MnROAD Research on Additives

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DEPARTMENT OF TRANSPORTATION

MnROAD
SAFER, SMARTER, SUSTAINABLE PAVEMENTS THROUGH INNOVATIVE RESEARCH

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MnROAD's Mission Statement (Michael's Version)

- *Our goal is to provide safe, long-lasting pavements that cost less to the taxpayer and the environment.*

Outline

- **Asphalt Additive = anything in mix other than binder or aggregates**
- “Additives”- 2022 MnROAD NCAT Additive Group
  - Recycled plastic; Ground Tire Rubber; Aramid Fibers; SBS Polymer
- “Warm Mix” – 2008 MnROAD and Upcoming RFP
- “High RAP / Recycling Agents” 2019 – Mix Rejuvenator Test Sections

MnROAD Additive Group

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MnROAD / NCAT Partnership

≈2015- Formalized Partnership working on National Needs:

- Full scale accelerated test facilities
- North / South Climatic Zones / Sections
- CAPRI (NCAT Lead National HMA Consortium)

2015-2021 - **Cracking Group Experiments**

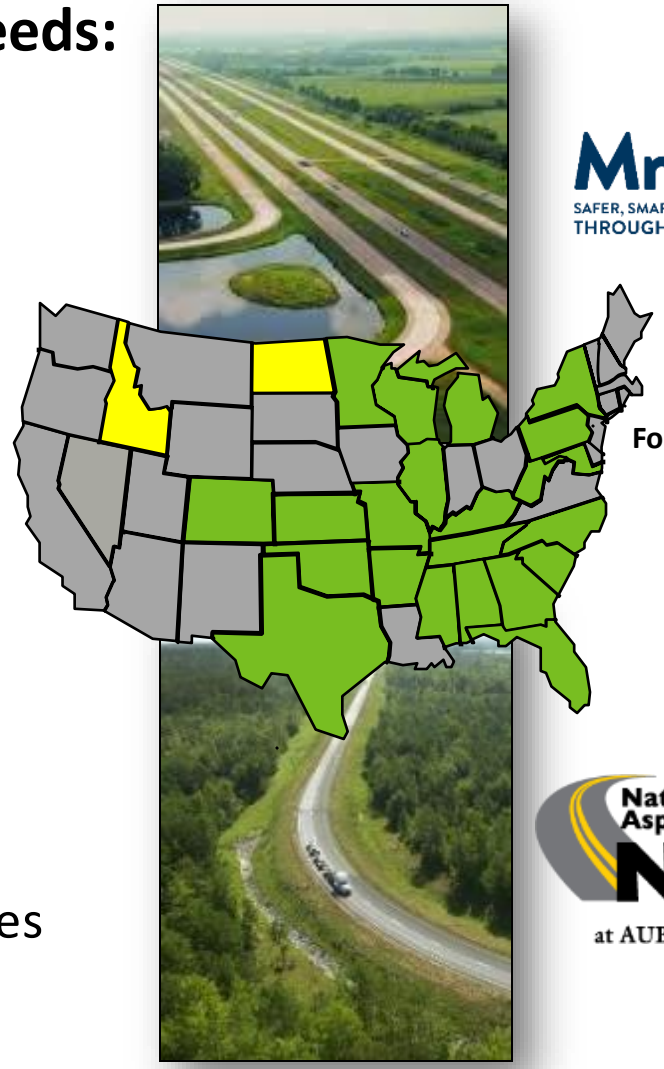
- 6 year of partnership with 10 Government Agencies
- HMA cracking test for LTC and fatigue cracking

2021- present - **Additive Group Experiment**

- NCAT focus on fatigue cracking
- MnROAD focus on Reflective Cracking
- Continued National Research Coordination

2012- present - **Preservation Group Experiments**

- Life extending benefits of pavement preservation techniques
- 8 year of partnership with over 24+ agencies
- Developing next phase – starting in January 2024



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Foundation for Pavement Preservation

Industry members

FHWA

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

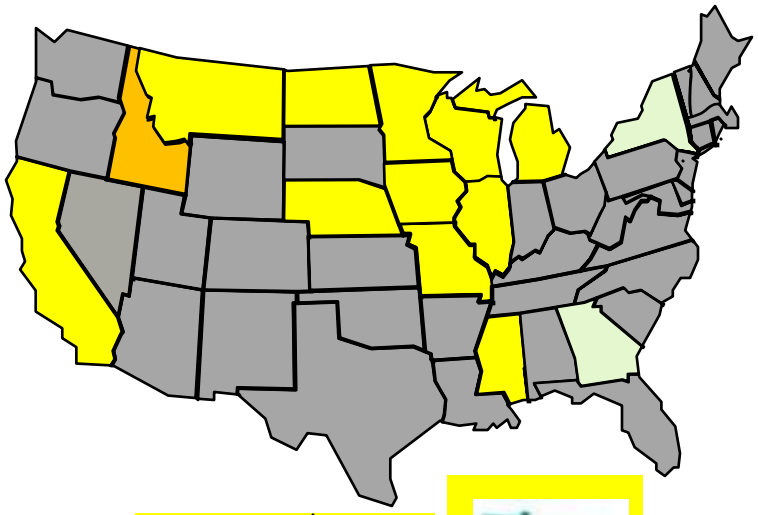
Sponsor Recognition

- **MnROAD Reflective Cracking Challenge**
  - Designed to simulate HMA overlay conditions (majority of DOT paving efforts)
  - **MnROAD / NCAT Additive Group (NY participation)**
  - NRRA research contract awarded to University of New Hampshire
    - Dr. Ben Bowers is sub-contractor for LCA Companion test sections on NCAT Test Track (2021) and in Missouri (2023)

mr

National Road Research Alliance

- TPF-5(466) - Fee Structure / year (five years)
  - Phase-1 complete (5 yr) – Now into Phase-2 (year 3/5)
  - 14 Full Agency Commitments (yellow)
    - $75K /$150K Annual Commitment
    - 12 States, Illinois Tollway, LRRB
    - FHWA is also a contributing partner
- 2 ICT Commitments (Green)
  - $25K (ICT Team only – Veta Efforts)
  - GA and NY
- ~85+ Associate membership
  - 2K/year - Associations, Industry, Consultants, Universities
  - Upper Great Plains Transportation Institute



