Performance Engineered Concrete

--It’s Time For a Change--

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FHWA Office of Asset Management,
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We Are **Horrible** With Change

- Timeframe for widespread use of SCM’s
- 28-day strength testing
- Slump test
Evolution of Concrete Testing

Concrete

- Slump Cone: 1922, ASTM C143
- Pressure Meter: 1949, ASTM C231
- Rapid Chloride Permeability Test: 1981, FHWA/PCA

Cars

- 1920
- 1940
- 1960
- 1980
- 2000

U.S. Department of Transportation
Federal Highway Administration
Motivation

- Increase in premature concrete deterioration
- MAP-21 and FAST ACT legislation focus on performance
- Desire by Public Agencies and Industry to move toward performance
  - Optimized mixture designs (gradation, cement content, cont.)
  - Improved durability
  - Sustainability
- Testing technology advancements
- Changes in agency and industry skills and personnel levels
Performance Engineered Mixture Concept

- Understand what makes concrete last and what failure mechanisms we see
- Specify 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 owner agencies
PEM Specification Development

- **The Team**
  - Dr. Peter Taylor, Director, CP Tech Center/Iowa State
  - Dr. Jason Weiss, Oregon State University
  - Dr. Tyler Ley, Oklahoma State University
  - Dr. Tom Van Dam, NCE
  - Cecil Jones, Diversified Engineering
  - Tom Cackler, CP Tech Center
  - Mike Praul, FHWA

- **Industry Participants/Reviewers**
  - Champion States
  - ACPA National, ACPA Chapter Execs
  - PCA
  - NRMCA
Champion States

- Indiana
- Iowa
- Michigan
- Minnesota
- Nebraska
- South Dakota
- Wisconsin
- Illinois Tollway
- Manitoba
AASHTO PP 84: A Better Specification

Require the things that matter

- Strength
- Shrinkage
- Cold weather resistance
- Transport properties (Permeability)
- Aggregate stability
- Workability
Why We’re Excited

Concrete Evolution

- PEM: It’s our Superpave
- 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?”
- Collaboration with industry (It’s more than just the tests!)
“It’s the agency’s responsibility to allow for innovation. It’s the contractor’s responsibility to deliver.”

Jerry Voigt, ACPA
How Do Contractors Deliver in a Performance Specification
Sources of Variability

Material  Process  Sampling  Testing

Composite Variability
Controlling Sampling and Testing Variability

- Standard procedures (AASHTO, ASTM, state)
- Laboratory accreditation/qualification program
- Technician training and certification programs
- State Independent Assurance Program
- Calibrated equipment schedules
Sources of Variability

Material, Process, Sampling, Testing

Composite Variability
Controlling Material and Process Variability
### Prescriptive vs. Performance Specifications

<table>
<thead>
<tr>
<th>Prescriptive</th>
<th>Performance</th>
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<tr>
<td>• Agency dictates how the material or product is formulated and constructed</td>
<td>• Agency identifies desired characteristics of the material or product.</td>
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<tr>
<td>• Based on past experience</td>
<td>• Contractor controls how to provide those characteristics</td>
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<td>• Minimal/uncertain ability to innovate</td>
<td>• Maximum ability to innovate</td>
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<tr>
<td>• Requires agency to have proper manpower and skill set to provide oversight</td>
<td>• Reduced oversight burden on the agency</td>
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U.S. Department of Transportation
Federal Highway Administration
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
  - 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
Mirror Design-Build (DB) Experience

- DB shifts control from agency to contractor
  - Risk shifts with control
- Agency retains responsibility and accountability to the taxpayers
- Contractor submits proposal including how they will develop and deliver the project
- Post-award, contractor submits a detailed QC Plan
- Performance specifications have a similar shift of risk and control
  ✔ QC Plans are analogous
Quality Control

- Uses **real time** feedback
  - Now possible with innovation and new tests

- 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
Quality in the Concrete Paving Process
Quality Control Evolution

- Change state mindset that QC is not their business
  - Gordon Smith example
- Change (some) industry mindset that QC is not their business
- Provide guidance on developing state specification language
- QC Testing Guide (very similar to guidance for the acceptance program but slanted to industry)
  - QC tests “one-pagers” and videos
  - Frequency
  - Control charts and usage
- QC Plan template and guidance
Unit Weight / Heat Signature / Permeability

Unit Weight – Real Time

Surface Resistivity – 28 Days

Heat Signature – Info in a day

Surface Resistivity – 56 Days

Field Data from an MCT project
“But Mike, You’re Asking for a Lot of Change”

Change has already happened!

- Cements
- Widespread use of SCM’s
- Advancements in chemical admixture technology
- De-icers
- Agency personnel and experience levels
- Industry knowledge base
Proven Concepts

- 1996 move to QA approach
- Contractor mix designs
- No agency personnel in plants
- Meaningful QC Plans (enforced)
- Cooperative approach
- Results!
Thank You

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