FHWA Program Update

National Concrete Consortium, Spring 2019
April 2 • Denver, CO

Images FHWA unless otherwise noted.

MICHAEL F. PRAUL, PE
SENIOR CONCRETE ENGINEER
FHWA, OFFICE OF INFRASTRUCTURE

U.S. Department of Transportation
Federal Highway Administration
Office of Infrastructure

Welcome Dr. Leslie McCarthy

- Past experience with FHWA
- Lead role in FHWA asphalt activities
- Mobile Asphalt Testing Trailer Program manager
- Remote employee (Philadelphia area)

Technology and Innovation Deployment Program

- 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, showcase, 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

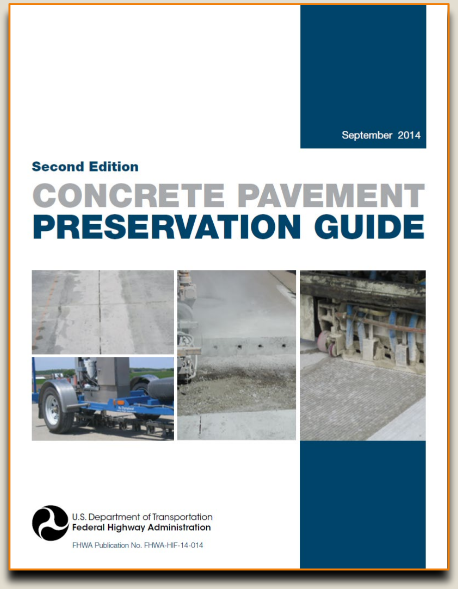
Concrete Cooperative Agreement Topic Areas

- 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



PEM Implementation Incentive Funds

- 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

MCT at Conferences

2018

- MD Concrete Conference
- NY Construction Materials Association Conference
- TX Concrete Conference
- IN American Society of Civil Engineers Annual Meeting
- Roadway Management Conference (PA)
- ConcreteWorks Conference (MA)

2019

- PA Concrete Conference
- National Road Research Alliance (MN)*
- UT Concrete Conference*

TFHRC Concrete Research Update

National Concrete Consortium

Spring 2019

Ahmad A. Ardani, P.E.

Infrastructure Materials Team, Turner-Fairbank Highway Research Center, FHWA

Performance Engineered Mixtures (PEM)
Assessment & Validation of Durability Testing Procedures

New AASHTO standards

- **Based on modified ASTM standards**
  - Rate of absorption ASTM C1585
- **Completely new procedures**
  - Total pore volume
  - Degree of saturation
  - Critical degree of saturation
  - PS expression practice
  - PS electrical resistivity test
  - PS elemental analysis, XRF
  - Temperature Correction

Fundamental research tool to validate/refine models

Modified AASHTO standards

- Surface Resistivity AASHTO T358
- Uniaxial Resistivity AASHTO TP119
- CAOXY Quantification AASHTO T365

Freeze-Thaw related

Formation factor related

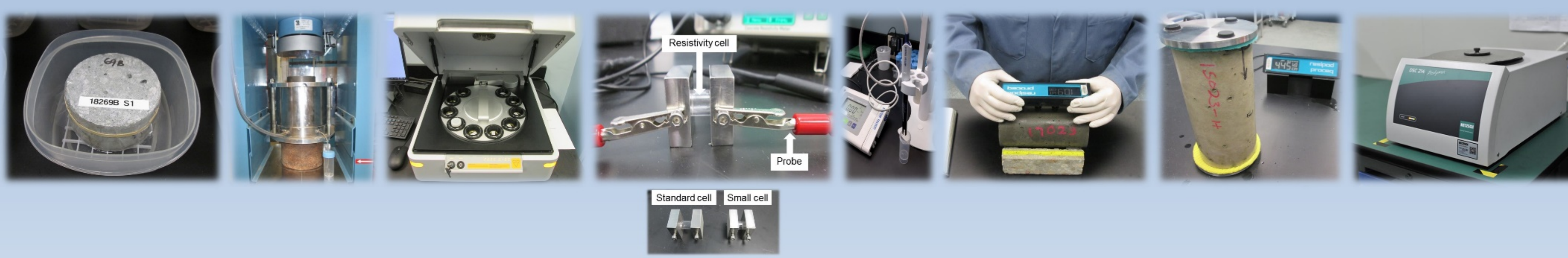
$$F = \frac{\rho}{\rho_0}$$

ρ: Surface or bulk resistivity

ρ_0: Pore solution resistivity

Salt damage related

Current focus for PEM



Stage 1: Impact of Conditioning Regimes on Transport Properties

TFHRC/NRMCA Collaboration (2-Phased study)

