Wisconsin Highway Research Program

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Bureau of Structures and Bureau of Technical Services Engineers

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UW-Milwaukee - Institute for Physical Infrastructure and Transportation
Milwaukee, WI

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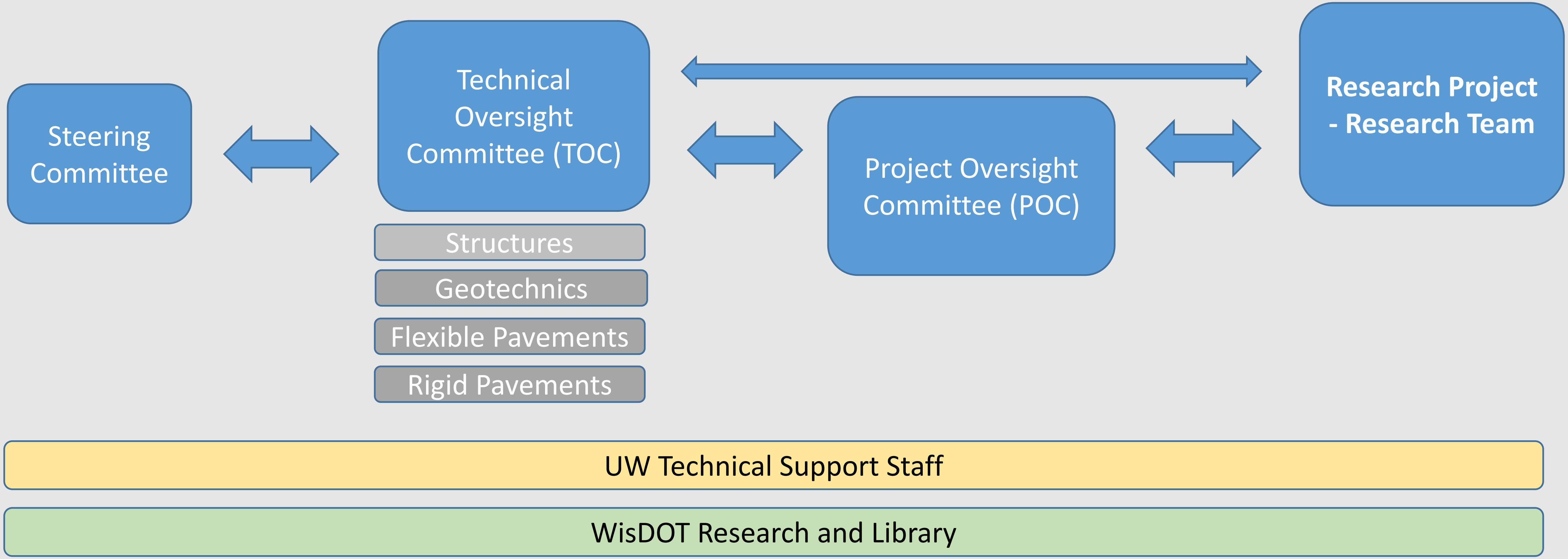
WHRP Overview