Illinois Tollway

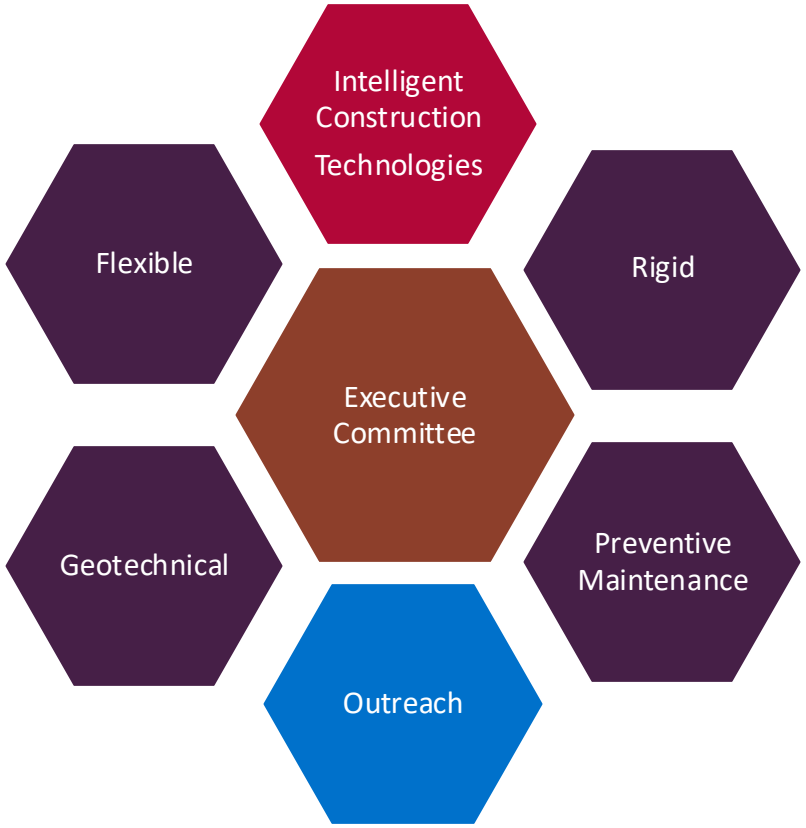
U.S. Department of Transportation Federal Highway Administration

LRRB Local Road Research Board

National Road Research Alliance Overview

- **Organizational Structure**
  - Executive Committee (2 reps/agency)
  - 5 Technical Teams (agency and associate reps)
    - Technical Chairs
    - MnDOT Representative
  - MnROAD Facility Utilized

  - Outreach is done in the technical teams
    - Lauren Dao, MnDOT



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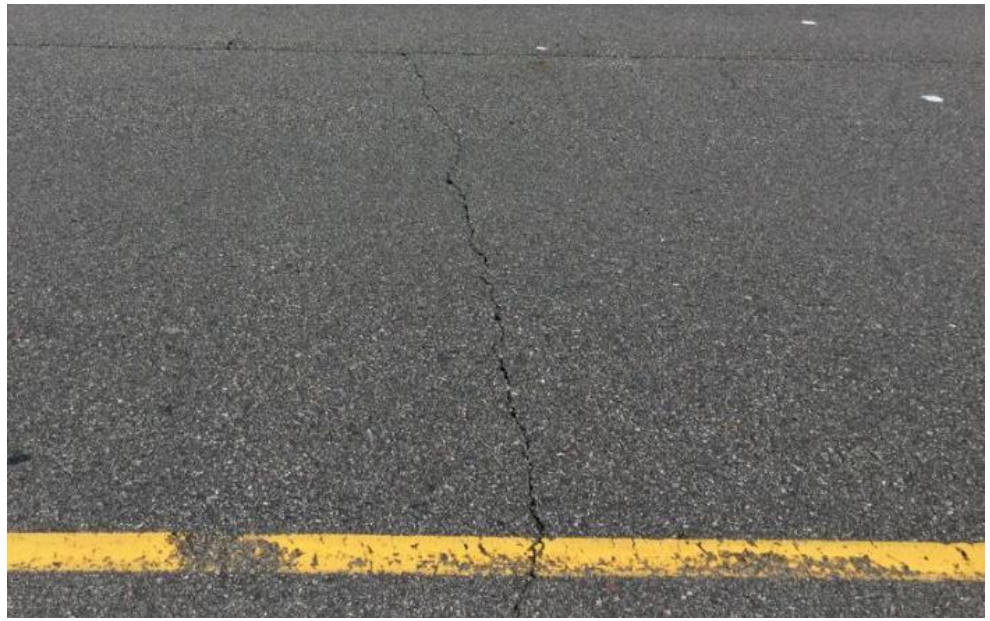
MnROAD- Minnesota Road Research Facility

2022 MnROAD Reflective Cracking Challenge

- **Experiment designed to better match research to MnDOT network applications**
  - BOB = bituminous over bituminous ~50% network

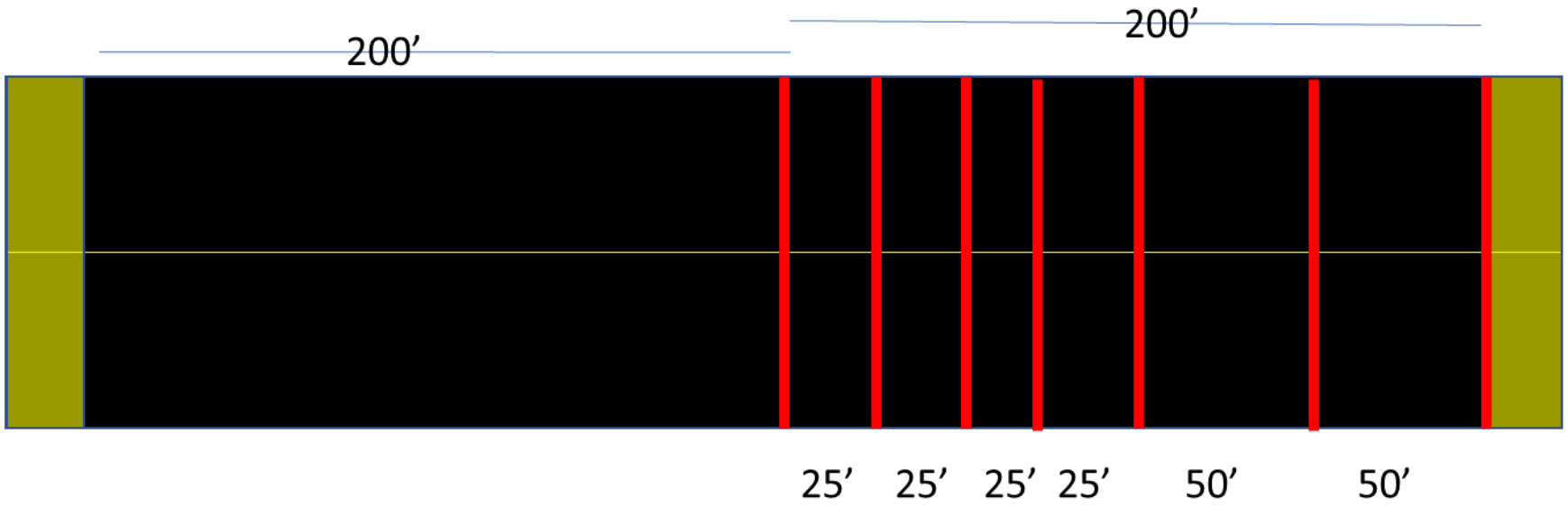


Statewide (All Districts)

Pavement	Percent	Miles
BIT	12%	1,682
BOB	50%	7,104
BOC	22%	3,136
CON	17%	2,377
CRCP	0%	2
All	**100%**	**14,301**

Pavement	PQI	RQI	SR
BIT	3.6	3.5	3.8
BOB	3.3	3.2	3.4
BOC	3.4	3.3	3.6
CON	3.6	3.4	3.9
CRCP	3.8	3.6	4.0
All	**3.4**	**3.3**	**3.6**