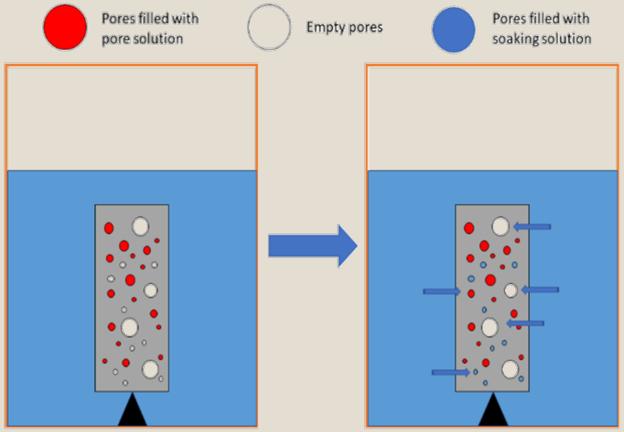
Objectives:

- 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
- Bucket test, reasonable indication of PS resistivity!
  - Eliminates the need for PS expression, streamlining FF

$$F = \frac{\rho_b}{\rho_{bucket}}$$

Experimental design:

- 4 mixtures & 7 different curing regimes



Effect of different curing conditions on transport properties

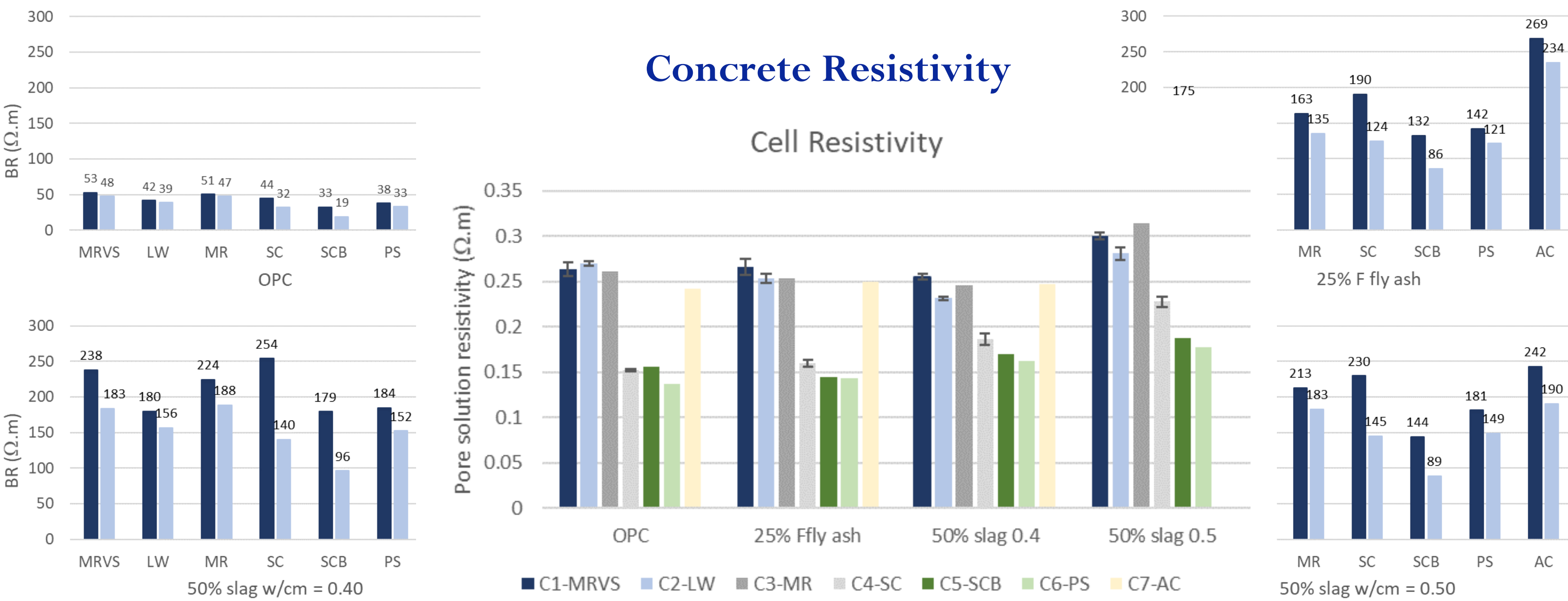
➢ Phase I Status:

- 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

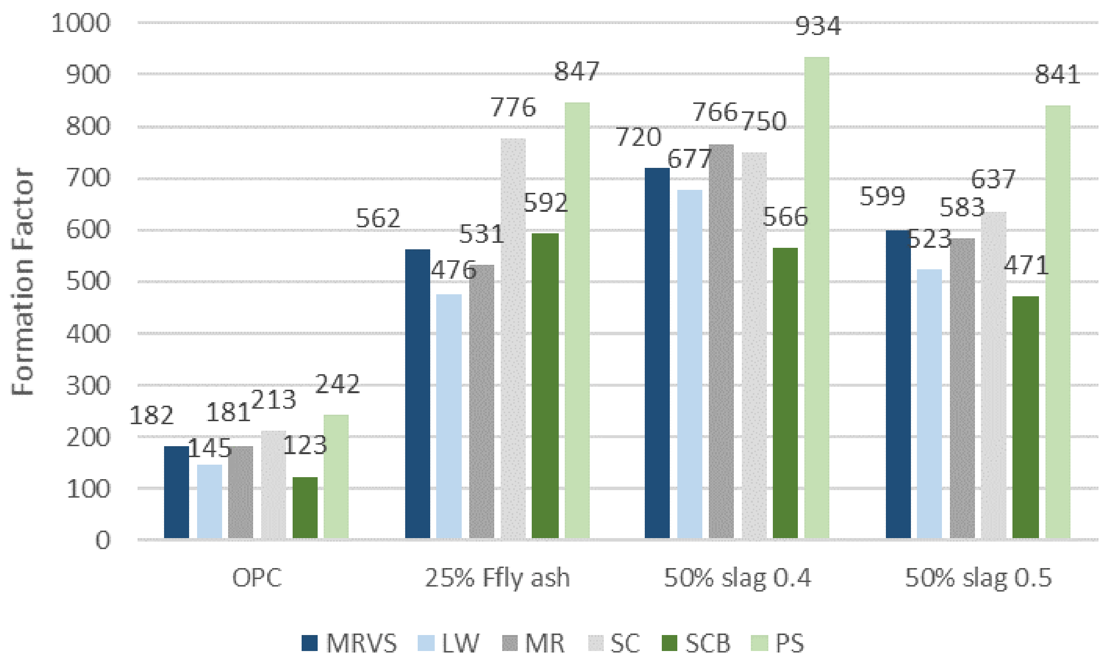
General Findings: A glimpse

- Values of DOS, FF, Concrete & PS Resistivity depends on the curing regime and the mix



General Findings: A glimpse

- **Values of DOS, FF, Concrete & PS Resistivity depends on the curing regime & the mix**

