TPF-5(368) PERFORMANCE ENGINEERED CONCRETE PAVING MIXTURES (PEM) INDUSTRY MEETING

Wednesday, July 22, 2020

Attendees:

Industry Reps		**Research Team**	
John Becker	ACPA Pennsylvania Chapter	Jerod Gross	Snyder & Associates
Bill Cuerdon	NY Chapter - ACPA	Cecil Jones	Diversified Engineering Services
Al Innis	Slag Cement Association	Melisse Leopold	Snyder & Associates
Rich Jucha	ACPA Pennsylvania Chapter	Tyler Ley	Oklahoma State University
Kevin McMullen	Wisconsin Concrete Pavement Assoc	Tom Van Dam	NCE
Paul Tennis	PCA	Jason Weiss	Oregon State University
Jerry Voigt	ACPA	Bob Conway	FHWA
Steve Waalkes	Michigan Concrete Association	Lisa McDaniel	FHWA
Matt Zeller	Concrete Paving Assoc. of Minnesota	Mike Praul	FHWA
		Gordon Smith	CP Tech Center
		Peter Taylor	CP Tech Center

Green text = verbal or written comment

<u>PEM VISION - Peter Taylor - see PPT slides</u>

- Planned Work
  - Implementation
    - Goal is to demonstrate progress being made instead of only discussing plans/ideas
  - Monitoring
  - Test Methods
    - VKelly provides good data but Peter is working with manufacturer to make more operator friendly. One suggestion is to make it battery powered and operable by one individual, ideally that it could be placed on the back of a truck, hit a button and measure the value.

- Implementation
    - Chart of implementation of PEM tests shows a lot has been accomplished. Working towards higher numbers in the "considering change" or "adopted change" columns. Assistance to states indicating "interest" will be offered.

- Future vision
  - What can the contractor do after it leaves the truck, curing, finishing, etc?
  - Currently writing quality assurance documents (Cooperative Agreement Task)
  - How do we encourage and keep the PEM momentum going?

<u>FHWA Update – Mike Praul</u>

- FHWA/CP Tech initiative through the cooperative agreement
  - Developing QC tools and control chart tools; guidance on how to move toward performance specifications

    - Phase 1 report will Include tools and tips for contractors of all sizes to improve their QC operations
    - Industry PEM TAC will be asked to review the report.
- Mobile Concrete Technology Center will not go out in 2020.
    - Technician level webinars are being offered by the MCT team
    - Local agency/industry can request specific topic; contact Mike Praul

<u>Team Updates</u>
<u>Jason Weiss</u>

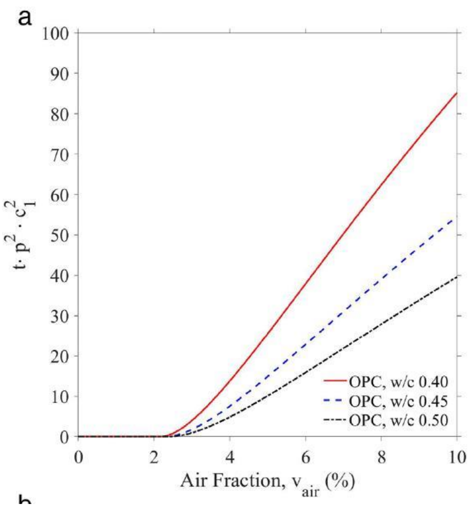
- Specifications – edits are being made so everyone can follow the same plan
- Test samples
    - Storing samples in buckets of water rather than pore solution changes the testing results, so potassium-hydroxide needs to be used to simulate the pore solution. Jason will talk to a supplier to make ingredients available and notify the states.
    - PFS states have been asked to send samples: 16 ounces of binder materials, cylinders and testing information on strength, air, SAM air and SAM number
    - Minnesota and Indiana have provided the most information on their test samples. With the available LTPP samples, there is the equivalent of 20 years of data from those sites in MN & IN allowing baselines to be established for these states.
- Resistivity testing from several states have shown problems with resistivity values. Jason is working on a device that would allow a state to determine the geometry correction factor to make sure their settings are correct
- Formation factor testing can relate formation factor directly to water/cementitious ratio and binder composition
- Using low water / cementitious ratio can cut pore connectivity in half
- There is a similar effect with porosity (reducing from 25% to 20%) with low w/cm
- Jason is working on a fly ash report that will discuss utilization of fly ash to durability. This report will be made available to the PEM state and industry TACs.

Colin Lobo: It seems like the bulk resistivity is a bit more robust method with lower variation and should be the preferred method to surface resistivity. NRMCA has completed some work on this. Resistivity is also sensitive to the method of conditioning the specimens.
Jason Weiss: Agrees the method of conditioning the sample is crucial.

Paul Tennis: Can you elaborate on the "no fly ash" estimates? strength? formation factor? service life?
Jason Weiss: We are able to run test parameter (strength, formation factor, freeze-thaw, service life) estimates to compare mixtures using some of the tests they have developed. Jason will send Paul a document on this method.

Al Innis: Can you share what materials or items have been sent to you so if the industry wanted to replicate some of these tests in their lab we could do that?
Jason Weiss: Will gladly share anything he has with industry.

Kevin McMullen: One of the advantage of Jason’s analysis is that all the assumptions and impacts are 'laid out' and people can then chose to implement or not implement.



Kevin McMullen: This graph shows the type of information that can be determined. The *x* axis is air and not SAM (although we can do that) and the *y* axis is some measure of life (it's normalized to be widely applicable). We can clearly see the impact of air content on the expected life. This is, however, only looking at freeze-thaw and not the other sources of degradation.

Tyler Ley

- SAM testing: 8 states (CO, MI, MN, KS, WI, NC, IA, SD, NY, ID, PA) have shared SAM data from their shadow testing
- Four states have been using SAM for mix design
- In 2021, three states will use SAM for acceptance in the field
- Continued work on making SAM more accurate and user friendly; the algorithm that shows if the test has been done correctly has been working well
- Pilot program for on-line training – agency/industry can submit videos of tests being done and they will be reviewed, resulting in suggestions/discussion for improving the testing methods
- The Phoenix test determines the w/cm ratio in about 15 minutes. We have data from about 800 tests (½ field and ½ lab). MN and FHWA MCTC are using the Phoenix test. Contractors are interested in using the tool to get consistent concrete.
- Quarterly PEM newsletter shared information on what various states are doing with the testing as well as with their specs.

Kevin McMullen: The specification state summary table is very important. Wisconsin is one of the states running the shadow specification. We are having a serious discussion about implementing the SAM test as part of our standard specifications. We were very close to getting it done. The tripping point was administering the spec out on the construction site. We can run tests, we can get results, but in the end the DOT and the owners want to know how good or bad the concrete is. The specification can't be implemented until we come to an agreement on the specific SAM value that would instigate a disincentive or penalty credit to the department. Is it .28 or is it .30? Also what is the dollar value or percentage of the bid item? As we move forward, we have to think about how the DOTs will implement the spec in the field. Contractors/industry want to know that information at the time of bidding so it can be covered. Until then, there will be reluctance in doing it.

Tyler Ley: It is important to think any change all the way through; how the change will be made and what it will mean. In the past, how were specifications for error treated? How was low air content treated?

Kevin McMullen: Right now 5.5 is 100% pay and 5.4 is a 20% reduction in pay. However, 4.5 its still 20% reduction, while 4.4 its 30%. Less than 4, is 50% to remove and replace. Those percentages were put in place 40 years go. Today we have a lot more information and we should start talking about these values and predict loss of life. We will be better off if we come up with ways to administer these specs.

Tyler Ley: Mike Praul's team is working on this topic. They are getting your field data and they are working on what your distribution of data shows. One way to attack this issue is to examine where you are now and base pay on that. The other way is to look at Jason Weiss's modeling predictions and use that method for predicting how long we think it will perform; our best guess based on what we have right now. These are two different approaches and every state has to decide how they want to proceed. A PWL is one approach. Not implementing because of this hurdle is something that needs to be overcome, and there is lots of information available to help.

Michael Praul: Bob Conway did a NCC presentation that illustrated how states should set the INITIAL spec limit for the SAM, based on their mixes today. How states choose to apply incentives/disincentives will be a case by case decision.

Bob Conway: We are available to discuss potential specification limits, pay factors and specification administration.

Cecil Jones

- Jesus Sandoval-Gil will replace Brian Egan as chair of the committee after AASHTO comp meeting
- No negatives comments on the PP84
- A task group will be setup to work on some of the comments on T358 and T119;
- Having discussions on PP84 and other provisions to move these towards becoming full standards

Tom Van Dam

- Database is a depository so the collected data remains available in the future
- Important to record accurate locations so the data can be linked back to a specific section of pavement for later reference.
- Looking at existing LTPP sections that are developing classic distress consistent with materials related distress.
- Samples of materials from the date of construction could be compared with present samples from these sections and try to determine what has happened

PEM Data – Jerod Gross and Lisa McDaniel (see PPT slides)

- At least 11 states have conducted shadow testing (CO, MN, IA, SD, ID, NC, KS, WI, MI, PA & NY)
- 6 DOTs have filled out the data entry table (IA, SD, MN, KS, NC, ID) from their shadow testing; information has been forwarded to Tom Van Dam for inclusion in the database
- Partial data from Michigan & New York was provided in addition to the 6 states above for interim data review. This small group worked on illustrating figures and plots to look at data in this interim approach until we get more data from the shadow tests.

Lisa McDaniel

- Lisa shared information on the data figures and statistical analysis on the properties
- Developed plots for the distribution of the data, (i.e. for the slump, and spacing factor) to compare what the states are doing

- Need the location information to prepare more meaningful analysis and make comparisons between test parameters
- States could send data in an excel spreadsheet to the team for plotting

The North Carolina PEM Implementation Strategy - Tara Cavalline (see PPT slides)

- NCDOT spec hasn't changed much over 85 years
- Desire fly ash in most of mixtures because of benefits
- Established preliminary spec recommendations, targets for selected PEM technologies and some prescriptive provisions
- Completed one pilot project
    - Lab testing of a broad matrix
    - Data on concrete containing PLC and fly ash
    - Developed special provisions
    - Developed a mixture matrix from pilot project
- The NCDOT shadow project (utilizing FHWA incentive funds) was reviewed with the group

Training – Gordon Smith

- Pooled fund plan was for one-time training, but there is a need for additional training. Also need to consider who can help with training – FHWA, SHAs, CP Tech, equipment vendors
- Need to get the right people trained - technicians, contractor QA, ready-mix QA consultants
- Need to look at national-local certification program
- Regional summits with states and industry to discuss what is being done and next steps would be advantageous.
- Need to keep our progress in front of people and show our success stories

Steve Waalkes: Michigan, offers the SAM training/certification as an add-on to the standard ACI Field Testing certification program.

