PERFORMANCE ENGINEERED CONCRETE PAVING MIXTURES (PEM)

Delivering concrete to survive the environment

National Concrete Pavement Technology Center

Tech Center

IOWA STATE UNIVERSITY
Institute for Transportation

WHAT IS THIS ALL ABOUT?

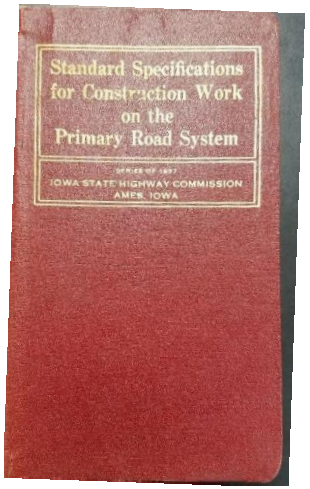
- Performance – choosing what we need
- Engineered – delivering what is needed
- Mixtures – focus on the mixture, for now

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

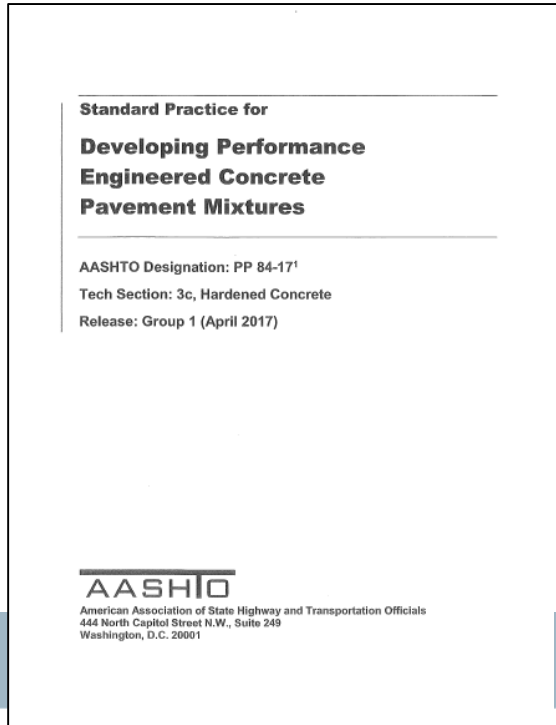
MODERNIZING CONCRETE PAVEMENT SPECIFICATIONS

- 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”



Standard Practice for

Developing Performance Engineered Concrete Pavement Mixtures

AASHTO Designation: PP 84-17[1]

Tech Section: 3c, Hardened Concrete

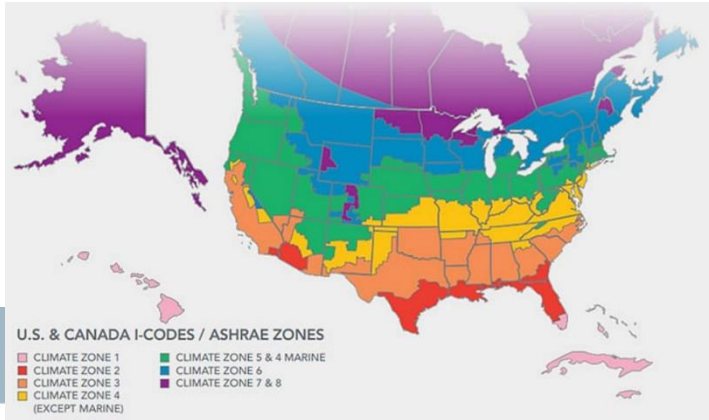
Release: Group 1 (April 2017)

AASHTO

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001

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)



