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National Concrete Consortium Meeting – Spring 2022

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MCTC Test Data Analysis

Jagan M Gudimettla
Project Manager
MCTC

U.S. Department of Transportation
Federal Highway Administration

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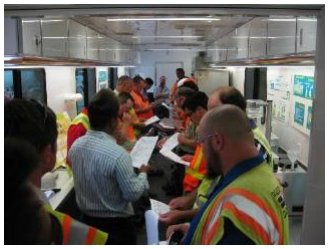
FHWA Mobile Concrete Technology Center (MCTC)

Technology Transfer to State Departments of Transportation (State DOTs)

- Field demos on active projects
- Equipment loan
- Training of staff
- Conferences and workshops
- Specification review and technical assistance



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FHWA Data Collection Efforts

- **Two Weeks**
  - Fresh Concrete
  - Hardened Concrete
- **Later Age Testing**
  - 28 Day
  - 56 Day
- **Wide Variety of Data**
  - 30+ parameters collected
    - Including several PEM related

Data and National Trends

- Performance Engineered Mixtures (PEM)
  - Strength
  - Transport Properties (Permeability)
  - Workability
  - Cracking Tendency
  - Freeze-Thaw Durability
  - *Aggregate Stability*
- Construction Aspects
  - Thickness Measurement
  - In-Place Strength of Concrete

Use of PEM practices is not a Federal requirement.

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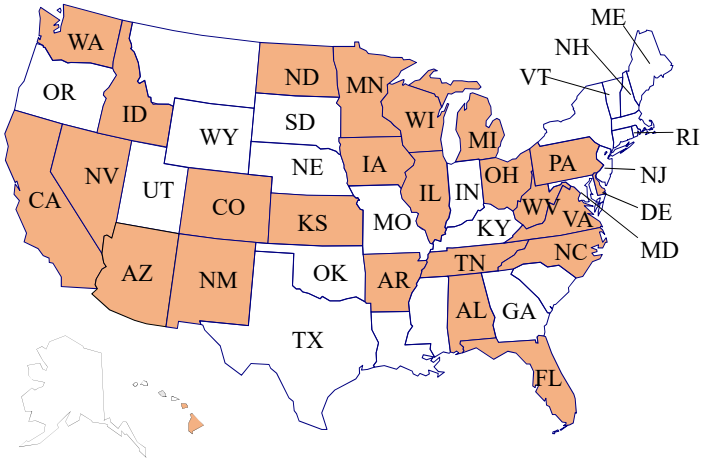
FHWA Data Collection Efforts

- Data from 24 States (28 projects)
- 2011-2019
- Only Mainline Paving projects
- 10 to 16 Samples from each State
- Each Sample
  - PEM Tests
  - Non-PEM Tests



How does today's concrete fare in the PEM criteria?

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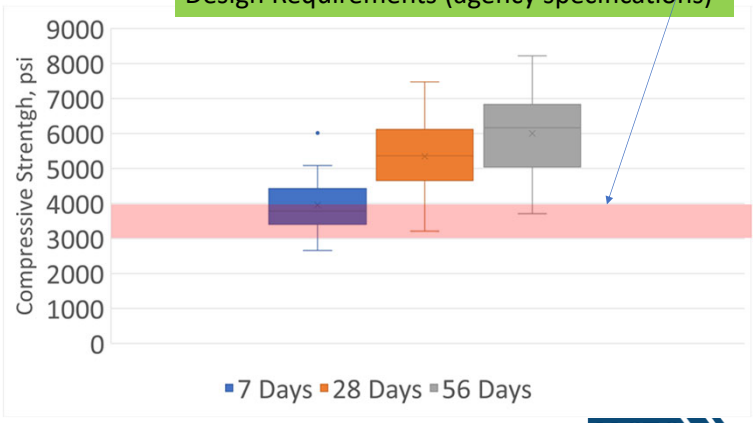
1. Compressive Strength

