Evaluation of Stripping Potential Tests for Bituminous Concrete

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September 14, 2022

VERMONT AGENCY OF TRANSPORTATION

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Background

- Moisture Susceptibility – Reduction in strength of the asphalt pavement in presence of moisture.

Longitudinal Cracks

Source: Veeraragavan (2020)

Alligator Cracks

Source: Williams (2010)

Potholes

Source: Colorado Pavement Solution (2019)

Raveling

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Moisture Susceptibility Tests

Qualitative

- Boiling Water Test (ASTM D3625)
- Static Immersion Test
- Texas Freeze-Thaw Pedestal Test
- Gagle Procedure
- Quick Bottle Test
- Rolling Bottle Method

Quantitative

- Lottman Test
- Modified Lottman Test (AASHTO T283)
- Hamburg Wheel Tracking Test (AASHTO T324)
- Tunnicliff and Root Test
- Resilient Modulus
- Double Punch Method
- Dynamic Strip Method
- Cold Water Abrasion Test

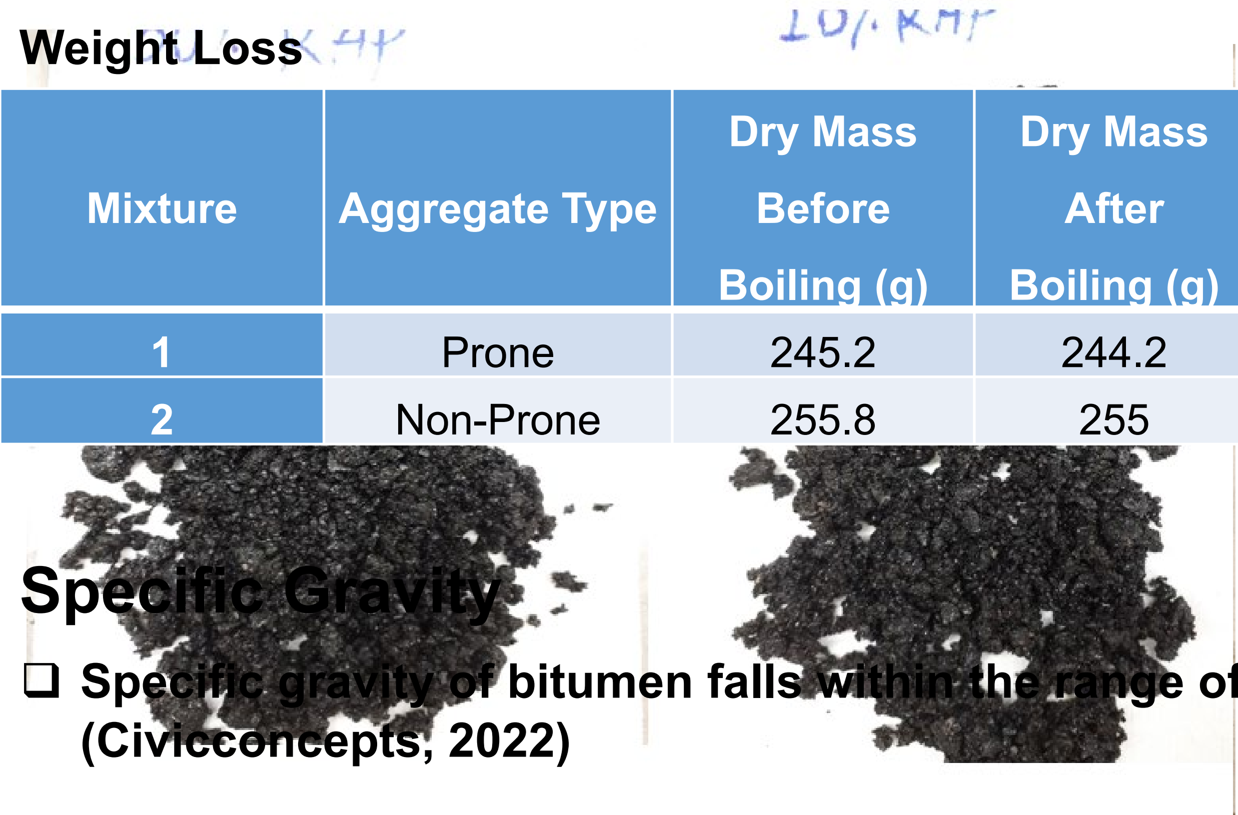
(Source: Putman and Amirkhanian, 2006)

Results – Boiling Water Test

Quantifying Result of Boiling Water Test

Weight Loss

Mixture	Aggregate Type	Dry Mass Before Boiling (g)	Dry Mass After Boiling (g)	Percent Loss in Asphalt Binder (%)
1	Prone	245.2	244.2	0.4
2	Non-Prone	255.8	255	0.3



30% RAP

20% RAP

Specific Gravity

- Specific gravity of bitumen falls within the range of 0.97 to 1.02 at 27 °C (Civicconcepts, 2022)

Sample ID	Mix Design	Box Numbering	Mix Type	Sample Date/Time	Asphalt Retained after boiling (%)
	9-752	20-001	IIS	NA	90-100
	9-752	20-002	IIS	NA	90-100
	9-752	20-003	IIS	NA	90-100
	9-752	20-004	IIS	NA	90-100
	9-752	20-005	IIS	NA	90-100
	9-752	20-006	IIS	NA	90-100
Pserven209H054644	19-752	NA	IIS	09/17/20-12:33	90-100
Pserven209H054644	19-752	NA	IIS	09/17/20-09:54	90-100
Pserven209H054644	19-752	NA	IIS	09/17/20-08:40	90-100
Burlington STP	IVS	NA	IVS	NA	90-100
Burlington STP	IVS	NA	IVS	NA	90-100
Burlington STP	IVS	NA	IVS	NA	90-100
Burlington STP	IVS	NA	IVS	NA	90-100
Burlington STP	IVS	NA	IVS	NA	90-100
NA	SP-18751	NA	IVS	11/03/20-10:30	90-100

