



The Super Air Meter MnDOT's Experience

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Acknowledgments

- Dr. Tyler Ley, Oklahoma State University
- Jake Indihar, MnDOT Graduate Engineer



Why should MN add air to concrete?



Why Do We Add Air to Concrete?

- Air-entrained bubbles are a key to the freeze-thaw resistance of concrete

Air volume \neq freeze-thaw performance

- Smaller bubbles are more effective in providing freeze-thaw resistance and have less of an impact on our concrete than larger bubbles

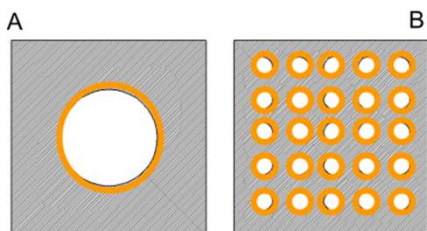


Why Do We Add Air to Concrete?

- The most challenging aspect of concrete to get right is the air content.
- Large bubbles are the enemy!



What Do You Want in an Air-Void System?

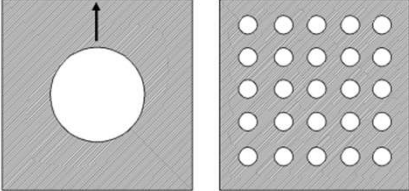


- Volume of air provided is the same for both.
- Case B has a better air void distribution.




What Do You Want in an Air-Void System?

A Large bubbles are more buoyant B




- Volume of air provided is the same for both.
- Case B has a better air void distribution.




Why are large bubbles bad?

- They leave the concrete and change your air volume
- They don't help with freeze-thaw durability
- They reduce your strength more than smaller bubbles



What causes large bubbles?

- Admixture incompatibility
- Admixture/cement incompatibility
- Sand gradation
- Inadequate mixing
- Alkali content of binder
- Cement grinding aids
- Changes in temperature
- Pumping



Why is MnDOT investigating the SAM



Current pressure meters only measure the volume of air (air content), not the size of the bubbles which is the key factor in freeze thaw durability.

Super Air Meter (SAM)



AASHTO TP 118

www.superairmeter.com

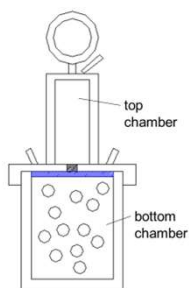


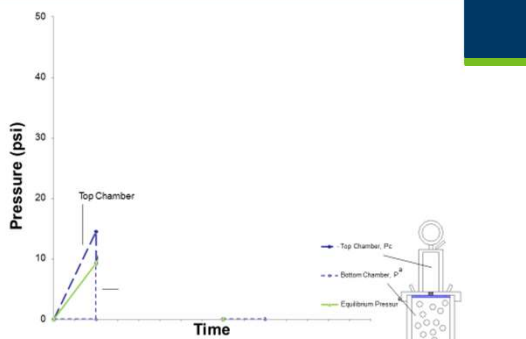
How does it work?

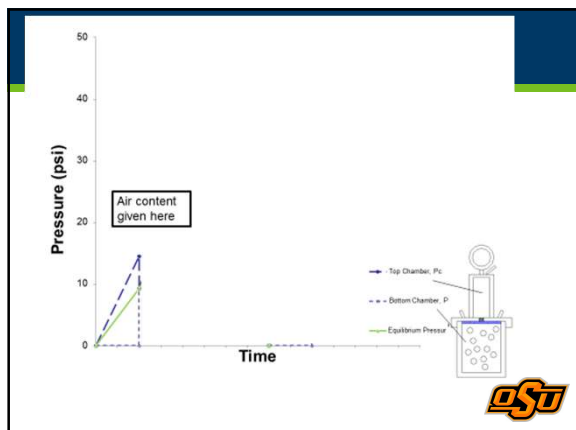
- You use multiple pressure steps instead of one.
- The meter measures the air volume and the bubble size distribution
- The test takes 5-10 minutes

