



# MnROAD

## Update for Accelerated Pavement Testing Group

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# MnROAD Background

- **MnROAD Owned and Operated by Minnesota DOT**
- **HMA and PCC Research**
- **30 Years of Long-Term Customer Service**
  - Minnesota Department of Transportation
  - Minnesota Local Road Research Board
  - SHRP II / NCHRP / FHWA / Partnerships
  - Pooled Funds Efforts (States) / Industry
- **Major Experiments**
  - Phase I (1994-2006)
  - Phase II (2007-2016)
  - Phase III (2017-2022) – NRRRA/NCAT
  - Phase IV (2022) – NRRRA/NCAT
- **MnDOT Funded Construction**
  - Used to support 2018 and 2022 NRRRA research efforts



# MnROAD Research Resources

- **Experienced Technical Staff**

- 19 Road Research
- 7 MnROAD Operations

- **Safe/Accessible Work Zone**

- **Pavement Database**

(Long Term Data ~ 30 years)

- Lab Testing
- Performance Monitoring
- Sensors
  - Data Collection Network
  - 8,500+ Sensors Installed
  - Static and Dynamic Data
  - Weather Data
  - Traffic Data



# MnROAD- Minnesota Road Research Facility



I 94 eastbound  
to Minneapolis

I 94 westbound  
to St. Cloud

MnROAD Site  
Office and  
Operations

MnROAD I 94 Original  
westbound (1972)

MnROAD Low  
Volume Road

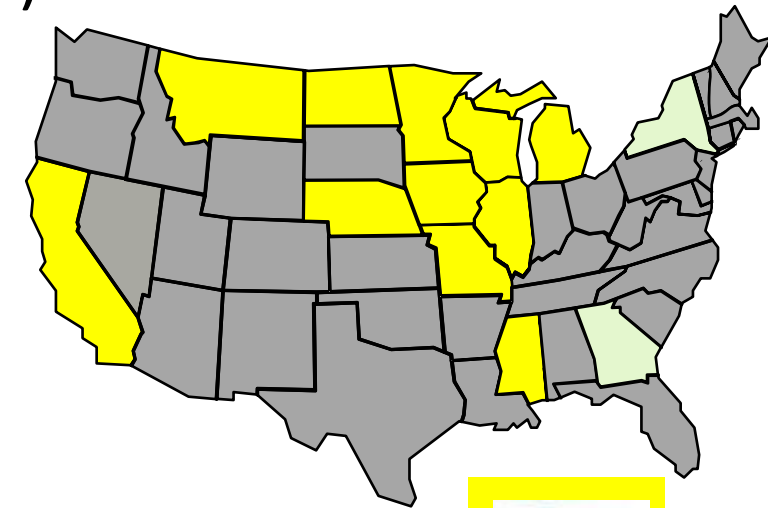
MnROAD I 94 Mainline

# National Road Research Alliance Membership Overview



## TPF-5(466) - Fee Structure / year (five years)

- **Phase-1 complete (5 yr) – Now into Phase-2 (year 2/5)**
- **13 Full Commitments (yellow)**
  - 75K /150K includes dedicated 25K of the funding to Veta
  - 11 States, Tollway, LRRB
  - FHWA contributing to Veta and Rigid Team
- **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



# National Road Research Alliance Overview

- **Organizational Structure**

- Executive Committee (2 reps/agency)
- 5 Technical Teams (agency and associate reps)
- Monthly Research Pays off Seminars
- Research and Implementation Support
- MnROAD Facility Utilized

- **NRRA has averaged ~\$1 million research/year**

- **NRRA Funded 48 projects (phase1) and 14 (phase2)**

- Multiple Researchers Contracted

- **2017 and 2022 MnDOT provided funding for construction at MnROAD to support NRRA**

- **2023 Call for Innovation ~\$1.7 million**

- NRRA members proposals due April 1st



# MnROAD / NCAT Partnership

## Formalized Partnership working on National Needs:

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

## Cracking Group Experiments

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

## Additive Group Experiment

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

## Preservation Group Experiments

- Life extending benefits of pavement preservation techniques
- 8 year of partnership with over 24+ agencies
- Developing next phase



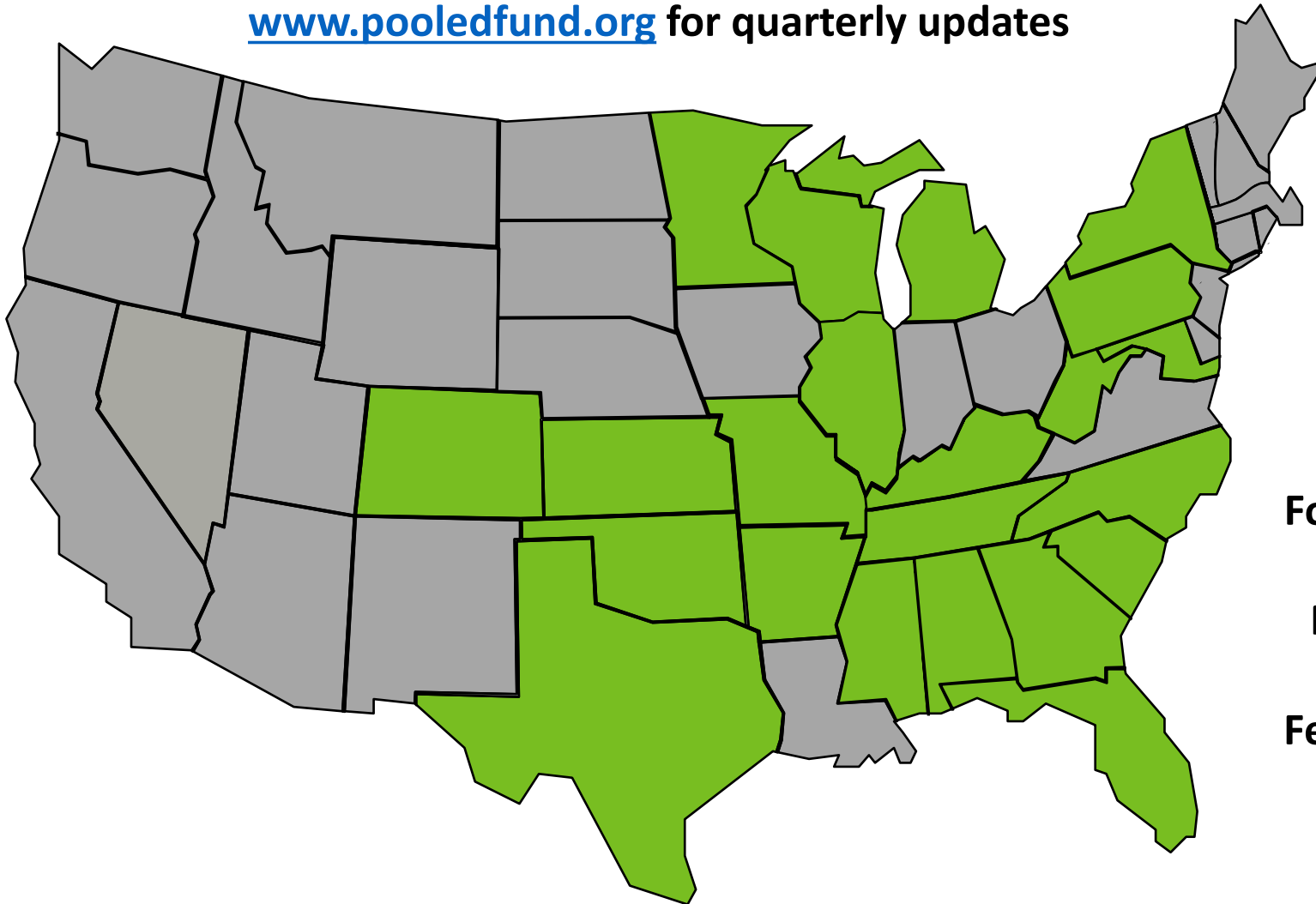
**MnROAD**  
Safer, Smarter, Sustainable Pavements Through Innovative Research



