FHWA Program Update

NATIONAL CONCRETE CONSORTIUM
SEPTEMBER 10, 2019 • KALISPELL, MT

MICHAEL F. PRAUL, P.E. AND GINA AHLSTROM
FHWA, OFFICE OF PRECONSTRUCTION, CONSTRUCTION, & PAVEMENTS

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

Unless otherwise noted, FHWA is the source of all images in this presentation.

Schultz

Schultz and Isabella

FHWA/ACI Workshops

- FREE to the host
- Host provides: Room, projector, attendees
- Under a cooperative agreement, FHWA/ACI provide instructors, all training materials
- 1-2 month lead time
- States may request multiple presentations
- Agreement expires September 18, 2020
- Contact: Tom Yu
  - tom.yu@dot.gov
  - (202) 366-1198

Chemical Admixtures for Concrete

Chemical Admixtures for Concrete

FHWA/ACI
One-day seminar

Location ▸

A facility of your choosing

Registration: 7:45 a.m.
Workshop: 8:00 a.m. - 5:00 p.m.

Continuing Education

Attendees receive 0.75 CEUs (7.5 PDHs).

Seminar Overview

This seminar, presented under a cooperative agreement between the Federal Highway Administration (FHWA) and the American Concrete Institute (ACI), will refresh and extend the practitioners' knowledge and understanding of chemical admixtures used in concrete. The two presenters listed below will clearly explain the benefits and limitations of chemical admixtures in concrete for pavements, bridges, and other transportation-related structures. This information will help designers understand the positive and negative effects of various types of admixtures and help construction personnel identify and prepare for possible issues in the field. In addition, a local representative will provide an overview of the particular practices and issues that are most common in the geographic area.

Who Should Attend

The variety of topics covered make this seminar beneficial to a broad range of attendees including DOT engineers, civil engineers, material testing technicians, specifiers, project superintendents, construction supervisors, QA/QC managers, inspectors, contractors, and concrete producers.

Topics to be covered

- Introduction to Chemical Admixtures
- Air Entrainment of Concrete
- Water Reduction and Set-Controlling Admixtures
- Durability-Enhancing Admixtures
- Special Admixtures: Viscosity-Modifying and Rheology-Controlling
- Compatibility Issues Between Chemical Admixtures and Other Concreting Materials
- Admixtures for High-Performance Concrete

Free Resource Materials

- ACI 212.3R, "Chemical Admixtures for Concrete"
- ACI 212.4R, "Guide for the Use of High-Range Water-Reducing Admixtures (Superplasticizers) in Concrete"
- ACI 305R, "Hot Weather Concreting"
- ACI 305.1, "Specification for Hot Weather Concreting"
- ACI 306R, "Cold Weather Concreting"
- ACI 306.1, "Standard Specification for Cold Weather Concreting"
- ACI Education Bulletin E4, Chemical Admixtures for Concrete
- PCA Design and Control of Concrete Mixtures – 14th Edition (Chapter 6)
- Glossary of Terms (from ACI's website)

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Advancing concrete knowledge

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Faculty

Two of the following will be your instructors:

Darrell F. Elliot, FACI, is a Technical Service Manager with Buzzi Unicem USA, Metairie, LA, and has over 30 years of experience in the concrete construction industry. He is the Chair of ACI Committee 233, Ground Slag in Concrete, and serves on several ACI committees for mass concrete, materials, certification, and education. He was named an ACI Fellow in 1999. He has served as President of the ACI Louisiana Chapter. He is also an active member of ASTM International, serving on committees for cement, concrete and concrete aggregates, and concrete pipe. He has been an instructor for PCA and NRMCA training programs.

Charles K. Nmai, PhD, PE, FACI, is Manager of Engineering Services at BASF Construction Chemicals, LLC, a leading manufacturer of specialty construction chemicals headquartered in Cleveland, OH. His duties include providing technical leadership and strategic guidance in the marketing of admixtures and high-performance concrete technologies, and troubleshooting concrete problems. He is also actively involved in high-performance concrete technology transfer activities. He is a past member of the ACI Board of Direction and Educational Activities Committee; past Chair of ACI Committees E701, Materials for Concrete Construction, and 222, Corrosion of Metals in Concrete; and a member of numerous ACI, ASTM, and PCI committees.

Celik Ozyildirim, FACI, is a Principal Research Scientist with the Virginia Transportation Research Council in Charlottesville, VA, a division of the Virginia Department of Transportation (VDOT). He received his PhD in civil engineering from the University of Virginia. He has been conducting research in concrete technology for over 30 years. He is active in ACI, ASTM International, and the Transportation Research Board (TRB). Ozyildirim is a past Chair of the TRB section on concrete and member emeritus of TRB Committee AFN10, Basic Research and Emerging Technologies Related to Concrete. He is an instructor in civil engineering at the University of Virginia and is a registered professional engineer in Virginia.

Paul J. Tikalsky, PhD, PE, FACI, is the new Dean for the College of Engineering, Architecture and Technology at Oklahoma State University. He received his BS in civil and environmental engineering at the University of Wisconsin at Madison and his MS and PhD in structural engineering at the University of Texas at Austin. He serves on FHWA's High-Performance Concrete Implementation Task Force and its Concrete Pavement Oversight Group. He has received numerous awards, including Utah Engineering Educator of the year, and is a trained ABET Program Evaluator.

Michelle Wilson is Director of Concrete Knowledge at the Portland Cement Association (PCA), where she is responsible for PCA's education and training programs and technical products covering concrete technology and cement manufacturing. Prior to joining PCA in 1999, she worked for Construction Technology Laboratories. She is a member of ACI Committees 201, Durability of Concrete; 301, Specifications for Concrete; and 311, Inspection of Concrete. She was awarded the prestigious ACI Young Member Award for Professional Achievement in 2008 and received her BS in architectural engineering from Milwaukee School of Engineering, with an emphasis in structural engineering and concrete materials.

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Cementitious Materials for Concrete

Cementitious Materials for Concrete

FHWA/ACI
One-day seminar

Location ▸

A facility of your choosing

Registration: 7:45 a.m.
Workshop: 8:00 a.m. - 5:00 p.m.

Continuing Education

Attendees receive 0.75 CEUs (7.5 PDHs).

(Photo Courtesy of FIGG Bridge Engineers, Inc., and Tim Davis)

Seminar Overview

This seminar, presented under a cooperative agreement between the Federal Highway Administration (FHWA) and the American Concrete Institute (ACI), will refresh and extend the practitioners' knowledge and understanding of cementitious materials used to make concrete. The presenters will clearly explain the attributes of various cementitious materials that affect performance, design, and construction and how chemical reactions and hydration processes impact the performance of both plastic and hardened concrete. This information will help design personnel select and specify the proper cementitious materials for a particular project and help construction personnel understand and prepare for the field behavior of concrete mixtures containing various cementitious materials. In addition, a local representative will provide an overview of the particular practices and issues that are most common in the geographic area.

Who Should Attend

The variety of topics covered make this seminar beneficial to a broad range of attendees including DOT engineers, civil engineers, material testing technicians, specifiers, project superintendents, construction supervisors, QA/QC managers, inspectors, contactors, and concrete producers.

Topics to be covered

- Cementitious and Pozzolanic Materials
- Cement Manufacturing, Process & Properties
- Cementitious Materials Specifications
- Hydration Mechanisms
- Concrete Properties
- Influence of Cementitious Materials on Concrete
- Regional Issues
- Future Trends

Free Resource Materials

- ACI 211.1, Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete
- ACI 225R, Guide to the Selection and Use of Hydraulic Cements
- ACI 232.2R, Use of Fly Ash in Concrete
- ACI 233R, Slag Cement in Concrete and Mortar
- ACI 234R, Guide for the Use of Silica Fume in Concrete
- ACI Education Bulletin E3, Cementitious Materials For Concrete
- Integrated Materials and Construction Practices for Concrete Pavements (Chapter 4)
- Glossary of Terms (from ACI's website)

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Cementitious Materials for Concrete

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David M. Suchorski, PE, FACI, is Senior Technical Services Manager/Sales Manager for the Ash Grove Cement Company, Des Moines, IA, and has over 30 years of experience in the cement and concrete industries. He serves on the ACI Board of Direction and is Chair of ACI Committee 308, Curing Concrete. He is also a member of several ACI committees for materials, concrete, certification, and education. He was named a Fellow of ACI in 2010. He has served as President of the ACI Kansas and Iowa-Minnesota chapters and is a member of the ACI Iowa, Nebraska, and Kansas chapters. He is a licensed professional engineer in Kansas and Wisconsin.

Paul J. Tikalsky, PhD, PE, FACI, is the new Dean for the College of Engineering, Architecture and Technology at Oklahoma State University. He received his BS in civil and environmental engineering at the University of Wisconsin at Madison and his MS and PhD in structural engineering at the University of Texas at Austin. He serves on FHWA's High-Performance Concrete Implementation Task Force and its Concrete Pavement Oversight Group. He has received numerous awards, including Utah Engineering Educator of the year, and is a trained ABET Program Evaluator.

