#### UPDATE ON THE PERFORMANCE ENGINEERED MIXTURES (PEM) INITIATIVE



April 2, 2019 Denver, CO



National Concrete Pavement Technology Center

IOWA STATE UNIVERSITY



Gordon L. Smith, P.E. Associate Director

**CP** Tech Center

#### **The PEM Initiative**

- A Partnership of Agency and Industry
  - Specifications that call for what assures expected concrete pavement performance
  - ➢Based on measuring the things that matter
  - ≻At the right time
  - Collecting data and evaluating tests nationwide



### What should we measure to get Good Concrete?

- 1. Shrinkage To reduce preventable cracking
- 2. <u>Transport (Permeability)</u> To reduce transport of aggressive unwanted fluids in order to survive the environment
- 3. <u>Freeze/thaw durability</u> To reduce expansive damage to the concrete pavement
- 4. <u>Aggregate Stability</u> To eliminate reactive aggregate that destroys concrete pavements
- 5. <u>Workability</u> To improve concrete placement that impacts concrete durability & improves rideability
- 6. <u>Strength</u> To ensure concrete pavement carries intended vehicle loads without failure



### **Standard Practice for Developing Performance Engineered Concrete Pavement Mixtures** (PP 84-17)

- Standard Practice guidance for FHWA-State DOTs-Industry
- A dynamic "work-inprogress" that initiates our endeavor to embrace Performance Engineered Mixtures

#### **Standard Practice for**

#### Developing Performance Engineered Concrete Pavement Mixtures

#### AASHTO Designation: PP 84-171

Tech Section: 3c, Hardened Concrete

Release: Group 1 (April 2017)

Tech Brief working copy

American Association of State Highway and Transportation Officials 444 North Capitol Street N.W., Suite 249 Washington, D.C. 20001





# How & when do we measure what matters?

	Shrinkage	Transport	Freeze/Thaw Durability	Aggregate Stability	Workability	Strength
How do we	Paste content	Resistivity	<u>w/cm ratio</u>	ASR	<u>Box Test</u>	Flexural/ Compressive.
measure?	Drying shrinkage	Formation Factor	<u>Air content</u>	<u>D-Cracking</u>	<u>V-Kelly</u>	
	Dual Ring		<u>SAM</u>			
			CaOxychloride ( <u>LT-DSC)</u>			
Mix Design	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$
QC/Acceptance		$\checkmark$	$\checkmark$		$\checkmark$	$\checkmark$









#### What can we adjust to get Good Concrete?

What can we adjust?	Shrinkage	Transport	Freeze/ Thaw Durability	Aggregate Stability	Workability	Strength
w/cm ratio		$\checkmark$				$\checkmark$
Paste content	$\checkmark$				$\checkmark$	
Air void			$\checkmark$			
SCM Type & dose		$\checkmark$		$\checkmark$		
Aggregate gradation					$\checkmark$	

### PEM Pooled Fund Participants TPF-5(368)



#### **The PEM Team**

FHWA – Mike Praul, P.E.

Researchers – Dr. Jason Weiss; Dr. Tyler Ley, P.E.

Consultants – Dr. Tom VanDam, P.E.; Cecil Jones, P.E.

CP Tech – Dr. Peter Taylor, P.E; Gordon Smith, P.E.; Jerod Gross, P.E.









Diversified Engineering Services, Inc





#### **HOW DO WE GET THERE?**

THE ROAD TO PEM



- 🖈 🔹 Start
  - Evaluate Process
  - Shadow Projects
  - Technical Assistance to State
  - Performance
     Monitoring
  - Technical Training for States
  - PEM Test Refinement
  - PEM Specification Refinement
  - Pilot Projects with PEM Construction Specs
  - Set Up Executive Task to Coordinate National
  - Activities
- ★ Implementation

### **PEM Activity 2018**

- MCT/PEM Open House/Demo
  - CO, MN, IA (2018)
  - ➢ NC, KS, ID, IL (Planned 2019)
- FHWA Incentive Program Participation
  - MN, IA, NC, PA, NY, SD, WS, IL (Independent PEM work MI, KS)
- Shadow Testing
  - WI, MI, IA, SD, PA, NY
- Spec Requirements
   > WI, NY
- Test Refinement/Development
- Data Collection
- State Specification Reviews
- Training (WI, NY, MI, CO)
- Industry Collaboration
  - ➤ (ACPA-PCA-NRMCA-SCC)



### Prescriptive vs Performance Specifications

- Goal of PEM is to understand how critical properties relate to performance
- PP 84 provides a range of options for each property moving from prescriptive to performance choices.
- <u>Initially</u>, prescriptive options prevail while specification requirements are being confirmed for the more performance-based tests.
- <u>Ultimately</u>, the performance options will allow innovation and cost-effectiveness, with acceptable risk, for all parties as we understand how to set the tests limits.





