TPF-5(368) PERFORMANCE ENGINEERED CONCRETE PAVING MIXTURES (PEM)
TECHNICAL ADVISORY COMMITTEE CONFERENCE CALL

June 11, 2020
1:00PM Central Time
Meeting Minutes

Attendees:

State DOT Reps			**FHWA**	
Arkansas DOT	Jeffrey Covay		FHWA	Bob Conway
Arkansas DOT	Dorothy Rhodes		FHWA	Mike Praul
Arkansas DOT	Tammy Jernigan		FHWA Iowa Division	Lisa McDaniel
California DOT	David Lim			
Colorado DOT	Eric Prieve		**Research Team**	
Georgia DOT	Jason Waters		University of NC-Charlotte	Tara Cavalline
Idaho DOT	Craig Wielenga		Diversified Engr Services	Cecil Jones
Illinois DOT	James Krstulovich		NCE	Tom Van Dam
Iowa DOT	Todd Hanson		Oklahoma State University	Tyler Ley
Kansas DOT	Dave Meggers		Oregon State University	Jason Weiss
Maine DOT	Richard Bradbury		Snyder & Associates	Jerod Gross
Michigan DOT	John Staton		CP Tech Center	Hamed Sadati
Minnesota DOT	Rob Golish		CP Tech Center	Gordon Smith
Minnesota DOT	Maria Masten		CP Tech Center	Peter Smith
New York DOT	Patrick Galarza		CP Tech Center	Sharon Prochnow
North Carolina DOT	Brian Hunter			
Ohio DOT	Dan Miller		**Guest**	
Pennsylvania DOT	Patricia Baer		Behnke Materials Engr.	Signe Reichelt
South Dakota DOT	Darin Hodges			
Tennessee DOT	Michael Mellons			
Wisconsin DOT	James Parry			

PEM UPDATE

Peter Taylor:

1. Implementation
    - Are we making a difference? We've had one-on-one calls with 19 states and tabulated some of the ways PEM is making a difference. There is a lot of interest in the testing with some states trying some of them, some making changes, while others some have not thought about the tests. Strength - many states have spec in place regarding strength. The numbers of states interested in change is growing. We will continue to update this matrix.
    - Workshops are available to all 19 pooled fund states - 8 states were run prior to Covid shutdown.
    - Field trips to demonstrate test methods are available – please get in touch with CP Tech and schedule time
    - Spec support is also available from CP Tech Center
    - PEM presentations have been done at local meetings; no one has requested the executive briefing.

2. Monitoring
    - Database has been set up and data entry form for shadow projects has been completed

- Mining LTPP database in underway; Jason is recreating old concrete using LTPP materials inventory
- Have been updating AASHTO annually

3. Test methods
   - Tyler - Box test is getting good feedback
   - Jason – transport and thermodynamic moving forward and getting good results

THE FUTURE:

- Will there be a need for another pooled fund in the future? The research team's goal is still supporting the states as PEM moves forward.
- There is still a need for discussion regarding mix variables, construction variables, and affected properties

FHWA UPDATE

Mike Praul:

- At a stakeholder feedback session last fall, FHWA heard concerns from states and industry regarding the PRS program and is currently re-assessing the program.
- The PEM pooled fund is not developing models or tools for practitioners related to PRS. Any models being developed are being used to validate and improve tests.
- PEM is providing new tests to practitioners that have been validated by models. PRS provides performance models that have been validated by tests.
- Jason Weiss continues to need samples for the PEM testing protocols.
- The FHWA trailer cannot commit to any in person contact this year. A new product the MCTC is focusing on is training and conducting technician-level webinars for individual states. From among the list of all tests available on the MCTC, states can choose which to have explained and demonstrated to their staff. FHWA envisions these being 1-hour webinars, states may request multiple webinars, and these will be available upon request. Please contact Mike if you are interested in a webinar for your state.
- The FHWA MCTC equipment loan program is still available.
- QC tools to support the PEM effort are being produced under the CP Tech Center's cooperative agreement. A preliminary report was submitted to FHWA and it looks great, should be available this fall. The report will set the bar for a QC program. It will be shared with this TAC for review and comment, likely in late summer/early fall.

DATA DISCUSSION

Gordon Smith:

- Shadow testing data has been received from 4 states
- Tom Van Dam, Lisa and Jerod have been analyzing the shadow test data.

Jerod Gross:

- Visit the PEM page of the CP Tech website: www.cptechcenter/PEM
- Working with states to get their data from the shadow projects
- Data entry spreadsheet is on the PEM website to download and input states data
- Website also includes project reports from 2018-2019 projects (Iowa, South Dakota, Minnesota and North Carolina)
- The more information the better for the data entry form.
- Sampling should have identifiers such as batch number and station location

- We are looking to modify the data entry spreadsheet to include latitude and longitude coordinates

Lisa McDaniel:

- Numerous spreadsheets are shown in the PowerPoint presentation. Box & whisker plots show the beginnings of what could be available; more information from more projects is needed to do analysis.
- Information was gleaned from the project info, fresh properties and the hardened properties
- Made some plots from the information to see what we have and where we can go from here
- States looked at their unit weight, but we only received information from 4 states; looking to get more information
- States need to decide what they want, work with Jerod or Tom to get the information to us
- We are getting data; as we get more we can get more correlation with other test results.

Tom Van Dam:

- Shadow projects are the reason we collect data. States are doing their normal testing; we are shadowing what you are doing and collecting data for some of the tests to see what would be useful to states.
- The data will tell a lot about the value of the parts of the project; if we have location information we can retrace the location and be able to address a problem. This would also help calibrate tests in the field while the concrete is fresh to tell us if conditions are good or bad for paving.
- Take the time to input location and stations for the data information on the project
- Looking at LTPP projects that have been in place for many years and we can run tests and see how they are performing now
- Looking to track the project and develop some models; use the data to calibrate it to a test that can done on fresh concrete. Is there a potential problem that can be mitigated early? Looking to answer some of the questions the TAC has been asking.
- Will look at the data form to improve it and include Tyler's algorithm

NORTH CAROLINA EXPERIENCE

Tara Cavalline:

- North Carolina shared their project strategy on their 2018-2019 project.
- They are getting information out to the region to help them with their projects
- Workability linked to performance was a finding from the data analysis
- Working on development specs for surface resistivity, shrinkage and early age strength
- Contractor was very engaged on doing testing and sharing the information
- Held an open house with CP Tech Center and shared technology information
- Planning to move to virtual delivery of technology for division and regional personnel

PP84 UPDATE

Cecil Jones:

- AASHTO has the ballot out now for several of the PEM standards.
- Most of the PEM standards are now fairly stable and we should consider moving them towards full standards.
- Any negatives and comments will be addressed at the virtual COMP meeting in July and August
- Brian Egan intends to set up another task group to address issues related to T 358.
- We are exploring options with Brian about the development of a standard device that can be used to verify the various instruments currently in use for measuring resistivity. Technology subcommittee has ballot out for 8 provisions, 4 of them regarding PEM process

<u>Jason Weiss:</u>

- Request for information form for sampling and testing items
- Want to make sure we are testing to establish a reference point
- Gather data using the test standards use it to establish if we get same answer from the neighbors, are we running the test right to get the right answer.
- Help evaluate the properties that are typical for the state to see where they are in the process
- Develop a simple device to correct the values of the testing
- We need to estimate the properties of concrete when challenges arise
- Using data obtained from tests to develop predictive approaches. Specifically utilizing the thermodynamic modeling to develop data for transport and water content tasks
- Minnesota mixtures show very low calcium oxychloride. This is attributed to the use of SCM

TRAINING

<u>Gordon Smith:</u>

- Summarized where training has taken place; 7 states have not requested training
- Will see if TAC would like to have another call to discuss the strategy for future training
- Notes & presentation slides will be sent to the TAC. (Please note that we have not included Lisa McDaniel's raw data due to the size of the files. If you would like to have that information, please let Gordon or Jerod know. We would also remind/encourage the states to share their test data at your earliest convenience so we can further focus on what the numbers are telling us. Contact Jerod Gross or Tom Van Dam if you have any questions.

<u>Notes in the chat column:</u>

- Maria asked about adding Tyler's algorithm into the data entry spreadsheet. Jerod asked Tom if this is possible and we agreed to look into adding the capability
- Maria asked about whether we keep erroneous data. Research team responded with yes but data that we know is erroneous should be marked accordingly.
- Maria: Need to find equivalent performance of mixtures without fly ash, in case of "what if scenario"
- Eric P: asked about how slag performs with oxychloride. Jason will respond to Eric after the call.
- Mike stipulated that he is not "anti-model". He is against using models to determine acceptability and pay factors at the project level.

PEM TPF Status

Iowa State University
Institute for Transportation

National Concrete Pavement Technology Center
Tech Center

Vision

- A better way of specifying concrete
  - Choose what matters
    - Six critical properties
  - Find tools to measure them
  - Choose appropriate limits
  - Measure them at the right time
    - Prequalification
    - QC
    - Acceptance

Planned Work

- 1. Implementation
  - Workshops to train in the basics of the program, 1 per state
  - Field trips to demonstrate test methods, 1 per state
  - Webinars
  - Spec support
  - Test support
    - New procedures to AASHTO
    - NC2 demo – One off
    - Guidance documents
    - Regional demos
    - On call by phone

Planned Work

- 1. Implementation
  - Workshops to train in the basics of the program, 1 per state
    - 8 completed
  - Field trips to demonstrate test methods, 1 per state
    - 8 completed (CO, IA, MN, SD, IL, KS, NC, CA)
  - Webinars – annual updates
  - Spec support – On-call
  - Test support
    - New procedures to AASHTO
    - NC2 demo – One off - Completed
    - Guidance documents – On line
    - Regional demos – No demand
    - On call by phone
  - PEM presentations at local and national meetings

Planned Work

- 2. Monitoring
  - Set up database
  - Collect, collate and publish field data
  - Mine LTPP database
  - Update at AASHTO

Planned Work

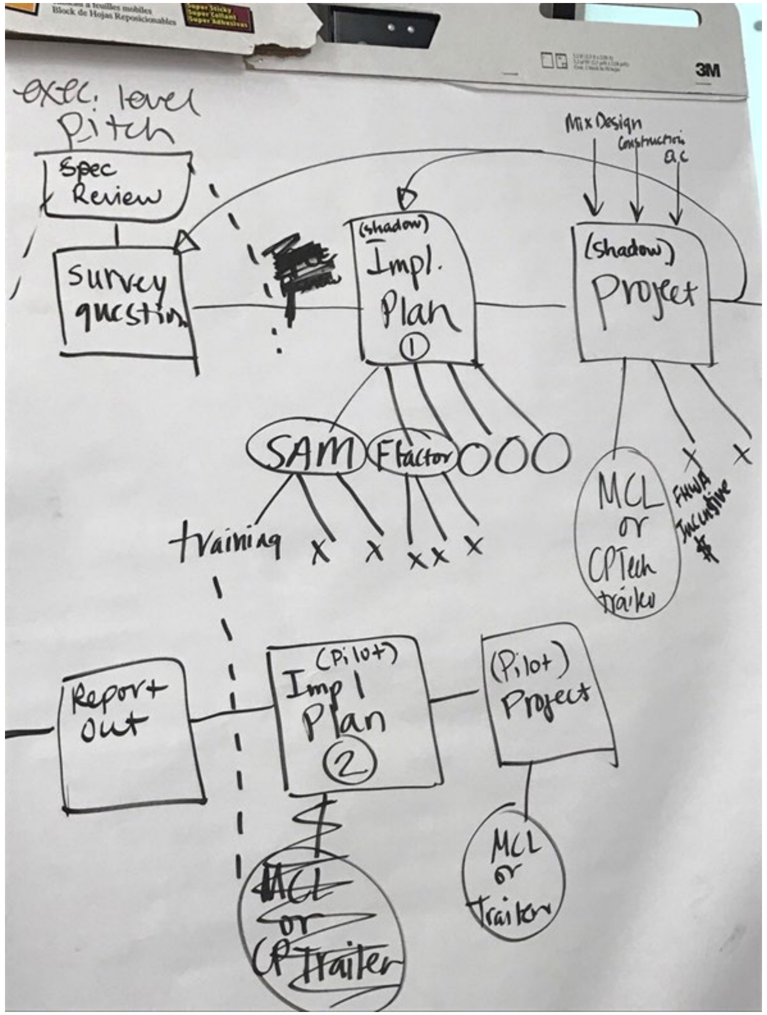
- 2. Monitoring
  - Set up database - complete
  - Collect, collate and publish field data – data received from 7 states
  - Mine LTPP database – Underway
  - Update at AASHTO - Annual

Planned Work

- 3. Test methods
  - Transport
  - Thermodynamics
  - Water movement
  - Water content
  - Constructability

Implementation

- DOT Executive briefing
- Specification review
- Workshop for DOT office staff
- Construction – demonstrate tests, collect data, train field staff
- Review data and report findings
- Ongoing data collection
- Data processing and storage
- Ongoing specification support
- Pilot project (future)



Implementation

- DOT Executive briefing – no-one has expressed interest
- Specification review – 19 calls completed
- Workshop for DOT office staff - slide set is ready – considering aiming at non p/f states
- Construction – demonstrate tests, collect data, train field staff
  - Been to 8 states
- Review data and report findings - 4 state reports received
- Ongoing data collection - ongoing
- Data processing and storage - ongoing
- Ongoing specification support - ongoing
- Pilot project (future) - later

Implementation

	Not a problem in our state	Haven't thought about it	A good spec already in place	Some interest	Considering change	Adopted change
Transport	1	3	3	8	3	1
Freeze thaw	2	2		10	5	
Oxychloride		15		3	1	
Aggregates	2	1	16			
Strength			19			
Shrinkage		11	3	1	3	1
Workability		4	6	6	1	2