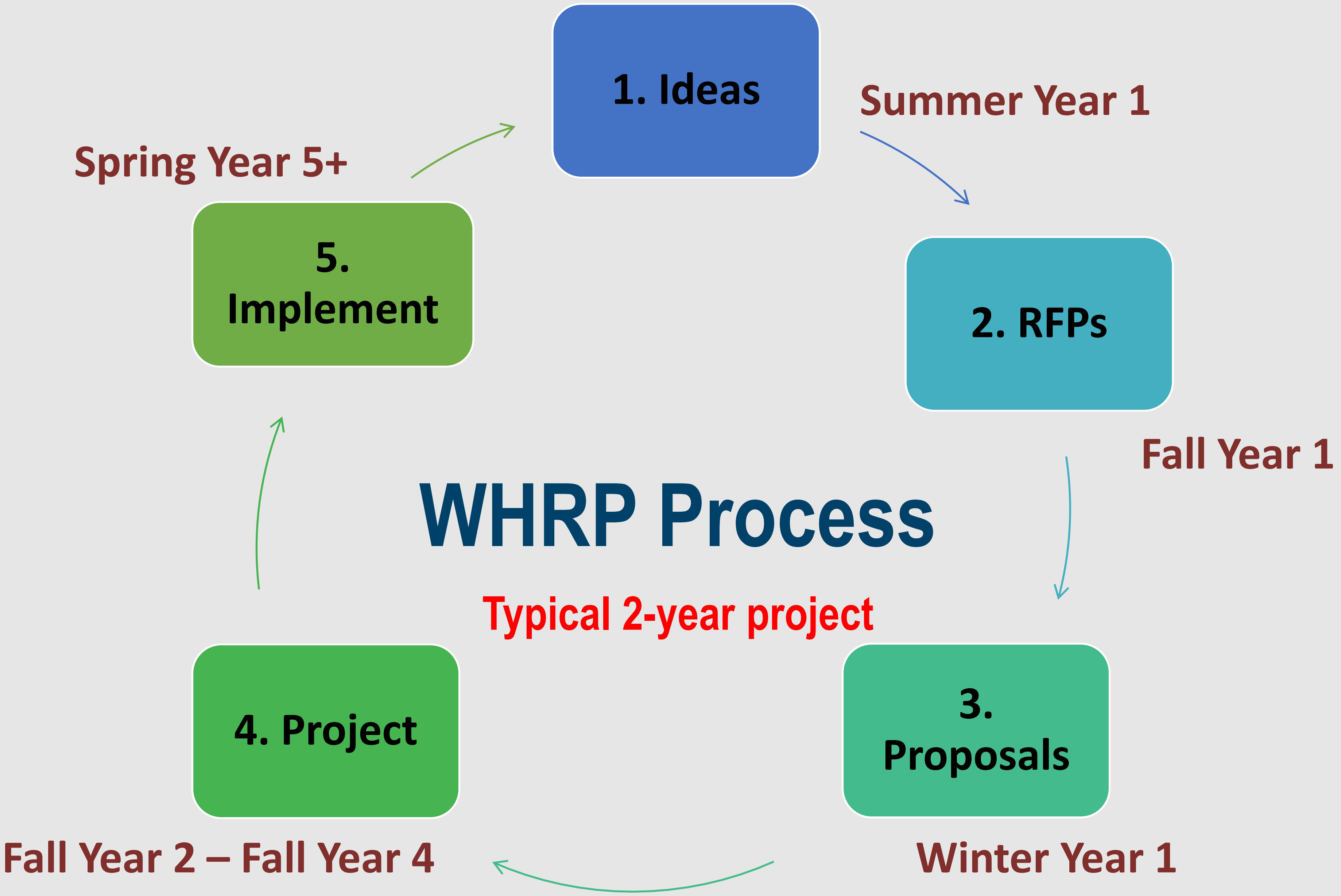
- Established in 1998
- Collaboration with the University of Wisconsin - Madison
- Four research areas
  - Flexible Pavements
  - Rigid Pavements
  - Geotechnics
  - Structures
- GOAL: Practical research → implementable results

WHRP Funding

- WHRP project funding is approximately $1 million annually
- Projects are funded by:
  - 80% FHWA federal funds (SPR, Part B Research), and
  - 20% WisDOT state funds

WHRP Organization




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

Wisconsin Highway Research Program (WHRP)

- Research and Library
- **Research**
  - Wisconsin Highway Research Program (WHRP)
  - Policy Research Program
  - Pooled Fund Research
  - For Researchers
  - Program Documents and Events
  - Find Research Reports
- **Library**
  - Archives
  - History
  - Partners
  - Reading Room
  - Resources

The Wisconsin Highway Research Program was established in 1998 by the Wisconsin Department of Transportation in collaboration with the University of Wisconsin-Madison to discover better ways to design, build and reconstruct the state's highways. WHRP research projects are selected and overseen by collaborative committees that include WisDOT, academia, industry, consulting engineers and the Federal Highway Administration. Through rigorous testing of innovative materials and methods, WHRP research leads to improved performance and service life of Wisconsin's highways.

WHRP

Strategic plan

Steering Committee

Technical Oversight Committee member lists

Outreach

Project details, final reports and technical briefs

- Flexible Pavements
- Rigid Pavements
- Structures
- Geotechnics

Having trouble finding a project? Try our search tool.

Wisconsin Highway Research Program contact Shari Krueger
608-261-6064
shari.krueger@dot.wi.gov

Website: https://wisconsindot.gov/Pages/about-wisdot/research/whrp.aspx

Project Highlight

- *Comparison of Five Different Methods for Determining Pile Bearing Capacities (2007)*
- Resistance factor (ϕ) increased from 0.4 to 0.5
- 25% increase in “allowable” pile capacity
- 2022 pile costs: $8.5M
- Estimated savings: $2.1M (!)
- Research project cost: $34,500 (!)