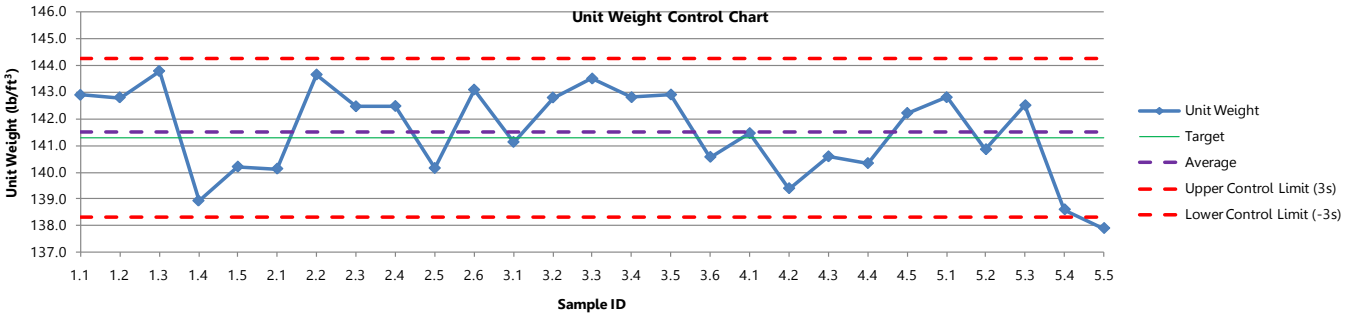
IMPLEMENTING TEST METHODS

- 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

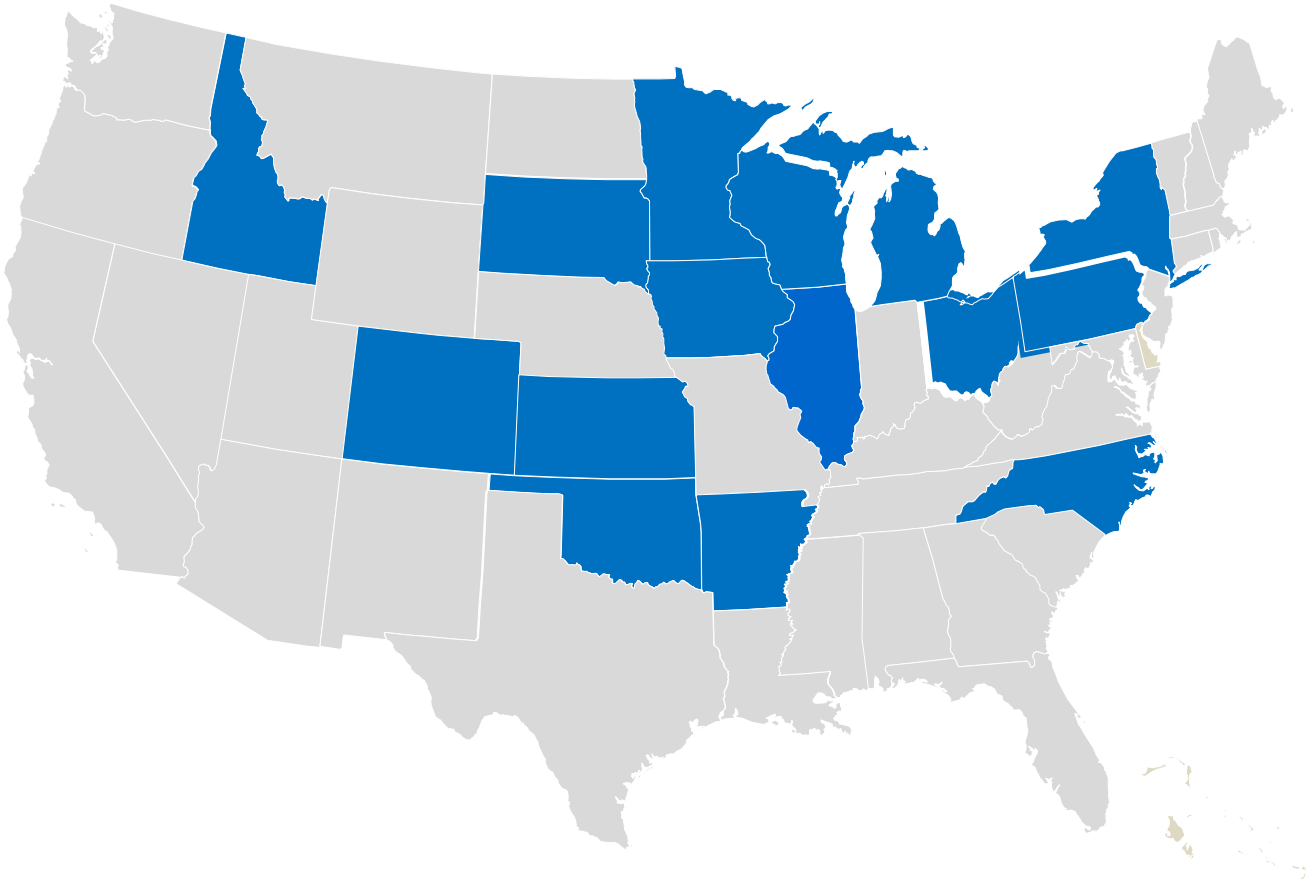
SCOPE OF WORK

- 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

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- Researchers – Jason Weiss, Tyler Ley
- Consultants – Tom VanDam, Cecil Jones
- Administration – Peter Taylor, Gordon Smith

Oregon State University

SNYDER & ASSOCIATES

OSU

NCE

U.S.Department of Transportation
Federal Highway Administration

Diversified Engineering Services, Inc.

CP Tech Center

IMPLEMENTATION

Implementation	PPTs	Prepare slides for workshops and webinars
	Webinars	Prepare overview of the PEM specification
	Spec support	Guide states in use of the spec
	Test support	Demo at NC2
		Guidance documents online including videos
		On-call service
	Shadow Project Support	Executive Level briefing
		Project level education
		Assist field staff with test methods on site with mobile labs

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

Monitoring	Data protocol	Set up database
	Database	Collect and publish field data and pavement performance
	LTTP	Mine existing data
	Update AASHTO	Annual update and revise specification
Test Refinement	Transport	Develop / improve test method
	Thermodynamics	Develop / improve test method
	Water movement	Develop / improve test method
	Water content	Develop / improve test method
	Constructibility	Review constructibility

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

PERFORMANCE ENGINEERED MIXTURES PROGRAM

Ensuring that agencies can specify—and contractors can deliver—durable concrete pavements, *every time*

March 2017

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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

CP ROAD MAP

shaping the future of concrete pavements

www.cproadmap.org

April 2017

ROAD MAP TRACK 1

PROJECT TITLE

Performance Engineered Mixtures for Concrete Pavements