**National Center for  
Asphalt Technology**  
**NCAT**  
at AUBURN UNIVERSITY

# MnROAD/NCAT Partnership Agencies (Preservation – Cracking – Additive) Group Studies

[www.pooledfund.org](http://www.pooledfund.org) for quarterly updates



**Foundation for Pavement Preservation**

**Many industry supporting members**

**Federal Highway Administration FHWA**



# MnROAD Mainline I-94

- Most cells reconstructed in 2022
- Cells numbered 2201-2230
- 2201-2208      Micro-surface/ UTBWC over 2003 FDR – ‘Recycled Perpetual’
- 2209-2224      PCC Alternative Cementitious
- 2225              WIM
- 2226-2227      PCC Early Loading Whitetopping
- 2228-2229      HMA Perpetual Pavement in Wet Freeze Climate
- 2230-2239      HMA Reflective Cracking Challenge

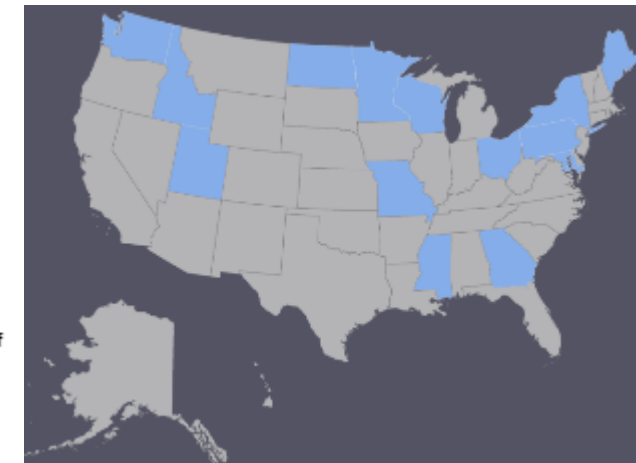
# DPS National Pooled Fund Program



DPS Contacts - Materials & Road  
Research - MnDOT  
www.dot.state.mn.us

## Continuous Asphalt Mixture Compaction Assessment Using Density Profiling System (DPS) [TPF-5(443)]

- **Objective:** Use the DPS method to improve asphalt pavement density
  - Increased coverage and comprehensiveness of assessment
  - Timely information to improve construction process
  - Reduce coring
- **Lead Agency:** MnDOT
  - Contact: Kyle Hoegh, [kyle.hoegh@state.mn.us](mailto:kyle.hoegh@state.mn.us) (MnDOT)
- **Committed agencies:** MN, FHWA, GA, ID, MD, ME, MO, MS, ND, NY, OH, PADOT, UT, WA, WI
- **100% SP&R Approval:** Approved
- **Commitment level:** \$25K/year



TPF - Study Detail  
www.pooledfund.org

Official TPF



Density Profiling System - Office of  
Materials and Research  
www.dot.state.mn.us

MnDOT TPF

# DPS National Pooled Fund Program



DPS Contacts - Materials & Road Research - MnDOT  
www.dot.state.mn.us

Informational Materials



## DPS DIGEST

SEPTEMBER 2022

Contractors, ask yourselves one question: Do you feel lucky?

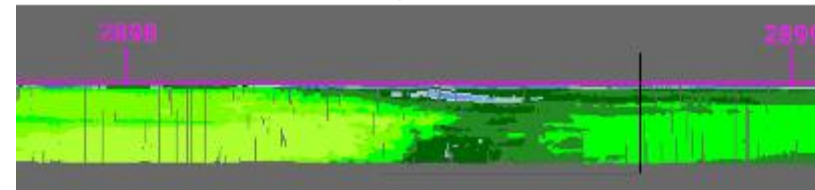
CONTRACTORS ROUTINELY cut cores from the roadway after construction to verify the pavement meets minimum density requirements. These singular random coring locations are used as the basis for acceptance of a larger portion of the pavement. The density results affect contractors and owners alike; for owners such as transportation agencies, a good core result can foretell the road's long-term durability, while contractors often have conditional financial incentives



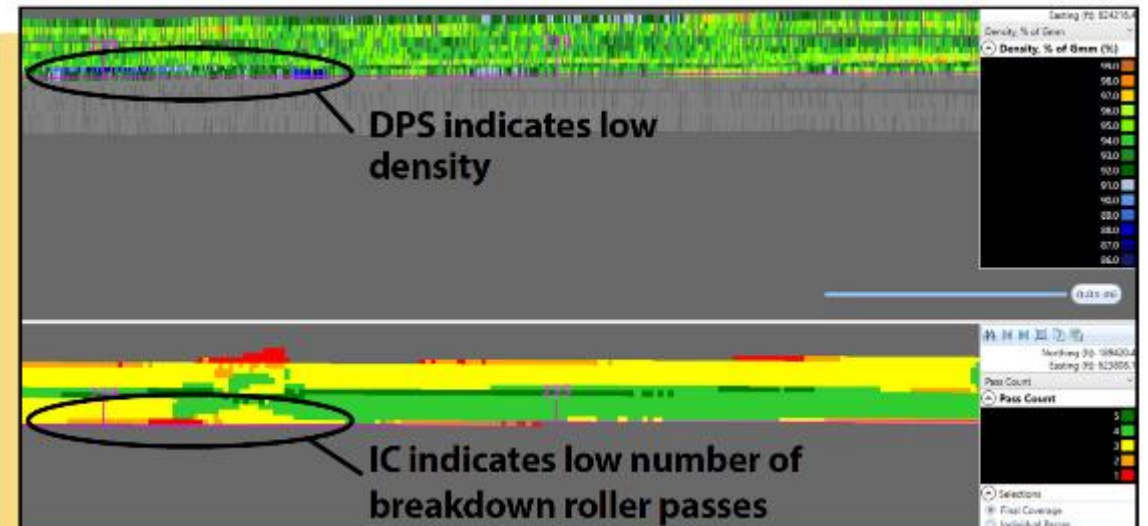
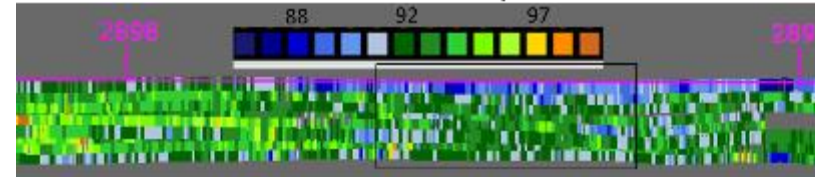
By rolling a DPS unit over the newly paved roadway, crews measured the pavement's density in real time.

## Process Improvement: Leveraging ICT technologies

PMTMP Measured Temperature at Placement, °F



DPS Measured Density, %Gmm



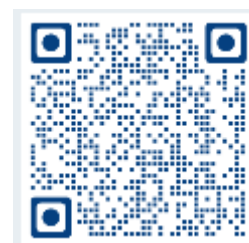
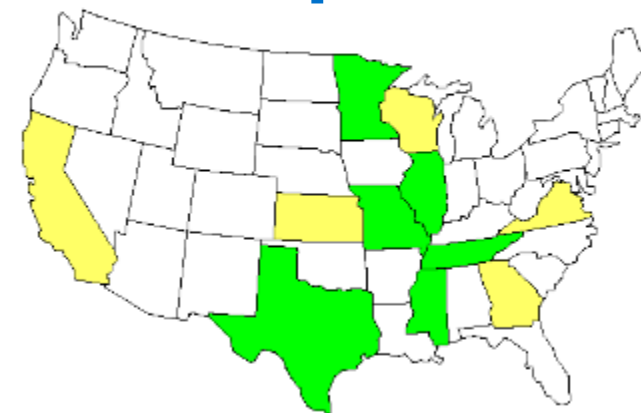
## Training/Peer Exchange Opportunities