Geotechnics

Geotechnics
Current Projects

Investigation of MSE Wall Corrosion in Wisconsin

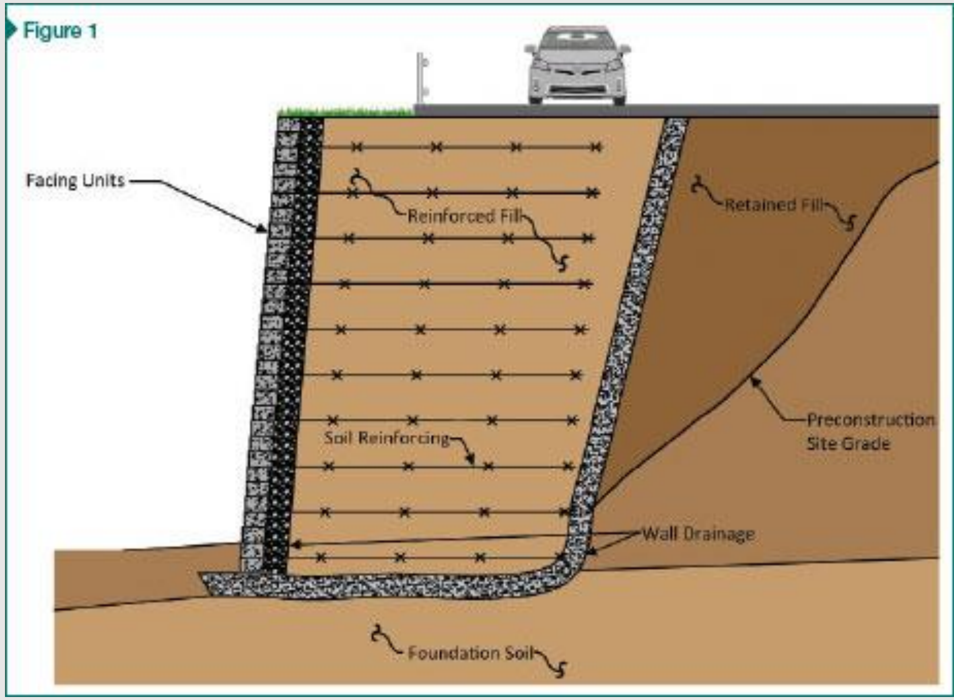
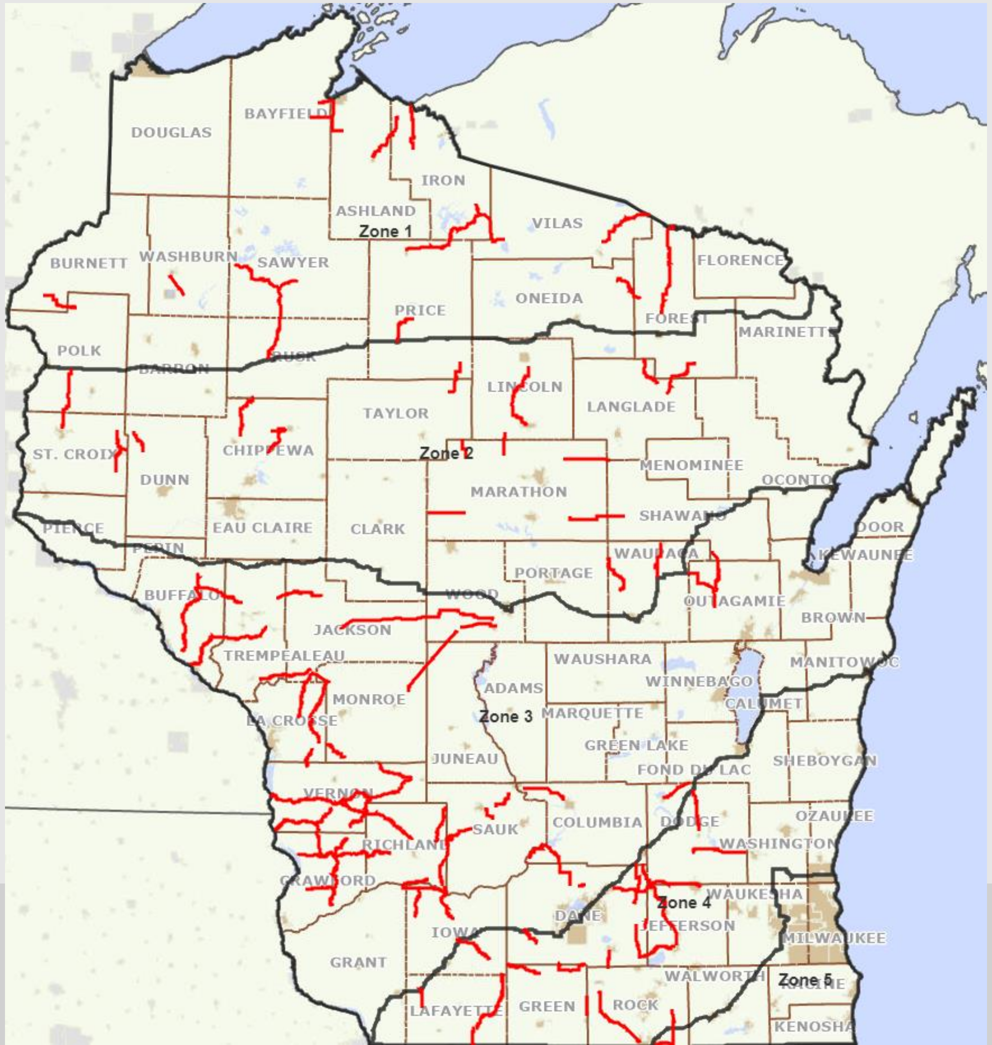