Unreliable due to insignificant difference in mass lost

Unreliable as specific gravity of asphalt is close to that of water

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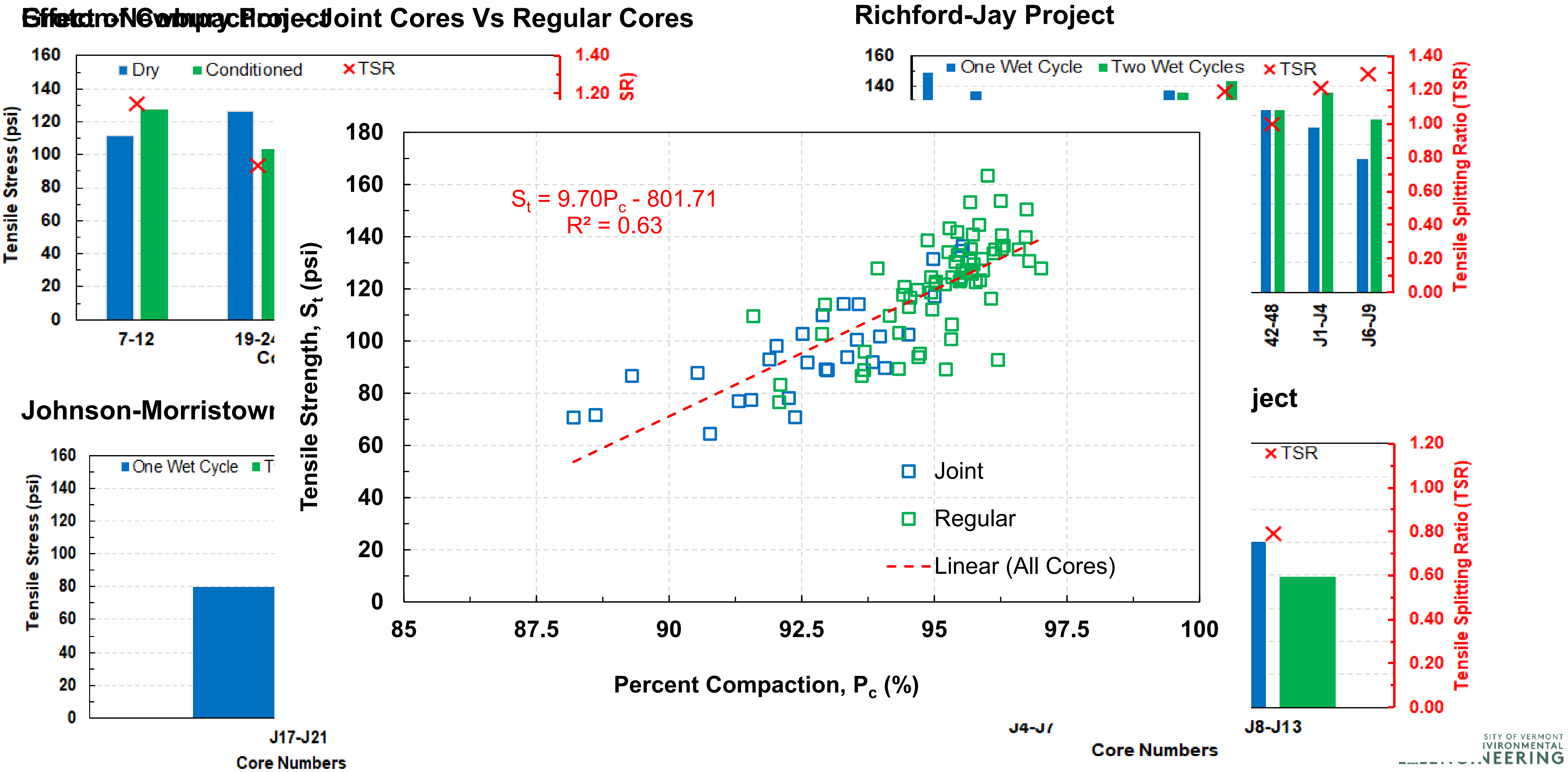
Results – Modified Lottman Test



Conclusions and Recommendations

- Plant produced HMA mixtures have low moisture susceptibility based on the ASTM D3625 and AASHTO T283. More robust test such as MiST could be useful.

- Adding 10% additional RAP (i.e. up to 30%) to the HMA mix showed same level of asphalt binder retainment as the plant produced HMA mix with 20% RAP.

- Quantification of ASTM D3625 is unreliable due to insignificant difference in weight loss and specific gravity of asphalt and water.

- TSR > 0.8 for all the mixtures. One extra wet cycle not enough to induce additional damage. More laboratory testing needed to determine the minimum cycles of Lottman conditioning.

Thank you for your attention

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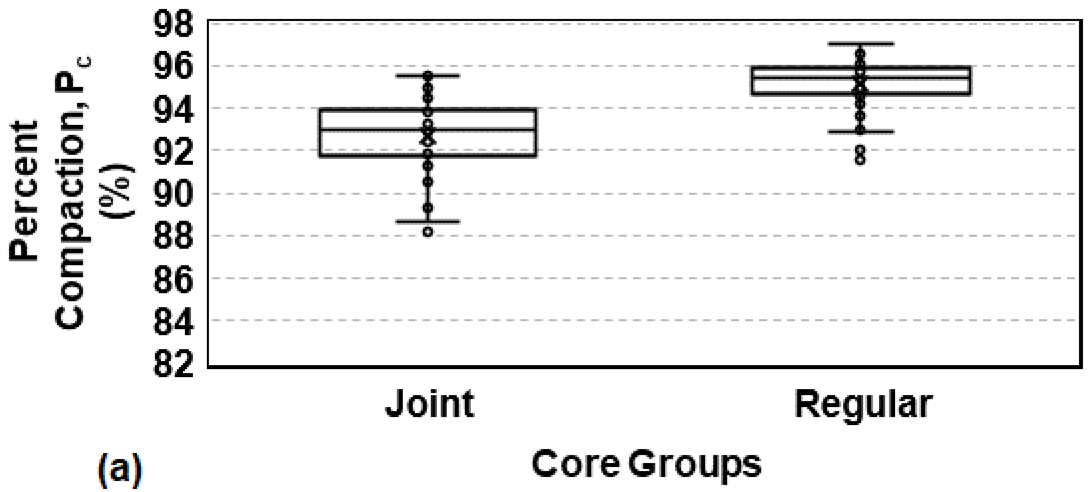
Additional Slides

