2016 APAO Conference

February 24, 2016

Tack Coat Materials, Application and Best Practices

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Oregon Dept. of Transportation

Tack Coat Agency Perspective

- Focus temporarily switched to tracking

Tack Coat Agency Perspective

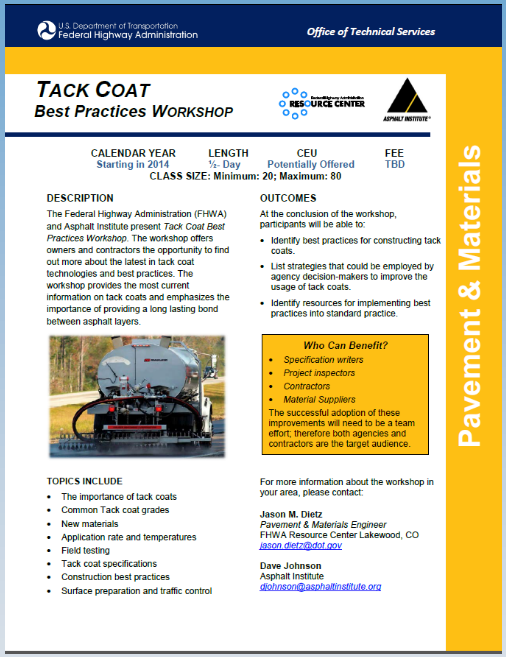
- Tracking is still work in progress

Tack Coat Agency Perspective

- Need to get back to basics

Tack Coat Agency Perspective

- Training
  - ODOT Inspector Training
    - Reinforce Tack use
  - ODOT/APAO Advance Pavers Workshop (2013)
  - FHWA Tack Workshop (2015)
  - ODOT Spec Notes and Best Practices (2015)



U.S. Department of Transportation
Federal Highway Administration
Office of Technical Services

TACK COAT
Best Practices WORKSHOP

Federal Highway Administration RESOURCE CENTER
ASPHALT INSTITUTE

CALENDAR YEAR	LENGTH	CEU	FEE
Starting in 2014	½- Day	Potentially Offered	TBD

CLASS SIZE: Minimum: 20; Maximum: 80

DESCRIPTION

The Federal Highway Administration (FHWA) and Asphalt Institute present *Tack Coat Best Practices Workshop*. The workshop offers owners and contractors the opportunity to find out more about the latest in tack coat technologies and best practices. The workshop provides the most current information on tack coats and emphasizes the importance of providing a long lasting bond between asphalt layers.

OUTCOMES

At the conclusion of the workshop, participants will be able to:

- Identify best practices for constructing tack coats.
- List strategies that could be employed by agency decision-makers to improve the usage of tack coats.
- Identify resources for implementing best practices into standard practice.

Who Can Benefit?

- *Specification writers*
- *Project inspectors*
- *Contractors*
- *Material Suppliers*

The successful adoption of these improvements will need to be a team effort; therefore both agencies and contractors are the target audience.

TOPICS INCLUDE

- The importance of tack coats
- Common Tack coat grades
- New materials
- Application rate and temperatures
- Field testing
- Tack coat specifications
- Construction best practices
- Surface preparation and traffic control

For more information about the workshop in your area, please contact:

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Pavement & Materials

Tack Coat Agency Perspective

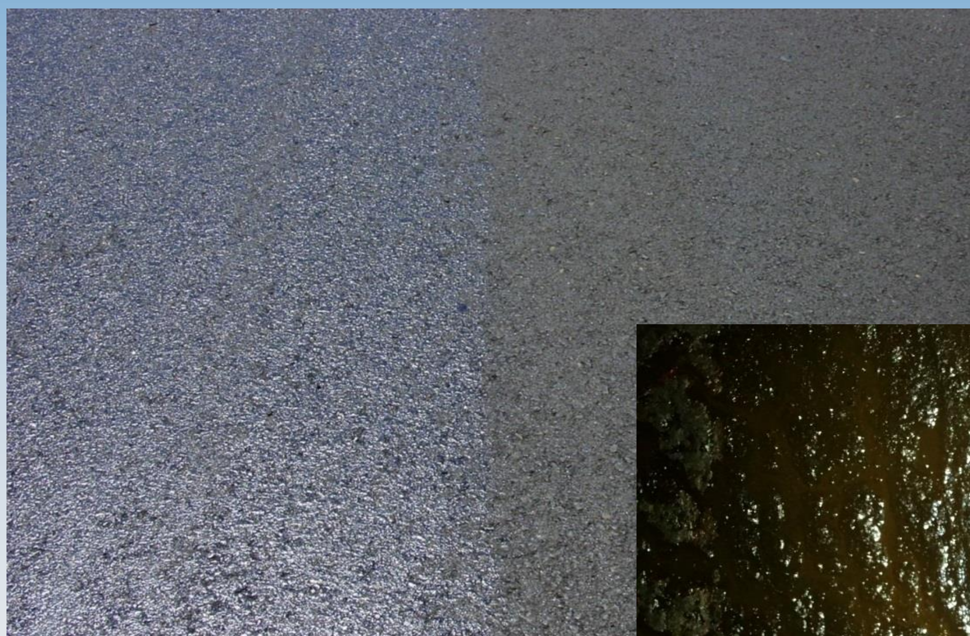
- Field Data Collection
  - ASTM D2995 Standard Practice for Estimating Application Rate and Residual Application Rate of Bituminous Distributors
  - Explore what other DOT's have as standard of practice.

Tack Coat Agency Perspective

- SPR 782 HMAC Layer Adhesion Through Tack Coat
  - Dr. Erdem Coleri, Oregon State University
    - Complete in 2016

Tack Coat Agency Perspective

- Working together, we can reach the goal



HMAC Layer Adhesion Through Tack Coat

Erdem Coleri
OSU

Larry Ilg
ODOT

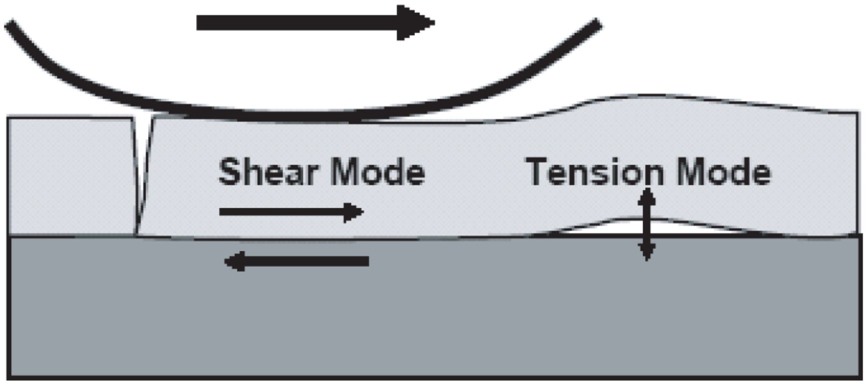
Other contributors

- Grad students at OSU:
  - David Covey
  - Aiman Mahmoud

- TAC members:
  - Norris Shippen - ODOT
  - Keven Heitschmidt - Albina Asphalt
  - Troy Tindall - BlueLine
  - Anthony Boesen - FHWA

- Thanks to Ron Depue and David Davies for their help with field testing

Why do the tack coats fail?



Critical stress types at the interface (Raab and Partl 2004).

Which mechanism is more critical?
Shear or tension?

Slippage cracking

How to improve tack coat performance?

Research Objectives

- Applying the optimum rate
- Develop a QC/QA device – Field tack coat tester
- Reduce tracking
  - Not allowing construction traffic before the set (How long do we need to wait?)
  - Using tack coats that track less
- Non-uniform and inaccurate spraying
- Using better tack coats (New emulsions, CO1 and CO2)
- Checking the bond strength for QC/QA
  - Coring and shear testing in the lab
  - Can we come up with a less destructive and an easier method?

HOW IMPORTANT IS THE BOND STRENGTH?

CAN WE EXTEND PAVEMENT STRUCTURAL LIFE BY USING BETTER TACK COATS?

Impact of bond strength on performance

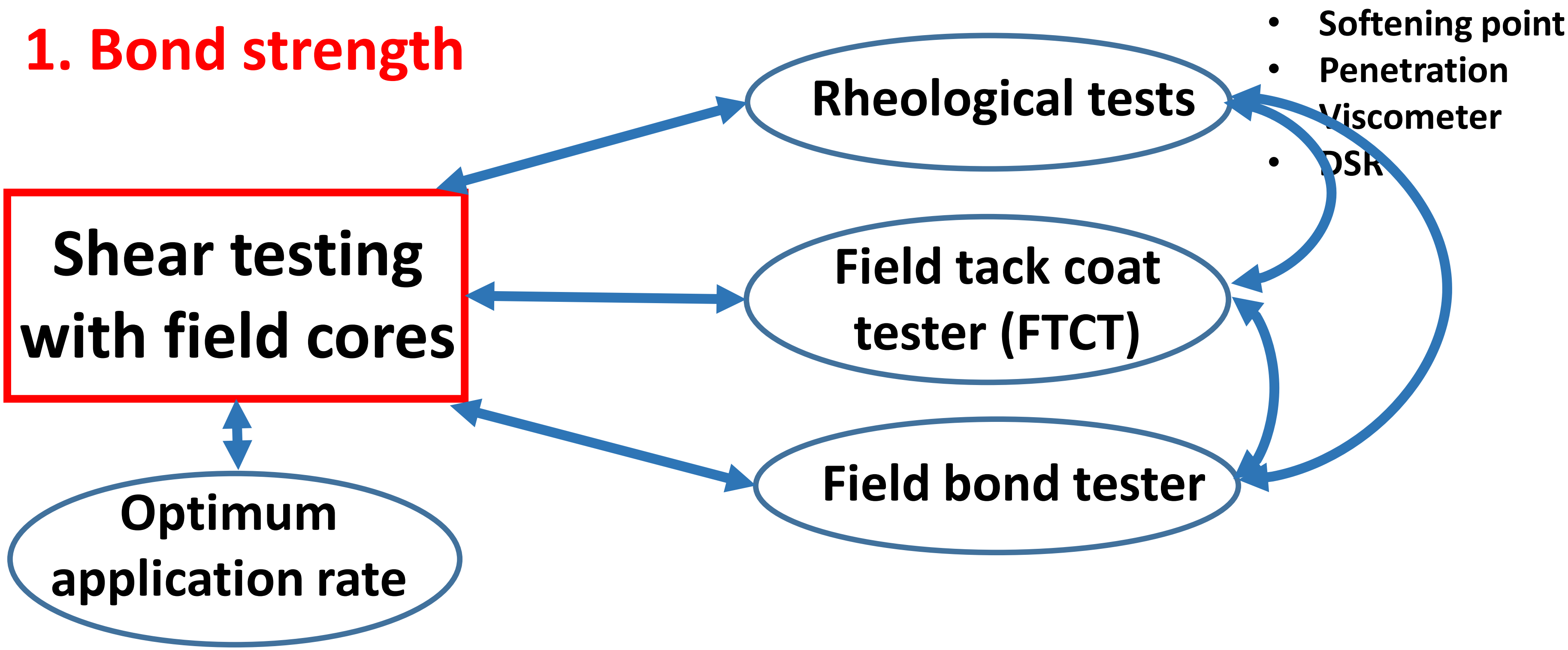
- **King and May (2003):**
  - Fatigue life decreases by 50 % when the bonding is reduced by 10 %.
- **Roffe and Chaignon (2002):**
  - Pavement service life can reduce from 20 years to 7 years due to the lack of bond between two asphalt layers.
- **Akhtarhusein et al. (2004):**
  - Delamination problem can be reduced by increasing overlay thickness. Increased overlay thickness reduces critical interface shear stresses and minimizes the risk of bond failure.
- **Mohammad et al. (2012):**
  - Tack coat type and application rates are determined to be more important for structures with thin overlays.

