

# Performance Engineered Concrete

--It's Time For a Change--



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U.S. Department of Transportation  
**Federal Highway Administration**

# We Are **Horrible** With Change

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



# Evolution of Concrete Testing

Concrete

Slump Cone



**1922**  
ASTM C143

Pressure Meter



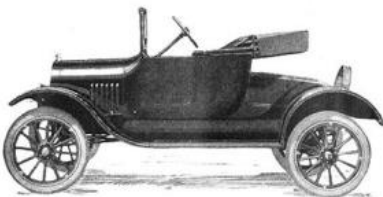
**1949**  
ASTM C231

Rapid Chloride Permeability Test



**1981**  
FHWA/PCA

Cars



1920

1940

1960

1980

2000



U.S. Department of Transportation  
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# Motivation

- Increase in premature concrete deterioration
- MAP-21 and FAST ACT legislation focus on performance
- Desire by Public Agencies and Industry to move toward performance
  - Optimized mixture designs (gradation, cement content, cont.)
  - Improved durability
  - Sustainability
- Testing technology advancements
- Changes in agency and industry skills and personnel levels



# Performance Engineered Mixture Concept

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



# PEM Specification Development

## ■ The Team

- Dr. Peter Taylor, Director, CP Tech Center/Iowa State
- Dr. Jason Weiss, Oregon State University
- Dr. Tyler Ley, Oklahoma State University
- Dr. Tom Van Dam, NCE
- Cecil Jones, Diversified Engineering
- Tom Cackler, CP Tech Center
- Mike Praul, FHWA