The Future

Activity	PEM TPF-5(368) (Oct. '17-Oct. '22)	PEM Future TPF (Oct.'22-Oct. ' 27)	FHWA Cooperative Agreement (2019-2023)
Overall Objective	Technical support thru shadow projects, move PP-84 to standard, performance monitoring, test development (focus is mixtures)	Continue performance monitoring, refining testing limits, technical support thru shadow projects for new SHAs (focus is mixtures)	Technical support for pilot projects and integration of PEM mixtures into SHAs standard specifications (focus is construction specifications)
PEM TAC	X	X	
Technical Training for SHA & Industry	X	X	
Technical Assistance for SHA & Industry	X	X	
Specification refinement	X		
Performance Monitoring	X	X	
Test refinement	X	X	
Develop framework for PEM for Structures	X		
Develop PEM for Structures AASHTO Guide Specification		X	
QA for SHA & Contractor			X
Development of model Construction Specification special provision for use with pilot projects			X
Percision & Bias Statements			X
Proficiency Training			X
Technical Assistance			X
Set up Executive Task Group to Coordinate National Activites			X

Thinking about construction effects

- **Mixture variables**
  - Cement content
  - SCM Dose
  - w/cm
- **Construction variables**
  - Pumping
  - Vibration
  - Mixture Adjustments
  - Time
  - Temperature
  - Curing
- **Affected Properties**
  - Air void system
  - Segregation
  - Water movement
  - Bleeding
  - Maturity
  - Surface quality

Performance-Engineered Mixture ×

cptechcenter.org/performance-engineered-mixtures-pem/

IOWA STATE UNIVERSITY
Institute for Transportation

Search CP Tech Center

ABOUT · NEWS · EVENTS · RESOURCES · RESEARCH · PUBLICATIONS · NC² · CONTACT

CP Tech Center

National Concrete Pavement Technology Center

CP Tech Center

CP TECH CENTER | PERFORMANCE-ENGINEERED MIXTURES (PEM)

cptechcenter.org/pem

Performance-Engineered Mixtures (PEM)

We have traditionally accepted concrete based on measurements like strength, slump, and air. These measurements, in their current form, have very limited correlation to future performance. However, recent developments in concrete testing technologies have yielded methods that are better predictors of long-term performance.

It is the goal of the PEM Transportation Pooled Fund (TPF) project to bring these newer technologies to state agencies and to assist states in adoption of the test methods that will help them deliver on the promise of concrete durability.The Federal Highway Administration (FHWA), 19 state departments of transportation, and 4 national associations representing the concrete paving industry have come together to fund this project. It is a coalition of federal, state, and industry leaders dedicated to maximizing pavement performance.

ABOUT THE PEM PROJECT

The PEM project is broken down into the following:

- **Implementing what we know:** This task is intended to provide support to study participants with implementation of performance engineered paving mixtures within their states. Implementation will include education, training, and project-level support.
- **Performance monitoring and specification refinement:** This task will provide field performance data for use in making decisions on specification limits in the areas of salt damage, transport, and freeze-thaw damage.
- **Measuring and relating early-age concrete properties to performance:** This task will build upon the foundational work done to date in measurement technologies to design and control concrete pavement mixtures around key engineering properties. It is planned that work under this task will address improved testing methods for improved accuracy and reduced cost.

JOIN THE PEM PROJECT

The work called for in the PEM project is both revolutionary and significant. The goal is to have FHWA, states, and industry each contribute one-third of the investment needed for this project. Join Transportation Pooled Fund TPF-5(368) to ensure better and longer-lasting concrete pavements.

STATE DOT DATA ENTRY

State transportation agencies that are participating in the pooled fund for this project will have a spreadsheet to assist in data entry. The form is currently placed here for review by participating state agencies. Please send review comments to Gordon Smith at glsmith@iastate.edu.

Download the data entry form. XLSX

SCHEDULE OF SHADOW PROJECTS

States anticipated to host the Mobile Concrete ce-Engineered Mixture

cptechcenter.org/performance-engineered-mixtures-pem/

- Formation Factor (with AASHTO TP 119-15) Test Summary PDF and Surface Resistivity: Conditioning and Summary (PDF)
- Resistivity Data Calculation Template Guidance (PDF)
- Resistivity Data Calculation Template (XLSX)

Additional Related Videos

- Oregon State University's Performance-Engineered Concrete Mixtures Recorded Video Series
- Tyler Ley's YouTube Channel

PEM PROJECT INFO

News

- PEM Newsletter (November 2019)
- PEM Newsletter (June 2019)

Overviews

- Performance-Engineered Concrete Paving Mixtures (PEM): Delivering Concrete to Survive the Environment (Slides–June 2018)
- Developing a Quality Assurance Program for Implementing Performance-Engineered Mixtures for Concrete Pavements (MAP Brief–July 2017)
- Performance-Engineered Mixtures (PEM) for Concrete Pavements (MAP Brief–April 2017)
- Performance-Engineered Mixtures Program Overview (Brochure–2017)

Shadow Project Reports

- South Dakota DOT PEM Demonstration Project Report (August 2019)
- Iowa DOT PEM Demonstration Project Report (June 2019)
- Minnesota DOT PEM Demonstration Project Report (April 2020)
- North Carolina DOT PEM Demonstration Project Report (May 2020)

PEM PROJECT SPONSORS

Federal Sponsor

- Federal Highway Administration, U.S. Department of Transportation

Data Entry Form

Performance Engineered Mixtures (PEM): Project Submission Forms

Basic Project Information

State:	South Dakota	
Route:	I 90 WB	
Begin Milepost:	153	
End Milepost:	163	
Road Classification:	Rural Interstate	
Project Latitude (begin):	43.842871	
Project Latitude (end):	43.851217	
Project Longitude (begin):	-101.254135	
Project Longitude (end):	-101.470727	
LTPP climatic region (if known):	Wet-Freeze	
Concrete Paving Begin Date:	9/29/2018	
Concrete Paving End Date:	11/23/2018	
Type of Structure:	Pavement	
Pavement Type:	JPCP	
Overlay Type:	Not an Overlay	
Construction Type:	Slip-form	
Lane Width:	14	feet

Pavement Drainage Information:

Material Type:		Layer Thickness:	
Layer 1	PCC	10.5	inch
Layer 2	Subbase	5	inch
Layer 3			inch
Layer 4			inch
Layer 5			inch

Subgrade Information:

AASHTO Soil Classification		
Design K-value		psi/in

State Data Entry Form V8.xlsx

Project Info

Data Entry Form

Performance Engineered Mixtures (PEM): Project Submission Forms

Concrete Mixture Properties

Mixture Designation: PCCP, Optimized

Mix Number: 1

Water content: 240 lb/yd^3

Volume of Paste: (%)

If PCC designed to follow standard specifications, year of specification:

Cements:

Cement 1: Specification: AASHTO M 85 Also specified under ASTM C150 Cement Type: Type I

Cement Type Suffix:

Content (lb/yd^3) 460 Alkali Content % Na_2O eq

Cement Source: GCC Dacotah Type I/II - Rapid City, SD

Cement 2: Specification: Cement Type:

Cement Type Suffix:

Content (lb/yd^3) Alkali Content % Na_2O eq

Cement Source:

Supplementary Cementitious Material (SCM):

SCM 1: Type Fly Ash F Content 115 lb/yd^3 Source Boral Resources

SCM Type-Other:

SCM 2: Type Content lb/yd^3 Source

SCM Type-Other:

SCM 3: Type Content lb/yd^3 Source

SCM Type-Other:

Chemical Admixtures:

Admixture 1:

Type:	Dosage	Manufacturer	Product Name
A-Water Reducer	17.3 oz/Cwt	GRT	Polychem Paver Plus

Admixture 2:

Type:	Dosage	Manufacturer	Product Name
Air Entrainment	4 oz/Cwt	GRT	Polychem VR

Admixture 3:

Type:	Dosage	Manufacturer	Product Name
	oz/Cwt		

Admixture 4:

Type:	Dosage	Manufacturer	Product Name

State Data Entry Form V8.xlsx

Mixture Properties

Performance Engineered Mixtures (PEM): Project Submission Forms

Concrete Mixture Properties

Mixture Designation:

Mix Number: 2

Water content: lb/yd^3

Volume of Paste: (%)

If PCC designed to follow standard specifications, year of specification: Class of Concrete:

Cements:

Cement 1: Specification: Cement Type:

Cement Type Suffix:

Content (lb/yd^3) Alkali Content % Na_2O eq

Cement Source:

Cement 2: Specification: Cement Type:

Cement Type Suffix:

Content (lb/yd^3) Alkali Content % Na_2O eq

Cement Source:

Supplementary Cementitious Material (SCM):

SCM 1: Type Content lb/yd^3 Source

SCM Type-Other:

SCM 2: Type Content lb/yd^3 Source

SCM Type-Other:

SCM 3: Type Content lb/yd^3 Source

SCM Type-Other:

Chemical Admixtures:

Admixture 1:

Type:	Dosage	Manufacturer	Product Name
	oz/Cwt		

Admixture 2:

Type:	Dosage	Manufacturer	Product Name
	oz/Cwt		

Admixture 3:

Type:	Dosage	Manufacturer	Product Name
	oz/Cwt		

Admixture 4:

Type:	Dosage	Manufacturer	Product Name

Project Info | Mixture Properties | Mix Qualification Tests | Fresh Properties | Hardened Properties | Other Relevant Info | Traffic | Weather | Comments

Data Entry Form

Performance Engineered Mixtures (PEM): Project Submission Forms

Concrete Mixture Properties

Mixture Designation: PCCP, Optimized

Mix Number: 1

Water content: 240 lb/yd^3

Volume of Paste: (%)

If PCC designed to follow standard specifications, year of specification:

Cements:

Cement 1: Specification: AASHTO M 85 Also specified under ASTM C150 Cement Type: Type I

Cement Type Suffix:

Content (lb/yd^3) 460 Alkali Content % Na_2O eq

Cement Source: GCC Dacotah Type I/II - Rapid City, SD

Cement 2: Specification: Cement Type:

Cement Type Suffix:

Content (lb/yd^3) Alkali Content % Na_2O eq

Cement Source:

Supplementary Cementitious Material (SCM):

SCM 1: Type Fly Ash F Content 115 lb/yd^3 Source Boral Resources

SCM Type-Other:

SCM 2: Type Content lb/yd^3 Source

SCM Type-Other:

SCM 3: Type Content lb/yd^3 Source

SCM Type-Other:

Chemical Admixtures:

Admixture 1:			
Type:	Dosage	Manufacturer	Product Name
A-Water Reducer	17.3 oz/Cwt	GRT	Polychem Paver Plus

Admixture 2:			
Type:	Dosage	Manufacturer	Product Name
Air Entrainment	4 oz/Cwt	GRT	Polychem VR

Admixture 3:			
Type:	Dosage	Manufacturer	Product Name
	oz/Cwt		

Admixture 4:			
Type:	Dosage	Manufacturer	Product Name

State Data Entry Form V8.xlsx

Mixture Properties

Performance Engineered Mixtures (PEM): Project Submission Forms

Concrete Mixture Properties

Mixture Designation:

Mix Number: 2

Water content: lb/yd^3

Volume of Paste: (%)

If PCC designed to follow standard specifications, year of specification: Class of Concrete:

Cements:

Cement 1: Specification: Cement Type:

Cement Type Suffix:

Content (lb/yd^3) Alkali Content % Na_2O eq

Cement Source:

Cement 2: Specification: Cement Type:

Cement Type Suffix:

Content (lb/yd^3) Alkali Content % Na_2O eq

Cement Source:

Supplementary Cementitious Material (SCM):

SCM 1: Type Content lb/yd^3 Source

SCM Type-Other:

SCM 2: Type Content lb/yd^3 Source

SCM Type-Other:

SCM 3: Type Content lb/yd^3 Source

SCM Type-Other:

Chemical Admixtures:

Admixture 1:			
Type:	Dosage	Manufacturer	Product Name
	oz/Cwt		

Admixture 2:			
Type:	Dosage	Manufacturer	Product Name
	oz/Cwt		

Admixture 3:			
Type:	Dosage	Manufacturer	Product Name
	oz/Cwt		

Admixture 4:			
Type:	Dosage	Manufacturer	Product Name

Project Info | Mixture Properties | Mix Qualification Tests | Fresh Properties | Hardened Properties | Other Relevant Info | Traffic | Weather | Comments

Data Entry Form

Performance Engineered Mixtures (PEM): Project Submission Forms
Concrete Qualification Tests

State Data Entry Form V8.xlsx

Mix Qualification

Mix Design # 1

Basic Mix Deisgn Properties:						
Unit Weight (AASHTO T 121)			143.3			
Slump (AASHTO T 119/ASTM C143)			2.5			
Concrete Strength (6.3):						
Compressive Strength (AASHTO T 22)	Age (days):	7	3887			psi
	Age (days):	14	4067			psi
	Age (days):	28	4840			psi
Flexural Strength (AASHTO T 97)	Age (days):					psi
	Age (days):					psi
	Age (days):					psi
Susceptibility to Slab Warping and Shrinkage Cracking (6.4):						
Unrestrained volume change @ 28 days (AASHTO T 160)						με
Unrestrained volume change @ 91 days (AASHTO T 160)						με
Coefficient of thermal expansion (AASHTO T 366)						(10^{-6}/°C)
Requirements for Freeze-Thaw Durability (6.5):						
Air Content	Method used:	AASHTO T 152	6.6			percent
Super Air Meter (AASHTO TP 118)	Pressure Step 1 Reading:					(unitless)
	Pressure Step 2 Reading:					(unitless)
	Pressure Step 3 Reading:					(unitless)
	Pressure Step 4 Reading:					(unitless)
	Pressure Step 5 Reading:					(unitless)
	Pressure Step 6 Reading:					(unitless)
Time of critical saturation (ASTM C1585)						Years
Secondary rate of absorption of water (Task 1.7)	Rate:					g/root-s
	Correlation Coeffecient:					
Total Pore Volume (Task 1.6a)	Permeable pore volume:					(%)
Calcium oxychloride limit (AASHTO T 365)						g CaOXY/g paste
Parameters of Air-Void System in Hardened Concrete	Spacing Factor:					inch
	Specific Surface:					$inch^2/inch^3$
	Air Content:					(%)
Transport Properties (6.6):						
Formation factor (AASHTO T 358 or AASHTO TP 119)						
	Method of determining pore solution resistivity:					
	Formation Factor:					(unitless)

