

2020 Annual Virginia Concrete Conference

Count on Concrete For Value and Performance

February 27-28, 2020
The Westin Richmond
Richmond, VA

Brought to you by the ACI, Virginia Chapter, Virginia DOT, FHWA, ACPA, Mid-Atlantic Chapter, Precast Concrete Association of Virginia, Virginia Ready Mixed Concrete Association, and Southeast Cement Promotion Association

IOWA STATE UNIVERSITY
Institute for Transportation

National Concrete Pavement
Technology Center



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***PERFORMANCE ENGINEERED
MIXTURES (PEM) FOR CONCRETE
PAVEMENTS***

***DELIVERING CONCRETE TO
SURVIVE THE ENVIRONMENT***

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**IOWA STATE
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**Institute for
Transportation**

An IOWA Story



Concrete Pavement Performance: An Old State Highway



8 " Thick- 16 ft wide. No joints.
Built in 1921. Shown in 2009.

Concrete Pavements



New challenges have to be addressed!

- Some pavement joints are deteriorating much faster than we would like!



Pavement Durability

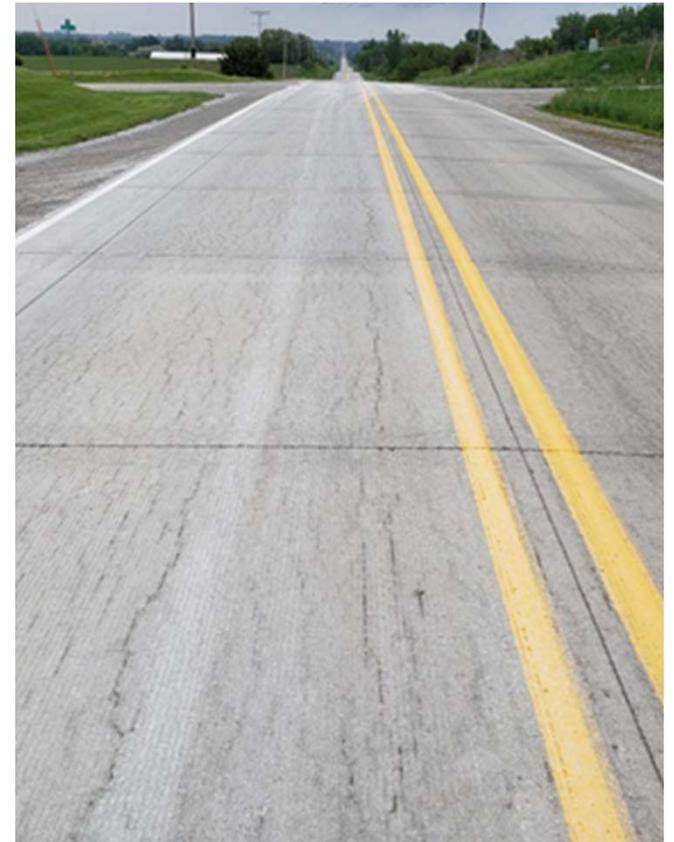


US Highway in North Carolina

(Mid 1980s)



A County Road in the Midwest (2009)