Oscar Tavares has more than of 30 years of knowledge and work experience in the cement and concrete industries. He is experienced in new plant start-up, possesses technical expertise in manufacturing portland cement, and has been involved in new product development and direct sales. He presently runs his own consulting company, Innovative Alternatives LLC, which provides expertise and consulting services to the cement and concrete industries. Tavares holds a BS Degree in chemistry from the University of Texas at El Paso.

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Performance Mixtures for Sustainable Concrete

Performance Mixtures for Sustainable Concrete

FHWA/ACI
One-day Workshop

Location ▶
Nevada Department of Transportation
District 1 — Training Room B
123 E. Washington Avenue
Las Vegas, NV 89101

Tuesday, Sept. 26, 2017
Registration: 7:45 a.m.
Workshop: 8:00 a.m. - 4:30 p.m.

Continuing Education
Attendees receive 0.75 CEUs (7.5 PDHs).

To register for the workshop, contact:
Mario C. Gomez, NDOT
Phone: +1.702.385.6502
E-mail: mgomez@dot.nv.gov

Workshop Overview

This Workshop, developed under a cooperative agreement between the Federal Highway Administration (FHWA) and the American Concrete Institute (ACI), will focus on steps DOTs can take toward improving the quality of their concrete pavements by specifying the performance they want. While many associate improved performance with longer life, other aspects such as reduced maintenance, earlier opening to traffic, or improved sustainability will also likely be significant contributing factors. The presenters will first summarize the background of performance specifications and the current state of testing methods for concrete performance. The presenters will then facilitate a discussion of the process of moving to performance specifications. Participants will then break into groups to discuss what a performance specification for their state would look like. Finally, performance specification implementation experiences by other states and the steps needed for implementation in the host state will be discussed.

Who Should Attend

Performance specifications affect all the parties involved in a project. Participation by a wide range of parties will benefit the discussion. Attendance by DOT management, DOT engineers, pavement contractors, consultants, material suppliers, and testing lab personnel is highly recommended.

Topics to be covered

- Evolution of specifications and concrete technology
- Motivation to advance performance specifications
- Implement issues
- Performance properties of fresh and hardened concrete
- Testing methods for performance properties
- Transitioning to performance specifications
- Elements of a performance specifications
- Acceptance criteria
- Examples of performance specification implementation
- Steps to introducing performance specification

Free Resource Materials

- Slide handout
- ACI 329R-14, "Report on Performance-Based Requirements for Concrete"

American Concrete Institute
Always advancing

Performance Mixtures for Sustainable Concrete

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To register for the workshop, contact:
Mario C. Gomez, NDOT
Phone: +1.702.385.6502
E-mail: mgomez@dot.nv.gov

Faculty

Cecil L. Jones is President of Diversified Engineering Services, Inc., located in Raleigh, NC, and has over 40 years of experience in construction and materials related to transportation. He provides quality management services to clients along with specification development, research, new technology development support, training, and general consulting services.

Prior to establishing Diversified Engineering Services, he worked with the North Carolina DOT for over 30 years with assignments ranging from field construction engineering to the position of State Materials Engineer, with responsibility for the overall management of the materials quality system for the Department's 80,000-mile state-maintained highway system.

Cecil received his BS in civil engineering from North Carolina State University and is a licensed professional engineer in North Carolina. He is active in several professional organizations including ACI, AASHTO, and ASTM International.

Tyler Ley, FACI, has more than 16 years of experience in the field of cement-based materials. He has worked as an engineer with a design consultant, construction contractor, government agency, and as a professor. This practical experience blended with his technical expertise has elevated both his teaching and research.

His research focuses on studying the durability and construction of cement based materials. His research has developed national and state specifications, test methods, and policy changes. Some of the technologies developed in his research lab include: The Super Air Meter, the Box Test, the Tarantula Curve, Pulpcure, Ctags, and a new method to classify fly ash.

Ley is a fellow of American Concrete Institute and the American Ceramic Society and has received several national awards, including the NSF Career Award, the ACI Faculty Achievement Award, and the Regents Research Award from Oklahoma State University.

Paul J. Tikalsky, PhD, PE, FACI, is Dean of the College of Engineering, Architecture and Technology at Oklahoma State University. He received his BS in civil and environmental engineering at the University of Wisconsin–Madison and his MS and PhD in structural engineering at the University of Texas at Austin. He serves on FHWA's High-Performance Concrete Implementation Task Force and its Concrete Pavement Oversight Group. He has received numerous awards, including Utah Engineering Educator of the Year.

American Concrete Institute
Always advancing

Self-Consolidating Concrete

Self-Consolidating Concrete

FHWA/ACI
One-day seminar

Location ▸

A facility of your choosing

Registration: 7:45 a.m.
Workshop: 8:00 a.m. - 5:00 p.m.

Continuing Education
Attendees receive 0.75 CEUs (7.5 PDHs).

Seminar Overview

This seminar, presented under a cooperative agreement between the Federal Highway Administration (FHWA) and the American Concrete Institute (ACI), will provide highway and transportation personnel with a comprehensive understanding of self-consolidating concrete (SCC). The two presenters listed below will clearly explain how SCC can be used to produce better and more durable concrete in transportation structures. In addition, a local representative will provide an overview of projects in the geographic area that have used SCC and relate their experience working with the material.

Who Should Attend

The variety of topics covered make this seminar beneficial to a broad range of attendees including DOT engineers, civil engineers, material testing technicians, specifiers, project superintendents, construction supervisors, QA/QC managers, inspectors, contractors, and concrete producers.

Topics to be covered

- History and Basic Overview
- Standardization Efforts and SCC Test Methods
- Materials and Mixture Proportioning Considerations
- Fresh and Hardened Properties of SCC
- Applications and Economic Benefits of SCC
- SCC in Drilled Shaft Construction
- Constructibility Issues/Formwork Pressure
- Specification Considerations

Faculty

Charles Nmai, PhD, PE, FACI, is Manager of Engineering Services at BASF Construction Chemicals, LLC, a leading manufacturer of specialty construction chemicals headquartered in Cleveland, OH. His duties include providing technical leadership and strategic guidance in the marketing of admixtures and high-performance concrete technologies, and troubleshooting concrete problems. He is also actively involved in high-performance concrete technology transfer activities. He is a Fellow of ACI; a past member of the ACI Board of Direction and Educational Activities Committee; Past Chair of ACI Committees E701, Materials for Concrete Construction, and 222, Corrosion of Metals in Concrete; and a member of other ACI, ASTM, and PCI committees.

Anton K. Schindler, PhD, PE, is the Gottlieb Associate Professor at Auburn University where he teaches courses in engineering mechanics, structural design, and concrete materials in the Civil Engineering Department. He received his MS and PhD in civil engineering from The University of Texas at Austin. He is a member of TRB's Technical Committee AFN20, Properties of Concrete, and a member of ACI Committees 231, Properties of Concrete at Early Ages, and 237, Self-Consolidating Concrete. He was a panel member on NCHRP Project 18-12 "Self-consolidating concrete for precast, prestressed concrete bridge elements." He is an active member of ACI, TRB, ASCE, RILEM, and ASTM and received ACI's Wason Medal for Concrete Materials Research in 2006.

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Implementing PEM

Prescriptive

- Agency dictates how the material or product is formulated and constructed
- Based on past experience
- Minimal/uncertain ability to innovate
- Requires agency to have proper manpower and skill set to provide oversight

Performance

- Agency identifies desired characteristics of the material or product
- Contractor controls how to provide those characteristics
- Maximum ability to innovate
- Reduced oversight burden on the agency

Accelerate Implementation and Deployment of Pavement Technologies

FAST Act Section 503 (c)(3)

(B) Goals.- The goals of accelerated implementation and deployment of pavement technologies program shall include-

- (i) the deployment of **new, cost-effective designs, materials, recycled materials, and practices** to extend the pavement life and performance and to improve user satisfaction;
- (ii) the reduction of **initial costs and lifecycle costs** of pavements, including the costs of new construction, replacement, maintenance, and rehabilitation;
- (iii) the deployment **of accelerated construction techniques** to increase safety and reduce construction time and traffic disruption and congestion;
- (iv) the deployment of **engineering design criteria and specifications** for new and efficient practices, products, and materials for use in highway pavements;
- (v) the deployment of **new nondestructive and real-time pavement evaluation** technologies and **construction techniques**; and
- (vi) the effective **technology transfer** and information dissemination to accelerate implementation of new technologies and to improve life, performance, cost effectiveness, safety, and user satisfaction.