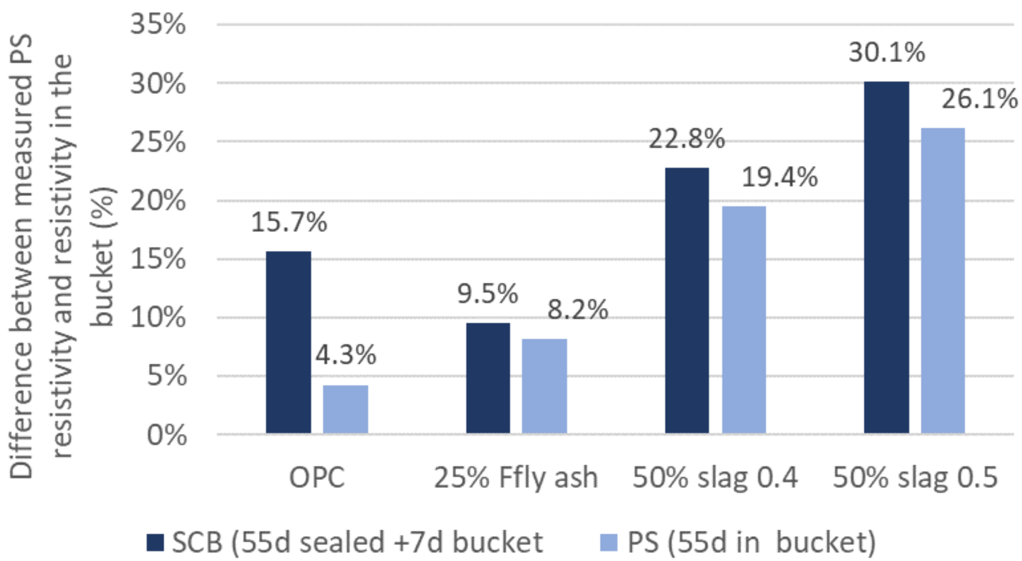


General Findings: A glimpse

- Bucket test – assume PS resistivity the same as the resistivity of bucket solution
- How reasonable is this assumption?
- Reasonable for 2 of the mixes!

$$F = \frac{\rho_{concrete}}{\rho_{pore\ solution}}$$

Assuming $\rho_{pore\ solution} = \rho_{bucket}$



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: $DOS_{critical} = 85\%$

Chlorides: Ca, Mg, Na

$$S(t) = S_{Nick} + \emptyset \cdot S_2 \cdot \sqrt{t} \leq DOS_{critical}$$

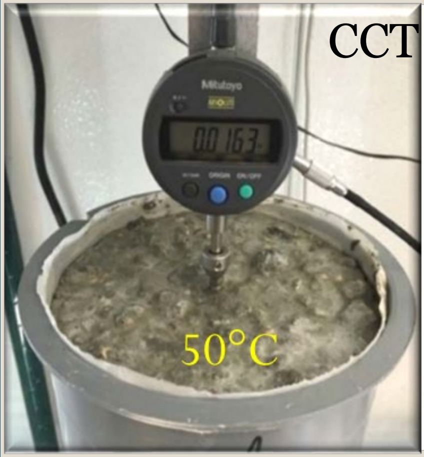
Upcoming Reports:

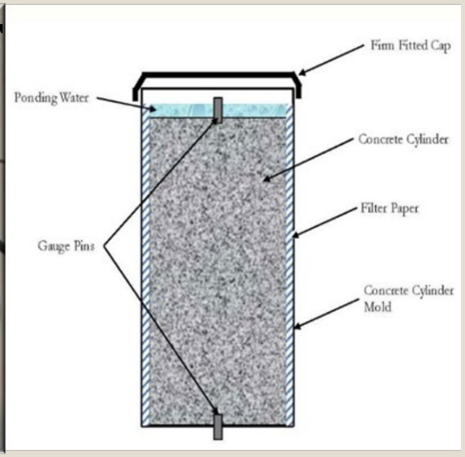
- Pore Solution Expression
- Influence of Curing Regimes on FF
- Flyer on FF and Bucket Test

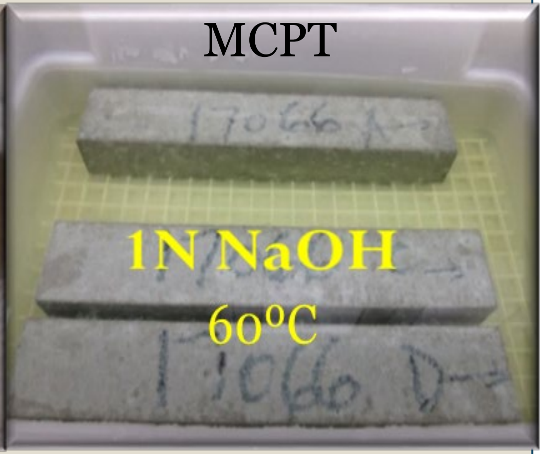
TFHRC/OSU/UT Collaboration

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!

