Moving to Performance Specifications for Concrete

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Performance Specifications

- Performance specifications are different from Prescriptive specifications
- Performance specifications communicate the desired characteristics of the material or product.
- Prescriptive specifications communicate how the material or product is to be formulated and constructed.

Why Move to a Performance Approach?

- MAP-21
  - Greater Federal emphasis on performance
  - Linking investments to outcomes
- Demographics in "Our World"
- Public agency and industry desire
  - It's a natural evolution
  - Improved durability and mix design
  - Sustainability

- Completed research and new tests → Innovation

How Things Change!

Slump Cone | **Pressure Meter** | **Rapid Chloride Permeability Test**

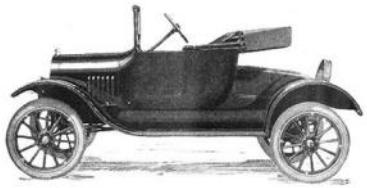
Concrete

1922
ASTM C143

1949
ASTM C231

1981
FHWA/PCA

Cars



1920 **1940** **1960** **1980** **2000**

Performance in Mix Design

- 1:2:3 in 1920s
- 1:2:3¼ in 1940s with max 6 gal water/bag
  - 350 minimum flexural strength at 28 days
- Slump, air, strength, minimum cement, gradations, …..

Is there a better way?

Performance Engineered Mixture (PEM) Development

- The Team
  - Dr. Peter Taylor, Director, CP Tech Center
  - Dr. Jason Weiss, Oregon State University
  - Dr. Tyler Ley, Oklahoma State University
  - Dr. Tom VanDam, NCE
  - Mike Praul, FHWA
  - Cecil Jones, Diversified Engineering
  - Tom Cackler, CP Tech Center
- Industry Participants/Reviewers
  - Champion States & ACPA Chapter Execs
  - ACPA National
  - PCA
  - NRMCA

PEM Concept

- Understand what makes concrete last and what failure mechanisms do we see
- Specify the critical properties and test for them
- Prepare the mixtures to meet those specifications
- Starting point for a performance-driven QA specification and acceptance program for states and other owner agencies

Why are PEM specifications needed?

- Pavements have not always performed as designed.
- Premature pavement distress has become more severe with changes in cements, SCMs, and winter maintenance (de-icing) practices.
- Allow/encourage innovation.
- Increase sustainability in our mixture designs.

PEM: A Better Specification

Require the things that matter

- Strength (everywhere)
- Shrinkage (dry locations)
- Cold weather resistance (cold locations)
- Transport properties/permeability (everywhere)
- Aggregate stability (everywhere)
- Workability (everywhere)

Concrete Strength (6.3)

Section	Property	Specified Test	Specified Value	Mixture Qualification	Acceptance	Selection Details	Special Notes
6.3.1	Flexural Strength	AASHTO T 97	600 psi	Yes	Yes	Choose either or both	
6.3.2	Compressive Strength	AASHTO T22	3500 psi	Yes	Yes		

Reducing Unwanted Cracking Due to Shrinkage (6.4)

Section	Property	Specified Test	Specified Value	Mixture Qualification	Acceptance	Selection Details	Special Notes	Section
6.4 Reducing Unwanted Cracking Due to Shrinkage								
6.4.1.1	Volume of Paste		25%		Yes	No	Choose only one	
6.4.1.2	Unrestrained Volume Change	ASTM C157	420 $\mu\varepsilon$	at 28 day	Yes	No		
6.4.2.1	Unrestrained Volume Change	ASTM C157	360, 420, 480 $\mu\varepsilon$	at 91 days	Yes	No		
6.4.2.2	Restrained Shrinkage	AASHTO T 334	crack free	at 180 days	Yes	No		
6.4.2.3	Restrained Shrinkage	AASHTO T ???	σ < 60% f'r	at 7 days	Yes	No		
6.4.2.4	Probability of Cracking	~	5, 20, 50%	as specified	Yes	No		

Hardened Cement Paste Freeze-Thaw Durability (6.5)