The discussions

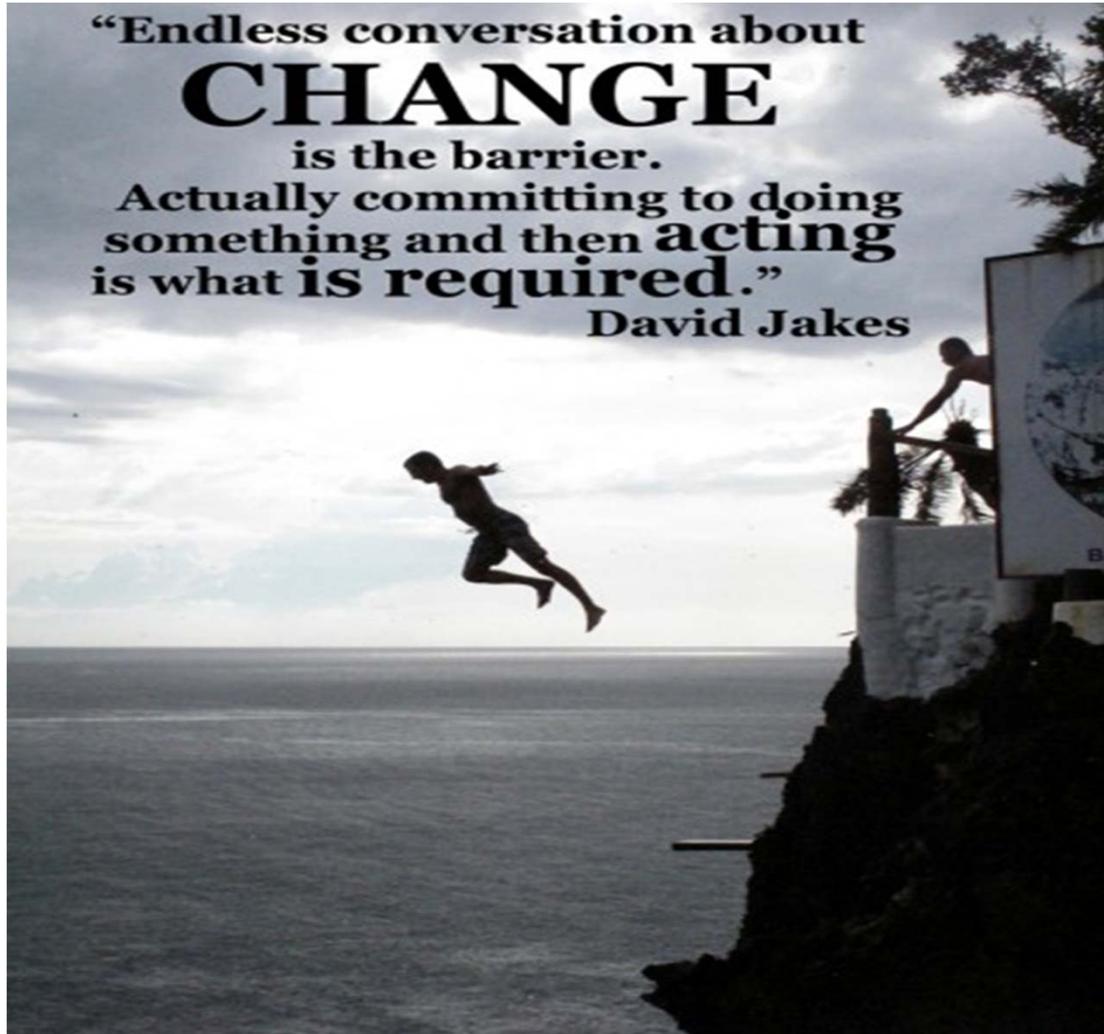
- Aggregate Durability/Gradation
- Chemical Reactions ASR/ACR
- Poor Air Entrainment
- Poor Consolidation-Workability
- Sawing Practices
- Effects of Deicers and Deicing Practices
- SCM/Admixtures
- ??????????????????



**“Endless conversation about
CHANGE
is the barrier.**

**Actually committing to doing
something and then acting
is what is required.”**

David Jakes



The PEM Initiative

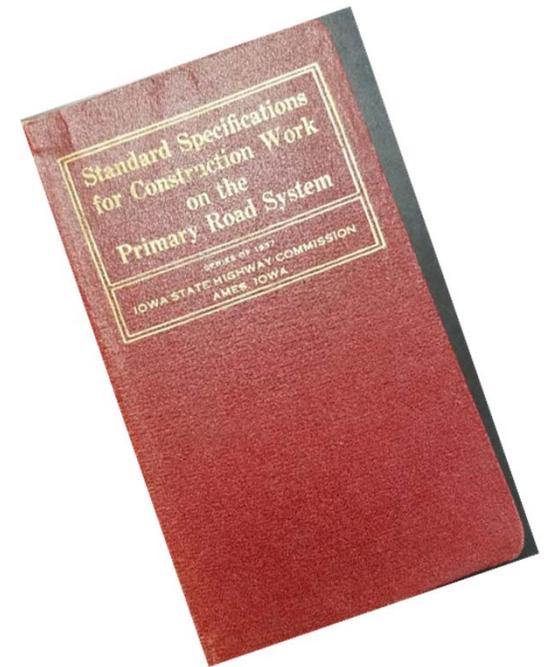
- ✓ Understand what makes concrete “good”
- ✓ Specify the critical properties and test for them
- ✓ Design the paving mixtures to meet those specifications



