Performance Engineered Mixtures

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What is it?

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

What is it?

- Performance – choosing what we need
- Engineered – delivering what is needed
- Mixtures – focus on the mixture, for now

Why bother?

- Current approaches
  - ✓ May not measure critical parameters
  - ✓ Are often built around previous failures – thereby introducing unintended consequences

Concrete Strength (6.3)

Section		Property	Specified Test	Specifed Value		Mixture Qualification	Acceptance	Selection Details	Special Notes
6.3 Concrete Strength									
	6.3.1	Flexural Strength	AASHTO T 97	4.1 MPa	600 psi	Yes	Yes	Choose either or both	
	6.3.2	Compressive Strength	AASHTO T 22	24 MPa	3500 psi	Yes	Yes		

Reducing Unwanted Cracking Due to Shrinkage (6.4)

Section		Property	Specified Test	Specifed Value		Mixture Qualification	Acceptance	Selection Details	Special Notes
6.4 Reducing Unwanted Cracking Due to Shrinkage									
	6.4.1.1	Volume of Paste		25%		Yes	No		
	6.4.1.2	Unrestrained Volume Change	ASTM C157	420 $\mu\varepsilon$	at 28 day	Yes	No		Curing Conditions
	6.4.2.1	Unrestrained Volume Change	ASTM C157	360, 420, 480 $\mu\varepsilon$	at 91 days	Yes	No	Choose only one	
	6.4.2.2	Restrained Shrinkage	AASHTO T 334	crack free	at 180 days	Yes	No		
	6.4.2.3	Restrained Shrinkage	AASHTO T ???	$\sigma < 60\%$ f'r	at 7 days	Yes	No		
	6.4.2.4	Probability of Cracking	~	5, 20, 50%	as specified	Yes	No		
	Commentary	Quality control check	~	~	~	No	Yes		Variation controlled with mixture proportion observation or F Factor and Porosity Measures

Durability of Hardened Cement Paste Due for Freeze-Thaw Durability (6.5)

Section	Property	Specified Test	Specifed Value		Mixture Qualification	Acceptance	Selection Details		Special Notes
6.5 Durability of Hydrated Cement Paste for Freeze-Thaw Durability									
6.5.1.1	Water to Cement Ratio	~	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

Note 1: Choose Either 6.5.1.1 or 6.5.2.1

Note 2: Choose either 6.5.1.2, 6.5.1.3, or 6.5.2.1

Transport Properties (6.6)

Section	Property	Specified Test	Specifed Value		Mixture Qualification	Acceptance	Selection Details	Special Notes
6.6 Transport Properties								
6.6.1.1	Water to Cement Ratio	~	0.45	~	Yes	Yes	Choose Only One	
6.6.1.2	RCPT Value	AASHTO T ???	2000	~	Yes	Yes		Other criteria could be selected
6.6.1.3	Formation Factor/Resistivity	AASHTO xx or AASHTO Yy	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 or AASHTO Yy	25 mm at 30 year		Yes, F	through ρ		

Aggregate Stability (6.7)

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

What next?

- Understanding and education
- Validate tests
- Parallel testing
- Pilot projects

PEM - The Path to Implementation

Transportation Pooled Fund to Support PEM Implementation

- Solicitation Number: 1439
- Posted: August 28,2016
- Lead State: Iowa DOT
- Research Team Will Include:
  - CP Tech Center
  - Tyler Ley, Oklahoma State
  - Jason Weiss, Oregon State
  - Tom VanDam, NCE
  - Cecil Jones
  - Supported by FHWA MCT

CP Tech Center

PEM - The Path to Implementation

Proposed TPF Elements

- Phase 1 with the Scope described
  - ➢5 years (2017-2021)
  - ➢$3 million
  - ➢Ready to support work by January 1, 2017

- Phase 2 (to support performance monitoring)
  - ➢5 years (2022-2026)
  - ➢$ TBD

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PEM - The Path to Implementation

Proposed Funding

- Total of $3 million over 5 years
  - FHWA - $200,000/ year = $1m
  - DOTs – 14 @ $15,000/ year = $1.05m
  - Industry - $200,000/ year = $1m

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PEM - The Path to Implementation

Proposed Work Tasks

1. Implementing what we know: Education, Training & Technical Support
2. Performance Monitoring and Specification Refinement
3. Measuring and Relating Early Age Concrete Properties to Performance