# MnDOT Road Doctor Program

## TPF-5(504): Continuous Bituminous Pavement Stripping Assessment Through Non-Destructive testing (4 years)

- **Objective:** Develop testing and analysis procedures for automatic detection and rating of stripped section for project and network level pavement evaluations
- **Lead Agency:** MnDOT
  - Contact: Eyoab Zegeye, [eyoab.zegeye@state.mn.us](mailto:eyoab.zegeye@state.mn.us) (MNDOT)
- **Committed agencies:** MN, IL, MO, TN, MS, TX, GA & FHWA
- **Pending:** CA, KS, WI, VA and IN
- **100% SP&R Approval:** Approved
- **Commitment level:** \$25K/year

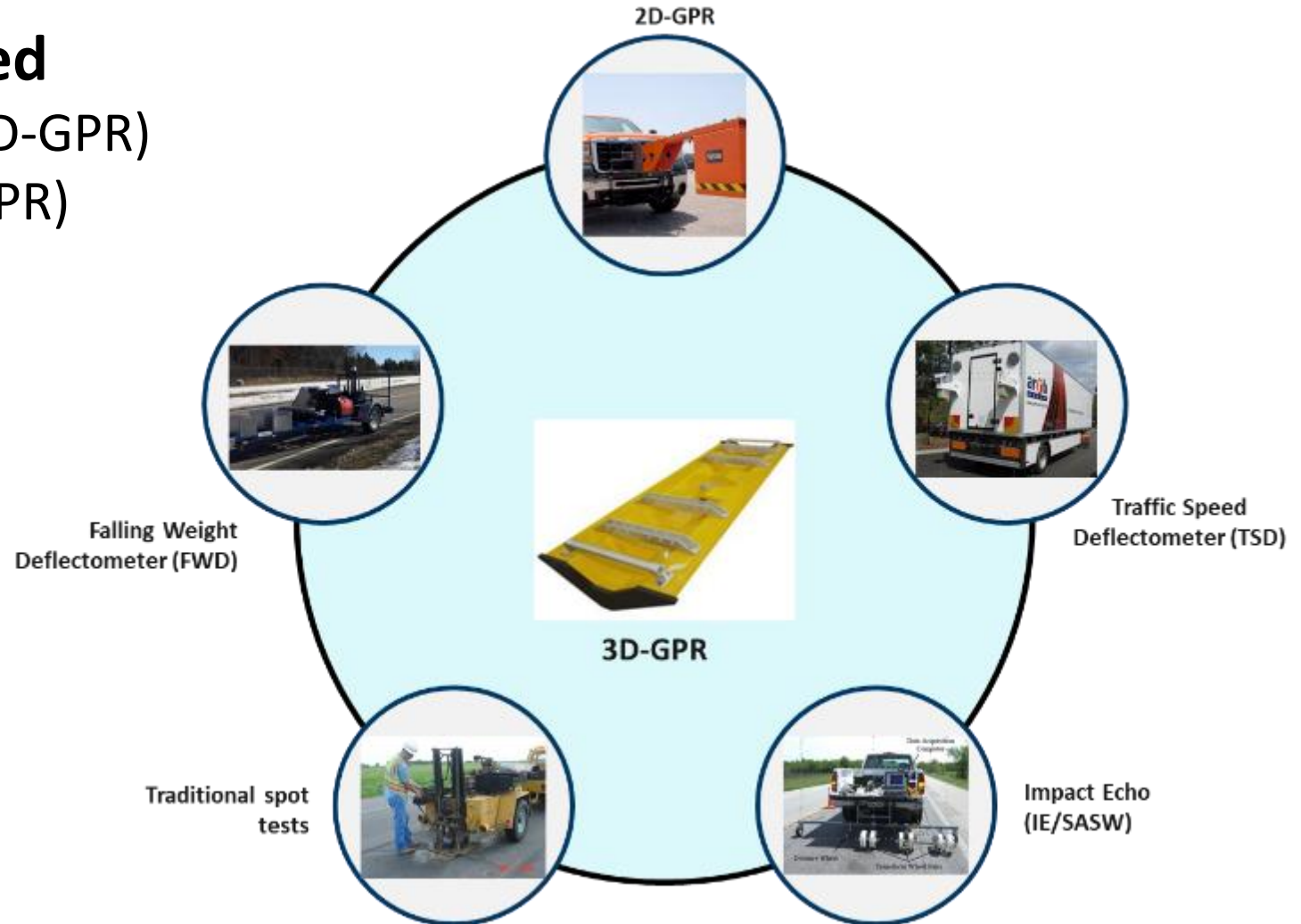


SCAN US

# MnDOT Road Doctor Program

- **Testing Technologies Considered**

- 3D Ground Penetrating Radar (3D-GPR)
- 2D Ground Penetrating Radar (GPR)
- Falling Weight Deflectometer
- Traffic Speed Deflectometer
- Impact Echo IE/SASW
- Coring/Boring



- **“Reclamation and Recycling Techniques to Achieve Perpetual Pavement Characteristics”**
  - **MnDOT TL= Emil Bautista**
- Original 1993 MnROAD construction; FDR in 2008
- Very good performance through 2022.
- Minor surface rehab in 2023. micro-surface or UTBWC
- NRRRA research aimed at answering if sections are “perpetual” and how to achieve perpetual with recycling/reclamation
- <http://dot.state.mn.us/mnroad/nrra/structure-teams/flexible/reclamation-recycling-for-perpetual-pavement-characteristics.html>

# MnROAD 2201-2209 'Recycled Perpetual'



2205 Micro surface



2201 UTBWC

# MnROAD Concrete Test Cells 2209 - 2224

- **Phase 3**

- Cells 2209-2224 – Mainline
- First traffic = 2022

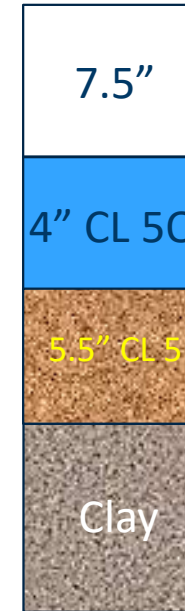
- **Design details:**

- Jointed concrete pavement
- Alternative cementitious, lower cement content, or carbon sequestration concrete mixes
- Panel length/width = 15 ft L / 13 ft W
- Unsealed joints
- 1.25" dia x 15" L dowel bars

- **Construction issues:**

- Very few, however some mixes not fully sorted by time of placement
- Needed to diamond grind most sections due to inadequate texture

2209-2224



2022

<http://dot.state.mn.us/mnroad/nrra/structure-teams/rigid/alternative-cementitious-materials.html>



