National Road Research Alliance Geotechnical Team April Meeting

Terry Beaudry
Reclamation/Grading Engineer

Agenda

1. Welcome and Introductions
   - New Members/New Attendees Introduction
2. NRRA Administrative Items
3. General NRRA Update
   - Review NRRA Research Idea Timeline
4. Review Surveymonkey Results *Top 10 Geotech Ideas*
5. Additional Discussion Top 10 Geotech Ideas
6. Review revised 2-pager
7. Next steps for Geotech Research Ideas
8. Feedback for Flex Team -> Perpetual sFDR Test Sections
9. Other NRRA Cross-Team Opportunities for MnROAD
10. Upcoming Geotech Events
11. Questions/Requests

NRRA Administrative Items

General NRRA Update

Team Efforts

- Each team has a little different variations on the process to get their 4-5 ideas pulled together.
- Team research leaders will provide more information on their induvial system being used as needed.
- Focus is on 2022 MnROAD construction research but its ok to have non-MnROAD mainline research also in your top-5

Timelines

Finalize Team Top Ideas	**April 1 and 7 – NRRA Team Monthly Meeting** • Geotech-ICT Meetings April 1st • Flex-Rigid-PM Meetings April 7th • NRRA teams develop/finalize 2-pagers **April 16 – Teams send in top 4-5 ideas to Ben Worel** **April 17-21 – MnROAD Staff combine into one set for EC** **April 22 – MnROAD staff share ideas from teams to the EC**
Executive Committee	**April 27** • Executive Team meeting to fund projects

Updated Idea Form

Updated with feedback from the teams – it is attached.

- Remember these are ideas that RFP's will be based on (everyone can participate in the research RFP)
- Focus the 2-pager on the research studies
    - Basic Idea / Study Needs
    - Highlight Partnerships on cost sharing/getting groups involved
    - Construction, instrumentation, and MnROAD monitoring
        - Do not need these costs in the proposal

Survey Results Top 10 Geotech Ideas

NRRA Geotech Research Idea
Use of IC for QA of base/subbase/subgrade construction with emphasis on assessing spatial variability of stiffness and moisture.
Optimizing Pavement Structure Considering Long-Term Performance and Fatigue Characteristics of Stabilized and Non-stabilized Pavement Foundation Materials.
Long term evaluation of wicking geotextiles for improving drainage and stiffness of road foundation.
Flooded Pavements Assessment App–Phase II.
Strategies to Define and Measure Resiliency of MnROAD Pavement Foundation Systems to Support the Need for Extended Pavement Life.
Determination of AASHTO Structural Layer Coefficient for bituminous stabilized Full Depth Reclamation, CIR and CCPR.
Evaluation of gravel stabilizers for use on gravel shoulders and gravel roads.
Impact of cement on flexibility of CIR.
RAB+LSSB Materials-Phase 2.
Towards a recycled base layer with optimum drainage, stiffness, and strength.

Open-Ended Questions

Other research ideas?

1. IC system performance in embankment construction - Sensitivity of IC in measuring resilient modulus in low range (CBR about 2.5 and Mr < 5000 psi)
2. Evaluating the effect of drop in emulsion content in summer hot temps on the performance of CIR mixtures containing cement

Open-Ended Questions

Thoughts on combining different efforts/ideas?

1. Not opposed to supporting ideas coming from other teams but want to focus our initial support on research ideas specifically the focus of the geotechnical team (i.e. bases) and not the focus of other teams.
2. Several projects are interested in demonstration of benefits of stabilization. Could those projects be combined? We need an accelerated approach to study stabilization.
3. Few areas could be combined depending where they fall in this initial rating from the team

Additional Discussion Top 10 Geotech Ideas

Determination of AASHTO Structural Layer Coefficient for bituminous stabilized Full Depth Reclamation, CIR and CCPR

- Lead Proposer: Stephen Cross (ARRA)
- Objective:

  Analyze new and existing data from the bituminous stabilized FDR, CIR and CCPR mixes on the MnROAD test track facilities to determine appropriate structural layer coefficients for use with the 1996 AASHTO Design Guide.

Determination of AASHTO Structural Layer Coefficient for Bituminous Stabilized Full Depth Reclamation.

- **Objective: Analyze new and existing data from the bituminous stabilized FDR mixes on the MnROAD test track to determine appropriate structural layer coefficients for use with the 1996 AASHTO Design Guide.**
- **NCHRP Research Report 863 (9-51 Study) *Material Properties of Cold In-Place Recycled and Full-Depth Reclamation Asphalt Concrete* Concluded:**
  - **FDR, CIR & CCPR had similar ranges of dynamic modulus values at intermediate and high reduced frequencies.**
  - **Many highway agencies specify lower structural values (whether layer coefficients or moduli) for FDR than for CIR and CCPR; these lower values may be too conservative.**
  - **There was no significant difference in master curve data between emulsified asphalt and foamed asphalt as stabilizing/recycling agents.**

Determination of AASHTO Structural Layer Coefficient for Bituminous Stabilized Full Depth Reclamation.

- **The NCAT and Virginia DOT studies on CIR, CCPR and FDR used cement or lime as the stabilizing agent on the FDR mixtures.**
- **An informal FHWA survey in 2015 of 17 state DOTs on layer coefficient for FDR showed:**
  - **< 0.20: 5 Agencies**
  - **0.20 – 0.25: 7 Agencies**
  - **0.26 – 0.30: 4 Agencies**
  - **> 0.30: No Agencies**
- **ARRA and many agencies use 0.36 for CIR.**

Determination of AASHTO Structural Layer Coefficient for Bituminous Stabilized Full Depth Reclamation.

- There are 3 bituminous SFDR sections with a 3 inch HMA overlay on the Mainline, cells 2,3 and 4.
- They were expected to last 5 years and carry 3 M ESALs.
- In 2017 they had carried 6M ESALS over 10 years and were in good condition.
- Performance data exists for these 3 cells that could be analyzed to determine more appropriate layer coefficients for bituminous SFDR.
- Increasing the layer coefficient by 0.05 would reduce the overlay thickness approximately 1 inch for an 8 inch FDR layer.

