/4”	12.5	7.0

Note: AC = Asphalt content; NMAS = Nominal Maximum Aggregate Size of the CIR Mix Design



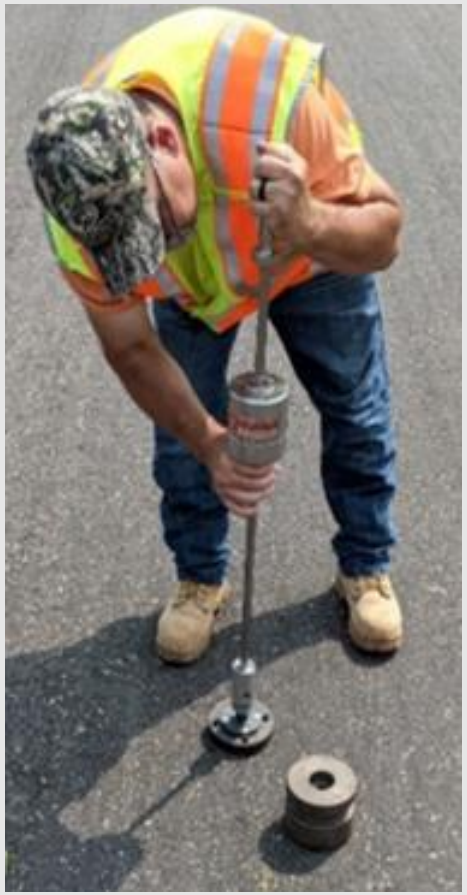
CIR Testing Layout





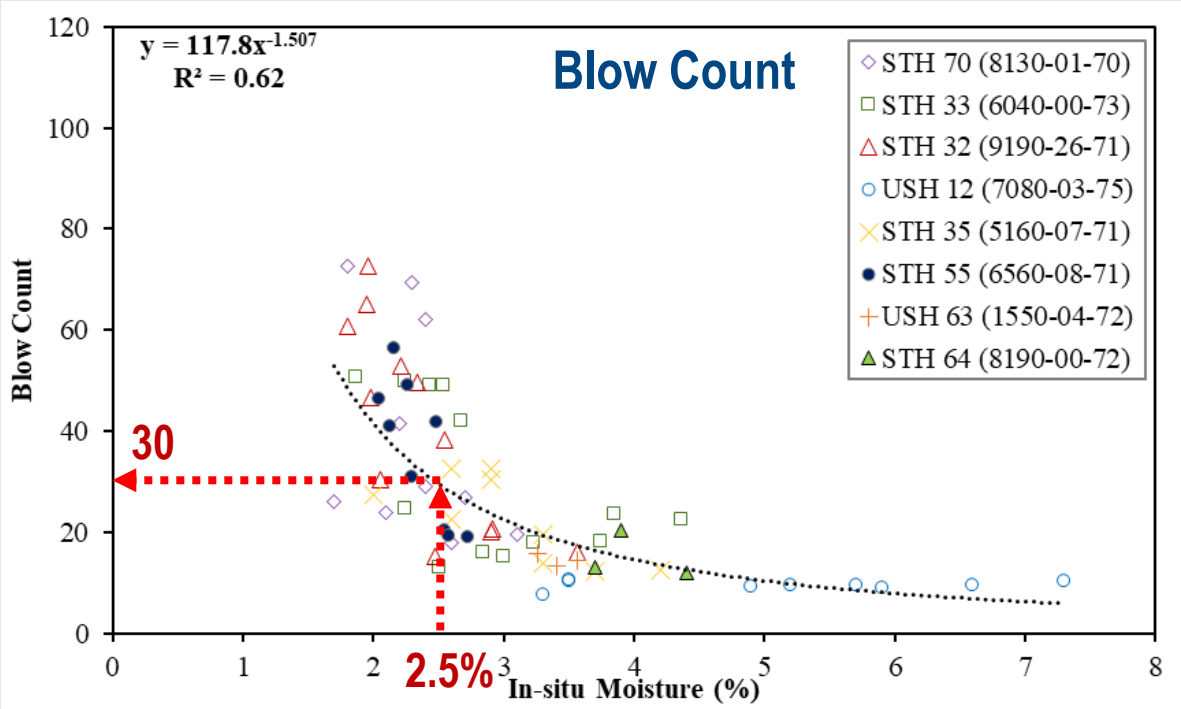
CIR Testing

Measuring Blow Count



Measuring Torque Value

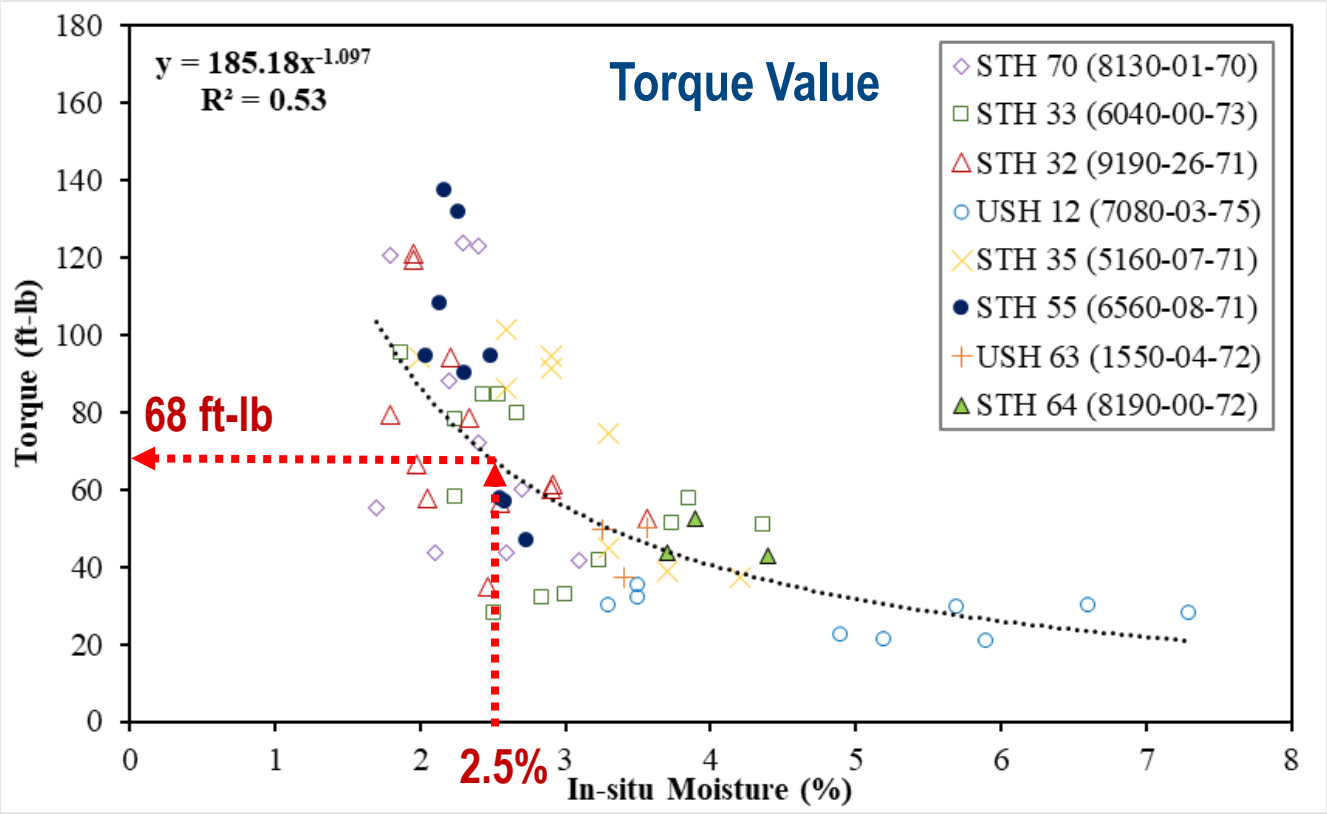
Long-Pin Shear Field Tests



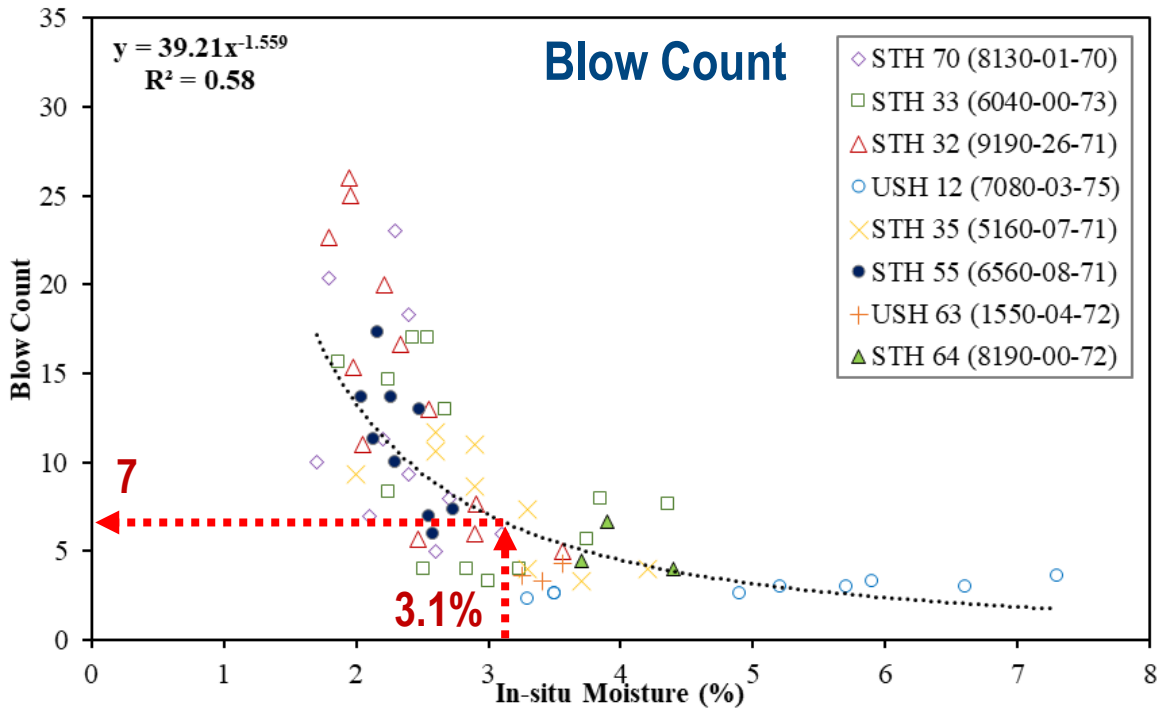
C.7 Curing and Surfacing

C.7.1 Curing

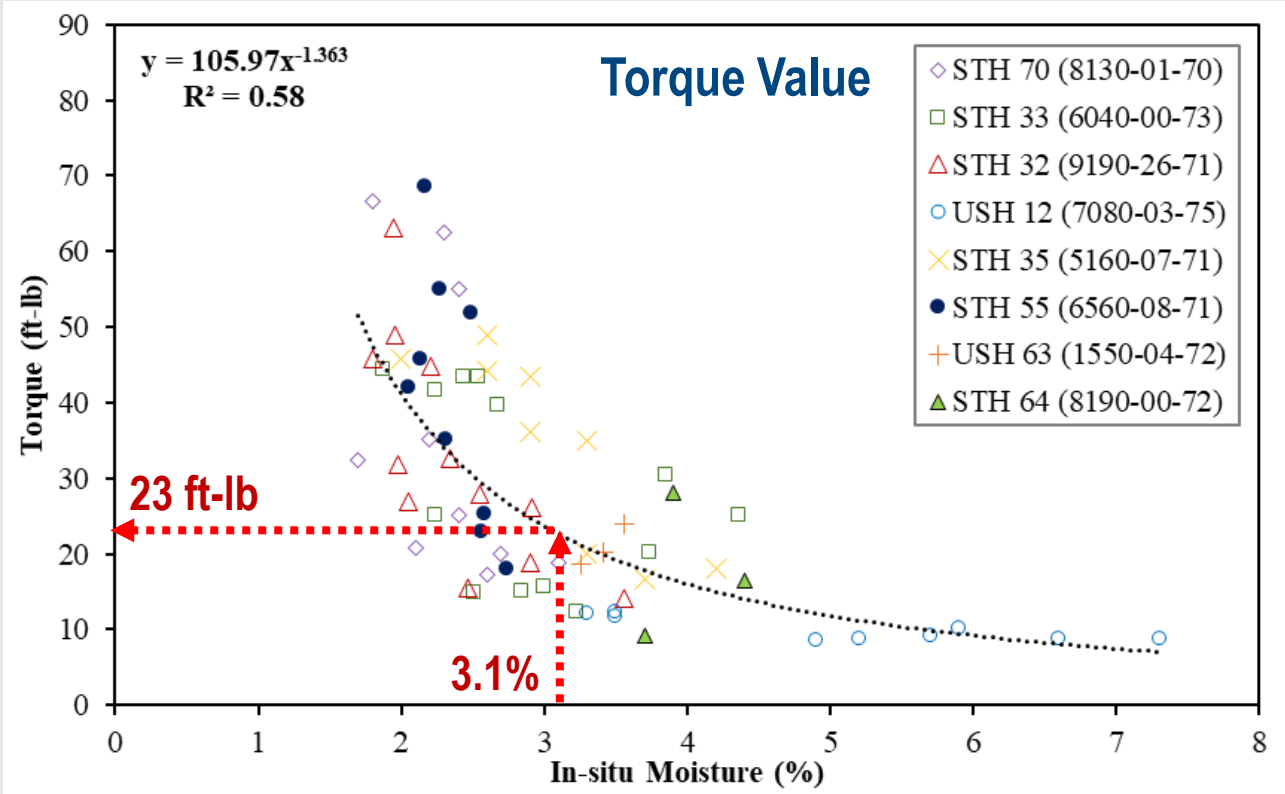
