FHWA Program Update
National Concrete Consortium, Spring 2019
April 2 • Denver, CO

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SENIOR CONCRETE ENGINEER
FHWA, OFFICE OF INFRASTRUCTURE

Images FHWA unless otherwise noted.
Welcome Dr. Leslie McCarthy

- Past experience with FHWA
- Lead role in FHWA asphalt activities
- Mobile Asphalt Testing Trailer Program manager
- Remote employee (Philadelphia area)
FAST Act provides $67,500,000 each year to carry out a Technology and Innovation Deployment Program (TIDP) relating to all aspects of highway transportation.

FAST Act reserves $12,000,000 each year from the TIDP program to accelerate the implementation and deployment of pavement technology (AIDPT).

AIDPT instructs FHWA to promote, implement, deploy, demonstrate, support, and document the application of innovative pavement technologies, practices, performance, and benefits.
AIDPT Cooperative Agreements

• FHWA has awarded multiple Cooperative Agreements under the AIDPT program between 2013-2017.

• Advantages of cooperative agreement vehicle:
  - Technical guidance and assistance
  - Ability to leverage Federal investments with private funding and partnerships
  - Collaboration increases public buy-in of deliverables

• Awards made to universities, transportation centers, others (ex. Asphalt Institute, National Asphalt Pavement Association, National Concrete Pavement Technology Center, American Concrete Institute, etc.).
Substantial Federal Oversight

Prior to/at Award
- Technical panel evaluates applications and selects recipient
- Subawardee/subcontractor review and approval
- Key personnel review and approval

During Agreement Performance
- Technical assistance and guidance
- Review and approval of initial work plan (including outreach and dissemination plan)
- Technical, performance, and financial monitoring
- Review and acceptance of agreement deliverables
Concrete Cooperative Agreement Topic Areas

- Extending Pavement Life and Performance
- Reducing Initial and Life Cycle Costs
- Accelerated Construction Techniques
- Design Criteria and Specifications (PEM)
- Non-Destructive Testing
- Technology Transfer

* Please share ideas with Mike Praul and/or Peter Taylor
Anticipated Deliverables

- Best Practices Guides
- Demonstration Projects
- Specification Language
- Literature Reviews
- Marketing New Technology
- QC Tools
- State-of-the-Practice Reports
- Technical Briefs
- Webinars
- Workshops
Available to pooled fund participating states
Eight states currently participating (NY, PA, IA, WI, MN, NC, IL, SD)
Deadline for new applications: 5/31/19
Reports coming from participating states will be shared with PEM Pooled Fund and available to all
Federal Lands projects coming!
2019 MCT State Site Visits

- South Carolina
- North Carolina
- Kansas
- California
- Florida
- Vermont
# MCT at Conferences

## 2016
- PA Concrete Conference
- International Society for Concrete Pavements (TX)
- Arkansas American Concrete Pavement Association (ACPA) Conference

## 2017
- NE Concrete Conference
- VA Concrete Conference
- National Society of Professional Engineers (TX)
- OH Transportation Engineering Conference
- AZ Equipment Expo
- AZ Pavements & Materials Conference
<table>
<thead>
<tr>
<th>2018</th>
<th>2019</th>
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<tbody>
<tr>
<td>• MD Concrete Conference</td>
<td>• PA Concrete Conference</td>
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<tr>
<td>• NY Construction Materials Association Conference</td>
<td>• National Road Research Alliance (MN)*</td>
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<tr>
<td>• TX Concrete Conference</td>
<td>• UT Concrete Conference*</td>
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<td>• IN American Society of Civil Engineers Annual Meeting</td>
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<td>• Roadway Management Conference (PA)</td>
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<td>• ConcreteWorks Conference (MA)</td>
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Performance Engineered Mixtures (PEM) Assessment & Validation of Durability Testing Procedures

**NEW AASHTO STANDARDS**
- Based on modified ASTM standards
- Rate of absorption ASTM C1585
- Freeze-Thaw related

**Fundamental research tool to validate/refine models**
- PS expression practice
- PS electrical resistivity test
- PS elemental analysis, XRF
- Temperature Correction

**Surface Resistivity**
- AASHTO T358

**UNIAXIAL RESISTIVITY**
- AASHTO TP119

**CAOXY QUANTIFICATION**
- AASHTO T365

**MODIFIED AASHTO STANDARDS**
- Uniaxial Resistivity
- Salt damage related

Current focus for PEM

\[
F = \frac{\rho}{\rho_0}
\]

Formation factor related
- Surface or bulk resistivity
- Pore solution resistivity
Stage 1: Impact of Conditioning Regimes on Transport Properties
TFHRC/NRMCA Collaboration (2-Phased study)

Objectives:

- How FF is affected in different curing regimes
  - Understand how DOS, DOH & PS resistivity varies in different curing regimes
- Prediction of PS resistivity using NIST model Vs. measured PS
  - Eliminates the need for PS expression, streamlining FF
- Bucket test, reasonable indication of PS resistivity!
  - Enables favorable FF

Experimental design:

- 4 mixtures & 7 different curing regimes

\[ F = \frac{\rho_b}{\rho_{\text{bucket}}} \]
Phase I Status:

- Enormous amount of data acquired analyzed in phase I: BR, SR, PSR, FF, RCPT, DOH, DOS, Leaching, NIST Model
- Testing on phase I mixes is complete
- Data analysis is about to be finalized
- Draft Phase I report on FF & bucket test under internal review
Values of DOS, FF, Concrete & PS Resistivity depends on the curing regime and the mix

Concrete Resistivity

Cell Resistivity

- General Findings: A glimpse
General Findings: A glimpse

- Values of DOS, FF, Concrete & PS Resistivity depends on the curing regime & the mix
Bucket test – assume PS resistivity the same as the resistivity of bucket solution

How reasonable is this assumption?

Reasonable for 2 of the mixes!

\[ F = \frac{\rho_{\text{concrete}}}{\rho_{\text{pore solution}}} \]

Assuming \( \rho_{\text{pore solution}} = \rho_{\text{bucket}} \)
Stage 2: F-T Durability, Salt Damage Related Tests

- Quantify CAOXY using LTDSC
  - Workplan developed
- Modified ASTM C642
  - Total pore volume, DOS
- Modified C1585: Rate of absorption
  - Time to critical degree of saturation:
    \[ S(t) = S_{Nick} + \phi \cdot S_2 \cdot \sqrt{t} \leq DOS_{critical} \]

Upcoming Reports:
- Pore Solution Expression
- Influence of Curing Regimes on FF
- Flyer on FF and Bucket Test
**TFHRC/OSU/UT Collaboration**

**Benchmarking MCPT & CCT to Outdoor Exposed Blocks**

- **MCPT**: Miniature Concrete Prism Test, Clemson U; 8-12 weeks
- **CCT**: Concrete Cylinder Test, U. of Texas; 9 month

**Problem Statement**: Many exposure blocks in Texas & across North America exhibiting signs of ASR, despite passing the ASTM C1293 two-year prism
TFHRC – OSU – UT Collaboration

- **Research Ideas:**
  - Identify tests that don’t promote leaching

- **Objectives:**
  - Examine CCT & MCPT as accurate/accelerated ASR mitigation measures
  - Determining duration & expansion limits
  - How it affects pore solution chemistry!
OVERALL PLAN

- 2 reactive coarse aggregates (Spratt, Placitas)
- 2 reactive fine aggregates (Jobe, Wright)

Mitigation Measures:

- 40 mixes total, TFHRC responsible for 15

Results:

- Encouraging results: MCPT, confirming field data – CCT Mimics C1293
- Final Report, September 2019
Quantifying Fly Ash Adsorption Using Sorbsensor
TFHRC/Headwaters Inc. Collaboration

- Fluorescence-based technology!
- Fly ash can adsorb AEAs & expose concrete to F-T durability
- Foam index: subjective, relying on visual observation, high variability

Objective: Quantifying fly ash adsorption capacity by fluorescence properties

Foam Index: Stages of foam formation

- No foam
- Foam stability in progress
- Stable foam
Sorbsensor - How it Works!

- Surrogate surfactant: nonylphenol ethoxylate (P10)
- 10 different ashes, 8 different states

Procedure:

- Fly ash is mixed with a solution containing 150 ppm of P10
- The remaining P10 fluoresces as existed by UV
- Fluorescence intensity $\propto$ concentration of P10
- Same 10 fly ashes tested with 3 different AEAs using Foam Index
Adsorption Capacity Measurement: Sorbsensor Vs. Foam Index

- Fluorescence results and Foam Index correlated well
- Each AEAs exhibited different correlation curve
- Game changer:
- No guesswork!

SBIR project (PhosphorTech): Advance this technology’s capabilities: Broader UV spectral range, use with any AEAs (not limited to P10)
FHWA Performance Related Specifications (PRS) Update
Performance related specifications (PRS) compare design expectations to what was constructed, and accordingly.

“Predict,” or more correctly “model,” as-constructed performance for each constructed lot on a project by measuring construction quality characteristics.

Provides a rational, technical, and defensible framework for awarding a contractor incentives and disincentives for construction quality by relating the as-constructed modeled performance to the target or as-designed performance.

Contractors have freedom to innovate in order to achieve targeted performance.
Concrete Pavement Performance

Pavement ME AND Engineering Experience and Expertise (Foundation, Design Features, factors not provided in Pavement ME)

Materials
PEMD: Lab Qualification for Concrete Mixture Design AND Other Lab Tests for Other Materials

Construction
PRS: Expected Life Acceptance for Concrete Mixture AND also includes Non-Mixture Properties

ALL THREE COMPONENTS ARE IMPORTANT FOR PERFORMANCE

U.S. Department of Transportation
Federal Highway Administration
Office of Infrastructure
Performance Engineered Mixture Design (PEMD)