Project Info | Mixture Properties | **Mix Qualification Tests** | Fresh Properties | Hardened Properties | Other Relevant Info | Traffic | Weather | Comments

Data Entry Form

Performance Engineered Mixtures (PEM): Project Submission Forms

Properties of Fresh Concrete during Production (Tabular data where several test results are available)

Property	Test Date	Test Time	Station	Batch Number	Test Results	Test Units	Super Air Meter Pressure Step Readings (if available)					
							Pressure Step 1	Pressure Step 2	Pressure Step 3	Pressure Step 4	Pressure Step 5	Pressure Step 6
Air Content	9/29/2018	4:30 PM	234+40		5.9	percent						
	10/1/2018	11:10 AM	224+40		6.6	percent						
	10/3/2018	8:40 AM	204+00		5.5	percent						
	10/6/2018	9:55 AM	186+00		5.7	percent						
	10/16/2018	9:25 AM	160+60		7.4	percent						
	10/18/2018	12:25 PM	236+50		5.8	percent						
	10/21/2018	12:55 PM	155+40		6.4	percent						
	10/21/2018	2:45 PM	150+80		6.6	percent						
	10/22/2018	9:50 AM	132+80		6.4	percent						
	10/23/2018	9:35 AM	108+00		7	percent						
	10/24/2018	9:30 AM	88+60		7	percent						
	10/26/2018	7:05 AM	78+60		7.4	percent						
	10/27/2018	9:30 AM	56+80		6.1	percent						
	10/28/2018	11:45 AM	21+20		7	percent						
	10/29/2018	1:45 PM	893+60		7.1	percent						
	10/30/2018	11:25 AM	870+40		5.7	percent						
	10/31/2018	12:20 PM	838+80		6.5	percent						
	11/1/2018	1:55 PM	808+00		7.1	percent						
	11/2/2018	9:35 AM	794+40		6.1	percent						
	11/4/2018	11:50 AM	763+60		7	percent						
	11/5/2018	11:15 AM	730+80		6	percent						
	11/14/2018	4:00 PM	697+20		7.5	percent						
	11/15/2018	12:10 PM	682+00		6.6	percent						
	11/16/2018	11:20 AM	670+40		6.6	percent						
	11/20/2018	1:15 PM	634+20		7.2	percent						
	11/21/2018	3:00 PM	600+80		7.8	percent						
	11/23/2018	1:25 PM	572+40		7.2	percent						
SAM	9/29/2018	4:30 PM	234+40		0.19	unitless						
	10/1/2018	11:10 AM	224+40		0.09	unitless						
	10/3/2018	8:40 AM	204+00		0.18	unitless						
	10/6/2018	9:55 AM	186+00		0.41	unitless						
	10/16/2018	9:25 AM	160+60		0.23	unitless						
	10/18/2018	12:25 PM	236+50		0.23	unitless						
	10/21/2018	12:55 PM	155+40		0.34	unitless						
	10/21/2018	2:45 PM	150+80		0.1	unitless						
	10/22/2018	9:50 AM	132+80		0.19	unitless						
	10/23/2018	9:35 AM	108+00		0.25	unitless						
	10/24/2018	9:30 AM	88+60		0.32	unitless						
	10/26/2018	7:05 AM	78+60		0.32	unitless						
	10/27/2018	9:30 AM	56+80		0.1	unitless						

Fresh Properties where individual test results not available, but average values are.

Test Name	Test Method	Average Value	St. Dev.	Number of Tests Performed	Test Result Units
Air Content	AASHTO T 152	6.6	0.628274896	27	percent
SAM	AASHTO TP 118	0.2	0.096815734	32	unitless
Unit Weight		144.5	1.174345911	27	pcf
slump		1.4	0.349246238	27	inches
Vkelly	AASHTO TP 129	0.485		2	in./ root-s
icrowave w/cm		0.404		1	unitless

State Data Entry Form V8.xlsx

Fresh Properties

Data Entry Form

Performance Engineered Mixtures (PEM): Project Submission Forms

Properties of Hardened Concrete during Production (Tabular data where multiple test results are available)

Property	Cast Date	Batch Number	Station	Test Date	Sample Age (days)	Test Result	Test Result Units	
Surface Resistivity (Resistivity Value-sample prep option A: immersion in CaOH solution)	10/18/2018	024S		10/25/2018	7	10.0	KΩ-cm	
	10/18/2018	024SB		10/25/2018	7	9.9	KΩ-cm	
	10/22/2018	026S		10/29/2018	7	10.7	KΩ-cm	
	10/22/2018	026SB		10/29/2018	7	11.6	KΩ-cm	
	10/23/2018	037S		10/30/2018	7	8.9	KΩ-cm	
	10/23/2018	037SB		10/30/2018	7	8.6	KΩ-cm	
	10/24/2018	042S		10/31/2018	7	10.7	KΩ-cm	
	10/24/2018	042SB		10/31/2018	7	10.2	KΩ-cm	
	10/29/2018	057S		11/5/2018	7	10.5	KΩ-cm	
	10/29/2018	057SB		11/5/2018	7	9.9	KΩ-cm	
	10/29/2018	063S		11/5/2018	7	9.7	KΩ-cm	
	10/29/2018	063SB		11/5/2018	7	9.1	KΩ-cm	
	10/31/2018	073S		11/7/2018	7	9.2	KΩ-cm	
	10/31/2018	073SB		11/7/2018	7	9.6	KΩ-cm	
	11/1/2018	078S		11/8/2018	7	8.3	KΩ-cm	
	11/1/2018	078SB		11/8/2018	7	8.0	KΩ-cm	
	11/14/2018	098S		11/21/2018	7	10.2	KΩ-cm	
	11/14/2018	098SB		11/21/2018	7	9.6	KΩ-cm	
	11/15/2018	101S		11/22/2018	7	9.5	KΩ-cm	
	11/15/2018	101SB		11/22/2018	7	10.1	KΩ-cm	
	11/16/2018	104S		11/23/2018	7	9.2	KΩ-cm	
	11/16/2018	104SB		11/23/2018	7	8.8	KΩ-cm	
	11/20/2018	111S		11/27/2018	7	9.5	KΩ-cm	
	11/20/2018	111SB		11/27/2018	7	10.1	KΩ-cm	
	11/21/2018	117S		11/28/2018	7	9.9	KΩ-cm	
	11/21/2018	117SB		11/28/2018	7	10.0	KΩ-cm	
	11/23/2018	123S		11/30/2018	7	11.3	KΩ-cm	
	11/23/2018	123SB		11/30/2018	7	11.3	KΩ-cm	9.8
Surface Resistivity (Resistivity Value-sample prep option A: immersion in CaOH solution)	10/5/2018	014S		10/19/2018	14	10.0	KΩ-cm	
	10/5/2018	014SB		10/19/2018	14	9.5	KΩ-cm	
	10/16/2018	019S		10/30/2018	14	9.8	KΩ-cm	
	10/16/2018	019SB		10/30/2018	14	9.5	KΩ-cm	
	10/18/2018	024S		11/1/2018	14	11.5	KΩ-cm	
	10/18/2018	024SB		11/1/2018	14	11.3	KΩ-cm	
	10/22/2018	026S		11/5/2018	14	11.5	KΩ-cm	
	10/22/2018	026SB		11/5/2018	14	11.0	KΩ-cm	
	10/22/2018	031S		11/5/2018	14	11.1	KΩ-cm	
	10/22/2018	031SB		11/5/2018	14	10.6	KΩ-cm	
	10/23/2018	037S		11/6/2018	14	9.7	KΩ-cm	
	10/23/2018	037SB		11/6/2018	14	10.7	KΩ-cm	
	10/24/2018	042S		11/7/2018	14	11.5	KΩ-cm	
	10/25/2018	042SB		11/8/2018	14	12.6	KΩ-cm	
	10/26/2018	045S		11/9/2018	14	13.1	KΩ-cm	
	10/26/2018	045SB		11/9/2018	14	13.4	KΩ-cm	
	10/27/2018	050S		11/10/2018	14	9.2	KΩ-cm	
	10/27/2018	050SB		11/10/2018	14	10.7	KΩ-cm	
	10/28/2018	057S		11/11/2018	14	9.9	KΩ-cm	
	10/28/2018	057SB		11/11/2018	14	9.2	KΩ-cm	
	10/29/2018	063S		11/12/2018	14	9.5	KΩ-cm	
	10/29/2018	063SB		11/12/2018	14	9.8	KΩ-cm	
	10/30/2018	067S		11/13/2018	14	10.5	KΩ-cm	

Project Info | Mixture Properties | Mix Qualification Tests | Fresh Properties | Hardened Properties | Other Relevant Info | Traffic | Weather | Comments

State Data Entry Form V8.xlsx

Hardened Properties

Data Collection

Project Information / State	A	B	C	D	E	F	G	H	I	J
Route	x	x	x	x	x	x	x	x		
Begin Milepost	x	x		x				x		
End Milepost	x	x		x				x		
Road Classification	x	x	x	x	x			x		
Project Latitude (begin)	x	x		x				x		
Project Latitude (end)	x	x		x				x		
Project Longitude (begin)		x		x				x		
Project Longitude (end)		x		x				x		
Paving Begin Date	x	x		x				x		
Paving End Date	x	x		x	x			x		
LTPP Climatic Region (if known)		x	x	x	x			x		
Type of Structure	x	x	x	x	x			x		
Pavement/Overlay Type	x	x	x	x	x			x		
Construction Type	x	x	x	x	x			x		
Lane Width	x	x	x	x	x			x		
Material Type	x	x	x	x	x			x		
Layer Thickness	x	x	x	x	x			x		
AASHTO Soil Classification	x	x								

Mix Design Information / State	A	B	C	D	E	F	G	H	I	J
Mixture Proportions	x	x	x	x	x			x		x
Cementitious Materials Data	x	x	x	x	x			x		
Aggregate Data	x	x	x	x	x			x		
Admixture Data	x	x	x	x	x			x		

Data Collection

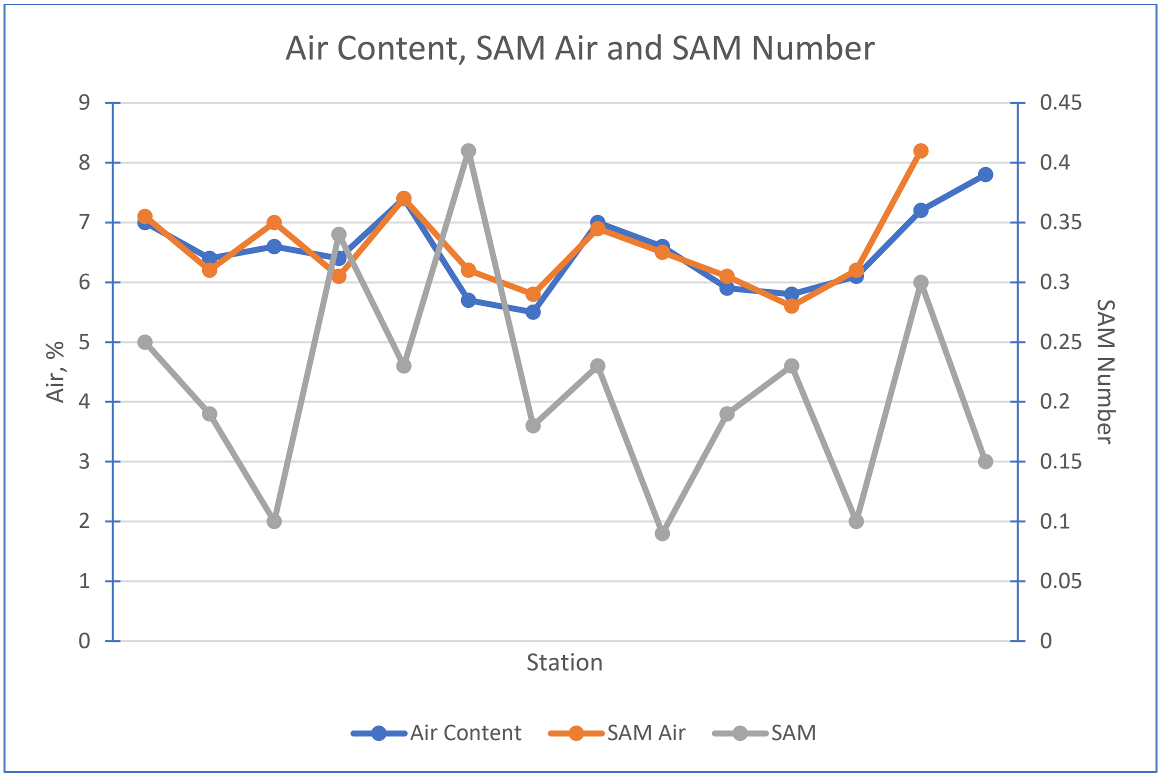
Mix Qualification / State	A	B	C	D	E	F	G	H	I	J
Unit weight	x	x	x	x	x			x		
Slump	x	x			x			x		
Copressive Strength	x	x	x		x			x		
Flexural Strength		x			x					
Shrinkage										
CTE										
Air Content	x	x	x	x				x		
SAM		x								
SAM Pressure Steps										
Sorptivity										
RCPT										
Total Pore Volum										
Oxychloride Potential										
Hardened Airvoid Syatem		x								
F-Factor		x								
Resistivity	x	x								
Aggregate D-Cracking										
ASR										
Workability, BOX		x		x				x		
Workability, Vkelly		x								