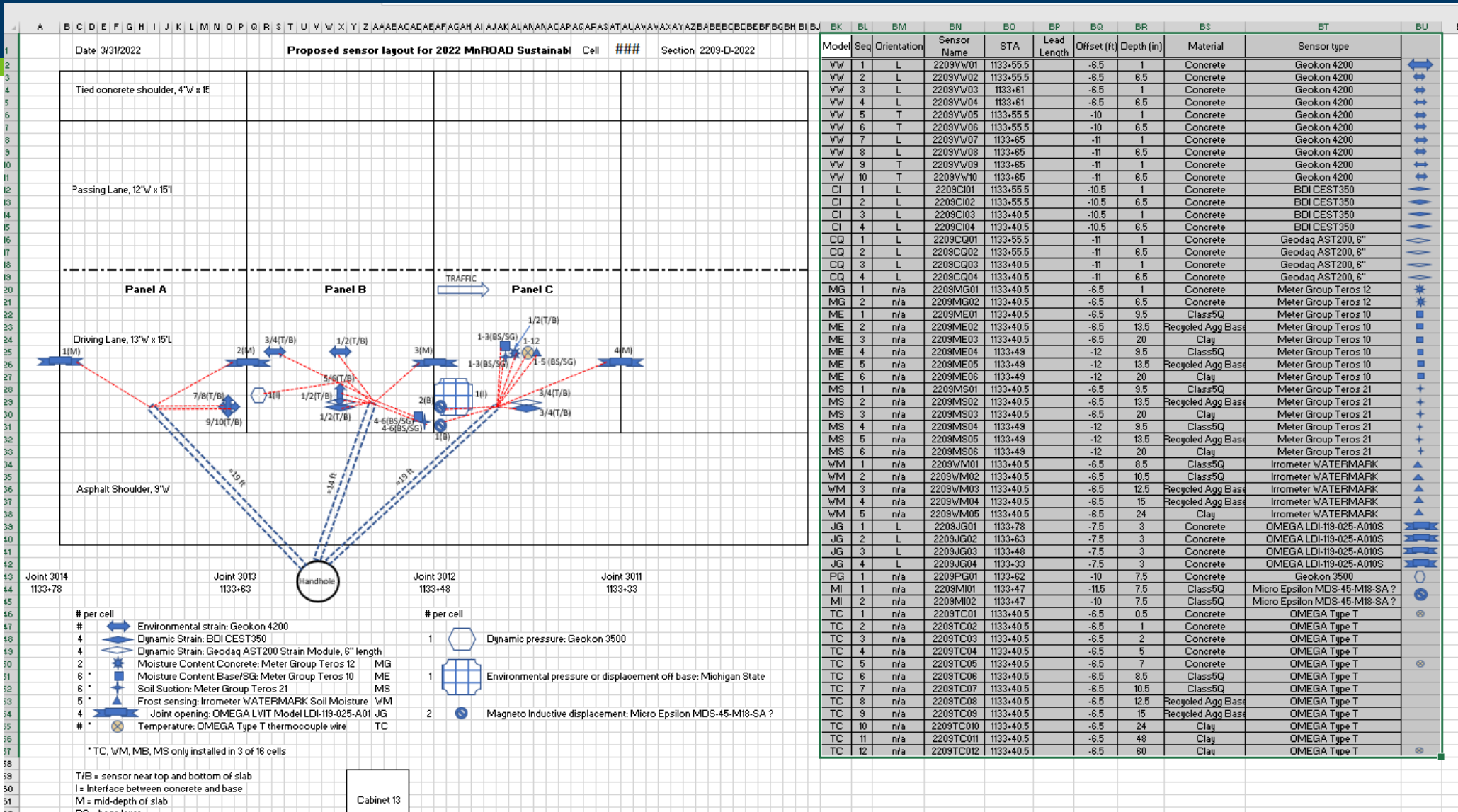
# MnROAD Concrete Test Cells 2209 - 2224

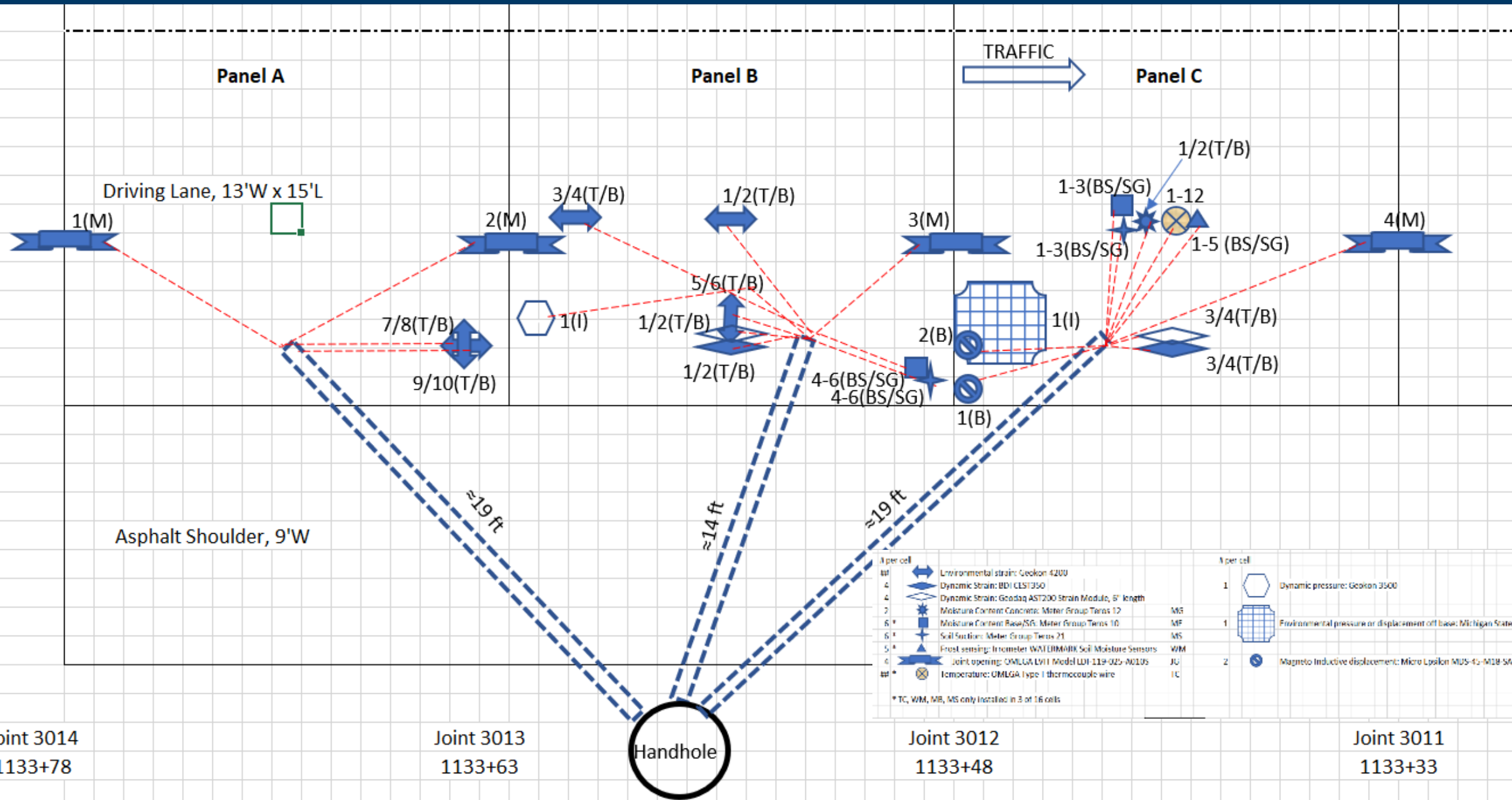
Cell	Supplier	Basic Components
2209	ACM – Ultra High Materials	Hydraulic non-Portland cement (100% cement replacement)
2210	Carbon Cure RGC1	Optimized mix w/ASTMC595 Type1L(10) + 30% FlyAsh + Carbon Cure
2211	Carbon Cure RGC2	Control mix w/ASTMC595 Type1L(10) + 30% FlyAsh + Carbon Cure
2212	Carbon Cure RGC3	Optimized mix w/ASTMC595 Type1L(10) + 30% FlyAsh (no Carbon Cure)
2213	Carbon Upcycling – Processed Flyash	ASTM C595 Type1L(10) reduced cementitious + 30% ASCM
2214	Ash Grove	ASTM C595 Type IP(30) with calcined clay pozzolan
2215	Urban Mining – Ground Glass	ASTMC595 Type1L(10) + 30% ground glass pozzolan
2216	TerraCO2 – Manufactured Flyash	ASTMC595 Type1L(10) + 30% ASCM
2217	Carbon Cure Control	ASTMC595 Type1L(10) + 30% FlyAsh
2218	Control Mix (MnDOT mix)	ASTM C595 Type 1L(10) + 30% Flyash
2219	Optimized Mix (CPTech mix)	ASTM C595 Type 1L(10) + 30% Flyash
2220	Burgess Pigments - Natural pozzolan	ASTM C595 Type 1L(10) + 12% Metakaolin + 18% Flyash
2221	3M - Natural pozzolan	ASTM C595 Type 1L(10) + 15% Natural Pozz + 15% Flyash
2222	Hess Pumice - Natural pozzolan	ASTM C595 Type 1L(10) + 30% Natural Pozzolan
2223	Continental Cement – High Limestone	Blended PLC (20% limestone) + 30% Flyash
2224	Carbon Limit – Blended ASCM	Natural Pozzolan + Catalyst (30% cement replacement)