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The Long-Term Plan for Concrete Pavement Research and Technology (CP Road Map) is a national research plan developed and jointly implemented by the concrete pavement stakeholder community. Publications and other support services are provided by the Operations Support Group and funded by the Federal Highway Administration.

Moving Advancements into Practice (MAP) Briefs describe innovative research and promising technologies that can be used now to enhance concrete paving practices. The **April** 2017 MAP Brief provides information relevant to Track 1 of the CP Road Map: Materials and Mixes for Concrete Pavements.

This MAP Brief is available at www.cproadmap.org/publications/MAPbriefMarch2017.pdf.

"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

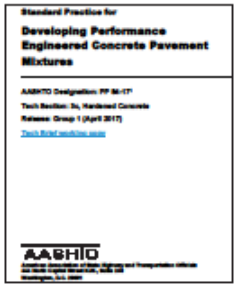
Concrete paving specifications have not kept pace with advancements in concrete science and innovations in testing technologies.

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.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AASHTO

Figure 1. AASHTO PP 84-17 specification

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shaping the future of concrete pavement

www.cproadmap.org

July 2017

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PROJECT TITLE
Performance Engineered Mixtures for Concrete Pavements

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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).

AASHTO PP-84-17 "Standard Practice for Developing Performance Engineered Concrete Pavement Mixtures"

The PEM specification is a leap forward for the concrete community. It incorporates measuring the critical properties identified in Table 1 into a specification framework (Table 2). The premise behind the specification is to target the mix-design testing and acceptance testing towards those tests that are indicative of concrete quality and that will address known failure mechanisms. The specification removes some prescriptive specification elements, such as minimum or

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