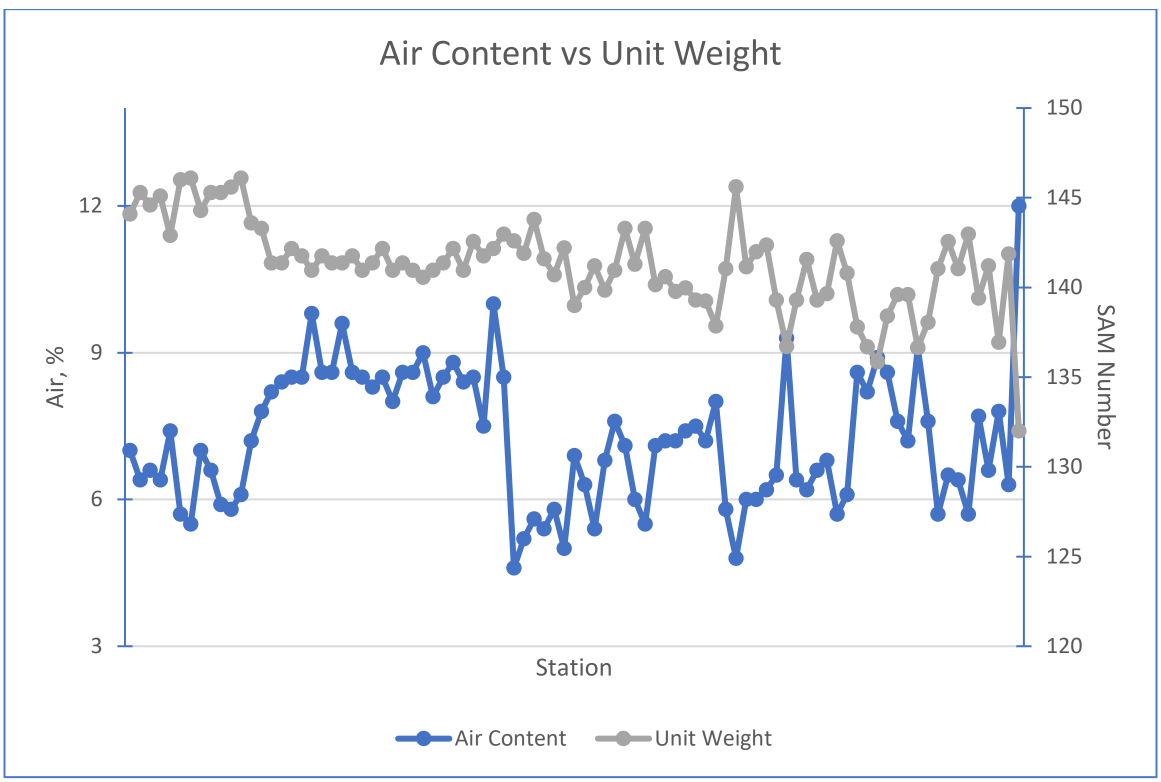
Fresh Properties / State	A	B	C	D	E	F	G	H	I	J
Station	x	x		x		x		x		
Test Date/Time	x	x	x	x	x	x	x	x		
Batch Number	?		x	x	x					
Unit weight	x		x	x				x	x	
Slump	x		x		x	x		x	x	
Air Content	x	x	x	x	x	x	x	x	x	x
SAM	x	x	x	x	x	x	x	x	x	x
SAM Pressure Steps	x	x	x							
Concrete Temperature	x	x	x		x	x	x	x		
Microwave w/cm								x		
Box				x				x		
Vkelly	x (only 1)							x		

Data Collection

Hardened Properties / State	A	B	C	D	E	F	G	H	I	J
Station	x	x								
Test Date/Time	x	x		x	x		x	x		
Batch Number	x	x (mix #)	x				x	x		
Maturity		x								
Compressive Strength					x			x	x	
Flexural Strength		x			x				x	
Unrestrained Shrinkage										
CTE										
Oxychloride				x						
Hardened Air Void	x			x			x	x		x
Formation Factor	x									
Resistivity	x		x	x	x	x	x	x		
F/T								x		
Sorptivity								x		
RCPT	x									

Other Information / State	A	B	C	D	E	F	G	H	I	J
Drainage Information	x	x								
Joint Details	x	x								
Dowel Bar Information	x	x								
De-Icer Information										
Traffic Data	x	x								
Wethear Data		x								
Comments										


Air Content, SAM Air and SAM Number
Air, %
SAM Number
Station
0
1
2
3
4
5
6
7
8
9
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Air Content
SAM Air
SAM


Air Content vs Unit Weight
Air, %
SAM Number
Station
3
6
9
12
120
125
130
135
140
145
150
Air Content
Unit Weight

Movement Towards PEM:
North Carolina DOT’s Approaches and Accomplishments

Tara Cavalline, Brett Tempest, Brian Hunter

PEM State Agency Members Meeting

June 11, 2020

UNC CHARLOTTE

Background

- NCDOT specifications for concrete have changed little over the past 85 years
  - Prescriptive specification
  - Little room for innovation
  - Over designed
- Resource reductions drive the need to reduce maintenance cost , increase service life
- Desire fly ash in most of our mixes because of the benefits
  - Encounter fly ash shortage throughout the years
  - Need to find equivalent performance of mixtures without fly ash (in case of “what if” scenario)
- Recently (2018) increased allowable fly ash substitution rate from 20% to 30%
  - Needed data to support/encourage use of higher substitution rate, account for slower early age strength gain
- Need data to support decision to allow use of portland limestone cement

UNC CHARLOTTE

Overall Objectives

1. Establish preliminary specification recommendations, targets for selected PEM technologies and some prescriptive provisions
   - surface resistivity
   - w/cm, cementitious content (prescriptive provisions)
   - shrinkage
   - SAM
   - potentially other tests

2. Explore ways to reduce paste/cement contents
   - optimized aggregate gradation
   - reduced cementitious contents

3. Support pilot project implementation
   - pavement projects
   - bridge projects
   - bridge deck overlay projects

4. Support technology transfer to NCDOT division/regional personnel as well as industry stakeholders

UNC CHARLOTTE

NCDOT PEM efforts so far...

- Participation in Pooled Fund

- Two internally funded projects
  - RP 2018-14 (August 2017 - December 2019)
    "Durable and Sustainable Concrete Through Performance Engineered Concrete Mixtures."
  - RP 2020-13 (August 2019 - July 2021)
    "*Continuing Towards* Durable and Sustainable Concrete Through Performance Engineered Concrete Mixtures."

- FHWA Implementation Funds

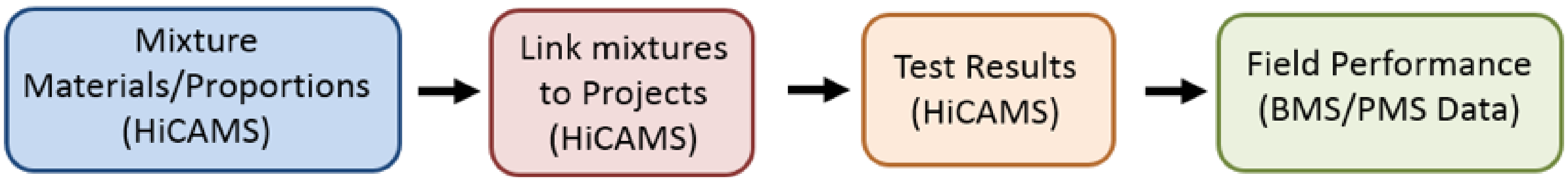
  Category A: Incorporating two or more AASHTO PP 84-17 tests in the mix design/approval process. Shadow testing is acceptable.
  Category B: **I**ncorporating one or more AASHTO PP 84-17 test in the acceptance process. Shadow testing is acceptable.
  Category D: **R**equiring the use of control charts, as called for in AASHTO PP 84-17.

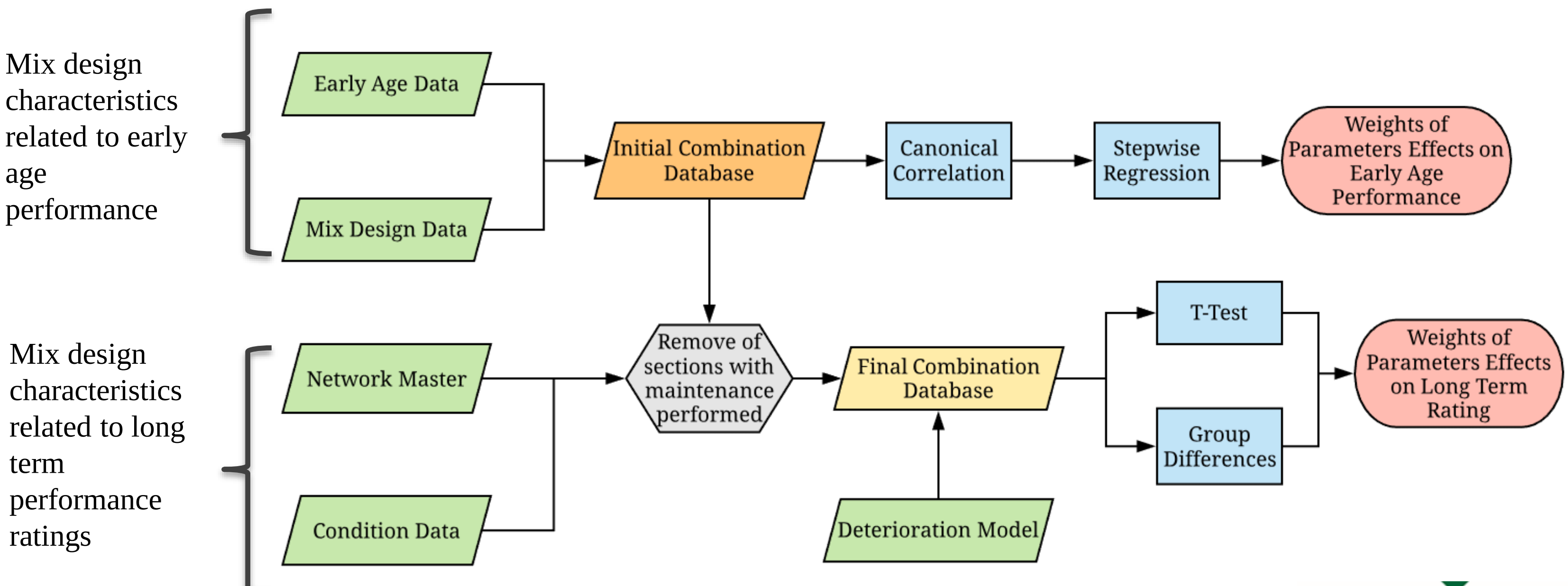
  - RP 2019-41 "Performance Engineered Concrete Mixtures – FHWA Implementation Funds" – technology transfer activities

UNC CHARLOTTE

RP 2018-14 Project Objectives

1) Utilize existing data on concrete materials, mixtures, and field performance, to identify trends in materials and proportions, and link to unacceptable, acceptable, and excellent performance.





UNC CHARLOTTE

RP 2018-14
Project Objectives

2) Perform laboratory testing of a broad matrix of conventional highway concrete mixtures, to establish performance-related criteria for selected tests + evaluate some existing prescriptive provisions:
   - Range of w/cm, range of cementitious materials contents
   - Representative materials for Piedmont region
   - Consistency in materials from previous studies to leverage data already obtained

3) Produce additional performance data on concrete containing PLC and fly ash to support a better understanding the potential enhanced durability and economy of these mixtures and provide additional justification for use.