Outline

- Research method
- Lab set time measurement and regression equations
- 3D viscoelastic finite element modeling
- Field testing and preliminary results
    - Field Tack Coat Tester (FTCT)
    - Wheel tracking device
    - Other tests
- Lab tack coat testing
- Coring and shear testing
- Summary

Research Method

1. Bond strength



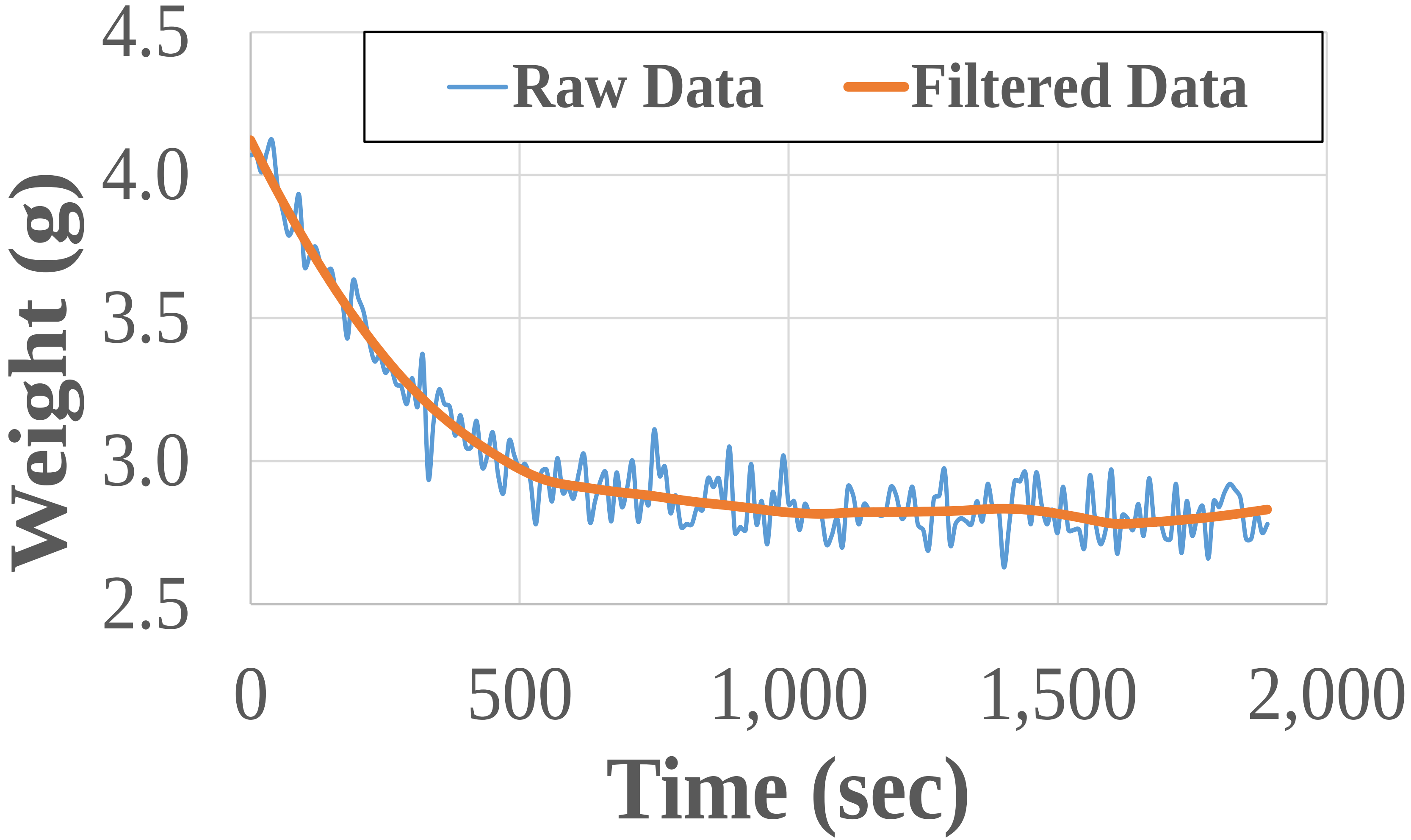
2. How important is the bond strength?

- 3D finite element modeling
- MEPDG simulations

3. Tracking

- Weight measurements
- Wheel tracking device

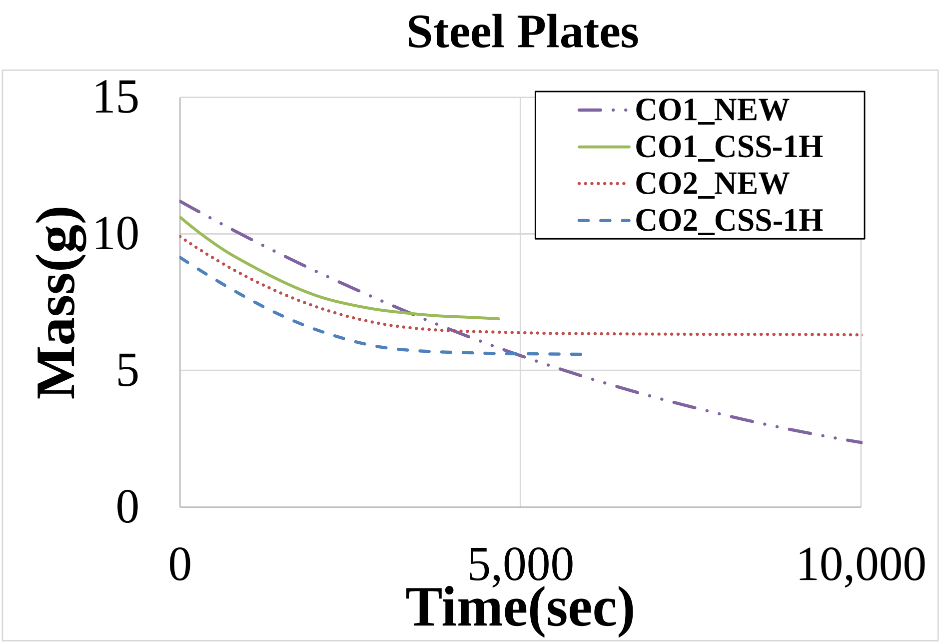
Lab set time measurements – Procedure

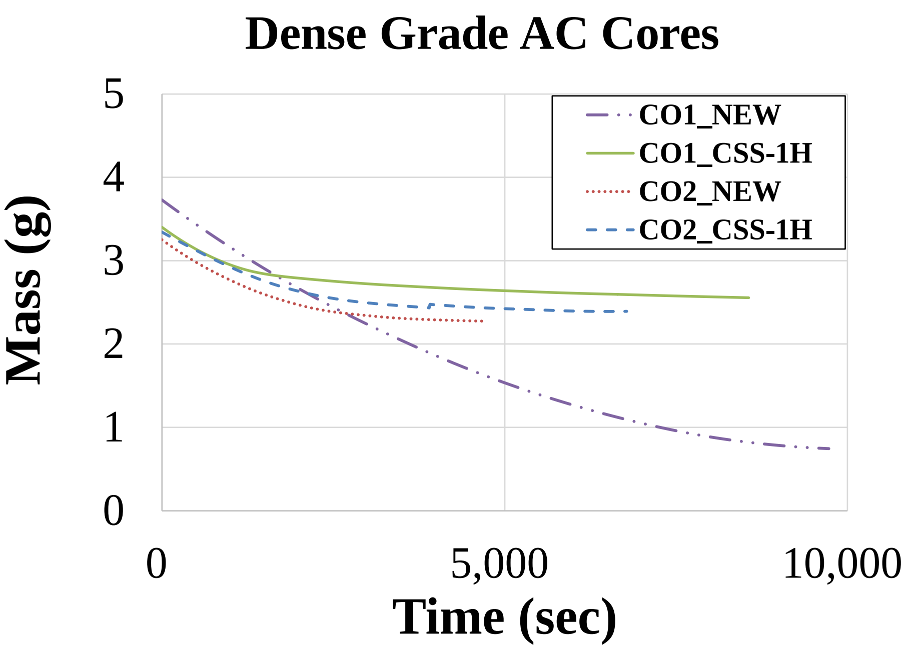


Tack coat types and test conditions

Parameter	**Experimental Plan**
Emulsion	CO1_CSS1H, CO1_New, CO2_NEW, CO2-SS1H
Temperature (°F)	Room: 59 °F, High: 95 °F
Application Rate (gal/yd^2)	0.045 (L), 0.105 (M), 0.164 (H)
Texture	Open grade (OG), dense grade (DG), steel plate (SP)
Replicates	2

Lab set time measurement – Results





Note: low temp (59 °F), medium rate (0.105 gal/yd²)

Regression equations – Developed models

$$\boldsymbol{Set\ Time \sim Temperature + Texture + Emulsion + Rate}$$

Model Type	Model Specification	R^2
Eq.#1: AC Core	SET = 612.60-29.856×TEMPF+10,877.52×MTD+539.11×CSS 1H+5,784.47×EBS.RBC-329.61×EE (0.7475) (0.1304) (0.4622) (0.5850) (0.0000) (0.7376) +46,226.40×ACTR (0.0000)	0.70
Eq.#2: AC Core w/ no MTD	SET = 1,063.70-28.076×TEMPF+489.71×CSS 1H+5,729.40×EBS.RBC-340.97×EE+46,026.99×ACTR (0.5533) (0.1488) (0.6169) (0.0000) (0.7274) (0.0000)	0.70
Eq.#3: AC Core + Steel	SET = 2,799.99-46.791×TEMPF+9,185.86×MTD+294.57×CSS 1H+5,336.73×EBS.RBC-493.39×EE (0.0342) (0.0011) (0.2618) (0.6732) (0.0000) (0.4802) +40,088.63×ACTR (0.0000)	0.72
Eq.#4: AC Core + Steel w/ no MTD	SET = 3,054.59-45.79×TEMPF+266.94×CSS 1H+5,305.85×EBS.RBC-499.74×EE+39,970.96×ACTR (0.0196) (0.0014) (0.7027) (0.0000) (0.4755) (0.000)	0.71

Note: Numbers inside the parentheses are the p-values of the regression coefficient.

Set time regression equations

- Set time regression equations were developed to calculate in-situ set times during construction in order to minimize vehicle tracking
- Various parameters were included
  - Texture of AC surface not significant

	Df	F Value	Pr(F)
Temperature (F)	1	1.79	0.1882
Texture (in)	1	0.00	0.9711
Emulsion	3	16.76	0.0000
Application Rate (gal/yd^2)	1	43.68	0.0000
Residuals	41		