Results – Modified Lottman Test

Comparison between Joint and Regular Cores



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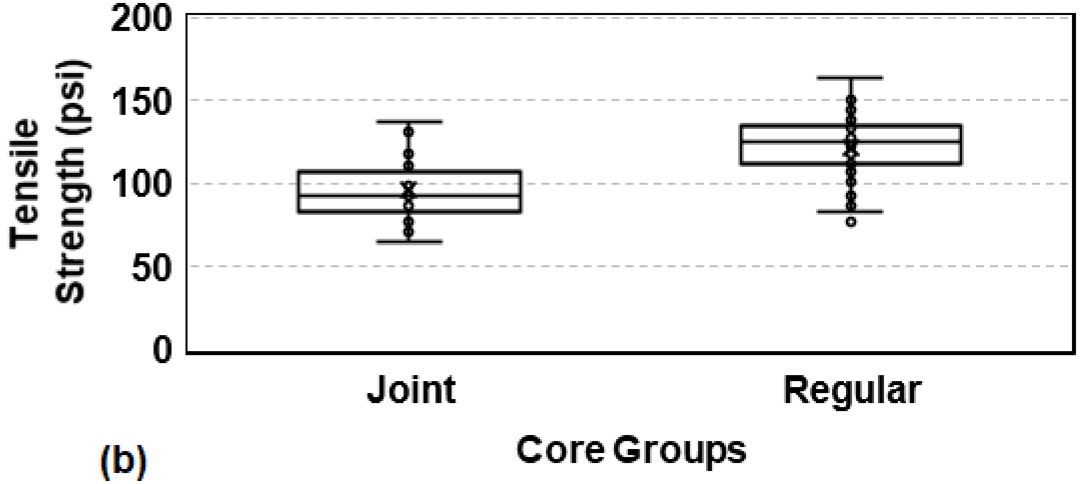

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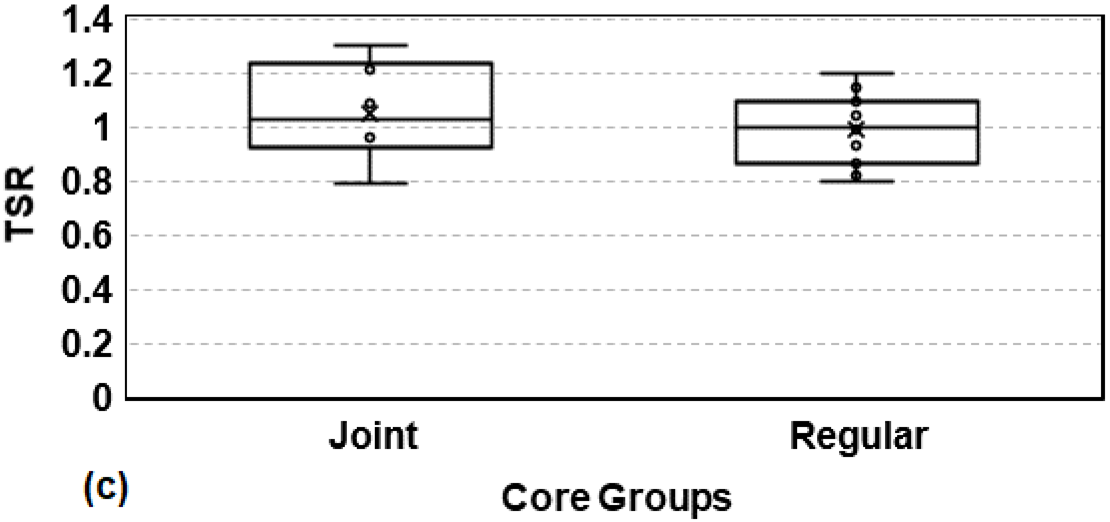

(c)

Results of two-tailed t-test

Parameters	Joint Cores	Regular Cores	P-value
Avg. compaction (%)	92.65	95.16	1.1×10^{-5}
Avg. Indirect Tensile Strength (psi)	95.67	121.71	5.2×10^{-5}
TSR	1.05	0.99	0.41

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Results – Boiling Water Test

Effect of RAP

Mix #	Aggregate type	RAP content	ASA	Production
1	Prone	30	Yes	UVM Lab
2	Non-prone	20	Yes	Plant produced

Job-Mix Formula (Provided by Dr. Anderson)

S.N.	AC Components	Percentage by weight (%)
1	Washed Stone Screening	37.5
2	Natural Sand	12.2
3	3/8 “Minus Course Aggregate (Prone/ Non- Prone)	25.4 15.4
4	RAP	20 30
5	Asphalt Binder	4.9

30% RAP 20% RAP

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Results – Boiling Water Test

Quantifying Result of Boiling Water Test

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Unreliable as specific gravity of asphalt is close to that of water