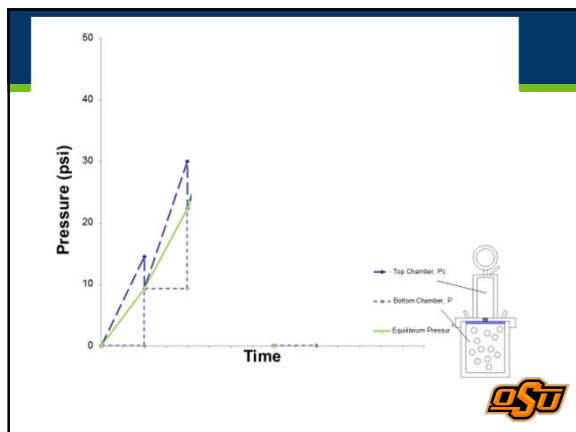


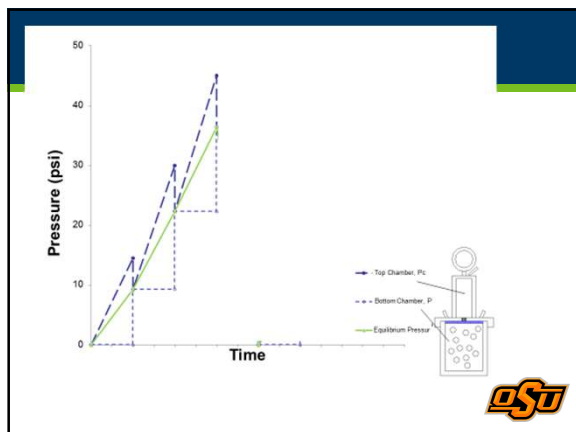
Super Air Meter (SAM)