Section	Property	Specified Test	Specified Value		MQ	AC	Selection Details		Special Notes
6.5 Durability of Hydrated Cement Paste for Freeze-Thaw Durability									
6.5.1.1	Water to Cement Ratio	AASHTO T 318	0.45	~	Yes	Yes	Choose Either 6.5.1.1 or 6.5.2.1		
6.5.1.2	Fresh Air Content	AASHTO T 152, T196, TP 118	5 to 8	%	Yes	Yes		Choose only one	
6.5.1.3	Fresh Air Content/SAM	AASHTO T 152, T196, TP 118	≥ 4% Air; SAM ≤ 0.2	%, psi	Yes	Yes			
6.5.2.1	Time of Critical Saturation	"Bucket Test" Specification	30	Years	Yes	No	Note 1	Note 2	Variation controlled with mixture proportion observation or F Factor and Porosity Measures
6.5.3.1	Deicing Salt Damage	~	35%	SCM	Yes	Yes	Choose one		Are calcium or magnesium chloride used
6.5.3.2	Deicing Salt Damage	~	~	~	Yes	Yes			Are calcium or magnesium chloride used, needs a use of specified sealers
6.5.4.1	Calcium Oxychloride Limit	Test sent to AASHTO	< 0.15g CaOXY/g paste		Yes	No			Are calcium or magnesium chloride used

Transport Properties/Permeability (6.6)

Section	Property	Specified Test	Specified Value		Mixture Qualification	Acceptance	Selection Details	Special Notes
6.6 Transport Properties								
6.6.1.1	Water to Cement Ratio	AASHTO T 318	0.45	~	Yes	Yes	Choose Only One	
6.6.1.2	RCPT Value	AASHTO T 277	2000	~	Yes	Yes		Other criteria could be selected
6.6.1.3	Formation Factor/Resistivity	AASHTO xx	500	~	Yes	through ρ		* Note this is currently based on saturated curing and an adjustment is needed to match with AASHTO Spec
6.6.2.1	Ionic Penetration, F Factor	AASHTO xx	25 mm at 30 year		Yes, F	through ρ		

Aggregate Stability (6.7)

Section	Property	Specified Test	Specified Value		Mixture Qualification	Acceptance	Selection Details		Special Notes
6.7 Aggregate Stability									
6.7.1	D Cracking	AASHTO T 161, ASTM C 1646	~	~	Yes	No			
6.7.2	Alkali Aggregate Reactivity	AASHTO PP 65	~	~	Yes	No			

Workability (6.8)

Section	Property	Specified Test	Specified Value	Mixture Qualification	Acceptance	Selection Details		Special Notes
6.8 Workability								
6.8.1	Box Test	~	<6.25 mm, < 30% Surf. Void	Yes	No			
6.8.2	Modified V-Kelly Test	~	15-30 mm per root seconds	Yes	No			

Quality Assurance Defined

23 CFR 637

- Agency Acceptance
- Contractor Quality Control

- Qualified (certified) Personnel
- Qualified Laboratories
- Independent Assurance
- Dispute Resolution for Test Results

} State processes, independent of material

Quality Control

- PEM acknowledges the key role of QC in a performance specification
- Requires an approved QC Plan
- Requires QC testing and control charts
  - Unit weight
  - Air content/SAM
  - Water content
  - Formation Factor (via resistivity)
  - Strength
- QC
  - Testing targets, frequency, and action limits
  - Guidance will expand on this

Quality Control

- Uses real time feedback

- A good Contractor QC system:
  - Doesn't just echo Agency requirements
  - Implements QC procedures as standard practice
  - Isn't just paperwork…it's a mindset

Long-Term Implementation of PEM

- Demonstration through shadow specification
  - IN, IA, MI, MN, ND, SD, WI, IL Tollway, Manitoba (ACPA chapters participating)