The Concrete	
Gray	<input checked="" type="checkbox"/>
Hard.....	<input checked="" type="checkbox"/>
Cracked.....	<input checked="" type="checkbox"/>

Current Specs and Testing

- **Slump**
 - ✓ No correlation with durability
 - ✓ Does not measure quality
- **Air content**
 - ✓ Poor correlation with durability
 - ✓ Does not measure the system
- **Strength**
 - ✓ No correlation with durability



We have to do better to ensure durability!

What has changed?

	1967	
No. of ingredients	Cement, water, rock, sand, AEA	
Opening	Weeks	
Curing	Weeks	
De-icing	Sand, NaCl	
Design life	20 years	
Knowledge base	In house	



What has changed?

	1967	2017
No. of ingredients	Cement, water, rock, sand, AEA	Add SCMs, Non-Portland cements, admixtures, intermediate aggregates, limestone...
Opening	Weeks	Days (or hours)
Curing	Weeks	Days
De-icing	Sand, NaCl	Other chlorides, formates, acetates
Design life	20 years	50 years
Knowledge base	In house	Contracted out



A modernized specification . . .

- ✓ Require the things that matter
- ✓ Measure them at the right time

- ✓ Develop test methods
- ✓ Develop “Guide Specification” (AASHTO’s PP-84)
- ✓ Develop tools to proportion mixtures

- ✓ Conduct Shadow evaluations

- ✓ Later
 - Guide/monitor Pilot projects
 - Develop PWL models
 - Guide in Q/C Programs



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



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

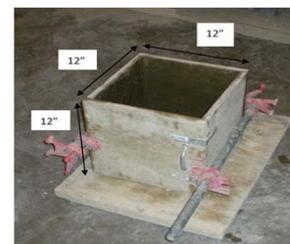
Test Methods

- Tests for those critical properties
 - VKelly (*Workability*)
 - Box (*Workability*)
 - Resistivity / Formation (*Transport*) factor
 - Bucket / Sorptivity
 - Dual ring (*Shrinkage*)
 - SAM (*Cold Weather Resistance*)



How & when do we measure?