2209 - 2224

- 16 sections
- Heavily instrumented







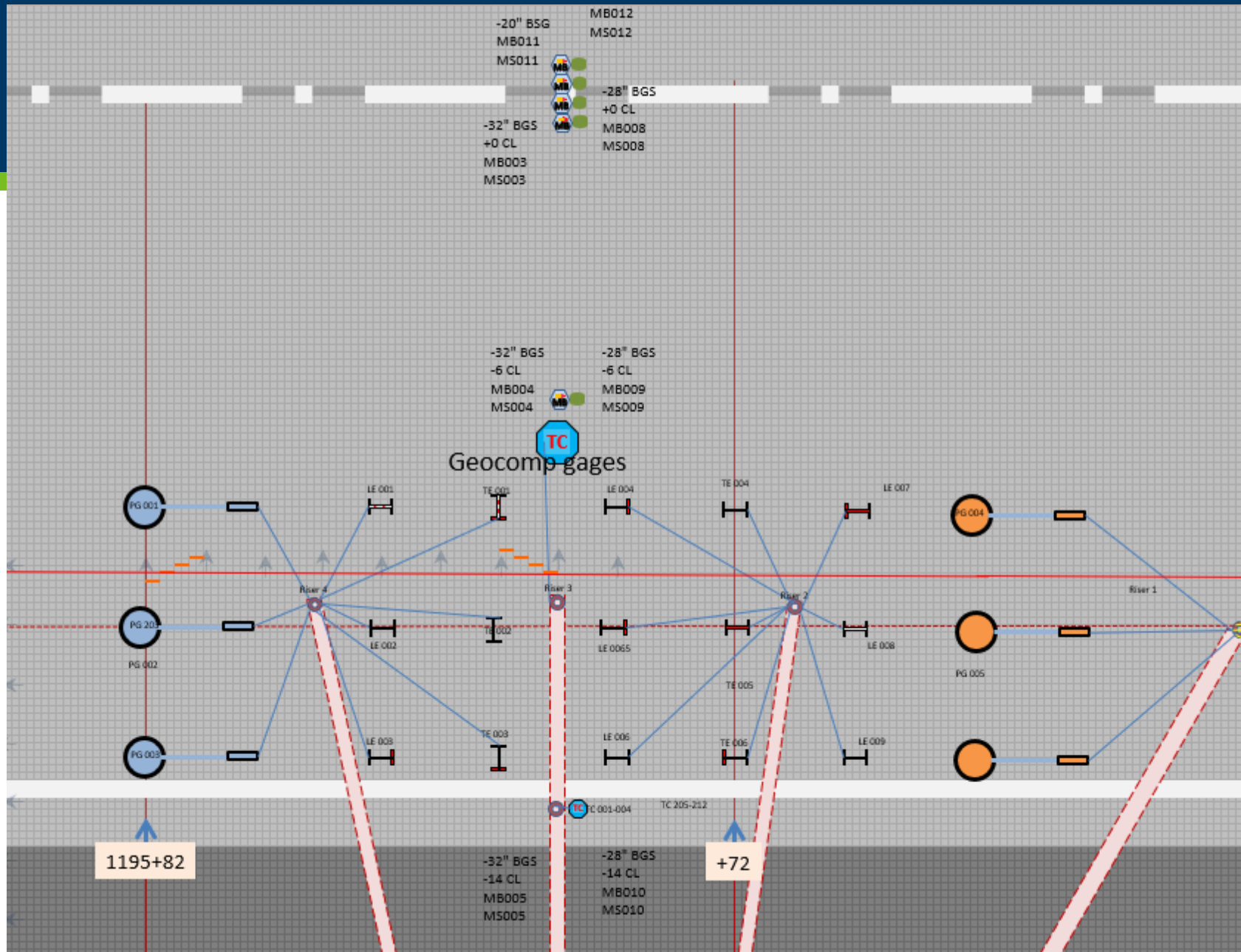
- |            |   |  |
|------------|---|--|
| 1 per cell | 1 | Dynamic pressure: Geokon 3500                                  |
| 1 per cell | 1 | Environmental pressure or displacement of base: Michigan State |
| 2          | 2 | Magneto Inductive displacement: Micro Epsilon MDS-45-M18-S6 ?  |
- 
- |            |   |  |
|------------|---|--|
| 1 per cell | 1 | Environmental strain: Geokon 4200                        |
| 4          | 4 | Dynamic Strain: BD1 CELS1350                             |
| 4          | 4 | Dynamic Strain: Goodaq AST200 Strain Module, 6" length   |
| 2          | 2 | Moisture Content Concrete: Meter Group Terns 12          |
| 6          | 6 | Moisture Content Base/SG: Meter Group Terns 10           |
| 6          | 6 | Soil Suction: Meter Group Terns 21                       |
| 5          | 5 | Frost sensing: Inometer WNI DIRMAR Soil Moisture Sensors |
| 4          | 4 | Joint opening: OMLGA LW1 Model LDI-119-025-M0105         |
| 1          | 1 | Temperature: OMLGA type I thermocouple wire              |
- \* TC, WM, MB, MS only installed in 3 of 16 cells

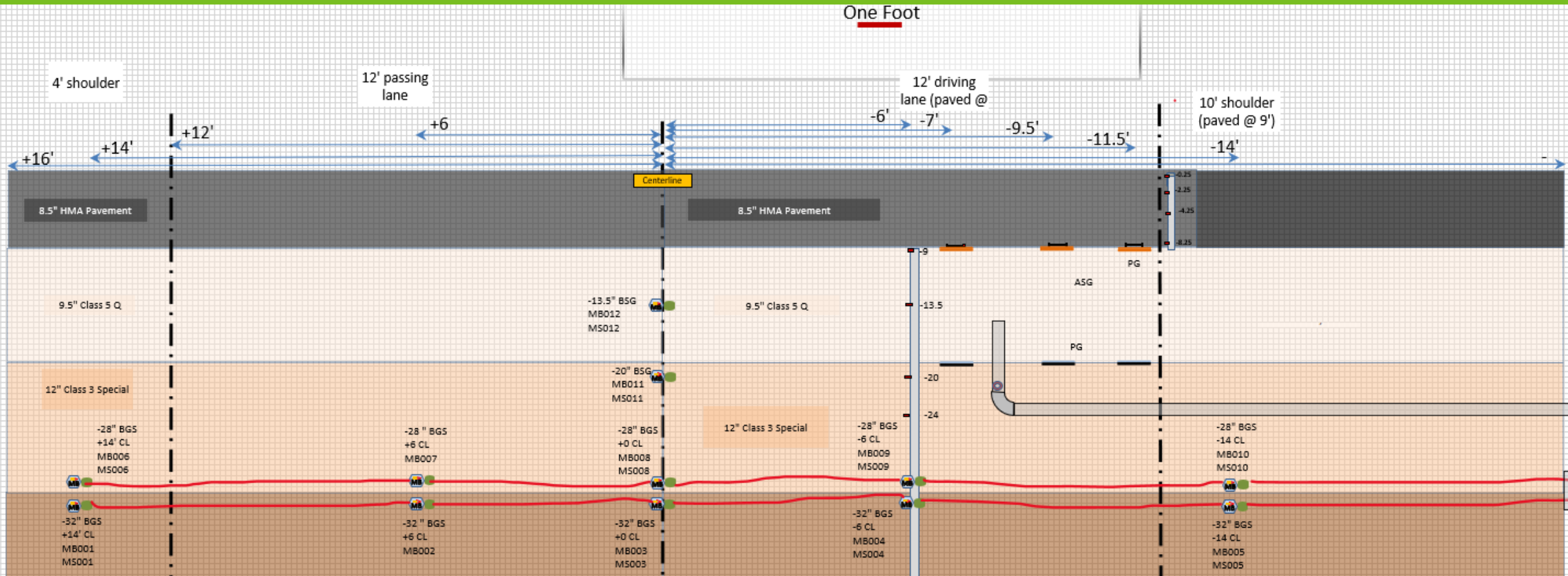
Joint 3014 1133+78      Joint 3013 1133+63      Handhole      Joint 3012 1133+48      Joint 3011 1133+33