Lab Mixture Qualification Before Construction

- D-Cracking, Alkali-Aggregate Reactivity
- Aggregate Stability
- Choose from w/cm ratio, formation factor, ionic penetration
- Transport Properties
- Choose from air content, SAM number, or time critical saturation
- Hydrated Cement Paste
  - F T Durability
  - Choose from several options
- Hydrated Cement Paste Durability – Salt Damage
- Choose from several options
- Slab Warping/Cracking Due to Shrinkage
- Choose from flexural strength or compressive strength
- Concrete Strength
- Choose from Box test or V-Kelly test
- Workability
- N/A

Performance Related Specifications (PRS)

Determination of Expected Pavement Life for Payment

- Performance Tests and Performance Model(s)
  - N/A
  - Choose from resistivity or formation factor + matrix porosity
  - Choose from air content or SAM number
  - Design check only
  - N/A
  - Choose from flexural strength or compressive strength
  - N/A
  - thickness, initial smoothness (IRI), dowel alignment ...

Non Mixture Factors

- N/A
Four Step Approach Towards Durability in PRS

1. Assess Performance w/ Standard Tests
   - Considerations:
     - Ability to assess performance
     - Relationship to fundamental properties
     - Ease of use
     - Cost

2. Convert Test Results to Fundamental Properties
   - Examples:
     - Measure Resistivity
     - Account for Pore Solution
     - Determine F-Factor

3. Relate Properties w/ Exposure Conditions
   - Use Exposure, Material Properties, and Models to Estimate Performance

4. Establish Performance Limits and Measure
   - Set Performance Limits
   - Use Tests to Measure
   - To Assure that You Receive what You Specified
Pavement Design

Establish Performance Criteria

Sampling and Testing

Identify AQC's and Target Values

Incorporate into Plans and Specifications

Performance Incentives and Disincentives

PASSRigid™

Design AQC vs. As-Constructed AQC

Model Performance

Quality

Design: Quality

Construct: Quality

As-Designed: Distress & IRI

As-Constructed: Distress & IRI

Pavement Age
Performance Related Specifications (PRS) are the implementation of some Performance Engineered Mixture Design (PEMD) tests to model expected life; and provide incentives/disincentives for performance.

PRS also includes other non-mixture quality characteristics such as slab thickness, initial smoothness, and dowel alignment to determine expected life.

Durability and structural performance is modeled in PASSRigid™.

Agency provides incentives for exceeding performance criteria and disincentives for not meeting performance criteria based on modeled performance.
<table>
<thead>
<tr>
<th>Name</th>
<th>Key Variable</th>
<th>Status</th>
<th>Temperature Correction</th>
<th>Surface Resistivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>F Factor Inputs Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bulk Resistivity</td>
<td>Pore Solution Resistivity</td>
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</tr>
<tr>
<td></td>
<td>$\rho_{\text{Bulk}}$</td>
<td>$\rho_{\text{Soln}}$</td>
<td>$E_{\text{AC}}$</td>
<td>$\rho_{\text{Surface}}$</td>
</tr>
<tr>
<td></td>
<td>Complete: Conditioning improved and includes the ‘bucket test’</td>
<td>Complete: There are several ways to obtain and it is simple to measure after obtaining solution</td>
<td>Complete: This is needed and exists for a clear way to perform temp. corrections</td>
<td>• Identical to bulk when done correctly • Requires a task force to revise*</td>
</tr>
</tbody>
</table>
## Freeze Thaw Model Inputs Status

<table>
<thead>
<tr>
<th>Name</th>
<th>Key Variable</th>
<th>Status</th>
<th>Matrix Saturation</th>
<th>Critical Saturation</th>
<th>Secondary Sorption</th>
<th>Drying Factor</th>
</tr>
</thead>
</table>
|      | S<sub>Matrix</sub> | • Bucket test under development  
• Computational model began with PRS (OPC)/now TPF | S<sub>Critical</sub> | dS<sub>2</sub>/dt | φ |

TPF – transportation pooled fund  
OPC – ordinary Portland cement
PCC PRS Project Status

- Freeze-thaw service life model, salt damage assessment, and transport model (finalizing)
- Standardized test procedures (previous two slides)
- PASSRigid™ software with non-mixture AQCs + durability AQCs (Spring 2019)
- Report on models and PASSRigid™ (Fall 2019)
- Shadow project – C470 Colorado (2018)
- Additional upcoming shadow project – additional States (Summer 2019 and 2020)
- Whiteboard Informational Videos (Spring 2019)
- Informational Video (Spring 2019)
- Implementation Report, Technical Briefs, Presentations (Summer 2019)
- Additional shadow projects in 2019 and 2020 (seeking agency participants)
- Workshops and in-person training (2019 and 2020)
Performance Related Specifications (PRS) are the implementation of some Performance Engineered Mixture Design (PEMD) tests to model expected life; and provide incentives/disincentives for performance. PRS also includes other non-mixture quality characteristics such as slab thickness, initial smoothness, and dowel alignment to determine expected life. Durability and structural performance is modeled in PASSRigid™. Agency provides incentives for exceeding performance criteria and disincentives for not meeting performance criteria based on modeled performance.
Questions? Interested in Shadow Projects?

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