FHWA Update on MCT & PEM/AASHTO PP 84

MICHAEL F. PRAUL, PE
SENIOR CONCRETE ENGINEER
FHWA, OFFICE OF INFRASTRUCTURE

U.S. Department of Transportation
Federal Highway Administration
Office of Infrastructure

We Are Horrible With Change

- Timeframe for widespread use of SCM's
- 28-day strength testing
- Slump test

Evolution of Concrete Testing

Concrete

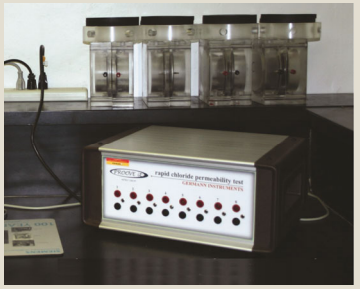
Slump Cone

1922
ASTM C143

Pressure Meter

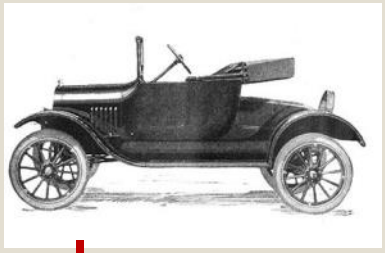
1949
ASTM C231

Rapid Chloride Permeability Test



1981
FHWA/PCA

Cars



1920 1940 1960 1980 2000

Performance Engineered Mixture Concept

- Understand what makes concrete last and what failure mechanisms we see
- Specify critical properties to address those failure mechanisms and test for them
- Starting point for a performance-driven QA specification and acceptance program for owner agencies

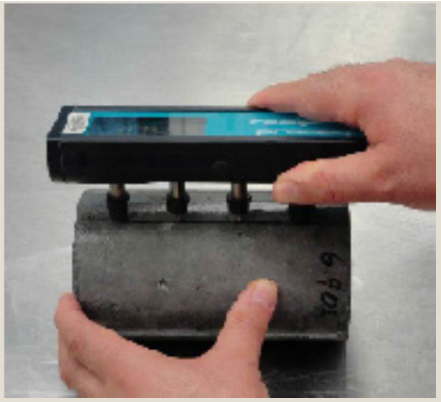
PEM Specification Development

- 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

AASHTO PP 84: A Better Specification

Require the things that matter

- Strength
- Shrinkage
- Cold weather resistance
- Transport properties (Permeability)
- Aggregate stability
- Workability*



What do we want these tests to do?

- Measure critical performance criteria
- Be completed economically and rapidly in the lab or the field
- Allow innovation while evaluating the performance that matters

AASHTO PP 84

- A ***guide*** specification with tests completed either during mixture design or at placement or both that focus on concrete performance.
- Allows DOTs to take what they like from the document and make it their own.
- DOTs should not give up what they already know is important for them.

AASHTO PP 84

- A commentary is included that gives the technical background behind the tests and limits
- Includes both prescriptive and performance approaches
- A tool to help you improve your concrete
- The document is not designed to be used without modifying for local practice and experience

The document is not designed to be used without modifying for local practice and experience!!!

Why We're Excited

Concrete Evolution

- PEM/PP 84: 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!)

Jerry Voigt, ACPA

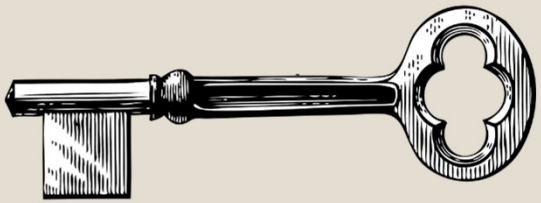
"It's the agency's responsibility to allow for innovation. It's the contractor's responsibility to deliver."