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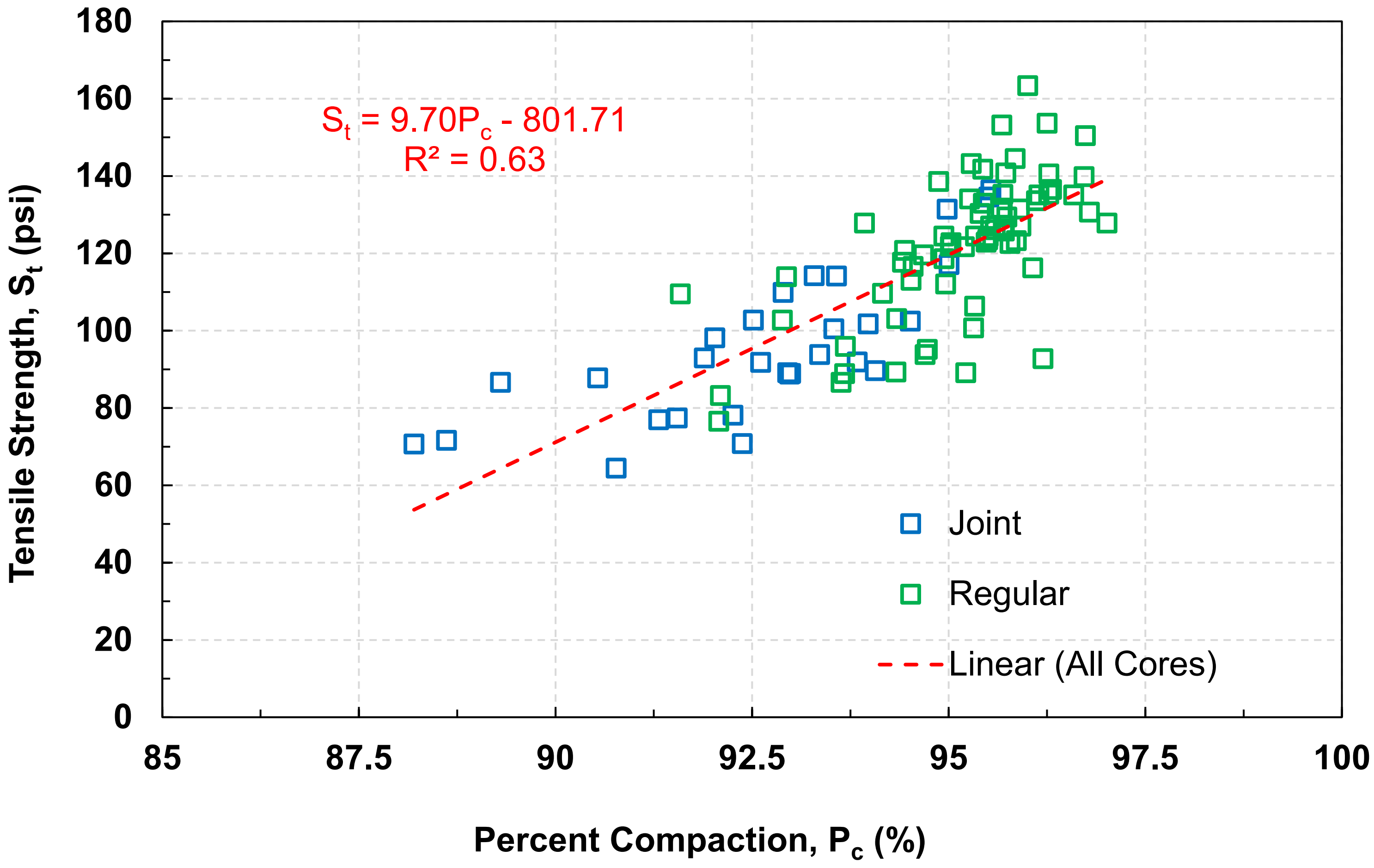
Results – Modified Lottman Test

Effect of Compaction – Joint Cores Vs Regular Cores



Materials

Plant Produced HMA

Raw Aggregates and RAP

Asphalt Binder and ASA

Asphalt Cores

Storage in the lab

Plant produced HMA and Raw Aggregates

Asphalt core boxes on a flat surface

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Test Procedure

Boiling Water Test – ASTM D3625

1

Asphalt Concrete

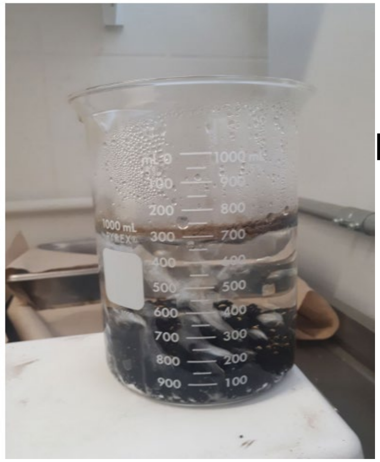
Loose HMA at 85 ºC for 2 hours

Weigh ~250g

2

Boil for 10 mins

3



Let it cool at room temperature

Decant the water

4

Visually evaluate the binder retained on aggregate

Also, measure weight

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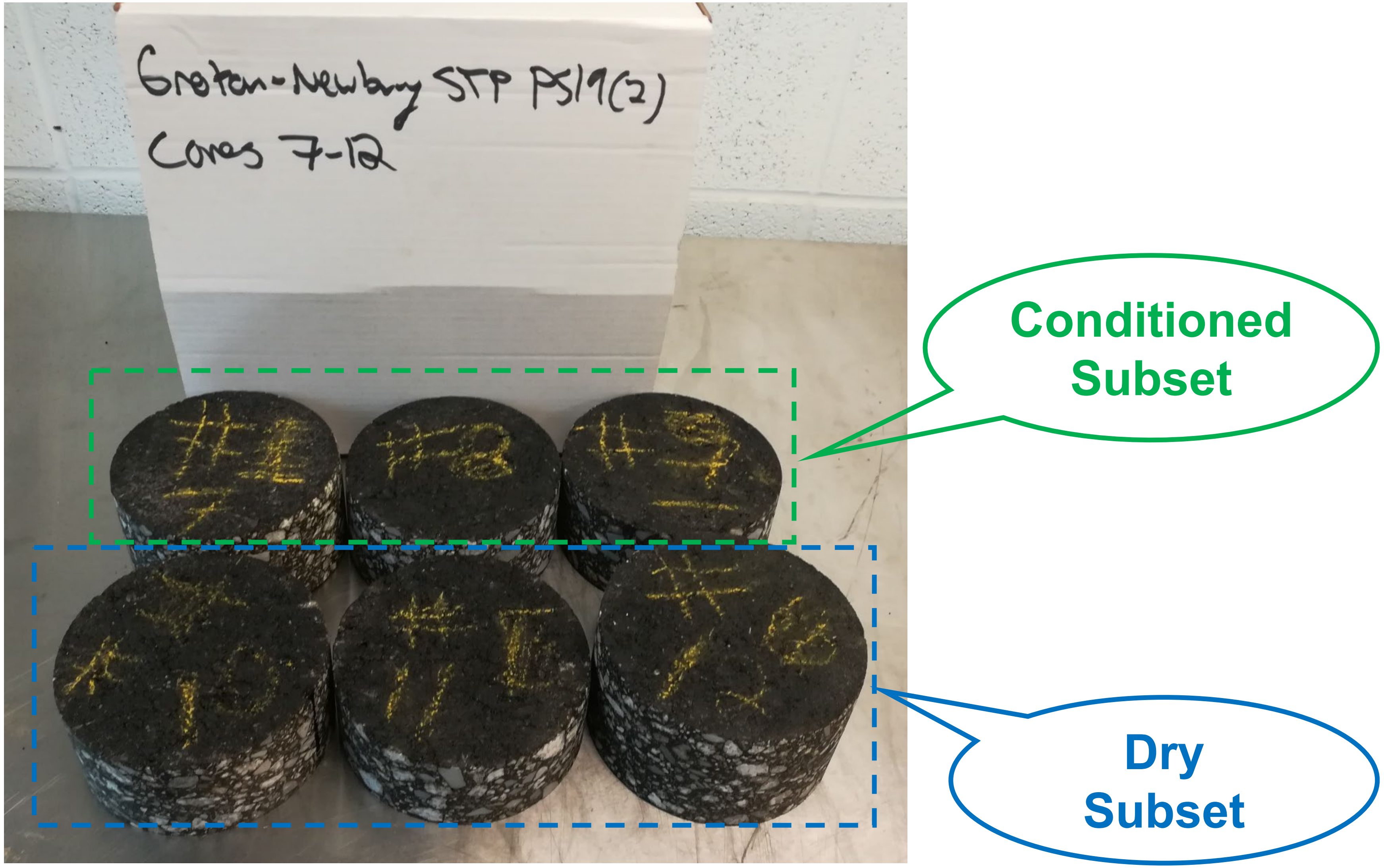
Test Procedure – Modified Lottman Test



