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Evaluating Tack Coat Materials' Durability in Asphalt Pavements

March 31, 2021

@NASEMTRB
#TRBwebinar

PDH Certification Information:

- 1.5 Professional Development Hour (PDH) – see follow-up email for instructions
- You must attend the entire webinar to be eligible to receive PDH credits
- Questions? Contact Reggie Gillum at RGillum@nas.edu

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Learning Objectives

1. Discuss appropriate selection of tack coat materials and application rates
2. Develop specifications for the use of tack coat materials

Effect of Tack Coat Materials on Durability of Asphalt Pavement

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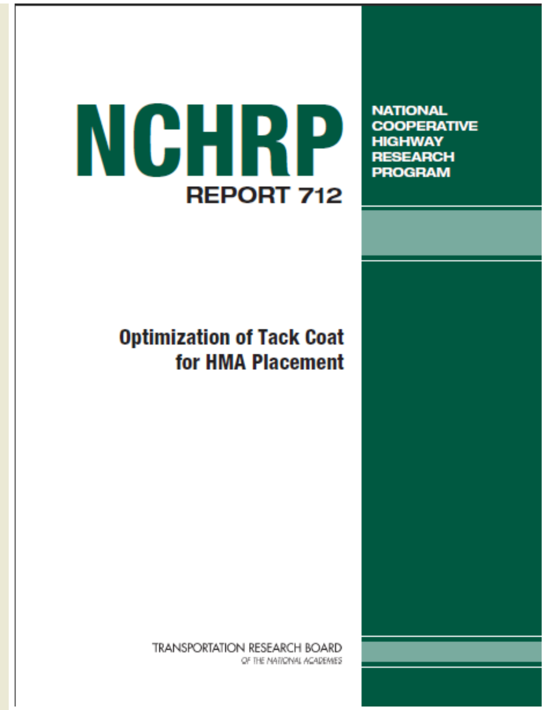
Department of Civil and Environmental Engineering
Louisiana Transportation Research Center
Louisiana State University

TRB Webinar: Evaluating Tack Coat Materials' Durability in Asphalt Pavements
March 31, 2021

Key Topics

- Durability
  - Pavement Performance
  - Bonding
- Tack Coat Research
  - NCHRP Project 9-40
    - » Report No. 712
  - NCHRP Project 9-40A
    - » Report No. 878
- Summary and Conclusions


NCHRP
REPORT 712
NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Optimization of Tack Coat for HMA Placement
TRANSPORTATION RESEARCH BOARD

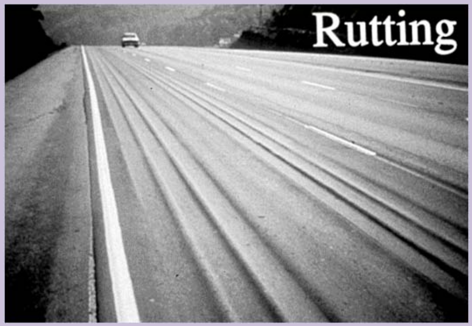

NCHRP
RESEARCH REPORT 878
NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Validation of the Louisiana Interlayer Shear Strength Test for Tack Coat

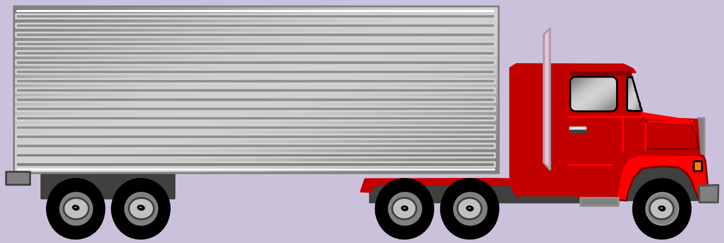
Acknowledgement

- **NCHRP**
  - Technical Review Panel
  - State DOTs
- **LTRC Asphalt Lab**
- **State DOTs**
  - **Missouri; Louisiana; Florida; Tennessee; Nevada; Oklahoma**
- **Material Suppliers and Contractors**
  - Asphalt Products Unlimited
  - Ergon Asphalts
  - Blacklidge
  - Coastal Bridge
  - …

Durable Flexible Pavement

- Permanent deformation
- Fatigue cracking – repeated load
- Low temperature cracking
- Moisture induced damage
- Raveling
- etc …





Durable Flexible Pavements

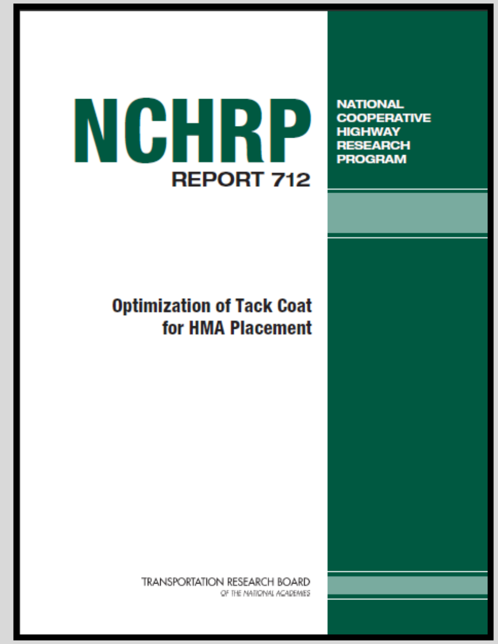
- **Mixture Design**
  - Components Materials
  - BMD
  - Sustainable Development
- **Construction**
  - Tack Coat Practices
  - Thermal segregation
  - Warm Mix Asphalt
  - Increased density
  - …

Laboratory Design

Field Construction

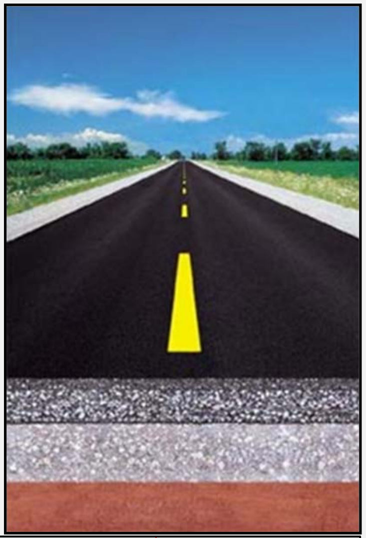
Durable Flexible Pavements

- **Mixture Design**
  - Components Materials
  - Engineered Performance /
  - Sustainable Development
- **Construction**
  - Tack Coat Practices
  - Thermal segregation
  - Warm Mi
  - Increase



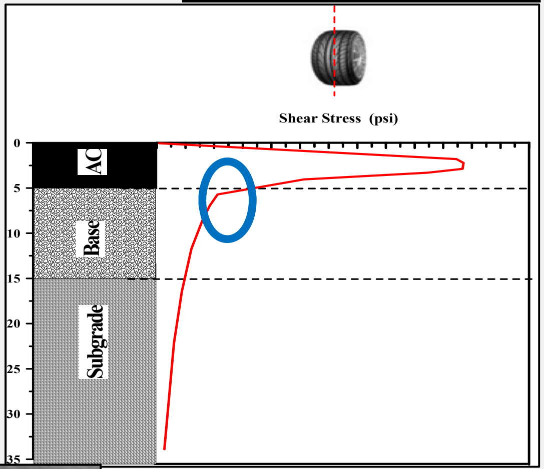
Field Construction

Durable Pavement – Construction Tack Coat



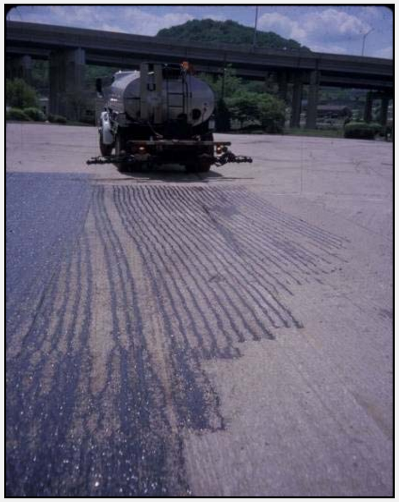
- **Purpose of tack coat application**
  - To ensure adequate bond between pavement layers
  - To transmit traffic loads down through the whole pavement structure
- **Not properly bonded, increase tendency for**
  - Cracking,
  - Debonding (delamination/slippage/sliding), and/or
  - Fatigue cracking

  …and thus failure in the new overlay



- **Tack coat material is relatively inexpensive portion compared to overall pavement construction cost**
  - Bonding failure is extremely $$$!!!

Improper Tack Coat Application



Courtesy of James A. Scherocman

Proper Tack Coat Application
Uniform Coverage

0.031 gsy

Low

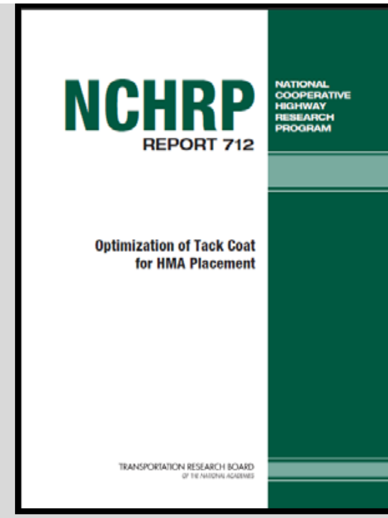
0.062 gsy

Medium

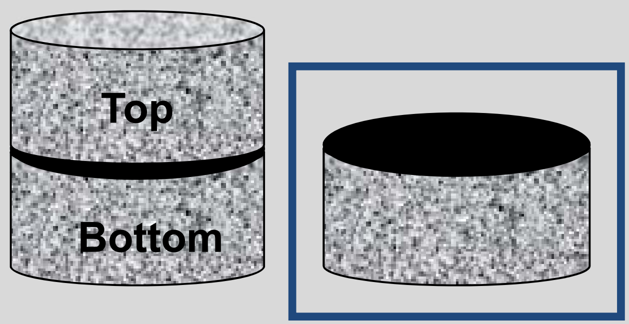
0.155 gsy

High

Objectives – NCHRP Project 9-40

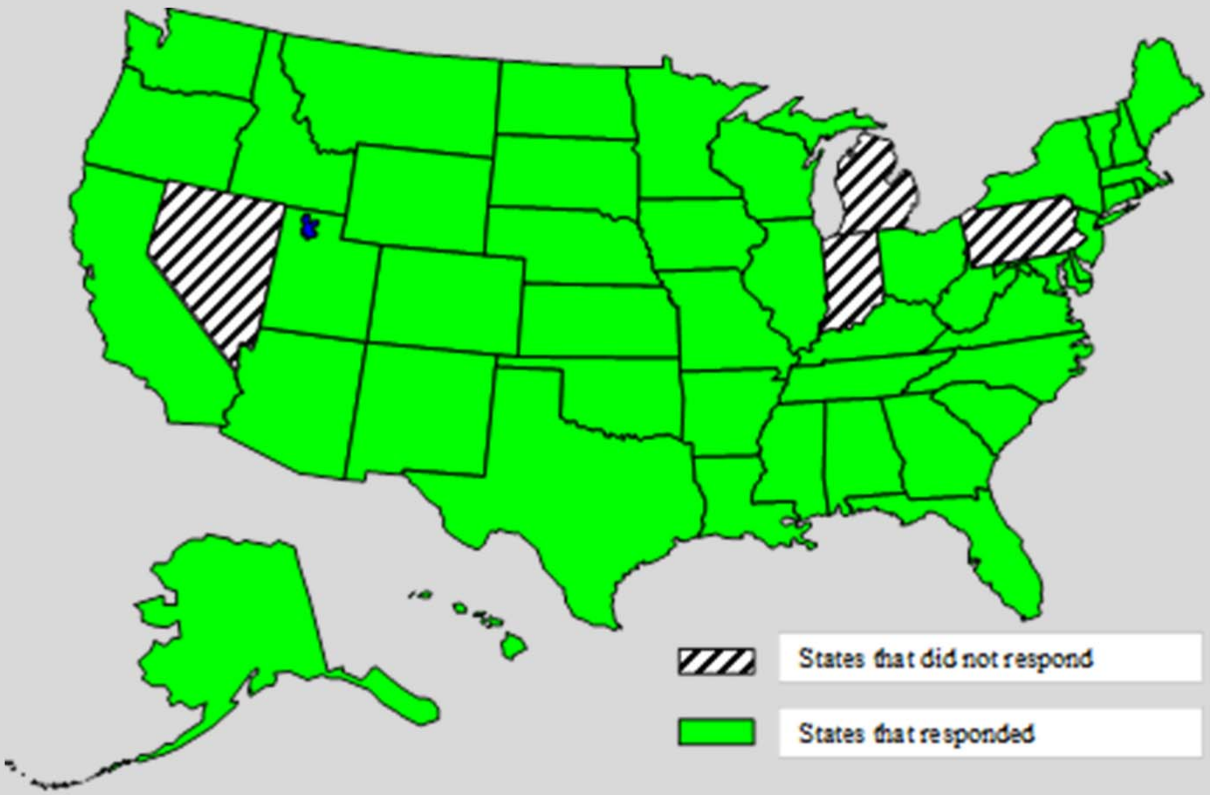


- **Evaluate factors that affect interlayer bonding**
  - Tack coat material type and application rate
  - Pavement surface type
  - Temperature
  - Construction condition
- **Develop AASHTO test methods and practices related to tack coats**
  - Tack Coat Quality
    - spray application
  - Interlayer Bond Strength



Outcome – NCHRP Project 9-40

- **Worldwide Survey on Tack Coat Practices**
  - **92% return**
  - **Canada, Denmark, Finland, South Africa, and the Netherlands.**
- **Best Practices and Training Manual**
  - **recommended construction and testing procedures**



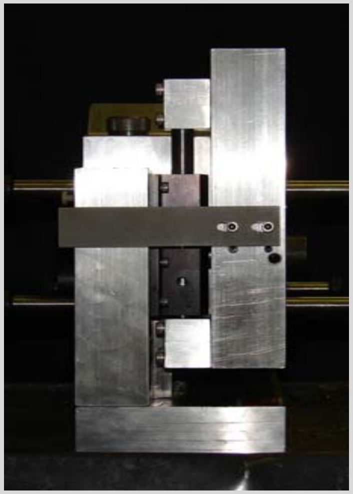
Tack Coat Application Inspection

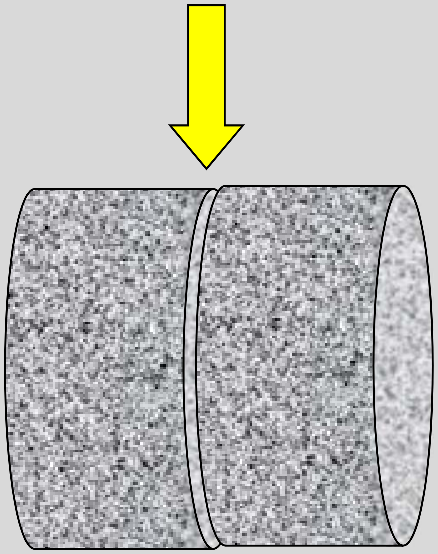
Outcome – NCHRP Project 9-40

- **Recommended tack coat residual application rates**
- **AASHTO TP 114 and AASHTO TP 115 test method was developed to characterize quality and Bond Strength of tack coats**
- **Recommended threshold Interface Shear Strength criterion**
  - **Minimum 40 psi – from AASHTO TP 114**

Surface Type	Residual Application rate, gsy
New HMA	0.035
Existing HMA	0.055
Milled HMA	0.055
PCC	0.045

AASHTO TP 114



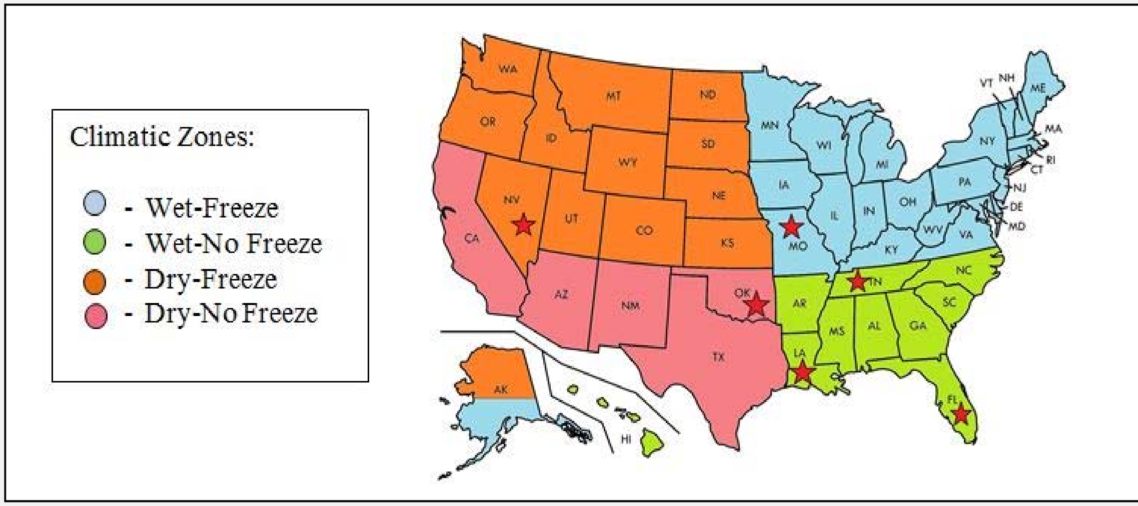


Objective – NCHRP Project 9-40A

- **Validate AASHTO TP 114 test method and minimum recommended ISS threshold (40 psi) criterion**
- **Evaluate factors that affects interface bonding**
  - Pavement Surface Type
  - Tack Coat Material Type
  - Residual Application Rate
  - Service Time
- **Investigate the effect of bonding on short-term pavement performance**