Bill Cuerdon: New York DOT is all ready-mix this year. And NYSDOT is trying to fit some PEM concepts into RM concrete; some hurdles - contractor owned plants, dumps, and slipform paving. At some point, can we do PEM for the RMC industry or is that beyond the focus of this group?

Michael Praul: PEM in RM is certainly of interest to FHWA. Idaho is also interested in RM.

Steve Waalkes: Michigan has done some SAM testing on ready-mix: A large I-75 bridge project over the Rouge River in Detroit, and a couple producers volunteered to run tests on a number of different mix designs / types.

Jerod Gross: North Carolina and Iowa shadow project contractors' have voluntarily chosen PEM approaches on current and upcoming projects.

Jerry Voigt: **C**onsidering COVID limitations, how far along are we in relation to where you thought we would be at this time?

Mike Praul

- Focus has been on the mixes. Using the new tests and getting them right.
- PEM is more than just adding a new test to your specification.

- States need to decide whether they are interested in just adding a new test or two. We hope that even doing only that will improve their program.
- However, if they are interested in moving to a performance specification, which is where this industry is evolving to, there are additional things states can do and start to transition their specs. FHWA will be having these discussions with the states, helping them to determine where they want their specs to be in the future.
- Some states couldn't get the support to join the pooled fund, but they are still interested in PEM and FHWA is working with them as well.

Peter Taylor

- Overall we are on track although field demos are delayed because of COVID
- We can do other things with the data the states provide
- Will share the slides/testing data when available with industry so they can get more engaged
- Keep going with asking states what they want and then how do we deliver that

Final Comments

- **Al Innis** – any information you can send us helps us get engaged. Very interested in what do we do with the testing data and how do we make decisions. If there is bad test on one of the loads how do we make the next truck load better, how do we improve it? I think we need the data that shows if mix A was working and stopped working, what is needed to make it work again.

- **John Becker** – has PEM been implemented into the FHWA Everyday Counts initiative?

- **Mike Praul** - Implementation of PEM to FHWA Everyday Counts initiative has not been done as it didn't meet all the requirements we were looking for and wasn't sure it needed that level of kick start. John your comment is noted and it may get submitted next year.

- **Kevin McMullen** – Right now Wisconsin has a wide range of contractors regarding acceptance of the PEM specifications. One is very supportive, has bought equipment, and knows a lot about what is going on with the mixes. But another contractor has stated they are not interested in PEM, want to continue to do "our thing". We need to keep in focus that all the contractors want to put down pavement and make a living. I think some are thinking the PEM stuff might be an additional risk; the fear of the unknown. We need to go from just running tests and collecting data to make it real and part of the specification. Remind the contractor that if they do their homework, they will be successful in understanding the specification and their risk will be low. We need to translate all of this stuff to the contractor's level to get buy-in from them. We need to focus on moving past the mixture to how does this impact their equipment, how does it impact the administration of the spec and how the contractor get paid.

- **Mike Praul** – agrees with Kevin's comments and Al stating the more industry knows the more they will be engaged. Agrees on the need to educate industry and contractors. The more they know, the more they understand and will buy-in to PEM.

- **Matt Zeller** – agree with Kevin's statements. Need to get specs involved. There will be some growing pains.

- **Tara Cavalline -** "what does NC want?" is presented on "overall objectives" in my presentation. Subject to change though, as new things emerge from the team.

- **Tyler Ley** – States and contractors don't always know what they want, until they get there.

- **Jerry Voigt** – I think we are farther along than we think we are. We are shaping the thinking of people - not just people who deal with materials, but the people who are involved in the equipment, etc. Let's think about where we are heading with the materials and working with contractors to get the implementation. I see the change in the mindset.

Peter Taylor

- Peter asked the group for input on how we keep this going. Would like to talk to the contractors and help them understand how this works. Call CP Tech Center if individual states and regions would like to talk about help with PEM.

PEM TPF Status

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National Concrete Pavement Technology Center

Agenda

- Opening comments & PEM status – Peter Taylor
- FHWA update - Mike Praul
- Team Updates
  - Jason Weiss
  - Tyler Ley
  - Cecil Jones
  - Tom Van Dam
- PEM Data – Jerod Gross, Lisa McDaniel & Tom Van Dam
- The North Carolina PEM Implementation Strategy – Tara Cavalline
- Training – Gordon Smith
- Regional State-Industry Discussions – Gordon Smith
- PEM Future – Where are we headed? – Peter Taylor

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

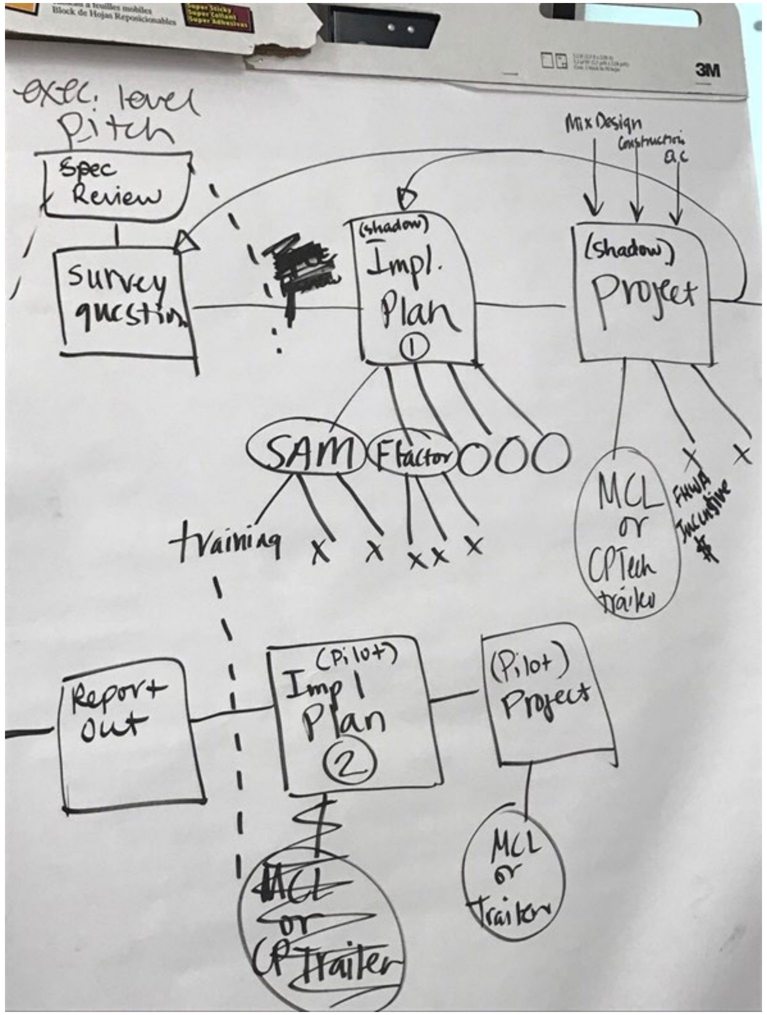
- 2. Monitoring
  - Set up database - complete
  - Collect, collate and publish field data – data received from 8 states
  - Mine LTPP database – Underway
  - Update at AASHTO - Annual

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

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Performance-Engineered Mixture ×

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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

Performance-Engineered Mixture

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

PEM PROJECT INFO

News

- PEM Newsletter (July 2020)
- 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

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

Meetings

- PEM TAC Meeting Notes (June 2020)
- PEM TAC Meeting Notes (November 2019)
- PEM TAC Meeting Notes (February 2018)