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

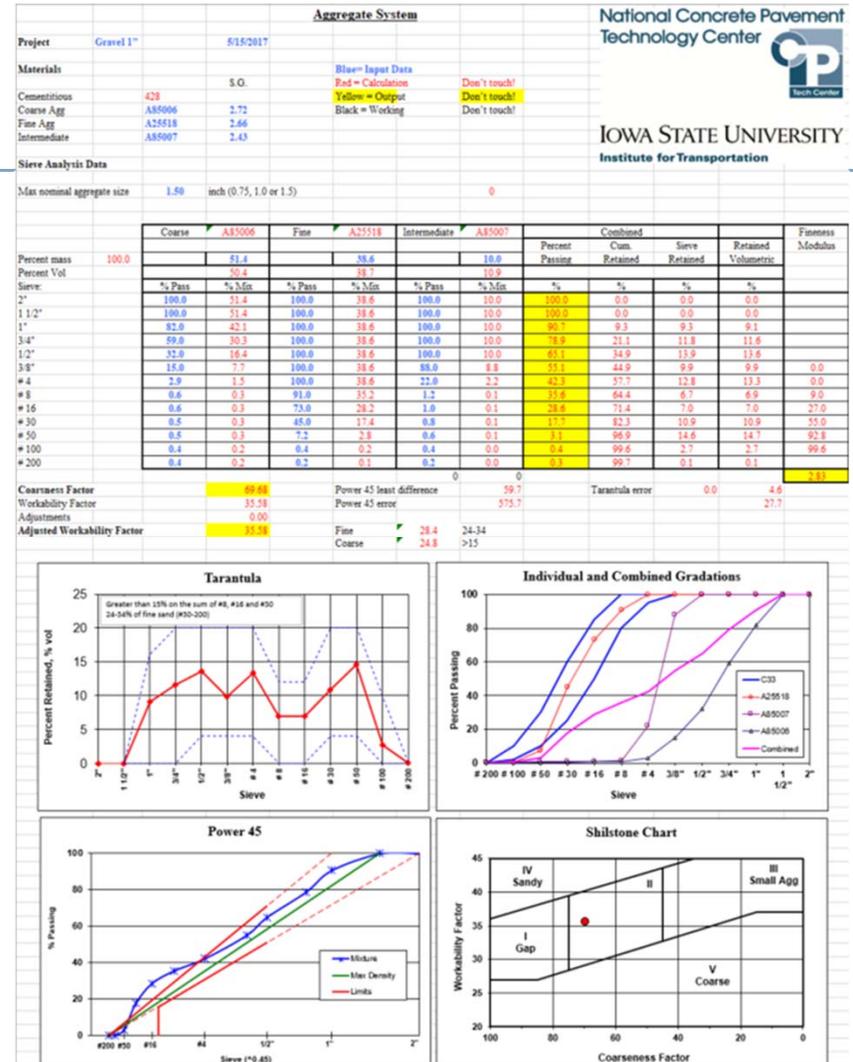


Mixture Proportioning

- Limited guidance on proportioning
 - w/cm
 - Paste content
- Allows contractor to work with their materials and equipment
- Tools available to help achieve performance

		Workability	Transport	Strength	Cold weather	Shrinkage	Aggregate stability
Aggregate System	Type, gradation	✓✓	-	-	-	-	✓✓
Paste quality	Air, w/cm, SCM type and dose	✓	✓✓	✓✓	✓✓	✓	✓
Paste quantity	Vp/Vv	✓	-	-	-	✓✓	-

Mixture Proportioning



What can we adjust to get Good Concrete?

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



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

- Standard Practice – guidance for FHWA-State DOTs-Industry
- A dynamic “work-in-progress” 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](#)

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The PEM Team

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PEM/TPF Project Emphasis



- Implementation
- Education and Training
- Adjustments in specification based on field performance
- Continued development of a knowledge base relating early age properties to performance

PEM Activity 2018

- MCT/PEM Open House/Demo in CO - May 2018
- MCT/PEM Open House/Demo in MN - July 2018
- MCT/PEM Open House/Demo in IA - July 2018
- Comparative Testing – SD/CP Tech – September 2018
- Demo/Open House(s) in PA - TBD
- FHWA Incentive Program Participation – MN, IA, NC, PA, NY, SD, WS, IL (Independent PEM work in MI, KS)
- PP-84 Guide Specification Update 2019
- Test Refinement/Development
- Equipment Loan Program from FHWA
- Shadow testing and data collection
- Industry Collaboration
 - (ACPA-PCA-NRMCA-SCC)



Why We're Excited

Concrete Evolution

- PEM: Most significant field-level advancement in decades
- Answers the question “With our loss of staff and resources, how are we going to be able to get the job done in the future?”
- Requires collaboration with industry (It's more than just the tests!)



Slide 29

PM(28 Image provided by CP Tech Center under FHWA contract.
Prall, Michael (FHWA), 2/1/2018

PEM Revisited (November 2019 TAC Meeting)



- AASHTO PP84 is an overall guide to mix design development. The document includes a quality control program framework consistent with performance specifications
- Development and implementation of enhanced Quality Control programs, including agency specifications and oversight
- Changing from the historically prescriptive approach to concrete specifications to a performance type specifications. Typical specification changes include removing slump requirements, eliminating minimum cement content requirements, and removing single aggregate gradation requirements, eventually including construction oriented examples as well.

Quality Control

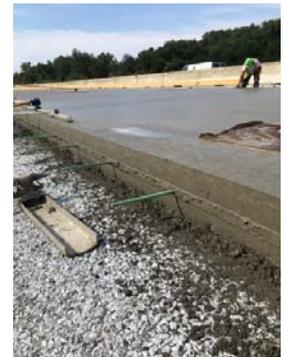
- PEM acknowledges the key role of QC in a performance specification
- Requires an approved QC Plan
 - Testing targets, frequency, and action limits
 - Equipment and construction inspection
 - Mirror design-build experience
- Requires QC testing and control charts
 - Unit weight
 - Air content/SAM
 - Water content
 - Formation Factor (via Surface Resistivity)
 - Strength