(1) Application of a surface treatment or leveling/lower layer of HMA will not be allowed until the moisture content of the CIR layer reduces to 2.50 percent or less.



Short-Pin Raveling Field Tests



No specification for opening to traffic



- Avg. moisture content from 0-3 hours:
  3.1% (20 data points)
- This moisture content value needs to be verified!

Threshold Values for Wisconsin

Test	Blow Count		Torque (ft-lb)	
	Wisconsin	National	Wisconsin	National
SPR	7	8	23	20
LPS	30	20	68	63

Acknowledgements:

- Brian Diefenderfer (VTRC)
- WisDOT Personnel: Devin Harings, Bredan Dirkes, Andrew Phillips, Matthew Bertucci, Dan Kopacz, Brian Heiden, Travis Maatta, Bryton Meyer, Steve Ames, Cory Mikshowsky, MK Kang, Erik Lyngdal, Adam Albers, Matthew Andreini, Erik Brattlund, Jaime Cynor, and Adam Johnson
- Industry personnel: Bryan Schaller and Robert Meyers Jr (Benesch), John Mueller and Eric Hoel (KL Engineering), Chelsea Seibert (Ayres Associates), and Denise Paddock (Cooper Engineering), and Derek Frederixon (Mathy)

TRB TRANSPORTATION RESEARCH BOARD

Event Type & Number:
Poster Session, # 3099
Event Title:
Asphalt Pavement Construction Compaction and Density, Segregation, and Optimized Cold Milling Operations
Event Date:
Tue 1/10/2023, 10:15 AM-12:00 PM ET
Event Location:
Convention Center, Hall A

Thank You!
QUESTIONS?

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Tirupan Mandal: Tirupan.Mandal@dot.wi.gov