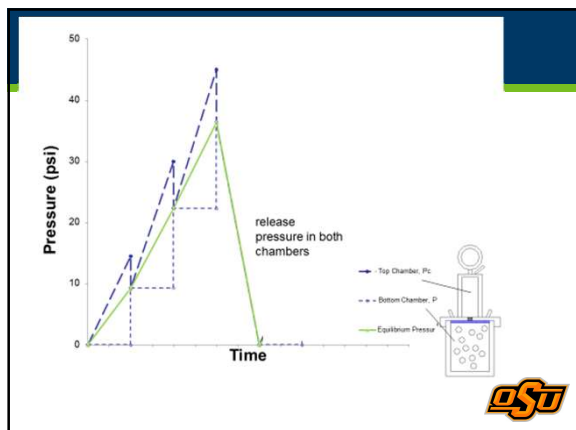


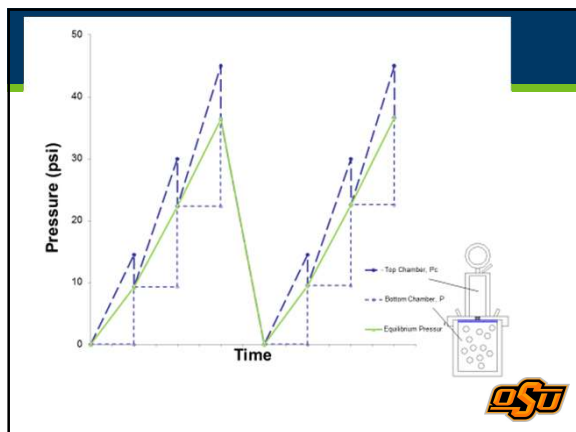


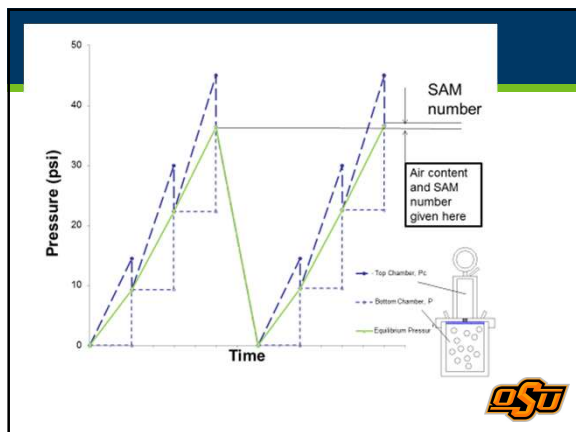


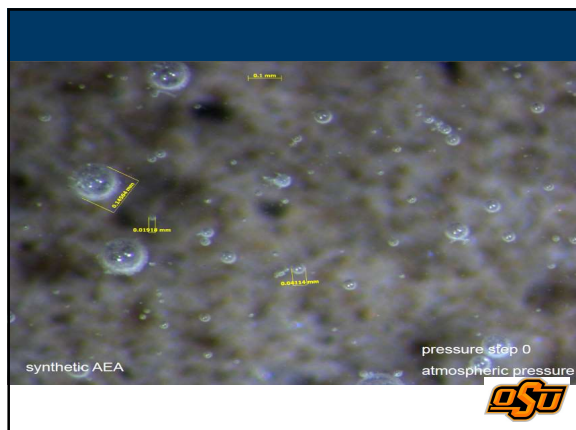




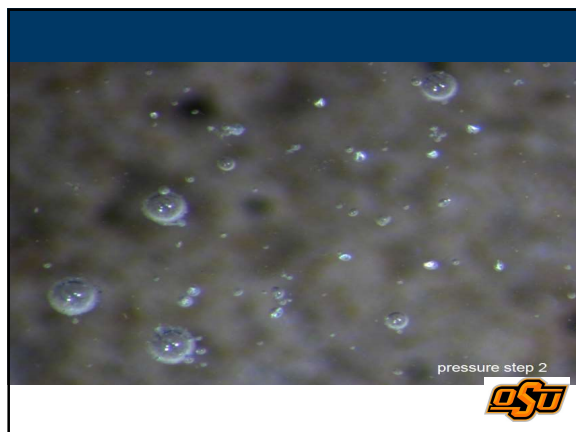


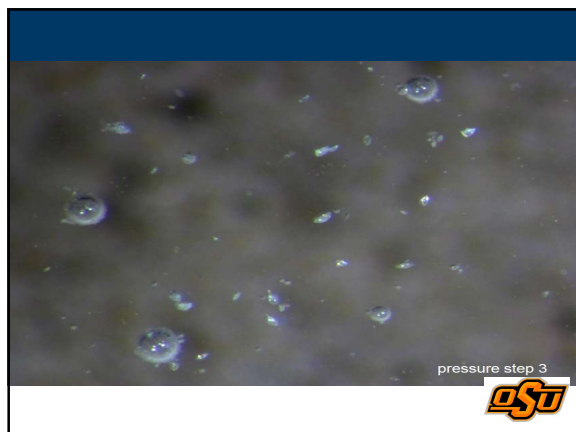


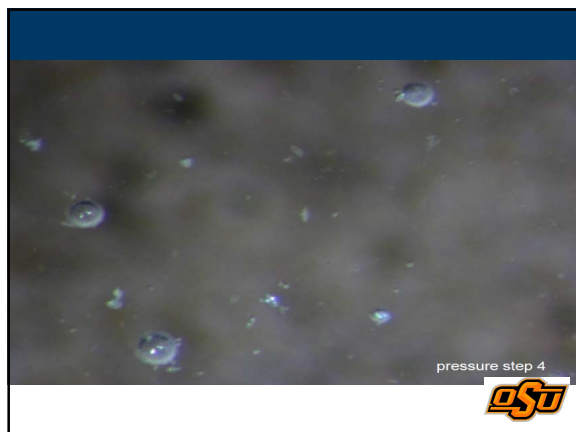


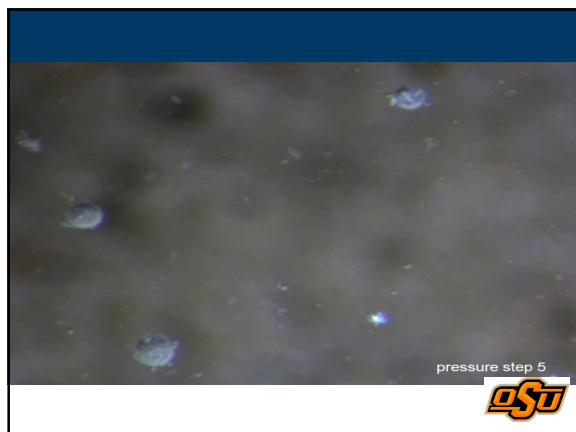


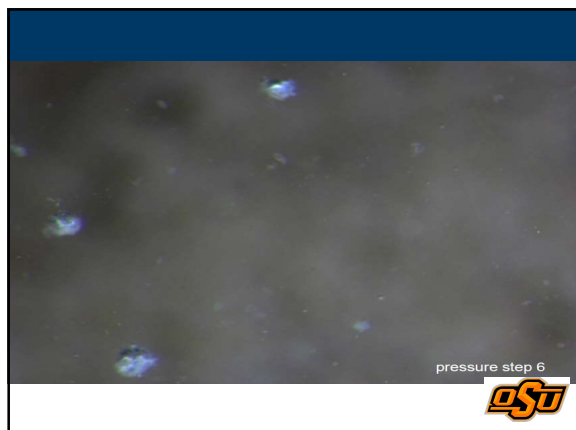


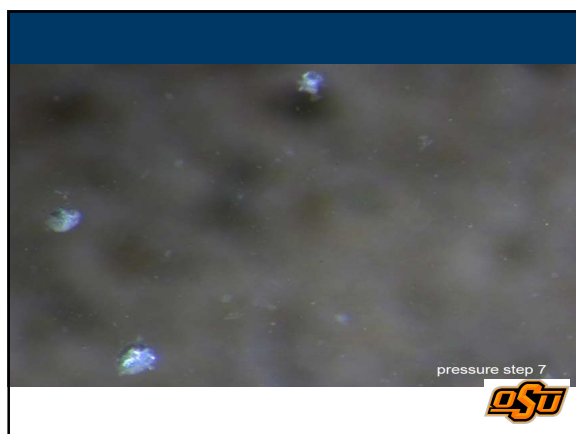


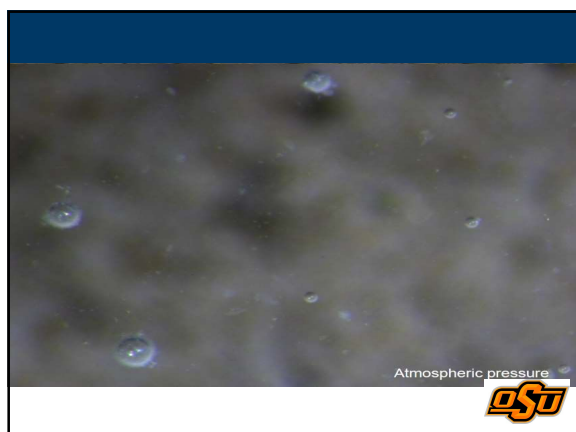






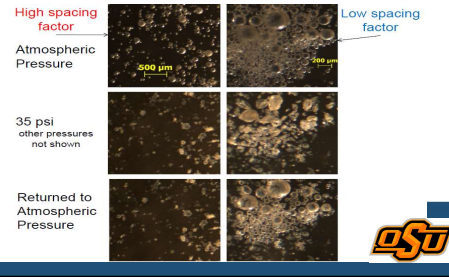


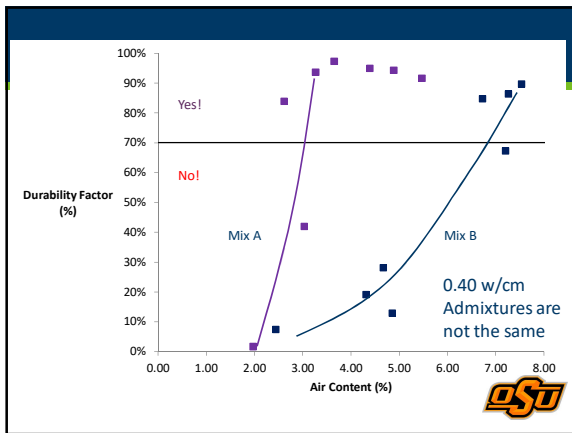


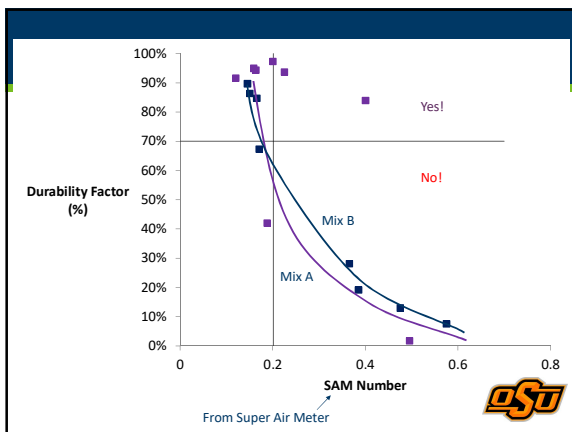


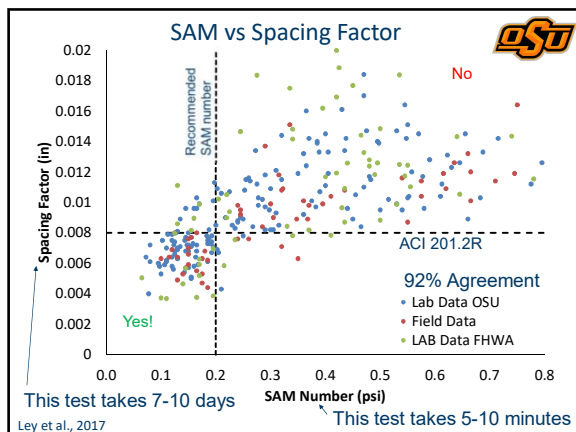
- As you increase the pressure you are dissolving the small bubbles into solution and then they do not immediately come back when you decrease the pressure