Figure: ConstructionSpecifier.com

Geotechnics
Current Projects

Seasonal Weight Restriction Decision Making based on Understanding and Monitoring Frost Susceptibility of Pavement Structures



Geotechnics
Current Projects

Wind-loaded Structures

Photo: Google Maps

Geotechnics
Current Projects

Weight-volume Relationships for Soils and Conversion Factors for Aggregates

Geotechnics
Recently-Completed Projects

- Aggregate Quality Testing
- MSE Wall Backfill Water Infiltration
- Cut Retaining Wall Evaluation
- Geogrid Strength Testing Standards Evaluation
- Geotechnical Asset Management (GAM) for Slopes

Geotechnical Asset Management for Slopes

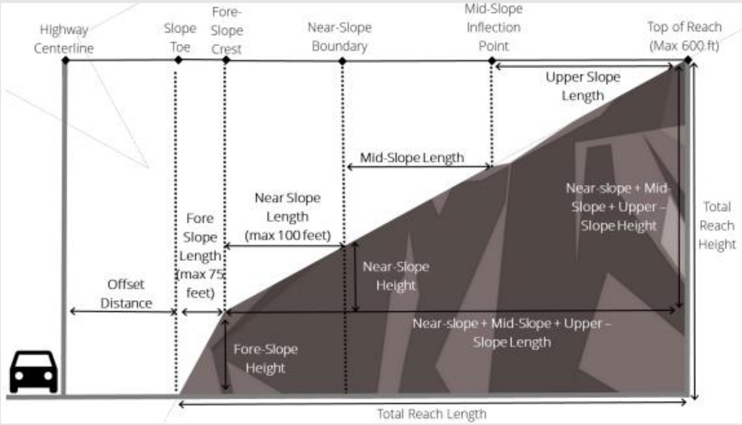
Landslide History

+

Geology Mapping

+

Slope Geometry (From LiDAR)



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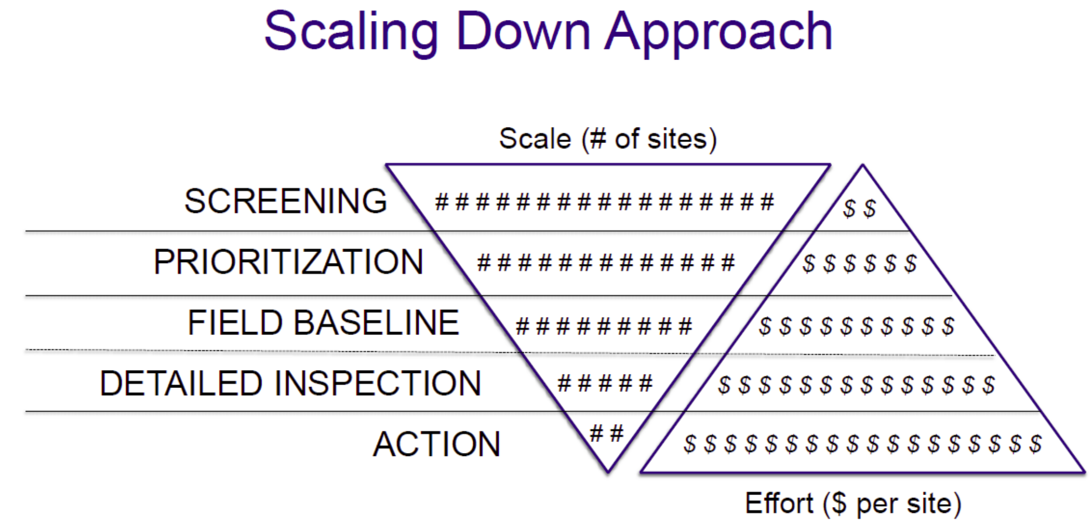
Slope Hazard Rating Map (GIS based)