MnROAD Reflective Cracking Challenge



2.0” Unique Surface	
1.5”	PG 58S-28
2.5”	PG 58S-28

- Paved 450’ per section
- 200’ reflective cracking
- 200’ conventional

MnROAD Reflective Cracking Challenge

Transverse Saw Cuts

2.5” PG 58S-28	2.5” PG 58S-28
2.5” PG 58S-28	2.5” PG 58S-28

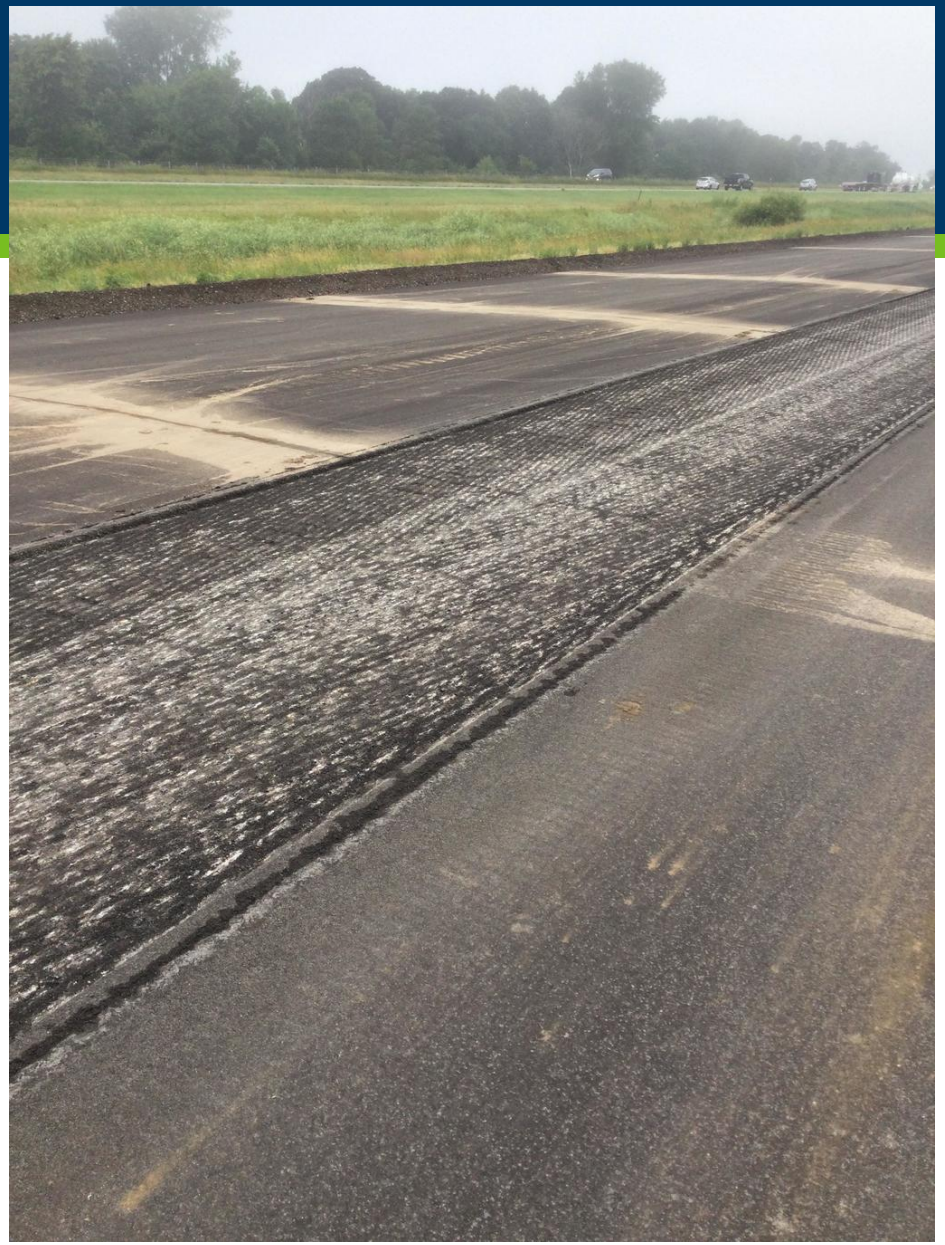
Milled surface

1.5” PG 58S-28
2.5” PG 58S-28

2.0” Unique Surface
1.5” PG 58S-28
2.5” PG 58S-28

Saw-cutting

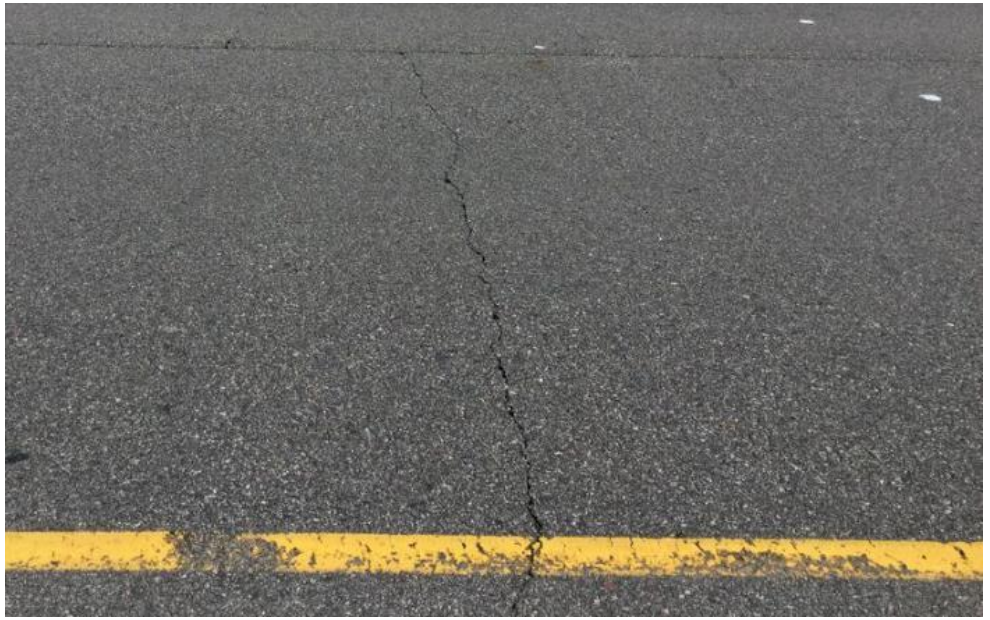
- Full depth (5”) saw cuts were made 24’ through travel lanes
- Cuts were minimally cleaned with leaf blower and wire
- No cleaning after milling