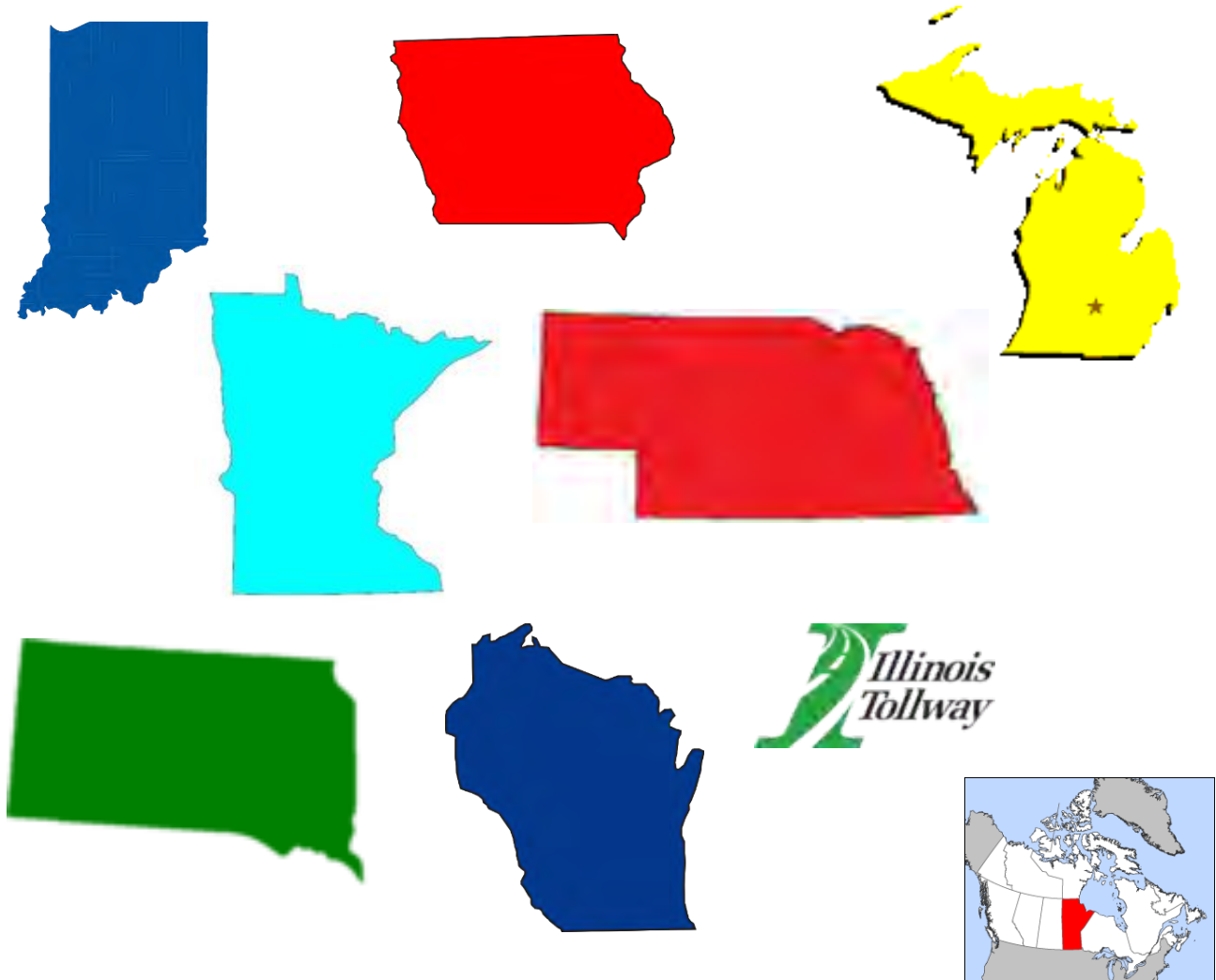
## ■ Industry Participants/Reviewers

- Champion States
- ACPA National, ACPA Chapter Execs
- PCA
- NRMCA



# Champion States

- Indiana
- Iowa
- Michigan
- Minnesota
- Nebraska
- South Dakota
- Wisconsin
- Illinois Tollway
- Manitoba





# AASHTO PP 84: A Better Specification

## Require the things that matter

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





# Why We're Excited

## Concrete Evolution

- PEM: It's our Superpave
- Most significant field-level advancement in decades
- Answers the question "With our loss of staff and resources, how are we going to be able to get the job done in the future?"
- Collaboration with industry (It's more than just the tests!)



## Jerry Voigt, ACPA

“It’s the agency’s responsibility to allow for innovation. It’s the contractor’s responsibility to deliver.”



# How Do Contractors Deliver in a Performance Specification



# Sources of Variability

*Material*



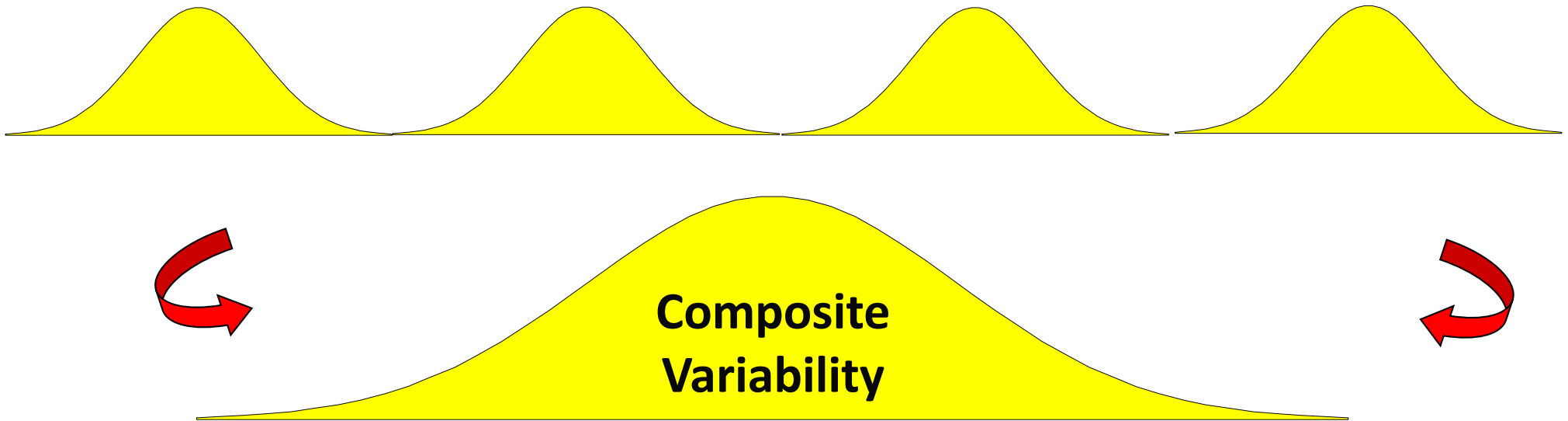
*Process*



*Sampling*



*Testing*



# Controlling Sampling and Testing Variability

- Standard procedures (AASHTO, ASTM, state)
- Laboratory accreditation/qualification program
- Technician training and certification programs
- State Independent Assurance Program
- Calibrated equipment schedules