- Tests at 7, 28 and 56 days
- Specimens cast at plant
  - Most projects

	7 Day, psi	28 Day, psi	56 Day, psi
Average	3957	5347	6001
Standard Deviation	766	994	1134



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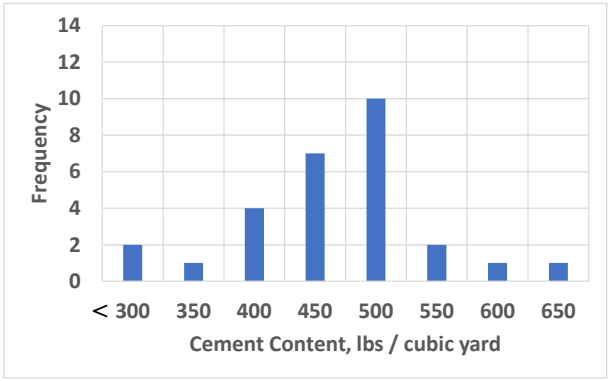
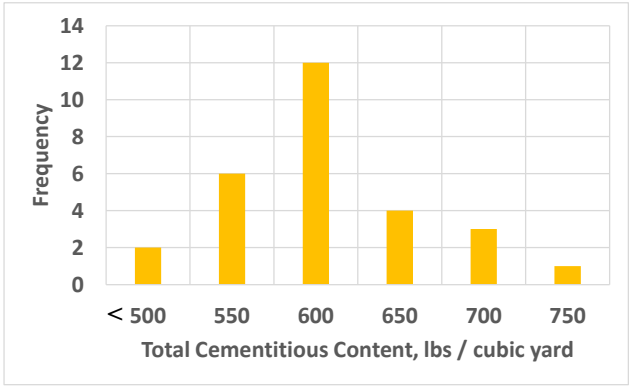
Cement and Cementitious Contents





	Cement Content, lbs/yd3	Total Cementitious Content, lbs/yd3
Average	443	581
STDEV	72	55

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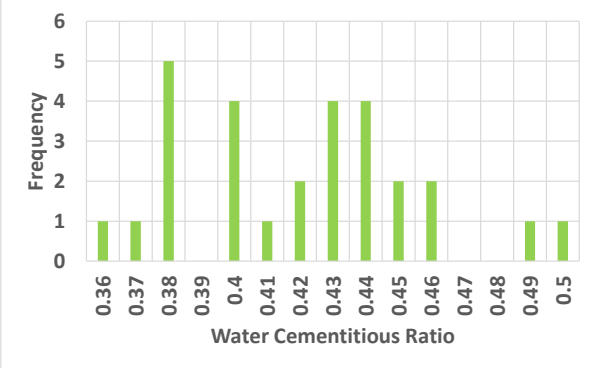
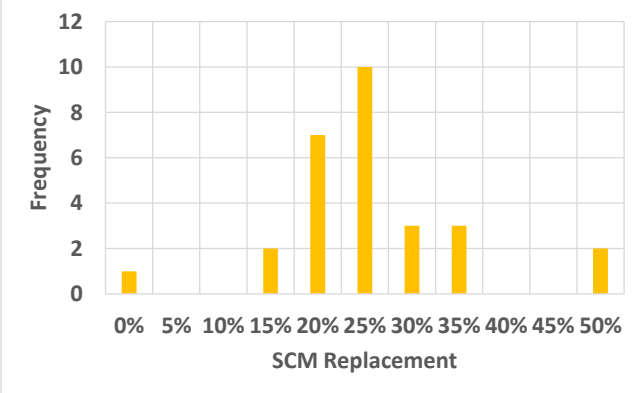
Water Cement Ratios and SCM Replacements