Other Information

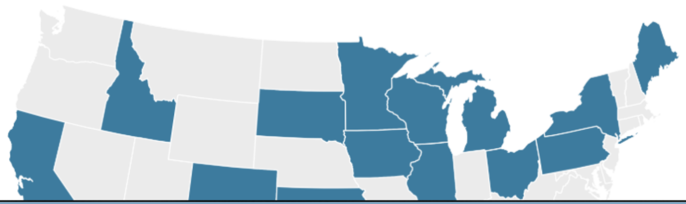
- PEM State Specification Review

PEM PROJECT SPONSORS

Federal Sponsor

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

State Sponsors



TOP

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

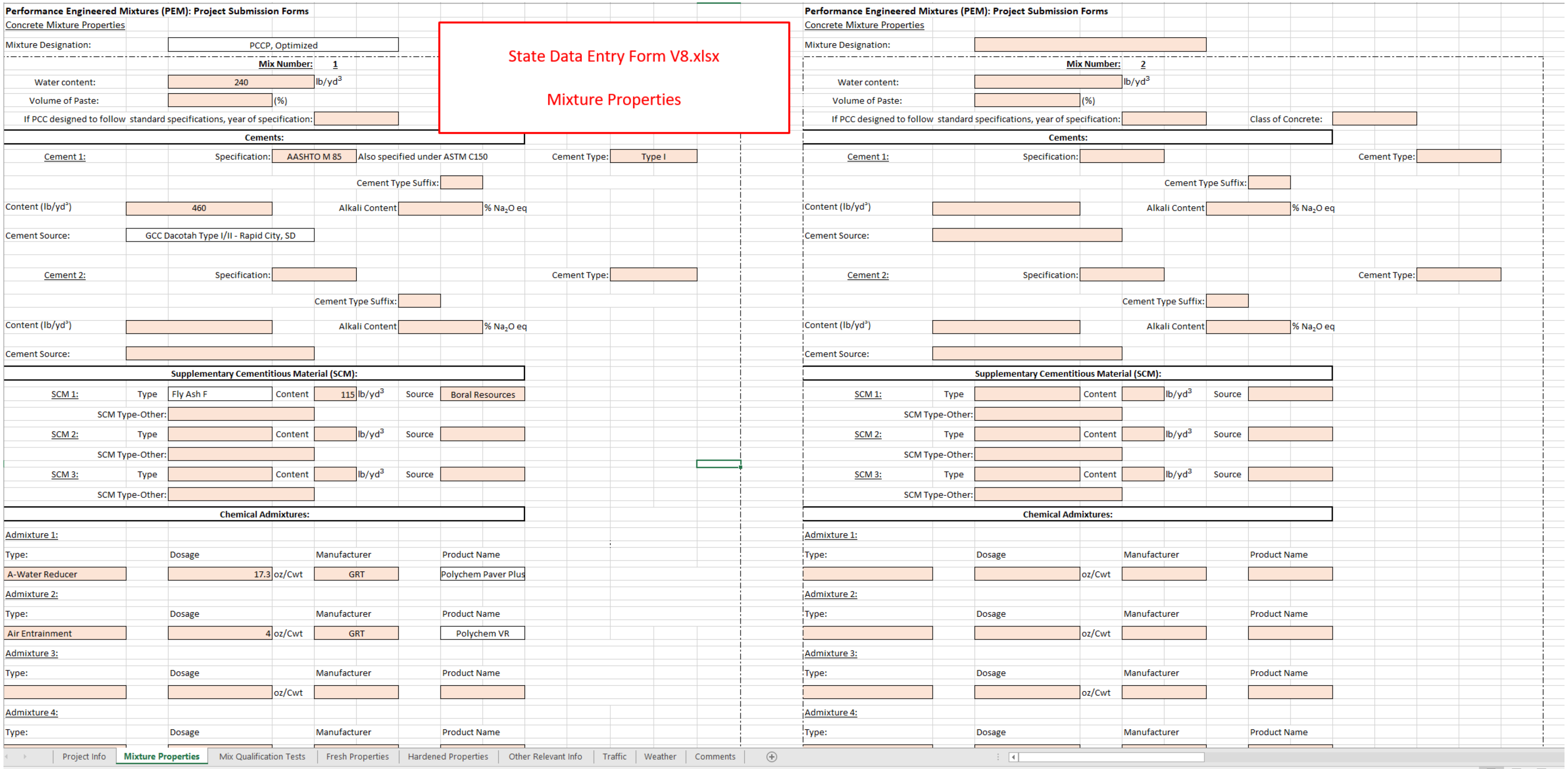
Subgrade Information:

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/yd³
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/yd³) 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/yd³) Alkali Content % Na_2O eq
Cement Source:

Supplementary Cementitious Material (SCM):

SCM 1: Type Fly Ash F Content 115 lb/yd³ Source Boral Resources
SCM Type-Other:
SCM 2: Type Content lb/yd³ Source
SCM Type-Other:
SCM 3: Type Content lb/yd³ Source
SCM Type-Other:

Chemical Admixtures:

Admixture 1:
Type: A-Water Reducer Dosage 17.3 oz/Cwt Manufacturer GRT Product Name Polychem Paver Plus
Admixture 2:
Type: Air Entrainment Dosage 4 oz/Cwt Manufacturer GRT Product Name Polychem VR
Admixture 3:
Type: Dosage oz/Cwt Manufacturer Product Name
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/yd³
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/yd³) Alkali Content % Na_2O eq
Cement Source:

Cement 2: Specification: Cement Type:
Cement Type Suffix:
Content (lb/yd³) Alkali Content % Na_2O eq
Cement Source:

Supplementary Cementitious Material (SCM):

SCM 1: Type Content lb/yd³ Source
SCM Type-Other:
SCM 2: Type Content lb/yd³ Source
SCM Type-Other:
SCM 3: Type Content lb/yd³ Source
SCM Type-Other:

Chemical Admixtures:

Admixture 1:
Type: Dosage oz/Cwt Manufacturer Product Name
Admixture 2:
Type: Dosage oz/Cwt Manufacturer Product Name
Admixture 3:
Type: Dosage oz/Cwt Manufacturer Product Name
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)

							Super Air Meter Pressure Step Readings (if available)					
Property	Test Date	Test Time	Station	Batch Number	Test Results	Test Units	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	

State Data Entry Form V8.xlsx

Hardened Properties

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

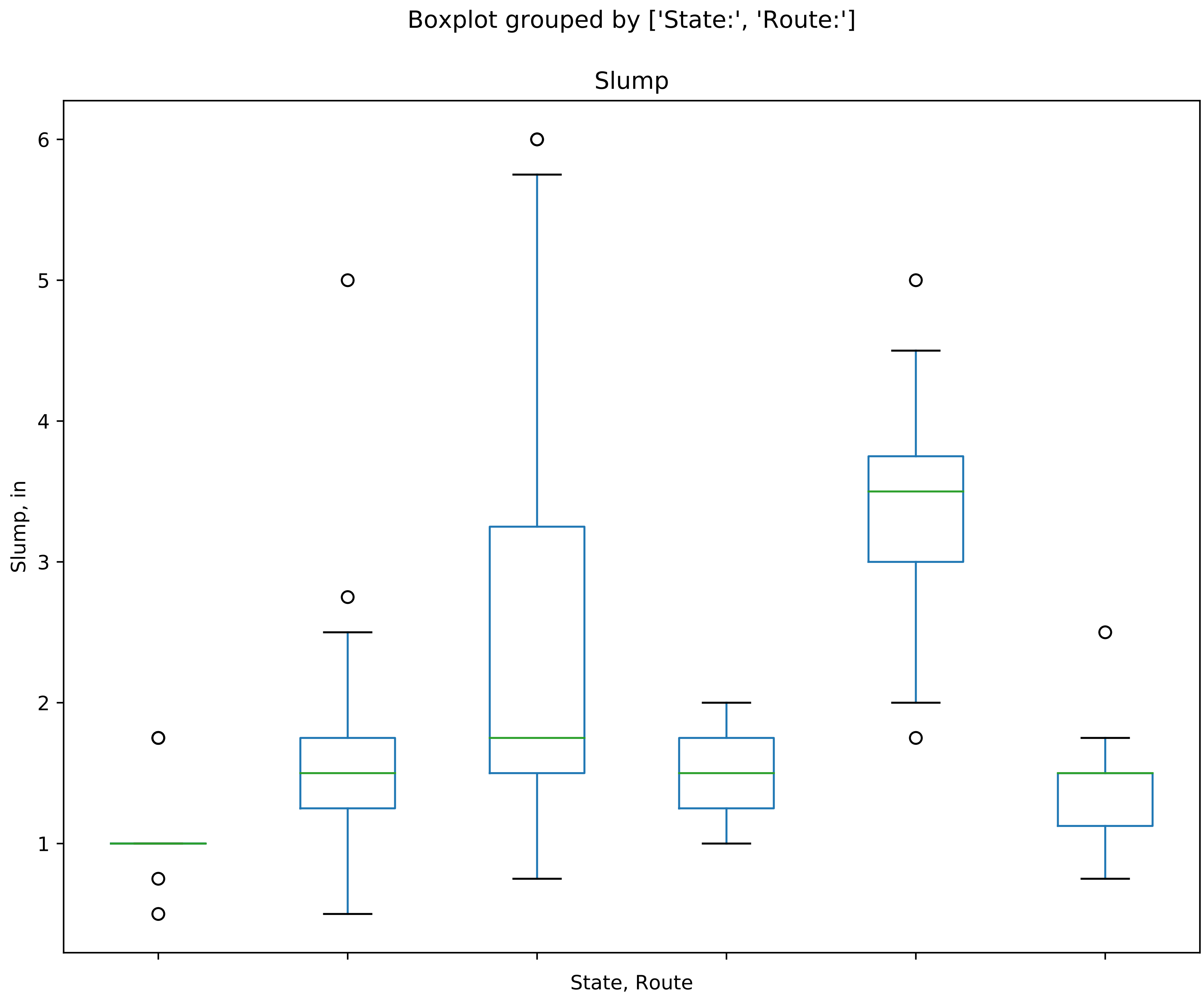
6/8/2020: Kansas, Minnesota, Idaho, Iowa, New York, Michigan US 31, Michigan I-69, South Dakota

Fresh Properties Descriptive Statistics

Property	count	mean	std	min	25%	50%	75%	max
Air Content	9	5.58	0.6906	4.60	5.20	5.40	5.80	6.90
Concrete Temperature	9	68.67	3.8079	64.00	65.00	68.00	71.00	74.00
SAM	9	0.28	0.0789	0.17	0.20	0.29	0.34	0.39
Slump	9	1.08	0.4146	0.50	1.00	1.00	1.00	1.75
Unit Weight	9	141.44	1.4301	139.00	140.70	141.60	142.20	143.80
Air Content	209	8.42	0.6685	6.30	8.00	8.40	8.80	10.00
Box Test (Voids)	14	1.50	0.8549	1.00	1.00	1.00	1.75	3.00
SAM	37	0.21	0.0507	0.10	0.18	0.21	0.25	0.30
SAM Air Content	37	8.51	0.7693	6.00	8.20	8.50	8.80	10.00
Unit Weight	37	141.53	0.5557	140.56	140.96	141.37	141.77	142.97
Air Content	45	7.00	1.3064	4.80	6.10	6.80	7.60	12.00
Concrete Temperature	26	85.17	4.6439	76.00	82.00	85.00	89.75	92.00
SAM	45	0.25	0.1177	0.06	0.17	0.26	0.32	0.63
Slump	45	1.58	0.7687	0.50	1.25	1.50	1.75	5.00
Unit Weight	42	139.97	2.4362	132.00	139.26	139.92	141.28	145.62
Vkelly Test	1	0.59		0.59	0.59	0.59	0.59	0.59
Air Content	87	6.98	0.6864	5.50	6.50	6.90	7.40	9.00
Concrete Temperature	88	68.83	8.3614	48.00	62.00	68.50	76.25	84.00
SAM	91	0.21	0.0638	0.03	0.18	0.21	0.24	0.40
SAM Air	9	6.09	0.9422	4.36	5.49	6.38	6.53	7.36
Slump	87	2.27	1.3510	0.75	1.50	1.75	3.25	6.00
Air Content	50	6.86	0.7126	5.10	6.23	6.80	7.48	8.10
Concrete Temperature	50	65.64	10.6900	50.00	56.25	65.50	75.00	84.00
SAM	50	0.20	0.1169	0.04	0.13	0.19	0.23	0.58
Slump	50	1.54	0.2526	1.00	1.25	1.50	1.75	2.00
Air Content	179	7.92	1.0763	5.00	7.35	7.90	8.40	12.80
Concrete Temperature	180	73.37	5.0747	59.00	70.00	73.00	75.00	93.00
SAM	45	0.21	0.1191	0.01	0.17	0.23	0.27	0.73
Air Content	39	7.11	1.4638	4.70	6.20	6.80	7.80	12.00
Concrete Temperature	41	67.39	5.6916	55.00	63.00	68.00	71.00	80.00
SAM	29	0.15	0.0742	0.04	0.09	0.12	0.21	0.28
SAM Air	24	7.23	1.8243	5.20	5.80	7.25	8.03	12.70
Slump	41	3.29	0.7663	1.75	3.00	3.50	3.75	5.00
Air Content	27	6.64	0.6283	5.50	6.10	6.60	7.10	7.80
Box Test (Voids)	2	2.00	0.0000	2.00	2.00	2.00	2.00	2.00
Concrete Temperature	27	62.81	2.6023	57.00	62.00	63.00	64.00	69.00
Microwave w/cm	1	0.40		0.40	0.40	0.40	0.40	0.40
SAM	32	0.24	0.0968	0.08	0.19	0.24	0.32	0.47
SAM Air	32	6.71	0.8079	5.30	6.10	6.70	7.23	8.30
Slump	27	1.38	0.3492	0.75	1.13	1.50	1.50	2.50
Unit Weight	27	144.57	1.1743	142.30	143.55	144.60	145.60	146.30
Vkelly Test	2	0.49	0.0636	0.44	0.46	0.49	0.51	0.53