Optimizing Pavement Structure Considering Long-Term Performance and Fatigue Characteristics of Stabilized and Non-stabilized Pavement Foundation Materials

- Lead Proposer: Soheil Nazarian (UTEP)
- Objective:

  Optimizing pavement structure considering long-term performance and fatigue characteristics of stabilized and non-stabilized pavement foundation materials

Evaluation of gravel stabilizers for use on gravel shoulders and gravel roads

- Lead Proposer: Terry Beaudry and John Bormann (MnDOT)
- Objective:

  Gravel stabilizers used on gravel roads have lowered maintenance cost for gravel roads by 50%. Evaluate their use in gravel shoulders.

Strategies to Define and Measure Resiliency of MnROAD Pavement Foundation Systems to Support Need for Extended Pavement Life

- Lead Proposer: David White (Ingios)
- Objective:

  Strategies to define and measure resiliency of MnROAD pavement foundation systems to support the need for extended pavement life

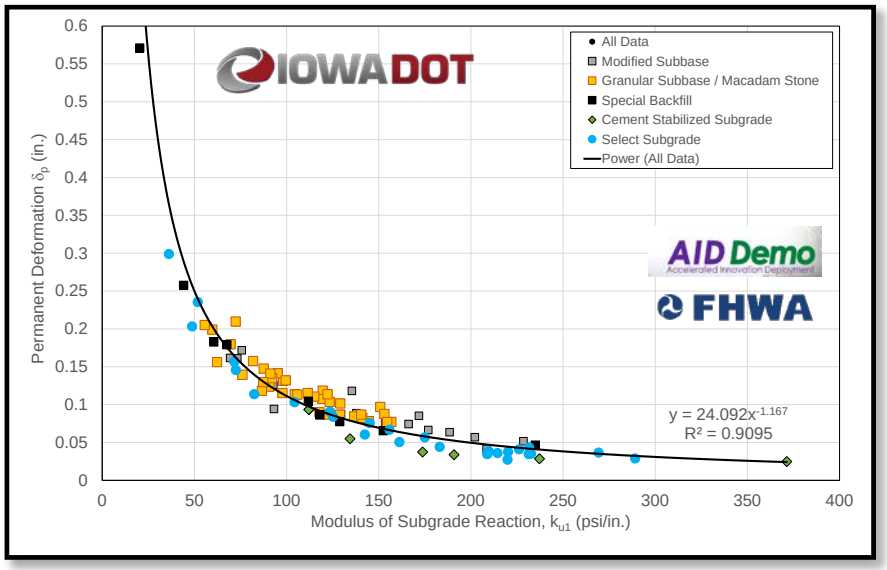
Strategies to Define and Measure Resiliency of MnROAD Pavement Foundation Systems to Support Extended Pavement Life

OBJECTIVES AND TASKS

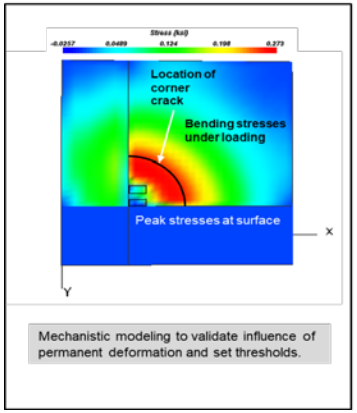
- Define resiliency: R = f(accumulated damage with time)
- Summarize literature on how to define and measure resiliency for pavement foundation systems, with a link to pavement foundation design assumptions and field performance. Recent national and international studies documented assessment of resiliency for pavements, but the influence of foundation layers lacks adequate data.
- Select pavement foundation systems in-service with different foundation stabilizations for characterization of resiliency.
- Investigate relationships between Modulus, Resilient Strain, and Permanent Strain within different pavement foundations, using accelerated load testing. [Note: Goal is to reduce accumulated permanent strain, not necessarily high modulus].
- Initiate a database of parameters assessing resiliency for calibration of ME pavement design models and related to performance for loading and weather events (floods, saturated subgrades, etc.).

VALUE/BENEFIT

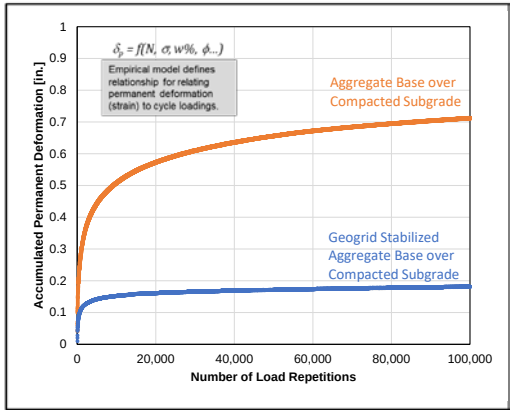
The results from this project can be used to better define resiliency for pavement foundations, obtain data that can be critical in adequately predicting the resilient behavior of pavement structures, and help agencies make informed investment decisions with respect to pavement foundations as part of building new resilient infrastructure.



Mechanistic Modeling



Empirical Modeling



RAB + LSSB Materials- Phase 2

- Lead Proposer: Bora Cetin (MSU) and Raul Velasquez (MnDOT)
- Objective:

  Phase I of this study is just completed. The goal of the Phase II project is to conduct forensic analyses on 11 test sections built and tested previously for this study. These forensic analyses aim to determine changes in index, physicochemical properties, and engineering properties of base and subbase materials tested in the previous phase.

Determining pavement design criteria for recycled aggregate base (RAB) & large stone subbase (LSSB) materials-phase II

Bora Cetin, Department of Civil & Environmental Engineering, Michigan State University
Raul Velasquez, Minnesota Department of Transportation

Motivation: *First phase is completed and recommends the following:*

- More continuous data collection is required for understanding long term behavior of RAB & LSSB materials
- Forensic analyses are required to understand long term intrinsic properties of these materials.
- Comprehensive thermal and physicochemical analyses are required to better understand the freeze-thaw behavior of these materials

Overall Research Goals:

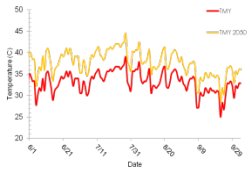
Conduct forensic analyses and more continuous field test on each test section to solve/answer the remaining challenges about the use of these materials in pavement foundation systems.