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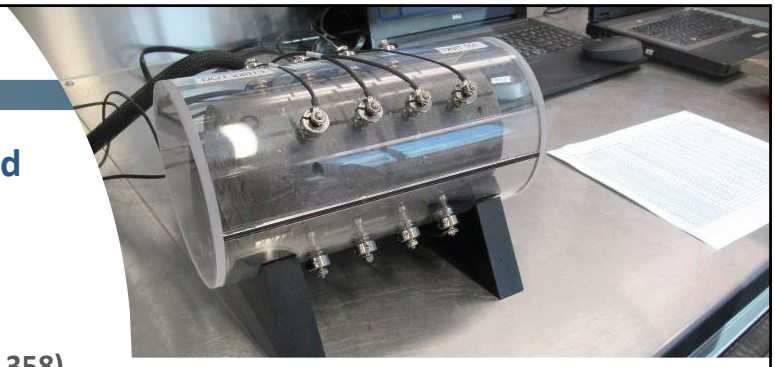
2. Transport Properties

- Instant results on hardened concrete
- Non-destructive test
- Two variants
  - Surface Resistivity (AASHTO T 358)
  - Bulk Resistivity (AASHO TP119)
- Specimen Conditioning very important

Use of AASHTO T 358 or TP119 is not a Federal requirement.



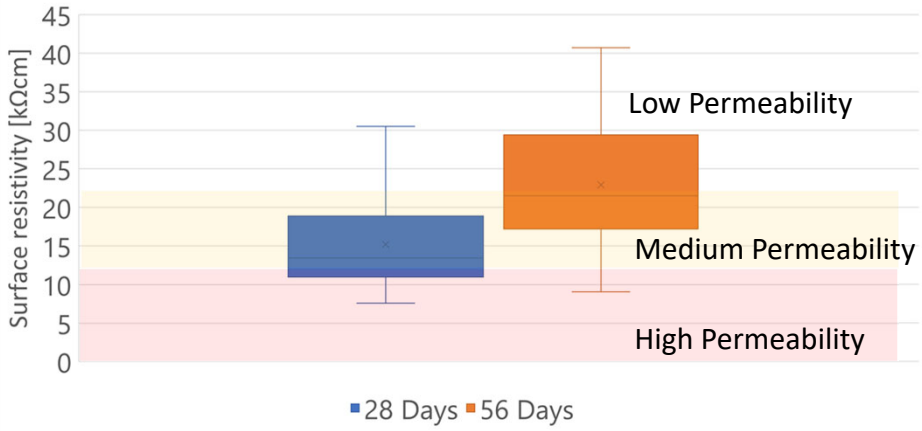
2. Transport Properties

- **Majority of the projects were in the medium permeability category**

	28 Day	56 Day
Low Permeability	31%	58%
Medium Permeability	46%	42%
High Permeability	31%	8%

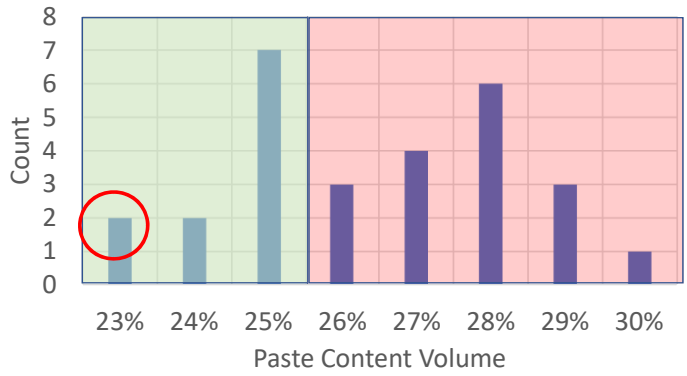
Surface Resistivity Results
Lime water bath conditioning
4"x8" cylinder

Chloride Ion Penetrability	Concrete Surface Resistivity (KΩ-cm)
High	≤ 12
Moderate	12-21
Low	21-37
Very Low	37-254
Negligible	≥ 254



3. Cracking Tendency

- **Paste Volume**
  - **Should be less than 25% for lowering the crack tendency of paving concrete**
  - **AASHTO PP-84/R101**



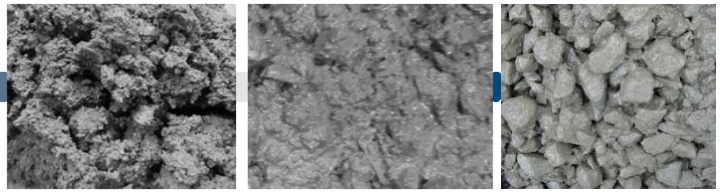
Use of AASHTO PP-84/R101
is not a Federal requirement.