Scope

- **Six field projects**
  - Missouri; Louisiana; Florida; Tennessee; Nevada; Oklahoma

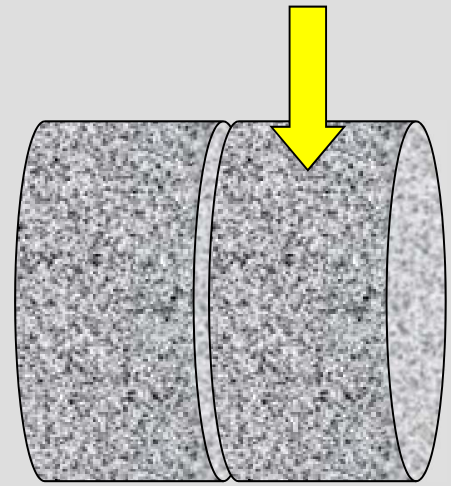


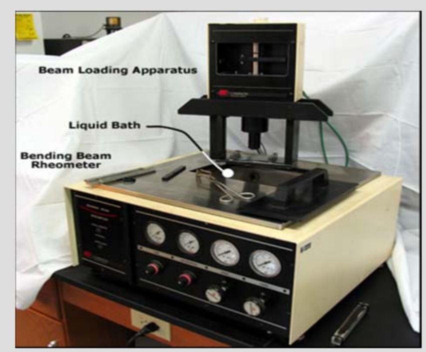
- **Four Pavement surface types:**
  - New HMA; Existing HMA; Milled HMA; PCC
- **Tack coat material types:**
  - Slow setting (SS-1H, CSS-1H, SS-1)
  - Non-tracking rapid setting (NTSS-1HM, CBC-1H, CRS-1 HBC)
- **Tack coat residual application rates:**
  - specified by state DOTs
  - recommended by NCHRP Project 9-40

Surface Type	Residual Application rate, gsy
New HMA	0.035
Existing HMA	0.055
Milled HMA	0.055
PCC	0.045

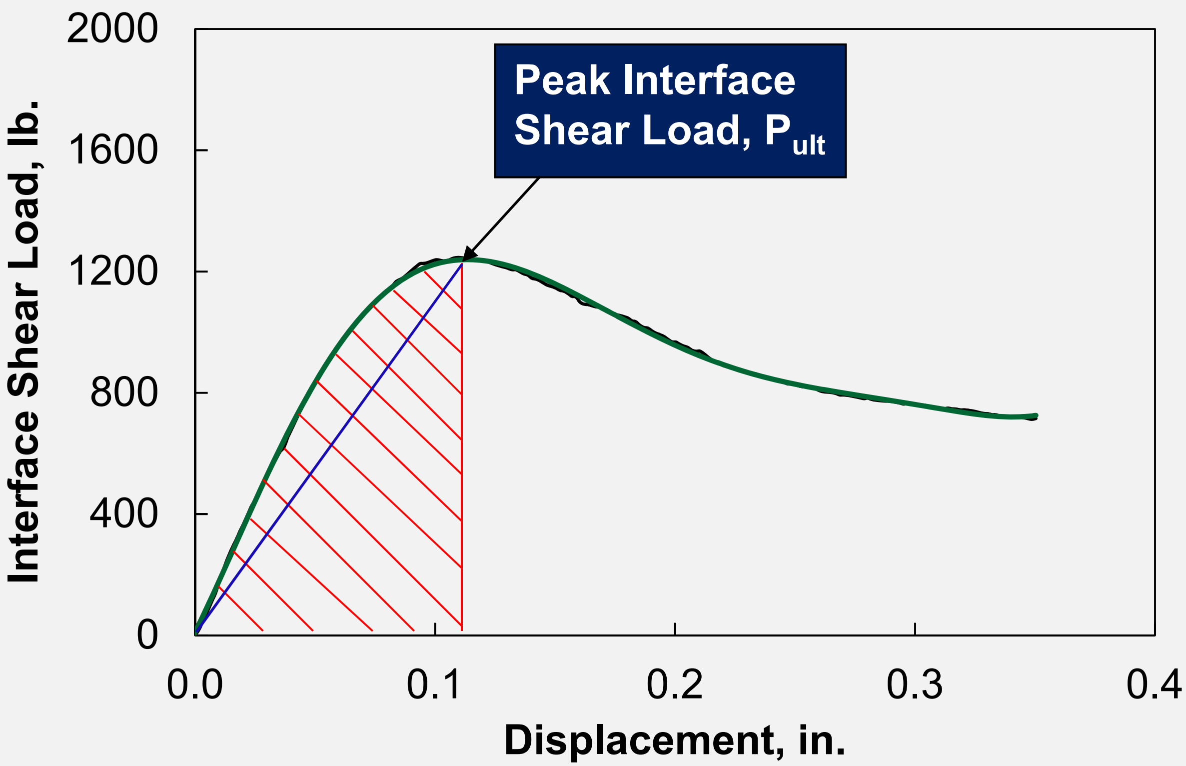
Experimental Program

- **Field Measurements**
  - Distributor Truck Calibration (ASTM D 2995)
  - Pavement Surface Texture Measurement (ASTM E 965)
  - Measured Field Application Rate (ASTM D 2995)
  - Distress Survey (LTPP Manual)
  - FWD (Structural Capacity)
- **Laboratory Measurements**
  - Interface Shear Strength Test (AASHTO TP 114)
  - Tack Coat Material Characterization (AASHTO M 320)





Laboratory Measurement – AASHTO TP 114
Tack Coat Materials Bond Quality



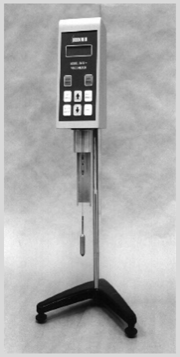
$$ISS = \frac{P_{ult}}{\frac{\pi D^2}{4}}$$

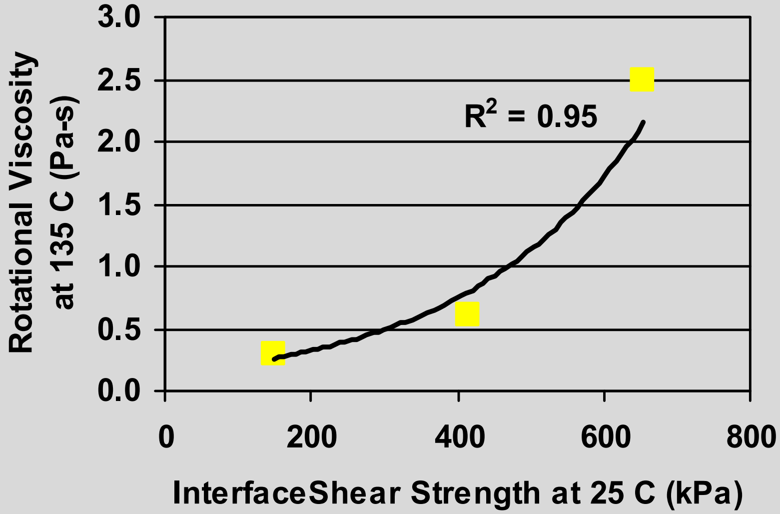
$$IBE = \frac{Area\ Under\ the\ Curve\ upto\ P_{ult}}{\frac{\pi D^2}{4}}$$

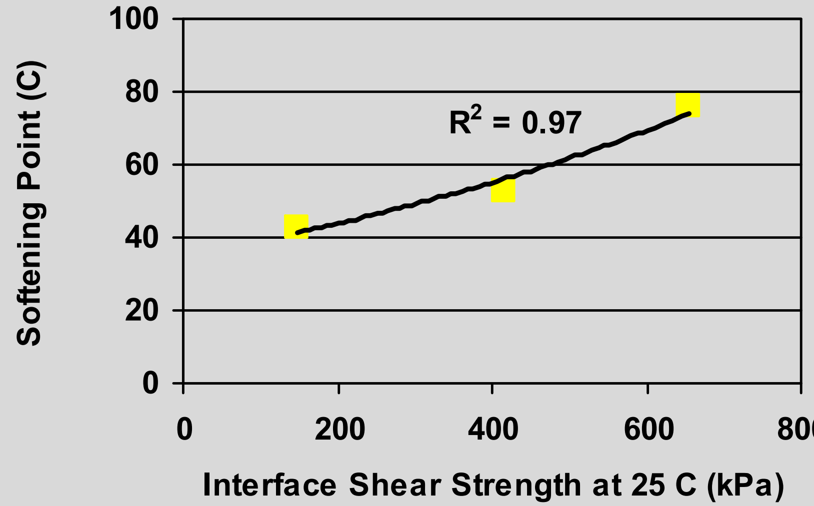
$$K-\text{modulus} = \frac{ISS}{Displacement\ at\ P_{ult}}$$

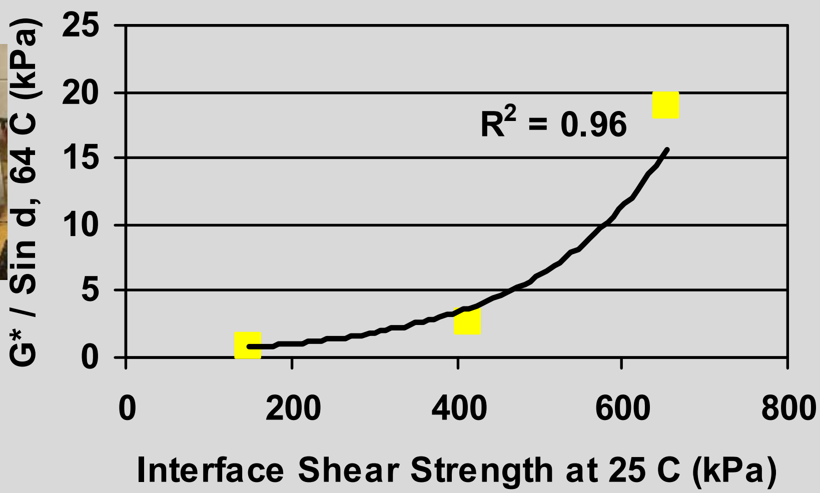
- **Interface Shear Strength (ISS, psi) : COV < 15%**
- **Interface Bond Energy (IBE, lb.-in/in²)**
- **Interface Shear Stiffness (k-modulus, psi/in)**