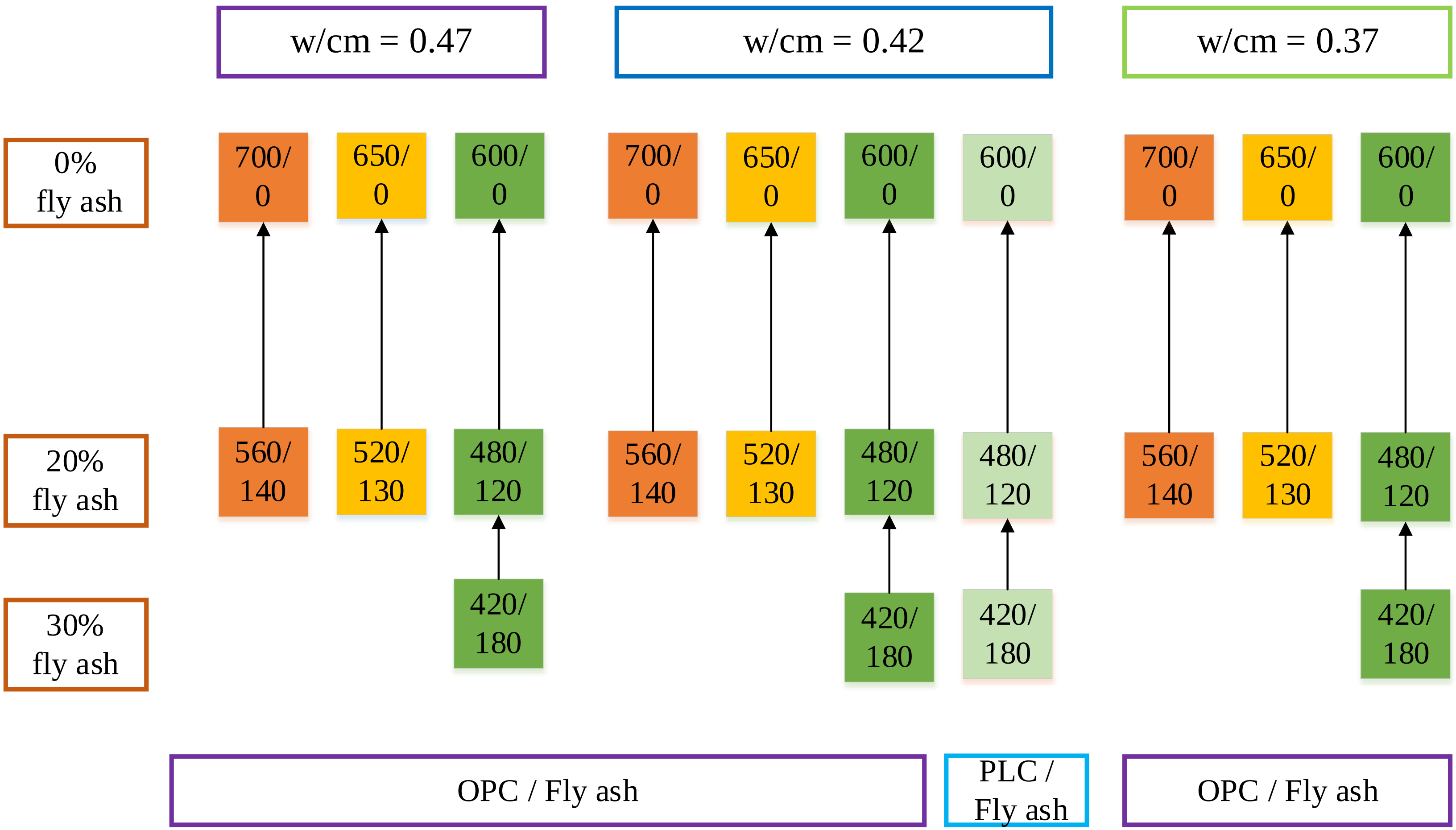
4) Develop specification provisions for surface resistivity, shrinkage, and early age strength for opening of pavements and bridge components to loads. Guide specifications or project special provisions were developed that could be utilized in pilot projects or other trial settings.

UNC CHARLOTTE

Mixture Matrix

24 Mixtures, shown in boxes:
cement content (pcy)/
fly ash content (pcy)

orange boxes represent higher cementitious material bridge deck (AA) mixtures
yellow boxes represent mid-range cementitious material bridge deck (AA) mixtures
green boxes represent lower cementitious material bridge mixtures (AA) and pavement mixtures



RP 2018-14 Outcomes

This project provided:

- Insight into “what concrete mixtures are being used, how they are doing”
  - Statistical analysis identifying mixture parameters that are linked to performance

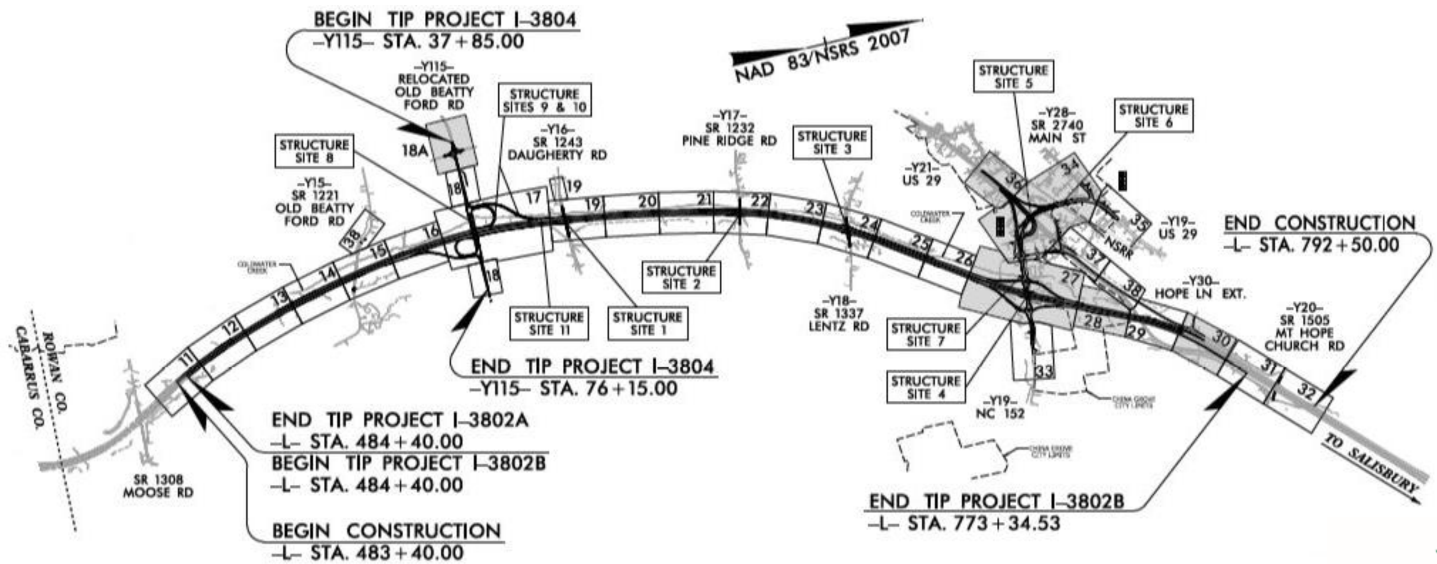
- Data to support increased use of fly ash at higher rates, PLC
- Data to support identification of performance targets for:
  - surface resistivity
  - early age strength for opening to traffic
  - shrinkage
- Recommended specification provisions for:
  - surface resistivity
  - early age strength for opening to traffic
  - shrinkage
- Additional data to support SAM specification recommendations

Ready for use as shadow specifications in upcoming pilot projects

UNC CHARLOTTE

FHWA Implementation Project

- I-85 widening project north of Charlotte, NC
  - 5.3 miles long
  - Existing 4-lane interstate widened to provide 4 additional travel lanes (2 lanes in each direction)
  - 500,000 SY of concrete pavement construction (12” thick JPCP)
  - Two phases:
    - April 2018 to September 2018
    - April 2019 to October 2019



FHWA Implementation Project Outcomes

This project resulted in:

- Engagement of a contractor to implement PEM tests for QC on a pavement project:
    - Box Test
    - SAM
    - surface resistivity

- Technology transfer to regional/divisional NCDOT personnel
- Data collection during FHWA Mobile Concrete Technology Center visit (April/May 2019)
- Technology transfer to NC stakeholders during Open House hosted at the Implementation Site





★ Support of a contractor and commitment to use of PEM tools on their next project ★

LANE

UNC CHARLOTTE

RP 2019-41 (Technology Transfer)

- Portion of FHWA Implementation funds used to support RP 2019-41
- Technology transfer to NCDOT Division and Region personnel
  - Industry stakeholders as invited by NCDOT

- Planned Format:
  - 45 to 60 minutes – Overview of PEM initiative
    - FHWA Initiative
    - Introduction to AASHTO PP 84
    - Pooled fund study
    - Ongoing research/implementation
  - 45 to 60 minutes – NCDOT's initial steps towards PEM
    - Findings of RP 2018-14, and ongoing research
    - FHWA Implementation site
    - Introduction to surface resistivity, SAM, Box Test, shrinkage
  - 1 to 2 hours – Hands-on demonstration of resistivity, SAM, shrinkage, Box Test
    - Testing of fresh concrete using SAM/Box Test
    - Testing of cylinders using resistivity
    - Shrinkage
    - Q & A, etc.

Planning to moving to virtual delivery due to travel restrictions

UNC CHARLOTTE

RP 2020-13 Objectives

1) Supplemental laboratory evaluation to expand the catalog of data to support development and refinement of PEM specifications

- same mixture matrix as RP 2018-14, with optimized aggregate gradations
- refine QA/QC protocol for resistivity, shrinkage, and SAM
- expand specification guidance to include w/cm ratios, aggregate gradations and/or paste contents
- Use of surface resistivity meter as a QA tool for overlay quality

2) Implementation of PEM tests and shadow specifications at additional pilot projects

- bridge project
- bridge deck overlay project
- additional pavement project through Lane Construction (*bonus*)

3) Development of guidance to support contractor QC plans

- refine technology transfer tools for NCDOT personnel developed as part of RP 2019-41 for QC use

UNC CHARLOTTE

Thank you!

We greatly appreciate the support of:

- FHWA
- MCTC Personnel
- CP Tech Center
- ACPA and Carolinas Concrete Paving Association
- Lane Construction
- Pooled fund research team
- Cecil Jones
- Material suppliers
- Research assistants at UNC Charlotte:
  - Blake Biggers, Austin Lukavsky, Memoree McEntyre, Ross Newsome, Joe OCampo, Alex Dillworth, Peter Theilgard

Planting PEM seeds!
Each of these young professionals knows how to specify/construct durable concrete, understands the PEM initiative, and brings this knowledge to their new workplace!

UNC CHARLOTTE

Sample

Then Test

Oregon State University
College of Engineering

Test so that we know

Use ‘established’ reference points to distinguish

How do we do this for concrete ....

Oregon State University
College of Engineering

Sample/Data Request

Oregon State University
College of Engineering

- PP-84 has several factors that are known to be related to durability
- Request 16 oz containers of binder materials (cement, supplementary cementitious materials). – Reference values; reactivity, chemistry
- We would also like to utilize these materials for testing (10 – 4 x 8 cylinders) - Physical Properties
- We have also asked for selected data (for example air content and strength) – Physical Properties

Sample/Data Request (Tests from Task 1)

Oregon State University
College of Engineering

- AASHTO T-365 - Standard Method of Test for Quantifying Calcium Oxychloride Amounts in Cement Pastes Exposed to Deicing Salts.
- AASHTO T-119 Standard Method of Test for Electrical Resistivity of a Concrete Cylinder Tested in a Uniaxial Resistance Test
- AASHTO T-XXX Degree of Saturation of Hydraulic-Cement Concrete
- AASHTO T-YYY Total Pore Volume In Hardened Concrete Using Vacuum Saturation
- AASHTO T-ZZZ Assessing the Rate of Secondary Sorption

Did I get the Same Value

Task 2 Example

- Maria had a large number of samples from the field
- We used these samples to help evaluate the properties that are typical for Minnesota
- This is very helpful to calibrate a local SHA performance to values that may be expected for the use of PEM

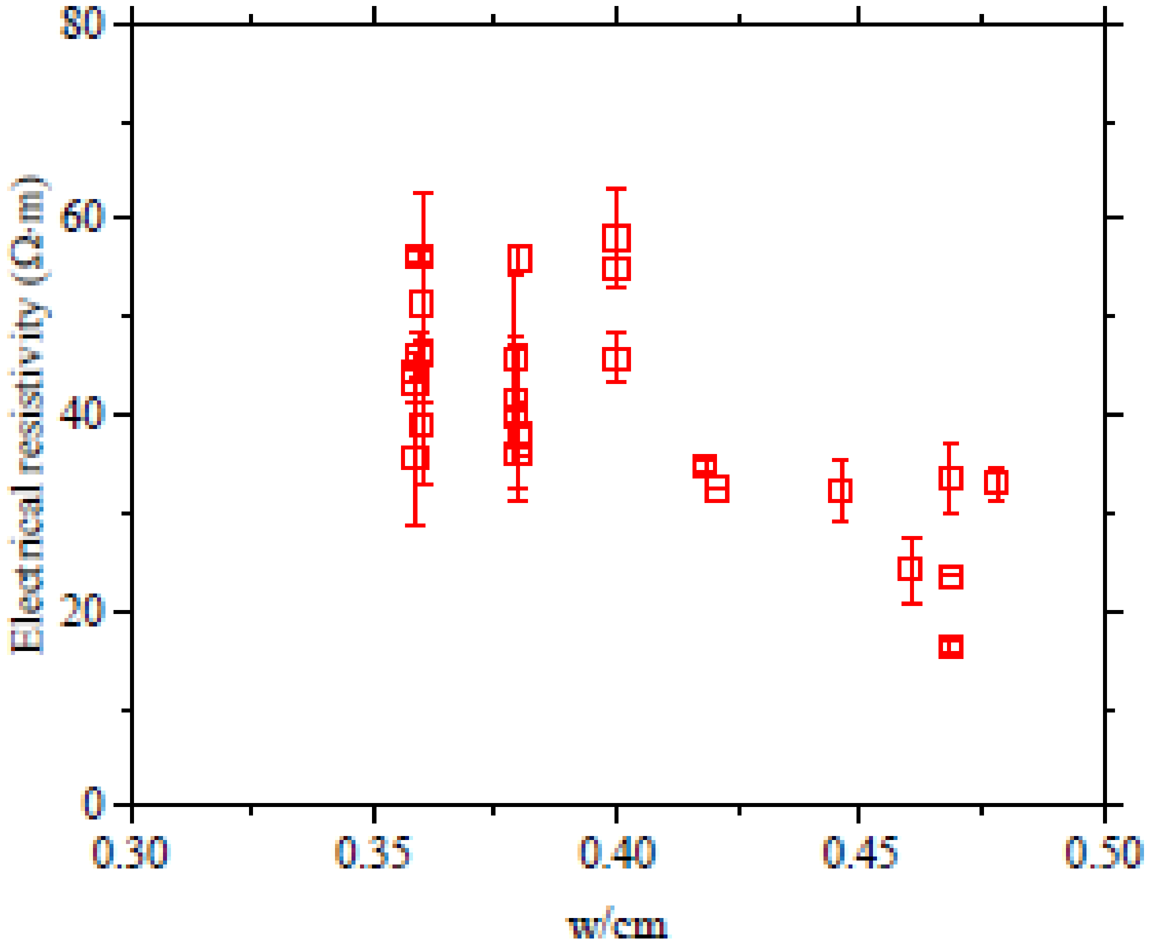
Table 1. The mixture proportion of the concrete cores (lb/yd³)