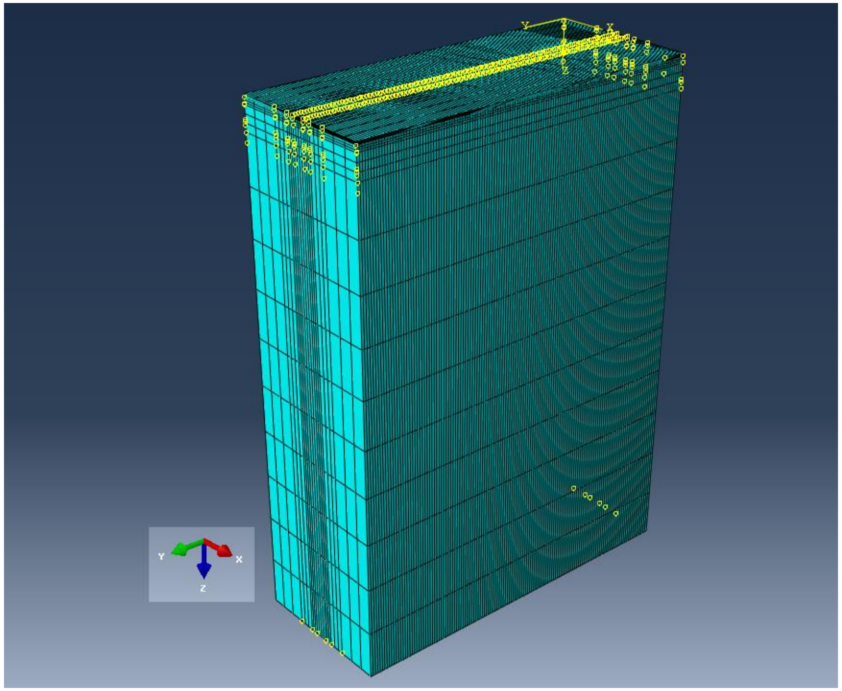
ANOVA analysis results for AC cores

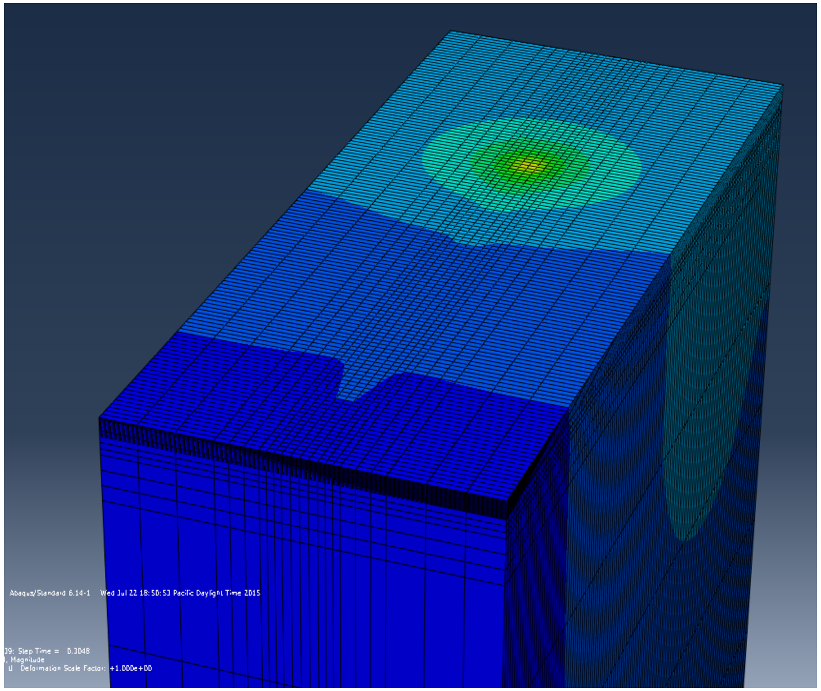
A smart phone app for set time

- Enter "Temperature", "Emulsion type", "Rate", and "Wind speed"
- App will calculate set time with a high reliability level
- App will start the countdown and send a notification when the tack coat is set.

$$\boldsymbol{Set\ Time \sim Temperature + Emulsion + Rate + Wind\ speed}$$

3D viscoelastic finite element model to evaluate the effects of structural characteristics on tack coat performance





Dynamic truck wheel

3D viscoelastic finite element model to evaluate the effects structural characteristics on tack coat performance

NEXT STEP:
Developed models will be used to evaluate the impact of tack coat strength on structural performance

HOW IMPORTANT IS THE BOND STRENGTH?

CAN WE EXTEND PAVEMENT STRUCTURAL LIFE BY USING BETTER TACK COATS?

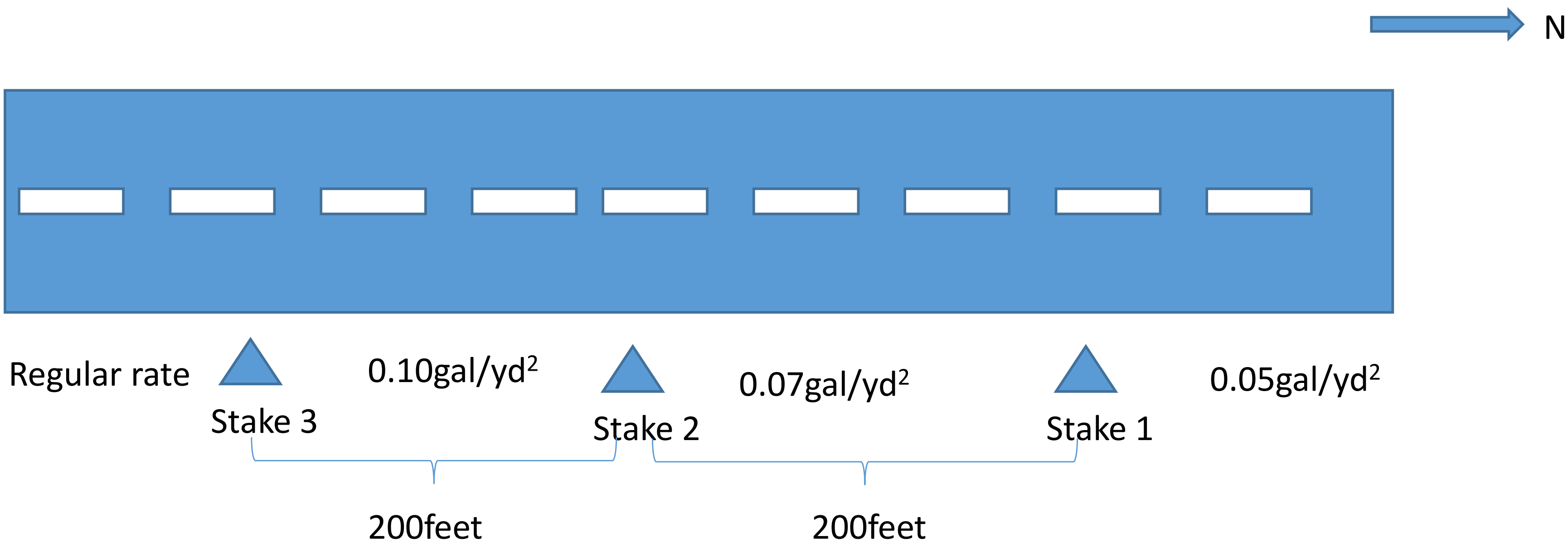
WHAT IS THE PERCENT INCREASE IN SERVICE LIFE THAT CAN BE CREATED BY USING BETTER TACK COATS?

Field testing and preliminary results

99W: Amity – Hoffman Road

Milled		
Day 1	CO1_CSS-1H	0.08, 0.10, 0.12 gal/yd^2
Day 2	CO1-NEW	0.08, 0.12, 0.16 gal/yd^2
Day 3	CO2-NEW	0.08, 0.12, 0.16 gal/yd^2
Overlay		
Day 4	CO1_CSS-1H	0.05, 0.07, 0.09 gal/yd^2
Day 5	CO2_NEW	0.05, 0.07, 0.10 gal/yd^2
Day 6	CO2_CSS-1H	0.05, 0.07, 0.10 gal/yd^2

Field testing – Typical site layout



First lift on a milled surface – August X 3 locations

Second lift on the new surface – September X 3 locations

Field Tack Coat Tester (FTCT)

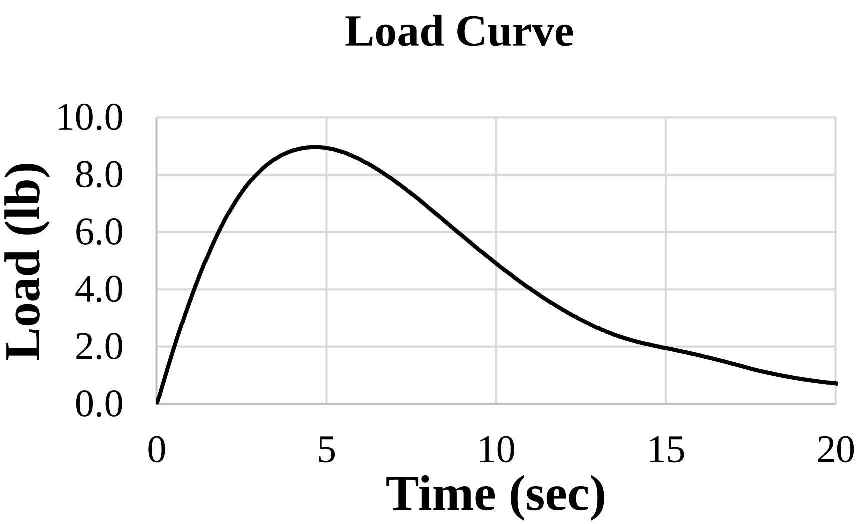
Earlier version
(wired c

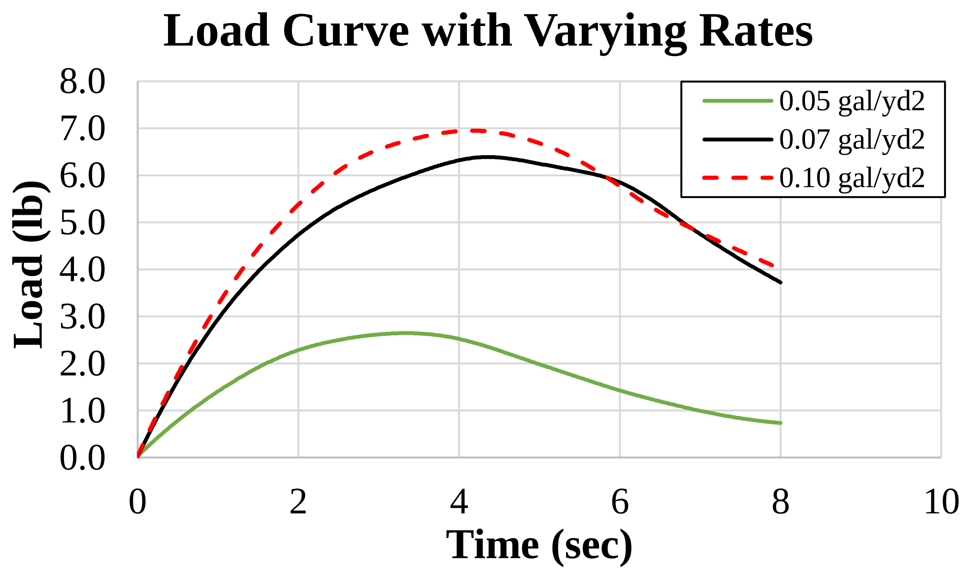
FTCT test procedure

Several parking lot experiments were conducted at OSU to develop a test procedure for FTCT

- Attach a thick foam material on load platen
- Place 80 Ib weight on the frame to be able to apply a compressive load on the surface with tack coat
- Heat the emulsion for 8 minutes using an infrared heating lamp to break the emulsion.
- Using the control software (laptop or tablet), apply a compressive load of 60 Ib and wait for three minutes.
- Pull the load up at a constant displacement rate of 0.008 in/sec and record the maximum tensile stress (tensile strength) applied.