Modified Lottman Test

- AASHTO T-283

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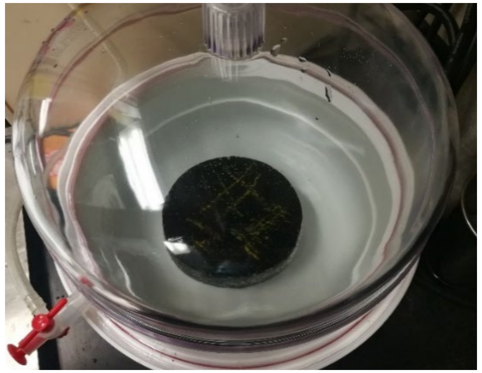
Test Procedure – Wet Conditioning for Lottman Test

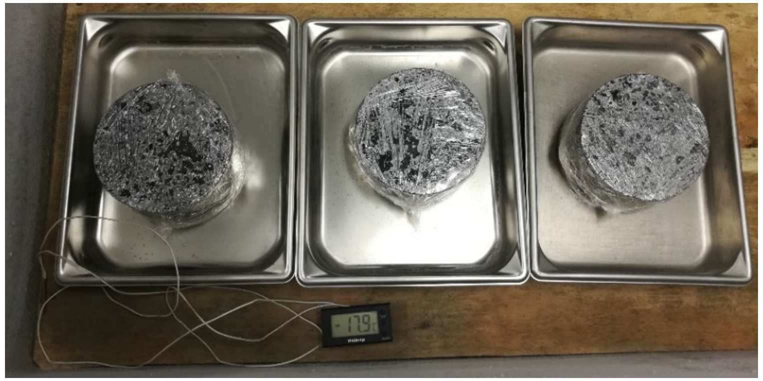
Vacuum for 5 mins



1 Submerged Weight

2 Plastic wrap

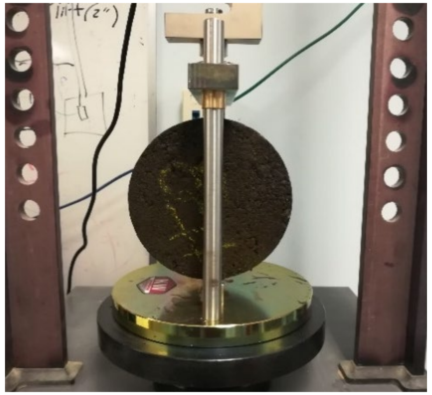
3 Freeze @ -18 ºC (0 ºF) for 16 hours



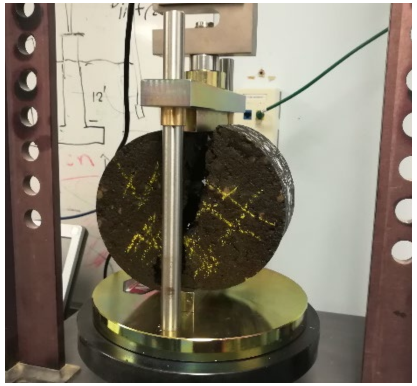
4 Water bath @ 60 ºC (140 ºF) for 24 hours

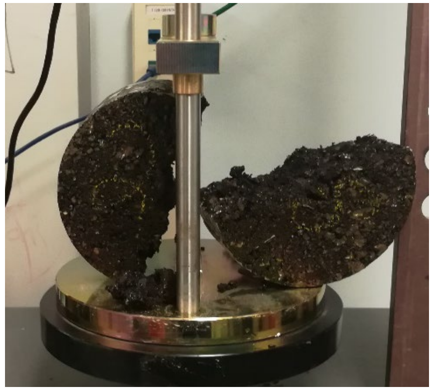
5 Water bath @ 25 ºC for 2-4 hours prior test

6 Loading @ 50 mm/min (2 in/min)



7 Measure the peak strength





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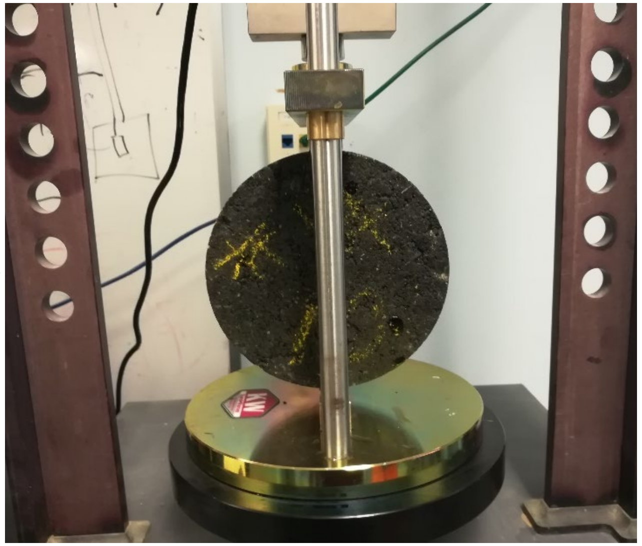
Test Procedure – Dry Conditioning for Lottman Test