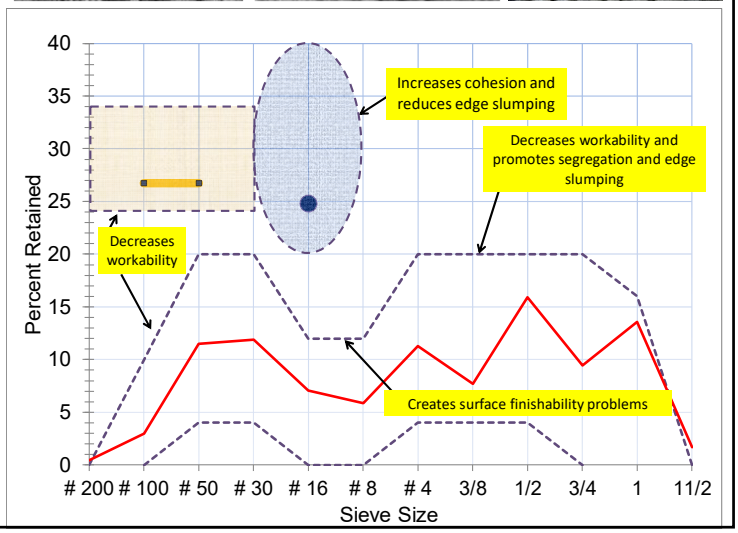
	Less then 25%	Greater than 25%
Paste Volume	39%	61%

Paste Volume = Volume of Concrete – (Volume of Aggregate + Volume of Air)

Aggregate Gradation

- Combined Aggregate Gradation
  - Tarantula Curve
  - Individual Aggregate Gradation not as critical



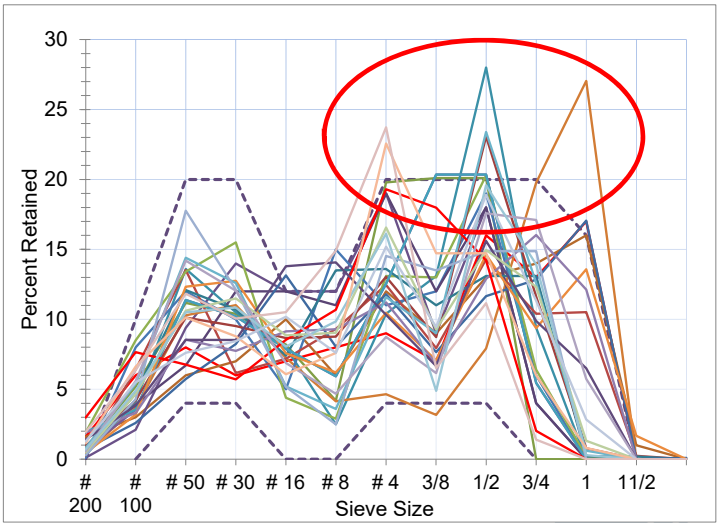


Photos Courtesy: Dr. Tyler Ley, Oklahoma State University

Aggregate Gradation

- Combined Aggregate Gradation
  - Tarantula Curve
  - Individual Aggregate Gradation not as critical