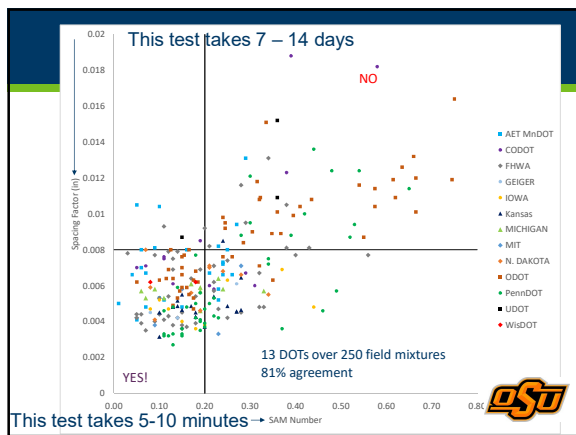
- SAM measures the bubbles that dissolve and don't come back.

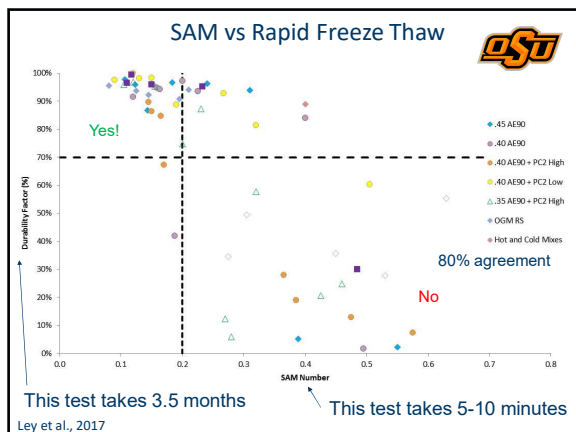












Discussion

- SAM # of 0.20 correlates with a spacing factor of 0.008 (Good F-T durability), shows a good indication of performance
- DOT's finding that SAM # of 0.25 correlates better for their mixes.
- The lower the SAM # = Better Freeze thaw performance and durability of the concrete



Why is MnDOT investigating the SAM

- SAM – 5 to 10 minutes
- ASTM C457 Hardened air – 7 to 14 days
- ASTM C666 Freeze Thaw – 2 to 3 months



What Research has MnDOT done?

- 2013 – present ~ Participation in Multi-State Pooled Funds
- 2015 -2016 ~ Contracted with American Engineering Testing to use SAM on paving projects (2 – 4 tests per project)
- 2017 ~ MnDOT Grad Engineer (6 to 8 tests per project)

1338/ # TPF-5(297) - Improving Specifications to Resist Frost Damage in Modern Concrete Mixtures

1. Validation of Super Air Meter (SAM)
2. Creation of AASHTO Testing Method and Spec for SAM
3. Use of X-Ray Tomography, Absorption and Desorption, Degree of Saturation and Damage to evaluate freeze-thaw mechanisms in concrete.
4. Complete precision and bias of the SAM and updated AASHTO TP118
5. Improved SAM testing equipment based upon feedback from SAM users
6. Support SAM implementation
7. Develop and validate more rapid Freeze-Thaw Test - a sample exchange will occur within the pooled fund states to measure freeze-thaw action in different freeze-thaw environments and correlate to the new testing technology.