Benchmarking MCPT & CCT to Outdoor Exposed Blocks

Overall Plan

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

20% F Ash	40%C Ash	40%C Ash 5%SF	40% Slag	Slag+SF 35/5	Lithium 4.9g/yd^3

- 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-base 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

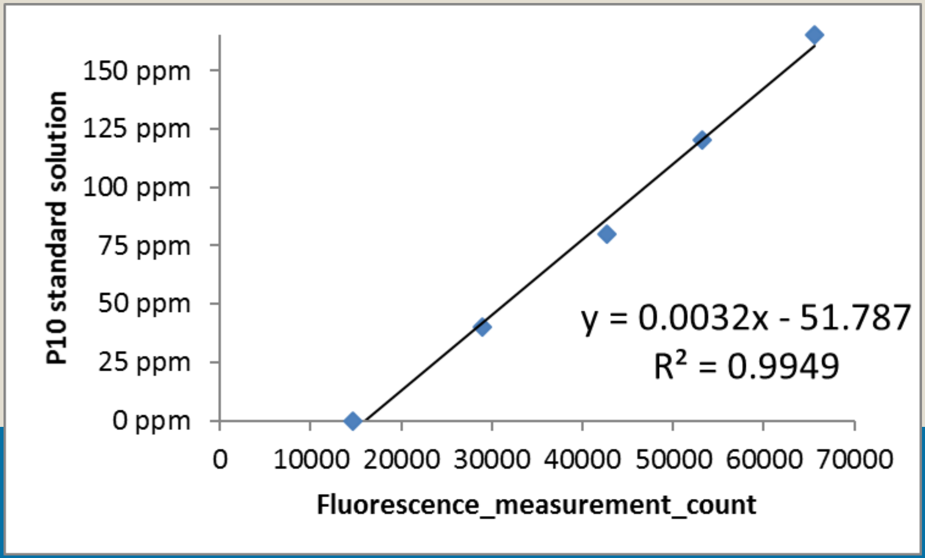
Sorbsensor - How it Works!

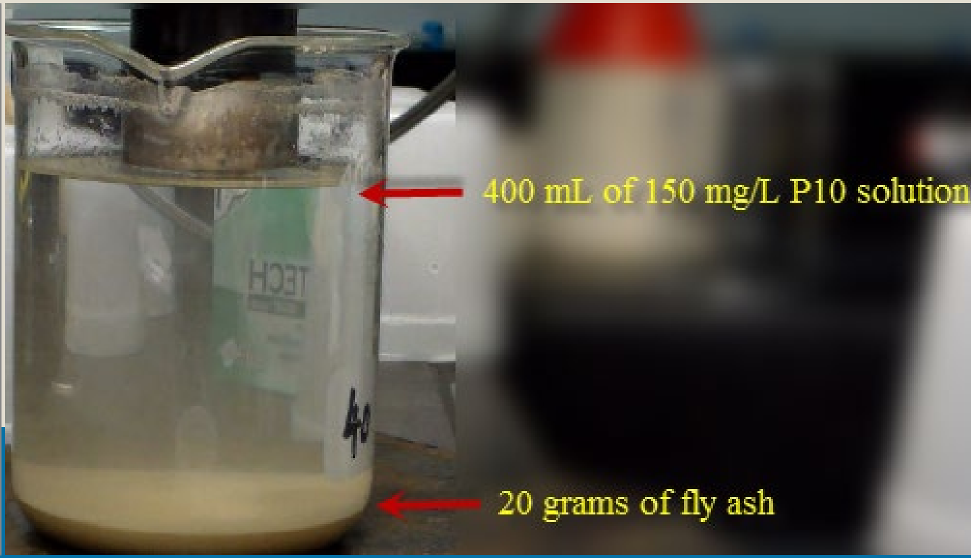
- Surrogate surfactant: nonylphenol ethoxylate (P10)
- 10 different ashes, 8 different states

Procedure:

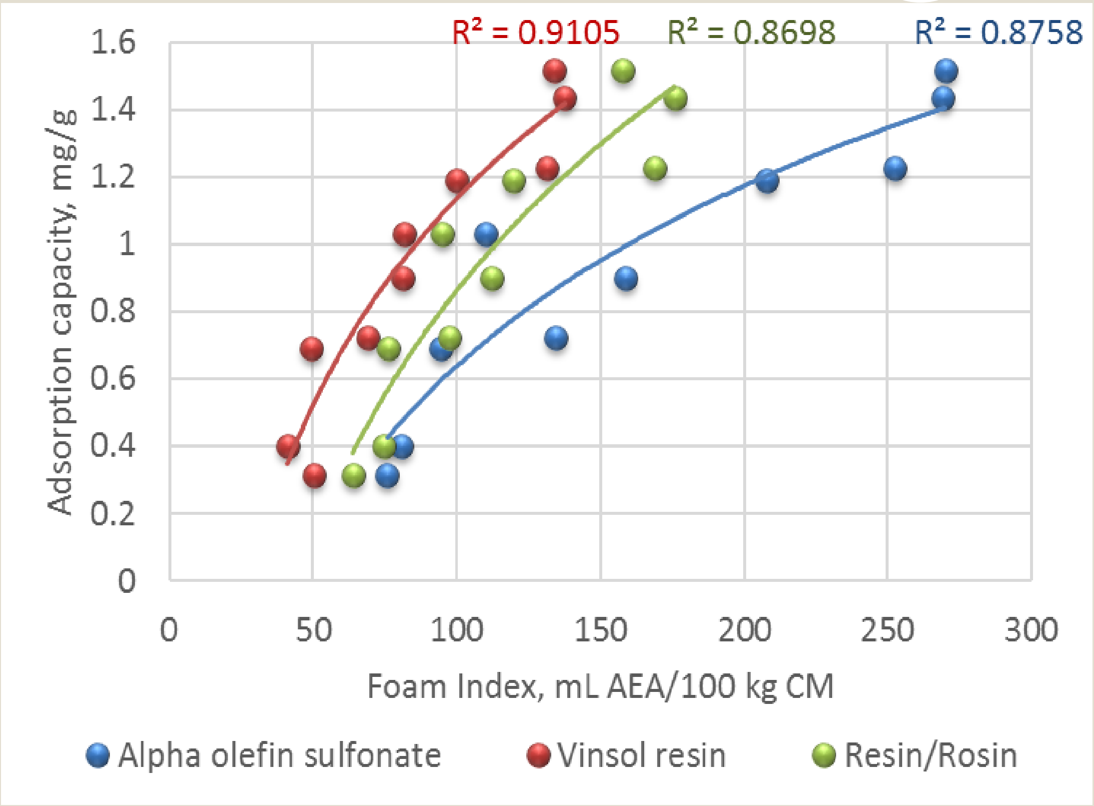
- Fly ash is mixed with a solution containing 150 ppm of P10
- The remaining P10 fluoresces as existed by UV
- Fluorescence intensity ∝ concentration of P10

- 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)


Thank You

FHWA Performance Related Specifications (PRS) Update

MATTHEW CORRIGAN, PE
CONSTRUCTION RESEARCH ENGINEER
FHWA, OFFICE OF INFRASTRUCTURE R&D

U.S. Department of Transportation
Federal Highway Administration
Office of Infrastructure

PRS Elevator Speech

- Performance related specifications (PRS) compare **design** expectations to what was **constructed**, and b 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)

Design

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

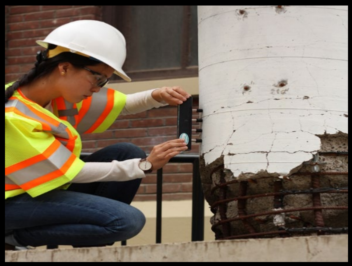
Performance Engineered Mixture Design (PEMD)
Lab Mixture Qualification Before Construction

→

Performance Related Specifications (PRS)
Determination of Expected Pavement Life for Payment

PP84 Parameter	PEMD	Performance Tests and Performance Model(s)
Aggregate Stability	• D-Cracking, Alkali-Aggregate Reactivity	• N/A
Transport Properties	• Choose from w/cm ratio, formation factor, ionic penetration	• Choose from resistivity or formation factor + matrix porosity
Hydrated Cement Paste F T Durability	• Choose from air content, SAM number, or time critical saturation	• Choose from air content or SAM number
Hydrated Cement Paste Durability – Salt Damage	• Choose from several options	• Design check only
Slab Warping/Cracking Due to Shrinkage	• Choose from several options	• N/A
Concrete Strength	• Choose from flexural strength or compressive strength	• Choose from flexural strength or compressive strength
Workability	• Choose from Box test or V-Kelly test	• N/A
Non Mixture Factors	• N/A	• thickness, initial smoothness (IRI), dowel alignment …