# Sources of Variability

*Material*



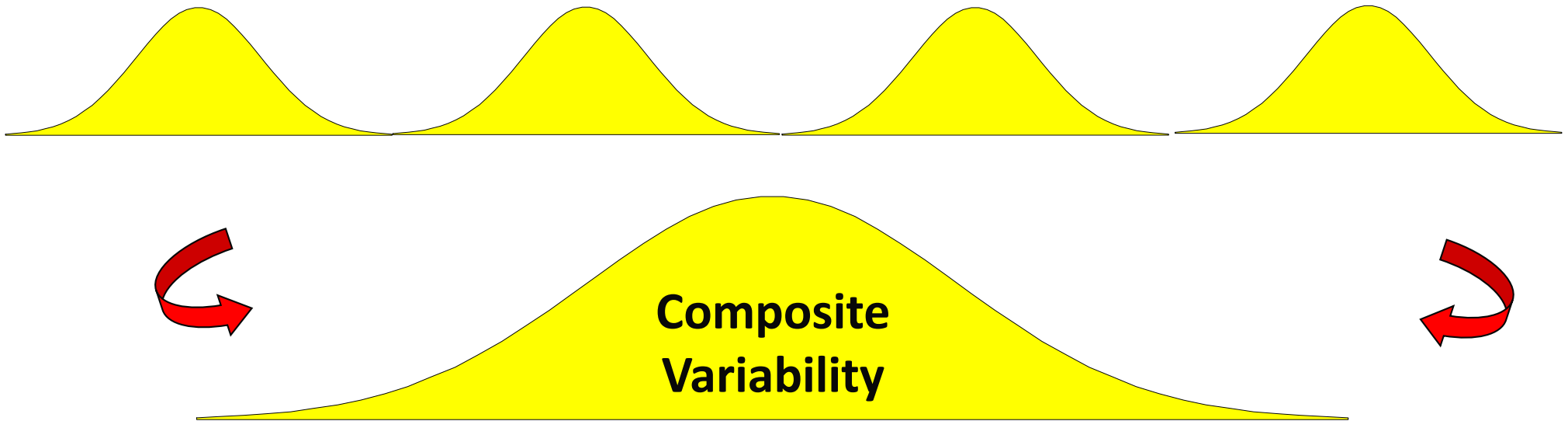
*Process*



*Sampling*



*Testing*





# Controlling Material and Process Variability





# Prescriptive vs. Performance Specifications

## 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



# Quality Assurance Defined

23 CFR 637

- Agency Acceptance
- **Contractor Quality Control**

- Qualified (certified) Personnel
- Qualified Laboratories
- Independent Assurance
- Dispute Resolution for Test Results



State processes,  
independent of  
material



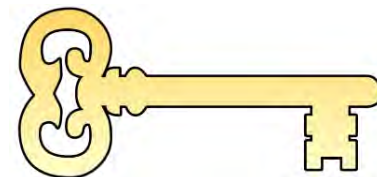
# Quality Control

- PEM acknowledges the key role of QC in a performance specification
- Requires an approved QC Plan
  - Testing targets, frequency, and action limits
  - Equipment and construction inspection
  - Mirror design-build experience
- Requires QC testing and control charts
  - Unit weight
  - Air content/SAM
  - Water content
  - Formation Factor (via Surface Resistivity)
  - Strength



# Mirror Design-Build (DB) Experience

- DB shifts control from agency to contractor
  - Risk shifts with control
- Agency retains responsibility and accountability to the taxpayers
- Contractor submits proposal including how they will develop and deliver the project
- Post-award, contractor submits a detailed QC Plan
- Performance specifications have a similar shift of risk and control
- ✓ QC Plans are analogous



# Quality Control

- Uses **real time** feedback
  - Now possible with innovation and new tests
- A good Contractor QC system:
  - Doesn't just echo Agency requirements
  - Implements QC procedures as standard practice
  - Isn't just paperwork...**it's a mindset**















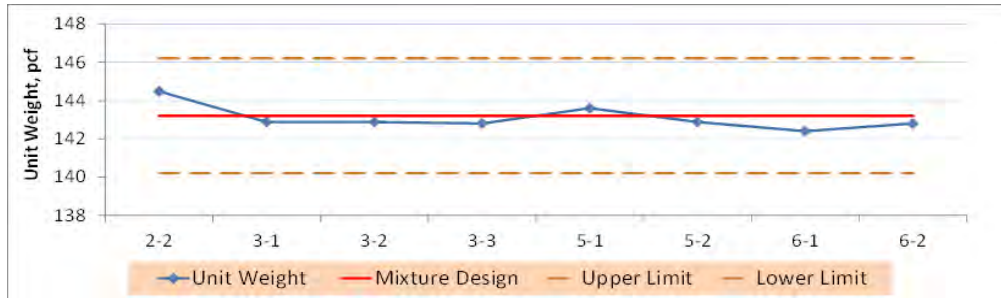
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# Quality Control Evolution