FHWA Cooperative Agreement with Iowa State University

Advancing Concrete Pavement Technology Solutions

The purpose of the Agreement is to…

- Deploy innovative technologies to improve pavement performance
- Develop and transfer new technologies
- Deliver tools and guidance documents to States to support the increased knowledge of concrete materials, concrete pavement design, construction, and maintenance

FHWA Cooperative Agreement with Iowa State University

Funding

Federal Share – $6,994,330

Non-Federal Share – $2,331,445

Total Agreement – $9,325,775

Federal Funds Obligated – $1,398,866

Period of Performance

60 Months

FHWA Cooperative Agreement with Iowa State University

Six Work Areas

1. Extending pavement life and performance
2. Reduction of initial costs and lifecycle costs of pavements
3. Deployment of accelerated construction techniques
4. Deployment of design criteria and specifications for new practices/products/techniques
5. Deployment of non-destructive testing and real-time pavement evaluation techniques
6. Technology transfer and information dissemination

Work Order Procurement Requests (WOPRs)

WOPR No. 01 – Recycling and Reuse of Waste Products

(Work Area 1 – Awarded)

- Technical Guidance on Use of Reclaimed Fly Ash and Natural Pozzolans
- Use of Construction Byproducts
- Use of Recycled Concrete Aggregate in Concrete Mixtures
- Industrial Waste Byproducts

FHWA Cooperative Agreement with Iowa State University

Work Order Procurement Requests (WOPRs)
WOPR No. 02 – Performance Engineered Pavements
(Work Area 4 – Pending ISU response)

- Performance Engineered Mixtures (PEMs)/AASHTO PP84
  - Guidance on PEM and QC
- Precision and Bias Statements

FHWA Cooperative Agreement with Iowa State University

Work Order Procurement Requests (WOPRs)
WOPR No. 03 – Reduction of Costs
(Work Area 2 – Pending FHWA submittal)

- Preservation Strategies and Technologies
- Rehabilitation with Concrete Overlays
- Continuously Reinforced Concrete Pavements and Overlays

What More Is Needed?

- Construction?
- Safety?
- Non-destructive technologies?
- Design criteria?

Research Needs

TRB AFN 30- Durability of Concrete
Chair- Gina Ahlstrom

Image: Pixabay

What would you like to see brought forward through TRB as a research need?

Statistical Analysis of Materials (SAM) and Percent Within Limits (PWL)

ROBERT CONWAY, PE, CCM
SR. PAVEMENT AND MATERIALS ENGINEER
FHWA, RESOURCE CENTER

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

Concrete Acceptance for Durability

- How do we accept concrete?
  - Slump
  - Temperature
  - Air
  - Strength
  - Thickness
  - Ride
- How do we adjust price?
  - Strength

Image: Pixabay

Concrete Acceptance for Durability

We are getting what we are willing to accept.

- We're getting strong concrete.
- We're not getting durable concrete.

Concrete Acceptance for Durability

Quality Control
Selective in material sources
Superior workmanship

Additional Cost

$$$$$$$$$$$$$

LOW BID

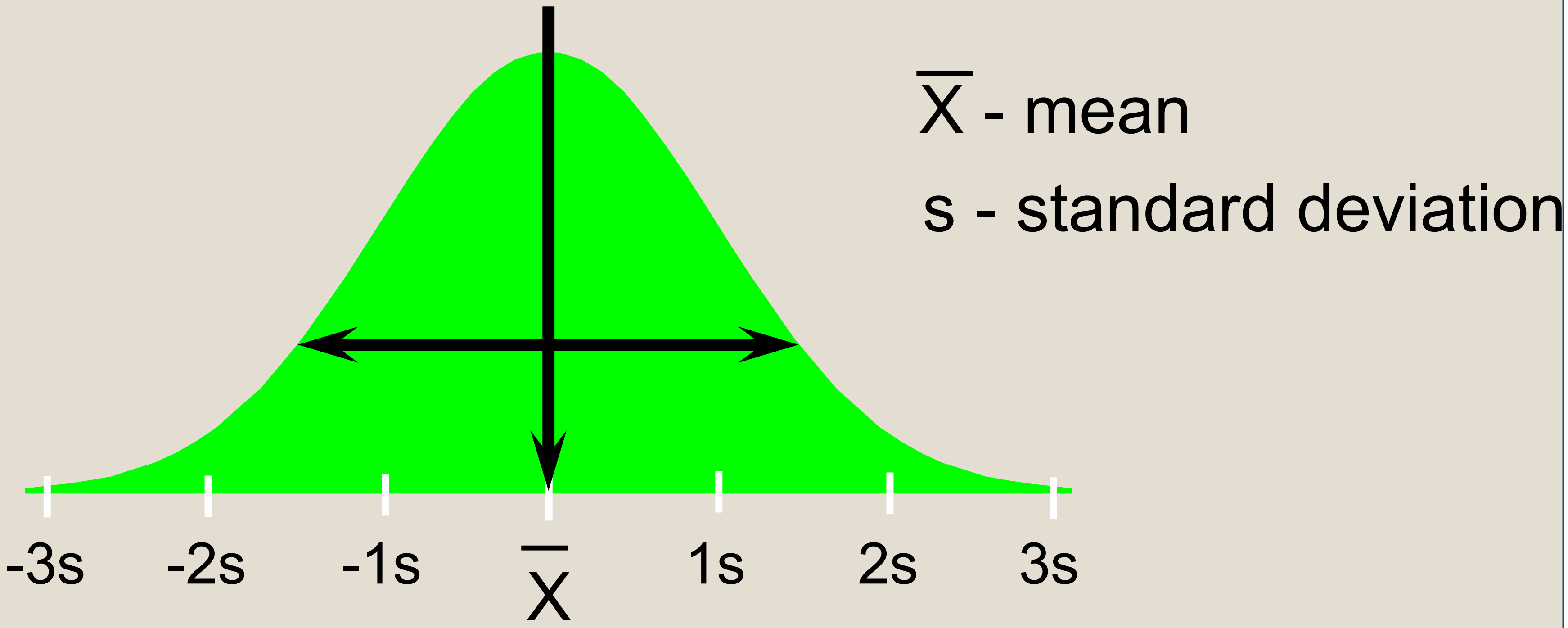
Concrete Acceptance for Durability

We are always going to get what we are willing to accept.

- Ask for durability
- Incorporating Durability Quality Characteristics for Acceptance
- Adjusting Payment Based on Durability Quality Measures

