Performance Centered Concrete Construction

Life After PEM

Peter Taylor, PhD, PE (IL), FACI

IOWA STATE UNIVERSITY
Institute for Transportation

National Concrete Pavement Technology Center
Tech Center

The Goal

But how do we get there?

- What tests inform our decisions?
- What levers can we pull?

PEM Philosophy

- What do we want from a mixture?
- How do we produce it?
- How do we know its good?

- P3C
  - What happens after it leaves the batch plant?

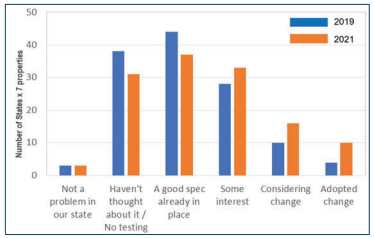
PEM – The mixture

- The critical properties:
  - Transport
  - Cold weather
  - Strength
  - Aggregates
  - Shrinkage

  - Workability

PEM – Impact

- At least 17 states have, or are, changing their specs
  - Adopting at least one of the suggestions of AASHTO R101
  - Removing slump
  - Changing cement content limits
- We aim to keep the momentum going
  - Training
  - Talking to agencies



Where Next?

- We have the perfect mixture in the truck…
- What happens after it leaves the plant
  - More research needed!
  - Performance Centered Concrete Construction (P3C)

Steps to Long Life

Target performance
Workability
Durability
Strength

Design Levers
Gradation
Paste Volume
Cementitious
Admixtures

Measure!

Batching
Uniformity – Water
– Cementitious system
– Aggregates
Mixing – Time
– Energy

Measure!

Transportation
Mixing
Workability
– Time and weather
– Added water / admixtures
Uniformity

Placement
Handling / Vibration
- Bleeding
- Segregation
- Air void system
- Water movement

Measure!

Finishing
Surface finish
Curing
Sawing

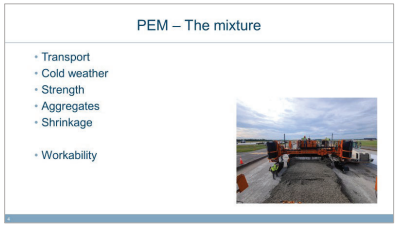
In the Lab

Proportioning to achieve performance goals

		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	✓	-	-	-	✓✓	-

In the Lab

- Design the mixture for the materials available
- Check that it meets performance requirements
- Assess sensitivity to normal variations
- Develop plans to react to changes



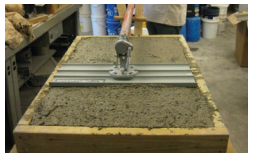
In the Lab

- Aggregate stability – sources and SCM dosages
- Transport properties (permeability) – resistivity and w/cm
- Cold weather resistance – air void system and SCM content
- Strength – w/cm
- Shrinkage – paste content

- Workability – aggregate gradation, paste content

In the Lab

- Fresh properties that affect construction
  - Response to vibration — VKelly / Box
  - Edge slump — VKelly / Box
  - Bleeding — C232
  - Segregation — No test (Tayabji)
  - Finishability — Ruler
  - — Tyler



At the Batch Plant

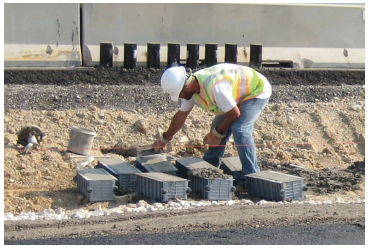
- Workability — Power meter
  Call from the paving supervisor
  Data from the paver?

At the Batch Plant

• Uniformity	No standard test
• Stockpile control	-
• Water control	Moisture probes
• Loading sequence	-
• Mixing time	-

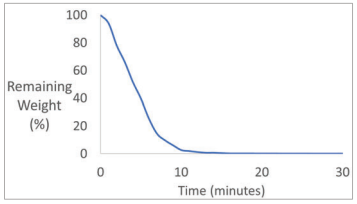
At the Paver

• Samples	Workability
	Air void system
	Resistivity
	Strength



At the Paver

• Water	Phoenix



At the paver

• Segregation	No field test
• Mixture proportions	
• Uniform delivery	
• Placing method	

At the Paver

Measure!

- Workability

Augur power demand?
Torque to move paver?
VKelly on a boom?

Behind the Paver

Measure!