Prioritize Effort/Resources

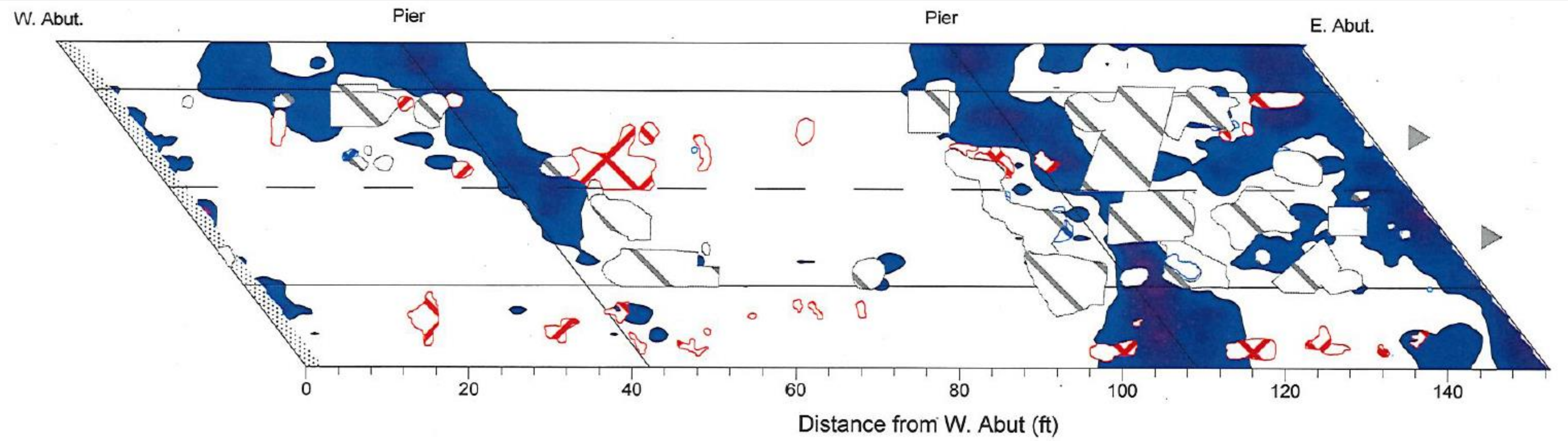


Figures from BGC Engineering, Inc.