Relationship between ISS vs. Rheology Test Results

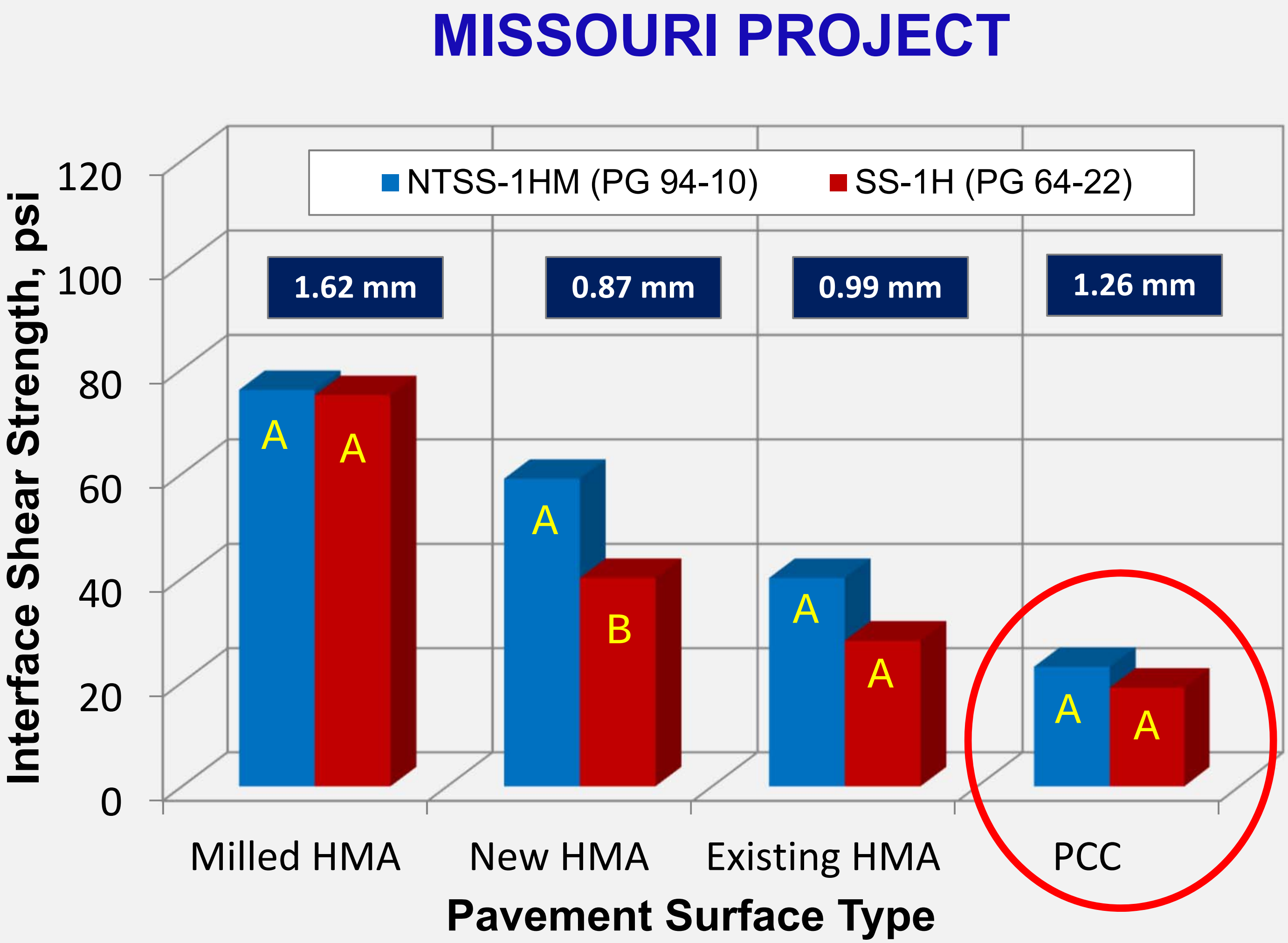








Effect of Pavement Surface Type on ISS



- **All tack coat material were compared at 0.05 gsy residual application rate**

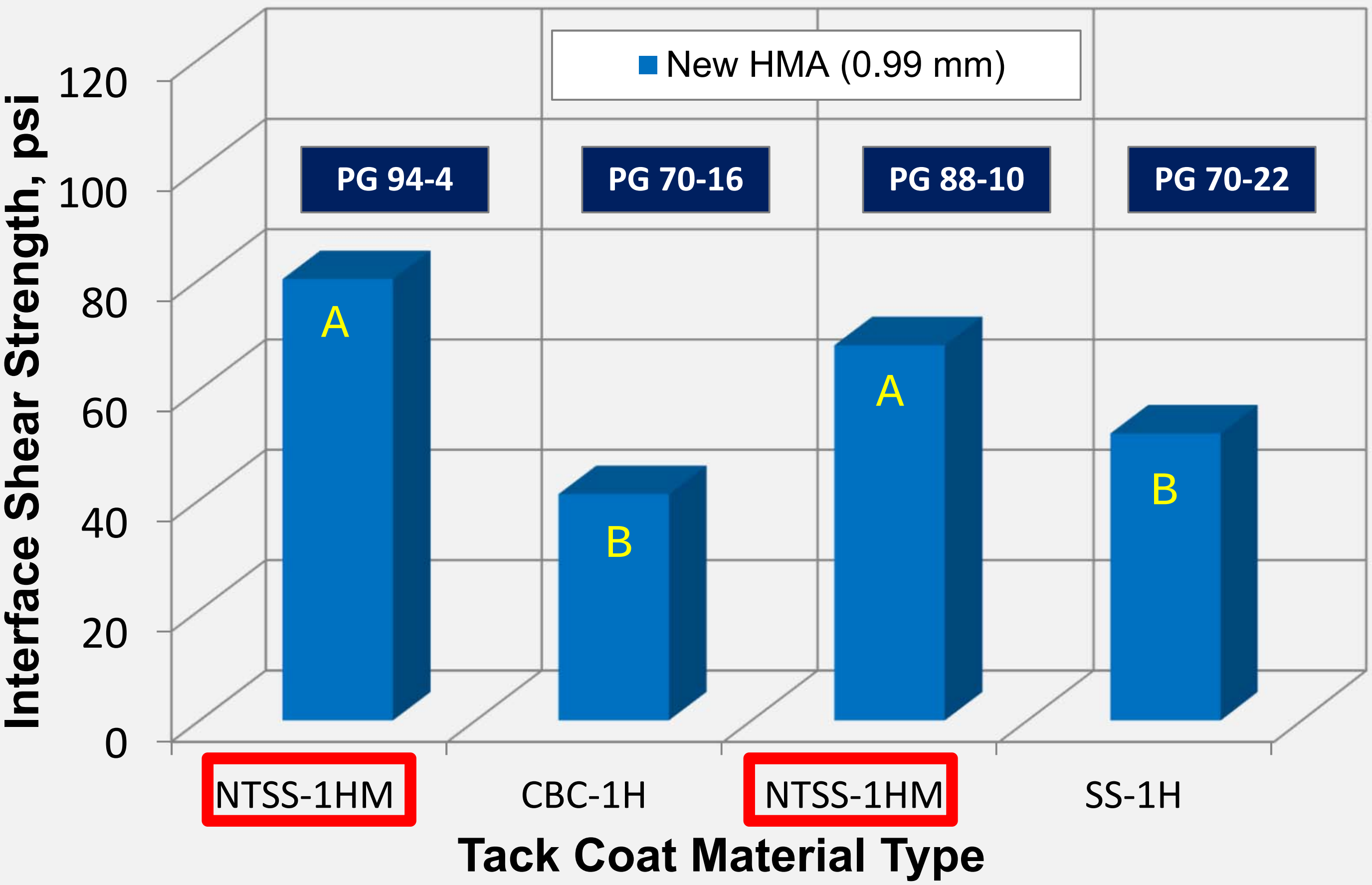
Effect of Pavement Surface Type on ISS

MISSOURI PROJECT

Pavement Surface Type

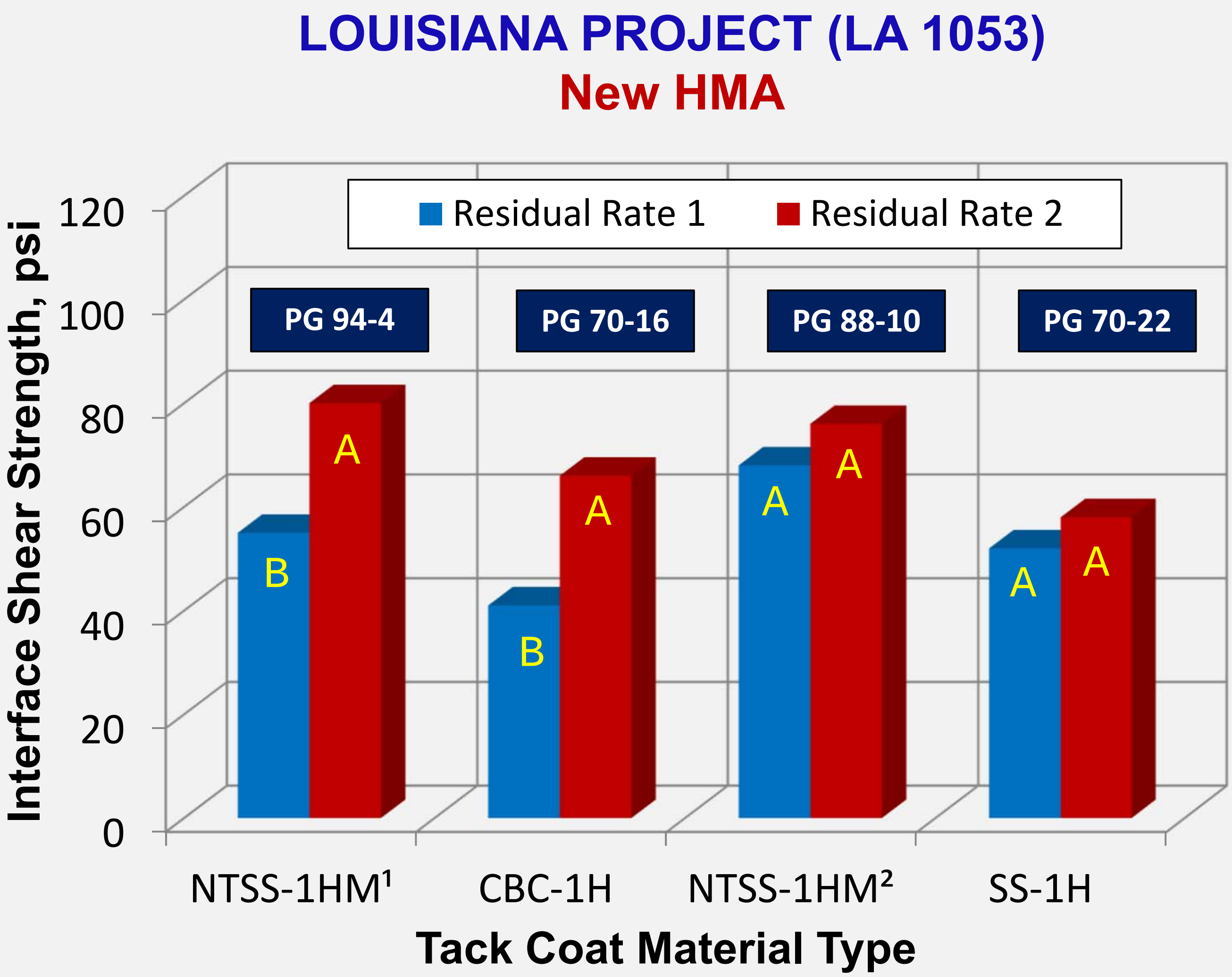
Effect of Tack Coat Type on ISS

LOUISIANA PROJECT (LA 1053)



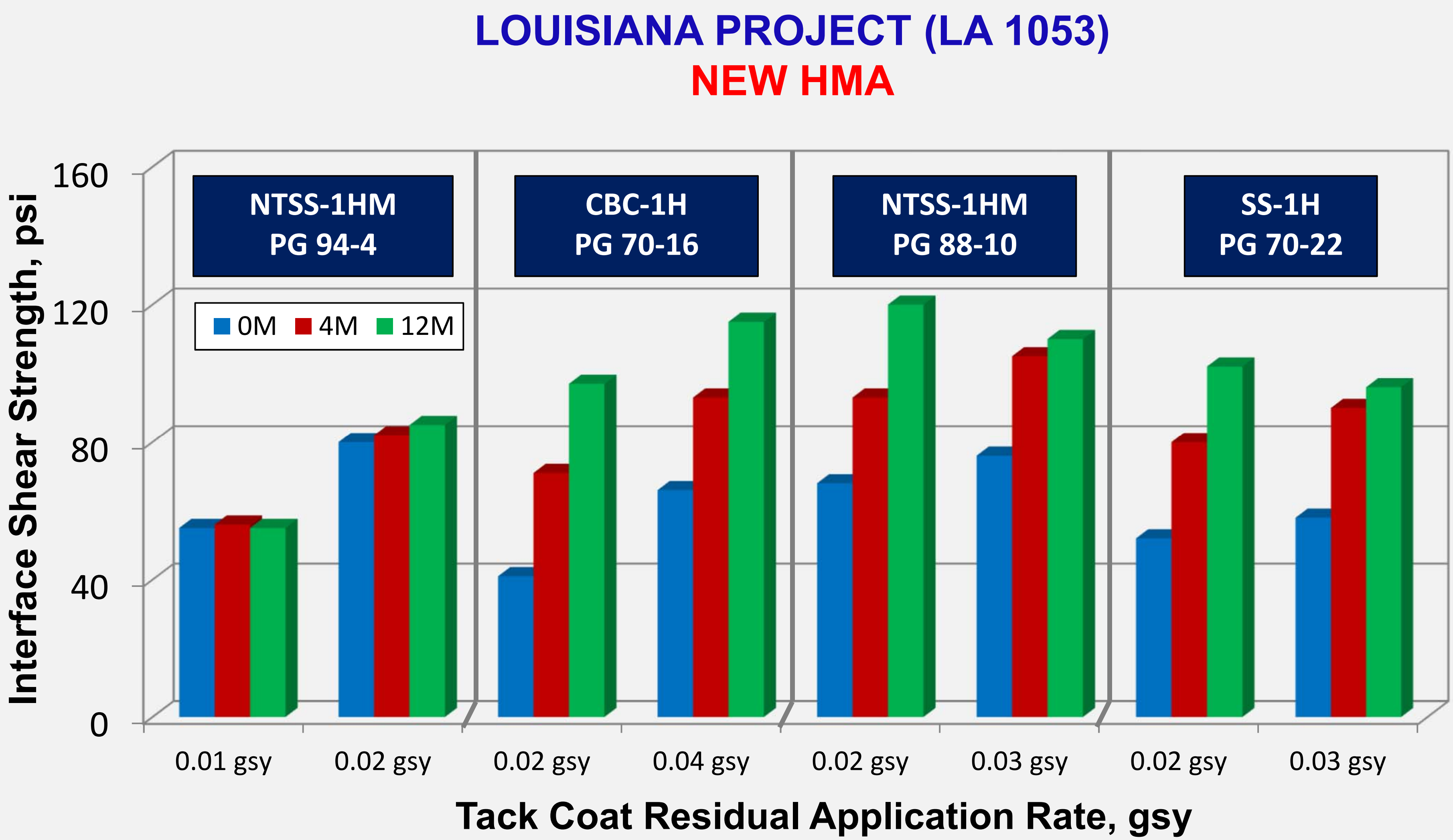
- **All tack coat material were compared at 0.02 gsy residual application rate**

Effect of Residual Application Rate on ISS

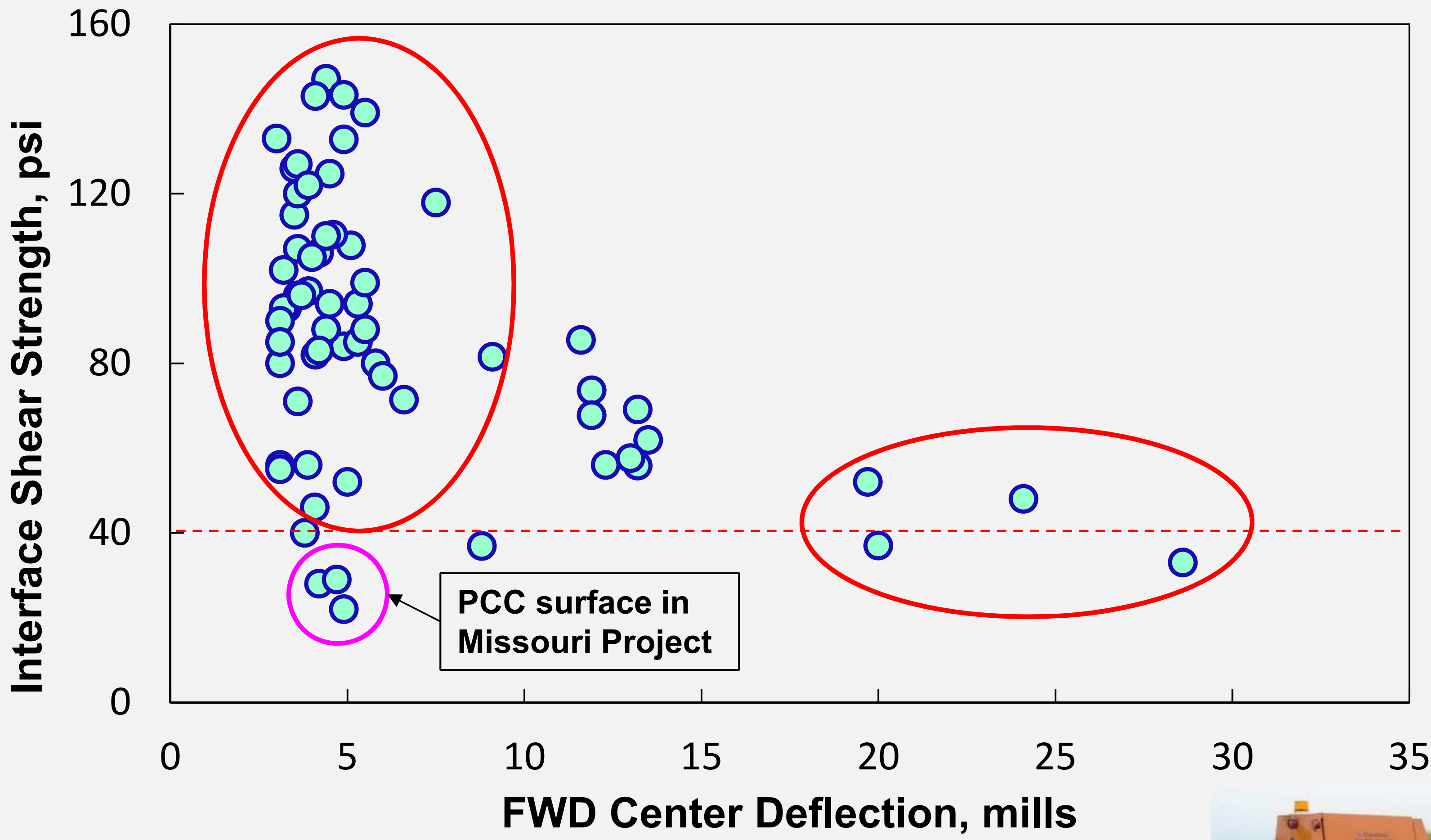


Tack Coat Material	Residual Rate, gsy	
	1	2
NTSS-1HM[1]	0.01	0.02
CBC-1H	0.02	0.04
NTSS-1HM[2]	0.02	0.03
SS-1H	0.02	0.03

Effect of Service Time on ISS

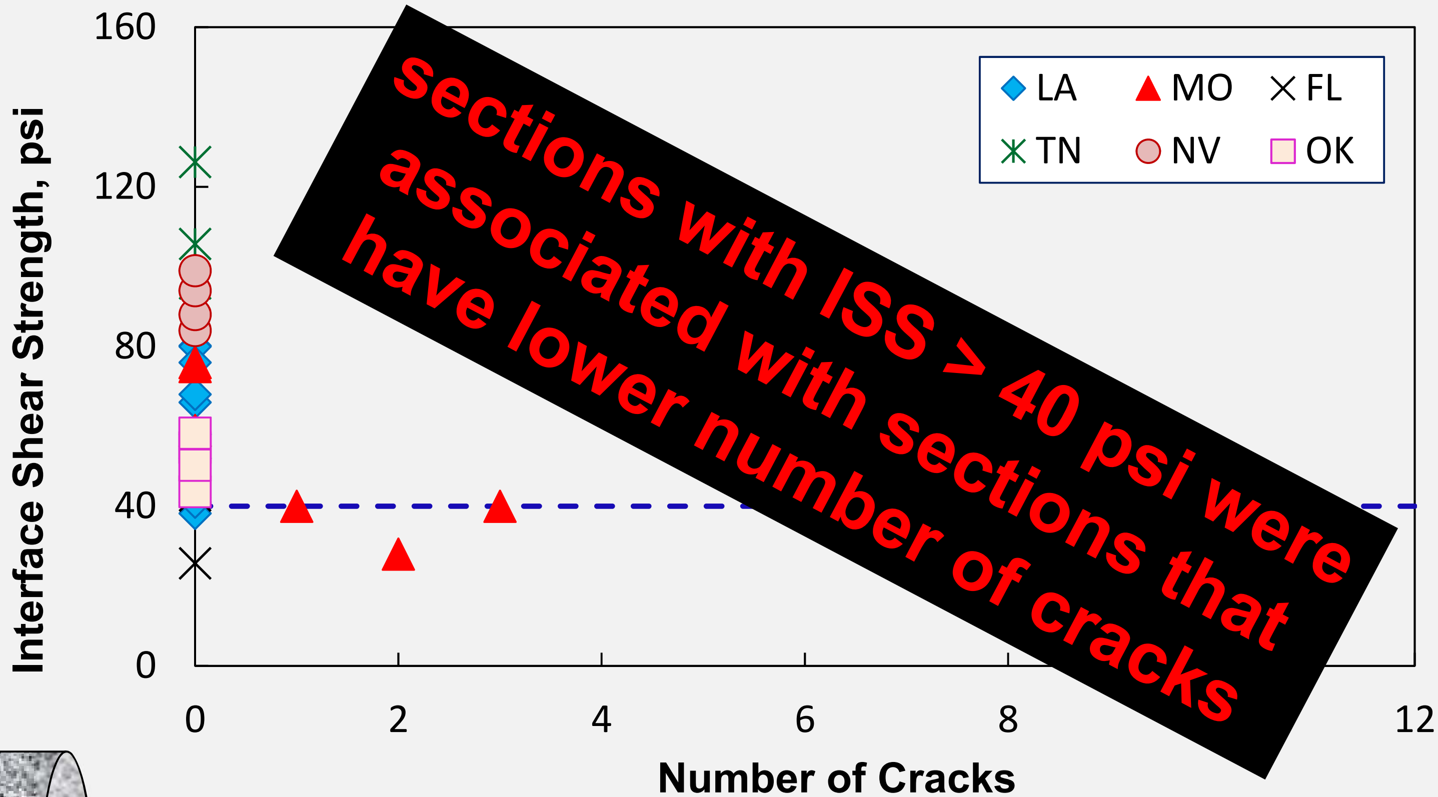


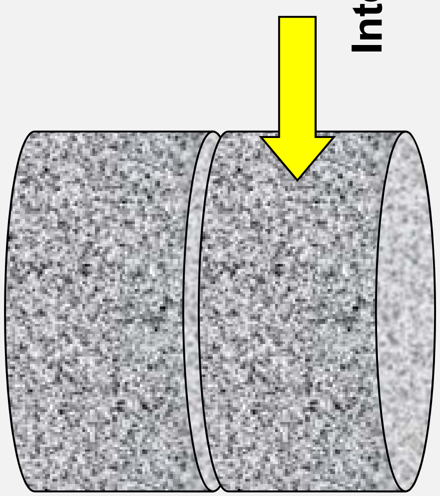
Structural Capacity (FWD) vs ISS



- **Indicates surface deflection depends on**
  - — the interface bonding between pavement layers