Surface HMA Mix Details

- **10 Sections with differing surface HMA**
  - Controls
    1. PG 58H -34 (modified) **2239**
    2. PG 58S -28 (unmodified) **2230**
    3. PG ~49 -34 (unmodified) **2238**
  - Additive Sections
    4. Aramid Fiber 1 w/ PG 58H -34 (modified) **2233**
    5. Aramid Fiber 2 w/ PG 58H -34 (modified) **2234**
    6. Dry Plastic Additive w/ PG ~49 -34 **2236**
    7. Dry Rubber Additive w/ PG ~49 -34 **2237**
    8. Wet Plastic Additive **2232**
    9. Wet Rubber Additive **2235**

    w/ PG 52-34 from Mathy
  - Super Pave 5.0
    10. PG 58V -34 (modified) (NRRA) **2231**



- **All mixes contain**
  - MnDOT Traffic Level 5 (10<30 mESALS)
  - Superpave Gyratory BMD
  - ¾” Max Agg (SP 12.5mm)
  - 20% RAP

Contractor and HMA Plant

- Great collaboration/ buy-in from paving contractor (C.S. McCrossan) and HMA plant (Martin Marietta – Elk River Plant)
- Additive Group Mix was procured separately from MnROAD I-94 paving contract
  - Allowed for early collaboration with MnROAD, plant (MM), and NCAT

NCAT Testing and Monitoring

- Buzz Powel and Nathan Moore at HMA plant (40 minutes from MnROAD)
  - Dialing in mix
  - Plant energy usage
- Suri Giaganti at MnROAD

Equipment		MTV	Paver	Static wheel roller	Pneumatic tire roller	Vibratory roller
Rated Power, kW		300	225	137	133	142
Operating Fuel Consumption Rate, gal/hr.		15.0	3.6	3.3	1.6	3.3
Idling Fuel Consumption Rate, gal/hr.		5.3	0.9	0.8	0.5	0.9
2239	Operating time, min	41	47	51	62	22
	Idle time, min	41	33			
2238	Operating time, min	50	48			

Cell ID	Mix ID	Natural gas consumption, ft^3/sh.ton	Electricity, kWh/sh.ton
2239	Control (PG 58H-34)	192.0	2.17
2238	Control (PG 58S-28)	187.8	2.17
2237	Dry Rubber	196.0	2.17

Field Performance through Fall 2024

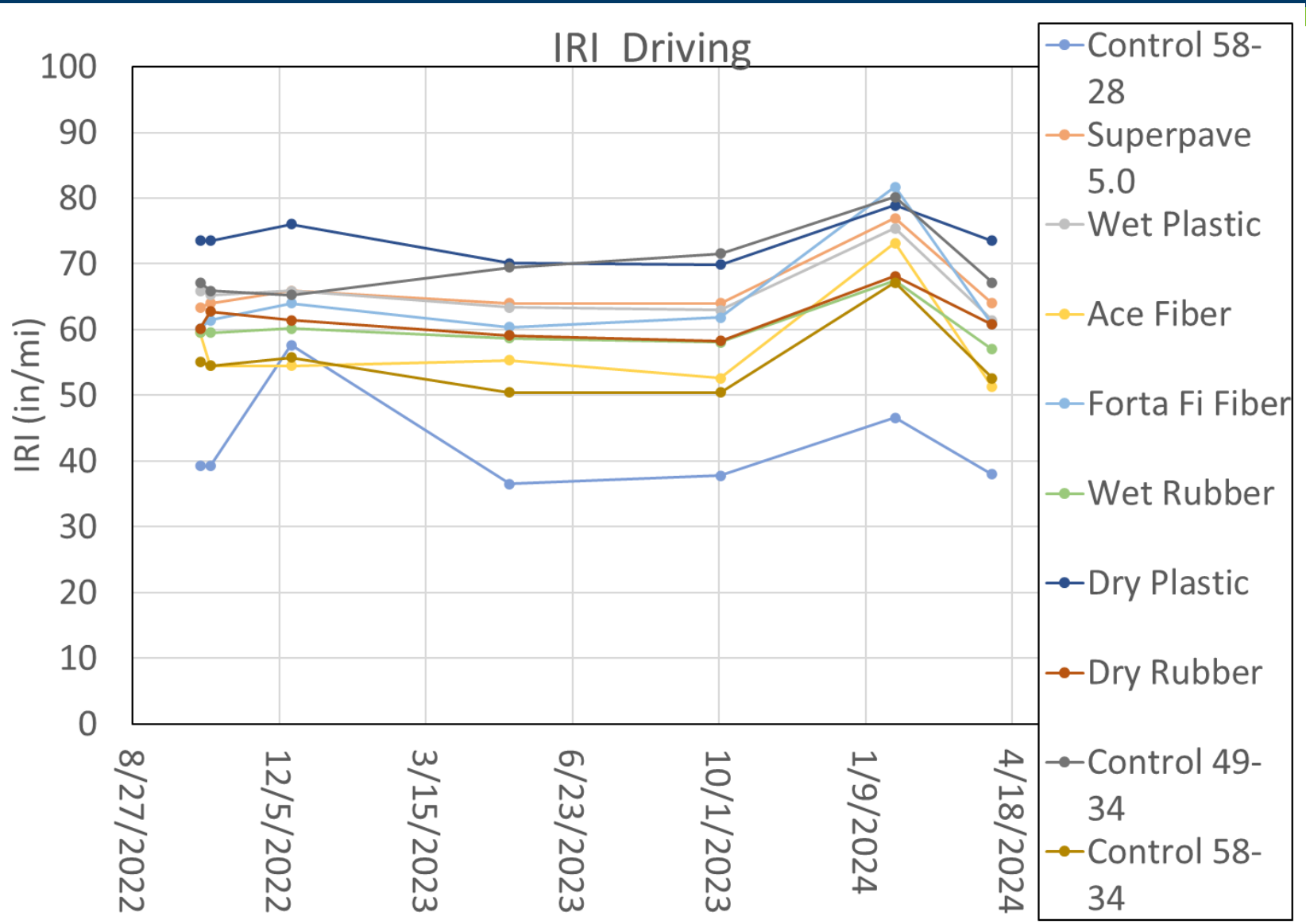
- No cracks
- Smooth ride
- No ruts

- **21 months of traffic**
- **Mild winter 2023-2024**
- **Some of summer 2023/2024 high temp days did not have traffic on mainline**
- **Past experiments show 2-3 years before cracking**