Quality Control

- PP 84 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

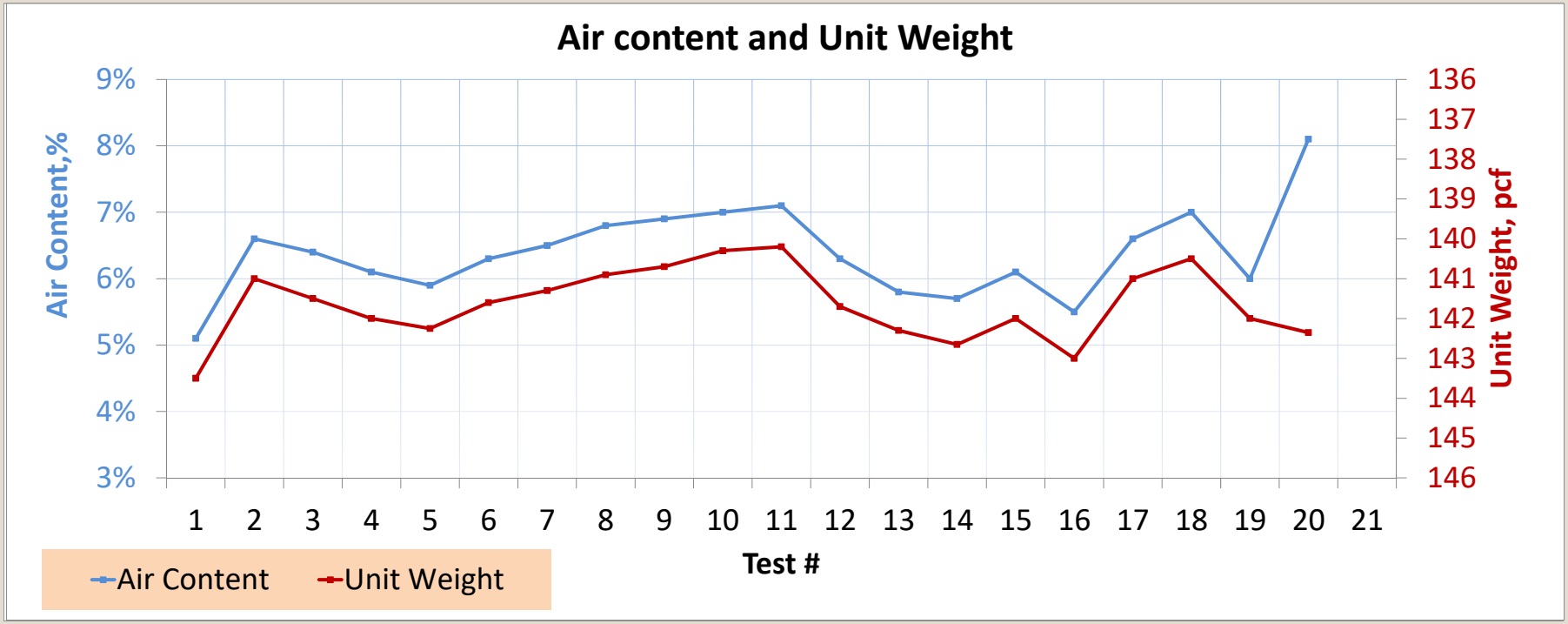


Quality Control Evolution

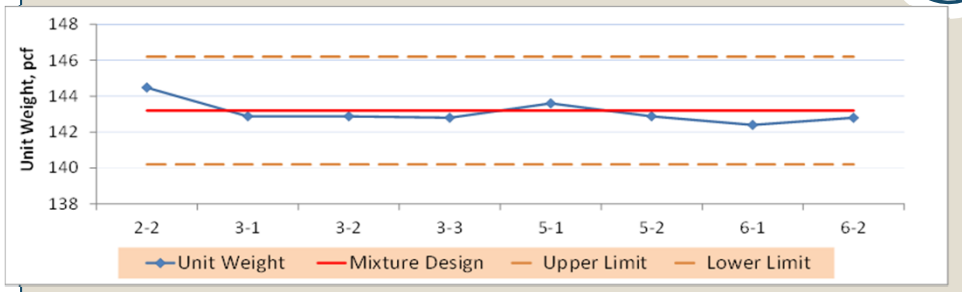
- Change state mindset that QC is not their business
  - Gordon Smith example
- Change (some) industry mindset that QC is not their business
- Provide guidance on developing state specification language
- QC Testing Guide (very similar to guidance for the acceptance program but slanted to industry)
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

Dual Axis Plot Example

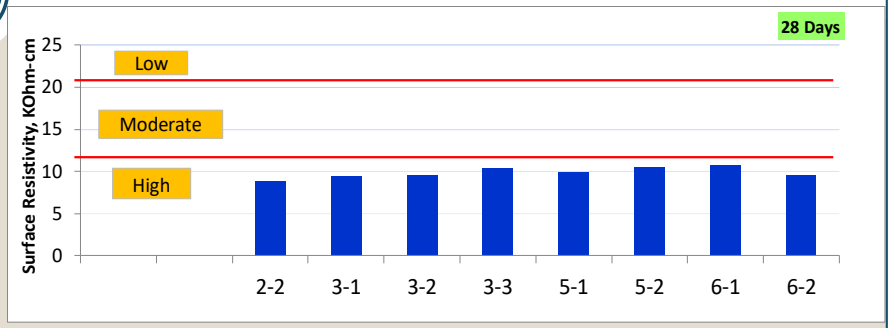
- Air content plotted on the left vertical axis
- Unit weight plotted on the right vertical axis