- Joseph Podolsky at MnROAD is leading study with multiple WIM vendors to provide detailed traffic data at MnROAD
- WIM will be installed summer 2023

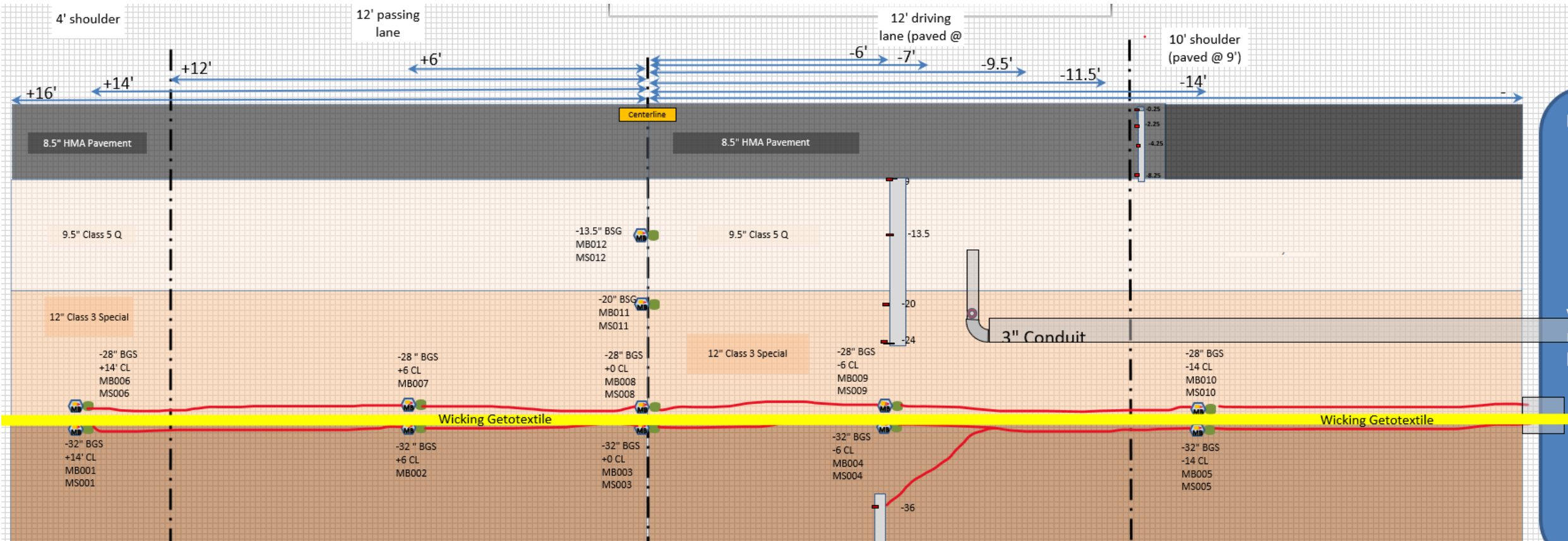
# HMA Perpetual Pavement Test Sections

- **Perpetual Pavements in Cold Freeze Climates**
  - MnDOT TL= Michael Vrtis
- 8.5” HMA sections built at MnROAD in 2022
- Two 12.5” HMA sections in Western Wisconsin on I-94 (2.5 hours from MnROAD)
- NRRRA research contract to update PP transfer functions and cumulative strain profile (PerROAD)
- <http://dot.state.mn.us/mnroad/nrra/structure-teams/flexible/perpetual-pavement-test-sections.html>





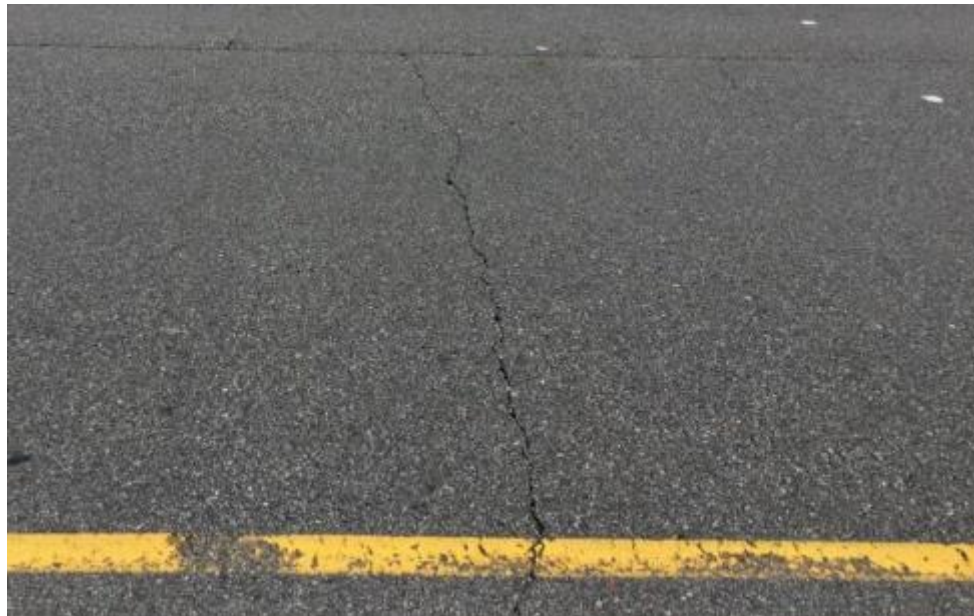




- **Performance Evaluation of Wicking Geotextiles for Improving Drainage and Stiffness of Road Foundation**
  - MnDOT TL= Raul Velasquez
- NRRA contract with Dr. Bora Cetin at MSU
- Installed novel Slope stability sensor in attempt to monitor differential heave
- <http://dot.state.mn.us/mnroad/nrra/structure-teams/geotechnical/geotextile-performance-evaluation.html>

# 2022 MnROAD Reflective Cracking Challenge

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



## Statewide (All Districts)

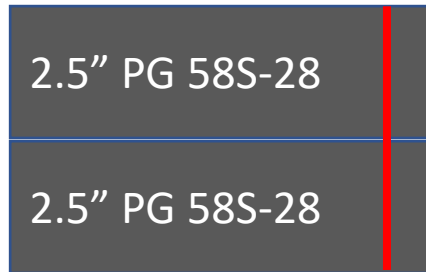
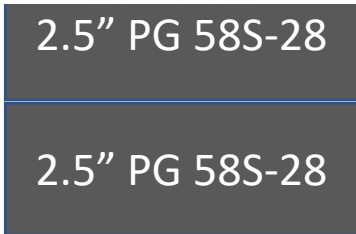
<u>Pavement</u>	<u>Percent</u>	<u>Miles</u>
BIT	12%	1,682
BOB	50%	7,104
BOC	22%	3,136
CON	17%	2,377
CRCP	0%	2
<b>All</b>	<b>100%</b>	<b>14,301</b>

<u>Pavement</u>	<u>POI</u>	<u>ROI</u>	<u>SR</u>
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
<b>All</b>	<b>3.4</b>	<b>3.3</b>	<b>3.6</b>