Summer of 2017 – MnDOT SAM Testing

- Feasibility of the SAM in the Field
 - Test out the additions to the SAM
- Compare to current Pressure Meter
- Test 2 SAM's at the same time
- Compare SAM # to Hardened Air
- Write a shadow specification



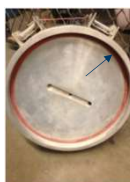
SAM Additions



Shotgun: Funnel that attaches to the petcock



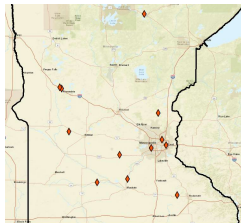
Cape: Portable Air Tank



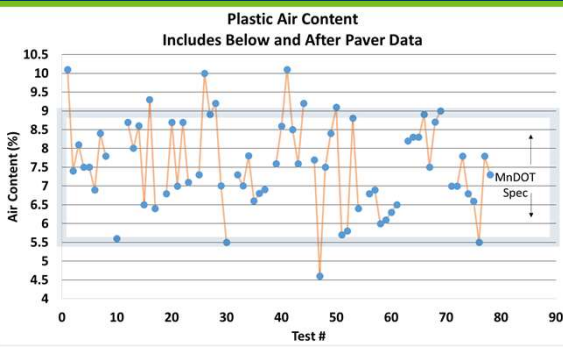
New O-Ring

Project Description

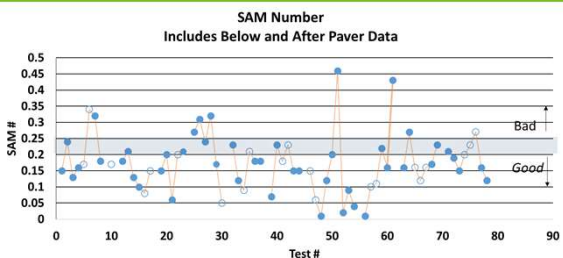
- Drove to a bunch of different concrete projects with Rob Golish.
- Ran about 6-8 SAM's at each project.
- Collected 2 samples one before and one after the paver.
- Documented the Paver speed, vibrator spacing, vibrator speed, SAM #, temperature, etc.



SAM's Air Content for all Projects

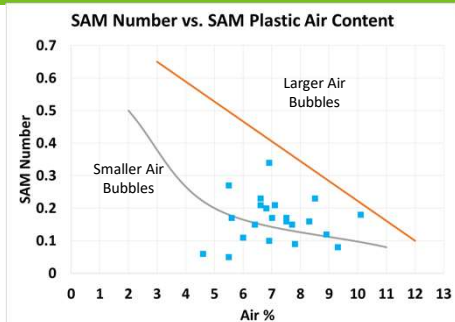


SAM Number for all Projects

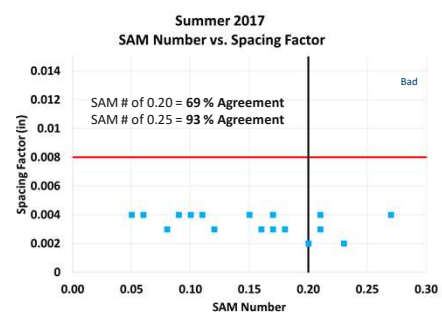


- Few outliers, but for the most part the numbers looked good.
- 4 tests come back with an error message.