Pavement Cracking ***vs*** *Bond Strength (ISS)*





Key Takeaways

- **Effect of tack coat type on ISS**
  - Non-tracking rapid setting tack coats with stiff base asphalt (NTSS-1HM) exhibited the highest ISS, and slow setting resulted in the lowest

- **Effect of pavement surface type on ISS**
  - ISS was largely dependent on
    - Type of pavement surface (HMA versus PCC)
    - Type of pavement surface texture (milled versus non-milled)
  - Milled surface yielded highest ISS, followed by new HMA, existing HMA, and PCC surface types
    - Higher surface roughness provided greater shear resistance

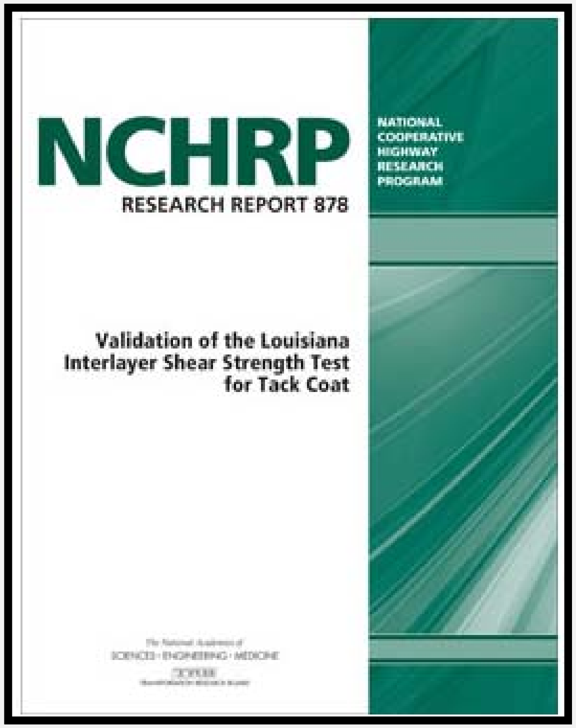
- **Effect of residual application rate on ISS**
  - ISS improved with increase in residual application rate for all tack coat types and pavement surface types

Key Takeaways

- **Effect of service time on ISS**
  - In geberal, ISS increased with increase in service time
    - tack coat curing
- **Pavement Structural Capacity (FWD test results)**
  - Mean center deflection decreased with service time
  - Densification of overlays was attributed to
    - in-service trafficking
    - improved ISS
- **Short-term pavement performance**
  - ISS values correlated well with short-term performance
  - test sections with ISS < 40 psi showed low to moderate cracking

Recommendations

- **AASHTO TP 114 test**
  - — Quality control and quality assurance testing of tack coat construction
  - — Evaluation of interface-bonding condition of in-service pavements
- **Use of minimum ISS threshold criterion (40 psi)**
  - — As the specification for satisfactory pavement performance



Thank you

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Tack Coat Performance in Cold Regions

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UNIVERSITY OF SASKATCHEWAN

TRB WEBINAR: EVALUATING TACK COAT MATERIALS’ DURABILITY IN ASPHALT PAVEMENTS

WEDNESDAY, MARCH 31, 2021 – 2PM EST

Outline

- Research Problem & Objectives
- Experimental Program
- Field Study & Findings
- Laboratory Testing Program
- Laboratory Testing Parameters
- Laboratory Study Findings
- Research Significance
- Future Research
- Acknowledgements
- Research Papers & Presentations

Research

Effect of Emulsion Type on Bond Behaviour of Asphalt Concrete Layers in Cold Regions

Transportation Research Board (TRB)/Transportation Research Record (TRR), Washington, D.C., January 2019

Conference Presentation & Journal Paper

Coauthored by Laura Stasiuk, Haithem Soliman, Ania Anthony

Subsequent research is included in my M.Sc. Thesis:

Performance of Tack Coat Materials in Saskatchewan Climate

University of Saskatchewan, February, 2020

http://hdl.handle.net/10388/12786

Research Problem

- The effectiveness of tack coat products has not been studied extensively in the cold climate of Western Canada.
- Tack coat application procedures are not well defined or followed.
- Contractors often dilute tack coats heavily which does not allow breaking and setting to occur before paving.
- Poor construction practices do not leave enough residue on the road for a good bond to form.
- There is a gap in current research about performance and testing of tack coat materials in cold climate.

Research Objectives

- Evaluate the performance of several tack coat materials in Saskatchewan climate.
- Monitor the field performance of tack coat materials during construction and in the following year.
- Compare the bond quality of tack coat materials using a Louisiana Interlayer Shear Strength Tester (LISST).
- Compare field and lab performance of tack coat materials to develop parameters that can be used to establish performance-based specifications for selection of tack coat materials.
- Compare the performance of materials subjected to simulated freeze-thaw cycling and real-world exposure.

Experimental Program

5 years in duration – 2 years included in my research

Field Study

- Construction parameter monitoring
- Distress survey – performance after construction and each summer
- Core Collection – five periods of collection (2 periods included in research)

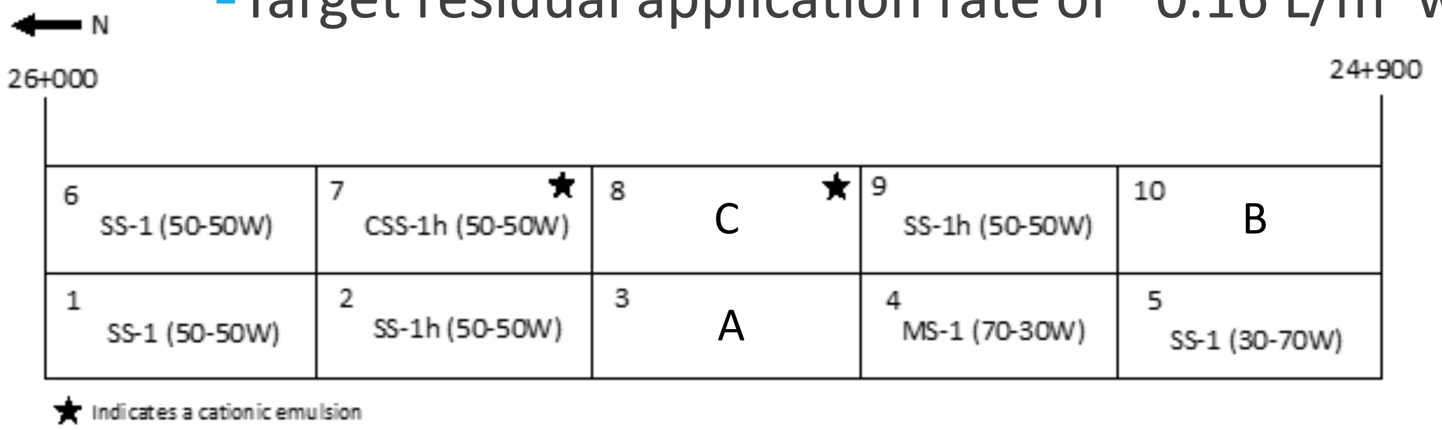
- Laboratory Testing Program
  - Bond strength testing
  - Lab conditioning to simulate freeze-thaw cycles

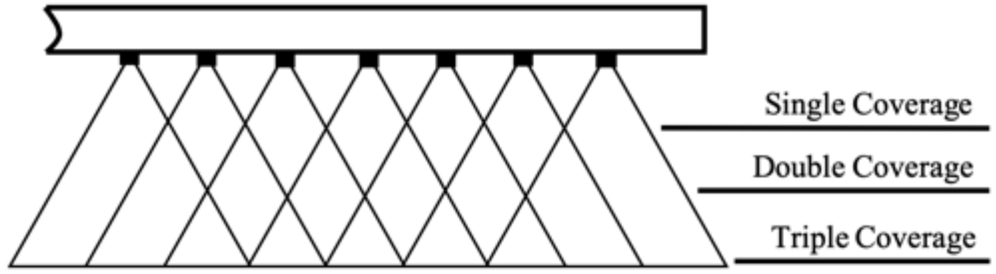
Field Study

- In August 2017 the tack coat trial project began
- Location: Highway 12 just south of Blaine Lake in Saskatchewan, Canada
- Highway 12: two-way, two-lane rural highway
- Resurfacing involved milling 30mm and laying 2 lifts of 50mm, placing the tack coat between the two lifts

Field Study Cont.

- A 1.1km section of the highway was designated for the project
- 10 test sections were set up – 5 in each lane
- Each section was approximately 225m long for a total of 1.1km
- Tack Coat Products: SS-1 (3 sections, different dilution ratios), SS-1H (2 sections), CSS-1H, MS-1, three non-tracking/quick setting proprietary products
- Target residual application rate of ~0.16 L/m^2 with triple overlap

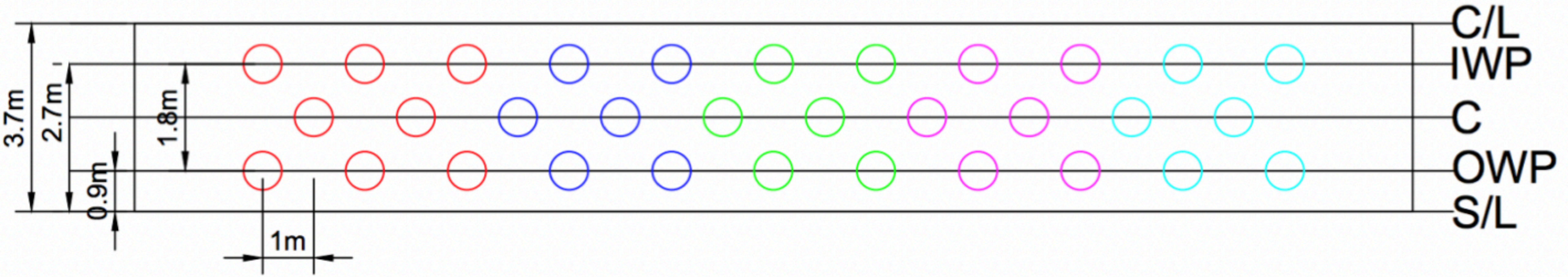




Coring

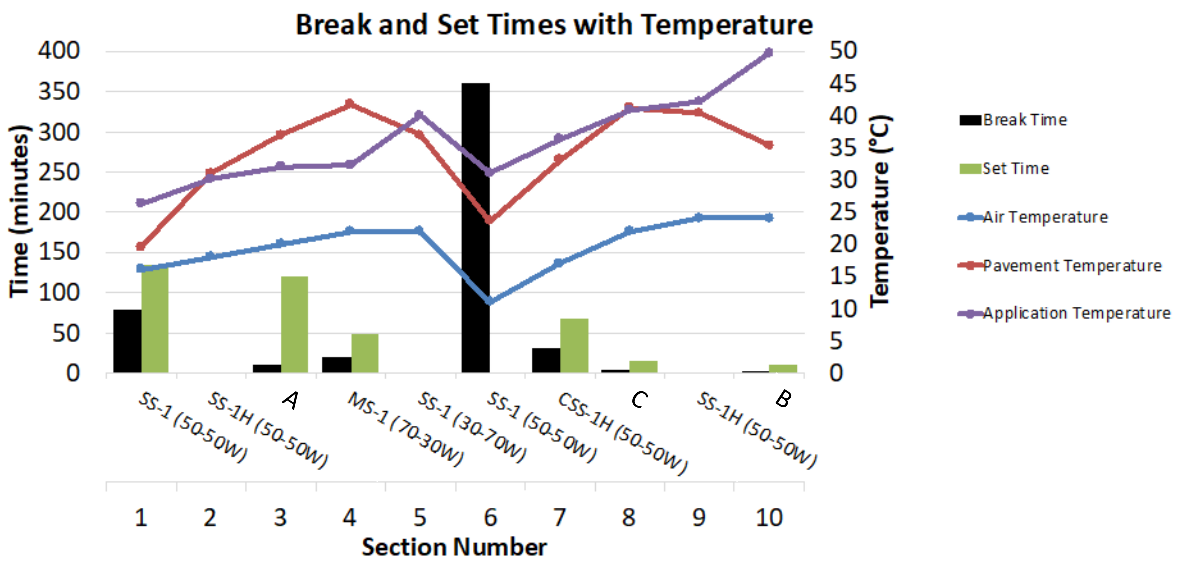
- Cores were collected in the wheel paths and centre of the lane, with 4-6 replicates per location and per product

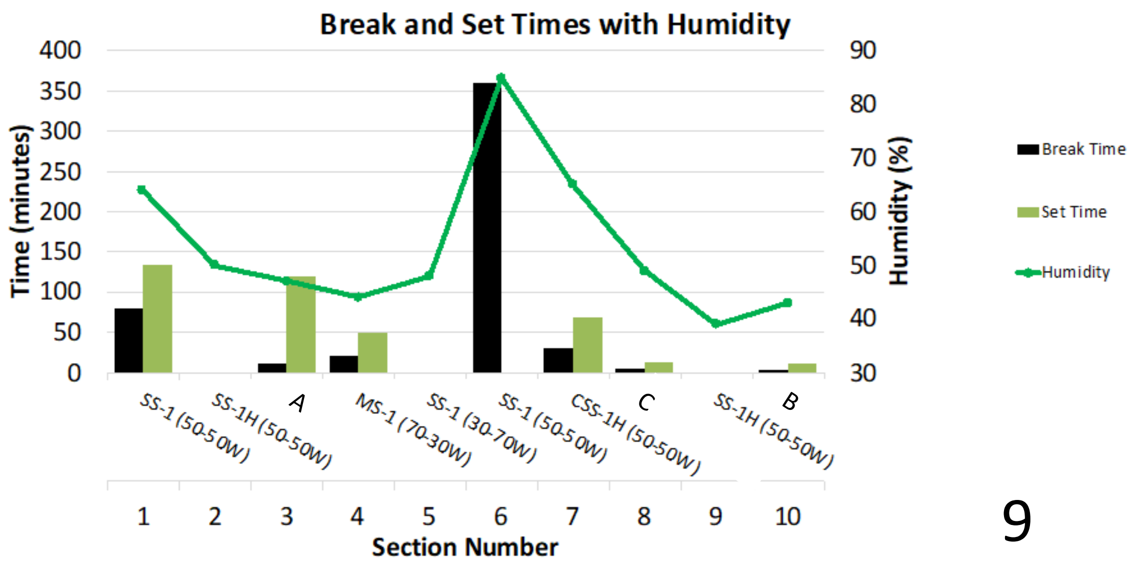
- Collected 3 weeks post-construction, after 1 year, will continue each summer



Field Study Findings

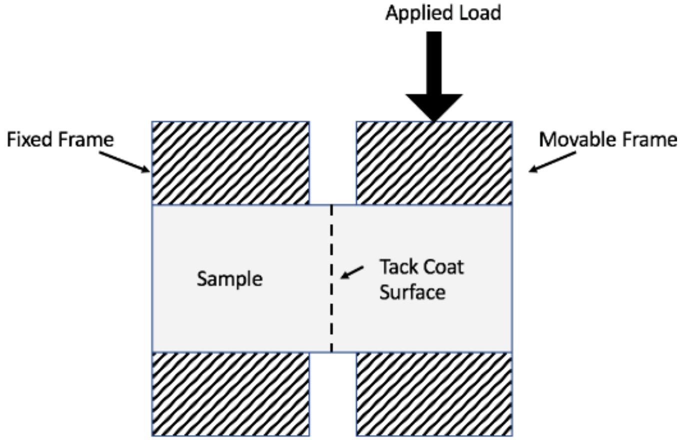
- Proprietary non-tracking products cure quickly which allows for less pickup and stronger bond.
- All other products perform better, in terms of breaking and setting, than the basic SS-1 emulsion.
- Weather conditions including temperature and humidity affect the speed of breaking and setting of tack coat materials. Hot dry weather will result in the fastest breaking and setting.
- The first two distress surveys, shortly after construction and one year post-construction, did not show any distresses due to the poor bond between pavement layers.