US Department of Transport

# Category A: Incorporating two or more AASHTO PP 84-17 in the mix design/approval process (shadow testing acceptable)

State	SAM	Box test	V-Kelly	Unit Weight	Bucket or CaOXY test	Surface resistivity	Additional tests
Illinois	$\checkmark$	$\checkmark$					ASTM C157
Iowa	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$		
Minnesota	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$		Maturity for flexural strength
New York	$\checkmark$					$\checkmark$	Compressive strength
North Carolina	$\checkmark$	$\checkmark$				$\checkmark$	
Pennsylvania	~					<ul> <li>✓ - formation factor from resistivity</li> </ul>	ASTM C157,rate of flexural strength development, w/c ≤ 0.45,, vol of paste
South Dakota	✓	~					
Wisconsin	$\checkmark$						Flexural strength, optimized aggregate gradation, concrete mix design

#### Category B: One or more new tests in the acceptance process (shadow testing acceptable)

State	SAM	Box test	V-Kelly	Unit Weight	Bucket or CaOXY test	Surface resistivity	Additional tests
Illinois	✓			✓			strength
Iowa	✓	✓		✓		✓ formation factor	Plastic air, temperature
Minnesota	✓						w/c with Phoenix, acceptance - optimized gradation and w/c ratio
New York	✓					✓	Exploring Payment factor for SAM, surface resistivity, f factor & strength
North Carolina	✓					√	Comparing to limits proposed in PP- 84 and UNC Charlotte Research
Pennsylvania	√	√				<ul> <li>✓ formation</li> <li>factor</li> </ul>	Require slump, air, temperature, comp strength and w/c on tickets
South Dakota	✓						Fresh air content by SAM
Wisconsin	✓						Flexural strength (typically use compressive strength)

## Category C. Requiring a comprehensive QC Plan from the contractor that will be approved and monitored by the state

State	QC plan	Notes
Iowa	required	QC will be modified include SAM, formation factor, PWL for plastic air content and related corrective action.
Minnesota	required	QC will be modified to reflect PP 84, including unit weight, air content, water content, formation factor, flexural strength, moisture and gradation testing.
New York	developed	Currently, DOT has been performing the QC through their acceptance program.
Pennsylvania	required	Additional tests will add unit weight, SAM, water content, resistivity (f) and box test.
Wisconsin	Will be developed	WI requires a QMP plan currently. SPV will be developed requiring contractor to submit QC plan.

#### Category D. Requiring the use of control charts as called for in AASHTO PP 84-17

State	Intend to use	Currently required for
Iowa	<ul> <li>SAM test</li> <li>Box test</li> <li>Formation factor</li> <li>PWL for plastic air specification compliance</li> </ul>	<ul> <li>Combined aggregate gradation</li> <li>Air content before and after paver</li> <li>Unit weight</li> <li>Moistures</li> <li>w/c ratio</li> </ul>
Minnesota	<ul><li>Unit weight</li><li>SAM number</li><li>Formation factor</li><li>Flexural strength</li></ul>	<ul> <li>Air content before and after paver</li> <li>Composite gradations</li> <li>Moisture content (%)</li> <li>w/c ratio</li> </ul>
New York	<ul><li>w/c ratio</li><li>Unit weight</li><li>Air content</li></ul>	Plan includes producer and contactor to use control charts to monitor and track performance.
North Carolina	<ul><li>Box test</li><li>SAM test</li><li>Resistivity test</li></ul>	<ul> <li>Air content</li> <li>Slump</li> <li>Unit weight</li> <li>Concrete temperature</li> </ul>
Pennsylvania	<ul> <li>SAM test</li> <li>Air content</li> <li>Unit weight</li> <li>Water content</li> <li>Strength</li> <li>Formation facto from resistivity</li> </ul>	Control chart is optional for concrete paving.

#### Iowa DOT Demonstration Project for Implementation of Performance Engineered Mixtures (PEM)/AASHTO PP 84

#### INTRODUCTION

The Iowa Department of Transportation applied for funds through the Performance Engineered Concrete Paving Mixtures pooled fund project (TPF-5(368)) to collect data and demonstrate the new tests. The FHWA approved the application for the full \$100,000 with a 20% match for a total of \$80,000. Application can be found in the Appendix.

The project location was on U.S. 20 in Woodbury County between Correctionville and Holstein. Ames Construction Inc. was awarded the \$62.9 million contract for this stretch of U.S. 20, which is divided into 6 construction segments. Cedar Valley Corporation, LLC is the paving subcontractor responsible for the U.S. 20 paving. Grading and paving began in 2016 and was completed in 2018. All of the sampling and testing was performed in segment 4 westbound, roughly 11 miles within the U.S. 20 corridor between Holstein and Correctionville, Iowa. Figure 1 shows the project location.



Figure 1: U.S. 20 Project Location



United States Department of Transportation

#### SUMMARY REPORT

#### **US 20 Expansion**

Holstein, IA July, 2018



FHWA MCT Project # IA1802

Federal Highway Administration Office of Preconstruction, Construction, and Pavements 1200 New Jersey Avenue, SE Washington, DC 20590



### **PEM Activity 2019**

- MCT/PEM Open Houses/Demos
   ➢ NC, KS, CA
- FHWA Incentive Program Participation
   ➤ MN, WI, NY, IL, CO, ID
- Shadow Testing
  - MI, WI, NY, ID, IL, NC, KS, MN, CO
- Spec Requirements
   > WI, NY
- Test Refinement/Development
- Data Collection/Analysis
- Industry Collaboration
   > (ACPA-PCA-NRMCA-SCC)



### **PEM Activity 2019**

- One-day engineering level PEM Workshops
   > Highlighting PEM Road to Implementation
- SHA assistance in establishing their PEM implementation strategy
- Technician training (ID, KS)
- Test refinements and new tests (AASHTO Task Force)
- PP-84-20 revision



- Construction specification development
- QC Guide for PEM (FHWA Co-Op)
- Precision and Bias for PEM Tests (FHWA Co-Op)

### DELIVERING CONCRETE TO SURVIVE THE ENVIRONMENT

- The framework is in place
- Now we focus on the details of implementation





www.cptechcenter.org