Field tack coat tester (FTCT) – Results

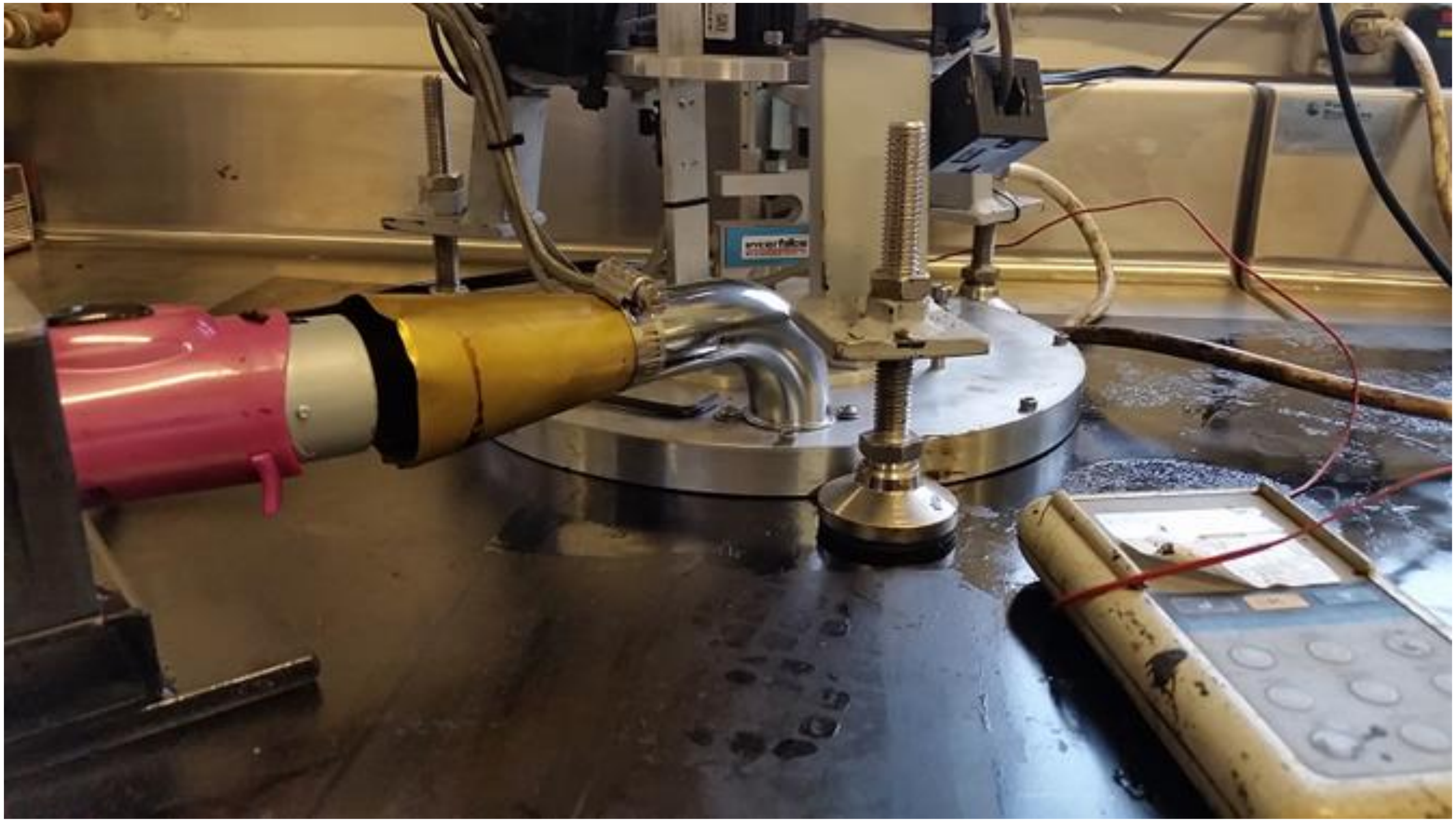




Note: Results from 0.08 gal/yd^2 rate

Note: Results from emulsion CO2_NEW on overlay surface

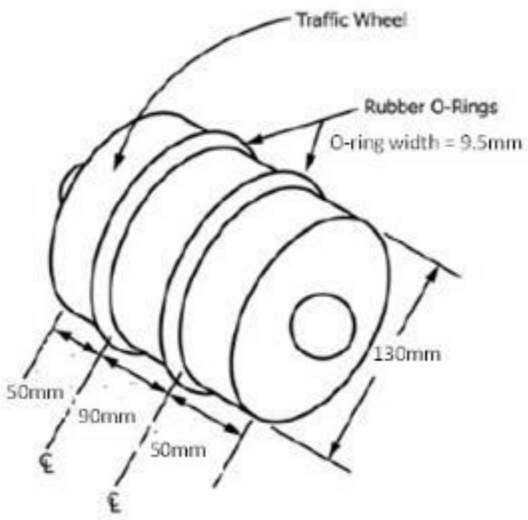
Field tack coat tester (FTCT) – New temperature control system



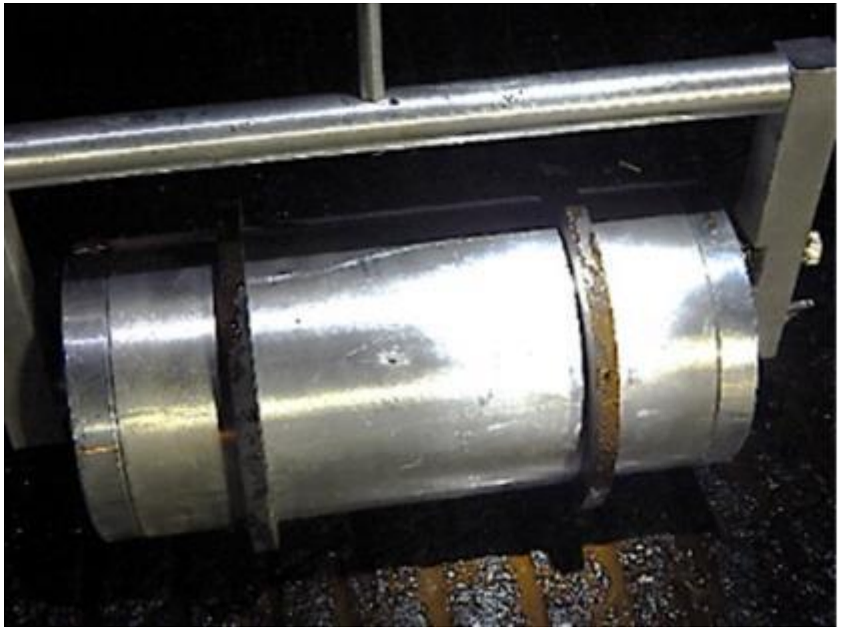
A new temperature control system is developed to reduce measurement variability.

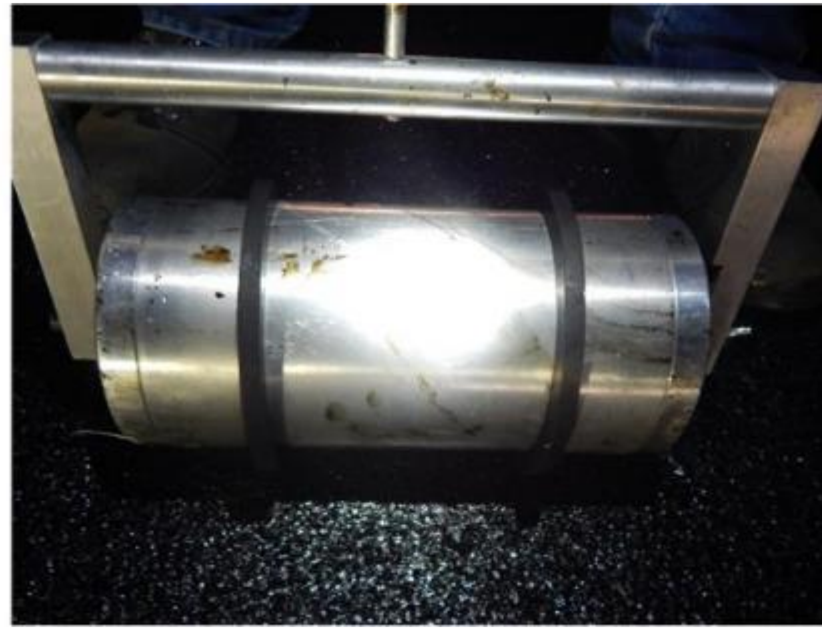
Wheel tracking device

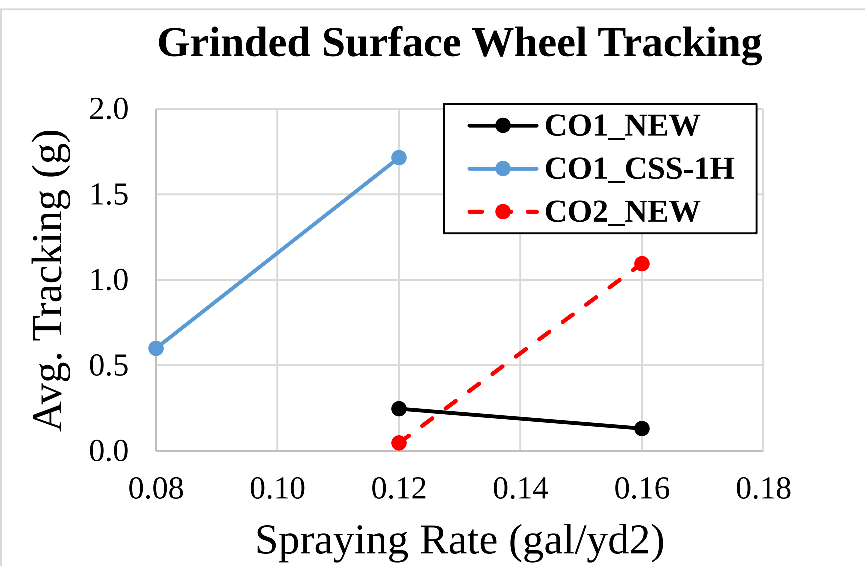
- Simulate rolling truck tire (match the actual truck tire pressure, 105 psi, by adjusting weight and tire area)
- Measure tracking of tack coat (weigh the tires or just visual inspection)