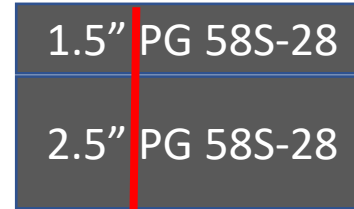
# MnROAD Reflective Cracking Challenge



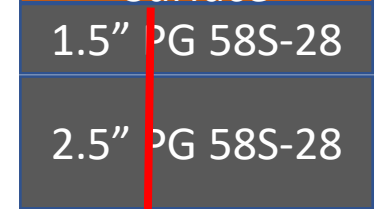
Transverse Saw  
cuts



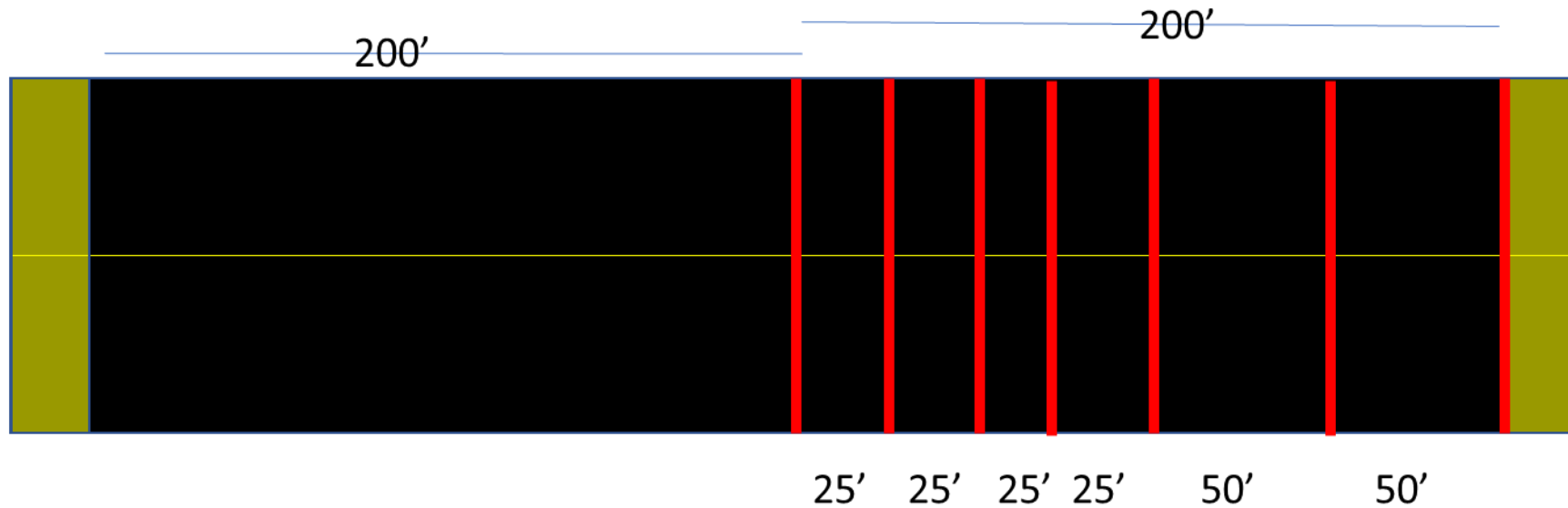
Milled surface



2.0" Unique  
Surface



# MnROAD Reflective Cracking Challenge



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

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

# 2022 MnROAD Reflective Cracking Challenge

- **MnROAD Reflective Cracking Challenge**

- Designed to simulate HMA overlay conditions (majority of DOT paving efforts)
- MnROAD / NCAT Additive Group (NY participation)
- NRRR 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)



# NRRA Reflective Cracking Challenge

- NRRA research contract awarded to University of New Hampshire led by Dr. Eshan Dave.
  - NCAT/Dr. Ben Bowers is sub-contractor for LCA efforts
  - <http://dot.state.mn.us/mnroad/nrra/structure-teams/flexible/reflective-cracking-challenge.html>
- Objective: develop necessary knowledge and tools to extend lives and serviceability of asphalt overlays by:
  - assessment of different types of overlay asphalt mixtures (including those produced with innovative additives),
  - benchmark overlay mixtures in terms of their laboratory test and in-service performance,
  - enhance the understanding of reflective crack formation in asphalt overlays on asphalt pavements due to traffic and environmental loadings,
  - develop a way to incorporate pavement life cycle assessment (LCA) tools into asphalt overlay selection and design, develop methods for reliable prediction of overlay lives and performance curves.

# NRRA and MCTI Collaboration

- Dr. Bill Buttlar and the Missouri Center for Transportation Innovation (MCTI)
- Companion sections being constructed in Missouri boot-heel in 2023
  - HMA over existing PCC on I-155
  - Investigating:
    - Engineered Crumb Rubber (ECR)
    - Waste Plastic – Low Density Polyethylene (LDPE)
    - Waste Plastic – Mixed Polyethylene
    - Balanced Mix Design (BMD) w/ polyphosphoric acid
    - BMD w/ SBS
    - SMA x3 (control, LDPE, and ECR)





# MCTI Testing on MnROAD Efforts

- Specific MCTI tasks are still being refined but focus on:
  - Automated distress survey from drone images using data science tools
  - Run-off water quality assessment (micro-plastics, etc.)
  - Advanced modeling of Simplified Wedge Shape Test (SWST)
  - Moisture susceptibility assessment (Tensile Strength Ratio)



# Reflective Cracking Challenge Instrumentation

- **Environmental sensors monitor temperature and moisture**
  - Thermocouples installed to monitor temperatures up to 6' from surface
- **Relatively limited dynamic instrumentation due to experiment design**
  - Surface performance study
- **3 sections with typical “MnROAD HMA Dynamic”**
  - Earthen pressure cells and H-type strain gauges

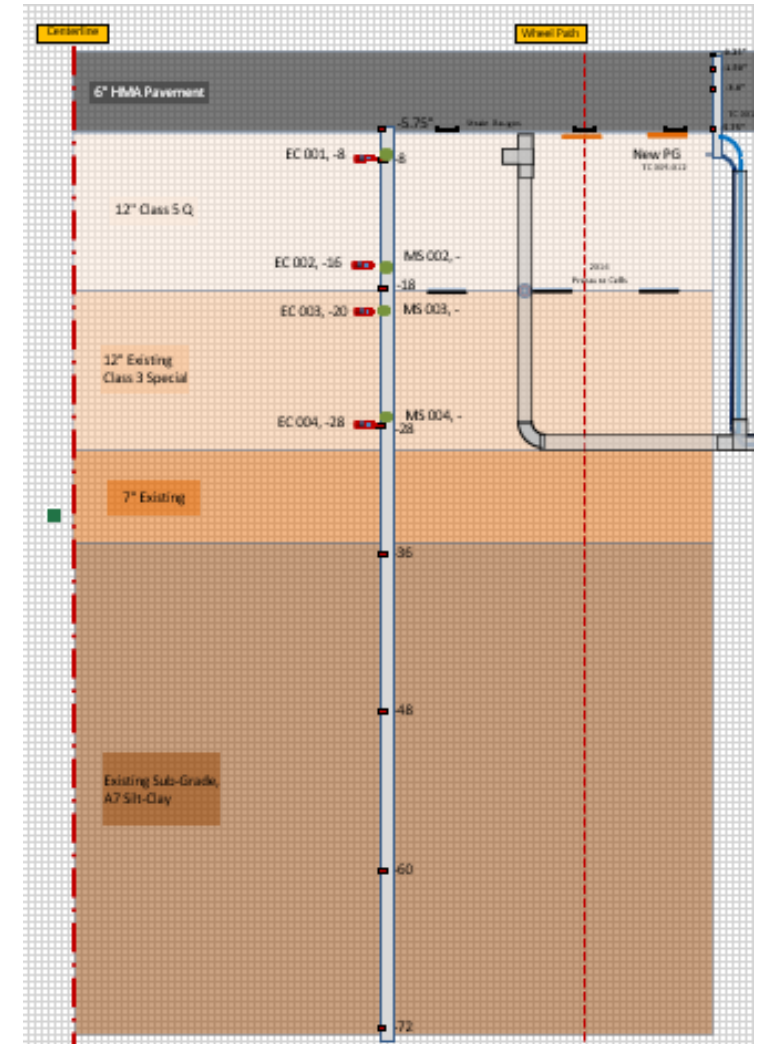


- **Collaboration with NCAT Team to create common data collection platforms, procedures, and analysis**

# 2230-2239

## Environmental Instrumentation

- Thermocouples to measure temperature
- 12 locations throughout structure
  - 4 HMA - ¼", 1.5", 3", 6"
- Moisture Content and potential sensors at top/bottom of granular base