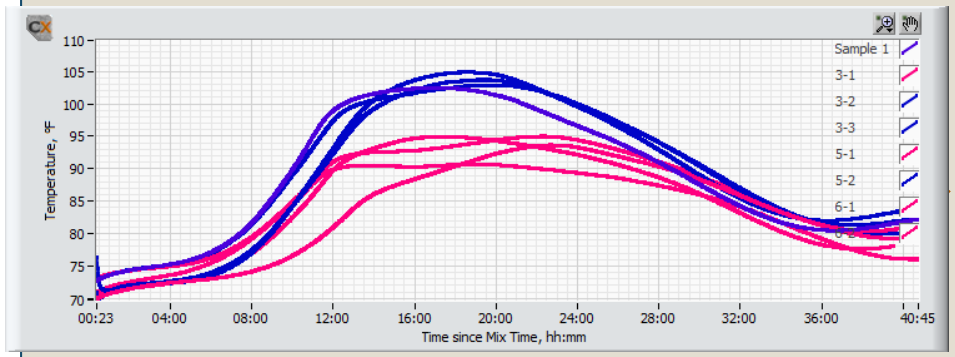
Unit Weight/Heat Signature/Permeability



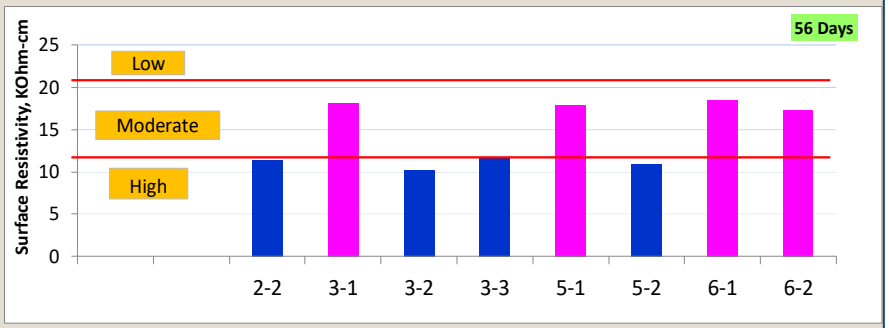
Unit Weight – Real Time



Surface Resistivity – 28 Days



Heat Signature – Info in a day



Surface Resistivity – 56 Days

Real Time

28 / 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

MAP Brief Topics – April and June 2017

- Why Performance Engineered Mixes
- Where will PEM be beneficial
- Overview of PEM Requirements
  - Aggregate Stability
  - Fluid Transport Properties
  - Cold Weather
  - Shrinkage
  - Concrete Strength
  - Workability
- State agency Quality Assurance with PEM
- Quality Control

CP ROAD MAP
shaping the future of concrete pavement

www.cproadmap.org

April 2017

ROAD MAP TRACK 1

PROJECT TITLE
Performance Engineered Mixtures for Concrete Pavements

TECHNICAL WRITERS
Tom Cackler (lead)
Dale Harrington
Peter C. Taylor

CONTRIBUTORS
Tyler Ley
Larry Sutter
Jason Weiss
Tom VanDam

EDITOR
Sabrina Shields-Cook

SPONSORS
Federal Highway Administration
National Concrete Consortium

MORE INFORMATION
Dale Harrington
Snyder and Associates, Inc.
(515)964-2020
dharrington@snyder-associates.com

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.

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.

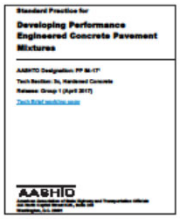

Standard Practice for
Developing Performance Engineered Concrete Pavement Mixtures
AASHTO

Figure 1. AASHTO PP 84-17 specification

CP ROAD MAP
shaping the future of concrete pavement

www.cproadmap.org

July 2017

ROAD MAP TRACK 1

PROJECT TITLE
Performance Engineered Mixtures for Concrete Pavements

TECHNICAL WRITERS
Tom Cackler (lead)
Mike Praul, FHWA
Richard Duval, FHWA

EDITOR
Sabrina Shields-Cook

SPONSORS
Federal Highway Administration
National Concrete Consortium

MORE INFORMATION
Dale Harrington
Snyder and Associates, Inc.
(515)964-2020
dharrington@snyder-associates.com

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 July 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/MAPbriefJuly2017.pdf.