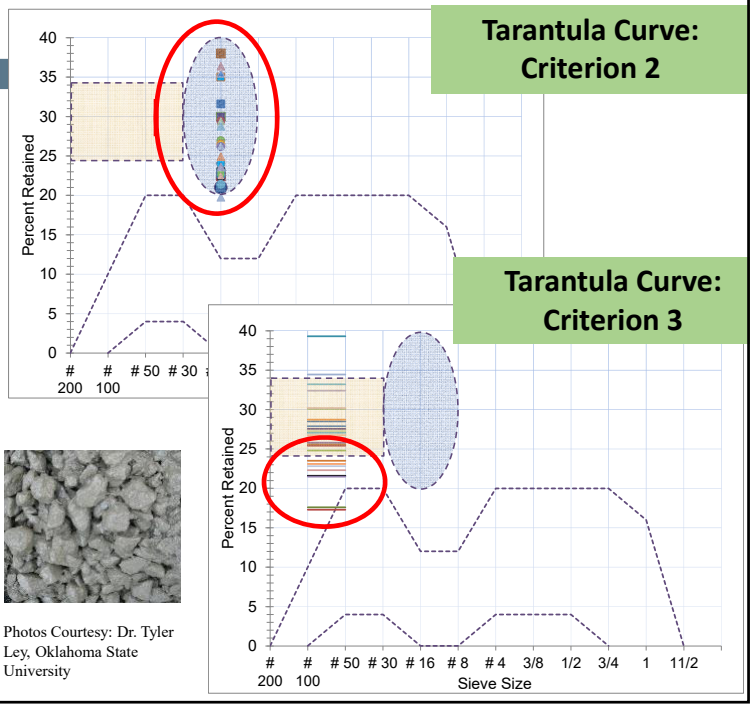
Tarantula Curve: Criterion 1



Tarantula Curve	Met	Did not Meet
Criterion 1	21	7

Aggregate Gradation

- Combined Aggregate Gradation
  - Tarantula Curve
  - Individual Aggregate Gradation not as critical

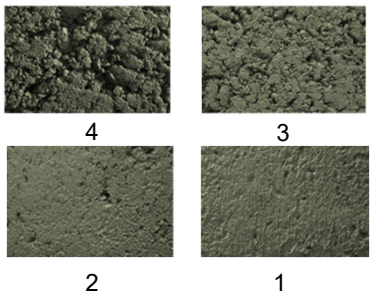


Tarantula Curve	Met	Did not Meet
Criterion 2	27	1
Criterion 3	18	10

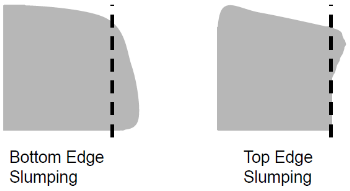
Photos Courtesy: Dr. Tyler Ley, Oklahoma State University