Standard Specification for

Performance Engineered Concrete Pavement Mixtures

AASHTO Designation: MP XX-17

DRAFT

AASHTO

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

TS-Yy MP XX-1 AASHTO

Standard Specification for

Performance Engineered Concrete Pavement Mixtures - Commentary

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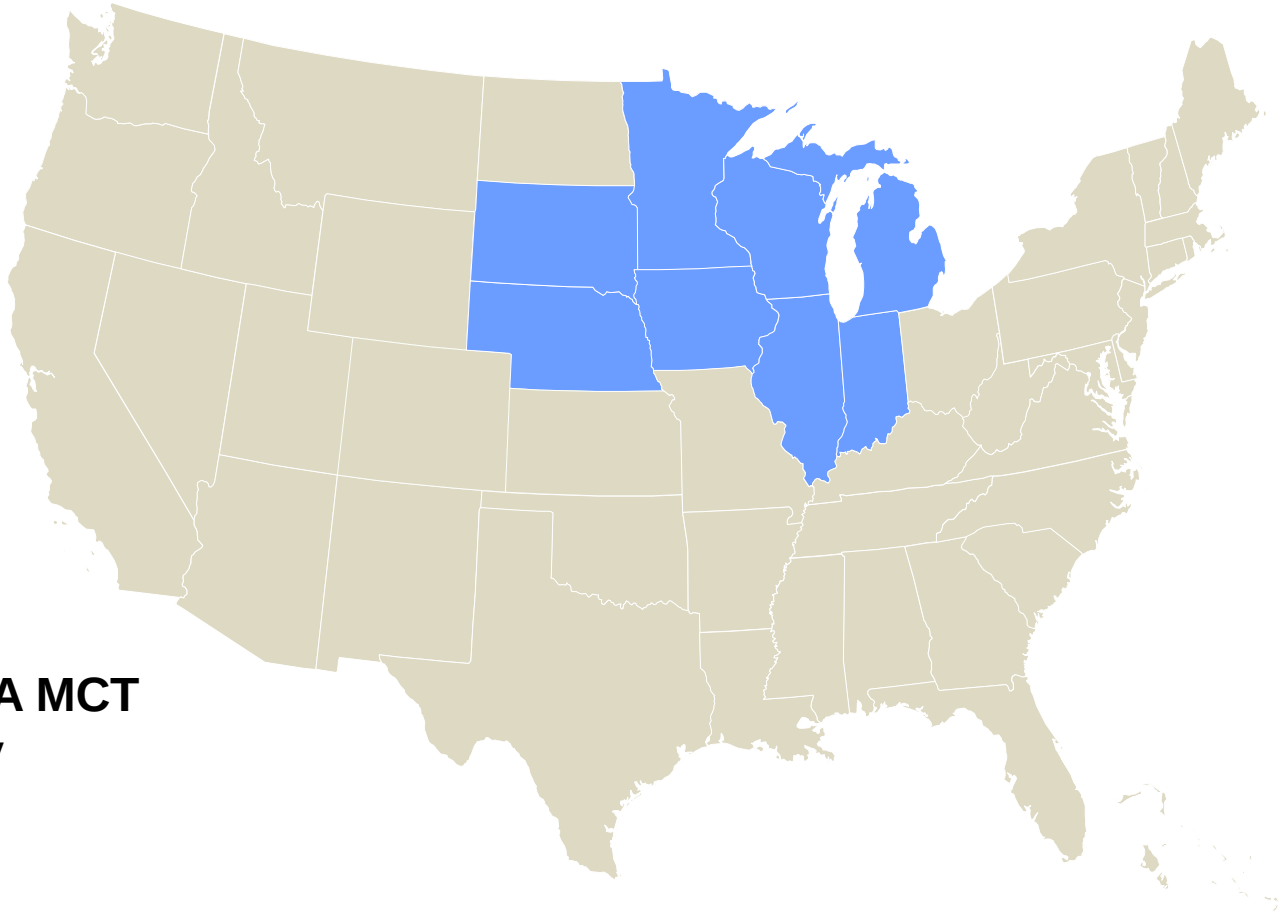
TS-Yy MP XX-1 AASHTO