Group	Project NO.	1.5" Coarse	3/4" Coarse	3/8" Coarse	Grit	Natural Sand	Water	Cement	Fly ash	Salg	w/cm	Cut
1	7380-199	650	1125	310		1075	208	450	130		0.36	√
2	2208-36	939	939			1200	244	451	79		0.46	
3	7380-200	770	910	390		1100	208	450	130		0.36	√
6	2782-268	575	800	350	440	950	220	384		206	0.37	
7	8480-26		1678			1200	260	472	83		0.47	√
8	6019-22	880	1075			1170	208	450	130		0.36	√
9	1907-54		1710			1200	260	472	83		0.47	
10	1907-54		1710			1200	260	450	120		0.46	
11	5680-111	950	950			1245	203	450	115		0.36	√
12	4013-41	1670				1190	232	450	130		0.40	√
13	5507-47	1113	740			1200	244	493	87		0.42	√
14	0280-049	603	1078	412		1078	209	472	111		0.36	
15	2208-36		1578			1200	290	512	90		0.48	
16	0980-127	579	1343			1200	244	451	79		0.46	√
17	1907-53		1703			1200	260	472	83		0.47	
18	2180-80	860	1020			1220	212	450	140		0.36	√
19	3805-67	852	1046			1220	228	450	150		0.38	√
25	2480-91	860	1021			1210	224	450	140		0.38	√
26	2208-36	939	939			1200	244	451	79		0.46	
27	2208-35											
28	8480-27	1955				1200	225	459	79		0.42	√
29	4705-30	1210	760			1100	232	450	130		0.40	√
30	6507-04		1616			1200	282	502	88		0.48	√
31	2480-88	850	1040			1220	216	450	150		0.36	√
32	3204-59	770	890	310		1120	207	403	172		0.36	√
33	6404-32	930	930			1174	228	450	150		0.38	√
34	2180-78	750	1118			1200	260	472	83		0.47	√
35	5306-37	908	927			1216	222	450	135		0.38	√
36	7204-13		1698			1200	260	472	111		0.45	√
37	4013-41	1670				1190	232	450	130		0.40	√
39	0712-32		1683			1200	260	472	83		0.47	√
40	0702-98	845	1030			1190	218	450	125		0.38	√
41	2782-268	575	800	350	440	950	220	384		206	0.37	
44	0702-98	845	1030			1190	218	450	125		0.38	√

Resistivity

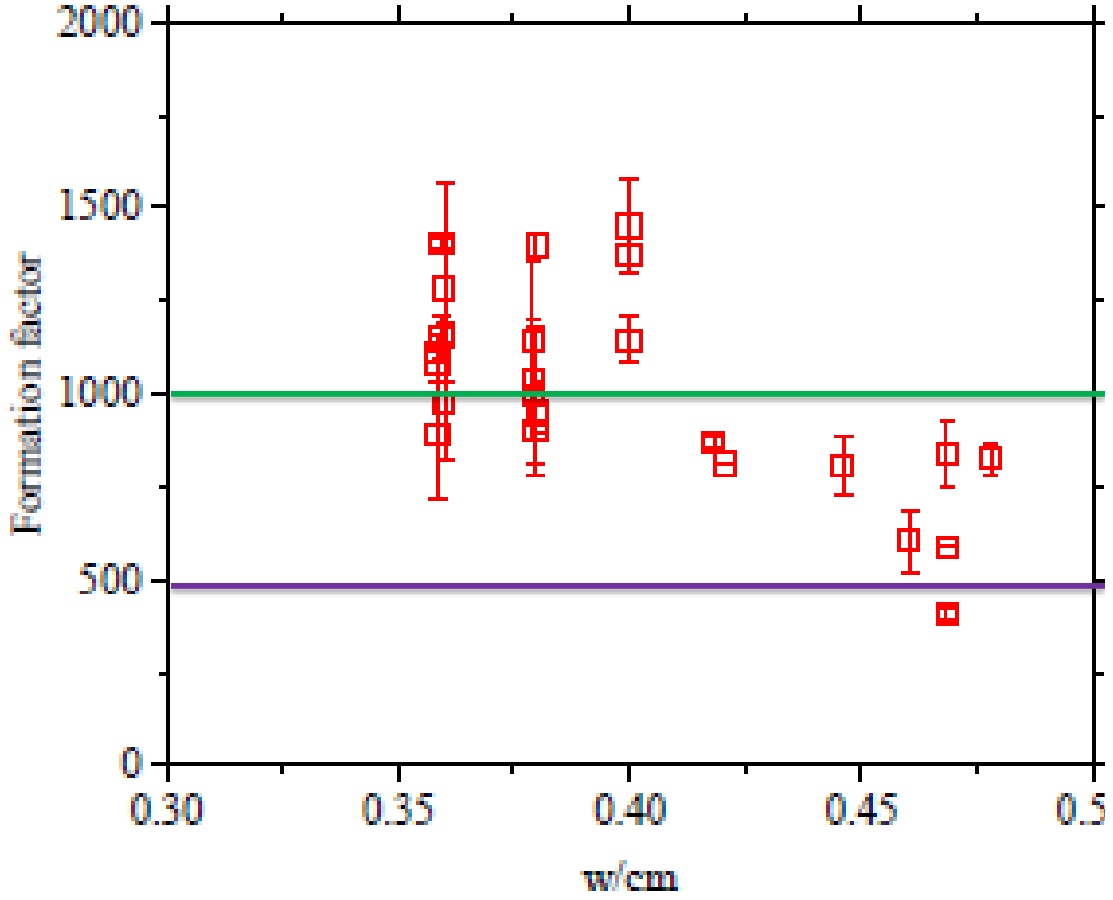
- Here we have used AASHTO TP-119-21?
- Dependent on thehe

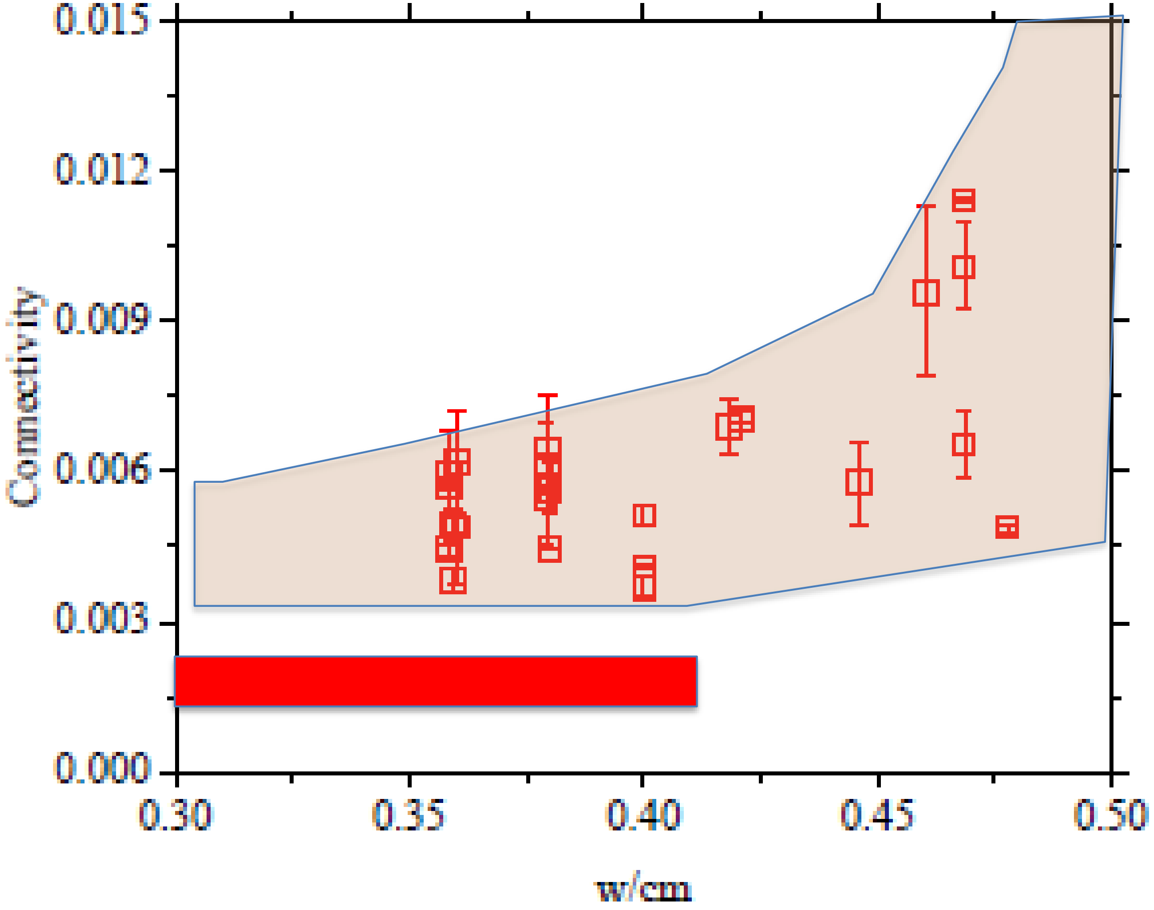
- Note – SR and Uniaxial give the same resistivity if the corrections for SR are done properly



Formation Factor and Connectivity

Oregon State University
College of Engineering



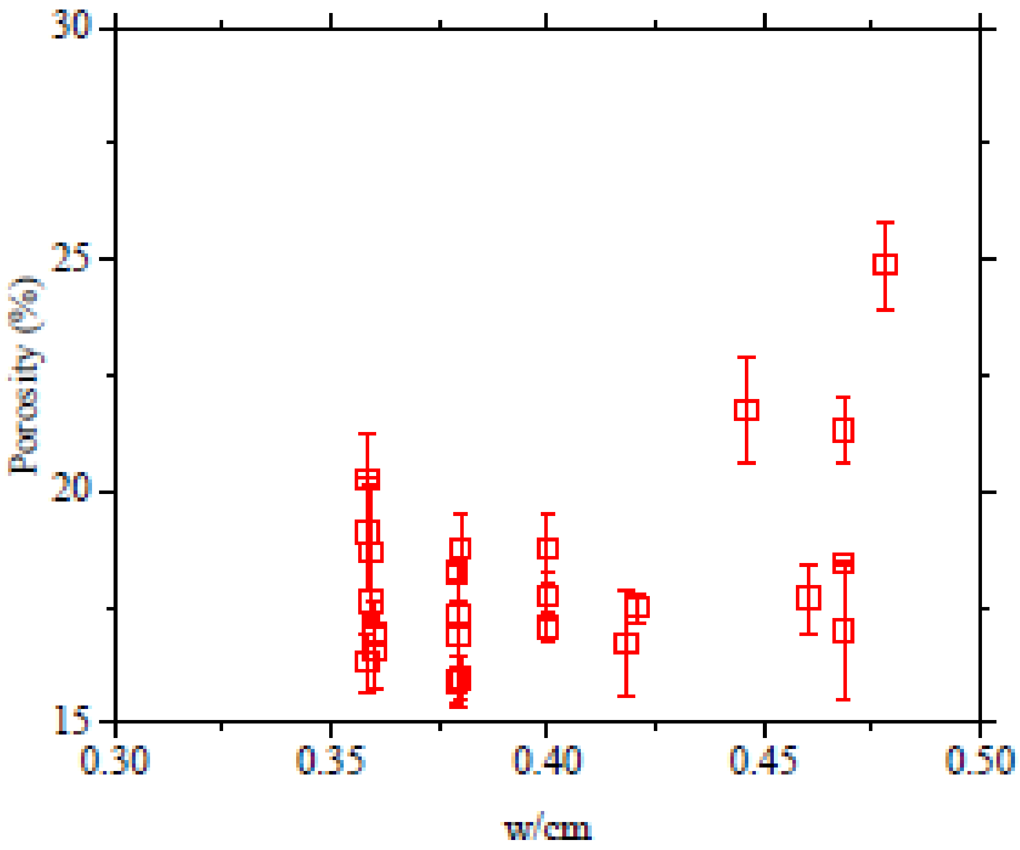


Porosity

Oregon State University
College of Engineering

- We can also measure the porosity of the concrete

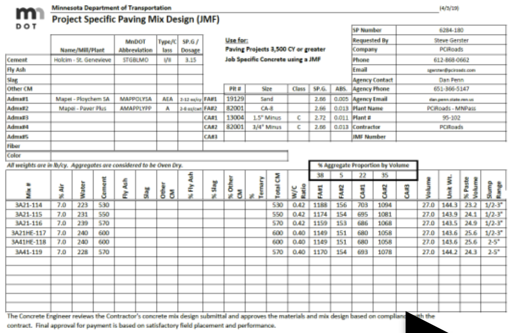
- Critically important for properties like strength and freeze thaw performance



Now a Challenge Arises

Oregon State University
College of Engineering

- We need to estimate the properties of concrete when challenges arise
- What if you need to speculate on resistivity (F)



Minnesota Department of Transportation (4/3/19)

Project Specific Paving Mix Design (JMF)

	Name/Mill/Plant	MnDOT Abbreviation	Type/Class	SP.G / Dosage
Cement	Holcim - St. Genevieve	STGBLMO	I/II	3.15
Fly Ash				
Slag				
Other CM				
Admx#1	Mapei - Ploychem SA	MAPPOLYSA	AEA	2-12 oz/cy
Admx#2	Mapei - Paver Plus	AMAPPLYPP	A	2-8 oz/cwt
Admx#3				
Admx#4				
Admx#5				
Fiber				
Color				

Use for:
Paving Projects 3,500 CY or greater
Job Specific Concrete using a JMF

	Pit #	Size	Class	SP.G.	ABS.
FA#1	19129	Sand		2.66	0.005
FA#2	82001	CA-8		2.66	0.013
CA#1	13004	1.5" Minus	C	2.72	0.011
CA#2	82001	3/4" Minus	C	2.66	0.013
CA#3					

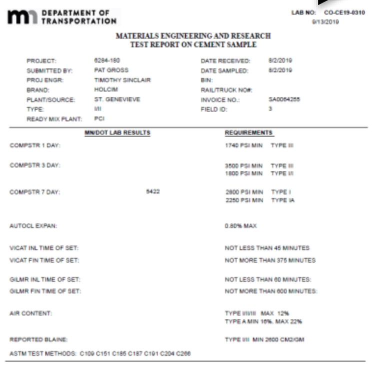
SP Number	6284-180
Requested By	Steve Gerster
Company	PCiRoads
Phone	612-868-0662
Email	sgerster@pciroads.com
Agency Contact	Dan Penn
Agency Phone	651-366-5147
Agency Email	dan.penn.state.mn.us
Plant Name	PCiRoads - MNPass
Plant #	95-102
Contractor	PCiRoads
JMF Number	

All weights are in lb/cy. Aggregates are considered to be Oven Dry.