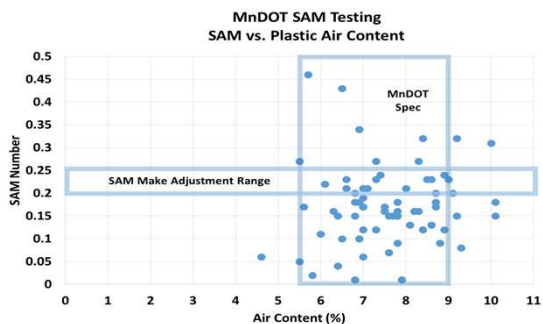
SAM Number vs. Plastic Air Content

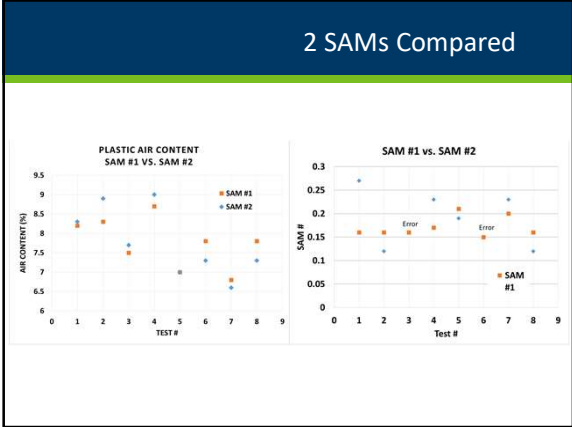


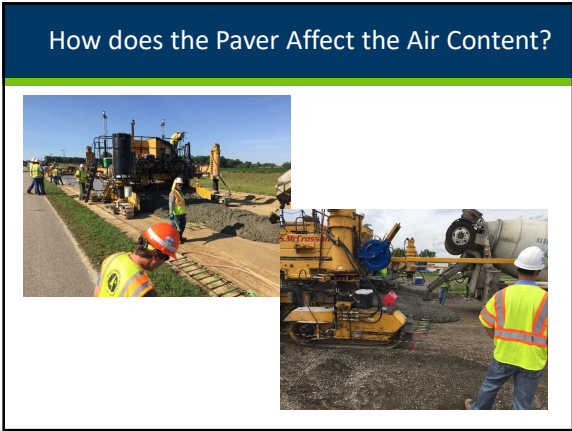
SAM Number vs. Spacing Factor

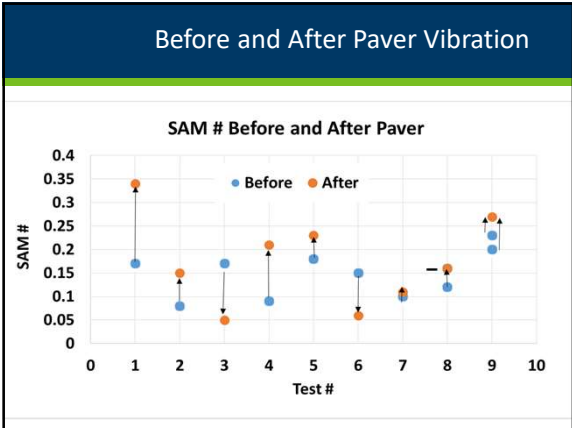


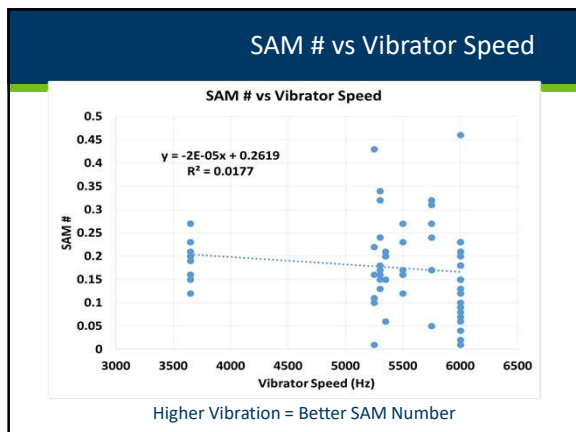
SAM # vs SAM Air Content

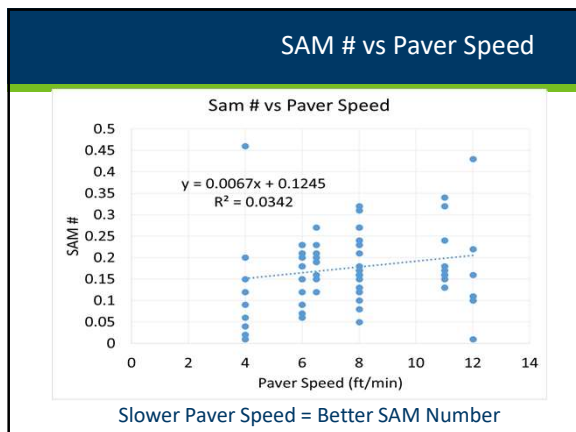












Use of SAM for Trial Batching

- AET Batched multiple mix designs for MnROAD Reconstruction this summer
- All materials the same
 - 1 batch failed the SAM testing, All other mixes passed
 - Rebatched using the same materials – SAM failed
 - Removed the VMA and the SAM passed
 - Why? Not sure

2/15/2018 Optional Tagline Goes Here | mndot.gov/ 54

Use of SAM for Extended Delivery Time Project

- MnDOT specifications require concrete placement within 90 minutes of batching with no additional water at 60 minutes
- Allow testing to extend delivery to 120 minutes
 - Trial/Field Batch
 - Plastic and Hardened Air Required

Use of SAM for Extended Delivery Time Project

- Northern MN project – needed 120 minutes
 - Hardened Air Content did not meet maximum spacing factor of 0.008
 - Braun contacted MnDOT and asked if MnDOT would consider using SAM to approve mix for extended delivery due to the tight timeline – committed to still doing hardened air testing to comply with Spec.

Use of SAM for Extended Delivery Time Project

	Air %	SAM Air%	SAM #	Hardened Air%	Spacing Factor	Comments
Batch 1	7.3	7.5	0.23	7.3	0.003	
Batch 2	8.3	8.3	0.25	6.7	0.003	
Batch 3	-	11.2	0.07	12.3	0.002	
Batch 4	-	8.5	0.14	6.7	0.004	Before Renu Added
Batch 5	-	8.1	0.06	8.6	0.004	After Renu Added
Batch 5 – 90	6.8	6.9	0.04	-	-	After 90 minutes
Batch 5 – 120	6.0	6.3	0.17	-	-	After 120 minutes
Batch 5 - 150	5.4	5.9	0.22	-	-	After 150 minutes

What's Next for Super Air Meter?

- Get the SAM in the Contractors Hands!
 - Focusing on Paving First