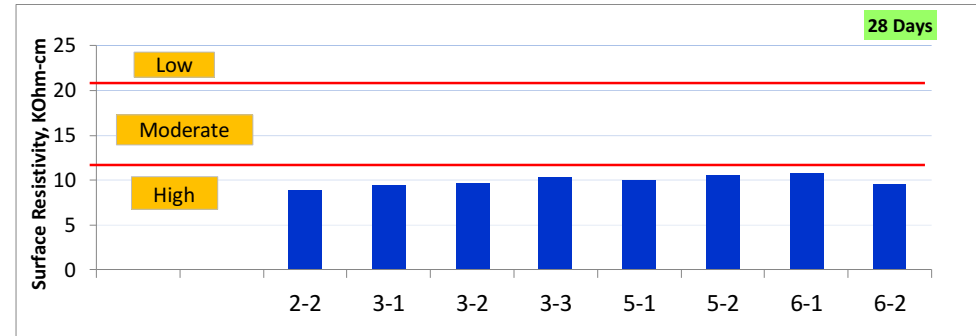
- Change state mindset that QC is not their business
  - Gordon Smith example
- Change (some) industry mindset that QC is not their business
- ✓ Provide guidance on developing state specification language
- ✓ QC Testing Guide (very similar to guidance for the acceptance program but slanted to industry)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



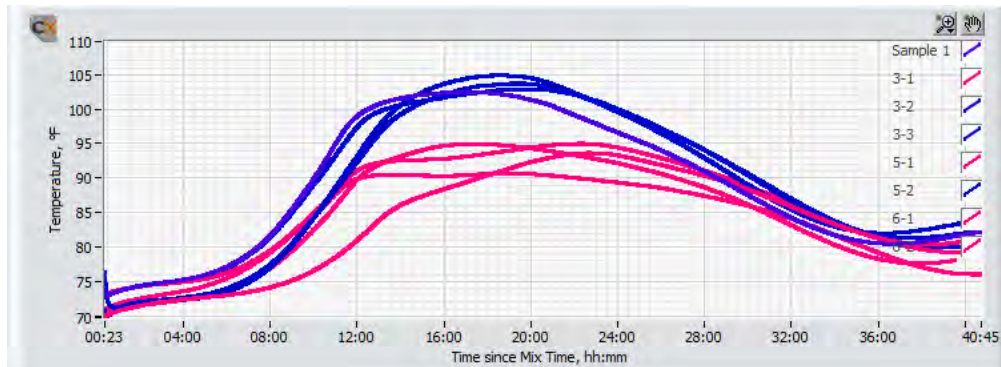
# Unit Weight / Heat Signature / Permeability



**Unit Weight – Real Time**

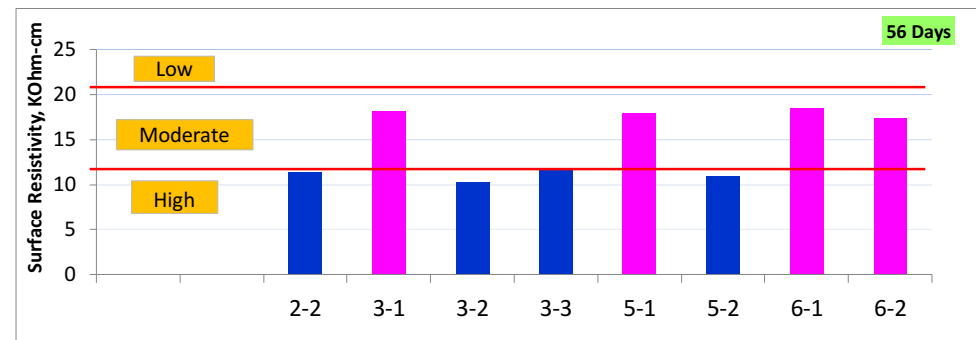


**Surface Resistivity – 28 Days**



**Heat Signature – Info in a day**

**Real Time**



**Surface Resistivity – 56 Days**

**28 / 56 days**

Field Data from an MCT project

# “But Mike, You’re Asking for a Lot of Change”

## **Change has already happened!**

- Cements
- Widespread use of SCM’s
- Advancements in chemical admixture technology
- De-icers
- Agency personnel and experience levels
- Industry knowledge base



# Proven Concepts

- 1996 move to QA approach
- Contractor mix designs
- No agency personnel in plants
- Meaningful QC Plans (enforced)
- Cooperative approach
- Results!





# Thank You

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