6/10/2020: Kansas, Minnesota, Idaho, Iowa, New York, Michigan US 31, Michigan I-69, South Dakota
Hardened Properties Descriptive Statistics

Property	count	mean	std	min	25%	50%	75%	max
Surface Resistivity (Sample prep: lime water soak)	93	10.0932	0.9379	7.77	9.5	10.12	10.6	13.9
Calcium Oxychloride	5	0.216	0.1442	0.07	0.15	0.17	0.24	0.45
Hardened Air Content	25	6.4224	1.4143	3.14	5.67	6.3	7.15	8.94
Spacing Factor	25	0.006	0.0007	0.0047	0.0056	0.0058	0.0065	0.0076
Specific Surface	25	741.368	81.2212	597.9	705.2	732.3	774.3	933.2
Surface Resistivity (Resistivity Value-sample prep option A: immersion in CaOH solution)	81	12.3675	5.4222	5.4625	7.8125	10.4875	18.5	23.8
Formation Factor	23	503.5571	291.7902	0.0042	401.3734	524.6787	603.6211	1051.145
Resist Chloride Ion Penetration (RCP)	3	3021.333	850.2884	2231	2571.5	2912	3416.5	3921
Spacing Factor	43	0.0058	0.0013	0.0022	0.005	0.0056	0.0066	0.0086
Surface Resistivity (Resistivity Value-sample prep option B: sealed)	20	10.03	2.1381	7.8	8.575	9.45	10.8	15.2
Hardened Air Content	10	6.087	0.8861	4.36	5.6475	6.24	6.4925	7.36
Spacing Factor	10	0.016	0.0189	0.0022	0.0046	0.0048	0.0318	0.0475
Specific Surface	10	928.8	295.1647	717	816.5	855.5	896.5	1751
Surface Resistivity (Resistivity Value-sample prep option A: immersion in CaOH solution)	375	16.3913	2.933	7.25	14.4688	15.8625	18.3438	24