Causes

Clogging

Long term traffic load

Environmental Influences



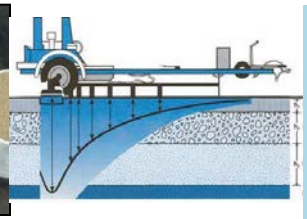
Effects

Increased maintenance cost, premature failure

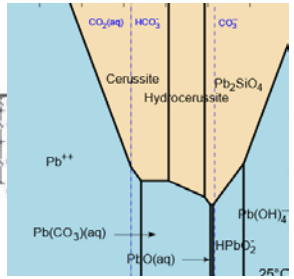
Research Techniques

Forensic Analyses

Lab/Field Testing

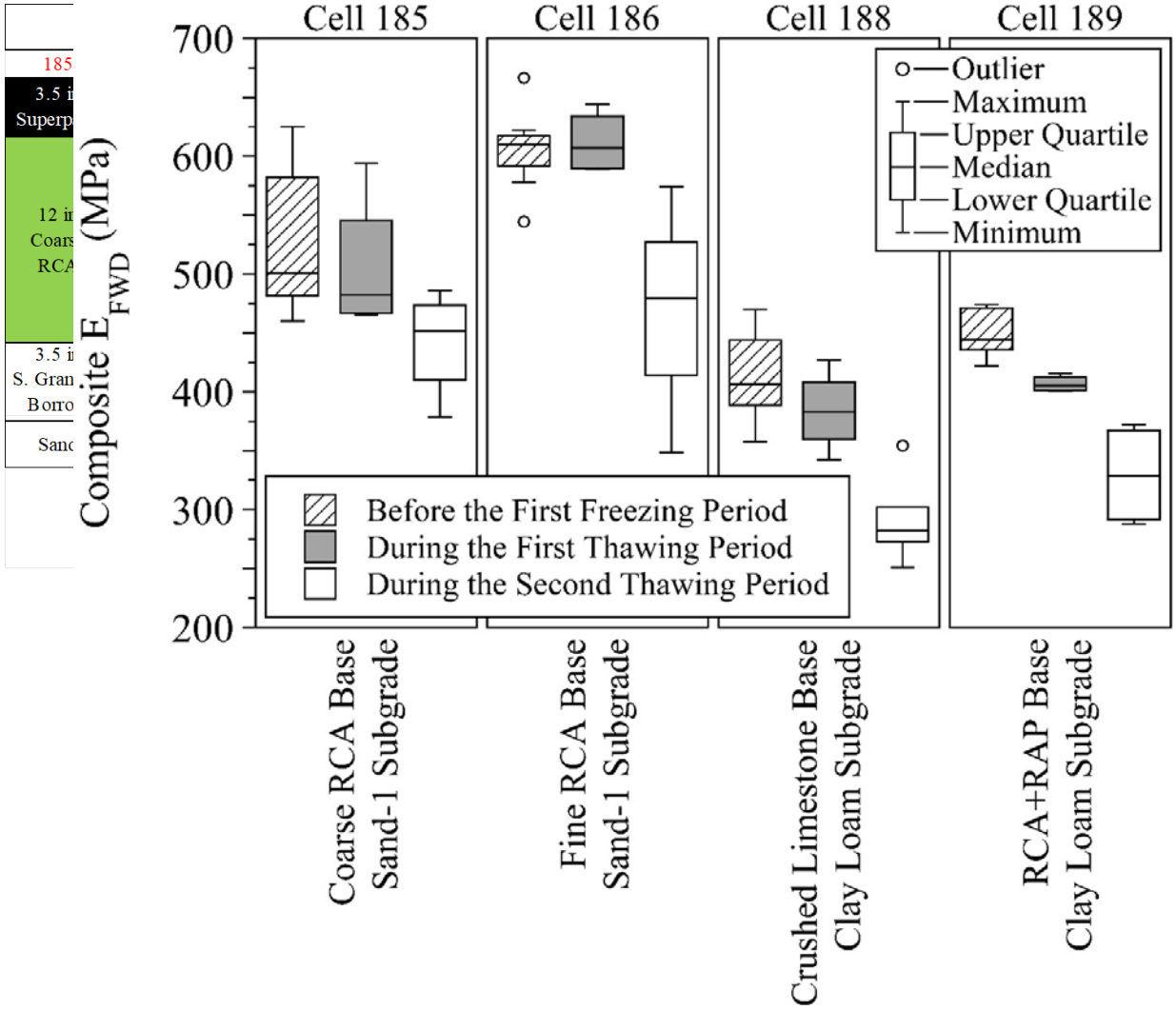


Geochemical Analyses



OBJECTIVES & TASKS

(1) Continue to run/analyze the FWD, IRI, rutting and other field tests



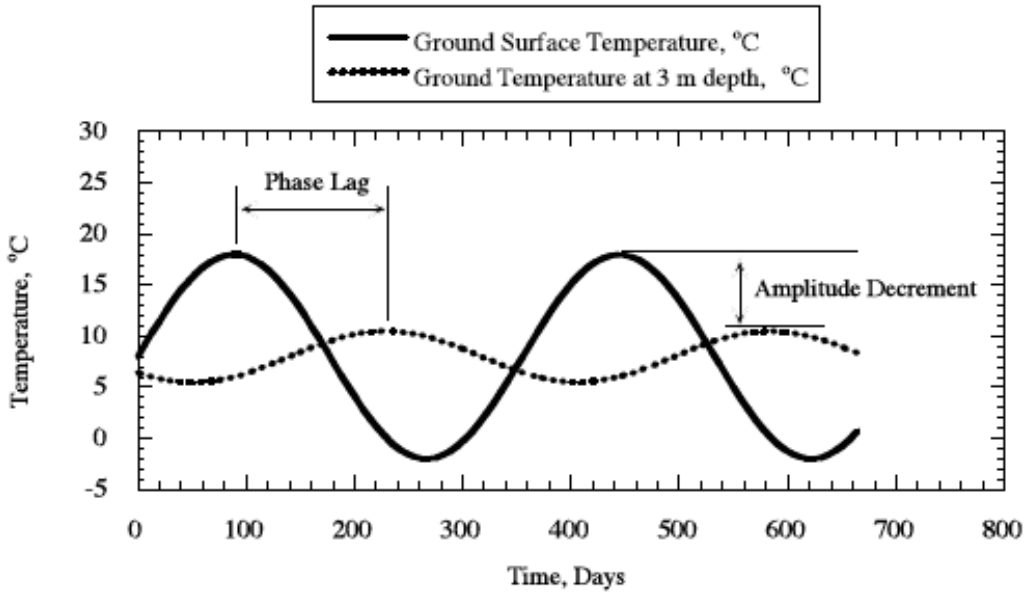
OBJECTIVES & TASKS

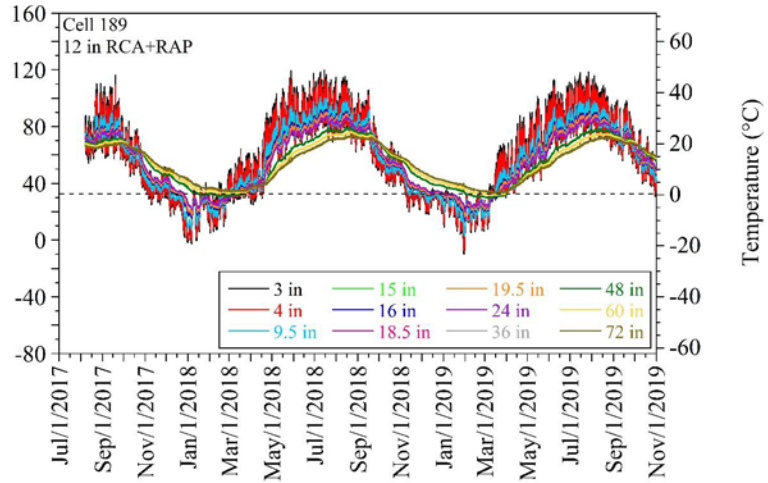
OBJECTIVES & TASKS

(3) In Depth Thermal Analyses

$$T(z,t) = \overline{T} + Ae^{-z\sqrt{\frac{\omega}{2\alpha}}} \sin\left(\omega t - z\sqrt{\frac{\omega}{2\alpha}} + C_4\right)$$

$\overline{T}$ = the average soil temperature
A = the surface amplitude of temperature
ω = the radial frequency $\left(\frac{2\pi}{p}\right)$
p = the period
α = the thermal diffusivity
C_4 = the phase constant

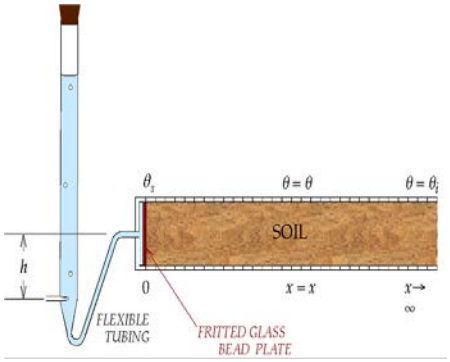




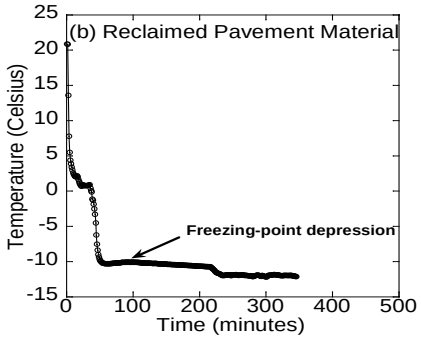
OBJECTIVES & TASKS

(3) In Depth Thermal Analyses

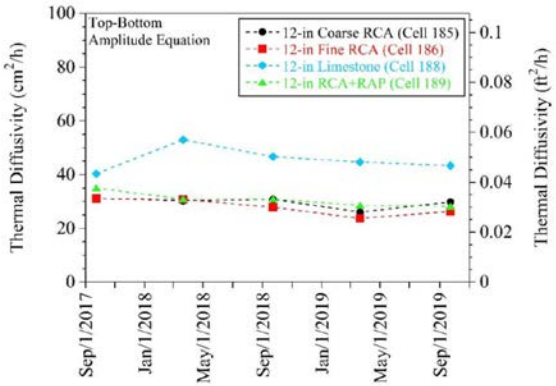
- **Water diffusivity**



- **Freezing point depression**



- **Thermal conductivity**