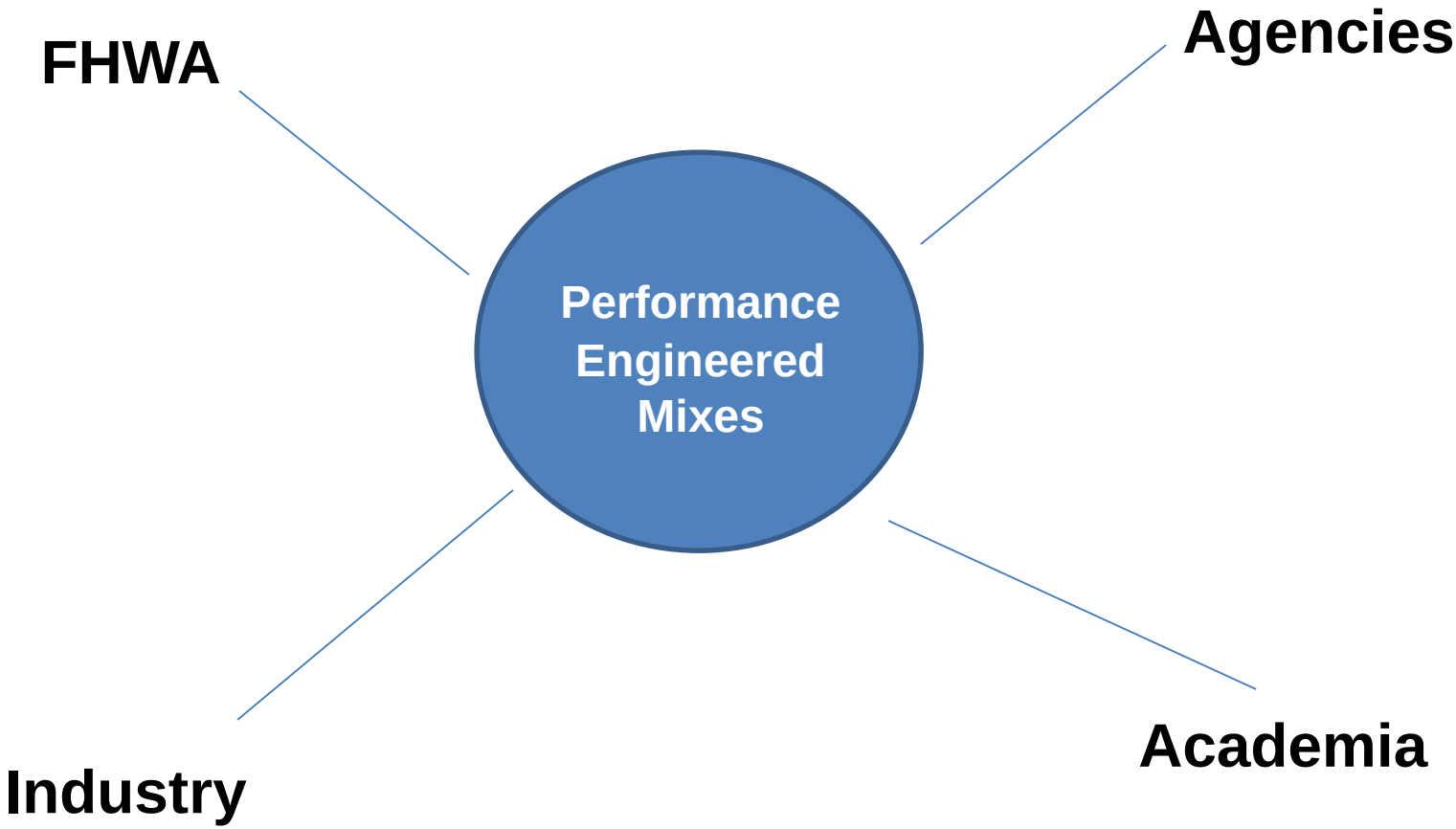
- Establish “enhanced” ETG
- Guidance on specification, tests, and quality control
- Fill in research gaps
- Build on PEM to establish a model concrete acceptance program

PEM Champion States



+Manitoba, FHWA MCT
& Illinois Tollway

A Coordinated Approach to Implementation



Road Map to the Future of Performance

- Pooled fund solicitation to support PEM refinement and implementation: 5 years
  - FHWA ($200,000/yr)
  - States (14 states, $15,000 each/yr)
  - Industry ($200,000/yr)

- Follow-up FHWA initiatives
  - Concrete Pavement Performance System (CPPS)
  - Support PEM with Concrete Pavement Trailer
  - Support PEM and a performance approach to concrete QA programs…training, training, training

Concrete Pavement Performance System

Coordinated effort to provide guidance and tools to states and industry to advance concrete Quality Assurance programs in the direction of performance.