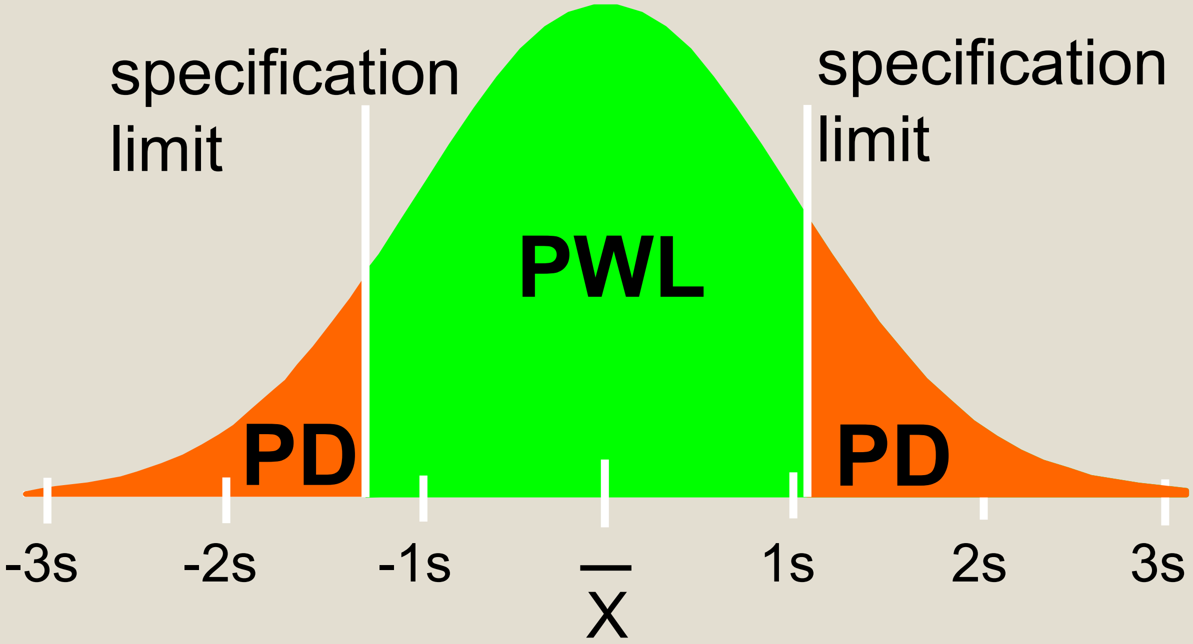
Percent Within Limits

- Efficiently captures mean and standard deviation in one quality measure

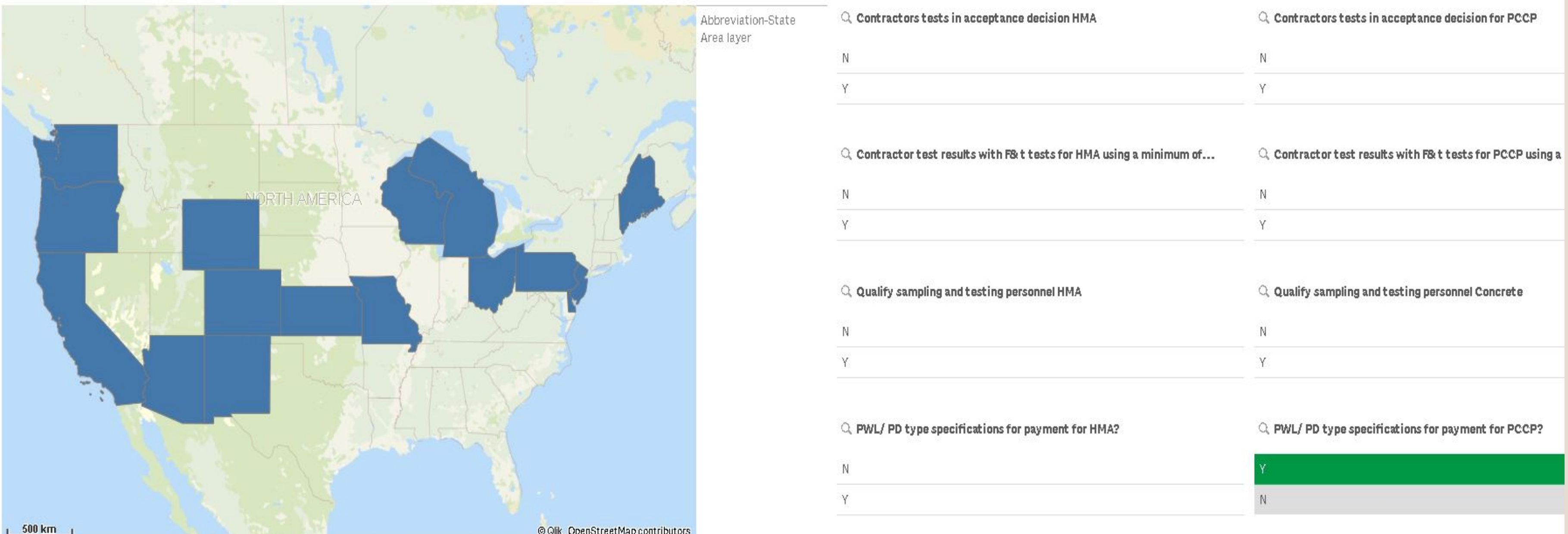


Recommended Quality Measure

- Percent within Limits (PWL)



Current Portland Concrete Cement PWL Acceptance States

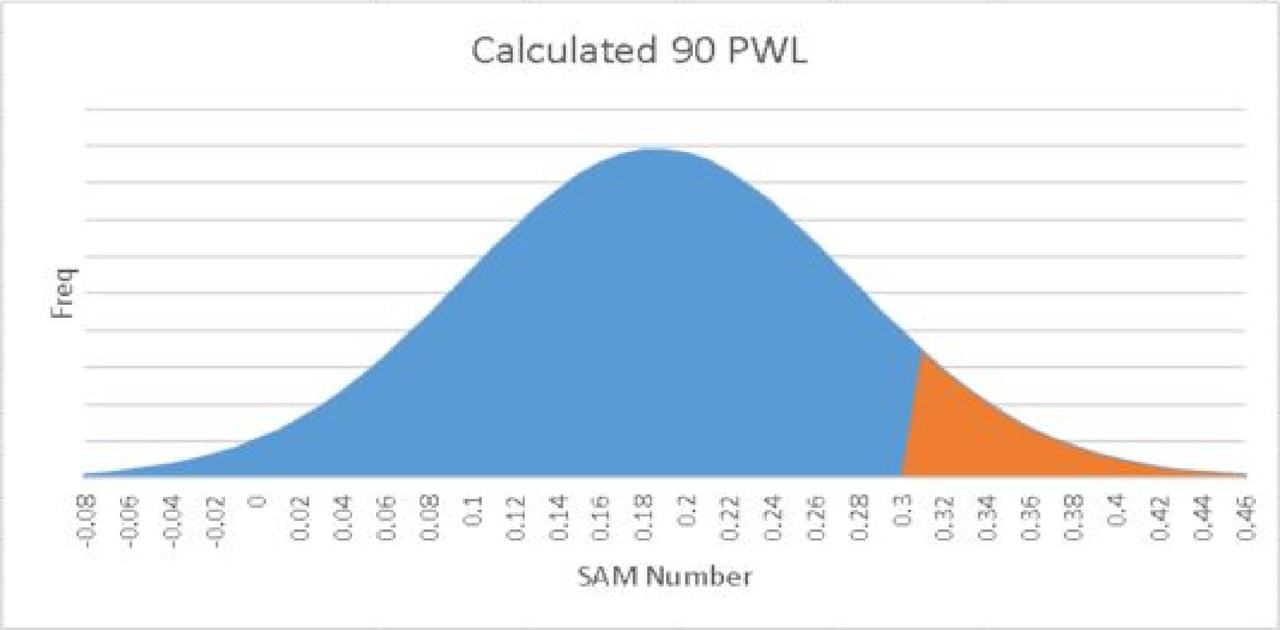


Map source: https://www.openstreetmap.org/copyright

Establishing PWL Spec Limits

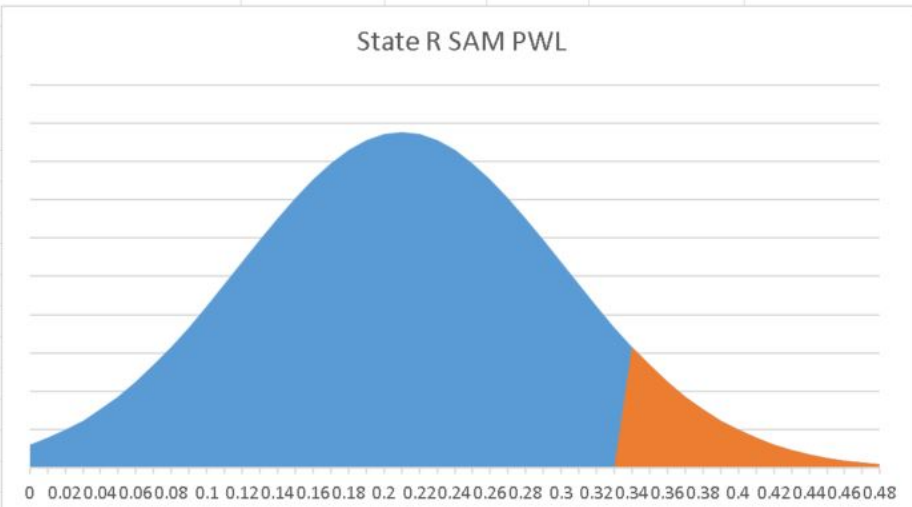
State S SAM

n	86	If 90 PWL = Upper Spec Limit
Pop. Range	0.01 to 0.46	90 PWL: 1 Limit z = 1.28
Pop. Median	0.18	Z = (Mean – Spec. Limit)/Std. Dev.
Population Mean μ	0.1864	Spec. Limit = Mean + (Z * Std. Dev.)
Population Variance σ^2	0.008021	
Pop. Stand. Deviation σ	0.089559	Upper Spec Limit
		Calculated **0.30**

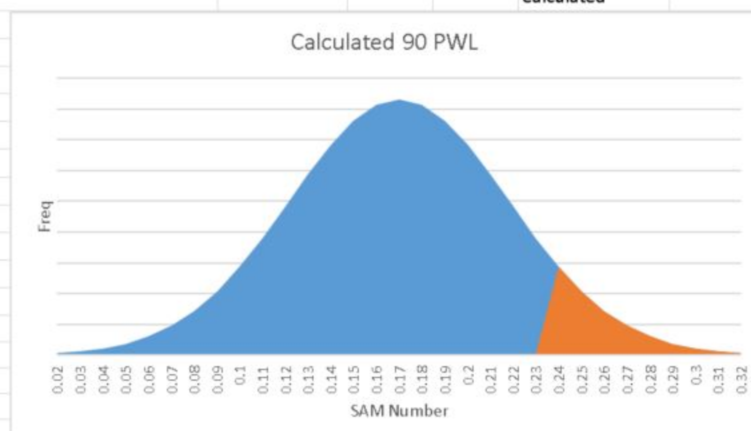


Establishing PWL Spec Limits

State R			
n	124	If 90 PWL = Upper Spec Limit	
Pop. Range	0.03 to 0.58	90 PWL: 1 Limit z = 1.28	
Pop. Median	0.21	Z = (Mean – Spec. Limit)/Std. Dev.	
Population Mean µ	0.21	Spec. Limit = Mean + (Z * Std. Dev.)	
Population Variance σ²	0.00824667		
Pop. Stand. Deviation σ	0.090811178		Upper Spec Limit
		Calculated	**0.33**