- **Volumetric specific heat capacity**
- **Thermal diffusivity**



OBJECTIVES & TASKS

(4) Conduct Forensic Analyses

In-Situ Tests for All Layers:

- Dynamic cone penetrometer
  - Thickness check
  - Shear strength
- Ground Penetration Radar
  - Thickness

Material Sampling for Base Layers:

- Core 6 x 12 inches samples
  - Permeability
  - Resilient modulus
- Regular Shelby tube samples
  - Gradation changes
  - Tufa formation (for RCAs in particular)- geochemical analyses
  - Creep behavior (for RCAs and RAP in particular)

Sampling for LSSB Layers:

- Geo-Endoscopic Imaging
  - Thickness
  - Subgrade Migration
  - Gradation
- Geosynthetics
  - Clogging Ratio
  - Puncture/fracture damage
  - Apparent opening size measurement (AOS)

OUTCOMES/BENEFITS

- Long Term Field Evaluation of RAB and LSSB Performances
  - Freeze-thaw durability
  - Stiffness
  - Strength
  - Permeability
  - Creep/compressibility

- Guidance on the following:
  - Evaluation/prevention of tufa information
  - Evaluation/prevention of subgrade soil migration into LSSB
  - Selection of geosynthetics for the use of LSSB
  - Evaluation of changes in gradation and angularity