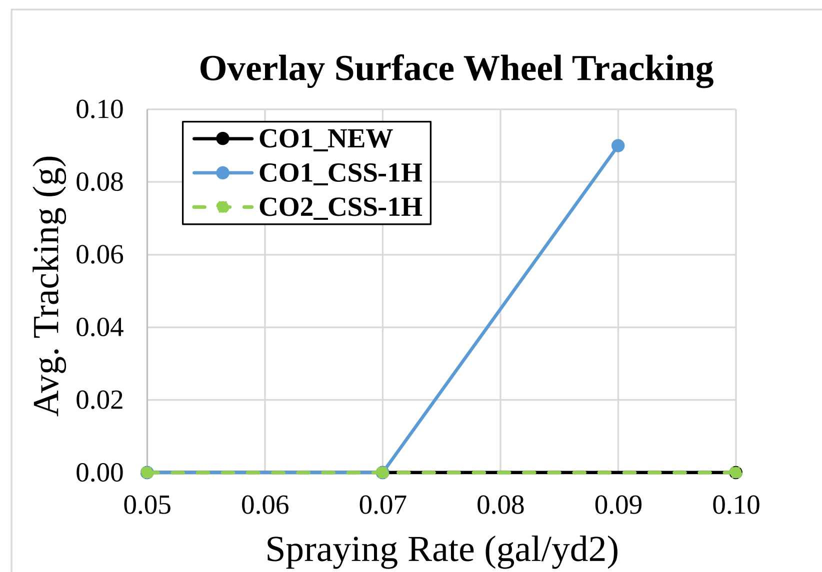


Wheel tracking device – Trends







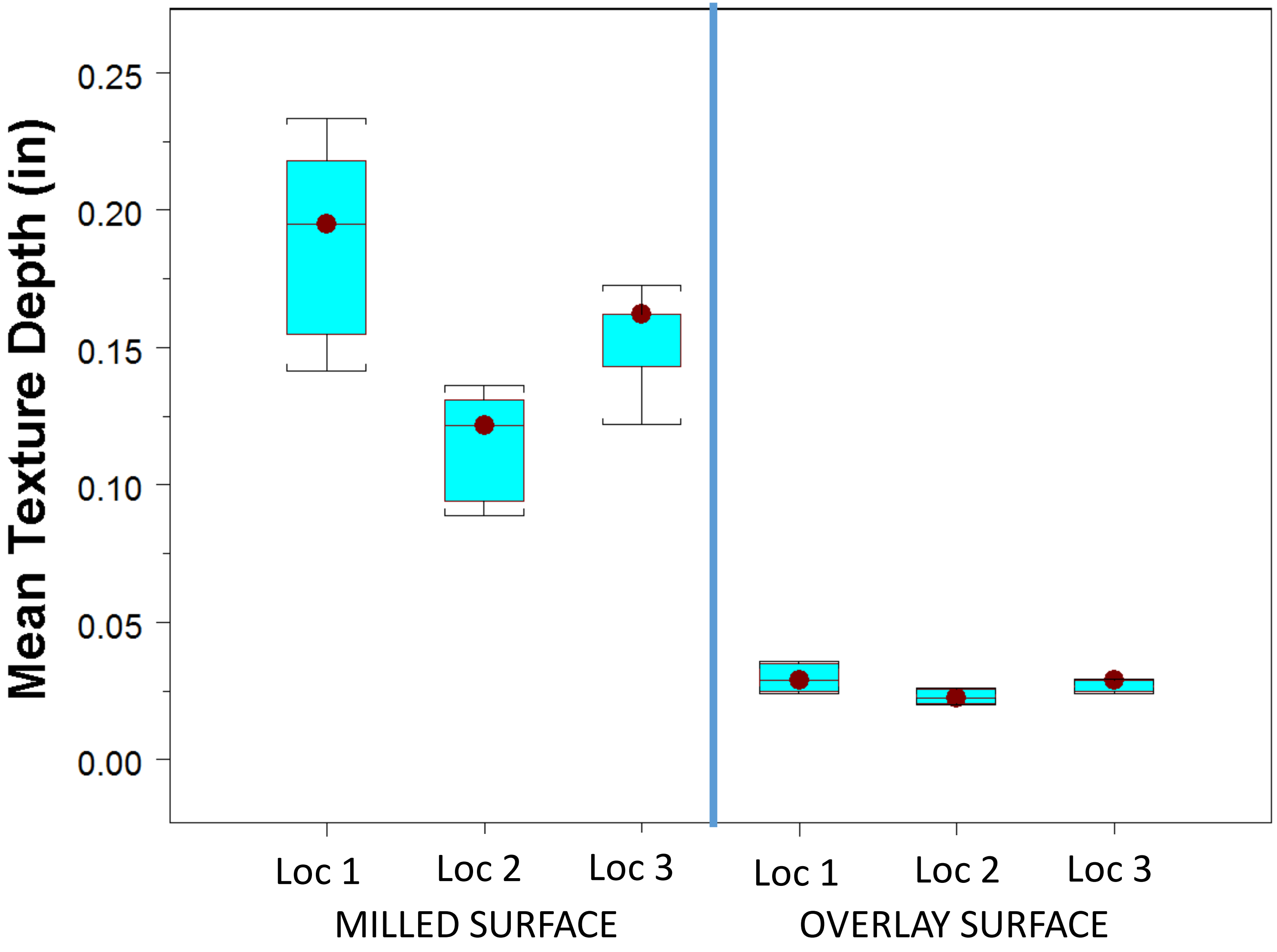


Field testing – Other tests

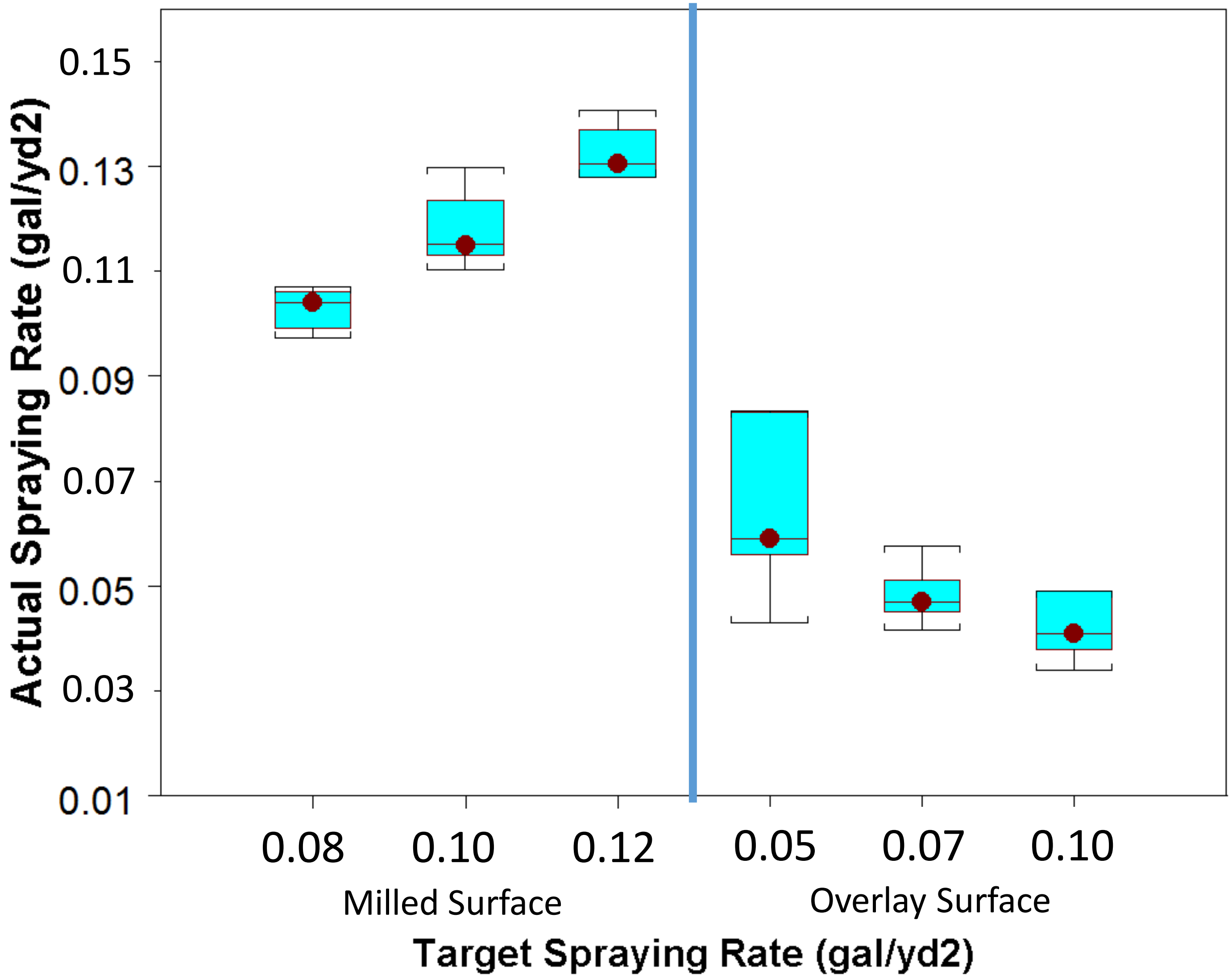
Field spraying rate measurement

Field texture measurements – Sand Patch

Field testing – Sand patch



Field testing – Spraying rate



Field testing – Tack coat sampling

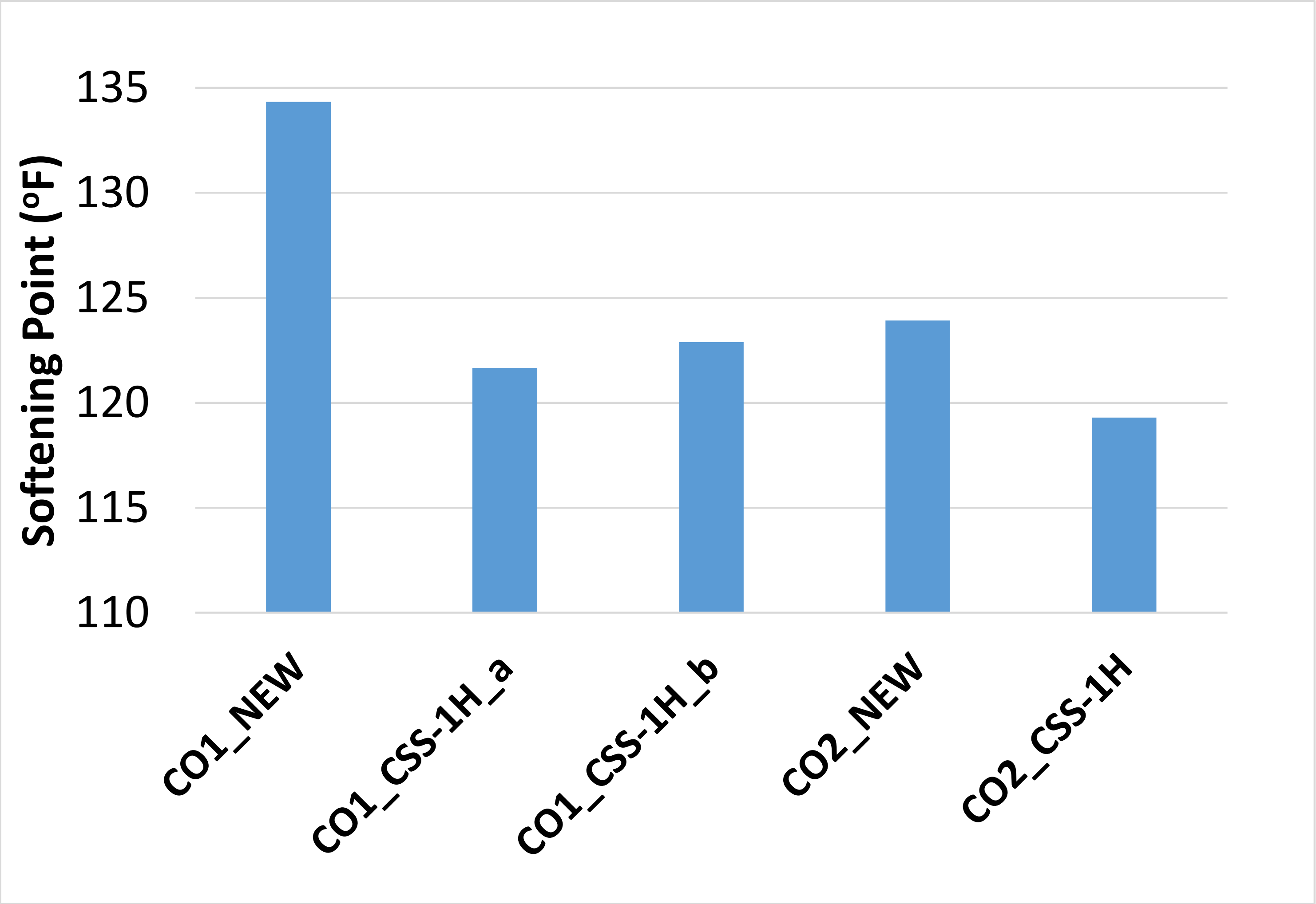
Field tack coat sampling

Lab tack coat testing

ASTM D6997: Distillation