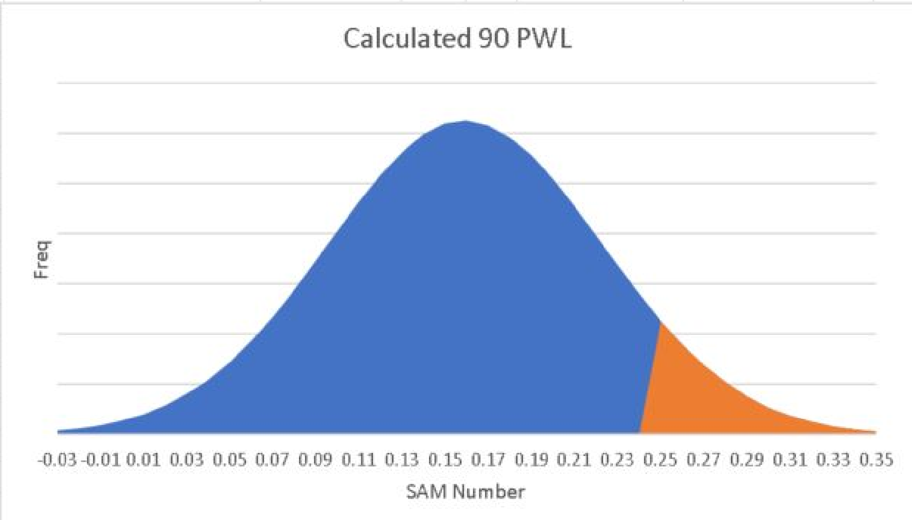
State T SAM			
n	21	If 90 PWL = Upper Spec Limit	
Pop. Range	0.1 to 0.285	90 PWL: 1 Limit z = 1.28	
Pop. Median	0.15500	Z = (Mean – Spec. Limit)/Std. Dev.	
Population Mean µ	0.16976	Spec. Limit = Mean + (Z * Std. Dev.)	
Population Variance σ²	2.3464E-03		
Pop. Stand. Deviation σ	0.048439363		Upper Spec Limit
		Calculated	**0.23**



Establishing PWL Spec Limits

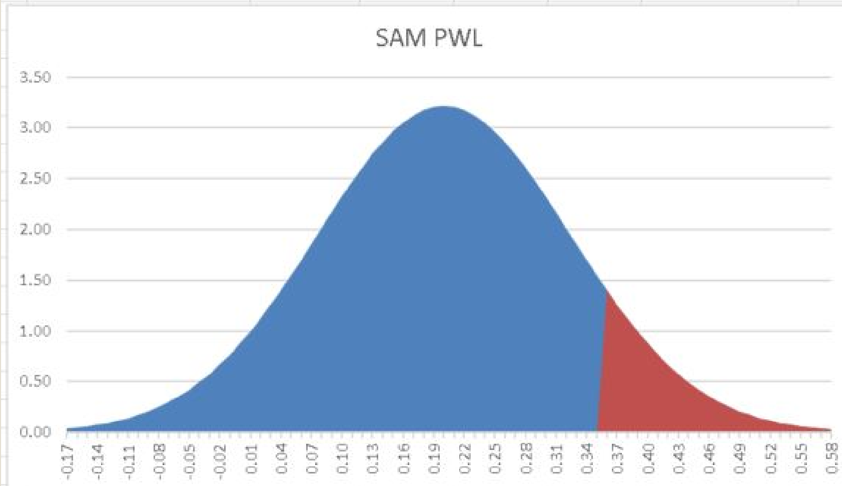
State U SAM

n	190	If 90 PWL = Upper Spec Limit	
Pop. Range	0.01 to 0.45	90 PWL: 1 Limit z = 1.28	
Pop. Median	0.16500	Z = (Mean – Spec. Limit)/Std. Dev.	
Population Mean µ	0.15921	Spec. Limit = Mean ± (Z * Std. Dev.)	
Population Variance σ²	4.0569E-03		
Pop. Stand. Deviation σ	0.063693539		Upper Spec Limit
		Calculated	**0.24**



State V SAM

n	173	If 90 PWL = Upper Spec Limit	
Pop. Range	0.0-0.64	90 PWL: 1 Limit z = 1.28	
Pop. Median	0.18	Z = (Mean – Spec. Limit)/Std. Dev.	
Population Mean µ	0.20	Spec. Limit = Mean ± (Z * Std. Dev.)	
Population Variance σ²	0.015		
Pop. Stand. Deviation σ	0.124		Upper Spec Limit
		Calculated	**0.36**



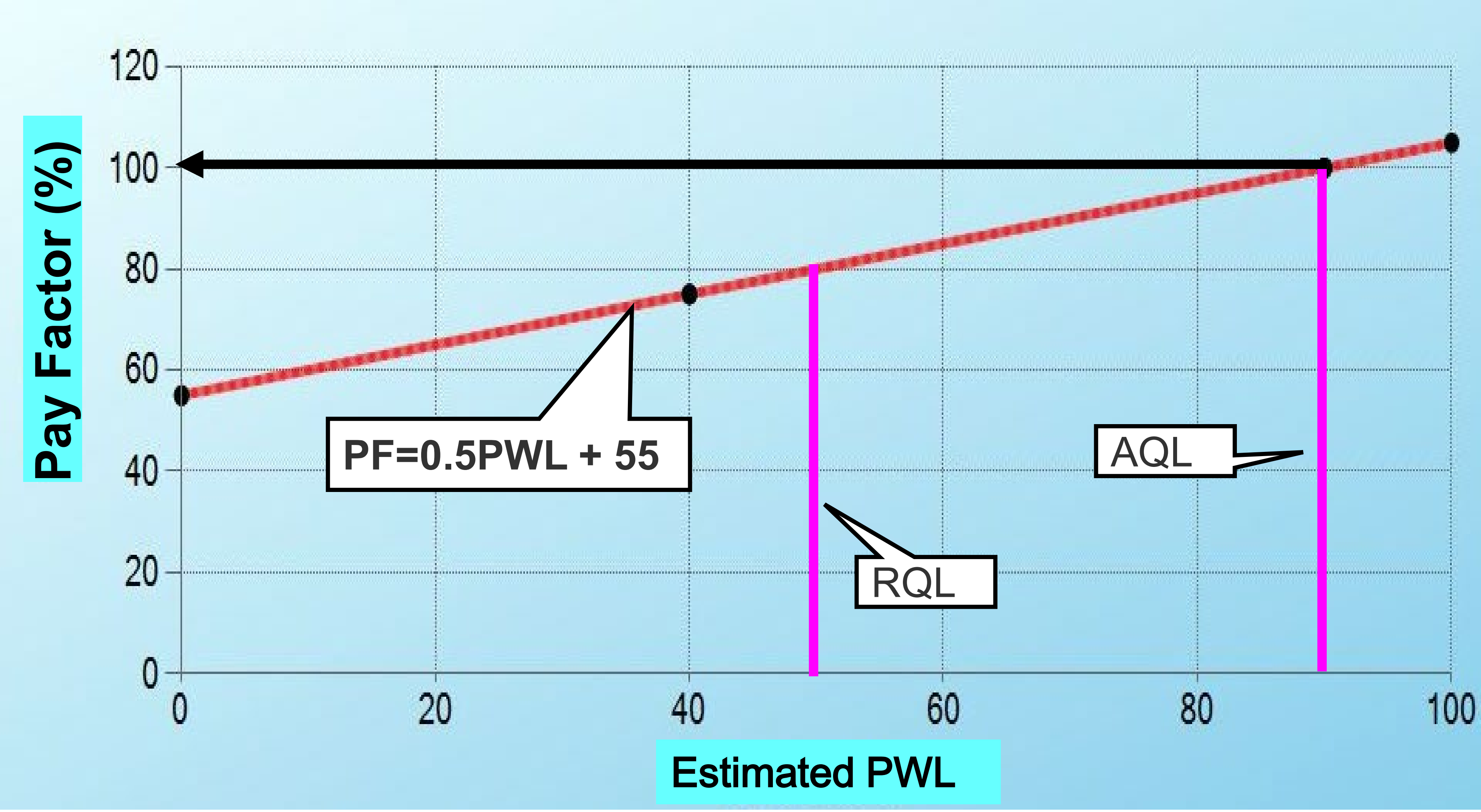
SAM Data Analyzed

State	n	Mean	Std Deviation	Calc Upper Spec Limit
R	124	0.21	0.0908	0.33
S	86	0.19	0.0896	0.30
T	21	0.17	0.0484	0.23
U	190	0.16	0.0637	0.24
V	173	0.20	0.124	0.36

PWL Benefits

- Quantifies how much of the material received was within contract
- Average and Spread of test data in a single quality measure
- More Accurately Characterizes the Quality of each Lot or Population of Data
- Methodology to Adjust Price Based on Quality Received