Structures

Structures
Current Projects

- Bridge Deck Thermography Verification and Policy

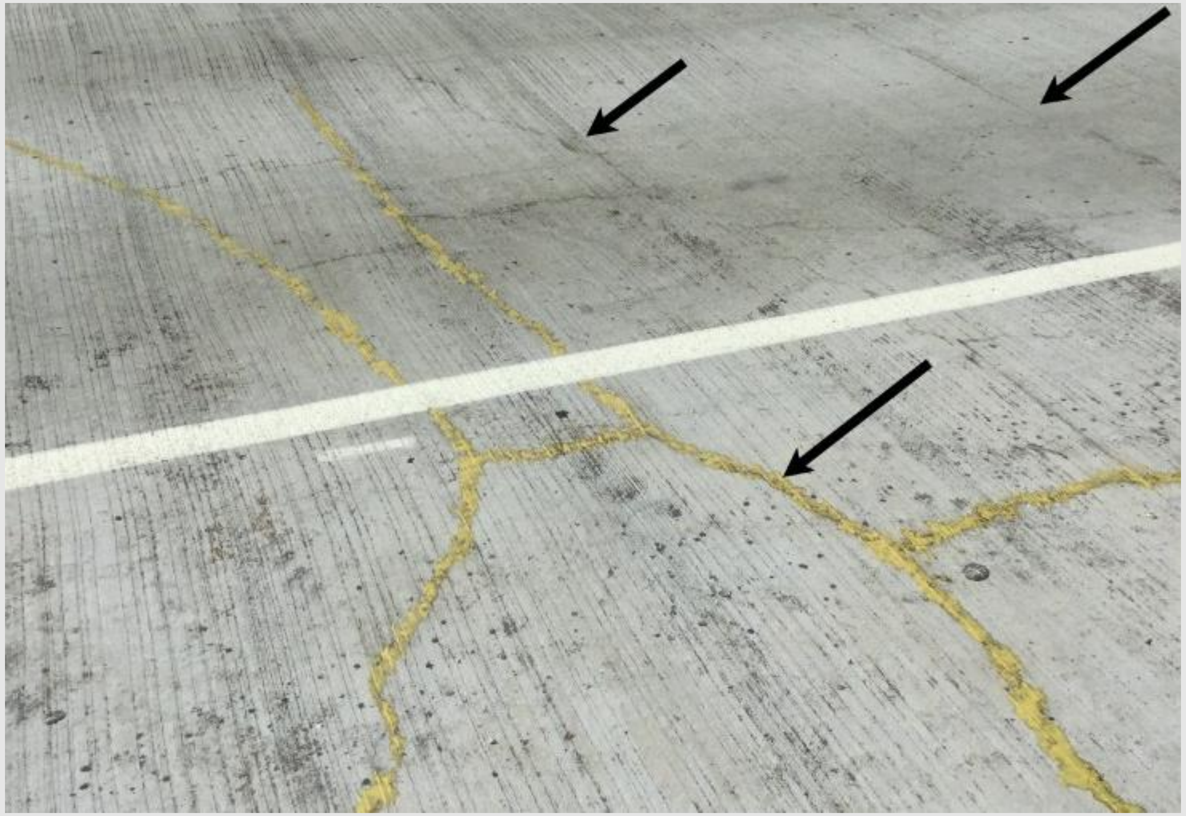


Structures
Current Projects

- Underwater Concrete Pours and Non-Segregating Concrete

Structures
Current Projects

- Improving Bridge Concrete Overlay Performance



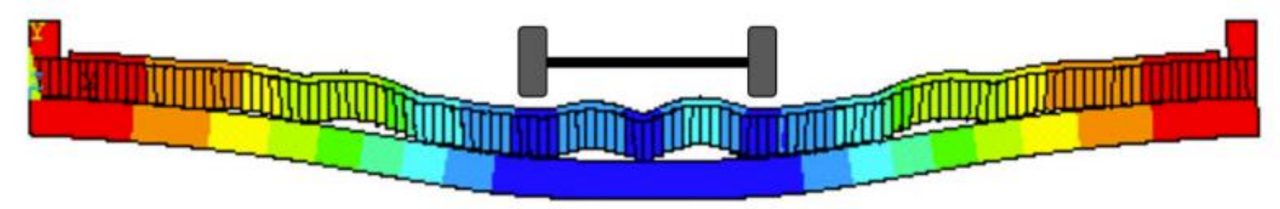
Structures
Recently-Completed Projects

- Optimizing Bridge Abutment Slope Protection at Stream Crossings
- Development of Design Procedures for Concrete Adhesive Anchors
- **Analytical and Testing Methods for Rating Longitudinal Laminated Timber Slab Bridges**

Structures
Project Highlight

Analytical and Testing Methods for Rating Longitudinal Laminated Timber Slab Bridges

- Objective: Develop a more accurate and reliable determination of wheel load distribution
- Research Benefit: Avoided new or lower weight postings (70+/-)



Structures
Project Highlight

Analytical and Testing Methods for Rating Longitudinal Laminated Timber Slab Bridges

- Field Tested 10 Bridges
- Developed 3D FE models
- Parametric Study
- Validated New Equation - Equivalent Strip Width

Rigid Pavements

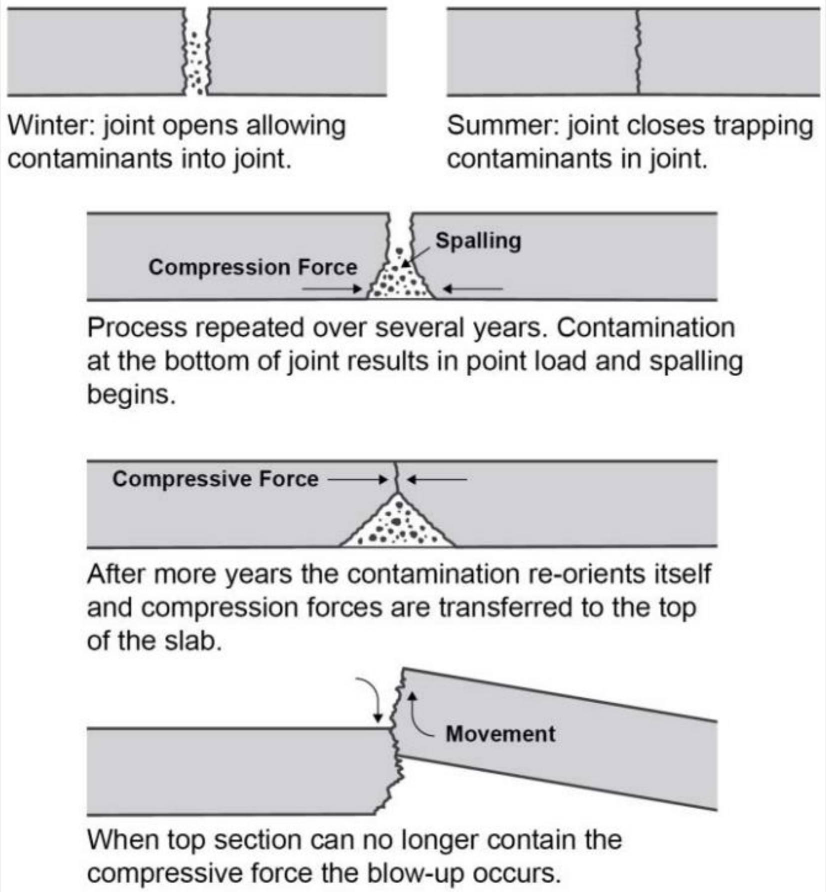
Rigid Pavements
Recently-Completed Projects

- Evaluation of Penetrating Sealers Applied to Saw Cut Faces in Concrete Pavement Joints
- Evaluation of Roadway Concrete Barriers and Materials
- Evaluation of Concrete Pavement Buckling in Wisconsin
- Evaluation of Current WI Mixes Using Performance Engineered Mixture (PEM) Testing Protocols
- Evaluating the Impact of Anti-Icing Solutions on Concrete Durability

What is Pavement Buckling?