Surface Resistivity (Resistivity Value-sample prep option A: immersion in CaOH solution)	376	21.5368	3.325	13.9	19.525	21.3375	23.275	40.325
Flexural Strength	45	546.8889	129.8701	310	440	530	660	765
Maturity Meter	24	2157.833	736.78	1066	1595.75	2150.5	2726.75	3688
Compressive Strength	41	4913.281	841.8555	3007	4448	4970	5429.5	6615
Flexural Strength	19	620.5932	74.3746	458.21	568.78	656.85	678.825	697.1
Surface Resistivity (Sample Prep: Immersion in water)	20	8.935	2.7263	6.8	7.75	8.6	9.125	20
Surface Resistivity (Sample Prep: Immersion in water)	100	13.0679	4.552	6.6358	9.9955	11.6827	14.6735	34
Compressive Strength	6	7873.193	898.2517	6771	7081.584	8150.08	8451.955	8890
F-T Durability Factor	4	86.2005	4.6723	79.6638	85.3027	87.1878	88.0856	90.7626
Hardened Air Content	11	6.6409	0.7234	5.46	6.29	6.74	7.115	7.76
Initial	2	0.0015	0.0001	0.0014	0.0014	0.0015	0.0016	0.0016
Secondary	2	0.0005	0	0.0005	0.0005	0.0005	0.0005	0.0005
Spacing Factor	11	0.0067	0.001	0.0057	0.006	0.0066	0.0072	0.0088
Special Surface	11	690.9031	65.7647	562.61	662.051	702.31	738.124	773.176
Surface Resistivity (Resistivity Value-sample prep option A: immersion in CaOH solution)	130	11.2839	2.0157	6.9	9.8125	11.0125	12.6188	16.725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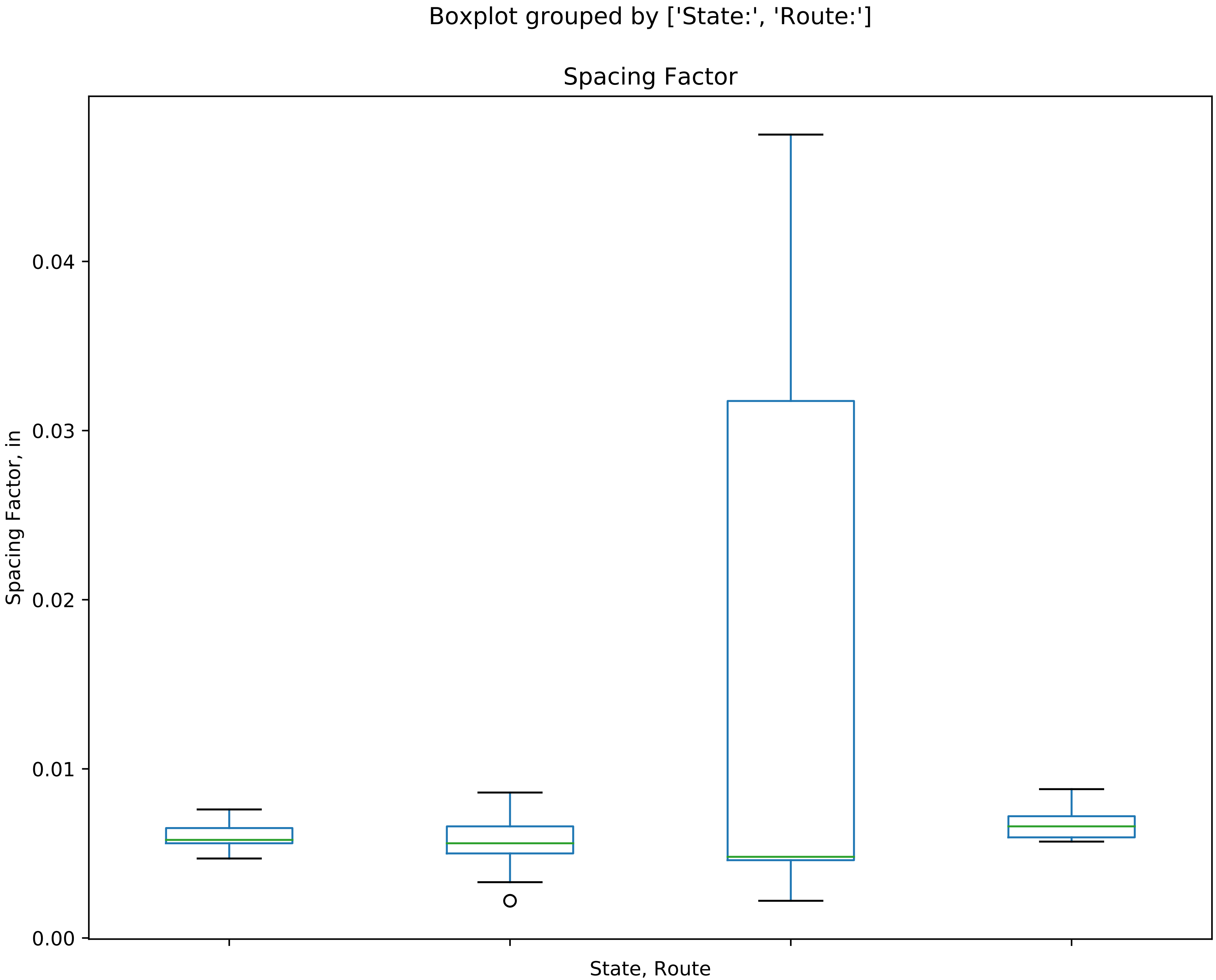
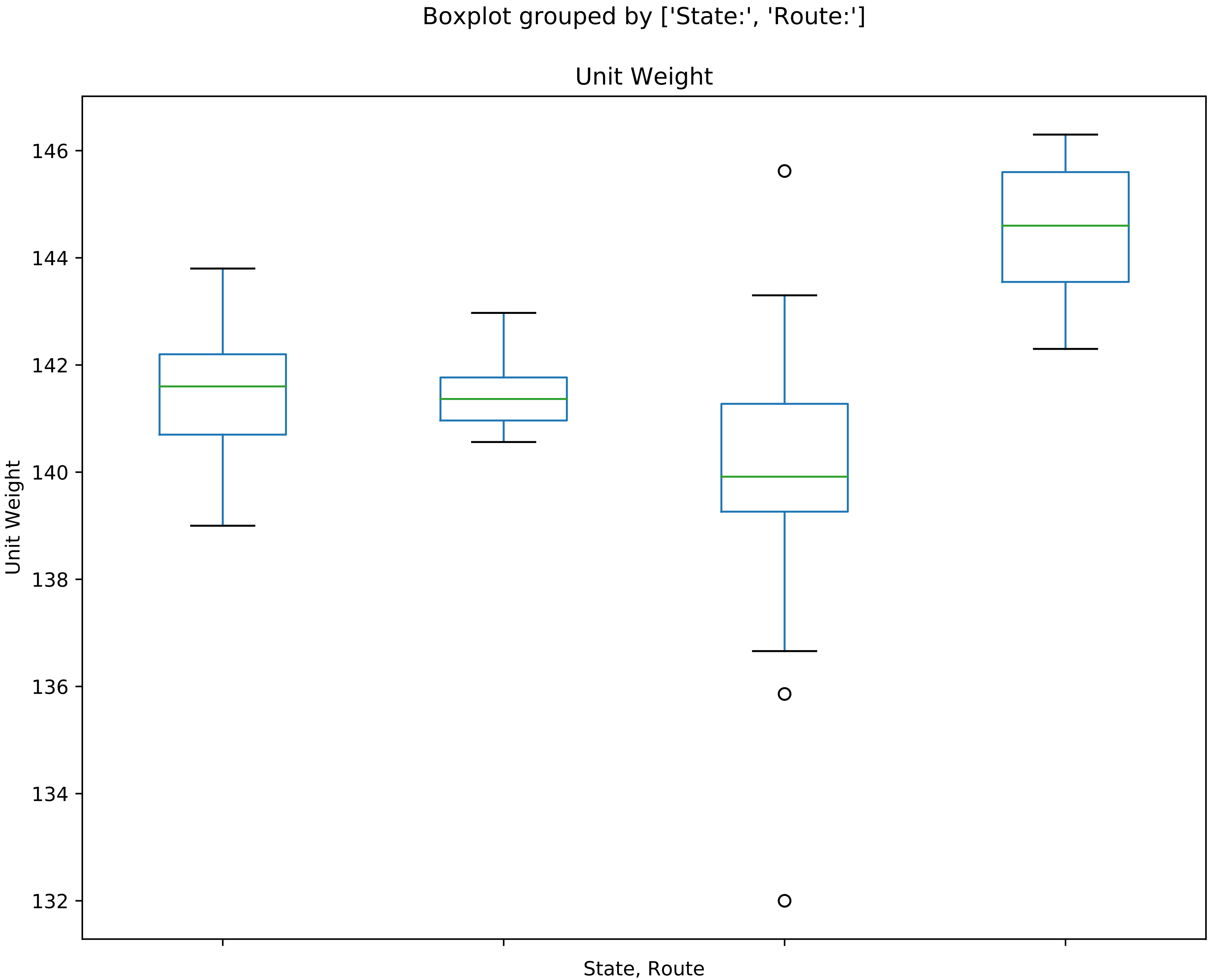
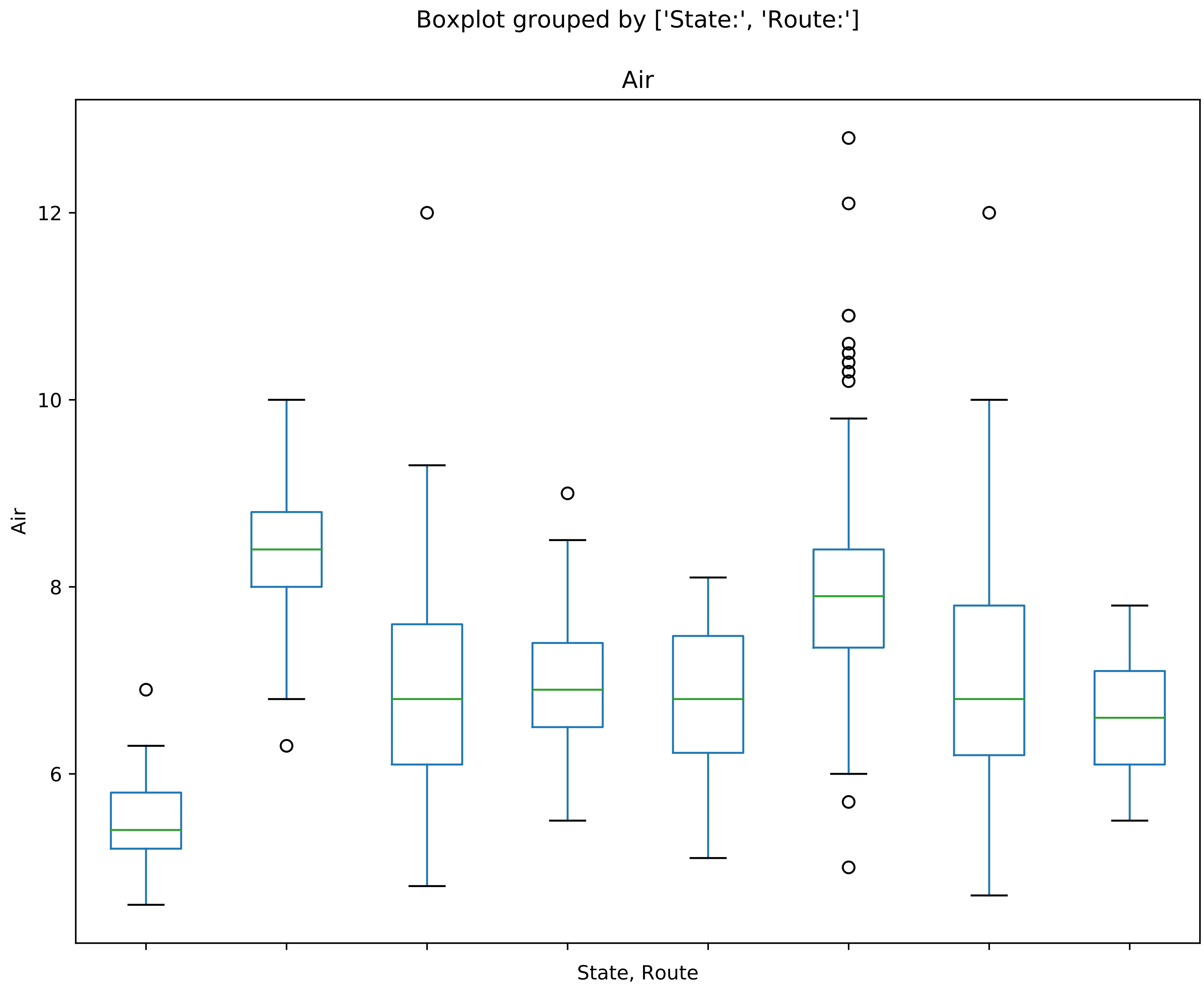
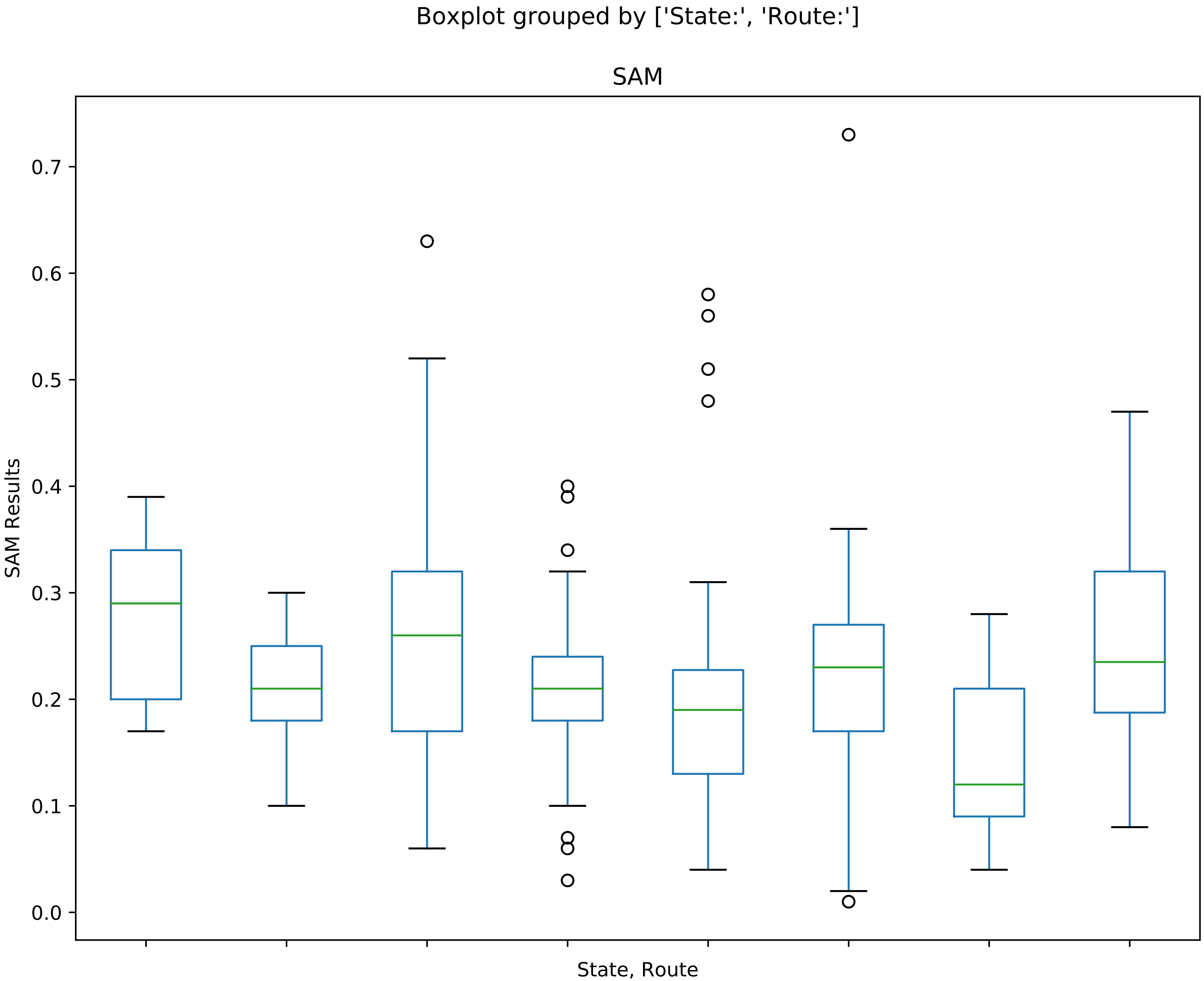
Slump
Slump, in
6
5
4
3
2
1
State, Route