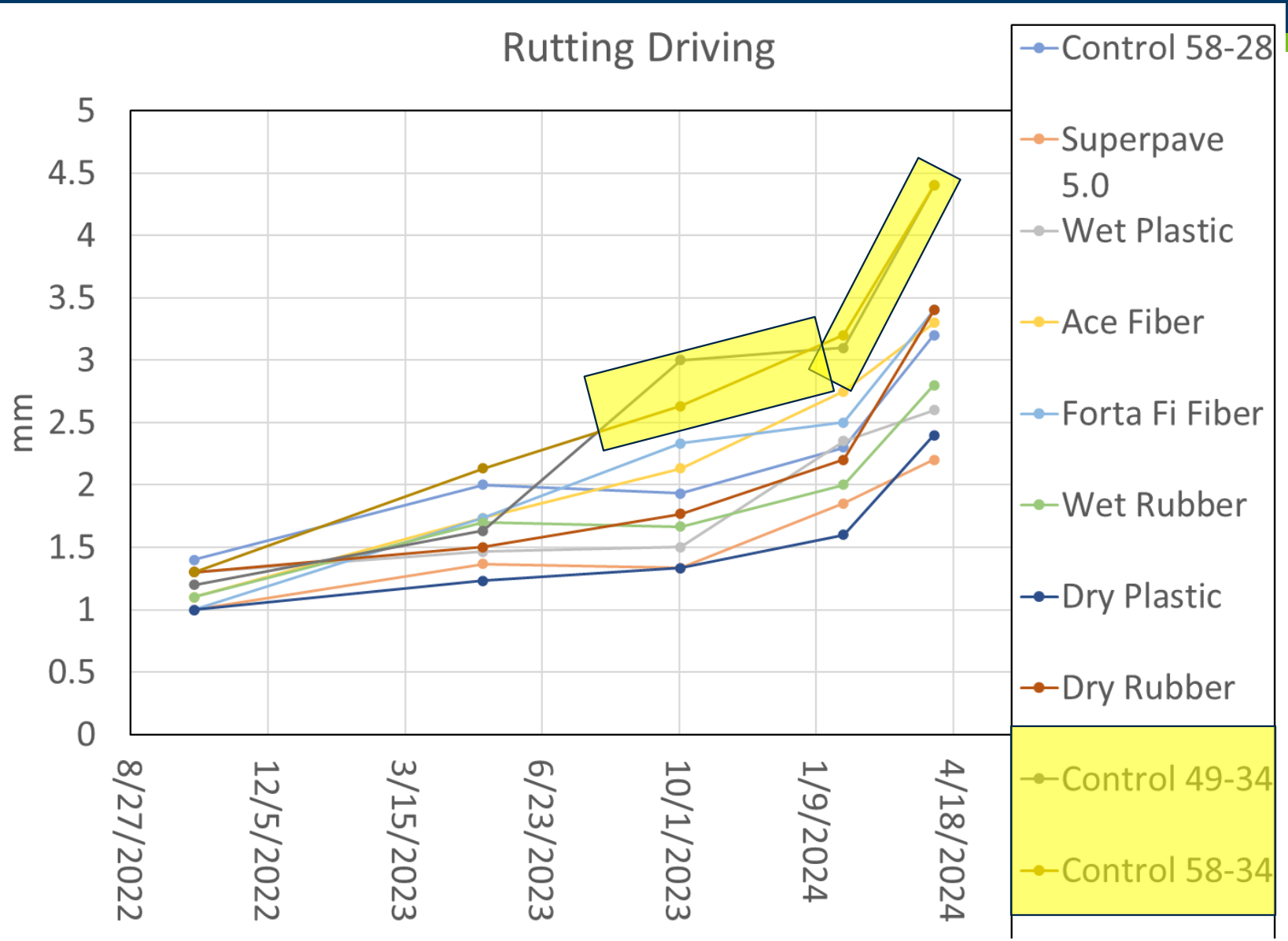
Rutting and Ride Data Collection

- Upgraded Pavement Condition Survey Vehicle
  - Pathway Van is now a Truck
    - Improved Laser Density
    - Single 3D Laser for Lane Width (Eliminates Noise From Laser Overlap Midlane)
  - New Software Package (with New Glitches)
    - Fine Tuning Needed

Performance - Ride



Performance - Rutting

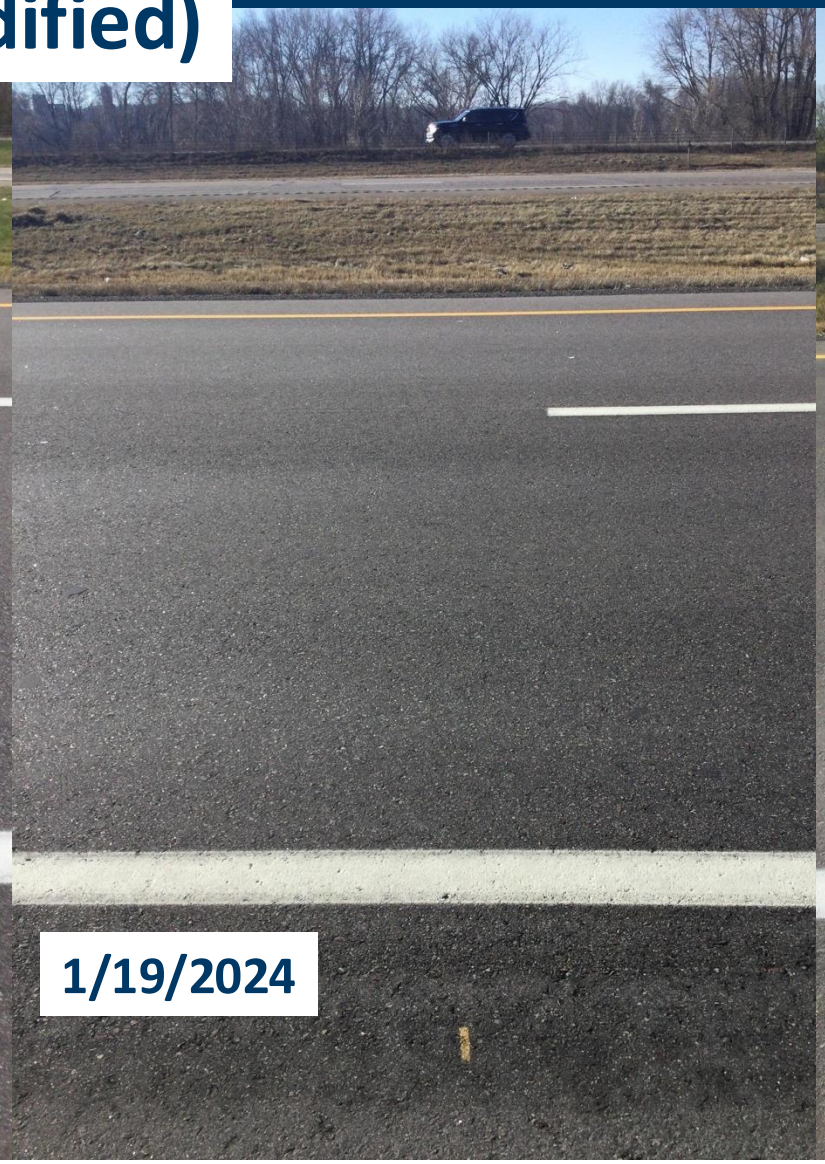


Performance - Rutting

Performance - Rutting

Performance- Cracking

2238 – XX-34 (unmodified)



Performance- Cracking

2232 – 52-34 (wet plastic additive)