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

FHWA Mobile Concrete Trailer (MCT)

MCT Staff

Mike Praul

Nicolai Morari

Jagan Gudimettla

Jim Grove

Jerry Clemons

MCT Program Goals

- Implement new and proven concrete technologies
- Evaluate new tests and equipment
- Demonstrate the benefits of statistical materials acceptance in both agency acceptance programs and industry quality control applications
- Assist states with concrete issues
  - Specification review and development
  - Technical assistance
  - Forensics

Source: Pixabay

MCT Activities

- Field visits to active construction projects
- Quality in the Concrete Paving Process Workshop
- Focus on PEM implementation
- Equipment Loan Program, One-on-one Training
- Conferences, papers, and other activities

MCT Conventional Tests

- Temperature
- Slump
- Air Content (Type B)
- Strength
  - Compressive
  - Flexural
  - Split Tensile
  - Elastic Modulus and Poisson's ratio

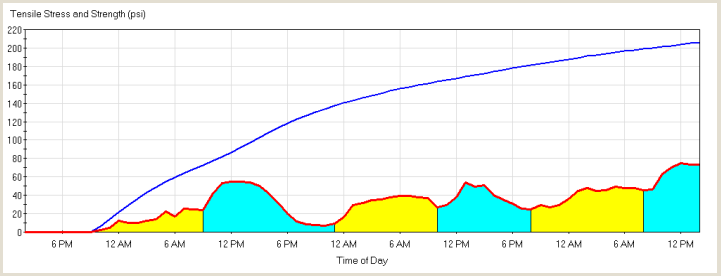
MCT Non-destructive and In-situ Tests

- Box Test
- Match Curing
- Maturity
- Pull Out Strength
- Pavement Thickness
- Dowel Bar Alignment

- Tensile Bond Strength
- Ultrasonic Tomography
- Capillary Pressure Sensing
- Handheld Ground Penetrating Radar

MCT Durability Tests

- Super Air Meter (SAM)
- Surface Resistivity
- Rapid Chloride Permeability
- Calorimetry
- Microwave Water Content
- Coefficient of Thermal Expansion
- HIPERPAV software
- Aggregate gradation software



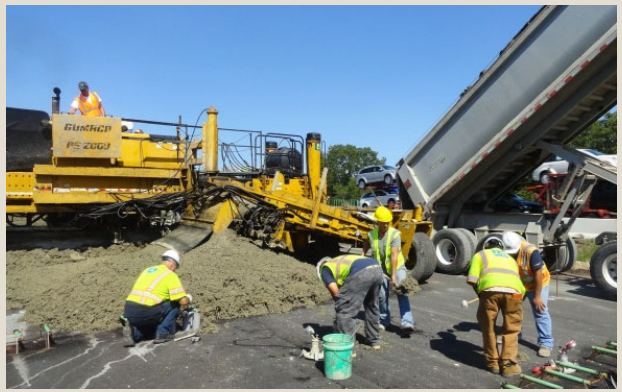
MCT Field Visits

- Active field project for a two-week period
- Traditional and innovative testing
- Week 1: Fresh properties

Source: FHWA

Kick-Off Meeting

Testing



Testing

Week 1

MCT Field Visits

- Week 2: Hardened properties
- Open House
- Data in control chart format

Source: FHWA

Testing

Testing

Open House

Week 2

MCT Field Visits

- Close out meeting with the state DOT, FHWA Division Office, and contractor
- Summary report/Action plan
- A free QA workshop using the field visit data

Close Out

QA Workshop

Planned 2018 State Site Visits

- Minnesota
- Iowa
- Colorado (PRS shadow)
- Texas (PRS shadow)
- Idaho
- Florida

2018 Conferences (so far)

- Maryland Concrete Conference
- NY Construction Materials Association Technical Conference
- Texas Concrete Conference
- ASCE Indiana State Section Annual Meeting
- Roadway Management Conference (PA)

Quality in the Concrete Paving Process Workshop

- Two-day workshop on concrete materials and construction
  - Benefits of a concrete Quality Assurance Program
  - Contactor benefits of improved Quality Control
  - New technologies and tools for testing and inspection
- Agency and Contractor Participation (50/50)
  - Class size 30 to encourage discussion
  - DOT (Materials, Construction Staff etc.)
  - Contractor staff (Superintendents, QC Managers etc.)
  - FHWA Division Office staff