- Long Term Resilient Modulus and Permanent Deformation Data for Pavement ME calibration

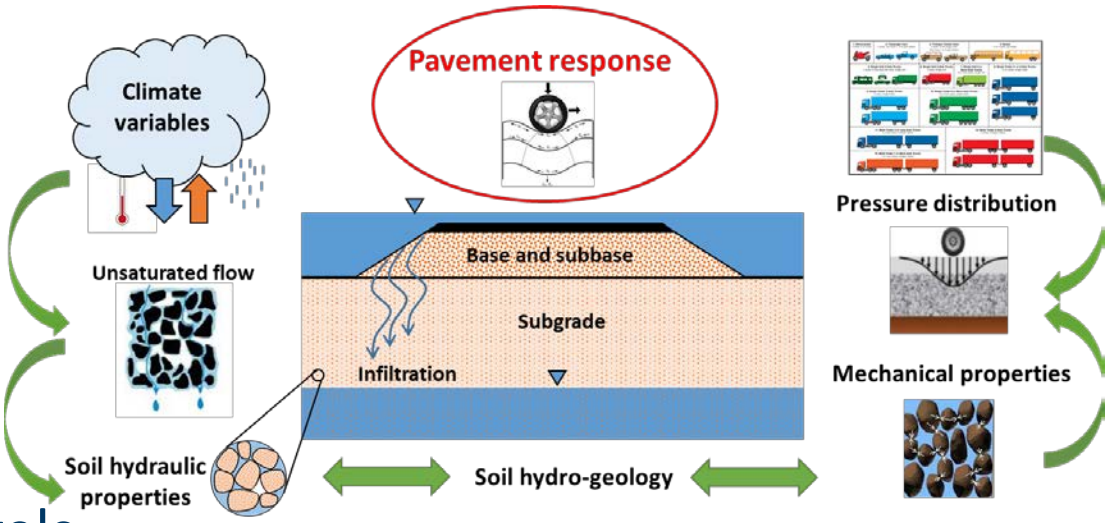
Flooded Pavements Assessment App–Phase II

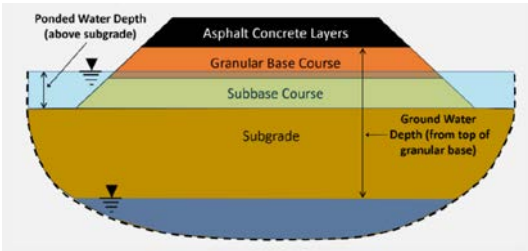
- Lead Proposer: Majid Ghayoomi and Eshan Dave (UNH)
- Objective:

  Enhance and amplify post-flooding toolkit . Calibration and validation campaign at different scales to provide a balanced practical approach.

Flooded Pavement Assessment App Phase II

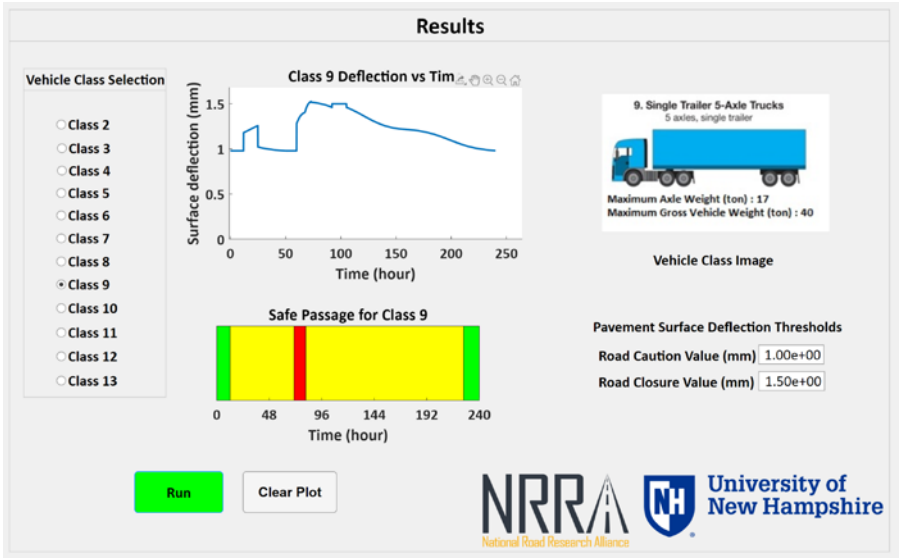
- Post-flooding Pavement Response Assessment:
  - Mechanistic
  - Coupled and Dynamic
  - Forecasted
  - Tiered I/O (Expert) Levels



