PERFORMANCE ENGINEERED CONCRETE PAVING MIXTURES (PEM)

Delivering concrete to survive the environment
WHAT IS THIS ALL ABOUT?

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

• A program to:
  – Understand what makes concrete “good”
  – Specify the critical properties and test for them
  – Prepare the mixtures to meet those specifications
MODERNIZING CONCRETE PAVEMENT SPECIFICATIONS

• 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
STANDARD PRACTICE FOR DEVELOPING PERFORMANCE ENGINEERED CONCRETE PAVEMENT MIXTURES (PP 84-17)

- Guidance for FHWA-State DOTs-Industry
- A “work-in-progress”
DEFINING THE THINGS THAT MATTER

- Transport properties (everywhere)
- Aggregate stability (everywhere)
- Strength (everywhere)
- Cold weather resistance (cold locations)
  - De-icer resistance
- Shrinkage (dry locations)
- Workability (everywhere)
IMPLEMENTING TEST METHODS

• Tests for those critical properties
  – Resistivity / Formation Factor (*Transport*)
  – Oxychloride formation (LTDSC)
  – SAM (*Cold Weather Resistance*)
  – Box (Workability)
  – VKelly (Workability)
  – Sorptivity
QUALITY CONTROL

• Requires an approved QC Plan
  – Testing targets, frequency, and action limits
  – Equipment and construction inspection

• Requires QC testing and control charts
  – Unit weight
  – Air content/SAM
  – Water content
  – Formation Factor (via Surface Resistivity)
  – Strength
POOLED FUND OBJECTIVES

- Investigate ruggedness of test methods and appropriate limits
- Collect data for lifetime modeling
- Educate users about the specification and test methods
- Help agencies select what approaches they want to take
SCOPE OF WORK

• Task 1 – Implementing what we know
• Task 2 – Performance Monitoring and Specification/Test Refinement
• Task 3 – Measuring and Relating Early Age Concrete Properties to Performance.
THE PARTNERS

• Federal Highway Administration (FHWA)
• State Departments of Transportation (DOTs)
• Industry (ACPA-PCA-NRMCA-SCA-Others)
PEM POOLED FUND PARTICIPANTS
TPF-5(368)

15 States + FHWA & Industry
THE TEAM

- FHWA - Gina Ahlstrom, Mike Praul
- Researchers – Jason Weiss, Tyler Ley
- Consultants – Tom VanDam, Cecil Jones
- Administration – Peter Taylor, Gordon Smith
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<td>Project level education</td>
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<td>Assist field staff with test methods on site with mobile labs</td>
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PROTOCOL FOR PEM SHADOW PROJECTS

• DOT Executive briefing
• Specification review
• Workshop for DOT office staff
• Construction, demonstrate tests, collect data, train field staff
• Review data and report findings / recommendations
• Ongoing data collection
• Data processing and storage
• Ongoing specification support
# Monitoring & Test Refinement

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<td>Develop / improve test method</td>
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<td>Database</td>
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<td>Review constructibility</td>
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MEASUREMENT & PERFORMANCE

• Accelerated test methods for transport properties
  – Formation factor
  – Time to critical saturation
• Thermodynamic model for transport
  – Linked to performance
• Moisture movement model
• Rapid method for w/c ratio or water content
• V-Kelly test method and calibration
FHWA IMPLEMENTATION INCENTIVE FUNDS

• Available to pooled fund participating states
• $40,000 for two or more new tests in the mix design/approval process (shadow testing acceptable)
• $20,000 for one or more new tests in the acceptance process (shadow testing acceptable)
• $20,000 for requiring an “enhanced” QC Plan from the contractor
• $20,000 for requiring the use of control charts
• Report required within 4 months of construction
• National announcement through Divisions soon
Ensuring that agencies can specify—and contractors can deliver—durable concrete pavements, every time

An Innovative Program for Pavement Reliability

The Performance Engineered Mixtures (PEM) program is designed to provide the tools for agencies to specify, and contractors to deliver, concrete mixtures that reliably and sustainably meet the needs for concrete infrastructure.

The PEM program will result in concrete pavements consistently achieving the performance life of the design. The program is based on the concept of measuring and controlling the concrete mixture around engineering properties that actually relate to performance:

- Identifying critical mixture properties for long-term durability specific to any climatic environment
- Achieving these properties through measuring the performance-related engineering parameters of the mixtures
- Developing a specification for mixtures
- Providing technical guidance and project-level support for preparing and delivering concrete mixtures that meet the specification

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Iowa State University
Institute for Transportation
Moving Advancements into Practice
MAP Brief April 2017

Best practices and promising technologies that can be used now to enhance concrete paving

Performance Engineered Mixtures (PEM) for Concrete Pavements

Introduction

Concrete pavements are designed to perform for decades under harsh service conditions. Owners invest in them because of their ability to provide a safe, low-maintenance, long-life solution to a full range of needs, from low-volume secondary roads to the highest volume interstate applications in the country. With recent advancements in testing technologies, it is now possible to more directly measure the key properties of concrete paving mixtures that relate to performance and design them to perform with increased reliability in all climatic regions.

