Determining Pavement Design Criteria for Recycled Aggregate Base and Large Stone Subbase

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Halil Ceylan, Co-PI
Junxing Zheng, Co-PI

MnDOT Project TPF-5(341)
Monthly Meeting
August 2nd, 2018
RESEARCH TEAM

Iowa State University

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  Assistant Professor – Department of Civil, Construction & Environmental Engineering

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  Assistant Professor – Department of Civil, Construction & Environmental Engineering

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  Professor – Department of Civil, Construction & Environmental Engineering

- Co-Principal Investigator – Junxing Zheng
  Assistant Professor – Department of Civil, Construction & Environmental Engineering

- Research Personnel – Haluk Sinan Coban
  PhD Student – Department of Civil, Construction & Environmental Engineering

University of Wisconsin-Madison

- Co-Principal Investigator – William Likos
  Professor – Department of Civil and Environmental Engineering

- Co-Principal Investigator – Tuncer B. Edil
  Professor Emeritus – Department of Civil and Environmental Engineering
NRRA Members (Agency Partners)

- MnDOT
- Caltrans
- MDOT
- Illinois DOT
- LRRB
- MoDOT
- WisDOT
NRRA Members (Industry Partners)

- Aggregate & Ready Mix of MN
- Asphalt Pavement Alliance (APA)
- Braun Intertec
- Concrete Paving Association of MN (CPAM)
- Diamond Surface Inc.
- Flint Hills Resources
- International Grooving & Grinding Association (IGGA)
- Midstate Reclamation & Trucking
- MN Asphalt Pavement Association
- Minnesota State University - Mankato
- National Concrete Pavement Technology Center
- Roadscanners
- University of Minnesota - Duluth
- University of New Hampshire
- Mathy Construction Company
- 3M
- Asphalt Materials & Pavements Program
- Husky Energy
- Hardrives, Inc.
- Testquip LLC
- The Transtec Group
- The Dow Chemical Company
- Pavia Systems, Inc.
- Michigan Tech Transportation Institute (MTTI)
- University of Minnesota
- National Center for Asphalt Technology (NCAT) at Auburn University
- GSE Environmental
- Helix Steel
- Ingios Geotechnics
- WSB
- Cargill
- PITT Swanson Engineering
- Collaborative Aggregates LLC
- American Engineering Testing, Inc.
- Center for Transportation Infrastructure Systems (CTIS)
- Asphalt Recycling & Reclaiming Association (ARRA)
- First State Tire Recycling
- BASF Corporation
- Upper Great Plains Transportation Institute at North Dakota State University
- All States Materials Group
- Caterpillar
- University of California Pavement Research Centre
- Payne & Dolan, Inc.
OUTLINE

• Follow-Up
• Task 3 – Construction Monitoring and Reporting
• Task 4 – Laboratory Testing
FOLLOW-UP

• Task 1 – Literature Review and Recommendations
• Task 2 – Tech Transfer “State of Practice”
• Task 3 – Construction Monitoring and Reporting
• Task 4 – Laboratory Testing
• Task 5 – Performance Monitoring and Reporting
• Task 6 – Instrumentation
• Task 7 – Pavement Design Criteria
• Task 8 & 9 – Draft/Final Report
## TEST SECTIONS

<table>
<thead>
<tr>
<th>Recycled Aggregate Base</th>
<th>Large Stone Subbase</th>
<th>Large Stone Subbase with Geosynthetics</th>
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<tbody>
<tr>
<td>185 3.5 in Superpave</td>
<td>186 3.5 in Superpave</td>
<td>188 3.5 in Superpave</td>
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<tr>
<td>12 in Coarse RCA (Class 5Q)</td>
<td>12 in Limestone (Class 6)</td>
<td>12 in RCA + RAP (Class 6)</td>
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<td>3.5 in S. Granular Borrow</td>
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<tr>
<td>Clean Sand</td>
<td>Clean Sand</td>
<td>Clay Loam (A-6)</td>
</tr>
<tr>
<td>187 3.5 in Superpave</td>
<td>189 3.5 in Superpave</td>
<td>190 3.5 in Superpave</td>
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<td>6 in Class 6</td>
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<tr>
<td>18 in LSSB (1 lift)</td>
<td>18 in LSSB (1 lift)</td>
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<tr>
<td>18 in LSSB</td>
<td>18 in LSSB</td>
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<td>12 in Fine RCA (Class 5)</td>
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**NOTE:**
- TX = Triaxial Geogrid
- BX = Biaxial Geogrid
- GT = Nonwoven Geotextile
TASK 3