PEM/PP 84 Implementation

- Assisting PEM Team and TFHRC with ongoing PEM-related research
- Continuing to assist with Super Air Meter
- Parallel PEM and state testing during field visits
- Demonstrating PEM equipment and testing
- Conferences and other venues
- Investment through Equipment Loan Program

Equipment Loan Program

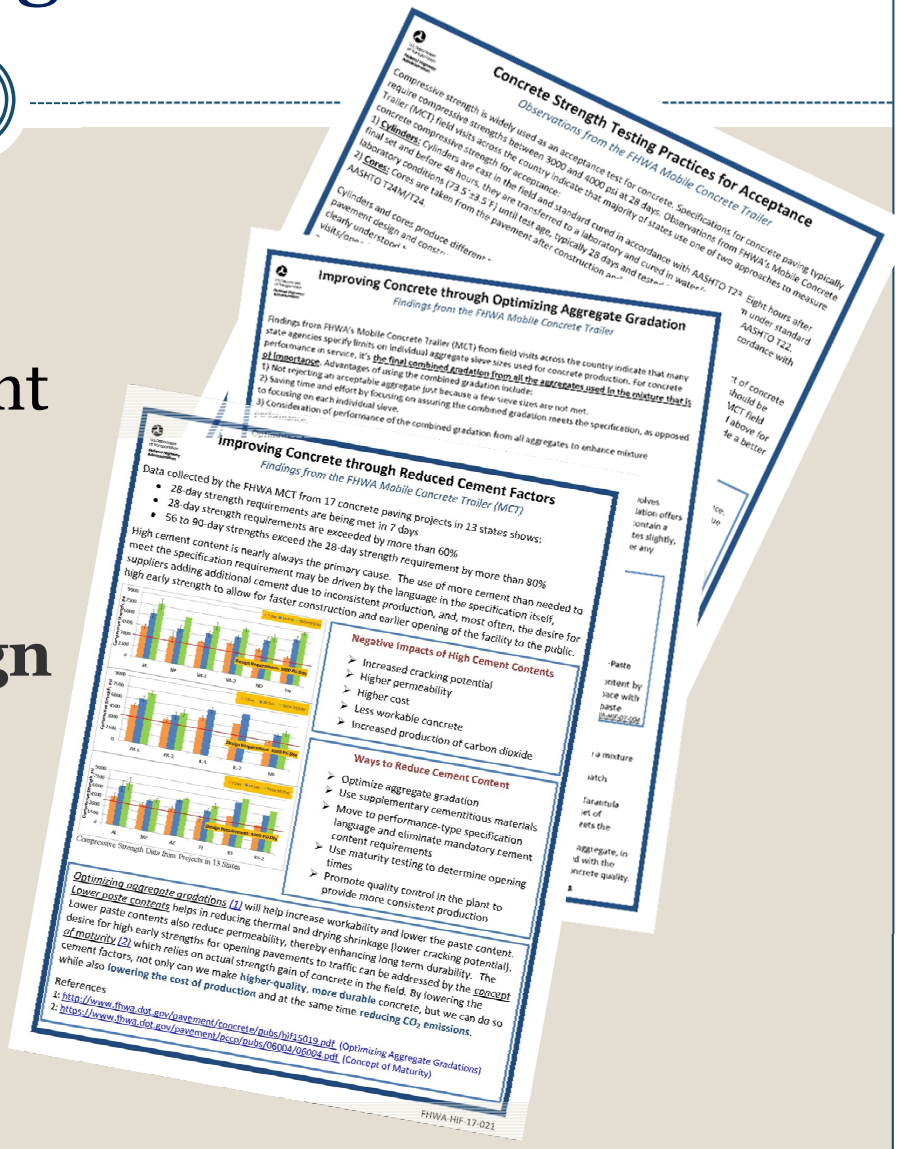
- States or industry can borrow MCT equipment
- MCT staff will provide training, if desired
- PEM/PP 84 focus
- New equipment purchase for Spring 2018
- Currently enhancing information on our website

Training

- One-on-one training to DOT engineers and technicians
- Side by side comparison of new technologies

One Pagers

- New effort to use MCT data
- Narrowly focused
- Meant to stir interest and point reader to resources
  - **1st : Cement Content**
  - **2nd: Optimized Mix Design**
  - **3rd : Cores vs. Cylinders**
  - **4th : NDT Pavement Thickness**
  - **5th: Tining**




END OF THE ROAD
MILE 92.5
DENALI NATIONAL
PARK AND PRESERVE

Questions?

- Contact info

Michael.Praul@dot.gov

207-512-4917