11/6/2023

1/31/2024

10/09/2024

Performance- Cracking

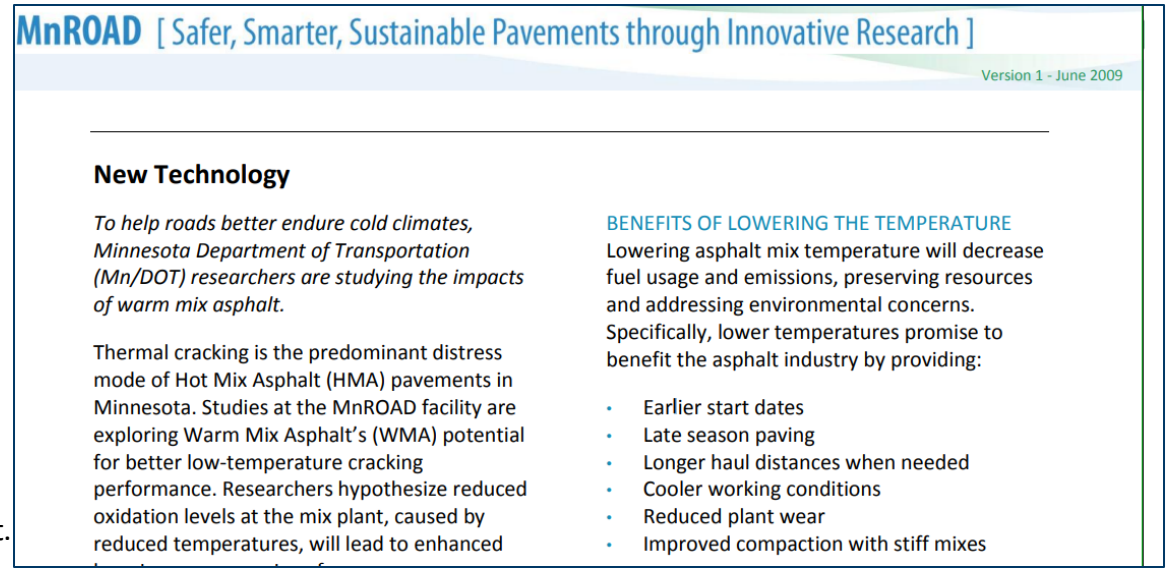
2230 – 58-28 (unmodified)

MnROAD NCAT Additive Group Project Takeaways

- HMA Plant able to accommodate additives with minimal disturbance
  - Martin Marietta – Elk River
  - Hi-Tec Asphalt Feeder system for dry process
- Good initial performance
- Waiting on field distress
- UNH / NCAT/ MU extensive laboratory testing being conducted
- LCA documented for each additive section
- Investigation into from MnROAD is not MnDOT Endorsment

Warm Mix Asphalt in Minnesota

- Used successfully for over 15 years
- More commonly used as compaction aid
- Research has shown promising performance in Minnesota; MnROAD 2008
- Crow Wing County successfully specifies reduced production temperatures



MnROAD [Safer, Smarter, Sustainable Pavements through Innovative Research]

Version 1 - June 2009

New Technology

To help roads better endure cold climates, Minnesota Department of Transportation (Mn/DOT) researchers are studying the impacts of warm mix asphalt.

Thermal cracking is the predominant distress mode of Hot Mix Asphalt (HMA) pavements in Minnesota. Studies at the MnROAD facility are exploring Warm Mix Asphalt's (WMA) potential for better low-temperature cracking performance. Researchers hypothesize reduced oxidation levels at the mix plant, caused by reduced temperatures, will lead to enhanced

BENEFITS OF LOWERING THE TEMPERATURE

Lowering asphalt mix temperature will decrease fuel usage and emissions, preserving resources and addressing environmental concerns. Specifically, lower temperatures promise to benefit the asphalt industry by providing:

- Earlier start dates
- Late season paving
- Longer haul distances when needed
- Cooler working conditions
- Reduced plant wear
- Improved compaction with stiff mixes

Warm Mix Asphalt in Minnesota

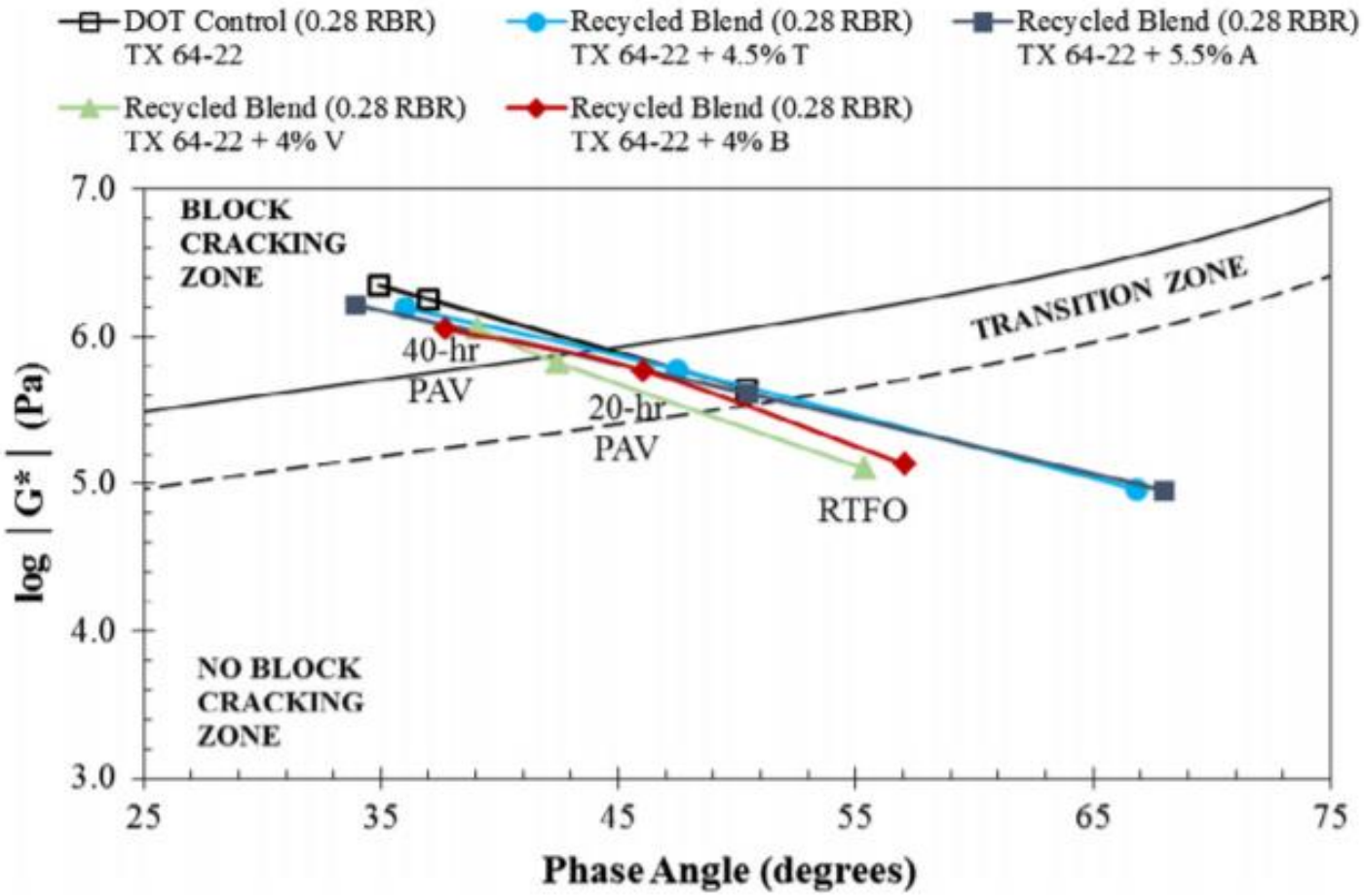
- 2025 Construction season MnDOT WMA Incentive
- NRRA Study - *Field Validation of Using Warm Mix Asphalt at Reduced Production Temperatures for Balanced Mix Design*
  - BMD with +oil versus BMD +WMA
  - Field project in Texas; + 2 more sites in 2025 (VA & MO)
  - National Center for Asphalt Technology – Dr. Fan Yin
  - Ingevity – Jenna Bowers (Industry Partners)
- MN LRRB Study
- MnDOT Research looking for 2025 projects