Oven @ 25 ºC for 1 hour prior to test

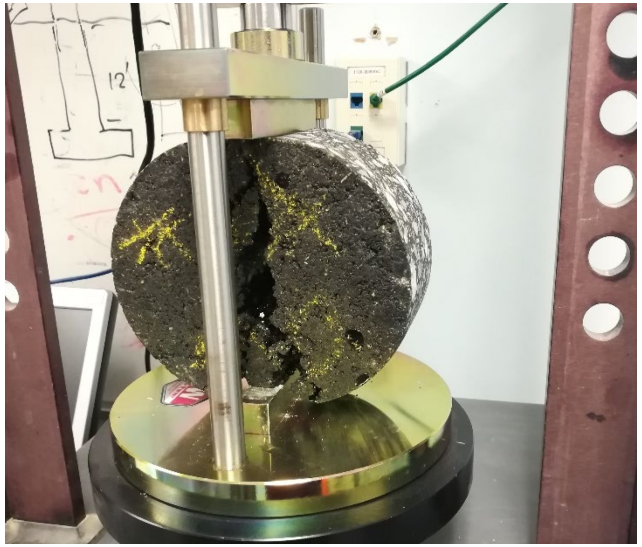
1

Loading @ 50 mm/min (2 in/min)



2

Measure the peak strength



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Calculation

- Calculate the indirect tensile strength of all the cores:

Tensile Strength, S_t (in psi) = $\frac{2*P}{\pi t D}$

P = Maximum peak strength, lbf
t = Average thickness of core, in
D = Core diameter, in

- Determine average peak strength for the sub-group i.e., dry and conditioned

- Calculate the Tensile Strength Ratio (TSR):

$$TSR = \frac{Avg.Tensile\ Strength\ of\ Conditioned\ Cores}{Avg.Tensile\ Strength\ of\ Dry\ Cores}$$

AASHTO T-280 threshold of TSR is 0.8

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Results – Boiling Water Test

Sensitivity of ASA

Prone

Non-prone

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Results – Modified Lottman Test

Stripping Prone Aggregate

S.N	Load (N)	$S_{t, cond.}$ (kPa)	Avg. S_t	Type	TSR
1	7892.50	0.66	0.65	Cond.	0.75
2	7359.10	0.62			
3	8047.90	0.67			
4	11841.00	0.99	0.87	Dry	
5	9294.00	0.78			
6	9997.10	0.84			

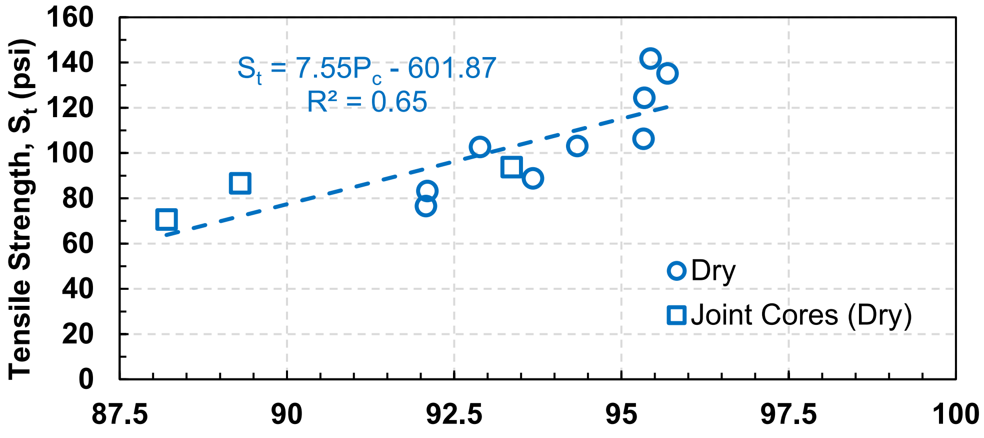
Stripping non-prone Aggregate

S.N	Load (N)	$S_{t, cond.}$ (kPa)	Avg. S_t	Type	TSR
1	7033.90	0.59	0.69	Cond.	0.88
2	8497.50	0.71			
3	9073.90	0.76			
4	9989.90	0.84	0.78	Dry	
5	8827.60	0.74			
6	9140.90	0.77			

Showed promising result to identify the moisture susceptible mixture even in the presence of ASA

Results – Modified Lottman Test

Effect of Compaction – Groton-Newbury Project (Dry Vs Wet Cores)



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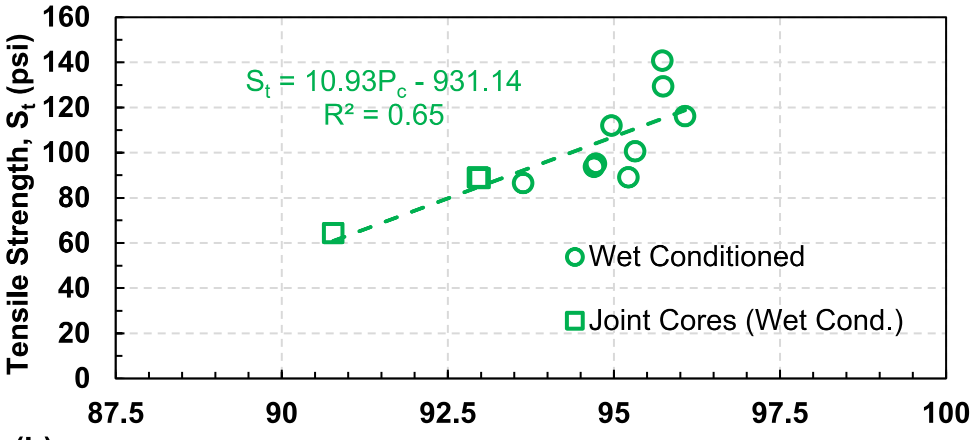

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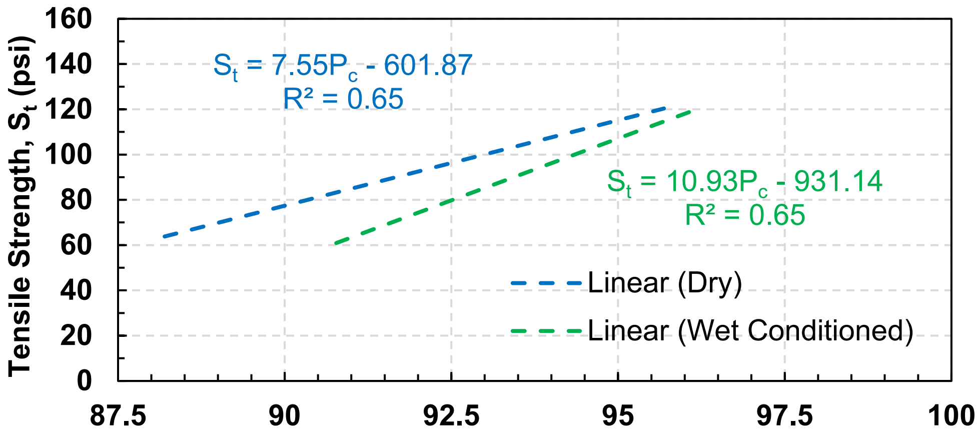