4. Workability

- Box Test



Consolidation Issues

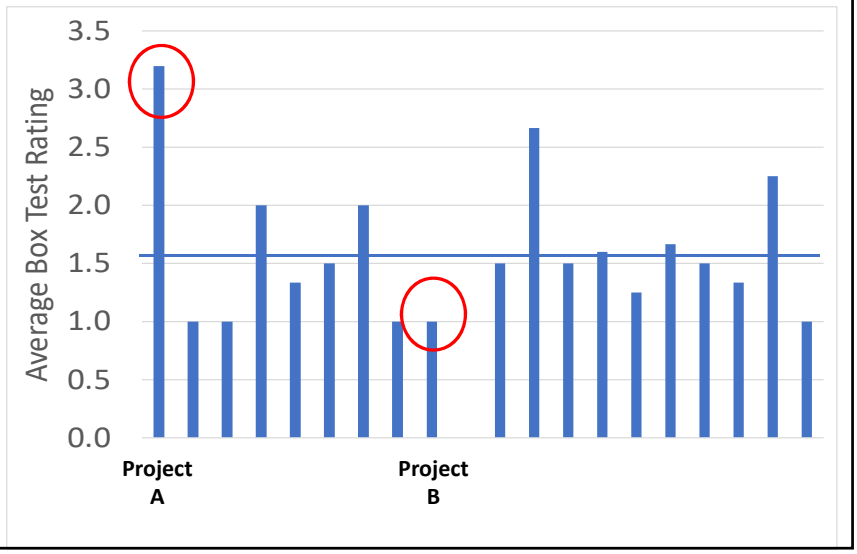


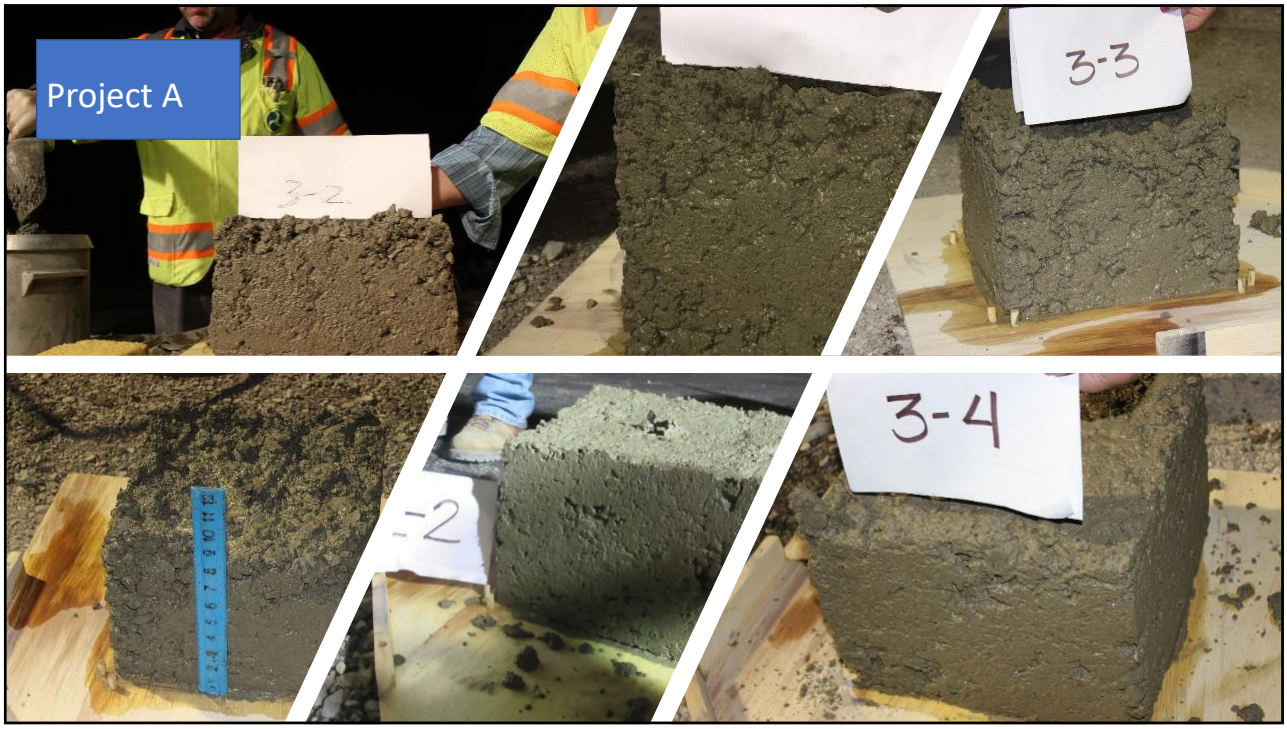
Edge Slump Issues

4. Workability

- Consolidation Ranking from Box Test
- Box Test Ranking from 19 Projects

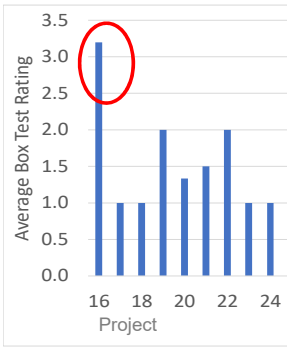
Box Test Ranking Over 1.5	7 out of 19 projects