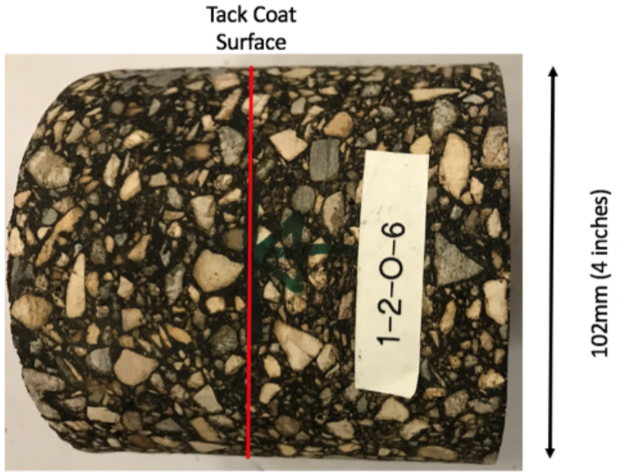


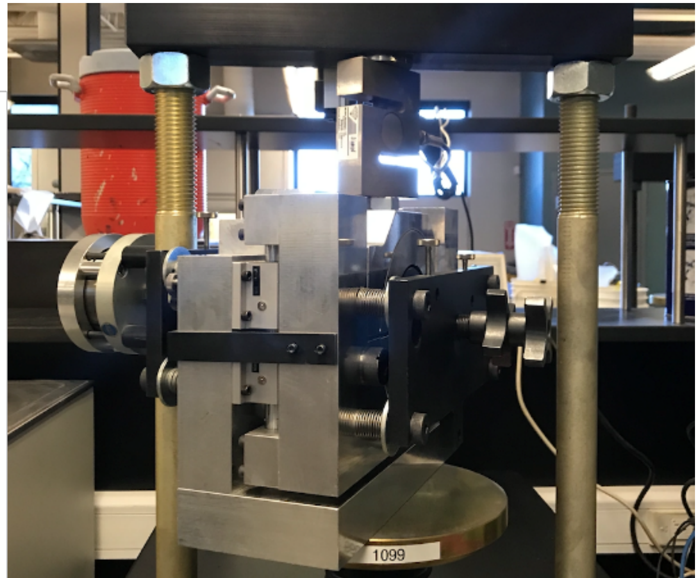


Laboratory Testing

- Interlayer Shear Strength Testing Cores (AASHTO TP 114)
  - Shear stress is applied to see how strong the bond is between the two pavement layers
  - Louisiana Interlayer Shear Strength Tester (LISST)
- Three groups of cores- post construction cores (baseline), year one cores, cores lab conditioned cores subjected to accelerated freeze-thaw cycling
- 4 replicates were tested for each test section

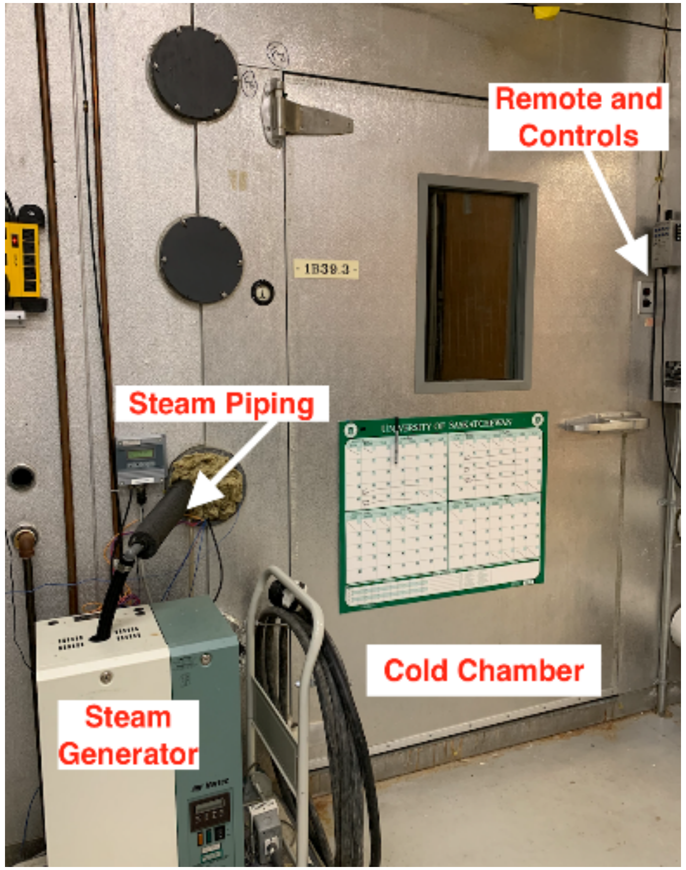


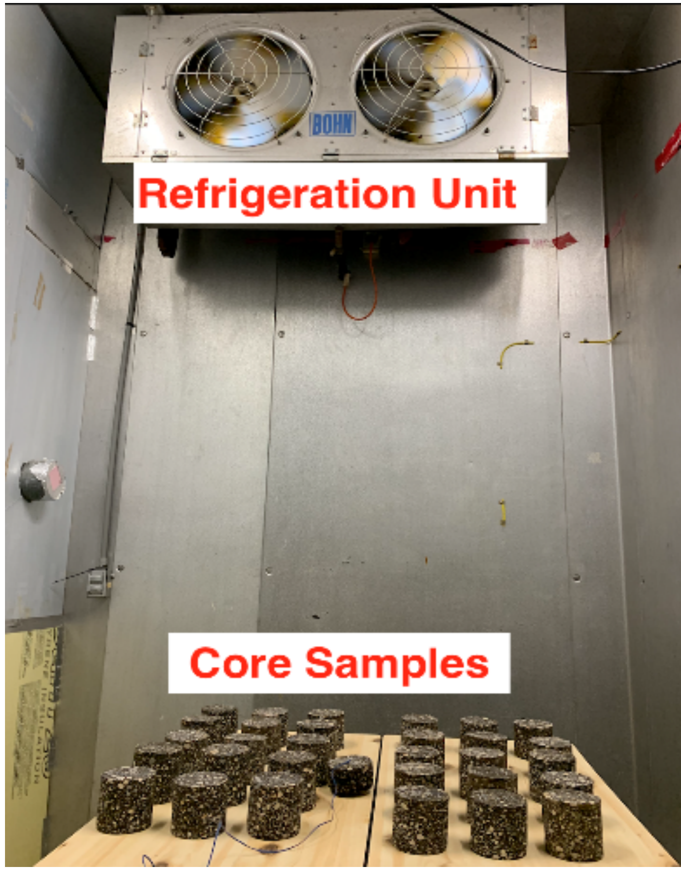




Environmental Conditioning

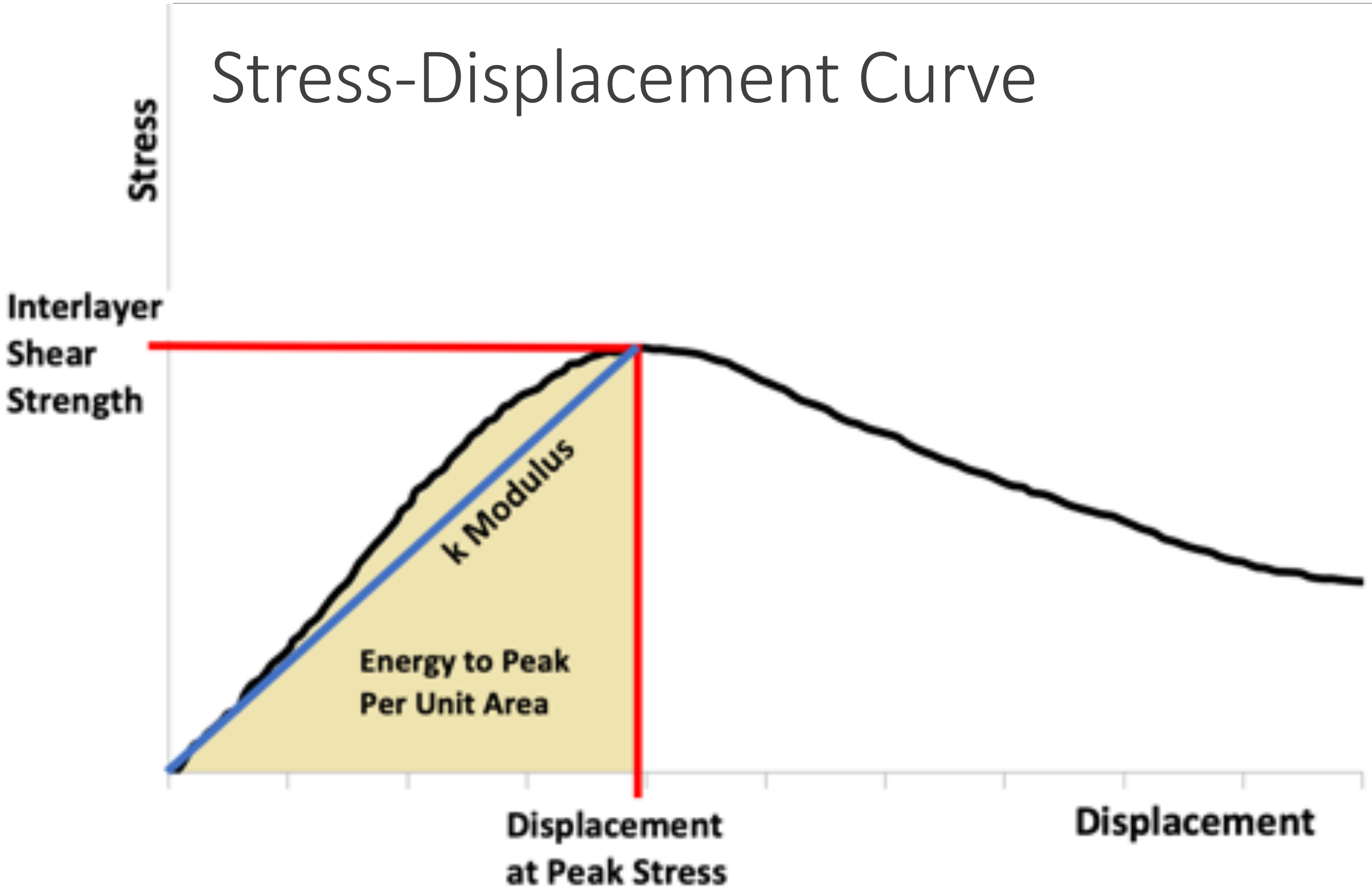
- A portion of the cores collected post construction were environmentally conditioned in a freeze thaw chamber prior to shear strength testing.
- Up to 15 Freeze-Thaw cycles, 12 hours at -25°C and 12 hours 15°C and 50-60% relative humidity
- 4 thermocouples measured the temperature of the chamber, one inside a core sample





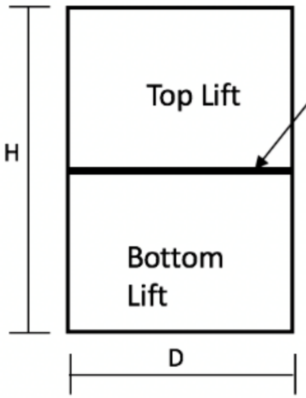
Parameters

Stress-Displacement Curve



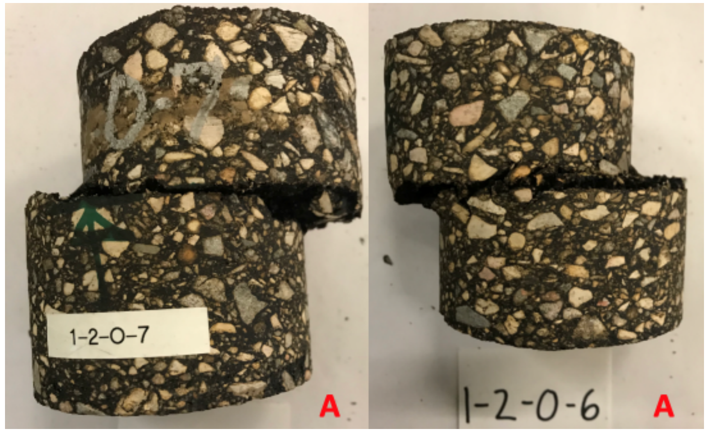
- Interlayer Shear Strength (ISS) is the peak stress
- Strain is displacement at peak stress/diameter of the sample
- Energy is the area under the stress-displacement curve in J/m^2
- k Modulus is the slope of the stress displacement curve