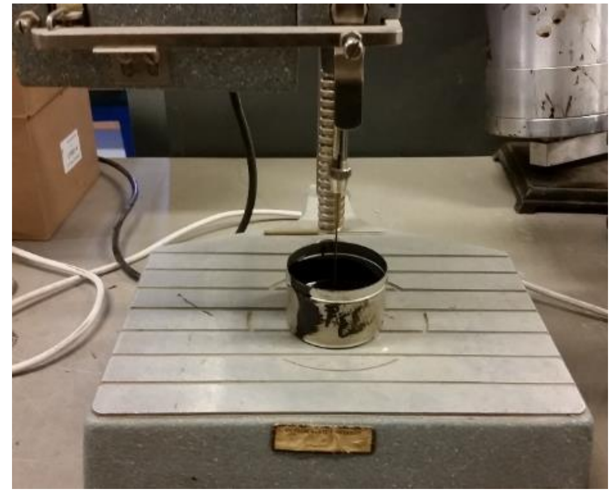
ASTM D36: Softening Point

Lab tack coat testing – Softening point



CO1: Company 1

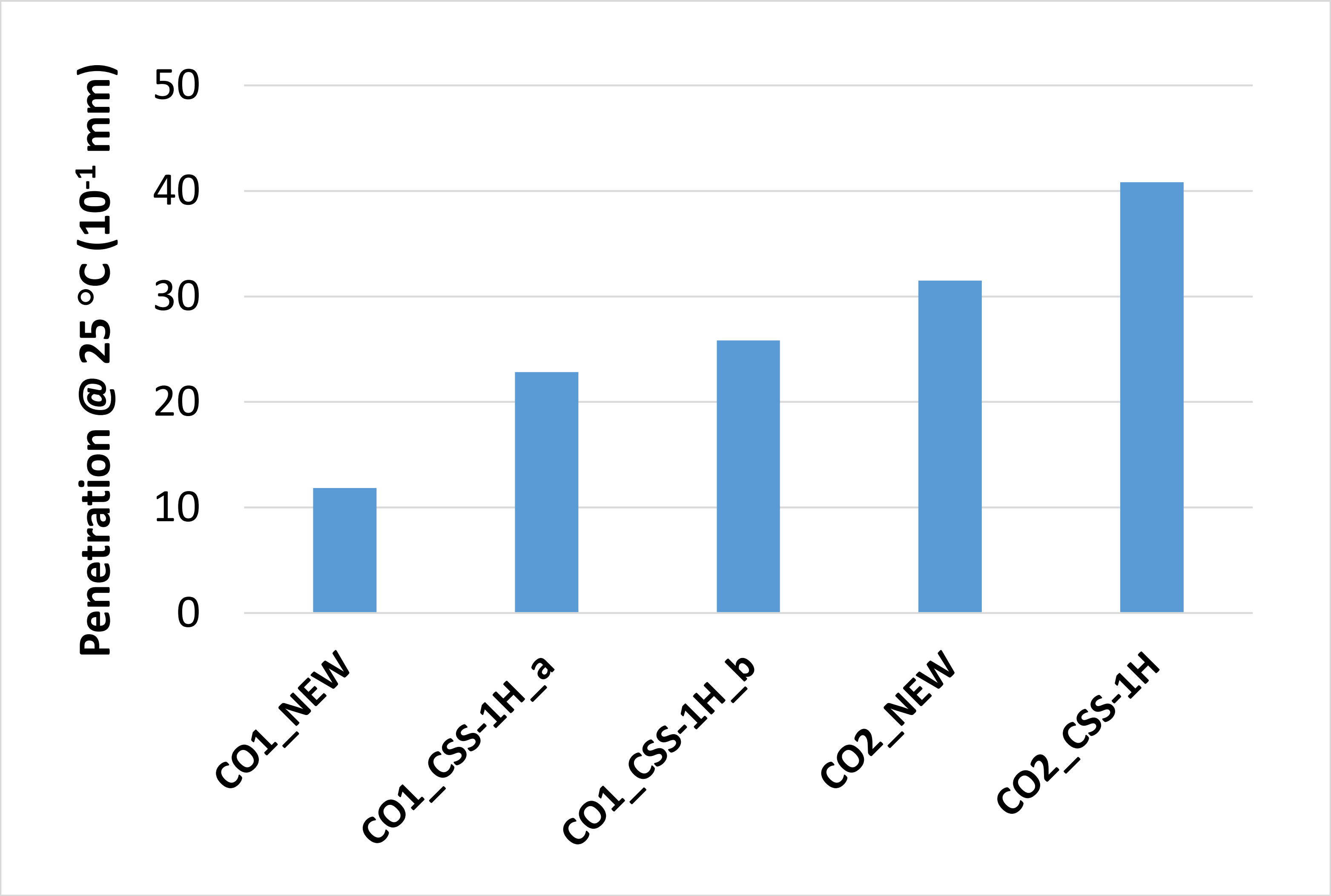
Lab tack coat testing



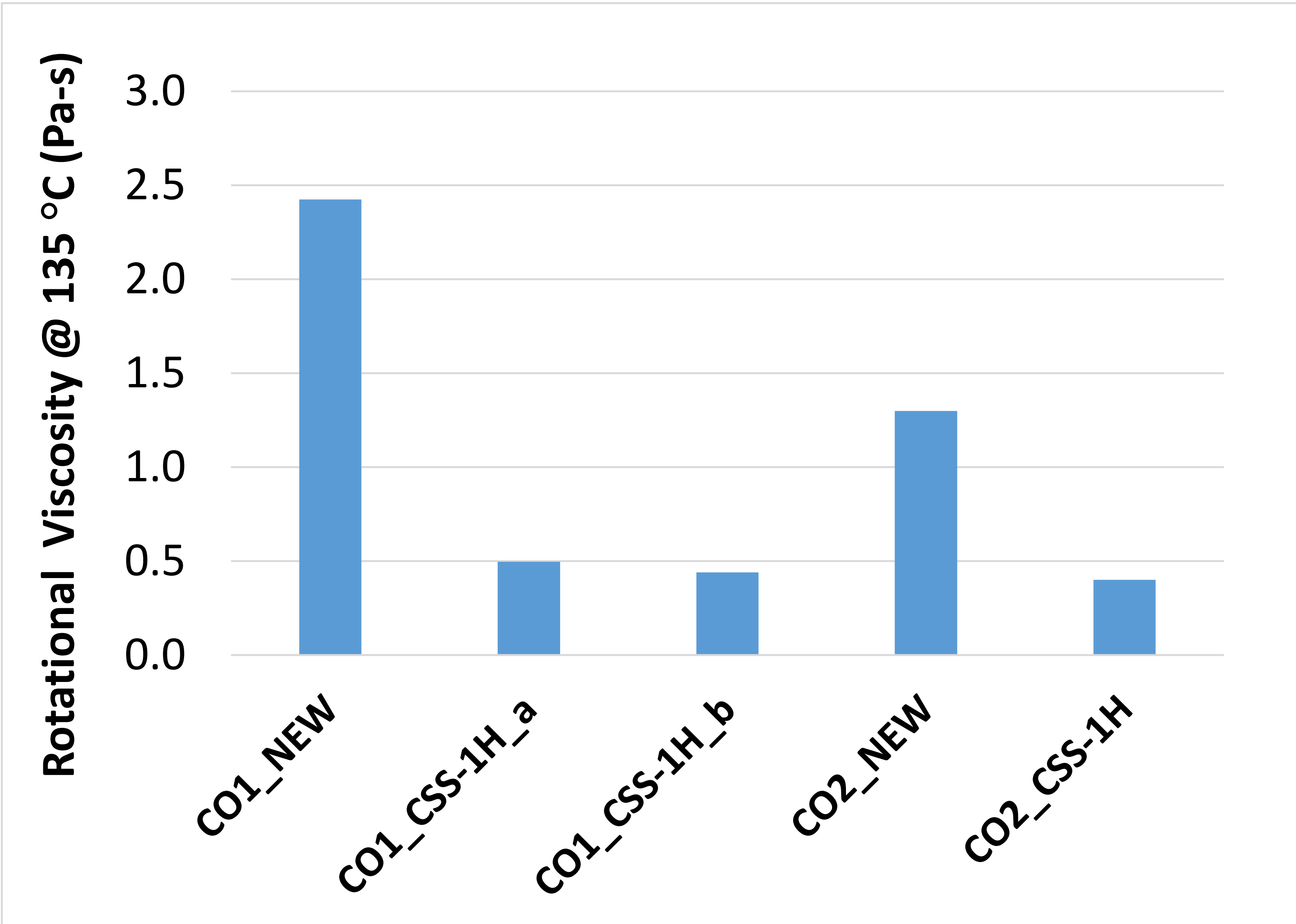
ASTM D5: Penetrometer

ASTM D4402:Rotational Viscometer (RV)

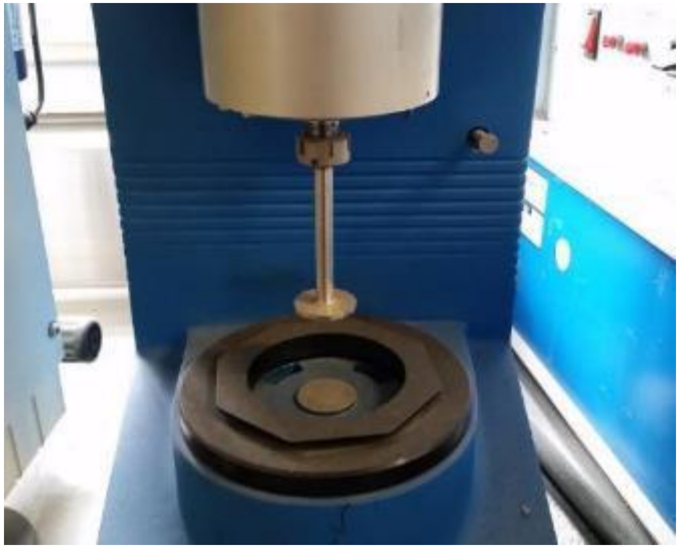
Lab tack coat testing – Penetration



Lab tack coat testing – RV



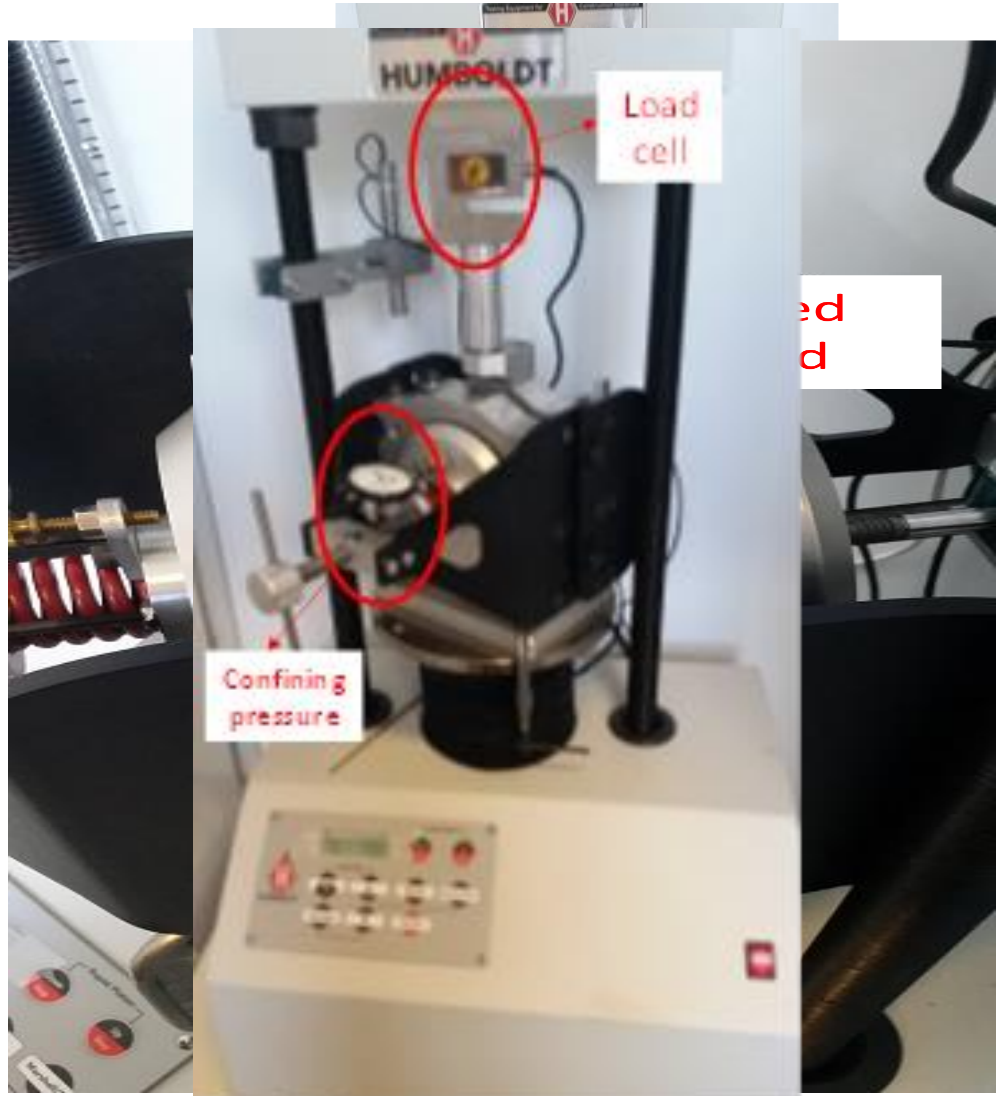
Lab tack coat testing



ASTM D2196: Dynamic Shear Rheometer (DSR)