Payment Plan with 5% Incentive



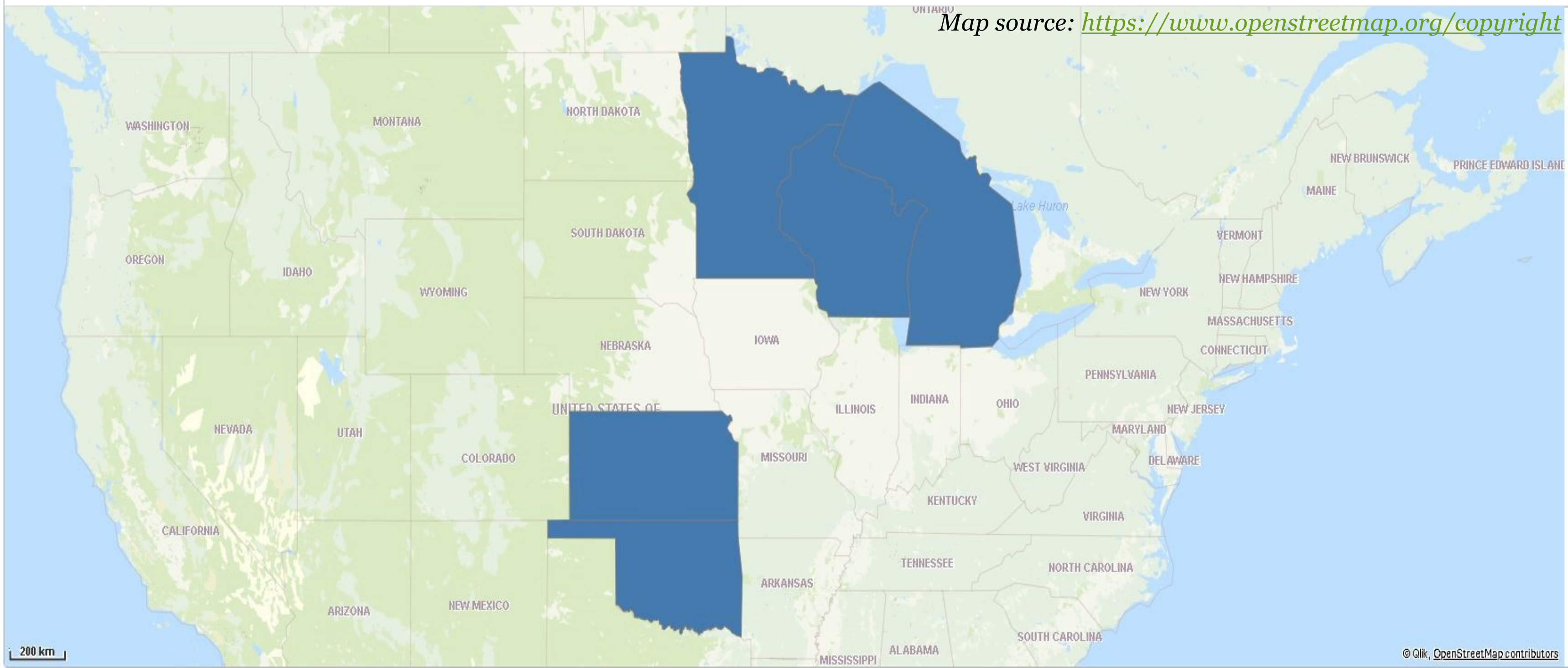
PWL Hypothetical Pay

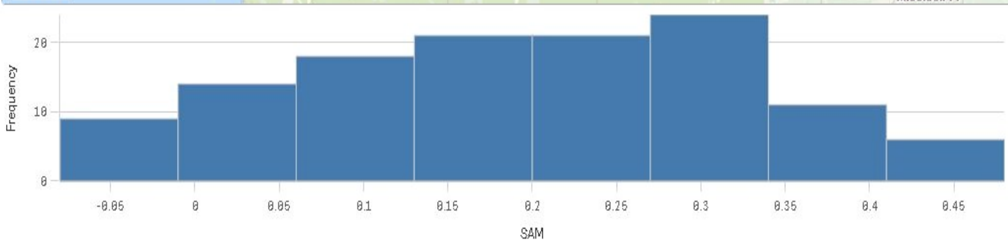
- Hypothetical payment scenarios
- PWL Spec with upper specification limit from pilot population

SAM PWL at 0.33 Upper Spec Limit							
Mean	Std. Dev	Q_U	n	d2	x	PWL	PF
0.26	0.01924	3.7431	5	2.23607	0	**100**	**105.00**
0.22	0.05148	2.13683	5	2.23607	0	**100**	**105.00**
0.23	0.04879	2.13179	5	2.23607	0	**100**	**105.00**
0.27	0.05508	1.14993	3	1.73205	0.00206	**97**	**103.55**
0.20	0.03	4.33333	3	1.73205	0	**100**	**105.00**
0.25	0.09381	0.8528	5	2.23607	0.26163	**79**	**94.58**

SAM Data Analyzed

Map source: https://www.openstreetmap.org/copyright





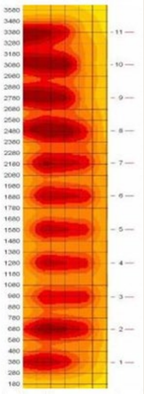
SAM n	SAM Range	SAM Mean	SAM Std Dev
173	0.0-0.64	0.2034	0.12387
45	0.10 to 0.33	0.2327	0.04874
86	0.01 to 0.46	0.1864	0.08956
21	0.1 to 0.285	0.1698	0.04844
190	0.01 to 0.45	0.1592	0.06369

Implementing PWL

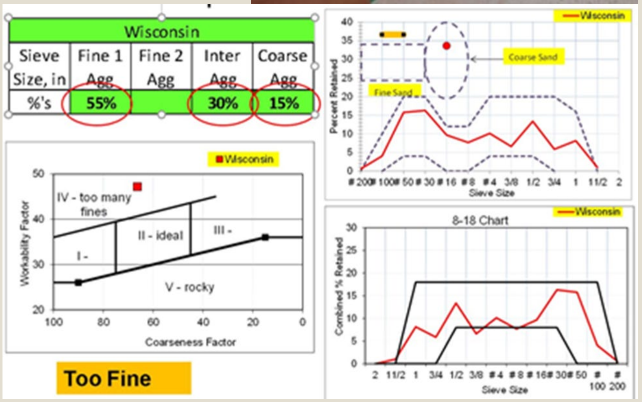
- Contractor is successful if they can control variability and target within limits
- Quality Characteristics
- Population of Test Data
- PWL Training
- Specification Development
- Individual PWL Training/Meeting
- Calibration

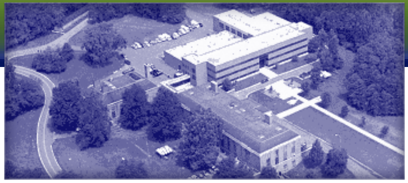
Consider PWL and Concrete Acceptance for Durability

Durability Quality Characteristics



- Optimized Gradation Acceptance Test
- Dowel Placement and Alignment MIT Scan-2
- Super Air Meter Acceptance Test
- Water/Cement Ratio Acceptance Test
- Surface Resistivity Acceptance Test
- Thickness MIT Scan T3
- Ride Quality
- Strength





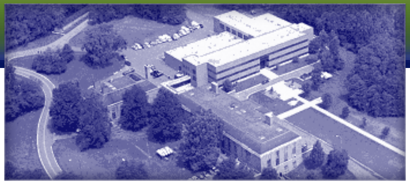
FHWA Performance Related Specifications (PRS) for Concrete Pavements

U.S. Department of Transportation

Federal Highway Administration

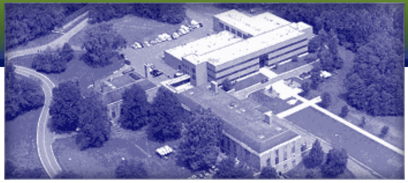
Office of Infrastructure Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

Matthew Corrigan, P.E.
Construction Research Engineer
Turner-Fairbank Highway Research Center
Infrastructure Analysis and Construction Team
matthew.corrigan@dot.gov
(202) 493-3365



FHWA's Construction Specifications Whiteboard Video (8:03)

https://youtu.be/-FfOUfIbfF4



PRS Definition

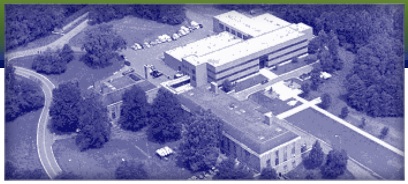
“QA specifications that describe the desired levels of key materials and construction quality characteristics that have been found to ***correlate with fundamental engineering properties that predict performance****”*