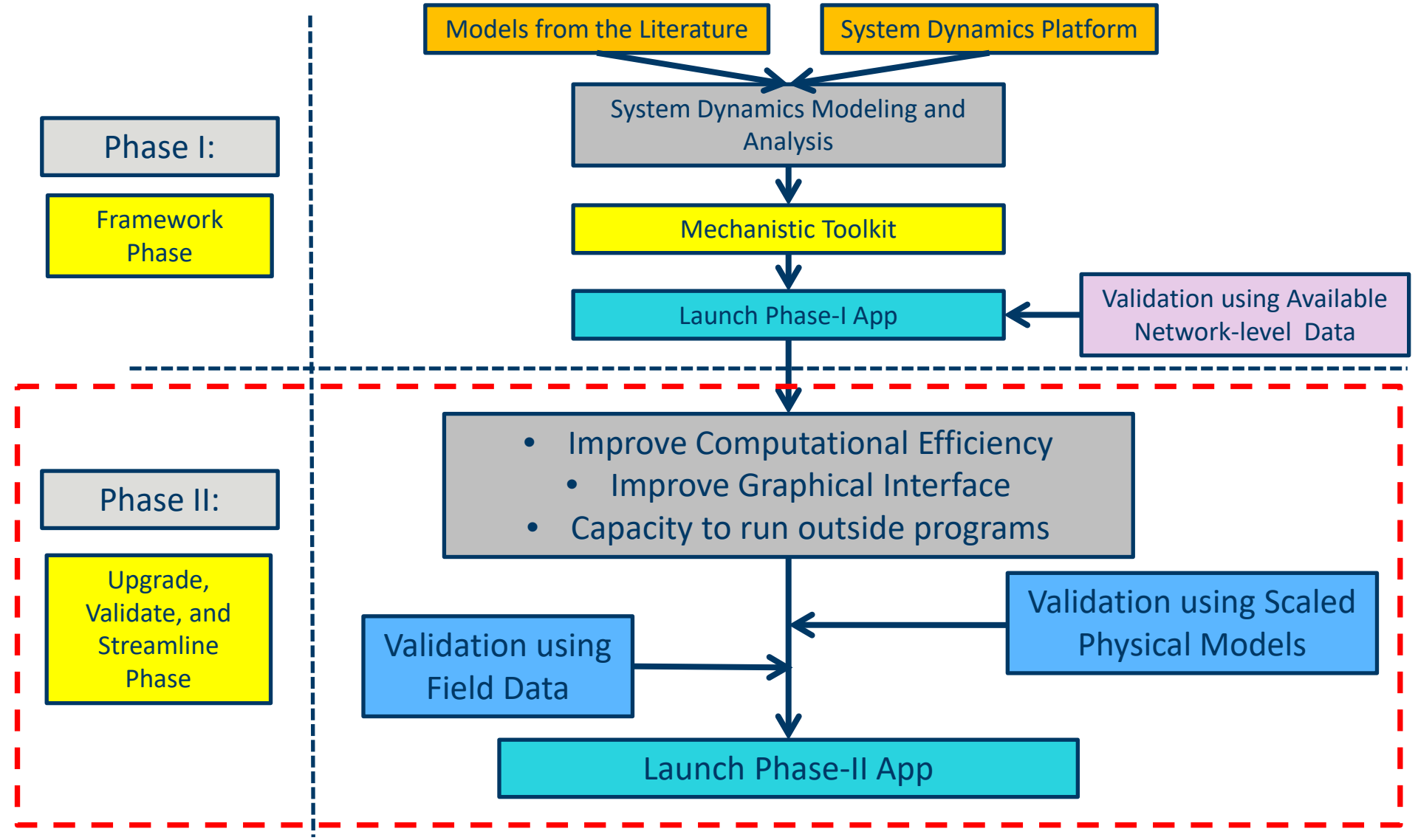


- **Phase II Goal:**

Enhance and amplify the recently developed post-flooding roadway assessment App



Flooded Pavement Assessment App
Phase II



Impact of cement on flexibility of CIR (1/4, ½, 1, 1.5%), both field and Lab

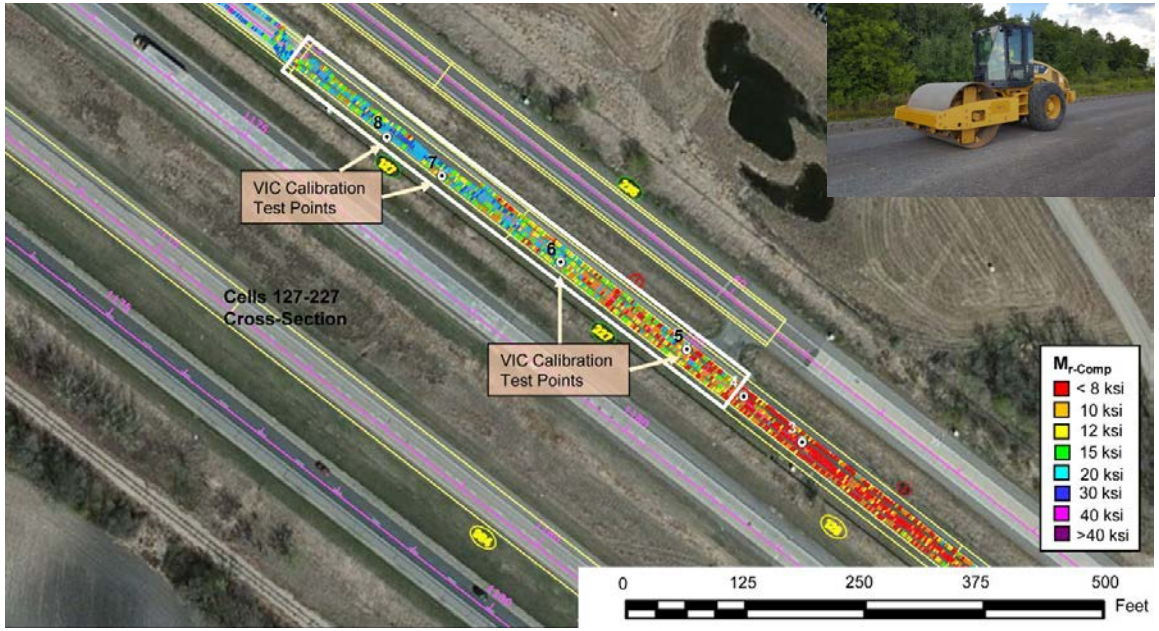
- Lead Proposer: Terry Beaudry and John Bormann (MnDOT)
- Objective:

  Bituminous, whether emulsions or foam asphalt add flexibility to CIR, whilst cement adds strength and lowers flexibility. What is the relationship between these two components? Additionally, what role does % crushing and type of aggregate play? Could be synthesis and/or lab project.

Use of IC for QA of base/subbase/subgrade construction with emphasis on assessing spatial variability of both stiffness and moisture

- Lead Proposer: Terry Beaudry and Raul Velasquez (MnDOT)
- Objective:

  Assessment of spatial variability of stiffness and moisture of foundation and its implication to performance.



*White and Vennapusa 2017

Towards a recycled base layer with optimum drainage, stiffness, and strength

- Lead Proposer: Raul Velasquez (MnDOT).
- Objective:

  Optimization of RAP (hydrophobic)+ RCA (hydrophilic) blends for balanced performance.