Task 3 – Construction Monitoring and Reporting

• Dynamic Cone Penetrometer (DCP) Test
• Lightweight Deflectometer (LWD) Test
• Validated Intelligent Compaction (VIC)
• Falling Weight Deflectometer (FWD) Test
TASK 3

Dynamic Cone Penetrometer (DCP) Test (ASTM D6951)

• Subgrade layers – data available for cells 188 and 189
  [penetration depth = 18 in (457.2 mm)]
  – Cells 185 – 186 ➔ No test due to bad weather
  – Cells 328 – 728 ➔ No test due to very soft subgrade (for LSSB)
    [DCPI: 2.5 - 3.5 in/blow (63.5 – 88.9 mm/blow)]

• Base layers – data available for each cell
  – Cells 185 – 189 ➔ Depths corresponding to 12 drops
  – Cells 127 – 728 ➔ Penetration depth = 6 in (152 mm)
TASK 3

Dynamic Cone Penetrometer (DCP) Test (ASTM D6951) – Cont’d

• Cells 185 – 186 (Base) ➔ Lowest DCPI
• Cells 188 – 189 (Base) ➔ Low DCPI (no outliers)
• Cells 127 – 782 (Base) ➔ Higher and wider DCPI (with outliers)
TASK 3

Lightweight Deflectometer (LWD) Test (ASTM E2583)

- Cells 127 – 728 ➔ No test due to very soft subgrade
- Cells 185 – 189 ➔ Base modulus > Subgrade modulus
- Cells 185 – 186 (Base) ➔ Higher modulus
- Cells 328 – 728 (Base) ➔ Lower modulus
Validated Intelligent Compaction (VIC) (White and Vennapusa 2017)

- Cells 328 – 628
  - No. of passes ↑, resilient modulus ↑
- Insufficient compaction
Validated Intelligent Compaction (White and Vennapusa 2017) – Cont’d

- Only in cells 185 – 186 (Base) ➔ Modulus @ 30 psi > Modulus @ 10 psi
- Cells 185 – 186 (Base) ➔ Highest modulus
- Cells 127 – 227 (Base) ➔ Similar or higher modulus than cells 188 - 189
- Cells 328 – 728 (Base) ➔ Lowest modulus
Falling Weight Deflectometer (FWD) Test

• Base Layers
  – Cells 185 and 186 ➔ Lowest deflections
  – Cells 188 – 227 ➔ Similar median but wider range in cells 188 – 189
  – Cells 328 – 728 ➔ Higher deflections

• Asphalt Surface
  – Similar deflections
Falling Weight Deflectometer (FWD) Test – Cont’d

- Possible frozen road condition during FWD testing on asphalt in November 2017.

![Air Temperature Graph]

- Date: 7/1/17 to 12/1/17
- Air Temperature (°F)
- Construction
- FWD Test on Asphalt Surface
Task 4 – Laboratory Testing

• Iowa State University
  – Soil classification
  – Image analysis
  – Proctor & gyratory compaction
  – Asphalt & cement content determination
  – Contact angle measurement

• University of Wisconsin-Madison
  – Soil-water characteristic curve
  – Permeability
TASK 4

Soil-Water Characteristic Curve (SWCC) and Hydraulic Conductivity Function (HCF)

Increasing Suction, Decreasing Saturation

Soil-Water Characteristic Curve (SWCC)

Hydraulic Conductivity Function (HCF)

(Lu and Likos, 2004)
TASK 4

Dry Sand

S = 0.17

S = 0.40

S = 0.70

S = 0.80
TASK 4

Axis Translation Method

- Effluent Water Mass (grams)
- Time (hours)

Air Pressure Increment:
- 9.7 kPa
- 12.4 kPa
- 15.2 kPa
- 20.7 kPa
- 23.4 kPa

Well Graded Sand porosity, n = 0.34
TASK 4

Large-Scale Axis Translation Methods
TASK 4

UW-Madison Flexible-Wall Permeameter for Coarse-Textured Soils

Photographic Portrayal by Xiaodong Wang & Craig H. Benson
TASK 4

Permeameter with Constant Head Reservoirs for Headwater & Tailwater
TASK 4
# SCHEDULE

<table>
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<th>MONTHS</th>
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Thank You!

QUESTIONS??