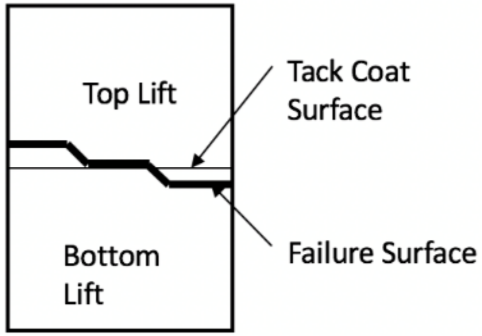
Failure Types



Type A: Clean Failure at Tack Coat Surface

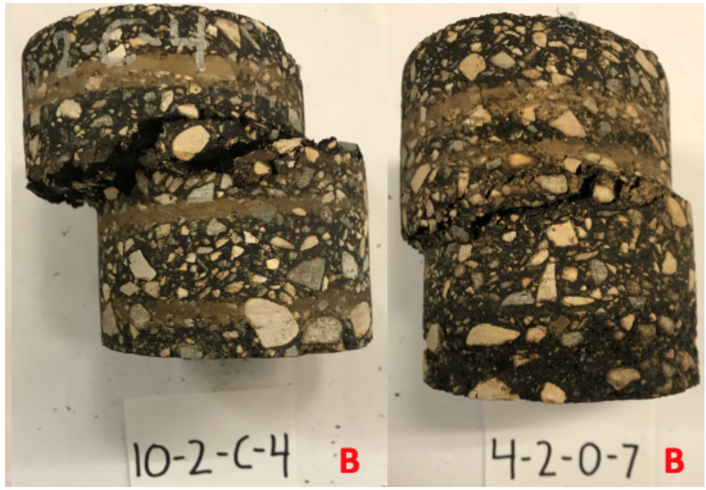
Poor Bond



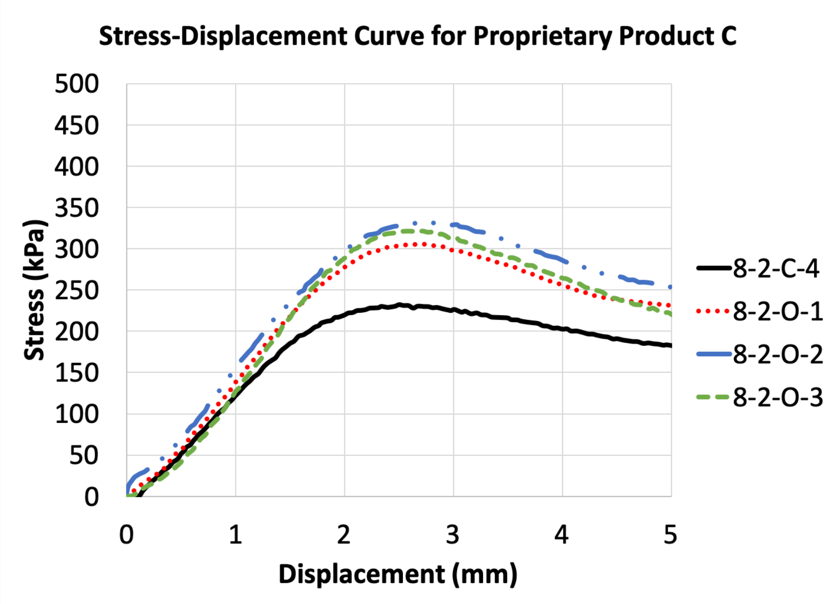


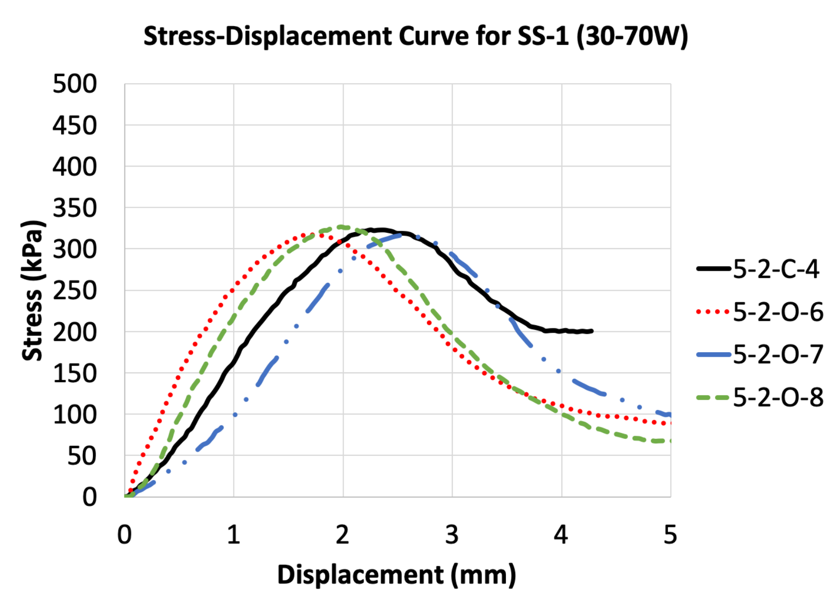
Type B: Failure Partially in the Mix

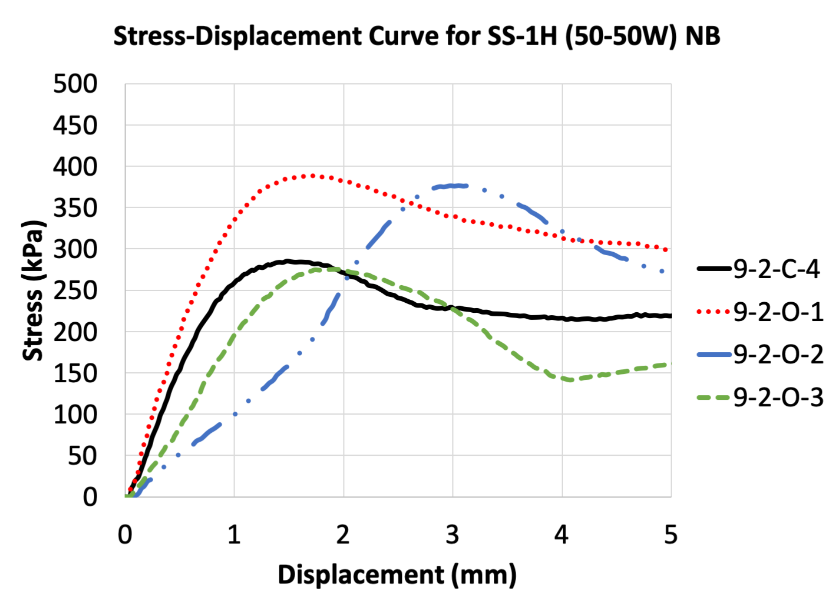
Good Bond



Stress-Displacement Curves

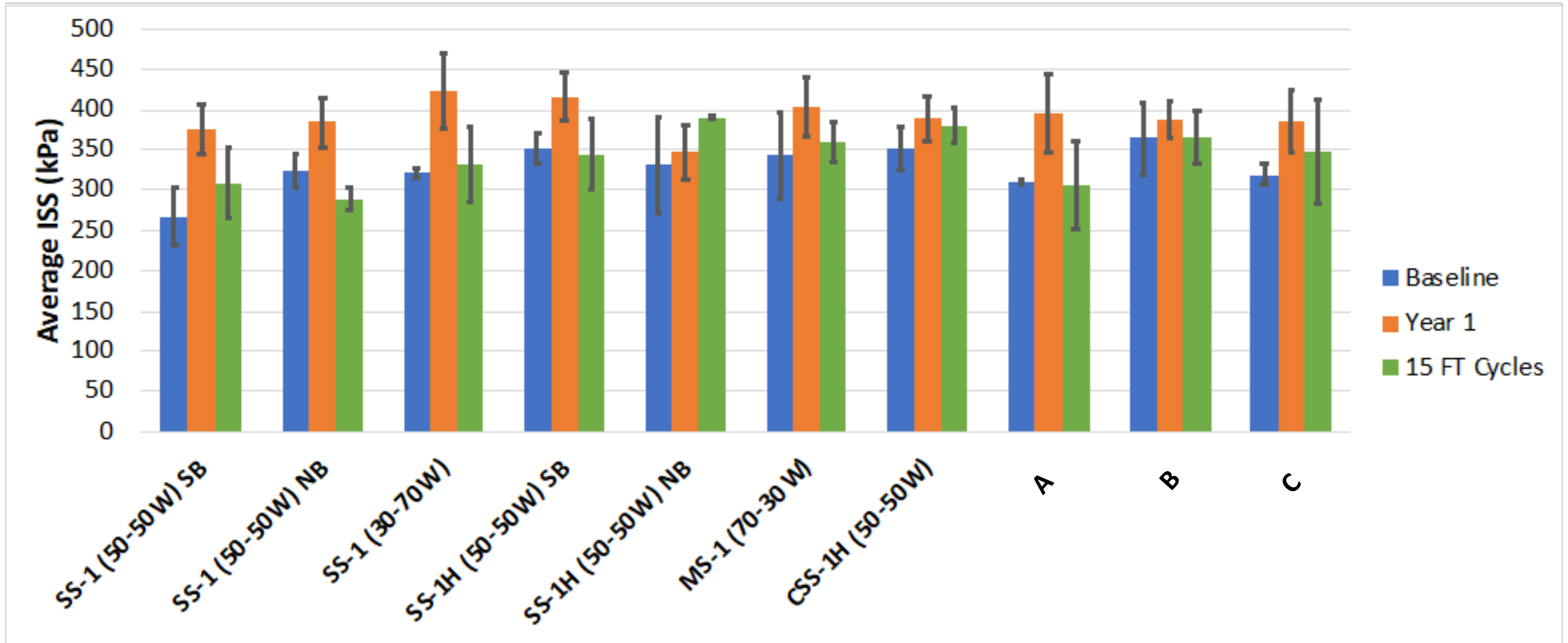






Lab Testing Program Findings – ISS

- One year cores had the highest ISS, followed by lab conditioned cores, and then baseline cores. The increase in ISS can be attributed to the continuous curing of tack coat materials.
- SS-1 products with 50-50W dilution consistently ranked low in terms of ISS among the three core groups.

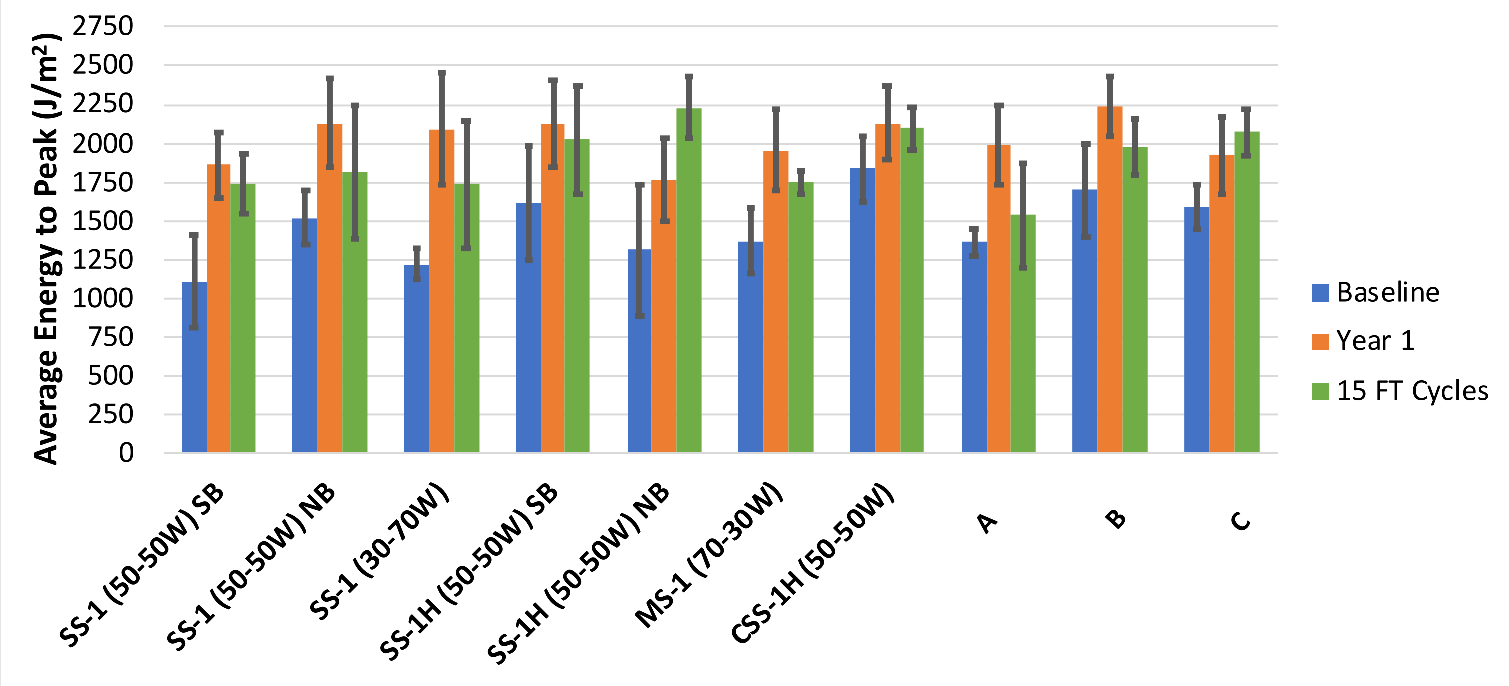


Lab Testing Program Findings – Failure Type

Section	Material	Baseline	Year 1	15 FT Cycles
1	SS-1 (50-50W) SB	A	A	A
6	SS-1 (50-50W) NB	A	A	B
5	SS-1 (30-70W)	A	A	A
2	SS-1H (50-50W) SB	B	B	B
9	SS-1H (50-50W) NB	B	A/B	B
4	MS-1 (70-30W)	B	A/B	B
7	CSS-1H (50-50W)	B	B	B
3	A	B	A/B	B
10	B	B	B	B
8	C	B	A/B	B

Lab Testing Program Findings – Energy

- The energy required to reach the peak shear stress accounts for both the applied stress and the amount of deformation that the sample undergoes before reaching bond failure. For the FT conditioned and one year cores, there is an increase in energy required to reach peak shear stress. SS-1 SB had a consistently low energy rank for all 3 core groups and CSS-1H had a consistently high energy rank for all 3 core groups.



Parameter Comparison – Baseline Cores

Material	Dilution	ISS Rank	Strain Rank	Failure Type	k Modulus Rank	Energy Rank
SS-1 SB	50-50W	10	6	A	9	10
SS-1 NB	50-50W	6	3	A	8	5
SS-1	30-70W	7	8	A	4	9
SS-1H SB	50-50W	2	5	B	5	3
SS-1H NB	50-50W	5	10	B	1	8
MS-1	70-30W	4	9	B	2	6
CSS-1H	50-50W	3	1	B	7	1
A	No dilution	9	7	B	3	7
B	No dilution	1	4	B	6	2
C	No dilution	8	2	B	10	4

Lab Testing Program Findings

- The lab conditioned cores did not show significant degradation in bond behaviour due to FT cycling.
- The ISS and energy values are affected by the placement of the core in the inner wheel path (highest), centre of the lane, or outer wheel path (lowest).
- Five parameters including the ISS, strain at bond failure, failure type, k modulus, and energy to bond failure were studied and showed merit in quantifying the quality of bond between two AC layers.
- Overall, SS-1H, MS-1, CSS-1H, and the 3 proprietary products showed better performance than SS-1 emulsion according to the test results of the baseline and year one cores.

Research Significance

- This research can help Saskatchewan Ministry of Highways & Infrastructure develop and implement performance based specifications for tack coat materials according to bond strength in terms of ISS value, failure type, k modulus, energy, and strain.
- With the completion of the study, the change in bond strength between AC layers will be fully characterized and acceptance limits can be established for bond strength of tack coat materials in cold regions.

Future Research

- Delayed by Covid-19, will be continued by someone else.
- Monitoring of the test sections should continue for at least three more years and should include collection of cores for bond strength testing and field distress surveys.
- The FT cycling completed in this study did not cause significant change in bond strength. More research should be completed to investigate the impact of higher number of FT cycling and different methods for sample conditioning.
- Further testing of non-tracking proprietary emulsions and products besides SS-1 should be considered as these products appear to have better performance based on year 1 results.
- Testing data should include monitoring the placement of core samples in the wheel paths and centre of the lane should be continued because the placement of the cores may yield different results in future testing.

Acknowledgements

Saskatchewan Ministry of Highways & Infrastructure

McAsphalt

Pounder Emulsions (Husky Energy)

Colasphalt

The City of Saskatoon

Research Papers and Presentations

Evaluating the Performance of Tack Coat Materials in Saskatchewan Climate

Transportation Association of Canada (TAC), Saskatoon, SK, October 2018

Conference Paper & Presentation

Coauthored by Laura Stasiuk, Haithem Soliman, Ania Anthony, Chris Dechkoff, Jen Penner

---

Characterizing Bond Strength Behaviour of Tack Coat Materials in Saskatchewan Climate

Canadian Technical Asphalt Association (CTAA), Regina, SK, November 2018

Conference Paper

Coauthored by Ania Anthony, Christ Dechkoff, Laura Stasiuk, Haithem Soliman, Nathan Prosko

---

Effect of Emulsion Type on Bond Behaviour of Asphalt Concrete Layers in Cold Regions

Transportation Research Board (TRB)/Transportation Research Record (TRR), Washington, D.C., January 2019

Conference Presentation & Journal Paper

Coauthored by Laura Stasiuk, Haithem Soliman, Ania Anthony

Tack Coats For Micro-Surfacing Applications

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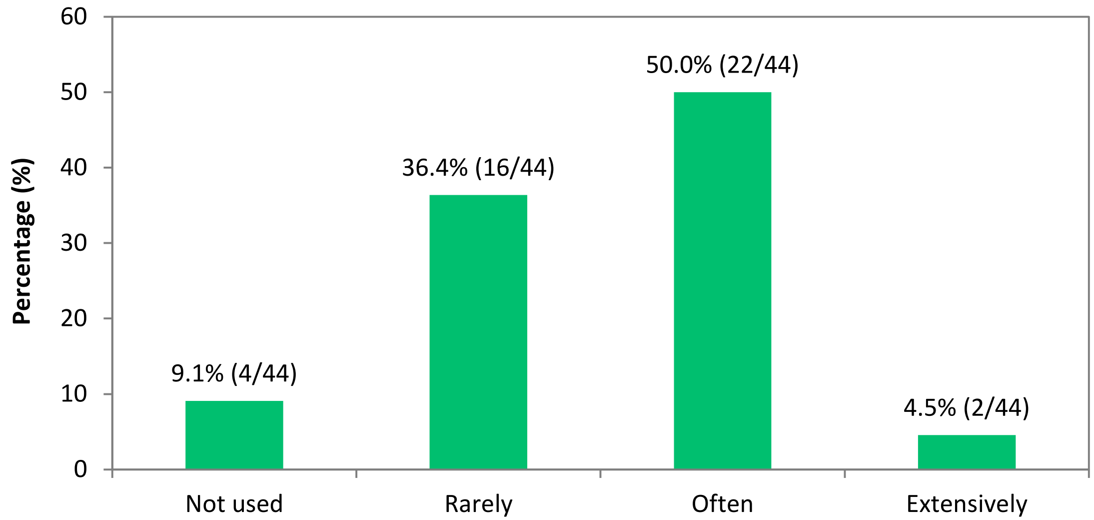
Department of Civil and Architectural Engineering & Construction Management
University of Cincinnati

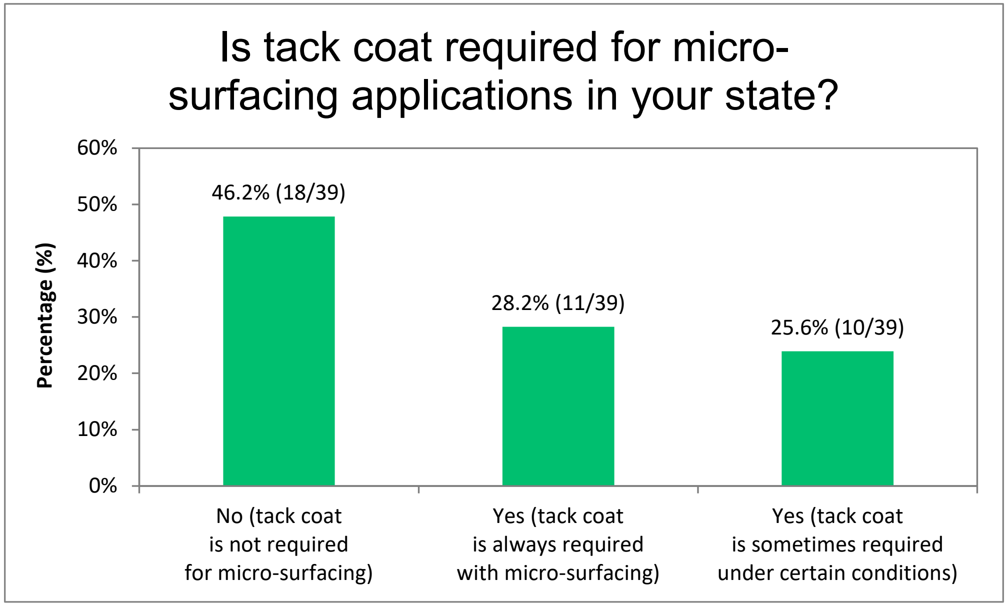
Background

How often is micro-surfacing used by your agency?