- FHWA Equipment Loan Program
 - MnDOT has requested 3 or 4 SAMs for use during the 2018 season

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What's Next for Super Air Meter?

- Applied for \$100,000 FHWA Incentive Program to Implement Performance Engineered Mix Designs for Concrete Paving
 - This will include SAM testing
 - FHWA Mobile Testing Lab to come to paving project in Summer 2018
 - FHWA Quality Workshop in Fall/Winter 2018

What's Next for Super Air Meter?

- Request for funding for SAM Implementation
- Shadow Testing on 4 paving projects and 2 bridge deck projects for information only.



<https://mndot-lrrb.ideascale.com/a/home>

SAM Shadow Specification

- Plastic Air Content – Target 7% (+2%/- 1.5%)
- SAM Number (Information Only)
 - < 0.25 and minimum air content of 4.0%
 - > 0.25 to < 0.30 make adjustments
 - ≥ 0.30 immediately sample the concrete from the same location and fabricate one (1) 4 in x 8 in cylinder.

SAM Shadow Specification - Testing

Table 2301-SAM Grade A Paving Concrete			
Pay Item No.	Test Type	Spec. No.	Contractor Testing
2301	SAM Before Consolidation for Type 3 Concrete (For Information Only)	2301 2461	1 per 1500 yd ³
	SAM After Consolidation for Type 3 Concrete (For Information Only)	2301 2461	Test 1 SAM number per ½ day of slip form paving. Perform the SAM number After Consolidation test at the same location as the Before Consolidation test.
	Hardened Air (For information Only)	2461	2 cylinders per day: 1 Before and 1 After Consolidation Use MnDOT standard cylinder mold size 4 x 8 inch.

MnDOT Implementation Plans - GOALS

- 2019 – Let pilot paving projects using a combination of plastic air content and SAM
- 2020 – Full implementation of SAM Specifications on paving projects
- 2019 – Start looking at Ready-Mix focusing on bridge decks



Thank you
Questions?

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