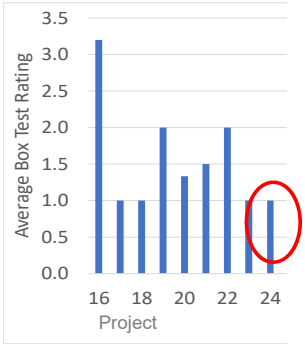
4. Workability

- Project A
  - Field Performance



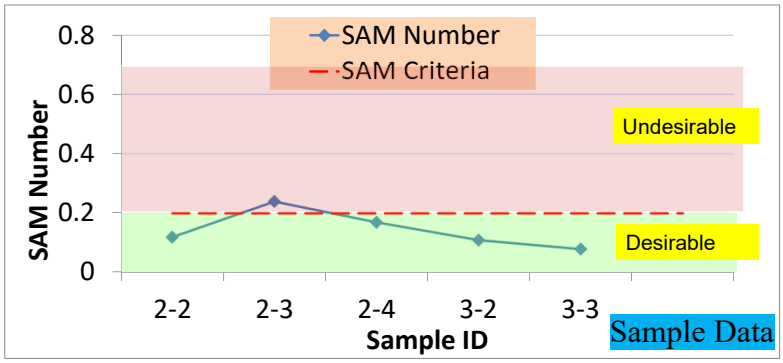
4. Workability

- Project B
  - Box Test
  - Field Performance



5. Super Air Meter

- Key indicator of freeze-thaw durability
- Yields SAM Number
  - Correlates to Spacing Factor
- AASHTO TP 118/R101
- SAM Number
  - Range from 0 to 0.8
  - Lower the better
  - Mixture design target
    - 0.2 SAM



Use of AASHTO TP 118/R101 is not a Federal requirement.

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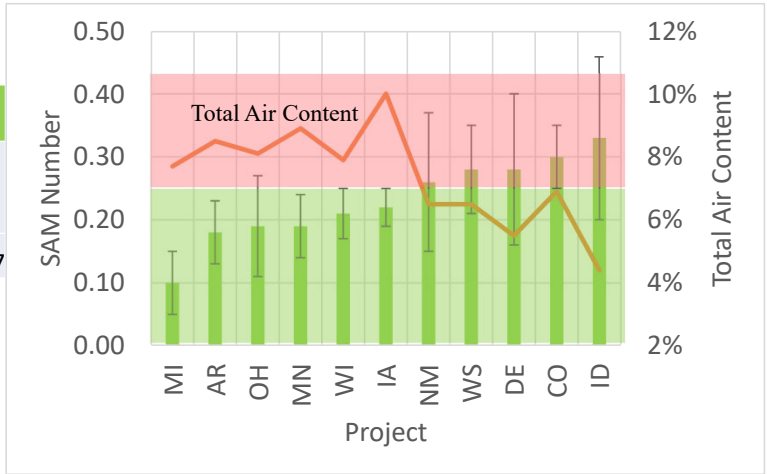
5. Super Air Meter

- SAM Number

Air Content		SAM Number	
Average	Standard Deviation	Average	Standard Deviation
7.4%	0.9%	0.23	0.07



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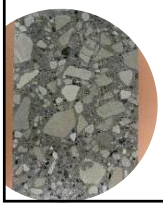
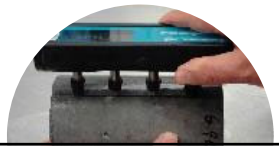
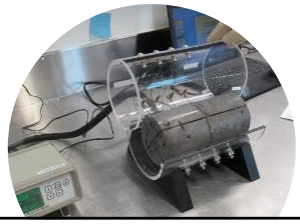
PEM Summary

- PEM Tests are simple to perform
- PEM is viable
- Today's concrete meet several PEM criteria
- PEM is not a gigantic leap. States and industry are already doing some of this

Pavement Thickness Measurement

- Traditional Method
  - Probing (QC)/Coring (QA)
- New Method
  - Pulse Induction (MIT Scan T3)
  - Cheaper, faster, accurate, real-time (almost), statistically more robust
  - AASHTO T 359




Use of AASHTO T 359
is not a Federal requirement.