This tech brief will explain how concrete paving mixtures can be engineered to meet performance requirements and how to incorporate key performance parameters into a robust specification and quality process.

Why performance-engineered mixtures are needed

Concrete paving specifications have not kept pace with advancements in concrete science and innovations in testing technologies. Current specifications are still largely based on strength, slump, and air content and have been for over 50 years. While these are important parameters, there are other parameters that are not being measured that are equally or more important. Mixtures have become more complex with a growing range of chemical admixtures and supplementary cementitious materials (SCMs). Traffic is increasing, more aggressive winter maintenance practices are the norm, and demands are growing for systems to be built more quickly, less expensively, and with increased longevity.

Many local specifications are predominantly prescriptive, thus limiting the potential for innovation and not necessarily addressing current materials, environments, or construction methodologies.

Recognizing the need to advance concrete paving specifications, the Federal Highway Administration (FHWA), the American Concrete Paving Association, the Portland Cement Association and other industry partners, and member states of the National Concrete Consortium (NCC) are collaborating with the research and technical community to modernize the specifications for paving mixtures. This partnership formally began in April of 2015 at the spring meeting of the NCC with the formation of an Expert Task Group that included seven champion states (Indiana, Iowa, Minnesota, Michigan, Nebraska, South Dakota, Wisconsin, the Illinois Tollway, and Manitoba). FHWA’s shared vision was to have a provisional American Association of State Highway and Transportation Officials (AASHTO) specification by 2017. This vision has become a reality.

In April of 2017, AASHTO will publish PP 84-17, Developing Performance Engineering Concrete Pavement Mixtures (figure 1). The focus now shifts from this first step to technical education of agencies and industry on how to apply the PEM specification within an integrated framework that provides for innovation and local optimization.
Developing a Quality Assurance Program for Implementing Performance Engineered Mixtures for Concrete Pavements

Introduction

TRB Circular 137 defines Quality Assurance as all those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. The Quality Assurance Program (QAP) for Performance Engineered Mixtures (PEM) for Concrete Pavements represents a system of individual and shared responsibilities that needs to be understood by the agency and contractor. This tech brief is the second of a two part series on PEM specifications and implementation. The April 2017 CP Road Map MAP Brief “Performance Engineered Mixtures (PEM) for Concrete Pavement” presented an overview of the PEM specification requirements. The CP Road Map MAP Brief and the AASHTO standard of practice PP 84-17 give details on the PEM specification requirements. This tech brief will overview QAP requirements specifically related to PEM, which are a subset of the overall QAP requirements for a project. An overview of the QAP elements related to PEM is shown in Table 1. It consists of those activities the owner agency does as part of their acceptance responsibilities and also those activities that the contractor is responsible for (Quality Control, QC) to ensure the product meets the contract requirements. Table 1 also summarizes the critical mixture performance requirements and implementation options. More detail is provided in the CP Road Map MAP Brief “Performance Engineered Mixtures (PEM) for Concrete Pavements.”

Background

Historically, agencies have relied too much on 28-day strength of a concrete mixture as a quality indicator. The traditional mindset has been that if the 28-day strength meets the specification requirements, it was “good” concrete strength was used as a quasi-indicator of durability. The concrete community was hampered by the lack of tests that were both indicators of concrete quality and those that could be done during production so that changes could be detected and corrected as needed while the project was still under construction.

New Tests

Recently, there have been significant advancement in testing technologies that measure engineering properties important for good performance of the concrete pavement. With these scientific advancements, agencies and contractors now have the ability to effectively monitor their production in real-time and adjust as needed to produce the desired level of quality. These new tests, particularly when used in conjunction with a performance specification and QAP, set the stage for significant advancements in pavement performance. Figure 1 (page 4) shows several of the tests used in the PEM Specification: surface resistivity, calorimetry, and Super Air Meter (SAM).
WHAT DO WE GET?

• Concrete that delivers what is needed
  – Efficiently
    • Cost
    • Environmental impact
  – Reliably
    • “Quality”
WHAT DO WE NEED?

• Join the Pooled Fund
• Talk to us about your specification
• Allow us to train your staff and demonstrate the tools
• Shadow a project