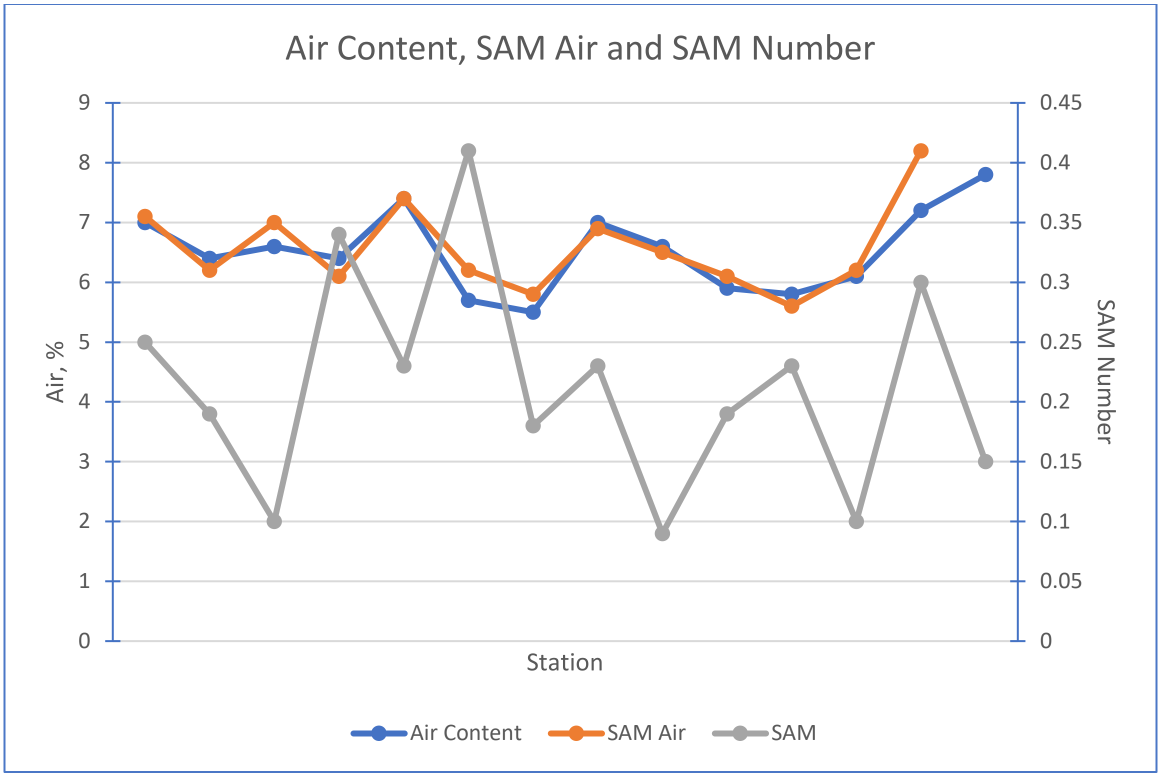

Boxplot grouped by ['State:', 'Route:']
Spacing Factor
Spacing Factor, in
0.00
0.01
0.02
0.03
0.04
State, Route

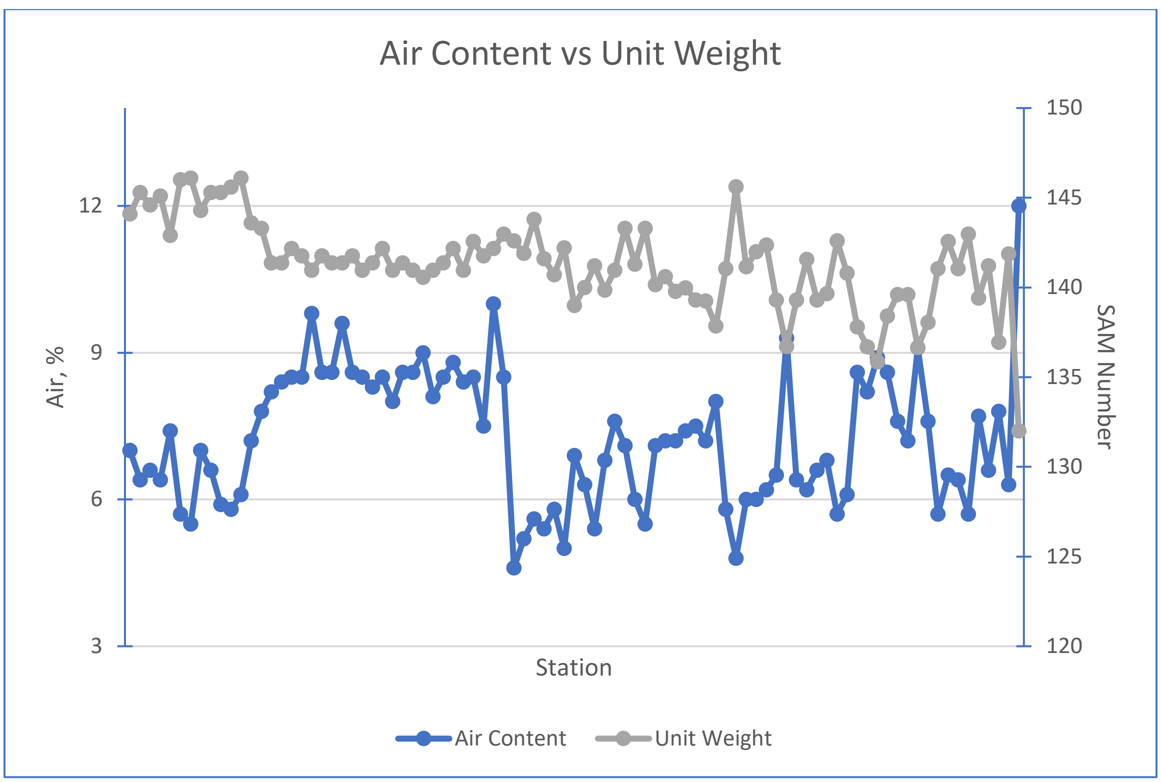


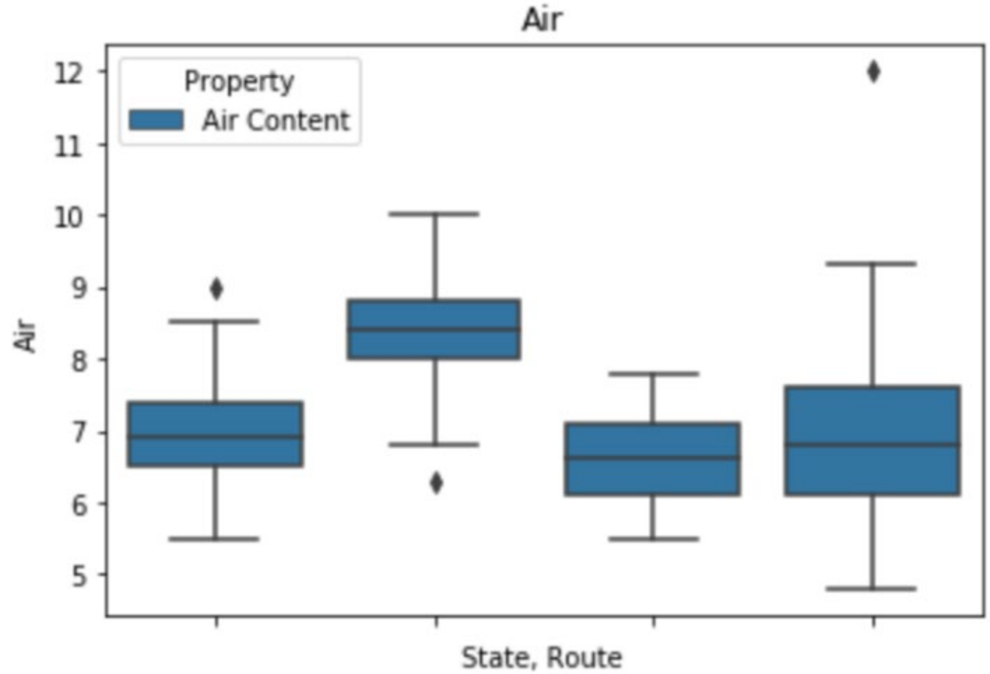
Boxplot grouped by ['State:', 'Route:']
Unit Weight
Unit Weight
146
144
142
140
138
136
134
132
State, Route