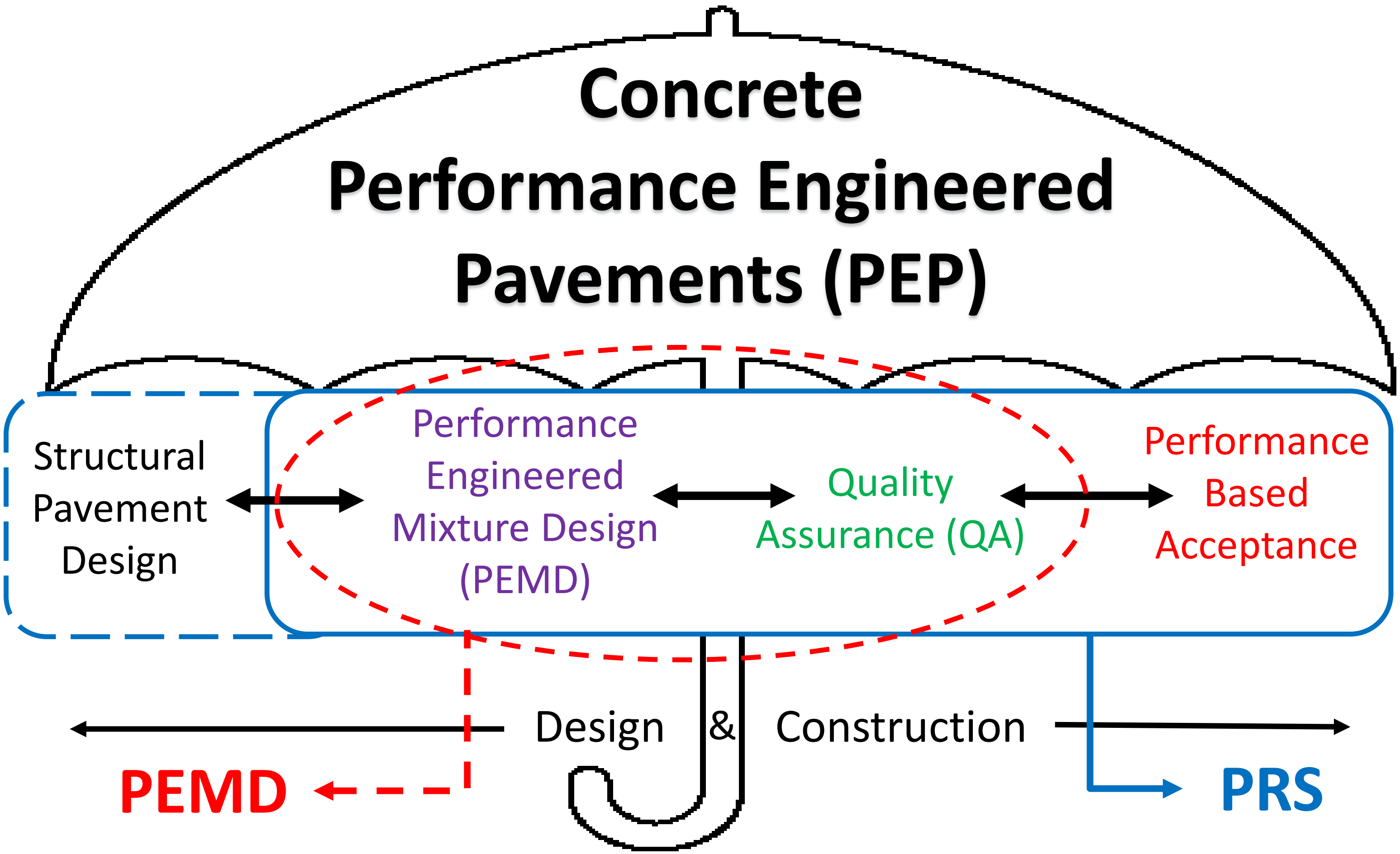
Source: Transportation Research Circular E-C137, Glossary of Highway Quality Assurance Terms

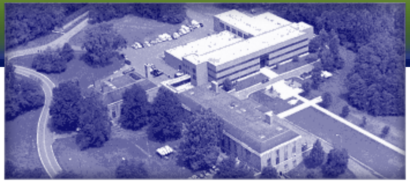
Performance Related Specifications (PRS) compare design expectations to what was constructed and pay for the product accordingly.

Performance Engineered Mixture Design (PEMD) and acceptance is a process that that optimizes pavement performance goals and environmental conditions while allowing for contractor innovation and properly assigned risk and reward.

Performance Engineered Pavements (PEP) initiative unifies several existing performance focused programs under a single strategic program vision. The vision seeks to incorporate the goal of long term performance into the design, construction and materials acceptance of our nations pavement infrastructure.




Concrete
Performance Engineered
Pavements (PEP)
Structural
Pavement
Design
Performance
Engineered
Mixture Design
(PEMD)
Quality
Assurance (QA)
Performance
Based
Acceptance
Design
&
Construction
PEMD
PRS



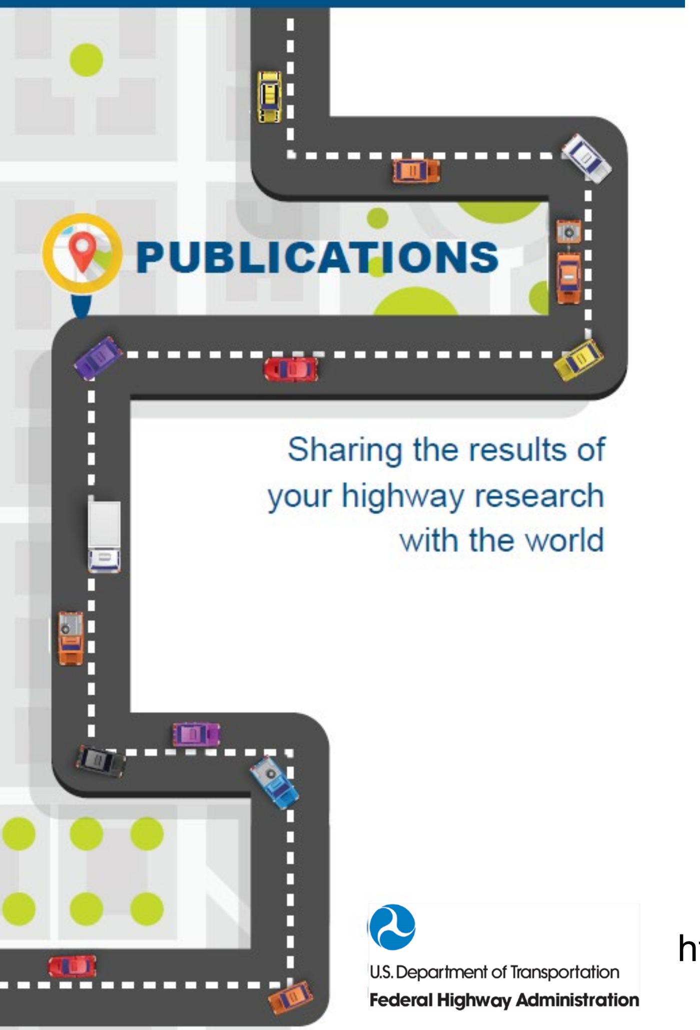
Concrete Pavement PRS Workshops & PRS Shadow Projects

- FHWA provided support, training, & resources for PRS shadow projects (aka "PRS-Shadow")
- Performance tests, specifications, tools, etc.
- Concrete Pavement PRS Workshops
  - June 2019
    - DOT participants: ID, IN, MI, PA, UT
  - Next Workshop – date tbd

Seeking Additional DOT Shadow Project Participants!
Contact Matthew Corrigan at matthew.corrigan@dot.gov

PRS Software

TFHRC TURNER-FAIRBANK HIGHWAY RESEARCH CENTER



Thank You!!

Recently completed research is available at:

- https://highways.dot.gov/research-resources

U.S. Department of Transportation
Federal Highway Administration

Formation Factor, Calcium Oxychloride, and Alkali-Silica Reaction (ASR)

National Concrete Consortium

Fall 2019

Luca Montanari
Infrastructure Materials Team
TFHRC

Index

- Formation Factor (FF)
  - FF measured on typical concrete pavement mixtures (AASHTO PP84)
- Calcium Oxychloride
  - Validation and Optimization of AASHTO T365
- ASR: Lab Tests vs. Exposure Blocks Performance
  - Validation and benchmarking of: ASTM C1293, MCPT, CCT

FF and Bucket Test: Current Status

TURNER-FAIRBANK HIGHWAY RESEARCH CENTER

U.S. Department of Transportation
Federal Highway Administration

https://highways.dot.gov/research/

FORMATION FACTOR DEMYSTIFIED AND ITS RELATIONSHIP TO DURABILITY

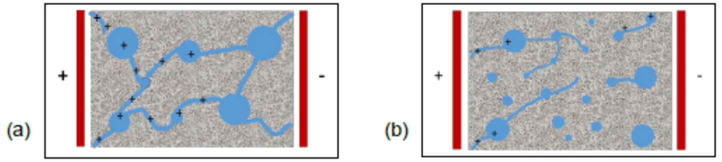
Jussara Tanesi, PhD., FACI, (i) Luca Montanari,(ii) and Ahmad Ardani, P.E.(iii)

WHAT IS ELECTRICAL RESISTIVITY AND WHY IS IT MEASURED?