- Consolidation
  - Vibration
    - vpm
    - Duration
    - Paver speed

No field test
Internal sensors

Samples Behind the Paver

- Great in theory but…

Behind the Paver

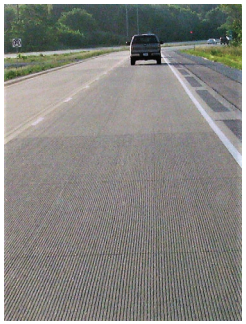
- Thickness
  - Probe
  - MIT SCAN T3

Behind the Paver

- Finish and Smoothness — Real time smoothness
  - Mixture
  - Pan setup
  - Grout box
  - Paver speed
  - Finishing

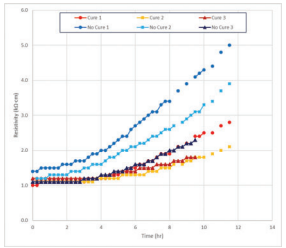

Behind the Paver

- Texture — Sand Patch
  - Tine setup
  - Bridge speed

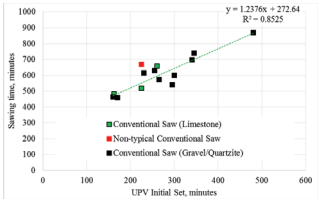
Behind the Paver

- Curing — No field test
  - Curing compound type
  - Timing
  - Spray rate




Behind the Paver

- Crack free
  - Saw type
  - Blade ttype and condition
  - Depth
  - Timing — UPV

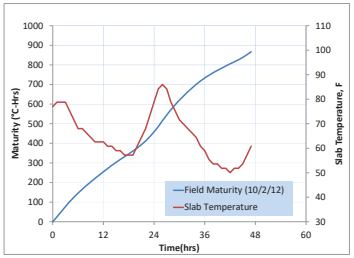


The Next Days

- Joint Activation Mira

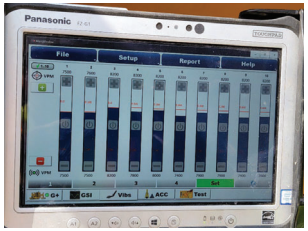
The Next Days

- Maturity
  - Opening to traffic



P3C

- Goals:
  - Continue to assist state agencies on specification improvements
  - Continue to offer training
  - Investigate tools to monitor the mixture through the paving process
  - Investigate feedback loop approaches



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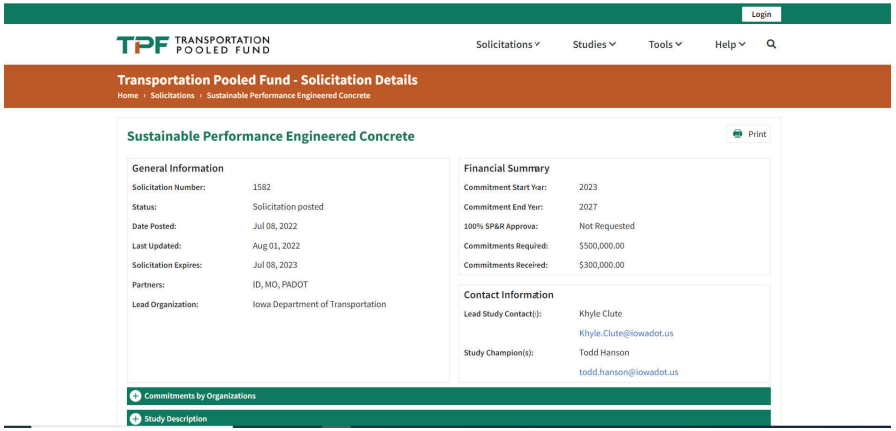


Performance Centered Concrete Construction (P3C)

Matt Fonte
Principal
Fonte and Company

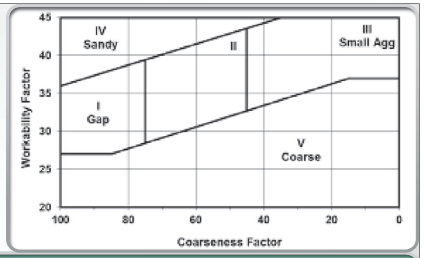
Water / Admixture

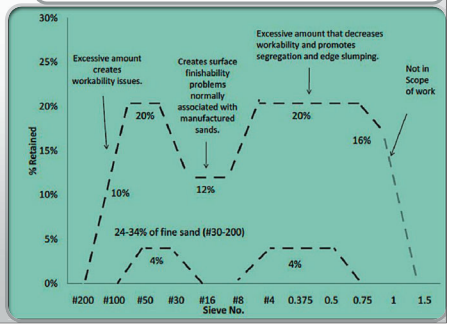
Concrete Mix Design

- Workability is dependent on the aggregate gradations.
- Testing for the effectiveness of the water reducers
- Not all admixtures are compatible with all SCM's
- Testing a range of water cement ratios and aggregate combinations at mix design time.