High RAP and Rejuvenators

Asphalt Mix Rejuvenators - General

- General term “Rejuvenator” used in this project
  - Proper name is Recycling Agent (RA)
- Used to increase recycled (RAP or RAS) content in mix
- Different products (and sources) behave differently
- “Rejuvenator” vrs. “softener”

Asphalt Mix Rejuvenators - General



Arambula, Edith & Kaseer, Fawaz & Epps Martin, Amy & Yin, Fan & Garcia Cucalon, Lorena. (2018). Evaluation of recycling agent dosage selection and incorporation methods for asphalt mixtures with high RAP and RAS contents. Construction and Building Materials. 158. 432–442. 10.1016/j.conbuildmat.2017.10.024.

Asphalt Mix Rejuvenators - Background

- Rejuvenators/Recycling Agents have been around for while but have recently gained more attention with bio-products entering the market
- Many producers, sources, and sales-representatives
- Varying performance and recycled content allowed
- NCHRP research on lab testing and dosing; field project ongoing
- Limited field performance available

Project Objectives

NRRA Flexible Team wanted to answer:

1. Can mix rejuvenator be incorporated into the HMA plant and construction process?

2. How well do these products perform in real world conditions?

3. What are rejuvenators doing to our asphalt and how long does it last?

Project Details

TH6 from south of Emily to Outing, MN

- 5 inch existing asphalt
- 2 inch mill and fill
- 1.5 inch wearing course overlay (SPWEA340B)
  - Rejuvenators in this lift only
- All Research Sections placed in southbound direction

Coordination

- Rejuvenator producers paid Anderson Brothers directly for construction delays and plant upgrade ($63,000/7 participants = $9,000 each)
- NRRA agencies to do mix testing
- Flexible Team $100,000 for performance analysis and binder testing (RFP currently open)

Field Sections

Not a direct comparison or ranking of product performance but a comparison to control


KRATON


Cargill


ingevity


POET
Energy inspired.


NRRA
National Road Research Alliance


GP
Georgia-Pacific


UNITED
SOYBEAN
BOARD


ASPHALT & WAX INNOVATIONS
GREEN ASPHALT TECHNOLOGIES

Dosage Targets

- Project used PG 58S-28
  - LTPP Bind -34 and -40
- RAP grade ≈ 75-23
- Target xx-34
  - Based on plant mix extracted binder + PAV
- Reported higher than typical “dosages”

Construction and Mix Sampling

- Construction on mornings of August 28-29, 2019
- No major issues during construction. All suppliers were happy with their sections
  - Anderson Brothers plant & paving crew were invaluable
- 300+ buckets collected
  - 30 buckets of HMA collected per section
  - Also collected: RAP, aggregates, virgin binder, and rejuvenator
- NRRA state agency testing
  - MnDOT- DCT & Hamburg
  - Illinois – I-FIT
  - Missouri – TSR
  - Wisconsin – IDEAL CT

NRRA Research

- Contract awarded to research team of University of New Hampshire and Matthy
  - Dr. Jo Sias
  - http://dot.state.mn.us/mnroad/nrra/structure-teams/flexible/mix-rejuvenator-test-sections.html
- MnROAD conducted field monitor and coring
  - Cores taken at 1 month; 12 months; 24 months; 36 months; and 48 months
- NRRA agency partners conducting mix testing to maximize research value!
  - E.g., WisDOT conducted Hamburg Wheel Test; Illinois DOT conducted I-fit; etc.

NRRA Research

- Objective- Evaluate the effectiveness of the seven RA products over time and evaluate their performance as compared to the control mixtures.
  - This will be accomplished through a combination of binder and mixture characterization and performance testing using different laboratory aging levels, field core testing, and performance monitoring of the field sections over time
- Binder testing:
  - Rheological – extracted & recovered binder sampled during construction
  - Chemical composition
  - Aging

Laboratory Testing Results

- **All products met target!!**
- See repo
  detailed

Binder ID (production day)	Continuous PG Temperatures (°C)		Performance Grade (°C)
	PGHT	PGLT	

- All RA binders (6001-6007) generally show improved rheological parameters as compared to the respective base binders after each aging condition (unaged, RTFO and 20 hrs. PAV).
- All RA binders (6001-6007) generally have a higher colloidal index and carbonyl ratio than the base binders. RA binders 6004 and 6005 have a higher sulfoxide ratio than the base binder.