													% Aggregate Proportion by Volume								
													38	5	22	35					
Mix #	% Air	Water	Cement	Fly Ash	Slag	Other CM	% Fly Ash	% Slag	% Other CM	% Ternary	Total CM	W/C Ratio	FA#1	FA#2	CA#1	CA#2	CA#3	Volume	Unit Wt.	% Paste Volume	Slump Range
3A21-114	7.0	223	530								530	0.42	1188	156	703	1094		27.0	144.3	23.2	1/2-3"
3A21-115	7.0	231	550								550	0.42	1174	154	695	1081		27.0	143.9	24.1	1/2-3"
3A21-116	7.0	239	570								570	0.42	1159	153	686	1068		27.0	143.5	24.9	1/2-3"
3A21HE-117	7.0	240	600								600	0.40	1149	151	680	1058		27.0	143.6	25.6	1/2-3"
3A41HE-118	7.0	240	600								600	0.40	1149	151	680	1058		27.0	143.6	25.6	2-5"
3A41-119	7.0	228	570								570	0.40	1170	154	693	1078		27.0	144.2	24.3	2-5"

The Concrete Engineer reviews the Contractor's concrete mix design submittal and approves the materials and mix design based on complian[ce] [w]ith the contract. Final approval for payment is based on satisfactory field placement and performance.

Task 3



DEPARTMENT OF TRANSPORTATION

LAB NO: CO-CE19-0310
9/13/2019

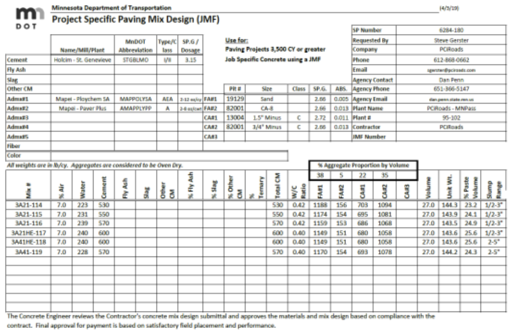
MATERIALS ENGINEERING AND RESEARCH
TEST REPORT ON CEMENT SAMPLE

PROJECT:	6284-180	DATE RECEIVED:	8/2/2019
SUBMITTED BY:	PAT GROSS	DATE SAMPLED:	8/2/2019
PROJ ENGR:	TIMOTHY SINCLAIR	BIN:	
BRAND:	HOLCIM	RAIL/TRUCK NO#:	
PLANT/SOURCE:	ST. GENEVIEVE	INVOICE NO.:	SA0064255
TYPE:	I/II	FIELD ID:	3
READY MIX PLANT:	PCI		

	MN/DOT LAB RESULTS	REQUIREMENTS
COMPSTR 1 DAY:		1740 PSI MIN TYPE III
COMPSTR 3 DAY:		3500 PSI MIN TYPE III 1800 PSI MIN TYPE I/I
COMPSTR 7 DAY:	5422	2800 PSI MIN TYPE I 2250 PSI MIN TYPE IA
AUTOCL EXPAN:		0.80% MAX
VICAT INL TIME OF SET:		NOT LESS THAN 45 MINUTES
VICAT FIN TIME OF SET:		NOT MORE THAN 375 MINUTES
GILMR INL TIME OF SET:		NOT LESS THAN 60 MINUTES:
GILMR FIN TIME OF SET:		NOT MORE THAN 600 MINUTES:
AIR CONTENT:		TYPE I/II/III MAX 12% TYPE A MIN 16%, MAX 22%
REPORTED BLAINE:		TYPE I/III MIN 2600 CM2/GM

ASTM TEST METHODS: C109 C151 C185 C187 C191 C204 C266

Now a Challenge Arises
Potential Solutions



Minnesota Department of Transportation (4/5/19)

Project Specific Paving Mix Design (JMF)

	Name/Mill/Plant	MnDOT Abbreviation	Type/Class	SP.G / Dosage
Cement	Holcim - St. Genevieve	STGBLMO	I/II	3.15
Fly Ash				
Slag				
Other CM				
Admx#1	Mapei - Ploychem SA	MAPPOLYSA	AEA	2-12 oz/cy
Admx#2	Mapei - Paver Plus	AMAPPLYPP	A	2-6 oz/cwt
Admx#3				
Admx#4				
Admx#5				
Fiber				
Color				

Use for:
Paving Projects 3,500 CY or greater
Job Specific Concrete using a JMF

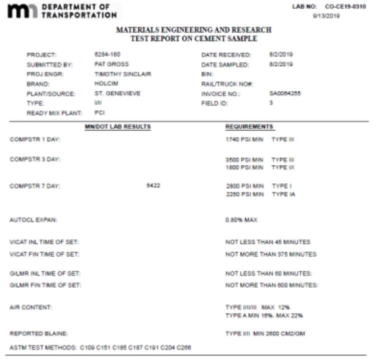
	Pit #	Size	Class	SP.G.	ABS.
FA#1	19129	Sand		2.66	0.005
FA#2	82001	CA-8		2.66	0.013
CA#1	13004	1.5" Minus	C	2.72	0.011
CA#2	82001	3/4" Minus	C	2.66	0.013
CA#3					

SP Number	6284-180
Requested By	Steve Gerster
Company	PCiRoads
Phone	612-868-0662
Email	sgerster@pciroads.com
Agency Contact	Dan Penn
Agency Phone	651-366-5147
Agency Email	dan.penn.state.mn.us
Plant Name	PCiRoads - MNPass
Plant #	95-102
Contractor	PCiRoads
JMF Number	

All weights are in lb/cy. Aggregates are considered to be Oven Dry.

Mix #	% Air	Water	Cement	Fly Ash	Slag	Other CM	% Fly Ash	% Slag	% Other CM	% Ternary	Total CM	W/C Ratio	FA#1	FA#2	CA#1	CA#2	CA#3	Volume	Unit Wt.	% Paste Volume	Slump Range
% Aggregate Proportion by Volume													38	5	22	35					
3A21-114	7.0	223	530								530	0.42	1188	156	703	1094		27.0	144.3	23.2	1/2-3"
3A21-115	7.0	231	550								550	0.42	1174	154	695	1081		27.0	143.9	24.1	1/2-3"
3A21-116	7.0	239	570								570	0.42	1159	153	686	1068		27.0	143.5	24.9	1/2-3"
3A21HE-117	7.0	240	600								600	0.40	1149	151	680	1058		27.0	143.6	25.6	1/2-3"
3A41HE-118	7.0	240	600								600	0.40	1149	151	680	1058		27.0	143.6	25.6	2-5"
3A41-119	7.0	228	570								570	0.40	1170	154	693	1078		27.0	144.2	24.3	2-5"

The Concrete Engineer reviews the Contractor's concrete mix design submittal and approves the materials and mix design based on compliance with the contract. Final approval for payment is based on satisfactory field placement and performance.



DEPARTMENT OF TRANSPORTATION

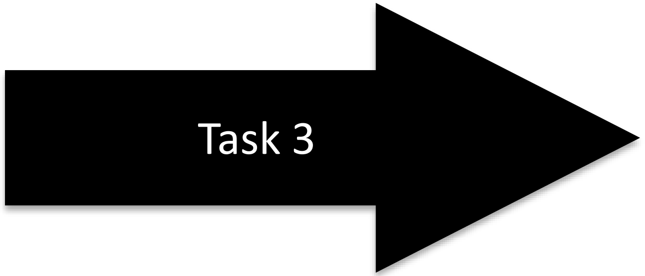
LAB NO: CO-CE19-0310
9/13/2019

MATERIALS ENGINEERING AND RESEARCH
TEST REPORT ON CEMENT SAMPLE

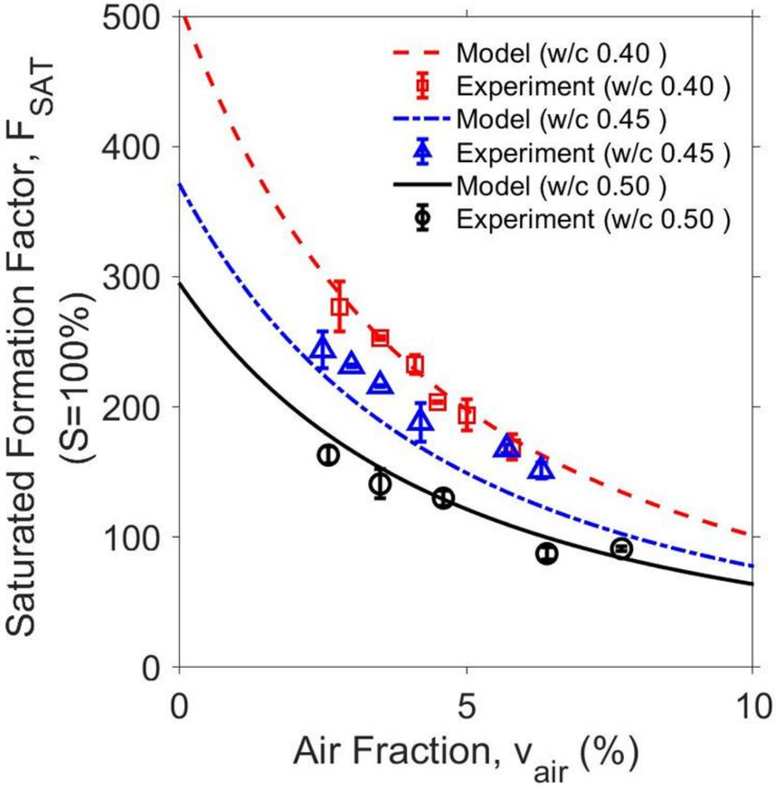
PROJECT:	6284-180	DATE RECEIVED:	8/2/2019
SUBMITTED BY:	PAT GROSS	DATE SAMPLED:	8/2/2019
PROJ ENGR:	TIMOTHY SINCLAIR	BIN:	
BRAND:	HOLCIM	RAIL/TRUCK NO#:	
PLANT/SOURCE:	ST. GENEVIEVE	INVOICE NO.:	SA0064255
TYPE:	I/II	FIELD ID:	3
READY MIX PLANT:	PCI		

	MN/DOT LAB RESULTS	REQUIREMENTS
COMPSTR 1 DAY:		1740 PSI MIN TYPE III
COMPSTR 3 DAY:		3500 PSI MIN TYPE III 1800 PSI MIN TYPE I/I
COMPSTR 7 DAY:	5422	2800 PSI MIN TYPE I 2250 PSI MIN TYPE IA
AUTOCL EXPAN:		0.80% MAX
VICAT INL TIME OF SET:		NOT LESS THAN 45 MINUTES
VICAT FIN TIME OF SET:		NOT MORE THAN 375 MINUTES
GILMR INL TIME OF SET:		NOT LESS THAN 60 MINUTES:
GILMR FIN TIME OF SET:		NOT MORE THAN 600 MINUTES:
AIR CONTENT:		TYPE I/II/III MAX 12% TYPE A MIN 16%, MAX 22%
REPORTED BLAINE:		TYPE I/II MIN 2600 CM2/GM

ASTM TEST METHODS: C109 C151 C185 C187 C191 C204 C266



Data from Oklahoma using this approach



Now a Challenge Arises
Potential Solutions

- 3. Test methods
  - Transport
  - Thermodynamics
  - Water movement
  - Water content

Minnesota Department of Transportation (4/3/19)

Project Specific Paving Mix Design (JMF)

	Name/Mill/Plant	MnDOT Abbreviation	Type/Class	SP.G / Dosage
Cement	Holcim - St. Genevieve	STGBUMO	I/II	3.15
Fly Ash				
Slag				
Other CM				
Admx#1	Mapei - Ploychem SA	MAPPOLYSA	AEA	2-12 oz/cy
Admx#2	Mapei - Paver Plus	AMAPPLYPP	A	2-8 oz/cwt
Admx#3				
Admx#4				
Admx#5				
Fiber				
Color				

Use for:
Paving Projects 3,500 CY or greater
Job Specific Concrete using a JMF

	Pit #	Size	Class	SP.G.	ABS.
FA#1	19129	Sand		2.66	0.005
FA#2	82001	CA-8		2.66	0.013
CA#1	13004	1.5" Minus	C	2.72	0.011
CA#2	82001	3/4" Minus	C	2.66	0.013
CA#3					

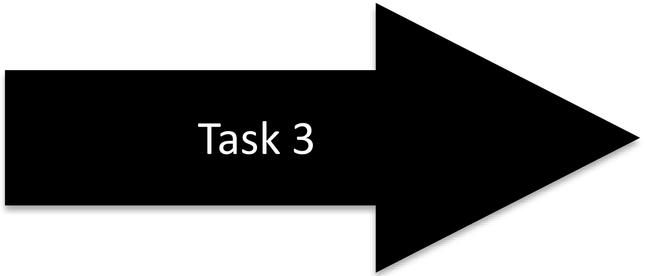
SP Number	6284-180
Requested By	Steve Gerster
Company	PCIRoads
Phone	612-868-0662
Email	sgerster@pciroads.com
Agency Contact	Dan Penn
Agency Phone	651-366-5147
Agency Email	dan.penn.state.mn.us
Plant Name	PCIRoads - MNPass
Plant #	95-102
Contractor	PCIRoads
JMF Number	

All weights are in lb/cy. Aggregates are considered to be Oven Dry.