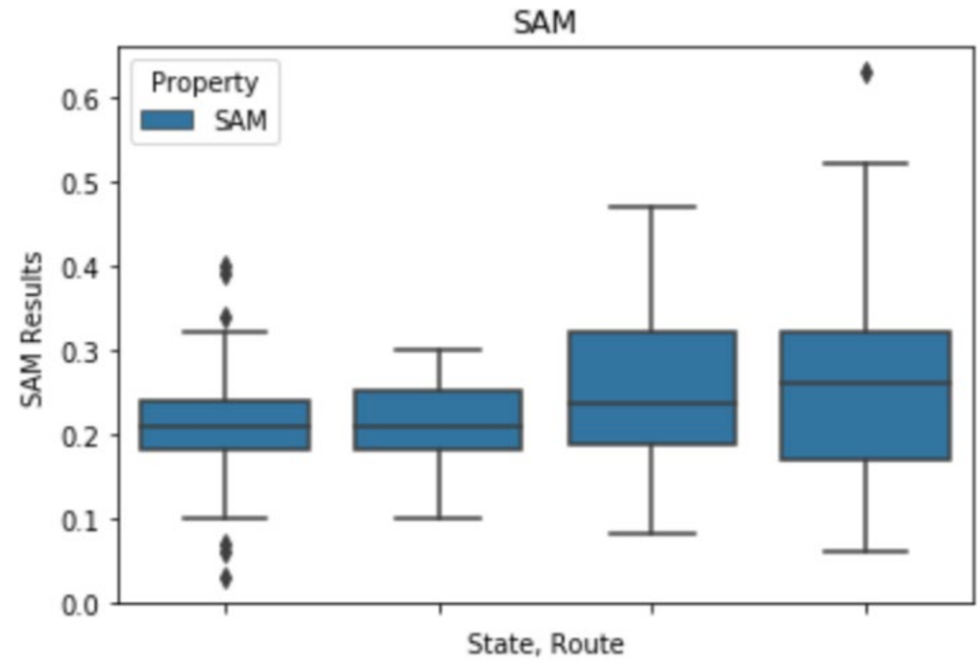

Boxplot grouped by ['State:', 'Route:']
Air
12
10
8
6
Air
State, Route

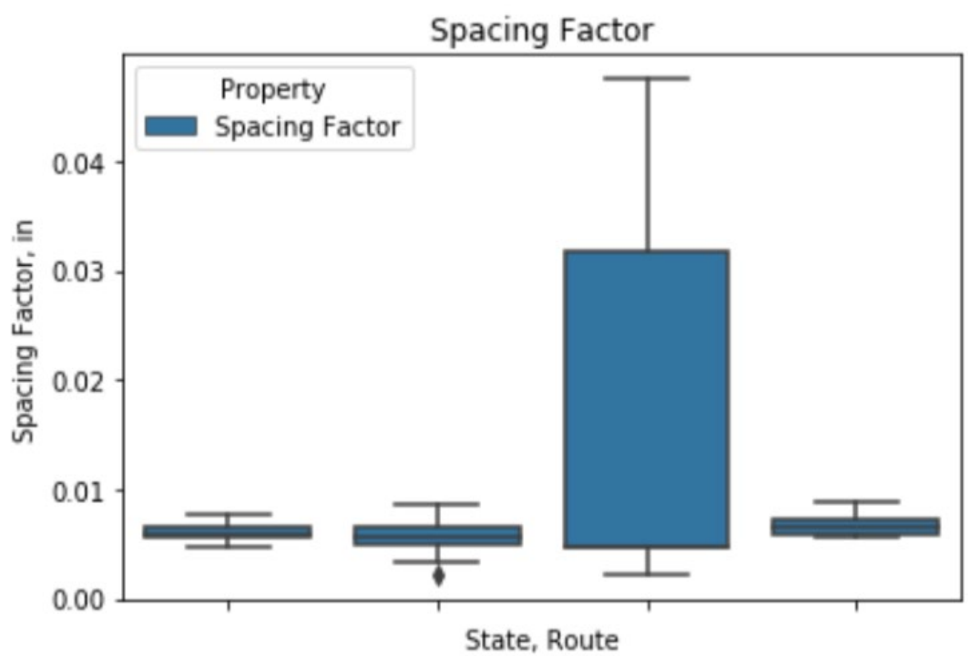

Boxplot grouped by ['State:', 'Route:']
SAM
SAM Results
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
State, Route

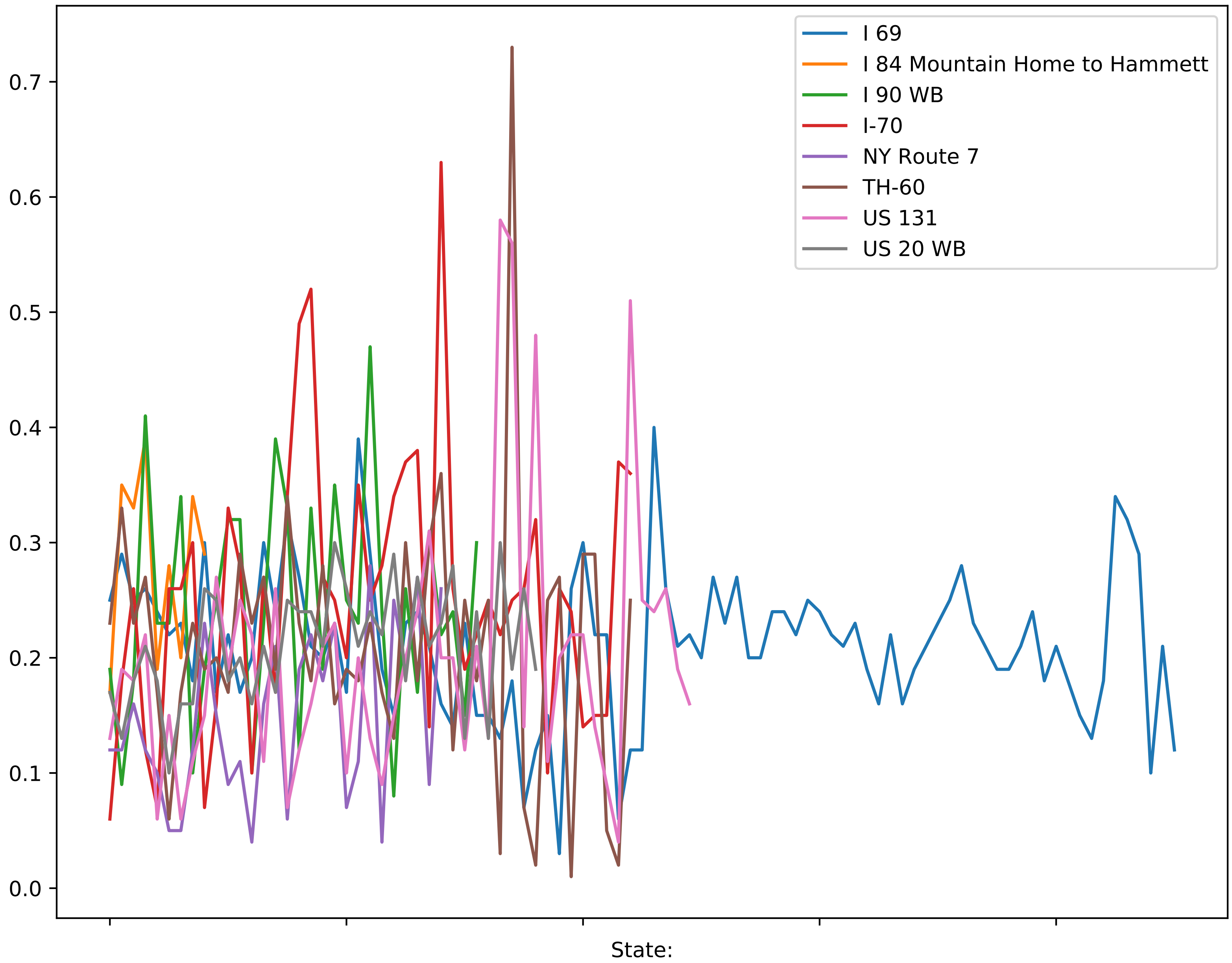

Air Content, SAM Air and SAM Number
Air, %
SAM Number
Station
9
8
7
6
5
4
3
2
1
0
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Air Content
SAM Air
SAM


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


Air
Property
Air Content
Air
12
11
10
9
8
7
6
5
State, Route


SAM
Property
SAM
SAM Results
0.6
0.5
0.4
0.3
0.2
0.1
0.0
State, Route


Spacing Factor
Property
Spacing Factor
Spacing Factor, in
0.04
0.03
0.02
0.01
0.00
State, Route



0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
State:
I 69
I 84 Mountain Home to Hammett
I 90 WB
I-70
NY Route 7
TH-60
US 131
US 20 WB

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

Tara Cavalline, Brett Tempest, Brian Hunter

PEM Industry Technical Advisory Committee Meeting

July 22, 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 mixtures 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

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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

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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

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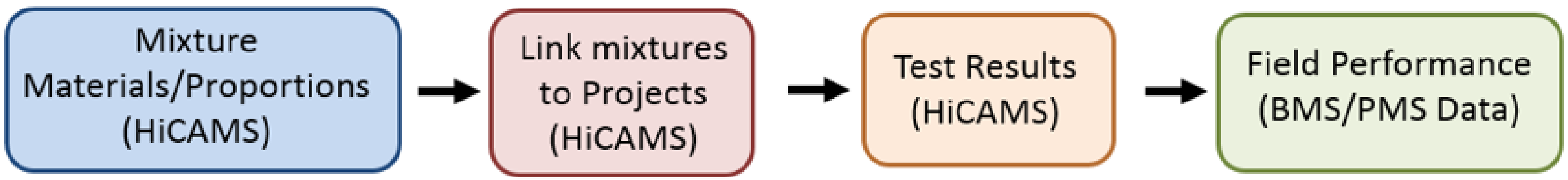
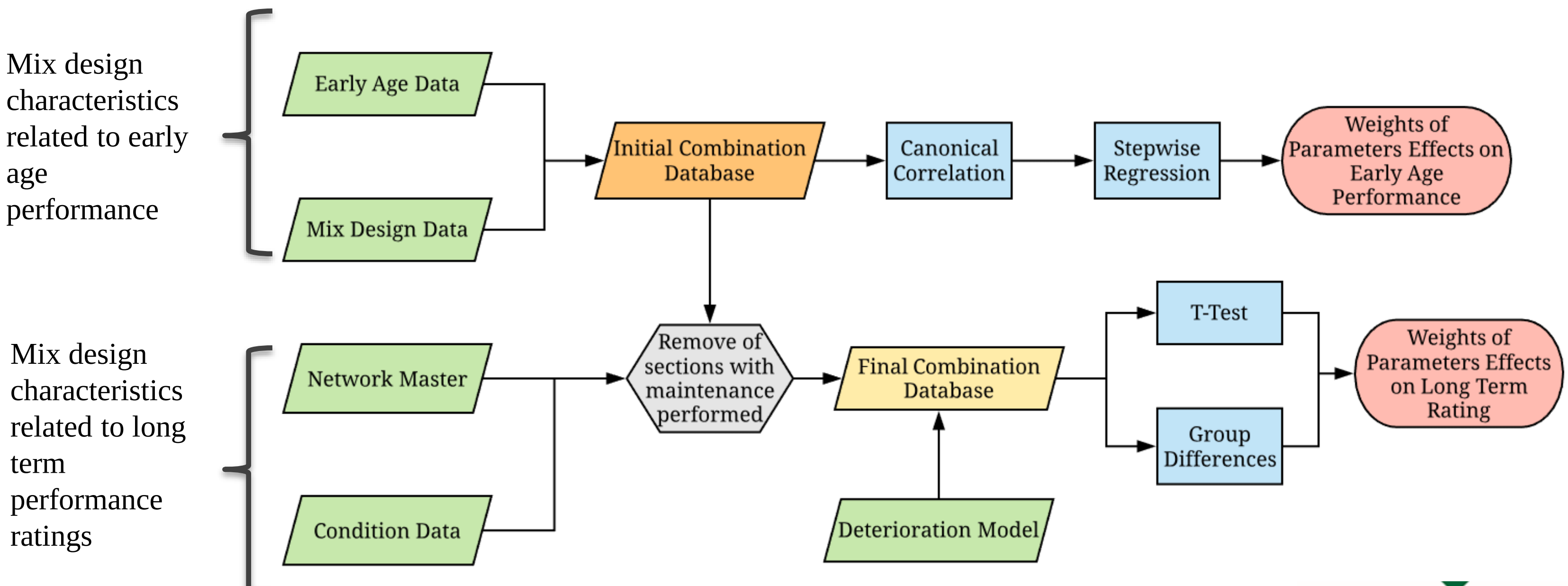
RP 2018-14 Project Objectives

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.





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
   - support a better understanding the potential enhanced durability and economy
   - provide additional justification for use.