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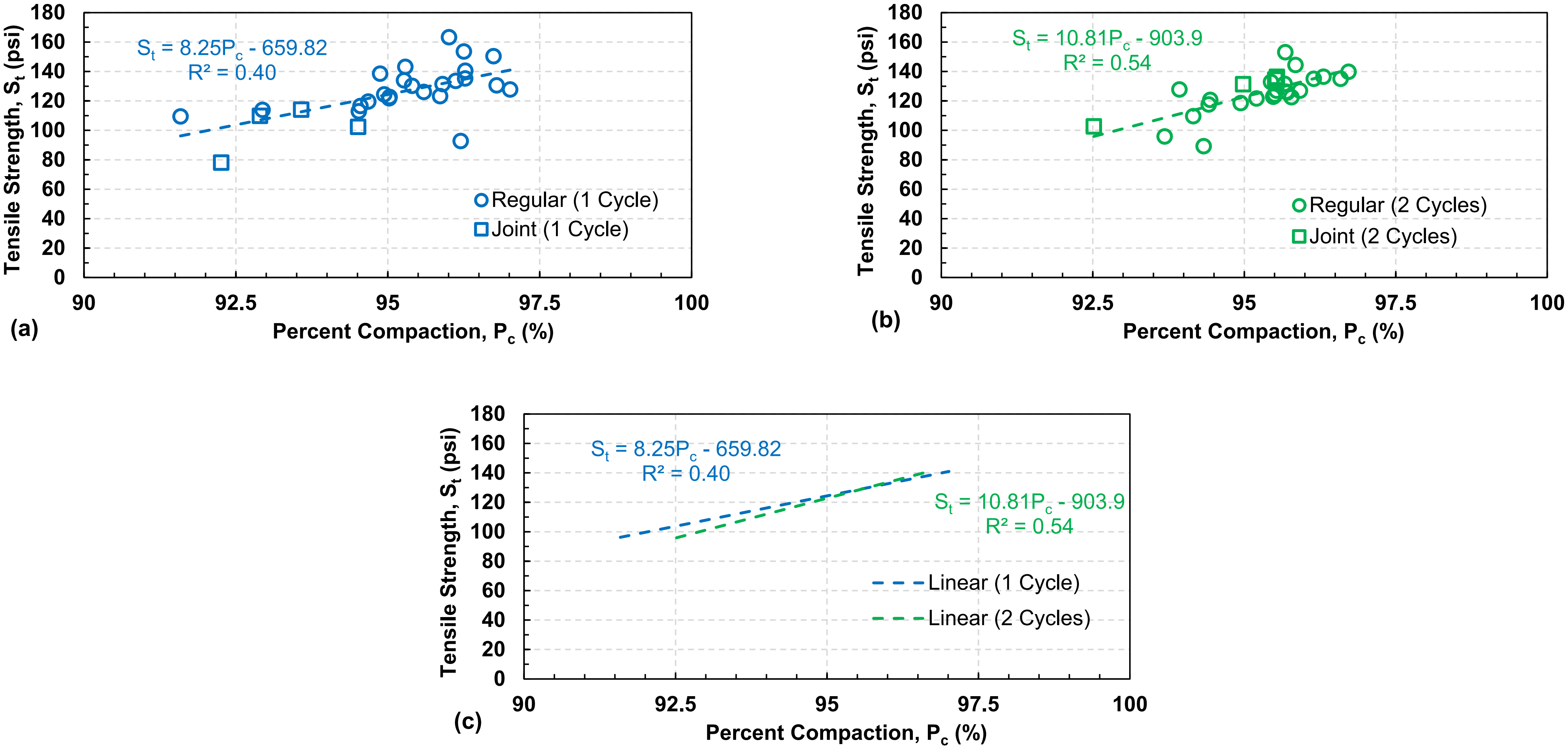
Results – Modified Lottman Test

Effect of Compaction – Richford-Jay Project (1 cycle Vs 2 cycles)



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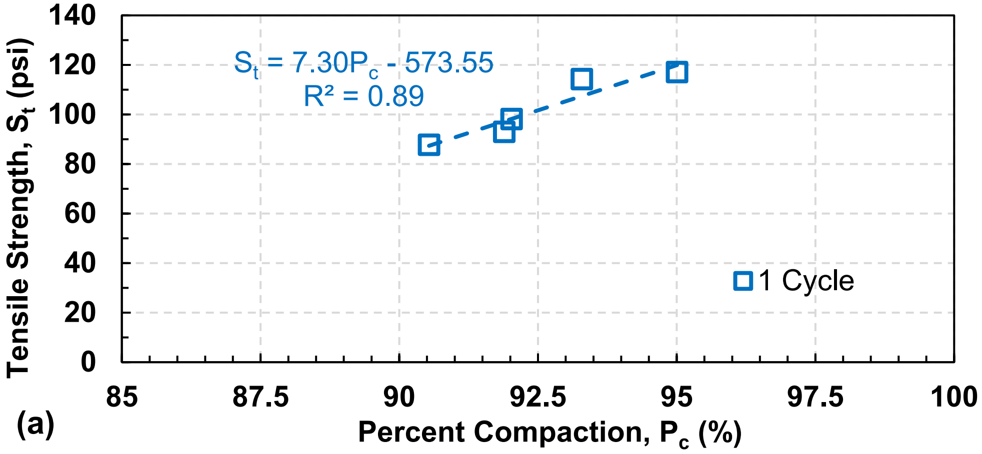
Results – Modified Lottman Test

Effect of Compaction – Cavendish-Weathersfield Project (1 cycle Vs 2 cycles)