% Aggregate Proportion by Volume: FA#1 38, FA#2 5, CA#1 22, CA#2 35, CA#3 —

Mix #	% Air	Water	Cement	Fly Ash	Slag	Other CM	% Fly Ash	% Slag	% Other CM	% Ternary	Total CM	W/C Ratio	FA#1	FA#2	CA#1	CA#2	CA#3	Volume	Unit Wt.	% Paste Volume	Slump Range
3A21-114	7.0	223	530								530	0.42	1188	156	703	1094		27.0	144.3	23.2	1/2-3"
3A21-115	7.0	231	550								550	0.42	1174	154	695	1081		27.0	143.9	24.1	1/2-3"
3A21-116	7.0	239	570								570	0.42	1159	153	686	1068		27.0	143.5	24.9	1/2-3"
3A21HE-117	7.0	240	600								600	0.40	1149	151	680	1058		27.0	143.6	25.6	1/2-3"
3A41HE-118	7.0	240	600								600	0.40	1149	151	680	1058		27.0	143.6	25.6	2-5"
3A41-119	7.0	228	570								570	0.40	1170	154	693	1078		27.0	144.2	24.3	2-5"

The Concrete Engineer reviews the Contractor's concrete mix design submittal and approves the materials and mix design based on compliance with the contract. Final approval for payment is based on satisfactory field placement and performance.



DEPARTMENT OF TRANSPORTATION

LAB NO: CO-CE19-0310
9/13/2019

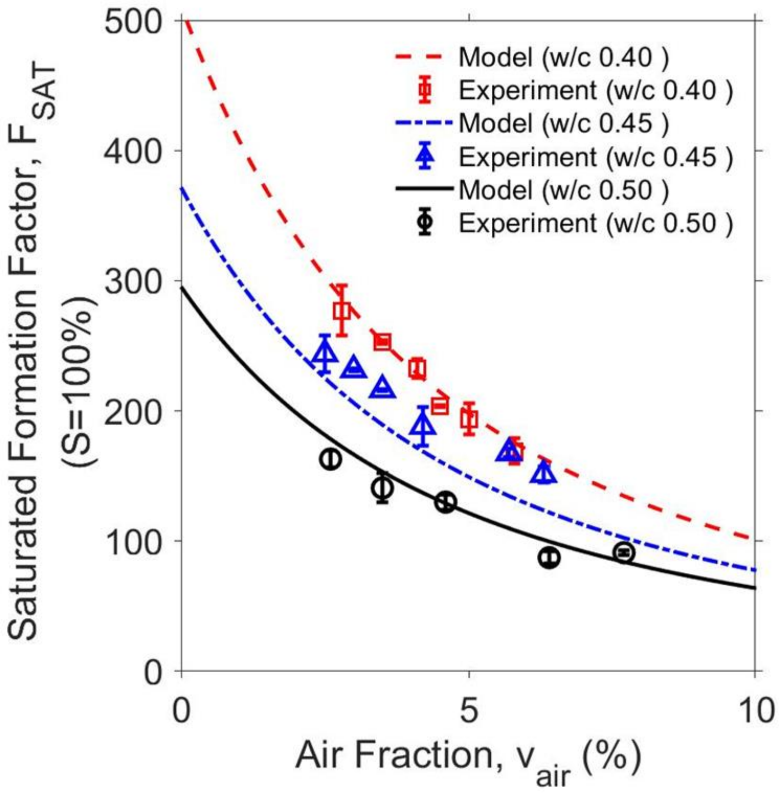
MATERIALS ENGINEERING AND RESEARCH
TEST REPORT ON CEMENT SAMPLE

PROJECT:	6284-180	DATE RECEIVED:	8/2/2019
SUBMITTED BY:	PAT GROSS	DATE SAMPLED:	8/2/2019
PROJ ENGR:	TIMOTHY SINCLAIR	BIN:	
BRAND:	HOLCIM	RAIL/TRUCK NO#:	
PLANT/SOURCE:	ST. GENEVIEVE	INVOICE NO.:	SA0064255
TYPE:	I/II	FIELD ID:	3
READY MIX PLANT:	PCI		

	MN/DOT LAB RESULTS	REQUIREMENTS
COMPSTR 1 DAY:		1740 PSI MIN TYPE III
COMPSTR 3 DAY:		3500 PSI MIN TYPE III 1800 PSI MIN TYPE I/I
COMPSTR 7 DAY:	5422	2800 PSI MIN TYPE I 2250 PSI MIN TYPE IA
AUTOCL EXPAN:		0.80% MAX
VICAT INL TIME OF SET:		NOT LESS THAN 45 MINUTES
VICAT FIN TIME OF SET:		NOT MORE THAN 375 MINUTES
GILMR INL TIME OF SET:		NOT LESS THAN 60 MINUTES:
GILMR FIN TIME OF SET:		NOT MORE THAN 600 MINUTES:
AIR CONTENT:		TYPE I/II/III MAX 12% TYPE A MIN 16%, MAX 22%
REPORTED BLAINE:		TYPE I/II MIN 2600 CM2/GM

ASTM TEST METHODS: C109 C151 C185 C187 C191 C204 C266

Data from Oklahoma using this approach

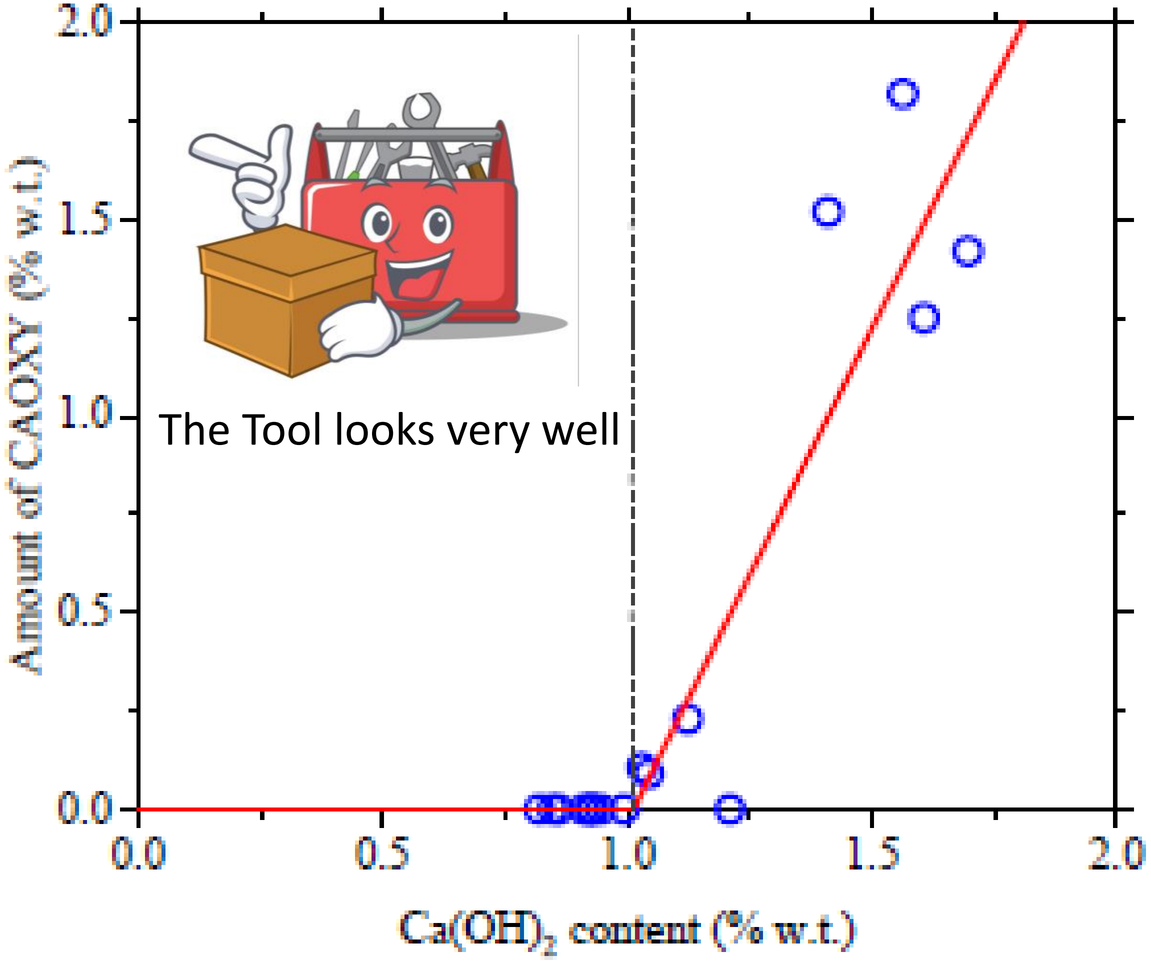


Thinking about CaOxy

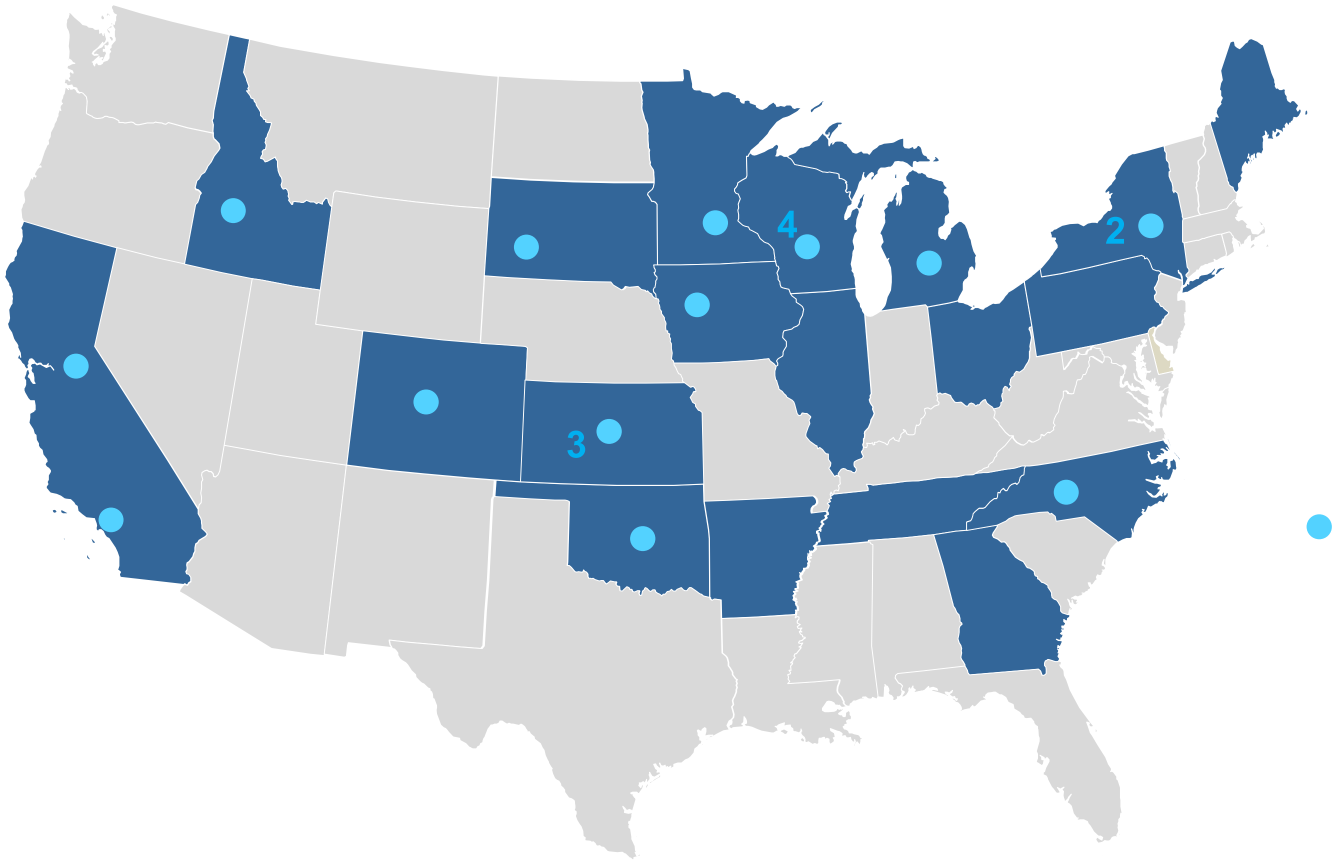
Oregon State University
College of Engineering

- Joint damage is a large problem
- This testing has shown that SCM can reduce CaOxy
- Mixtures from MN show very low CaOxy (due to SCM) used to treat ASR

Much Lower than the Critical Threshold



PEM PROGRESS – Training



Training Locations
(CP Tech, MCTC, OSU, Industry)
- Updated April 2020

PEM Training/Next Steps

- Who do we train?
  - SHA engineers
  - SHA technicians
  - Contractor QA
  - Ready Mix QA
  - Consultants

- How do we train?
  - On site
  - Virtual

PEM Training/Next Steps

- Who helps train?
  - FHWA
  - SHAs
  - CPTC
  - Equipment Vendors
  - National-Local Certification programs

- It's time to develop a strategy for the future!

Is this something we can achieve collectively or will it be governed by individual SHA?


National Concrete Pavement
Technology Center
Tech Center
Iowa State University
Institute for
Transportation