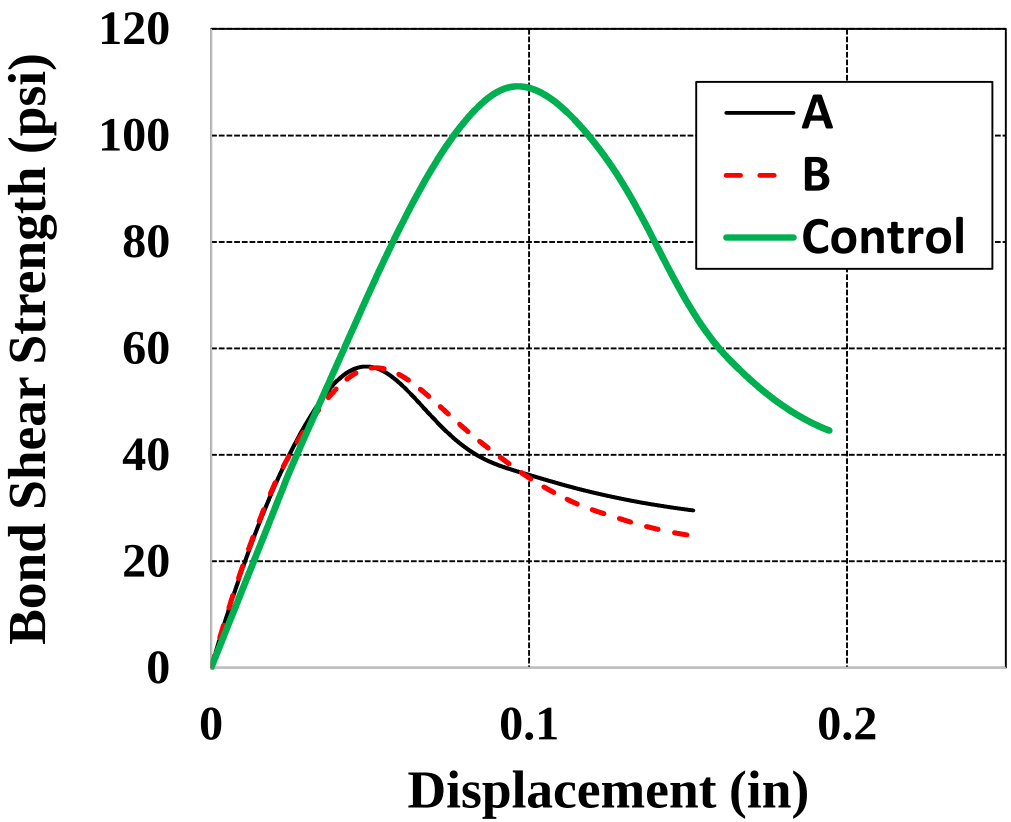
DSR tests will be conducted soon.

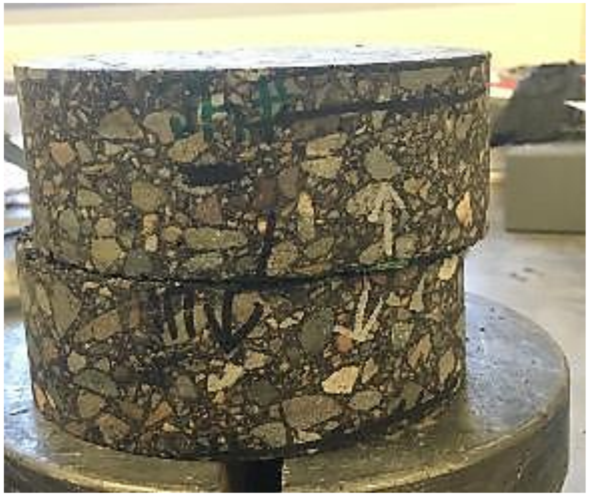
Coring and shear testing



Inter-layer shear strength testing device

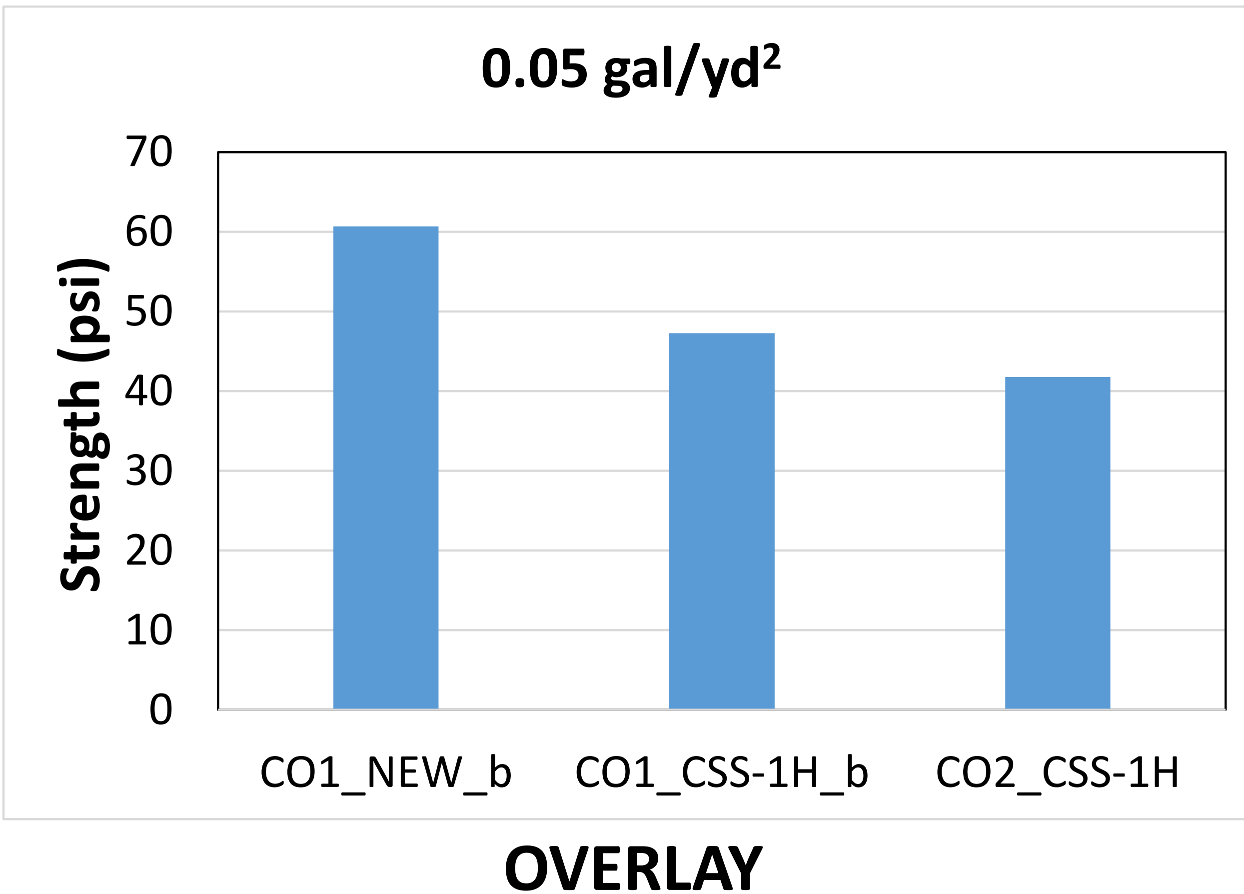
Shear testing – Impact of rain on bond strength





Shear testing – Results for field cores

Experiments with 90 cores from field test sections were completed last Friday. Results are currently being processed and analyzed. Some preliminary results:



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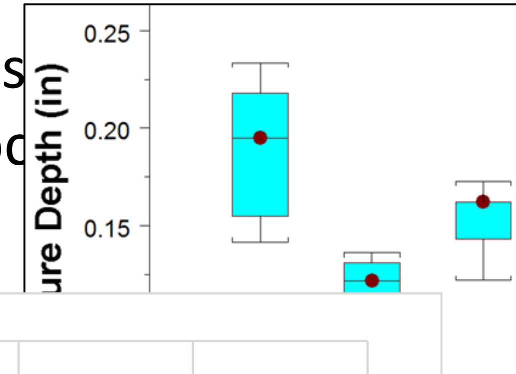