Electrical resistivity is a property that indicates the material's resistance to the passage of electrical charges at a defined temperature. Concrete is a porous material and the porosity in concrete consists of a system of nano- and microscopic pores, interconnected at different degrees. In concrete, resistivity is directly proportional to the resistivity of the pore solution, and inversely proportional to the volume and connectivity of the pores. This means that:

- The more pores and the more these pores are connected, the lower the resistivity (Figure 1).
- The higher the concentration of ions in the pore solution, the lower the resistivity.

In other words, concrete resistivity depends on the pore structure and on the pore solution. While concrete resistivity measurements are used as a surrogate test by many state DOTs and commercial labs for durability testing and quality assurance purposes, these tests fail to capture the influence of the pore solution.



Source: FHWA

Figure 1. Illustration. Applied charges through concrete with a) high connectivity and b) reduced connectivity between macroscopic pores.

https://rosap.ntl.bts.gov/view/dot/40951

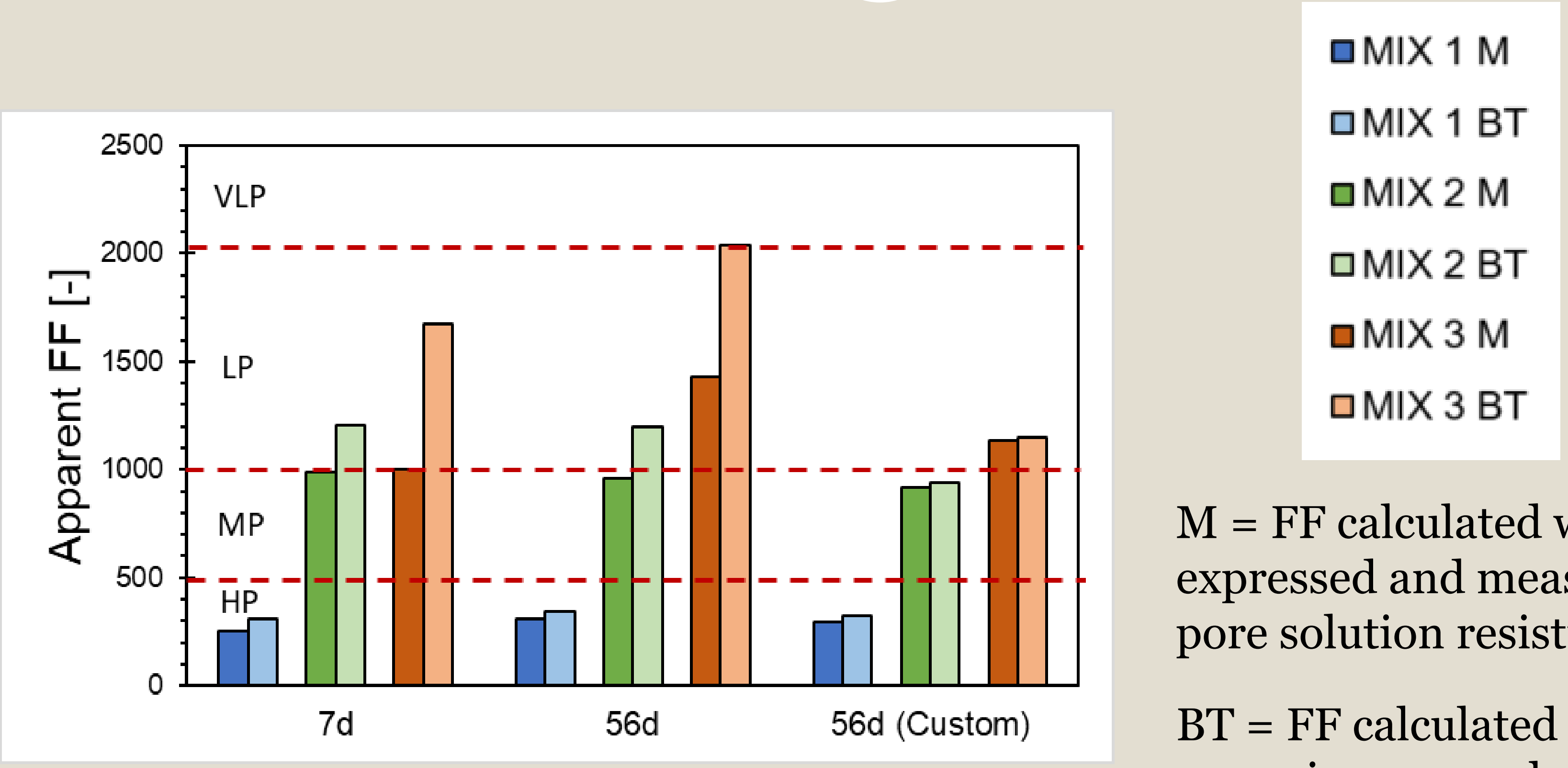
FF and Bucket Test: Current Status

FF measurements and classification based on AASHTO-PP84 guidelines

Paper submitted to TRB

- Different approaches studied to promote test reliability:
  - Soaking time in bucket solution of 7d
  - Soaking time in bucket solution of 56d
  - Using estimated pore solution as the bucket solution (56d Custom)

FF and Bucket Test: Current Status



M = FF calculated with expressed and measured pore solution resistivity

BT = FF calculated assuming pore solution resistivity = resistivity of bucket solution

FF Factor and Bucket Test: Equilibrium

- Extending conditioning time (from 7d to 56d)
  - Not successful in improving test reliability
- Increasing the # of bucket solutions to choose from (to 2 / 3)
  - Can highly improve the test reliability

Impact on Test Reliability

	Monte Carlo Distribution					
# Bucket Solutions	1	2		3		
Resistivity of bucket solution [Ohm-m]	0.13	0.13	0.24	0.10	0.19	0.30
Data > 30% Diff	45%	14%		5%		

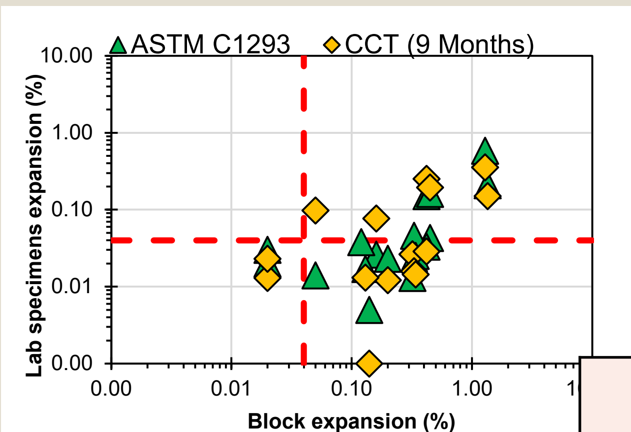
CAOXY AASHTO T365 Optimization

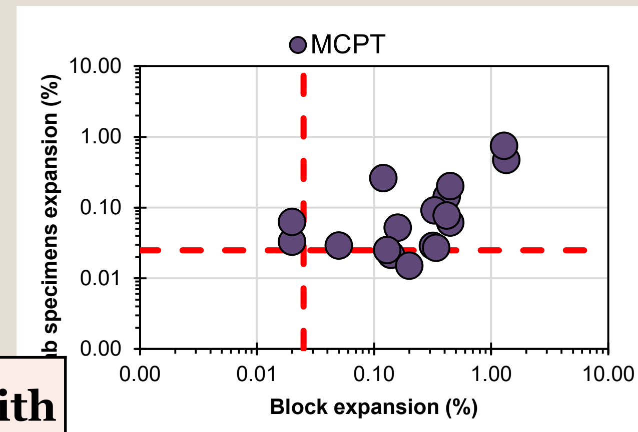
- Verification:
  - Studying the test over a range of different mixtures for:
    - Paste
    - Mortar
    - Concrete

- Optimization (Reduction of test time and gas consumption):
  - Increasing the minimum temperature,
  - Increasing the heating rate (with machine re-calibration)
  - Extending the test to high T DSC

- Benchmarking MCPT (AASHTO T380) and CCT to field exposure:

Paper submitted to TRB





Test method	% Agreement with Exposure Blocks
ASTM C1293	41
CCT	47
MCPT	76

Summary

- Bucket Test and FF:
  - Bucket test showed reliable classification of mixtures (TRB Paper).
  - Reliability of test can be improved by adding more options for bucket solutions (1 or 2)
- Calcium Oxychloride:
  - AASHTO T365 currently being validated and optimized over paste, mortar and concrete specimens
- ASR
  - MCPT showed 76% of cases in agreement with exposure blocks, better than CCT and ASTM C1293 (both showing under 50% cases in agreement with exposure blocks)

Questions