- QA Toolkit
  - Videos
  - Testing guidance
- QC framework
- Implementation Workshops
- Mobile Concrete Trailer

FHWA Working Group

- Mike Praul, Office of Asset Management, Pavements, and Construction
- Gina Ahlstrom, Office of Asset Management, Pavements, and Construction
- Katherine Petros, TFHRC
- Richard Duval, TFHRC
- Ahmad Ardani, TFHRC
- Dennis Dvorak, RC
- Bob Conway, RC

CPPS Testing Videos and Guidance

- YouTube style 5-10 minute videos of PEM and other tests
- Will include narrative and be appropriate for technician training
- Mobile Concrete Trailer will participate
- “One pagers” (possible app)
  - Describe the test, what it measures and why
  - Incorporating the test into acceptance or QC programs
  - Suggested frequency
  - Data analysis (PWL, single test pass/fail, control charting)

CPPS Tests

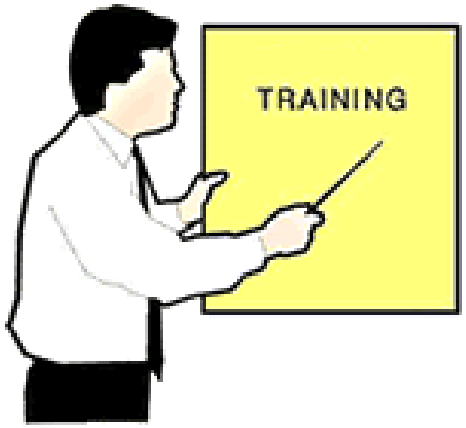
- Super Air Meter
- Unit weight
- Strength
- Surface Resistivity
- MIT Scan
- MIT Scan T2
- Maturity
- Microwave water content
- Box Test
- V-Kelly
- Formation factor
- Coefficient of thermal expansion
- Calorimetry

CPPS Quality Control

- Change state mindset that QC is not their business
- Gordon Smith example
- Provide guidance on developing state specification language on:
  - Equipment inspection
  - Construction inspection
  - Testing guide (very similar to guidance for the acceptance program but slanted to industry)
    - Appropriate QC tests
    - Frequency
    - Control charts and usage

PEM/CPPS Implementation Workshops

- FHWA is being called on by states and industry to provide training
- PEM and CPPS workshop
- Timing for development of workshop dependent on PEM and CPPS progress and implementation
- Conceptual phase



Other "One pagers" Related to Performance

- Largely based on MCT results
- Lowering Cement Content is nearly ready for distribution
- 2nd will be on Optimized Gradation (including spreadsheet tool)
- Looking for suggestions

FHWA Mobile Concrete Trailer

Mission

- Technology Transfer to SHA's
  - Field demos on active projects
  - Equipment loan
  - Training of staff
  - Conferences and workshops

FHWA Mobile Concrete Trailer

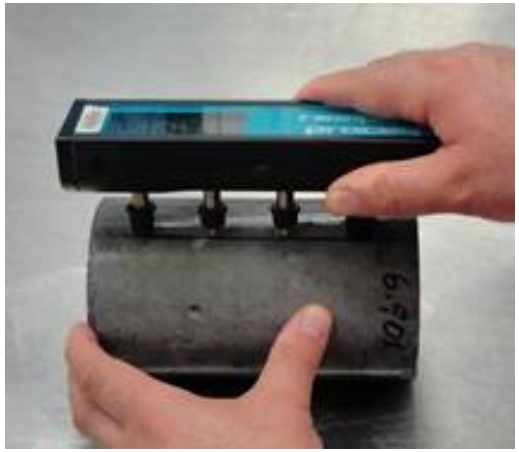
- Nondestructive/In-situ Tests
- Performance Related Specifications

MCT Focus Areas

- Sustainability
- Quality Assurance
- AASHTOWare Pavement ME Design
- Performance Engineered Mixture

Additional Benefits / Outcomes

- Evaluate new technologies / equipment
  - On actual field projects / geographical regions
  - Under **practical** working conditions
  - Feedback to researchers
  - Lowers the technology refinement time



Thank You

- For more information:

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QUESTIONS
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