Four Step Approach Towards Durability in PRS



Assess Performance w/ Standard Tests

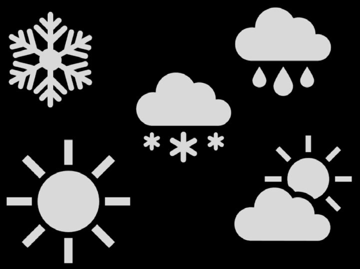
Considerations:

- Ability to assess performance
- Relationship to fundamental properties
- Ease of use
- Cost

Convert Test Results to Fundamental Properties

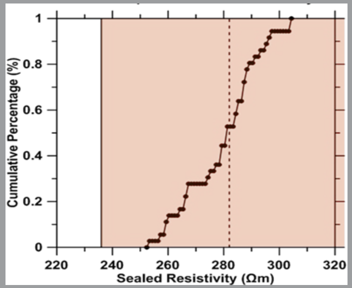
Examples:

- Measure Resistivity
- Account for Pore Solution
- Determine F- Factor



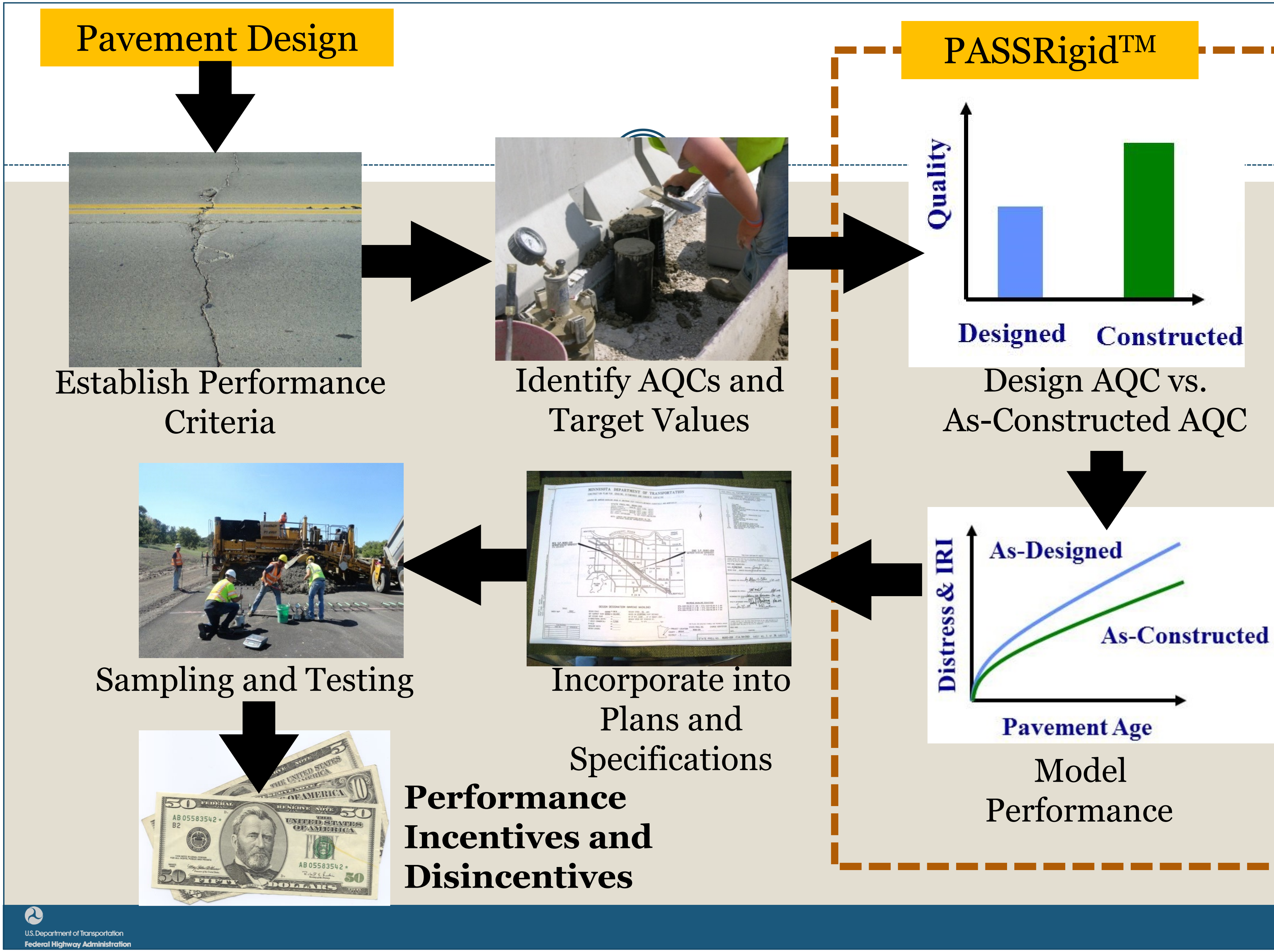
Relate Properties w/ Exposure Conditions