*Bora et al., 2021

Long term evaluation of wicking geotextiles for improving drainage and stiffness of road foundation

- Lead Proposer: David White (Ingios), Tom Fennessey (MoDOT), Terry Beaudry (MnDOT), and Raul Velasquez (MnDOT)
- Objective:

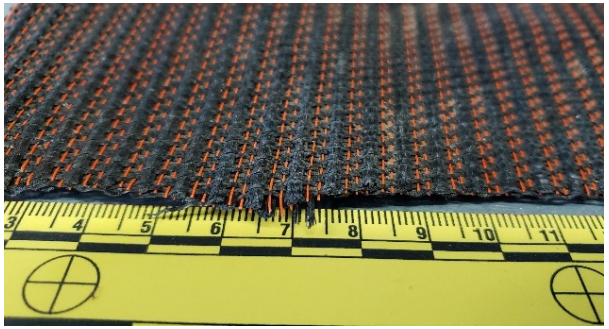
  Evaluate performance benefit (*both stiffness and drainage*) of wicking geosynthetic using accelerated load testing and MnROAD. Research studies completed are limited on this recently developed technology and what is available focuses on the drainage capabilities only and in the short-term performance.

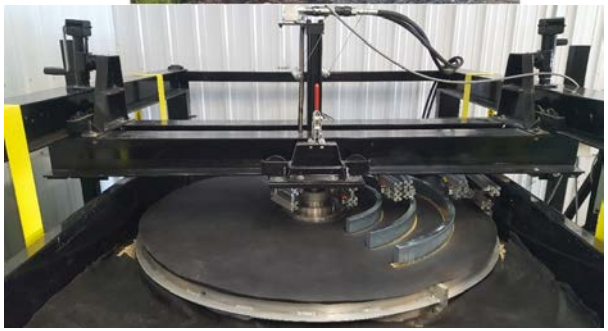
Performance evaluation of wicking geotextiles for improving drainage and stiffness of road foundation

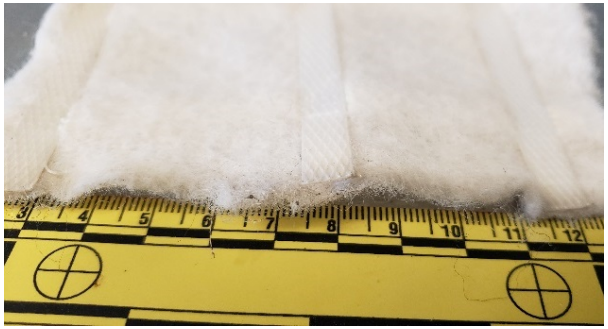
NRRA
National Road Research Alliance

MoDOT

Figure 2.12 Preparing a trench for sensor installation using a trench-digger







OBJECTIVES AND TASKS

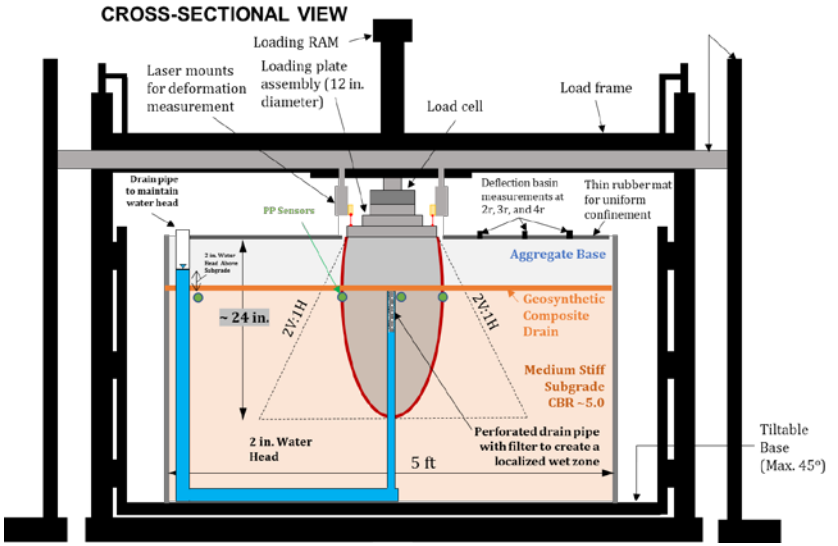
A. Review literature to summarize performance studies that incorporate wicking geosynthetics (example projects in Missouri and Alaska). Specific performance details to extract include moisture content variations over time, rutting/permanent deformation, and performance in areas with freeze/thaw and wet/dry cycles.

B. Perform set of accelerated laboratory tests with a large-scale box study to evaluate the performance benefit of geosynthetic products relative to a control section with no geosynthetic subject to controlled drainage and cyclic load testing.

C. At MnROAD perform direct field testing on new and in-serve pavement sections with wicking geosynthetics, to evaluate mechanistic pavement design input parameters (e.g., stress-dependent resilient modulus), foundation layer permanent deformation during wet seasons, and long-term moisture control in the foundation layers.

VALUE/BENEFIT

The results from this project would be used to quantify the benefit of using wicking geosynthetics in terms of long-term performance and providing an enhanced design input parameter for pavement design engineers.



Review 2-Pager

National Road Research Alliance

2021 Initial Idea Development

2021-2022 NRRA Research and MnROAD Construction Development
(Updated Form – March 23, 2021)

Initial Proposal is for NRRA Executive Team to Approve for further development (keep to two pages)

Research Title:	
NRRA Team(s):	
Type of Effort:	**Research/Synthesis**
Developed By:	
Email:	
Phone:	

Research Funding Estimate:	$X,XXX (include funding sources and partnership matches)
Research Years Expected:	**X years**
Beneficial Partnerships:	**Detail partnership ideas and who**

Number of Test Sections:	(How many test sections / total length per section)
Instrumentation Effort:	**(Minimal – Med – Extensive)** (Actual costs will be determined later once it is approved)
MnROAD Monitoring:	**MnROAD staff will cover routine monitoring and dynamic testing as did before)**

Research Objectives:

What are the objectives of this research effort?

Pavement Test Cells Needed:

What test sections (MnROAD or other roadways) do you propose to provide data? (None, if synthesis).

NRRA Sustainability/Resiliency and or Intelligent Construction:

How will this project fit the primary themes of NRRA Phase-II efforts?