# New Instrumentation Technology

- Michigan State University
  - Dr. Nizar Lajnef
  - Piezo-strain gauge
  - Wireless Strain Gauge
- North Dakota State University
  - Xinyi Yang
  - Fiber Optic Strain Gauges
  - Temperature Sensors



# 2230-2239

## 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



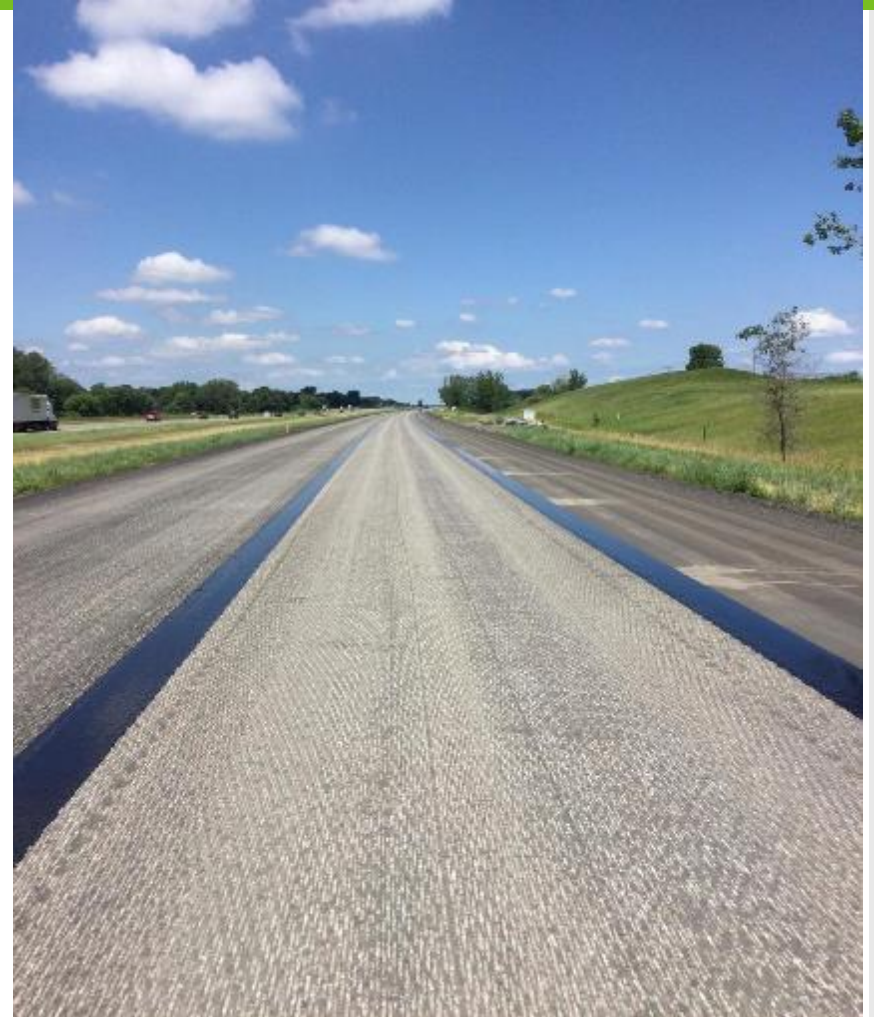


- Tack applied at 0.05 gal/yd between lifts 1/2
- Tack applied at 0.07 gal/yd on mill HMA
- Residual tack coat rate was measured
- CSS1H



# Longitudinal Joint Treatment

- J-Band applied on centerline and longitudinal shoulder joint
- Driving lane paved 13' wide with 12' lane to push longitudinal joint away from traffic
- J-Band donated application for this effort

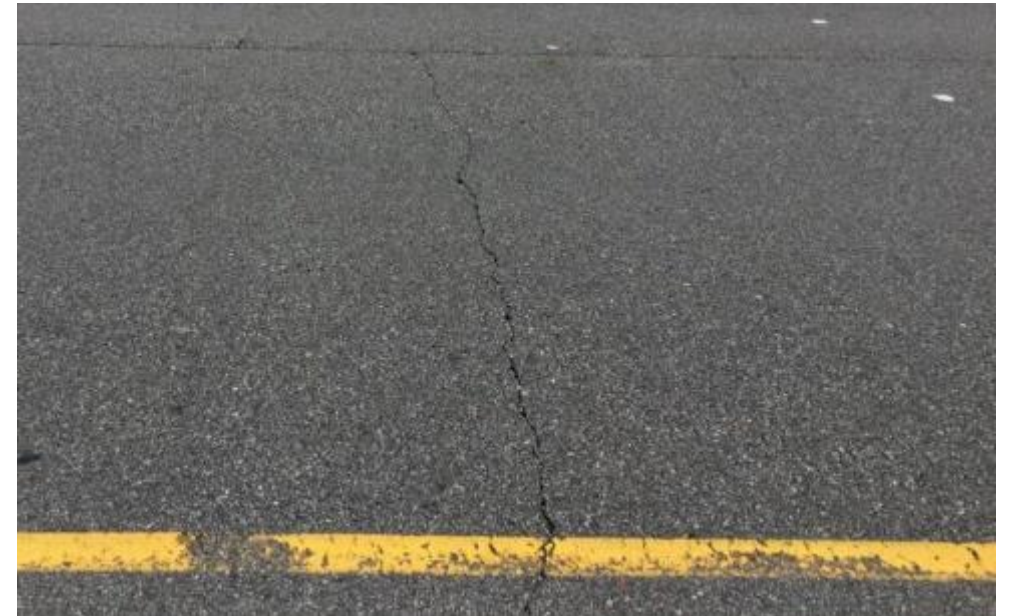




# Surface HMA Mix Details

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

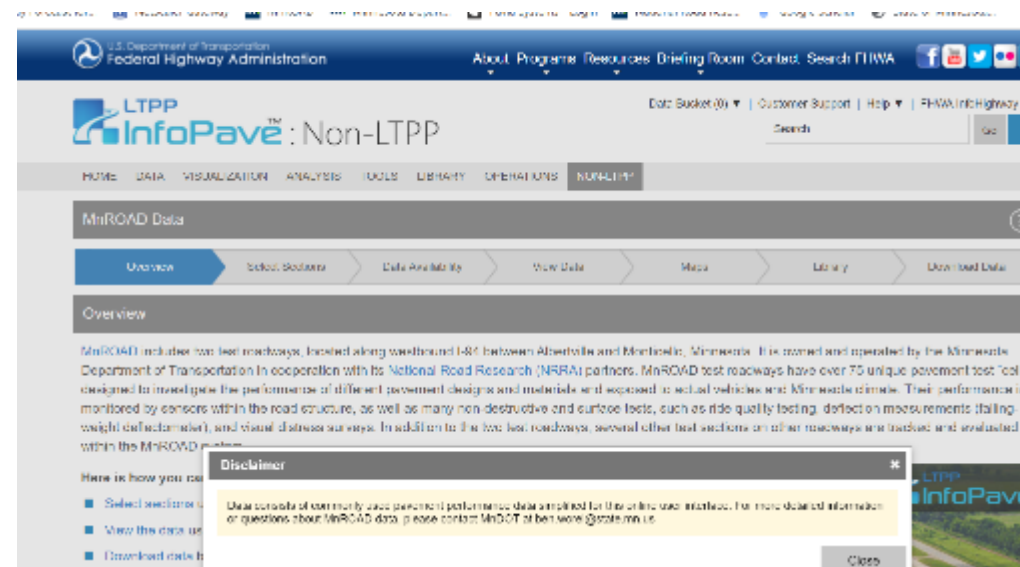
} w/ PG 52-34 from Mathy
  - Super Pave 5.0
    10. PG 58V -34 (modified) (NRRRA)



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

# Data Sharing Need from APT

- MnROAD has recognized need for large dataset
- Effort into cleaning data to make available for large downloads and analysis
- <https://infopave.fhwa.dot.gov/Mnroad/index>



# Thank You!

**Michael Vrtis**

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612-360-9852