Background

- Some DOTs including ODOT currently requires placing a tack coat on the existing pavement.
- Some industry professionals argue that tack coat is not necessary in micro-surfacing applications.



- However, there will a risk of premature failure due to poor bonding between the micro-surfacing mix and the existing pavement surface.

Objectives

- Determine if it is needed to apply tack coat in micro-surfacing applications.
- Identify the factors that affect the interlayer bond strength in micro-surfacing applications.
- Develop a standard test procedure and sample preparation technique for measuring the interface bond strength for micro-surfacing applications after construction.

Testing Program

- Different factors can affect the bonding strength between micro-surfacing mix and existing surface:
  - Tack coat application rate
  - Tack coat material type
  - Micro-surfacing mix emulsion content
  - Existing surface conditions

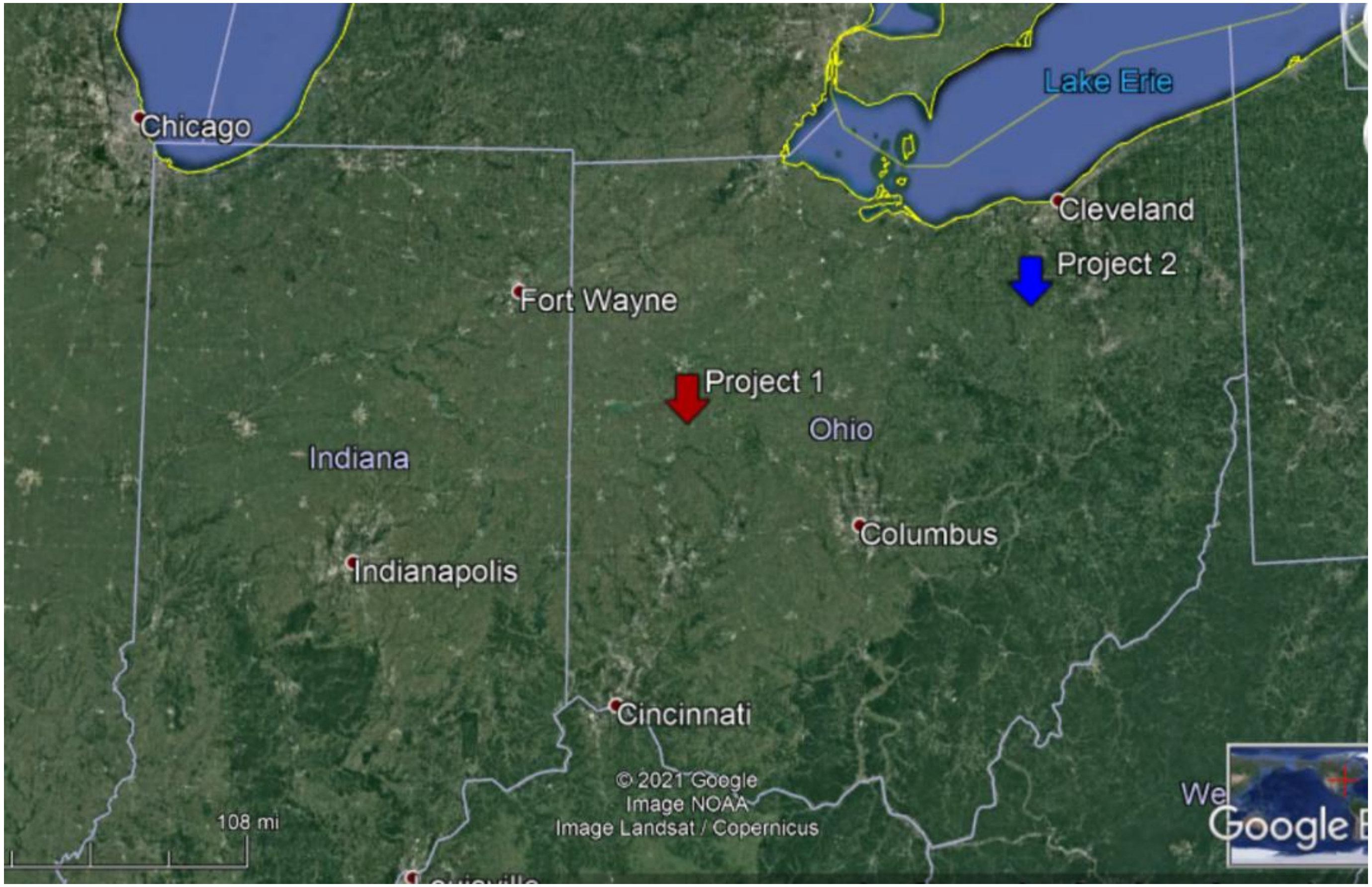
Testing Program to Evaluate those factors

Field Testing Program

Lab Testing Program

Testing Program

- To evaluate the different factors the field testing program included constructing a total of 23 test sections were constructed in two different project in Ohio.



Field Testing Program

Project 1-Single Micro-surfacing layer

<table>
<tr><th>Section</th><th>Tack Coat Material Type</th><th>Tack Coat Application Rate (g/sy)[1]</th><th>Residual Asphalt Binder Content of Mix</th><th>Road Condition</th></tr>
<tr><td>1-A</td><td>SS-1h</td><td>0.03</td><td rowspan="3">0.75% Lower Than Typical Design</td><td rowspan="3">Typical Aging</td></tr>
<tr><td>1-B</td><td rowspan="2">CSS-1hM</td><td>0.03</td></tr>
<tr><td>2</td><td>0.06</td></tr>
<tr><td>3</td><td rowspan="5">CSS-1hM</td><td>0.06</td><td rowspan="6">Typical Design</td><td rowspan="3">Highly aged</td></tr>
<tr><td>4</td><td>0.1</td></tr>
<tr><td>5</td><td>0.03</td></tr>
<tr><td>6</td><td>0.03</td><td rowspan="3">Typical Aging</td></tr>
<tr><td>7</td><td>0.1</td></tr>
<tr><td>8</td><td>SS-1H</td><td>0.1</td></tr>
</table>

Field Testing Program

Project 2-Single Micro-surfacing layer

Section	Tack Coat Material Type	Tack Coat Diluted Application Rate (g/sy)	Residual Asphalt Binder Content of Micro-Surfacing Mix
1	CSS-1hM	0.03	0.75% lower than typical design
2	None	None	Typical Design
3	CSS-1hM	0.03	
4		0.06	
5		0.10	
6	SS-1h	0.10	
7		0.03	

Project 2-Double Micro-surfacing layer

Section	Sections on Existing Pavement Surface			Sections on New Leveling Course	
	Tack Coat Material	Tack Coat Diluted Application Rate (g/sy)	Residual Binder Content of Mix	Tack Coat Material	Tack Coat Diluted Application Rate (g/sy)
8	CSS-1hM	0.03	0.75% lower than typical design	CSS-1hM	0.03
9	None	None	Typical Design	None	None
10	CSS-1hM	0.06	Typical Design	None	None
11		0.06		CSS-1hM	0.03
12		0.06			0.06
13	SS1h	0.06		SS1h	0.03
14		0.06			0.06

Field Testing Program

Monitor construction& measure tack coat application rate during construction

Obtain cores after one week, 3 months & 12 months

Evaluate the different sections after 1 and 2 years

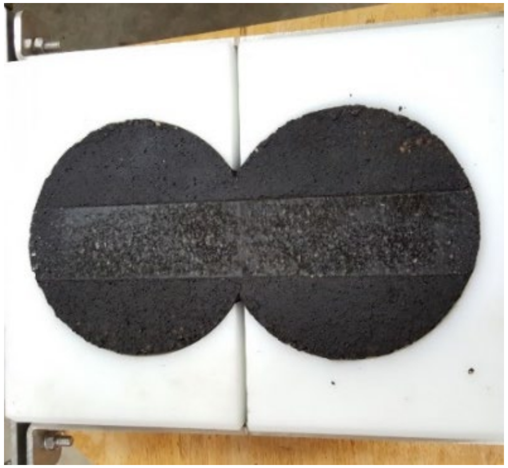
Lab Testing Program

- Micro-surfacing samples were prepared in the lab using the aggregates and emsulsion samples obtained from the field according to field testing matirx.


(a)


(b)


(c)


(d)

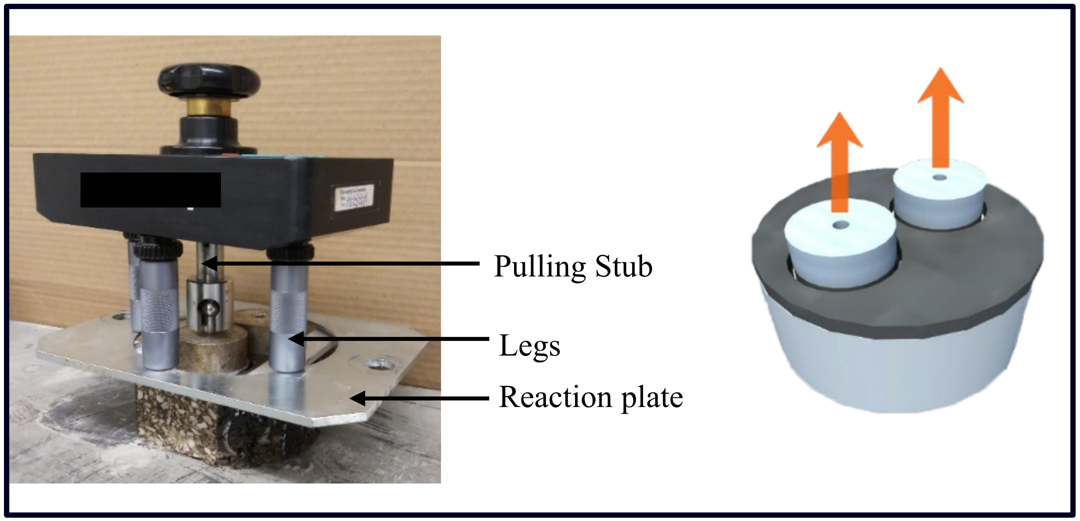

(e)


(f)

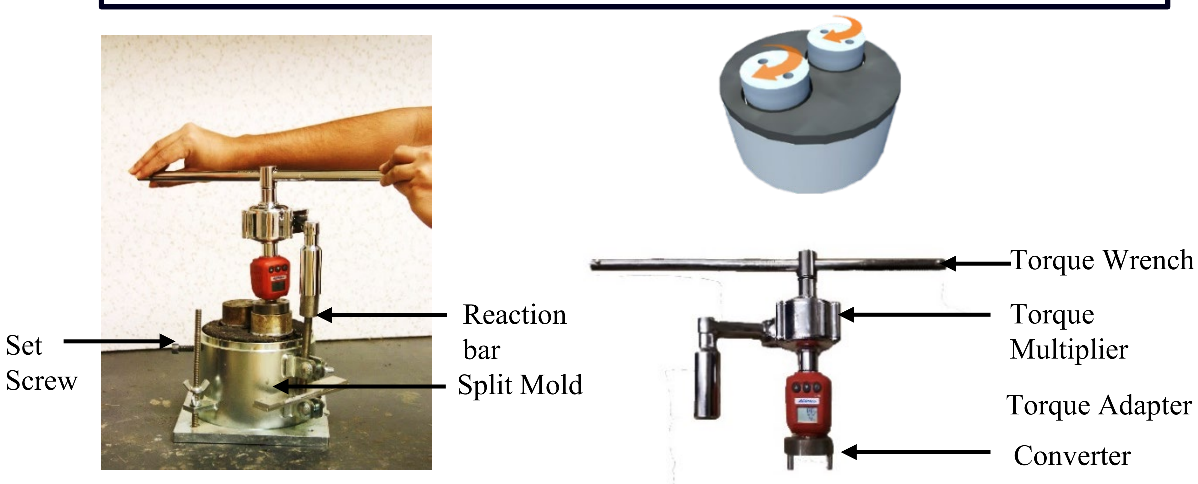
Core and Lab Samples Testing

- Two different bond strength tests were performed on the field core samples and the lab prepared samples.

Pull-off Tests

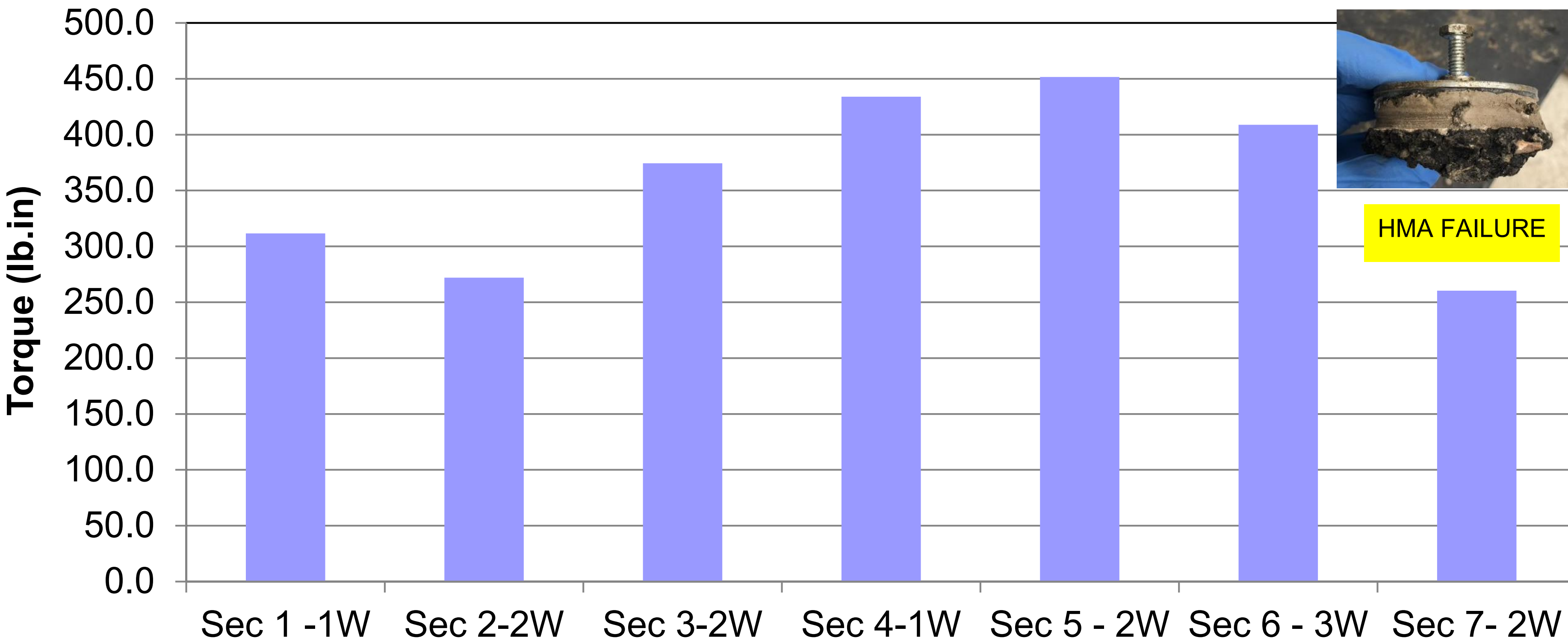


Torque Shear Tests



Torque Test Results –Cores Obtained after 12 Months

Sample ID	Sec 1	Sec 2	Sec 3	Sec 4	Sec 5	Sec 6	Sec 7
Em. Cont	7.05%	7.8%	7.8	7.8%	7.8%	7.8%	7.8%
TC type	CSS-1hM	None	CSS-1hM	CSS-1hM	CSS-1hM	SS-1h	SS-1h
TC rate (gsy)	0.019	0	0.022	0.054	0.111	0.105	0.022