4. Develop specification provisions for:
   - surface resistivity
   - shrinkage
   - early age strength for opening of pavements and bridge components

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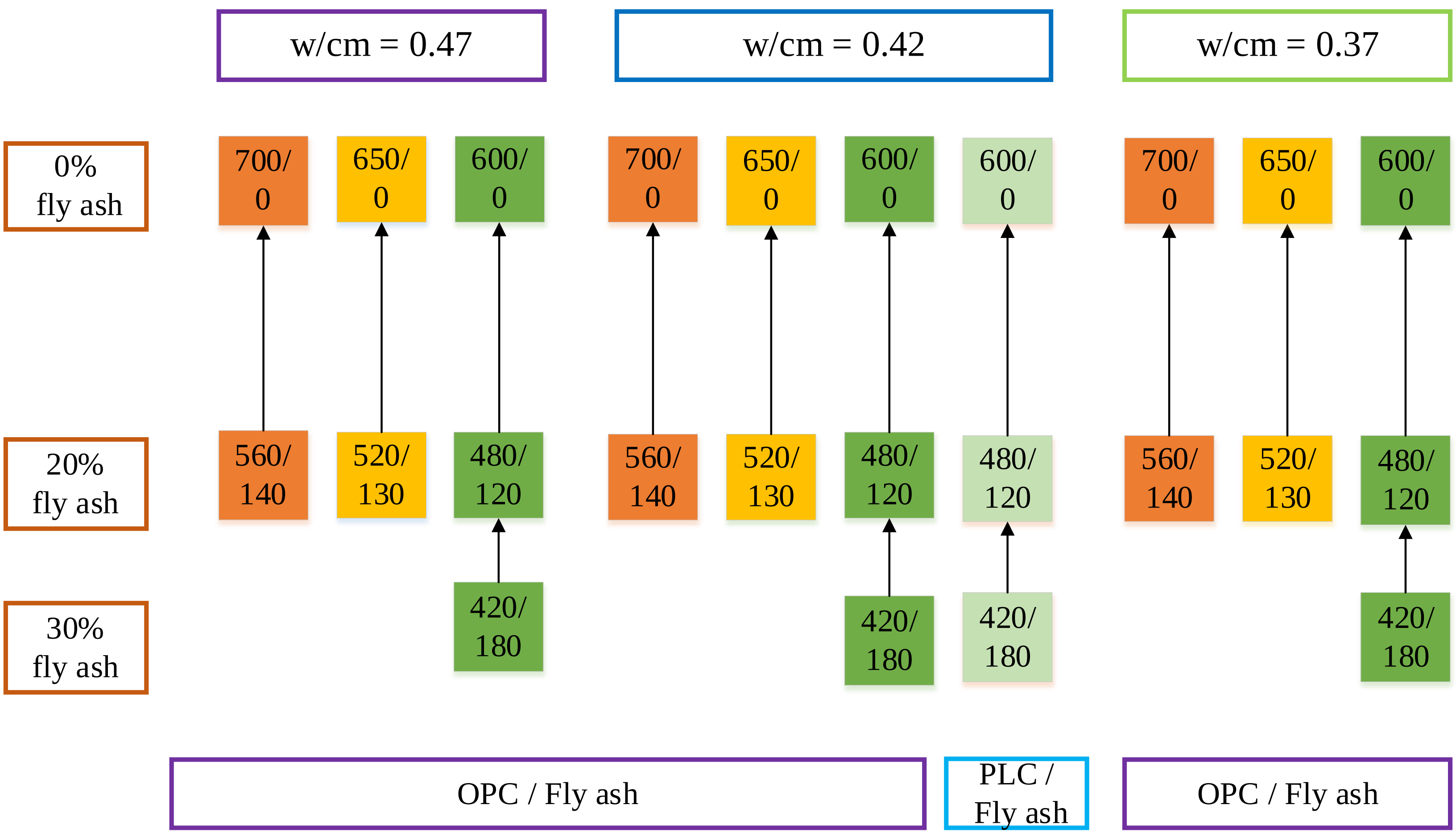
Mixture Matrix

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

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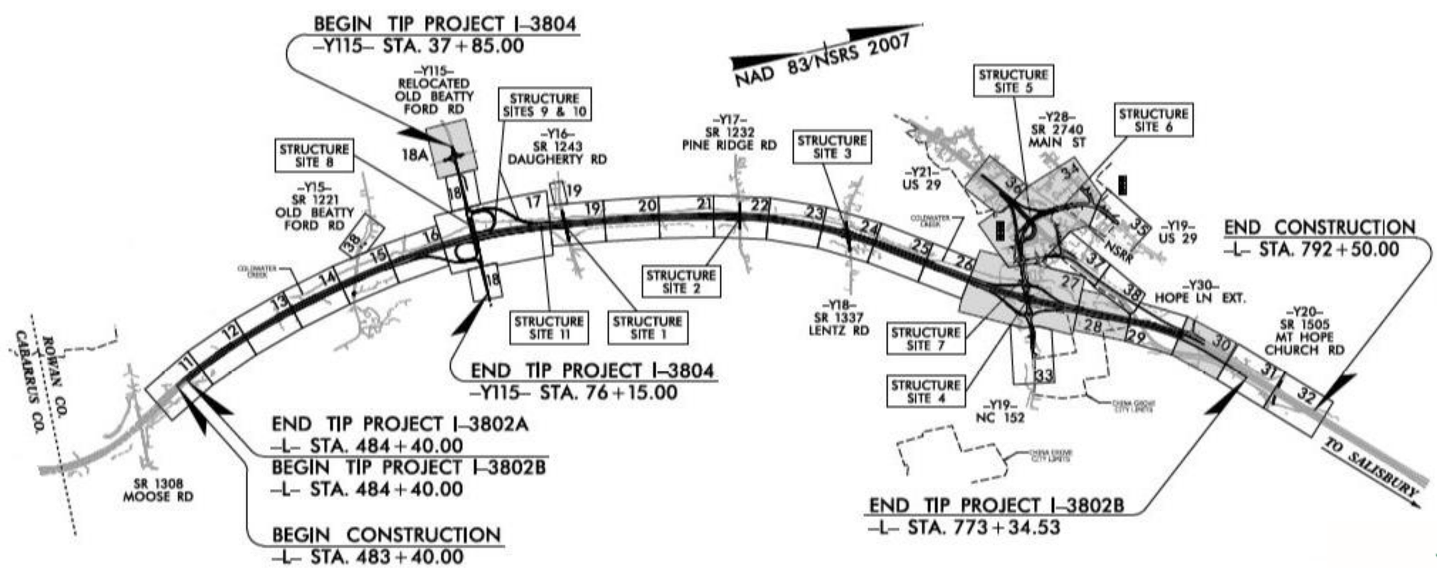
FHWA Implementation Project

- 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

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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

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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

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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!

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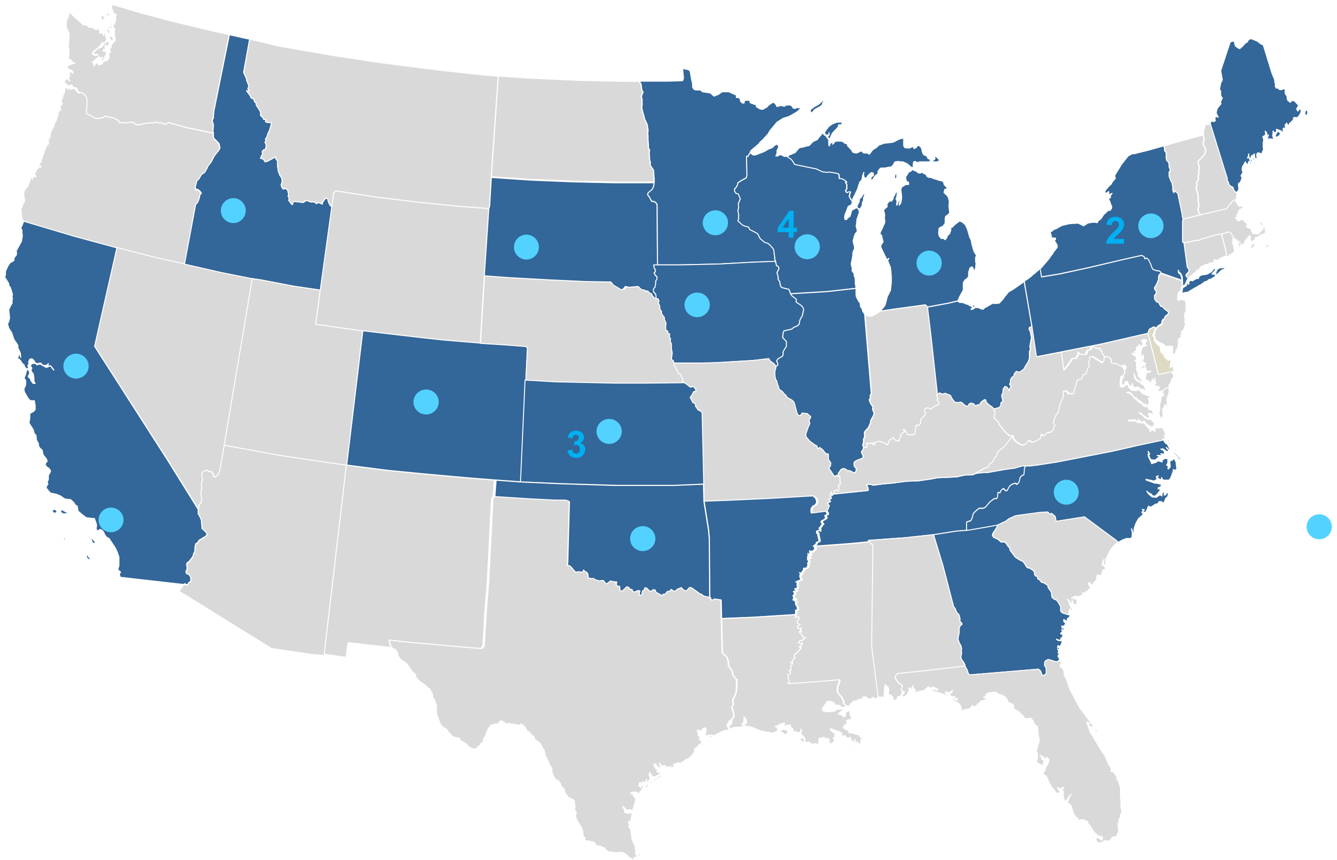
PEM PROGRESS – Training



- 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
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