Use Exposure, Material Properties, and Models to Estimate Performance



Establish Performance Limits and Measure

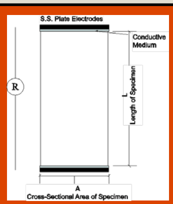
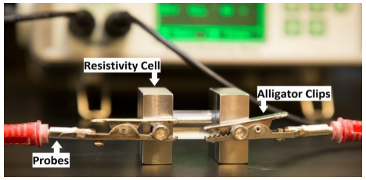
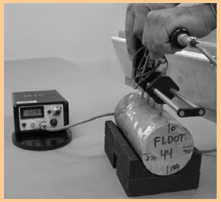
- Set Performance Limits
- Use Tests to Measure
- To Assure that You Receive what You Specified


Pavement Design
PASSRigid™
Quality
Designed
Constructed
Establish Performance Criteria
Identify AQCs and Target Values
Design AQC vs. As-Constructed AQC
As-Designed
As-Constructed
Distress & IRI
Pavement Age
Model Performance
Incorporate into Plans and Specifications
Sampling and Testing
Performance Incentives and Disincentives
U.S. Department of Transportation
Federal Highway Administration

PRS Summary

- 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

F Factor Inputs Status

Name	 			
Key Variable	**Bulk Resistivity**	**Pore Solution Resistivity**	**Temperature Correction**	**Surface Resistivity**
	ρ_{Bulk}	ρ_{Soln}	E_{AC}	ρ_{Surface}
Status	Complete: Conditioning improved and includes the 'bucket test'	Complete: There are several ways to obtain and it is simple to measure after obtaining solution	Complete: This is needed and exists for a clear way to perform temp. corrections	• Identical to bulk when done correctly • Requires a task force to revise*

Freeze Thaw Model Inputs Status

Name				
Key Variable	Matrix Saturation	Critical Saturation	Secondary Sorption	Drying Factor
	S_{Matrix}	$S_{Critical}$	dS_2/dt	ϕ
Status	• Bucket test under development • Computational model began with PRS (OPC)/now TPF	Work to relate this to air content and/or SAM number is underway in OK TPF	Work is underway to obtain these values from the formation factor OK TPF, TPF *simplified	Started with the TPF, however may need a separate project & may be needed for modeling warping

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)

PCC PRS Project Status

- Whiteboard Informational Videos (Spring 2019)
- Informational Video (Spring 2019)
- Implementation Report, Technical Briefs, Presentations (Summer 2019)

PCC PRS Project Status

- Additional shadow projects in 2019 and 2020 (seeking agency participants)
- Workshops and in-person training (2019 and 2020)
- PRS Marketing Implementation Report and Informational Materials (2019/2020)
- PRS & PEMD Framework Development Report (tools, guidelines, advance PRS & PEMD durability test procedures for implementation) (2019/2020)

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Questions? Interested in Shadow Projects?

Image Pixabay

Michael.Praul@dot.gov
207-512-4917

Ahmad.Ardani@dot.gov
202-493-3422

Matthew.Corrigan@dot.gov
202-493-3365