Optimized Gradations

- Shilstone opened our eyes to the need for optimized gradations
- Ley took it one step further with an emphasis on workability
- Shilstone focus on the relation between 3/8 and the #8
- Tarantula focuses on all the sieves





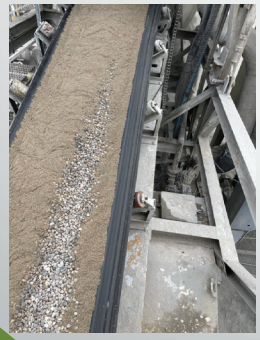
Slump

- Consistent
- Water vs Water Reducer
- What is your upper water cement ratio limit?

Uniformity – Aggregate Moisture

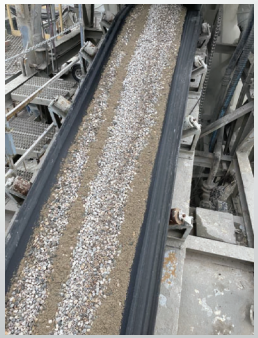
Uniformity – Combined Aggregates

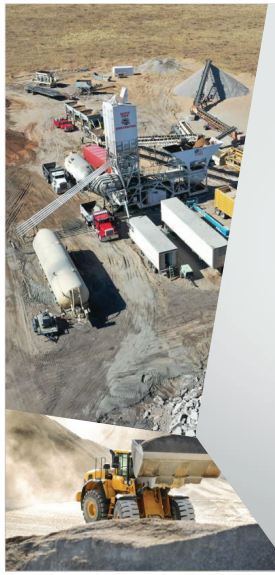
Beginning



Middle

End



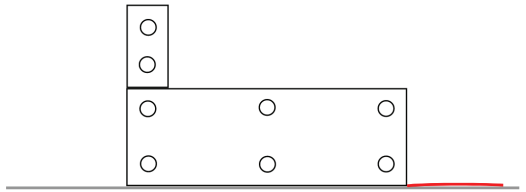


Concrete Batching

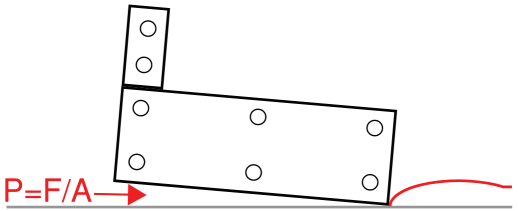
- Mixer efficiency
  - What is the condition of your drum liners?
- How is the drum loaded
  - Are all the aggregates on the charge belt from start to finish?
  - Cementitious throughout the charging of the drum
  - Water throughout the charging of the drum
  - When is each admixture introduced to the drum
- 60 second batching
  - Is the mix consistent throughout the drum in 60 seconds?
  - This is not in relation to slumping out a batch.

Segregation

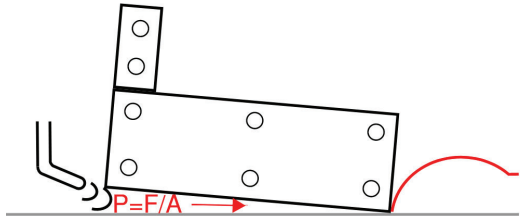
Machine Setup



Plane of the paving pan



Plane of the paving pan



Plane of the paving pan

Consolidation / Vibration

Smoothness

Smoothness
3 Key Factors

- Consistency in everything all day long
  - con·ti·nu·i·ty
  - 1. the unbroken and consistent operation of something over a period of time.
- Volatility mitigation in the operation
  - vol·a·til·i·ty
  - 1. liability to change rapidly and unpredictably, especially for the worse.
- Reduction in the Energy applied to the concrete
  - Using less energy to preform the same task

Tining?

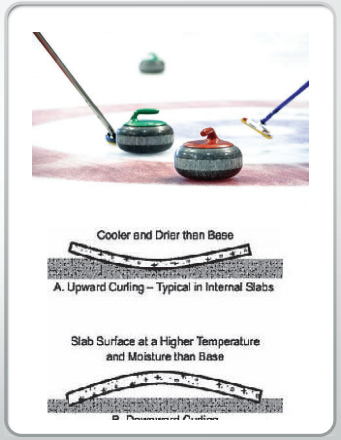
Why?

Is it delaying when you apply your cure?

Curing

Curling & Warping

- Saturate the subgrade
- Cure quickly and thoroughly
- White as a sheet of paper



Cracking

Sawing

- What effects the sawing window?
- SCM type and dosage
- Admixture type and dosage
- Ambient temperature
- Concrete mix temperatures
- Slab temperatures
- And…

Opening to traffic

Summary

- How do we address what we have discussed?
- Funding for this pooled study.
- Research – determine what is affecting durability during construction.
- Change in specification language.
- Training – Inspector training, Construction supervisor training.
- Tech briefs & Manuals
- Training videos for crews and construction management teams.
- Workshops & Webinars

- Funding the research to identify legitimate areas of concern and getting the right message out to resolve these concerns.

Thank You

Matt Fonte

303-478-1529

matt@fonteandco.com

www.fonteandco.com

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