Laboratory Testing Results

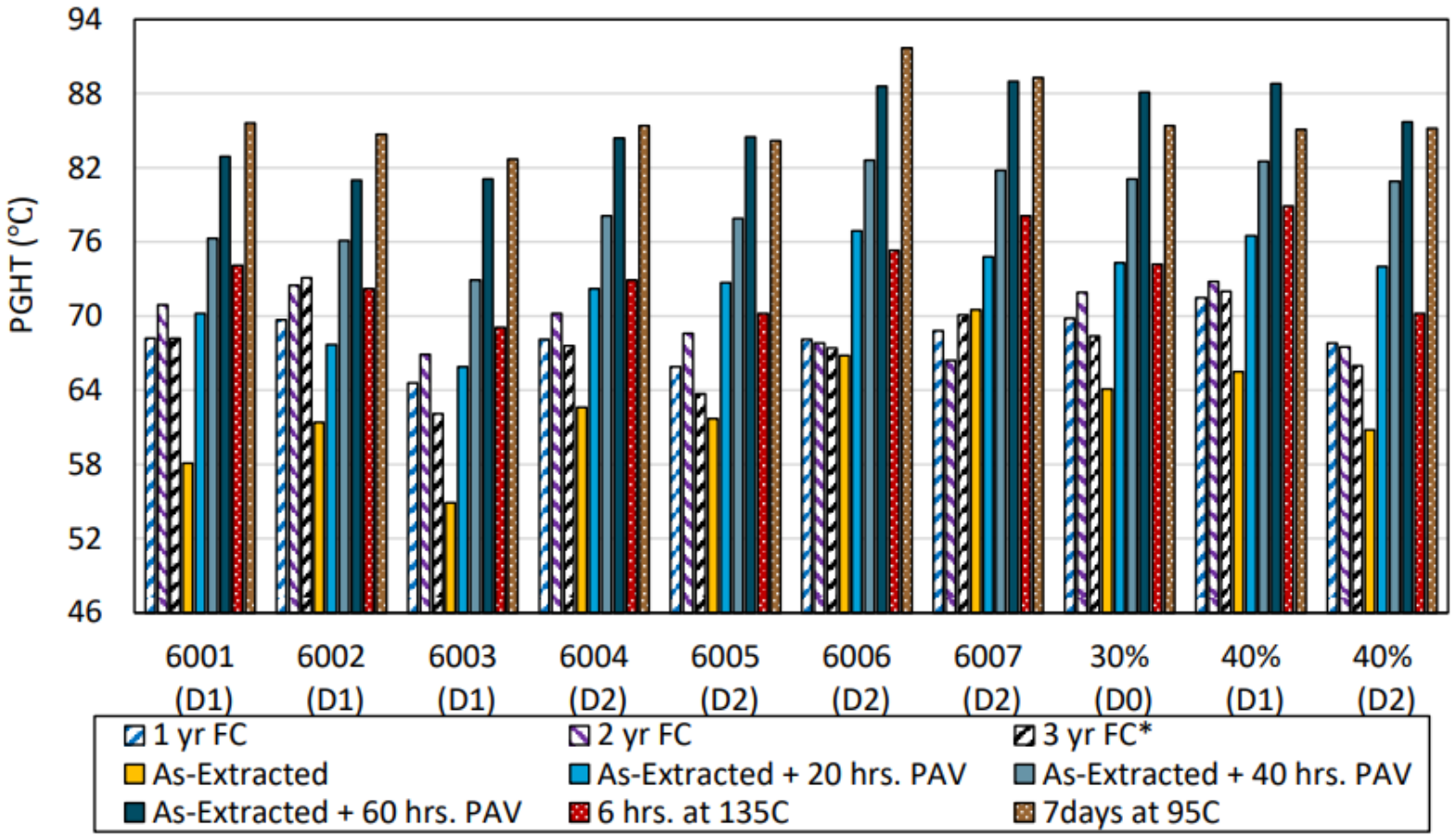
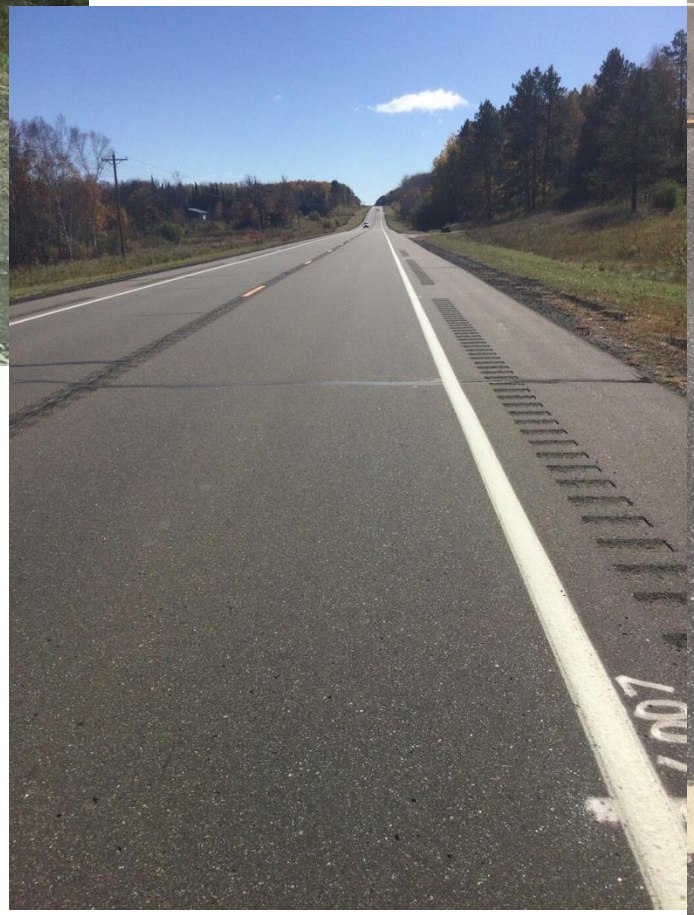


Figure 4-1: High Temperature Grade at Various Aging Conditions – Day 1 Controls and Rejuvenator Sections

Field Performance

- 500’ test sections established for long-term performance monitoring
- Rutting and Ride – MnDOT Digital Inspection Vehicle (Pathways Van)
- Reflective cracking – Visual Distress Surveys

Reflective Cracking



Field Performance Results Summary

- Ride is still very good for all sections!
- No rutting
- Transverse reflective cracking throughout all sections
- Longitudinal cracking beginning in outside wheelpath
- Continued monitoring and coring funded through 2026
- https://www.dot.state.mn.us/mnroad/nrra/structure-teams/flexible/mix-rejuvenator-test-sections.html

Project Objectives

NRRA Flexible Team wanted to answer:

1. Can mix rejuvenator be incorporated into the HMA plant and construction process?

Yes, plant expertise and knowledgeable product reps

2. How well do these products perform in real world conditions?

As well as our conventional HMA; underlying condition limits performance

3. What are rejuvenators doing to our asphalt and how long does it last?

See upcoming NRRA Research
http://dot.state.mn.us/mnroad/nrra/structure-teams/flexible/mix-rejuvenator-test-sections.html

Takeaways

- Rejuvenators can be successfully added at the HMA plant and have little impact on regular plant / paving operations
- Collaboration is key!!!
  - **Agency + Contractor + Industry + Academia = NRRA Success**
- Mix and binder results showed impact from rejuvenators
- UNH team evaluating results with eye towards “balanced mix-design”
- Continued monitoring of long-term durability

THANK YOU AGAIN!!!

- NRRA TAP and Flex Team Members
- MnDOT Bituminous Office
  - Only possible with team effort facilitated by NRRA!!!
- MnDOT District 3
- Contractor – Anderson Brothers
- MnDOT Research Staff
  - Ben Worel and Dr. Raul Velasquez
- Rejuvenator Suppliers/producers

National Road Research Alliance

Additives in Asphalt Summary (Michael's Soapbox)

- Additives are:
  - Nothing to be afraid
  - Everything they are promised to be*
  - Good tool for toolbox to provide high quality asphalt
- Additives are not:
  - Free. Need to justify extra cost
  - Solution to waste / recycling problems
  - Everything they are promised to be* (at the same time)
  - Solution to construction / workmanship issues

References / Resources

- Waste Plastic in Infrastructure
  - https://www.nationalacademies.org/our-work/repurposing-plastics-waste-in-infrastructure
- NRRA Studies
  - https://www.dot.state.mn.us/mnroad/nrra/structure-teams/flexible/wma-reduced-temperatures-bmd.html
  - https://www.dot.state.mn.us/mnroad/nrra/structure-teams/flexible/i94-monitoring-mrcc-data.html
  - https://www.dot.state.mn.us/mnroad/nrra/structure-teams/flexible/reflective-cracking-challenge.html

Questions???


MnROAD
SAFER, SMARTER, SUSTAINABLE PAVEMENTS
THROUGH INNOVATIVE RESEARCH
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