Torque Test Results-Cores Obtained after 12 Months

Sample ID	Sec 1	Sec 2	Sec 3	Sec 4	Sec 5	Sec 6	Sec 7
Em. Cont	7.05%	7.8%	7.8	7.8%	7.8%	7.8%	7.8%
TC type	CSS-1hM	None	CSS-1hM	CSS-1hM	CSS-1hM	SS-1h	SS-1h
TC rate (gsy)	0.019	0	0.022	0.054	0.111	0.105	0.022

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Section	5	11	15.61	0.0001

Section	Estimate	Letter Group
5	451.60	A
4	434.00	A
6	408.80	AB
3	374.40	B
1	362.40	B
2	272.00	C

Torque Test Results – Overall Comparison

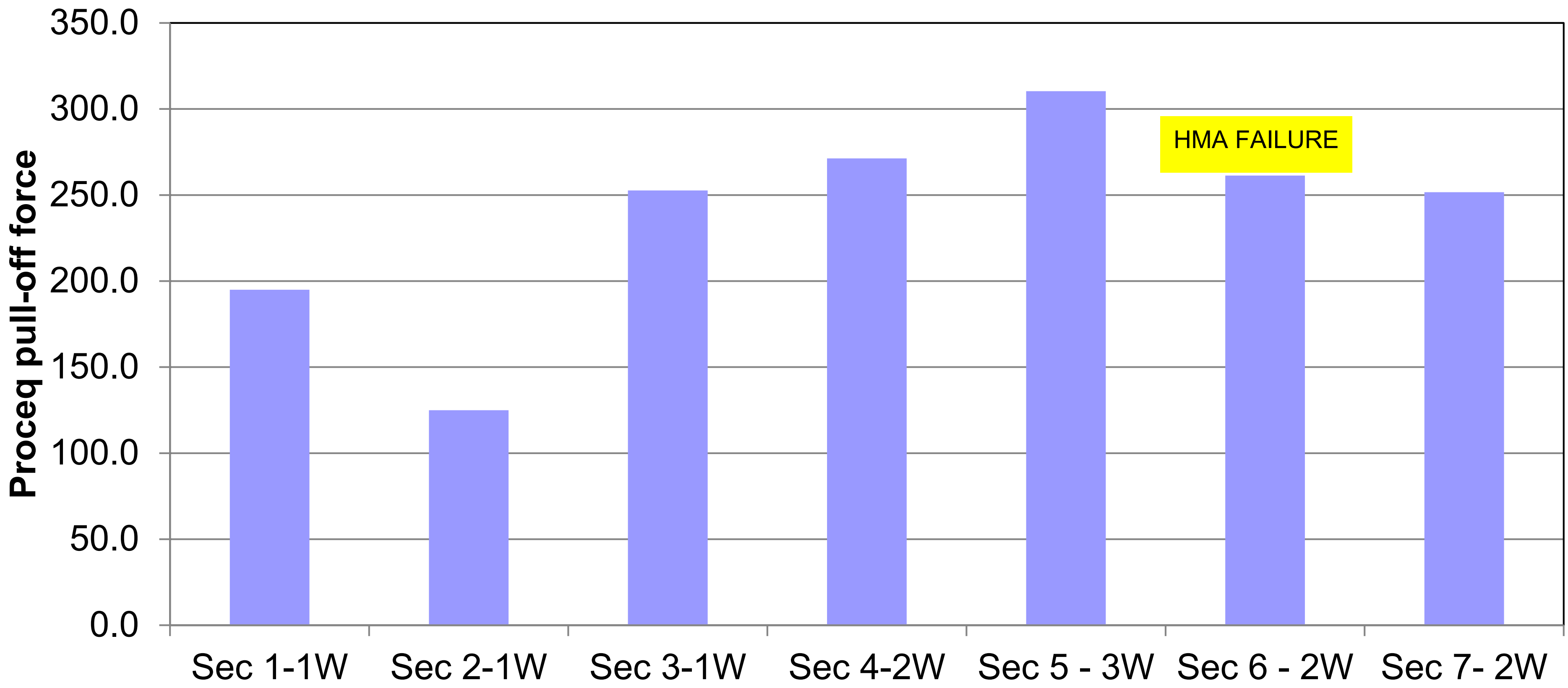
Effect	Num DF	Den DF	F Value	Pr > F
Section	5	33	33.87	<.0001
Time	2	33	223.06	<.0001
Section*Time	10	33	9.59	<.0001

Section	Estimate	Letter Group
5	366.13	A
6	349.20	AB
4	336.80	B
3	300.13	C
1	274.40	D
2	242.31	E

Time	Estimate	Letter Group
12 Months	383.87	A
4 Months	334.62	B
One Week	216.00	C

Proceq Test Results –Cores Obtained after 12 Months

Sample ID	Sec 1	Sec 2	Sec 3	Sec 4	Sec 5	Sec 6	Sec 7
Em. Cont	7.05%	7.8%	7.8	7.8%	7.8%	7.8%	7.8%
TC type	CSS-1hM	None	CSS-1hM	CSS-1hM	CSS-1hM	SS-1h	SS-1h
TC rate (gsy)	0.019	0	0.022	0.054	0.111	0.105	0.022



Proceq Test Results – Cores Obtained after 12 Months

Sample ID	Sec 1	Sec 2	Sec 3	Sec 4	Sec 5	Sec 6	Sec 7
Em. Cont	7.05%	7.8%	7.8	7.8%	7.8%	7.8%	7.8%
TC type	CSS-1hM	None	CSS-1hM	CSS-1hM	CSS-1hM	SS-1h	SS-1h
Res. TC rate (gsy)	0.019	0	0.022	0.054	0.111	0.105	0.022

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Section	5	12	18.64	<.0001

Section	Estimate	Letter Group
5	310.33	A
4	271.33	AB
3	252.67	B
7	251.67	B
1	195.00	C
2	125.00	D

Proceq Test Results –Cores Obtained after 12 Months

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Section	5	36	31.05	<.0001
Time	2	36	199.05	<.0001
Section*Time	10	36	8.26	<.0001

Section	Estimate	Letter Group
5	241.11	A
4	224.33	AB
7	209.33	BC
3	196.78	C
1	178.78	D
2	147.44	E

Time	Estimate	Letter Group
12 Months	234.33	A
4 Months	234.06	A
One Week	130.50	B

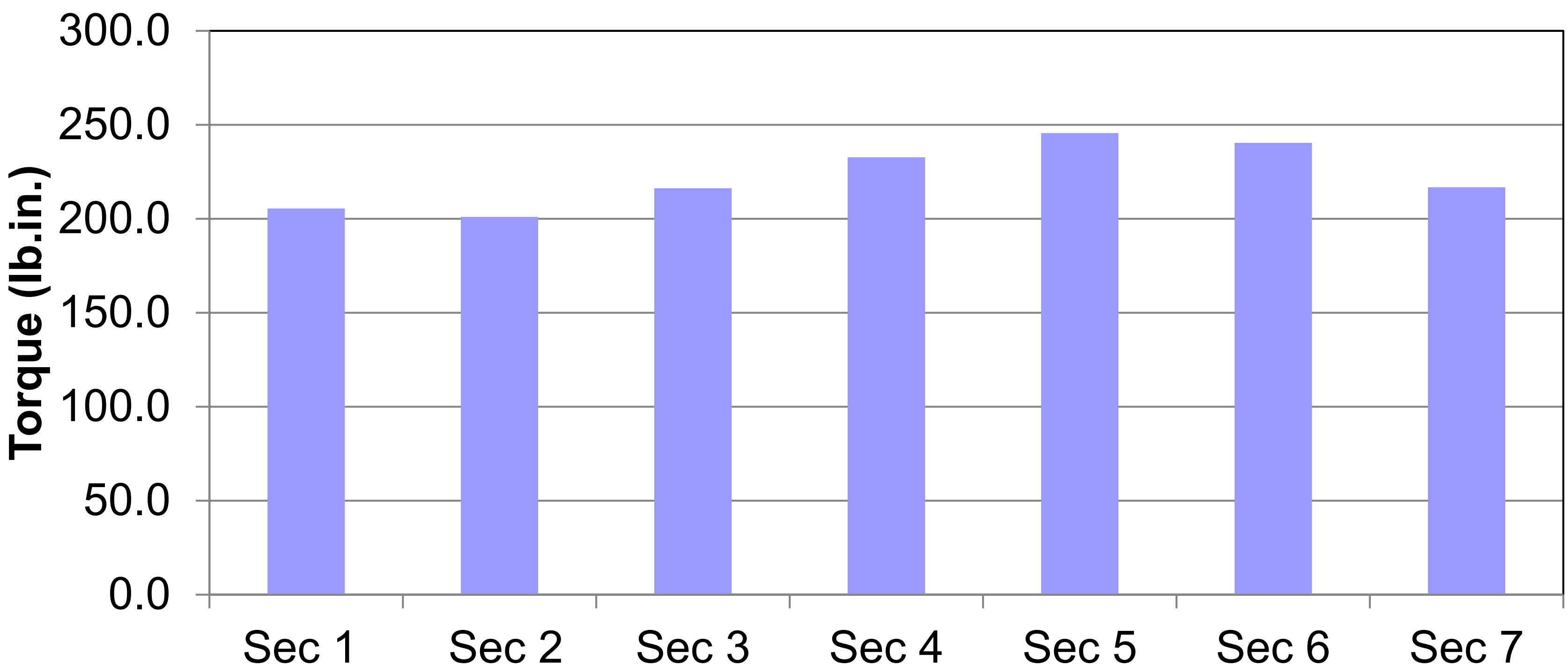
Proceq Test Results –Effect of Tack Coat Type& Rate

Effect	Num DF	Den DF	F Value	Pr > F
Tack coat type	1	6	0.00	0.9518
Tack coat rate	1	6	13.21	0.0109

TCT	TCR	Estimate	Standard Error	Letter Group
CSS1hm	H	310.33	11.2200	A
CSS1hm	L	252.67	11.2200	B
SS1h	L	251.67	11.2200	B

Torque Test Results –Lab Prepared Samples

Sample ID	Sec 1	Sec 2	Sec 3	Sec 4	Sec 5	Sec 6	Sec 7
Em. Cont	7.05%	7.8%	7.8	7.8%	7.8%	7.8%	7.8%
TC type	CSS-1hm	None	CSS-1hm	CSS-1hm	CSS-1hm	SS-1h	SS-1h
TC rate (gsy)	0.025	0	0.025	0.06	0.108	0.108	0.025



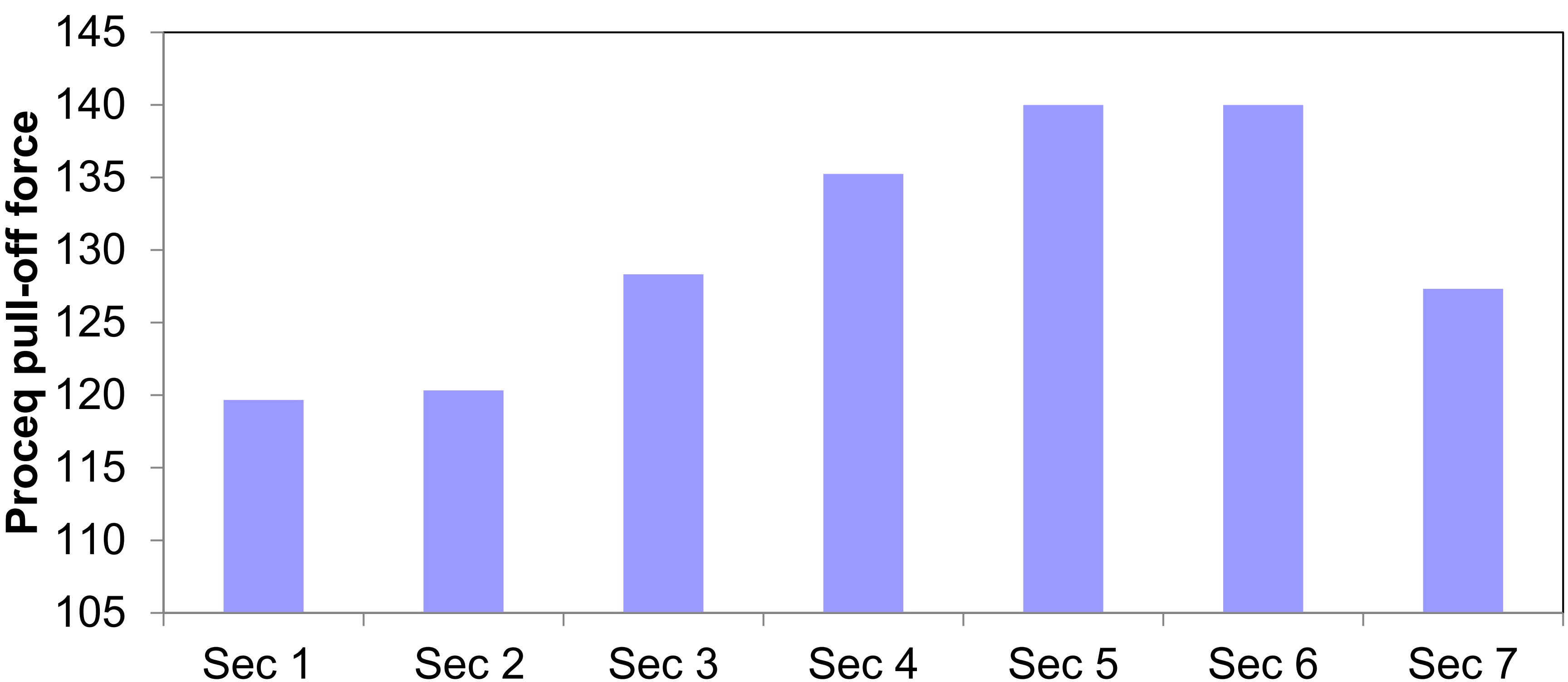
Torque Test Results –Lab Prepared Samples

Sample ID	Sec 1	Sec 2	Sec 3	Sec 4	Sec 5	Sec 6	Sec 7
Em. Cont	7.05%	7.8%	7.8	7.8%	7.8%	7.8%	7.8%
TC type	CSS-1hm	None	CSS-1hm	CSS-1hm	CSS-1hm	SS-1h	SS-1h
TC rate (gsy)	0.025	0	0.025	0.06	0.108	0.108	0.025

Section	Estimate	Letter Group
Sec 5	245.60	A
Sec 6	240.40	A
Sec 4	232.80	B
Sec 7	216.80	BC
Sec 3	216.30	BC
Sec 1	205.50	C
Sec 2	201.00	C

Proceq Test Results –Lab Prepared Samples

Sample ID	Sec 1	Sec 2	Sec 3	Sec 4	Sec 5	Sec 6	Sec 7
Em. Cont	7.05%	7.8%	7.8	7.8%	7.8%	7.8%	7.8%
TC type	CSS-1hm	None	CSS-1hm	CSS-1hm	CSS-1hm	SS-1h	SS-1h
TC rate (gsy)	0.025	0	0.025	0.06	0.108	0.108	0.025



Proceq Test Results –Lab Prepared Samples

Sample ID	Sec 1	Sec 2	Sec 3	Sec 4	Sec 5	Sec 6	Sec 7
Em. Cont	7.05%	7.8%	7.8	7.8%	7.8%	7.8%	7.8%
TC type	CSS-1hm	None	CSS-1hm	CSS-1hm	CSS-1hm	SS-1h	SS-1h
TC rate (gsy)	0.025	0	0.025	0.06	0.108	0.108	0.025

Section	Estimate	Letter Group
Sec 5	140.00	A
Sec 6	140.00	A
Sec 4	135.25	A
Sec 3	128.33	AB
Sec 7	127.33	AB
Sec 2	120.33	B
Sec 1	119.67	B

Findings

- The results of bond strength tests conducted on the samples obtained from the field test section indicated that, at 95% confidence level, the sections with no tack coat had significantly lower bond strength than those with tack coat with least 0.06 gsy application rate (0.01 gsy residual application rate).
- The results indicated that, at 95% confidence level, the use of 0.75% lower residual asphalt binder content in micro-surfacing mix resulted in significantly lower bond strength between the micro-surfacing and existing pavement.

Findings

- The results indicated that increasing the tack coat application rate resulted in improving the bond strength. However, the improvement was not significant when the total application was higher than 0.06 gsy (0.01 gsy residual application rate).

Questions?

Today’s Panelists

#TRBWebinar

Moderator: Danny Gierhart, *Asphalt Institute*

Louay Mohammad, *Louisiana State University*

Laura Stasiuk, *University of Saskatchewan*

Munir Nazzal, *University of Cincinnati*

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