- This distress is localized upward movement, typically at or near joints or cracks resulting in associated failure of the concrete

- Commonly known as blowup or blowout



McBride and Decker (1975)

Concrete Pavement Buckling in Wisconsin

98 instances

101 instances

Project Highlight
Evaluation of Concrete Pavement Buckling in Wisconsin

- Project Team:

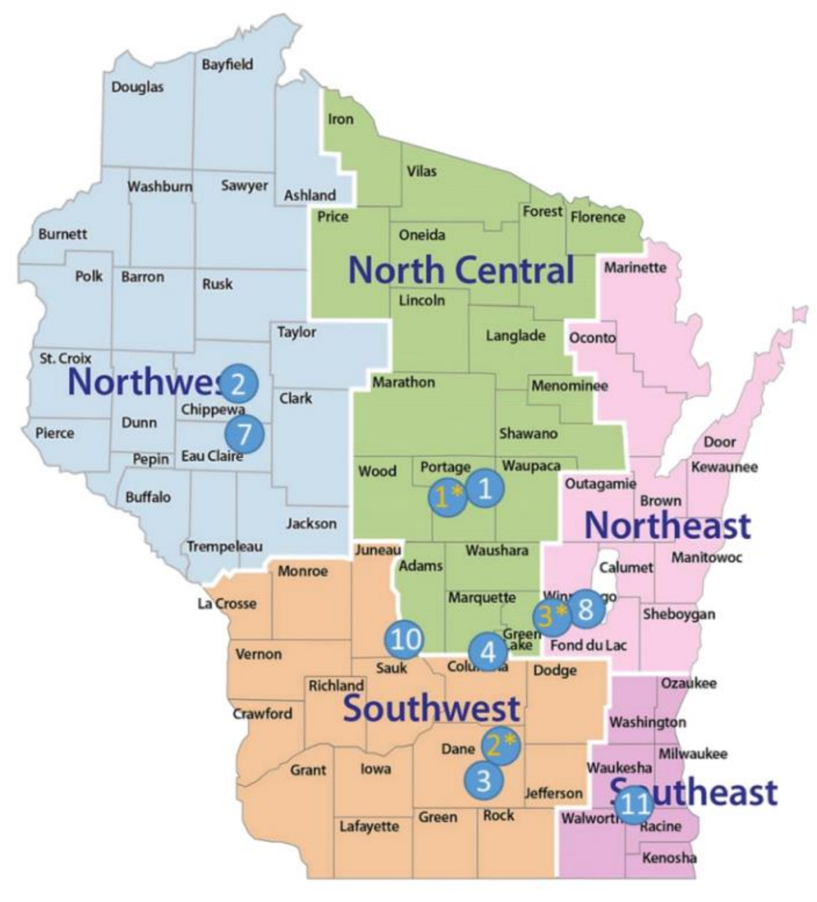
  ARA

- Objectives:
  - ❿Investigate buckling of concrete pavements in Wisconsin roadways
  - ❿Reveal the key mechanisms for buckling in Wisconsin with forensic studies
  - ❿Identify innovative methods to mitigate buckling incidents and associated costs

STH 14, Rock County

Project Highlight
Evaluation of Concrete Pavement Buckling in Wisconsin

- Research included:
  - 8 buckling sites for field forensic investigation
  - 3 control sites
- Factors considered:
  - Thickness
  - Joint Spacing
  - Age of Pavement
  - Shoulder Type



Project Highlight
Evaluation of Concrete Pavement Buckling in Wisconsin

- Field investigation for each site included:
  - Visual inspection
  - Evaluation of joint conditions
  - Coring
  - Evaluation of subsurface drainage system
  - Evaluation of pavement geometrical parameters
  - Pulse induction scanning for dowel alignment

Project Highlight

Evaluation of Concrete Pavement Buckling in Wisconsin

- Data Analysis
  - Statistical Analysis
  - Sensitivity Analysis
  - Analytical Model

Input	Variable
Structural	Joint Spacing
Concrete	Elastic Modulus, E
	Thickness, h
	Poisson's Ratio, ν
	CTE, α
	Unit Weight, γ
Concrete/Base Interface Shear (GB)	Steady-State Friction, τ_o
	Slippage, δ_o
Concrete/Base Interface Shear (CSB)	Steady-State Friction, τ_o
	Slippage, δ_o

Project Highlight
Evaluation of Concrete Pavement Buckling in Wisconsin

- There is no “design procedure” to prevent buckling as there is for other distress types
- Buckling as a distress type is an incredibly rare event as compared to other distress types
- Risk of buckling is highest during the highest temperatures and moisture contents of the slab, which occurs during the hot and humid summer afternoons following days of precipitation

Project Highlight

Evaluation of Concrete Pavement Buckling in Wisconsin

- There are several factors impacting buckling:
  - Temperature and humidity of concrete slab
  - Higher CTE values
  - Incompressibles that infiltrate joints
  - Distresses at transverse joints and cracks
  - Longer joint spacing
  - Thinner concrete slabs (<7 inches)
  - Concrete pavements with unpaved shoulders (gravel or turf shoulders)