Cross-cutting Opportunities:

Can your idea fit with or utilize concepts proposed by other NRRA teams?

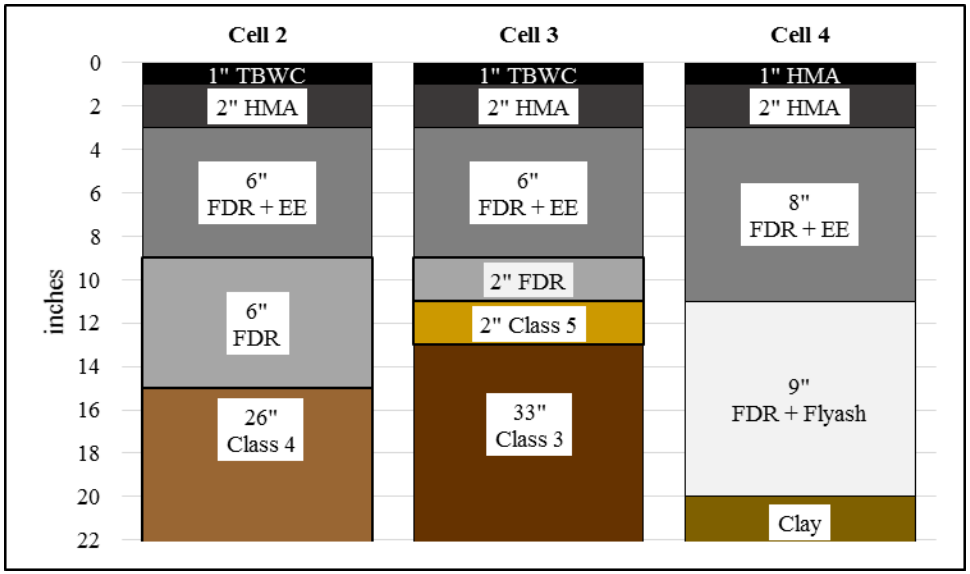
Implementation Plan:

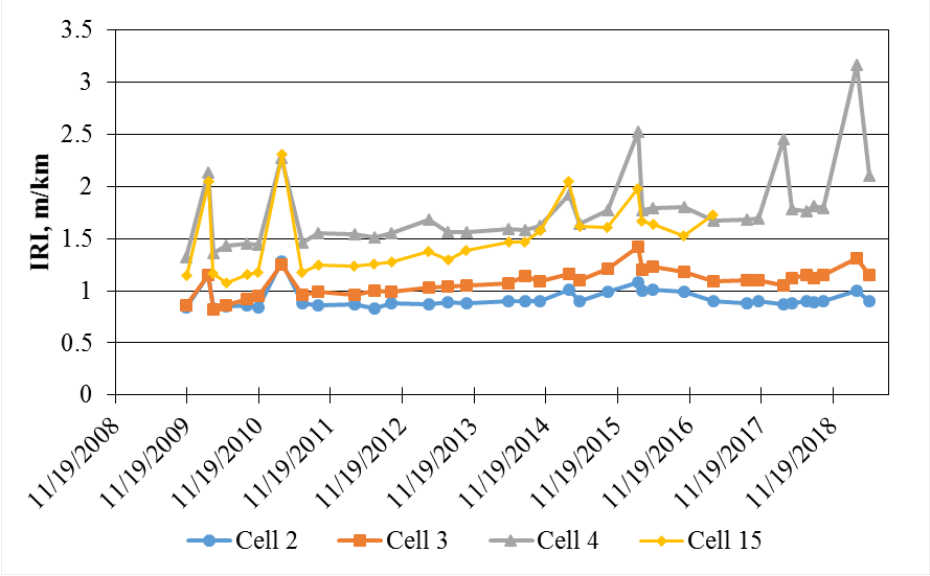
How do you envision implementing the findings from this study?

Next Steps for Geotech Ideas

- March Meeting:
  - Champion(s) of ideas provide an *elevator pitch* to Team
  - Surveymonkey (ranking/voting - All Members) after listening to all ideas
- Ranking is summarized and shared with team. Top 10 go to next round
- April Meeting:
  - Additional discussion on Top 10 ideas
  - Surveymonkey (ranking/voting only State Members)
- Ranking by State Members is summarized and share with Team
- *Develop 2-pagers for Top 5 ideas*
- Submission of Top 5 ideas to Executive Team

Cross Team Collaboration
Perpetual sFDR Test Sections (Flex Team)





Other NRRA Cross-Team Opportunities for MnROAD

- Concrete Team
  - Longitudinal Joint Optimization

Upcoming Geotech Events

- RPO:
  - April 20: "*Recycled Bases*" presented by Bora Cetin Ph.D., Michigan State University and Raul Velasquez, Ph.D., P.E., MnDOT

    A summary of a comprehensive laboratory and field study of recycled aggregate bases (including RCA and RAP) is presented. Field study included over 2 years of monitored performance of several MnROAD test sections.

Upcoming Geotech Events

- 4th International Conference on Transportation Geotechnics – Virtual, May 24-27

  http://conferences.illinois.edu/ICTG2021/

Upcoming Geotech Events

- 4th International Conference on Transportation Geotechnics – Virtual, May 24-27

4th ICTG Pre-Conference Workshops / Short Courses / YTGE Meeting

Event Type	Event	Organized by
Meeting (Full day)	**YTGE Meeting**	Yu Qian
Short Course (Full day)	**Geosynthetics in Transportation Geotechnics – Instructors Jorge Zornberg & Erol Tutumluer**	IGS NA – John McCartney & Jennifer Nicks
Workshop (Full day)	**Developing Specifications to Address Track Support and Substructure Maintenance & Safety Challenges**	Ted Sussmann & Dingqing Li
Workshop	**IC Technologies in Earthworks**	Soheil Nazarian
Workshop	**Sustainability & Climatic Effects in Mechanistic based Designs of Highway & Airfield Pavements**	Hasan Ozer & Halil Ceylan
Workshop	**Airfield Pavement Design & Rehabilitation**	Nav Garg & Jeb Tingle

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