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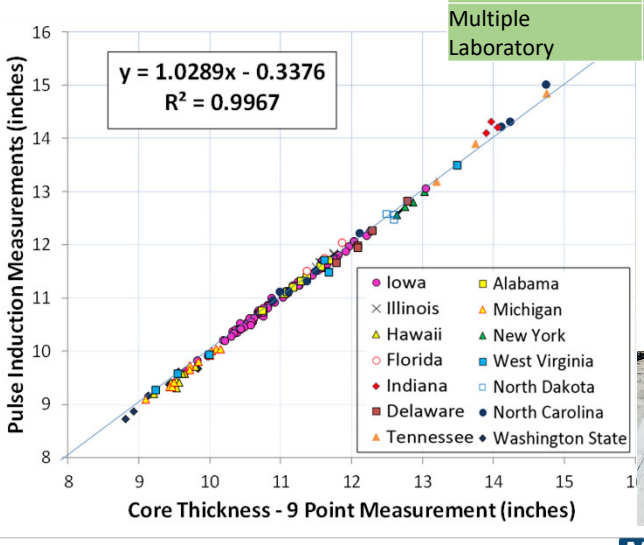
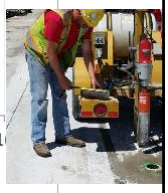
Pavement Thickness Measurement

Precision	Coefficient of Variation	
	1S	D2s
Single Operator	0.3%	0.8%
Multiple Laboratory	0.5%	1.3%

- Implementation
  - Iowa
  - Wisconsin
  - Minnesota
  - Kansas
  - Idaho
  - North Dakota
  - Illinois Tollway
  - Pennsylvania
  - North Carolina
  - Washington State





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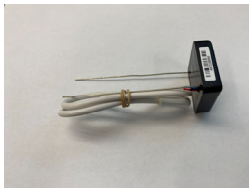
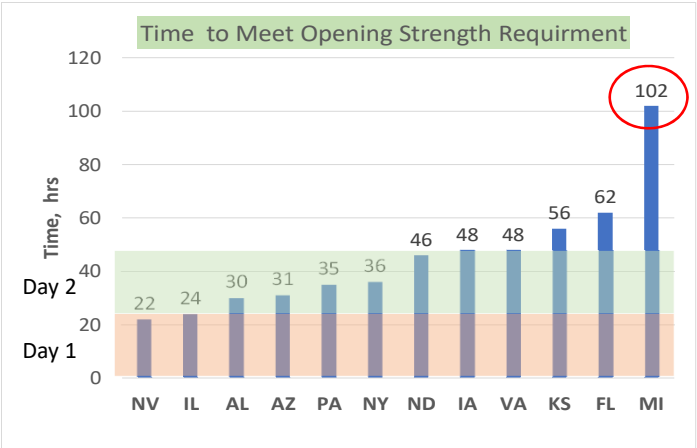
State Strength Requirements to Opening to Traffic

- Maturity Concept to Determine In-Place Strength of Concrete





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MCTC Recent Publication

- **TRB Paper - 2019**
  - **Variability in Data of Fresh and Hardened Properties of Paving-Concrete Mixtures**
    - Jagan Gudimettla, Lisa McDaniel, Mike Praul, Jim Grove, Robert Conway

Fresh Concrete Properties

- Slump
- Concrete Temperature
- Unit Weight
- Air Content
- Spacing Factor (Air Void Analyzer)
- Microwave water content

Hardened Concrete Properties

- 7 Day Compressive Strength
- 28 Day Compressive Strength
- 56 Day Compressive Strength
- 28 Day Surface Resistivity
- 56 Day Surface Resistivity
- 56 Day and beyond RCPT
- Coefficient of Thermal Expansion (CTE)

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THANK YOU!

https://www.fhwa.dot.gov/mctc