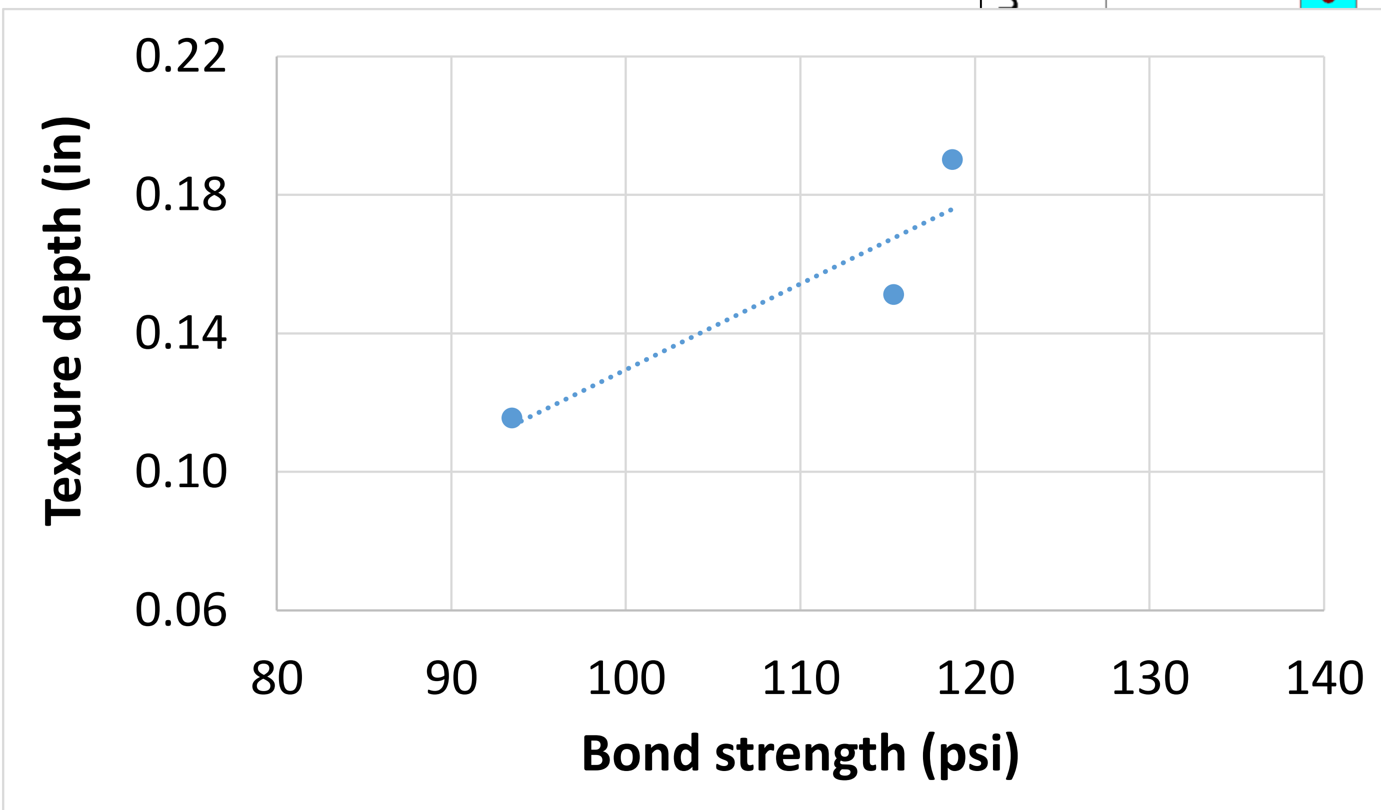

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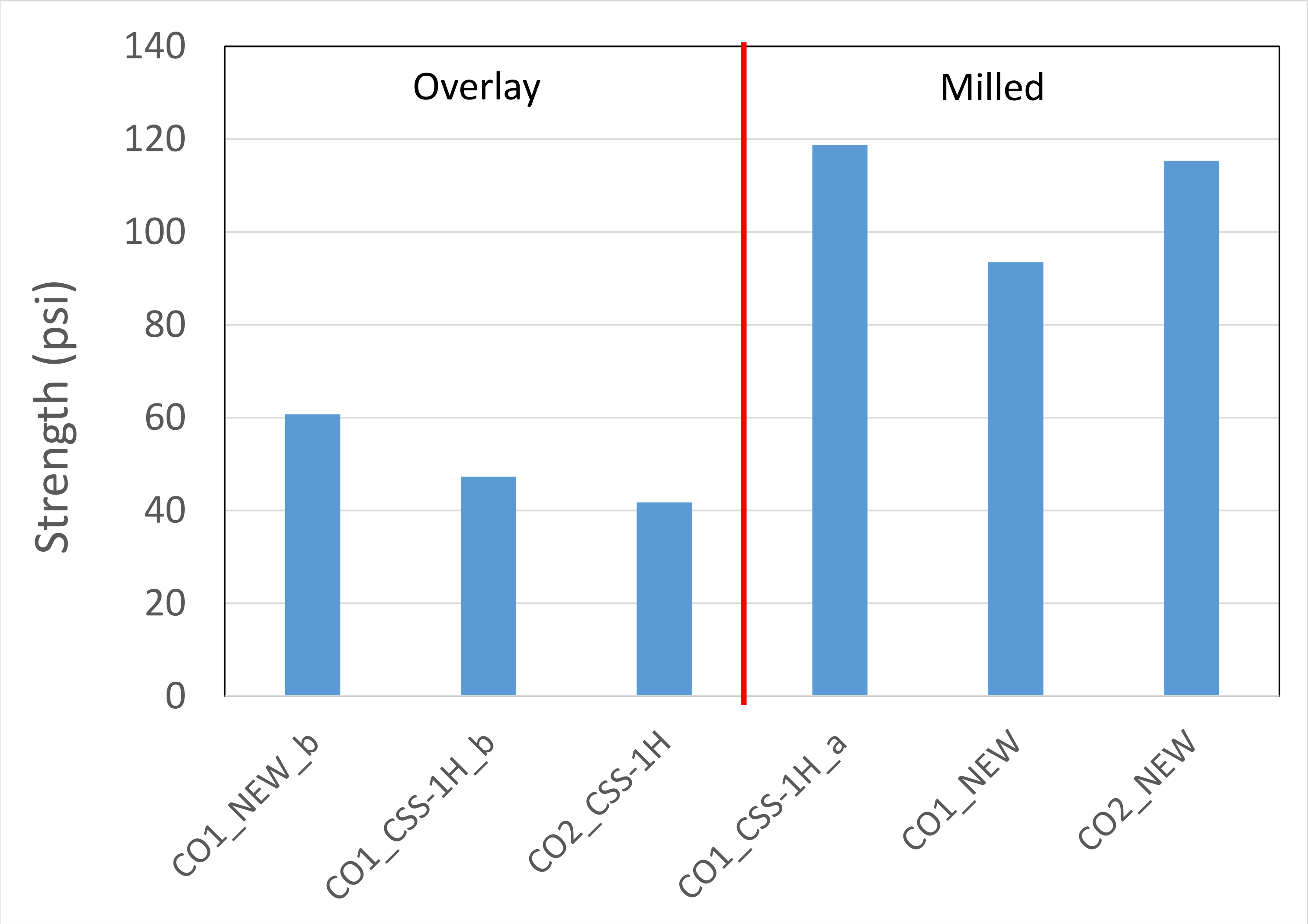
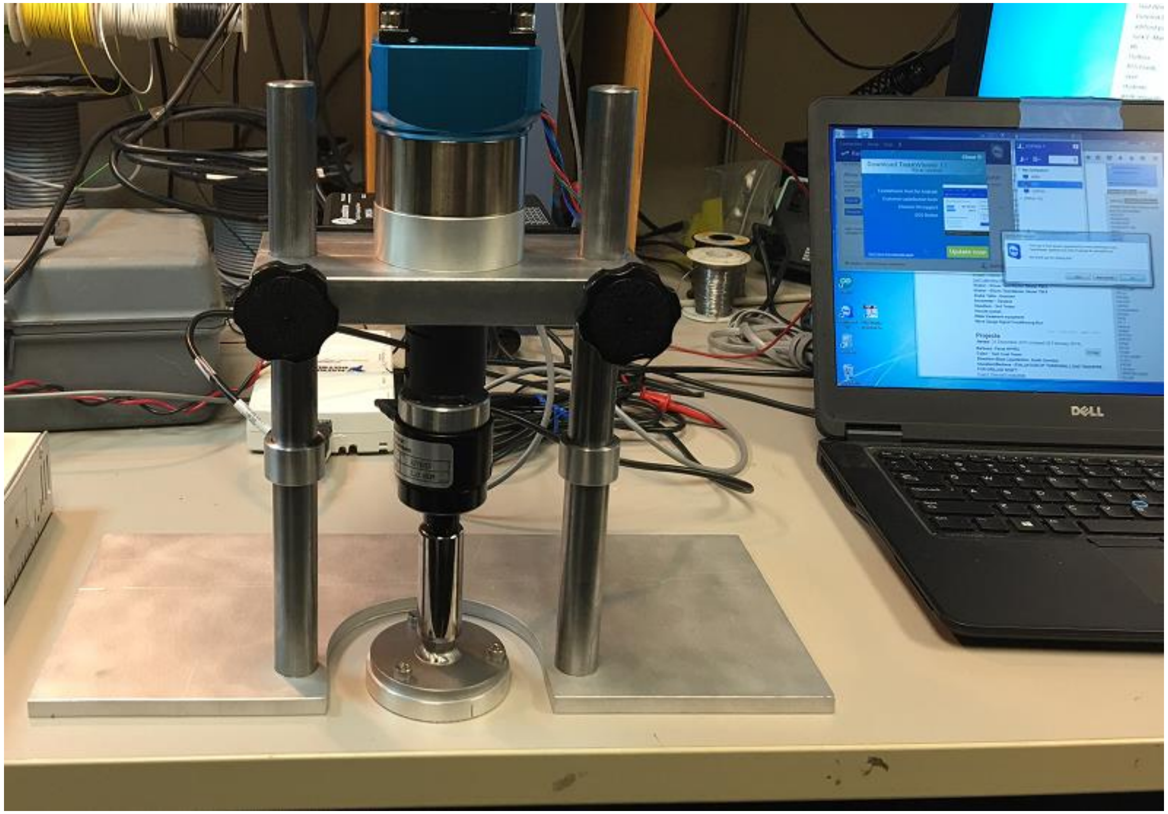
Shear testing – Texture effect



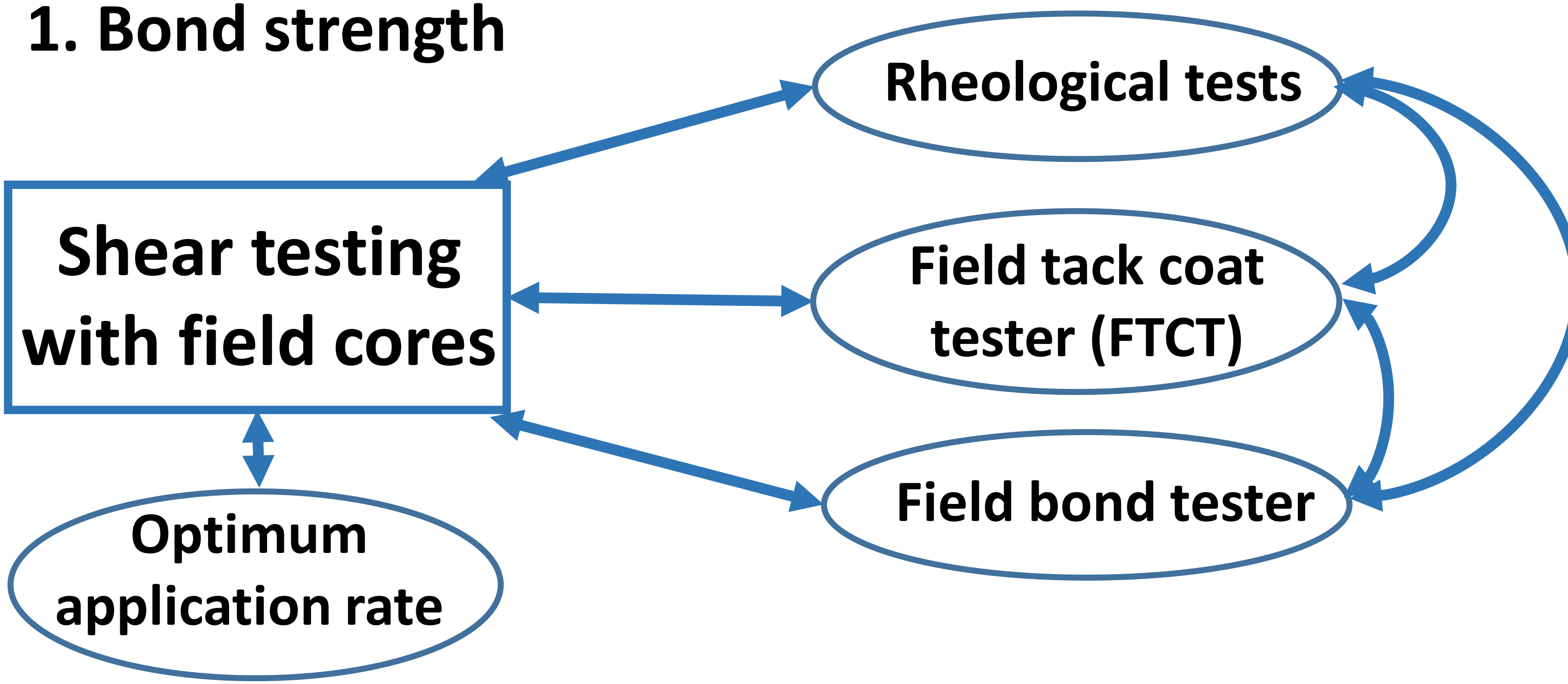
A field shear tester for tack coat performance monitoring



- Less destructive than taking cores
- Faster and does not require coring or testing in the lab

Progress and remaining tasks

1. Bond strength



2. How important is the bond strength?

- 3D finite element modeling
- MEPDG simulations

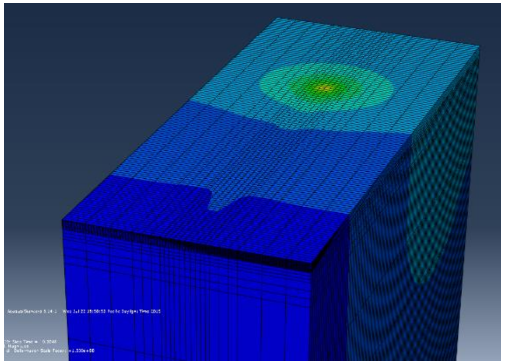
3. Tracking

- Weight measurements
- Wheel tracking device

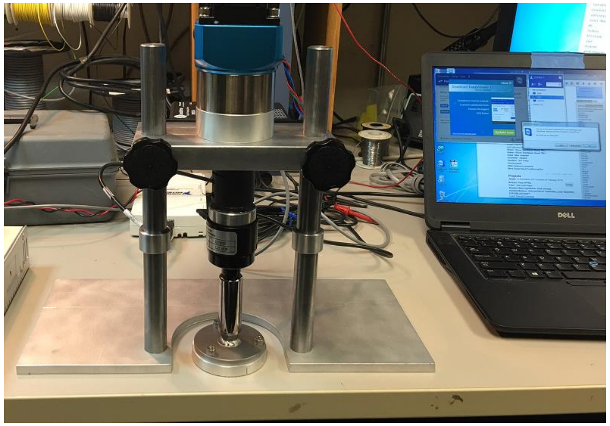
Technologies that are being developed

Wireless field tack coat tester

IOS and Android apps for set time notification



Model to evaluate bond strength



In-situ shear strength tester

Wheel tracking device

Other contributions to the knowledge and practice

- **Correlation functions to predict long-term bond strength from simple binder experiments**
- **Recommendations to reduce tracking**
- **Most effective spraying rates to maximize bond strength**
- **Models to predict the impact of bond strength on service life**
- **Recommendations to improve current QC/QA procedures**
- **Effectiveness of new tack coat products**

Spray pavers and current method

Spray pavers

Taken from worldhighways.com

Current method

Q & A

Thank you!

This study is sponsored by Oregon Department of Transportation (ODOT). This funding is gratefully acknowledged.