Rigid Pavements
Current Projects

Proactive Prevention of Pavement Buckling

- Objectives:
  - Develop an updatable mechanistic model to predict buckling
  - Identify the characteristics that contribute to significant and non-significant consequences resulting from buckling
  - Assess buckling vulnerability through the WisDOT's network using the developed mechanistic model
  - Recommend a set of mitigating and proactive repair strategies at the most critical sites in Wisconsin

Rigid Pavements
Current Projects

- Field Investigation of Dowel and Tie Bar Placement
- Timely and Uniform Application of Curing Materials
- Chemistry and Performance of Supplementary Cementitious Materials (SCMs) for Wisconsin Concrete Pavement
- Alternative Conditioning Method to Calculate Formation Factor for Wisconsin Concrete Pavement

Flexible Pavements

Flexible Pavements
Active/Recently Completed Projects

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

Benchmarking Delta Tc (ΔTc) for Wisconsin Materials

Project Team:

RUTGERS THE STATE UNIVERSITY OF NEW JERSEY

abatech consulting engineers

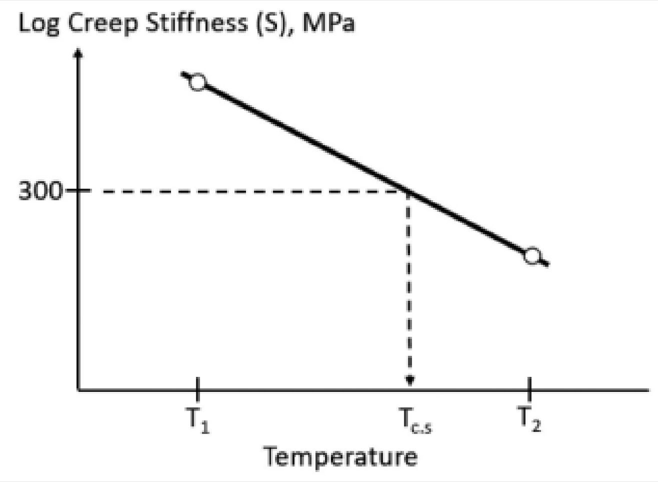
Objective:

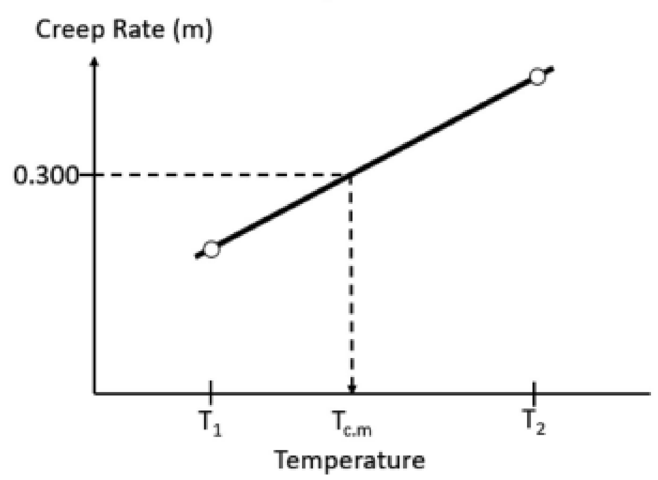
- Evaluate the use of the ΔTc parameter to help predict the non-load-related cracking susceptibility of Wisconsin asphalt mixtures, including recycled asphalt binders and rejuvenators
- Use past research to standardize, validate, and recommend an aging procedure prior to measurement of ΔTc

Benchmarking Delta Tc (ΔTc) for Wisconsin Materials

Objective (Contd.):

- Compare the bench marking results of study 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

Balanced Mixture Design (BMD) 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

BMD 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

BMD Implementation Support

Suggested Preliminary Performance Test Criteria

<table>
<tr><th rowspan="2">Traffic Level</th><th colspan="2">HWTT*</th><th>IDEAL-CT#</th><th>DCT#</th></tr>
<tr><th>CRD_{20k} (mm)</th><th>SN (passes)</th><th>CT_{Index}</th><th>G_f (J/m^2)</th></tr>
<tr><td>SMA Mix</td><td rowspan="2">$\leq$ 6.0</td><td rowspan="4">$\geq$ 2,000</td><td>$\geq$ 80</td><td>$\geq$ 400</td></tr>
<tr><td>HT Mix</td><td rowspan="3">$\geq$ 40</td><td rowspan="3">$\geq$ 300</td></tr>
<tr><td>MT Mix</td><td>$\leq$ 7.0</td></tr>
<tr><td>LT Mix</td><td>$\leq$ 8.0</td></tr>
</table>

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

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

BMD 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 balanced mix design pavements

BMD 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

BMD 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
  - <u>Expected completion:</u> November 2023

Thank you!

Any Questions?