Looking Forward

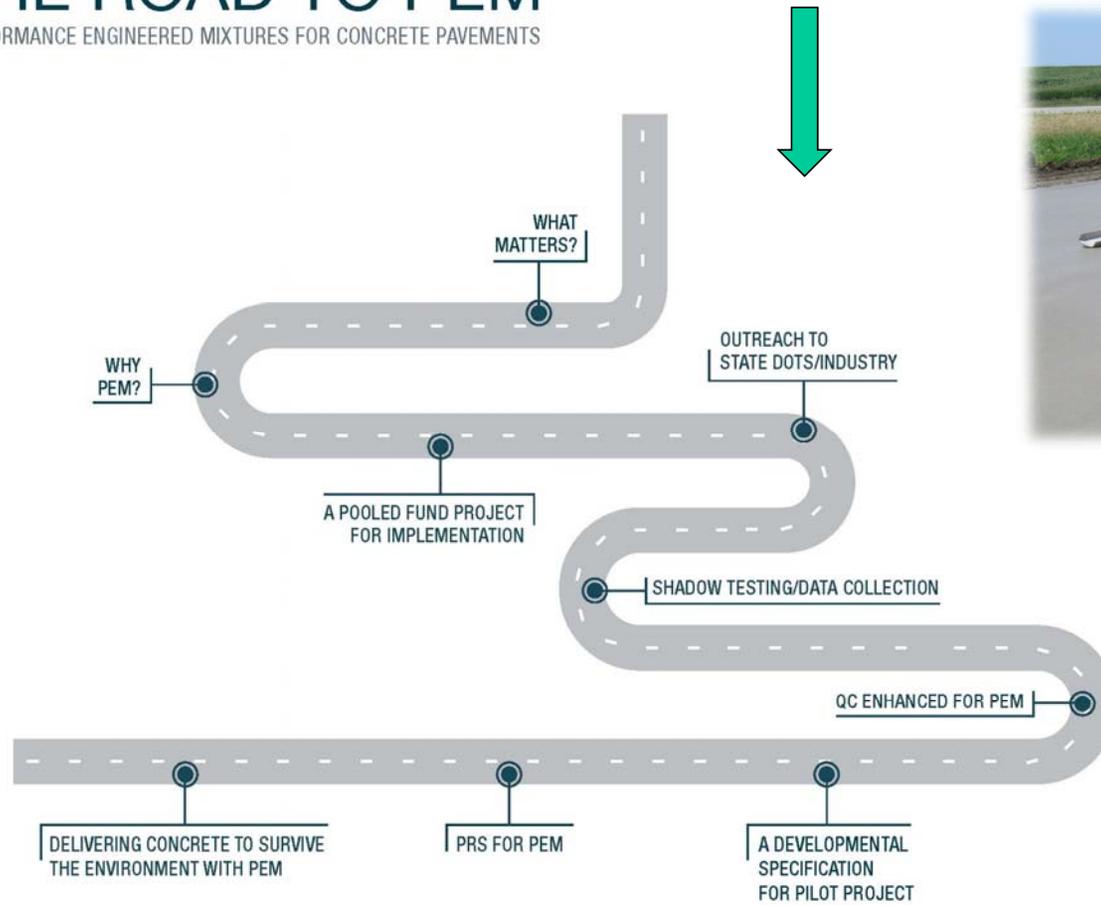
FOCUS

- Collaboration with SHAs, FHWA and Industry along the road toward PEM implementation for concrete pavements – (Specs/Training/Questions)
- Shadow testing - shadow testing - shadow testing
- Data gathering/analysis/sharing for PEM test verification and a long term pavement performance record
- Training model for PEM tests (Who, When, How)
- ✓ Emphasis on a PEM QC guide/format
- ✓ Precision and Bias for PEM tests
- ✓ A PEM construction specification incorporating incentives/PRS
- Pilot projects WI & KS



THE ROAD TO PEM

PERFORMANCE ENGINEERED MIXTURES FOR CONCRETE PAVEMENTS



DELIVERING CONCRETE TO SURVIVE THE ENVIRONMENT

- The framework is in place
- Now we are focused on the details of confirmation and implementation



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