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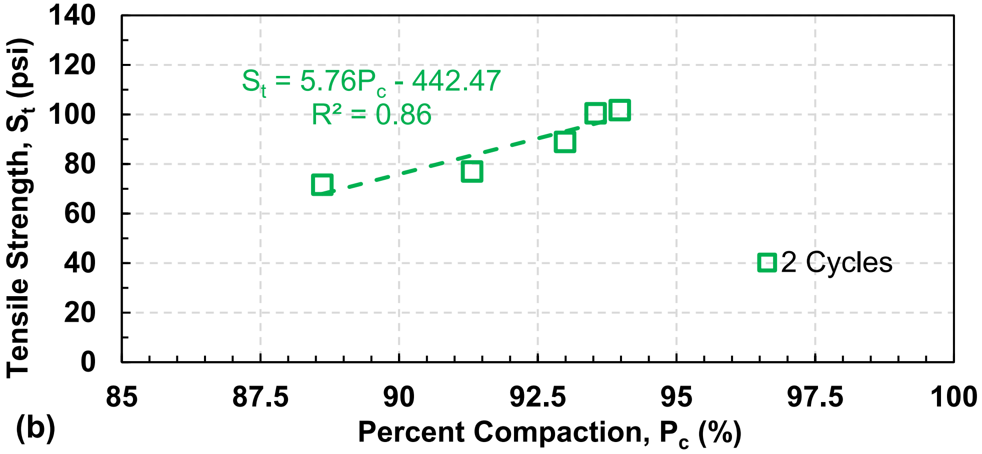

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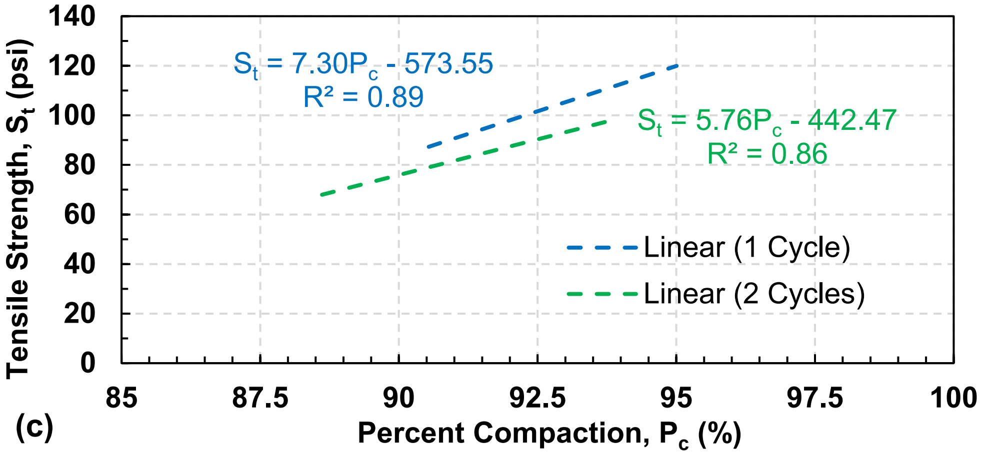

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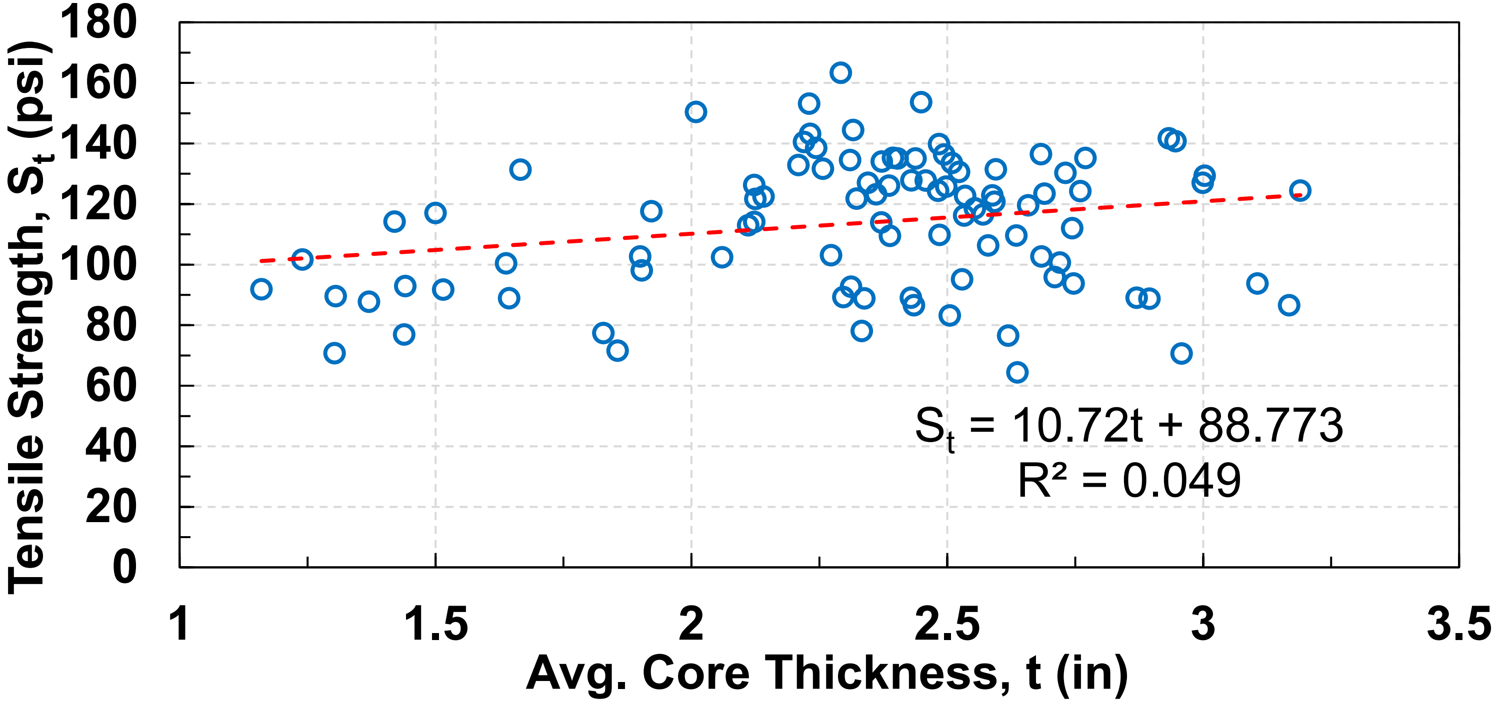
Results – Modified Lottman Test

Effect of Core Thickness



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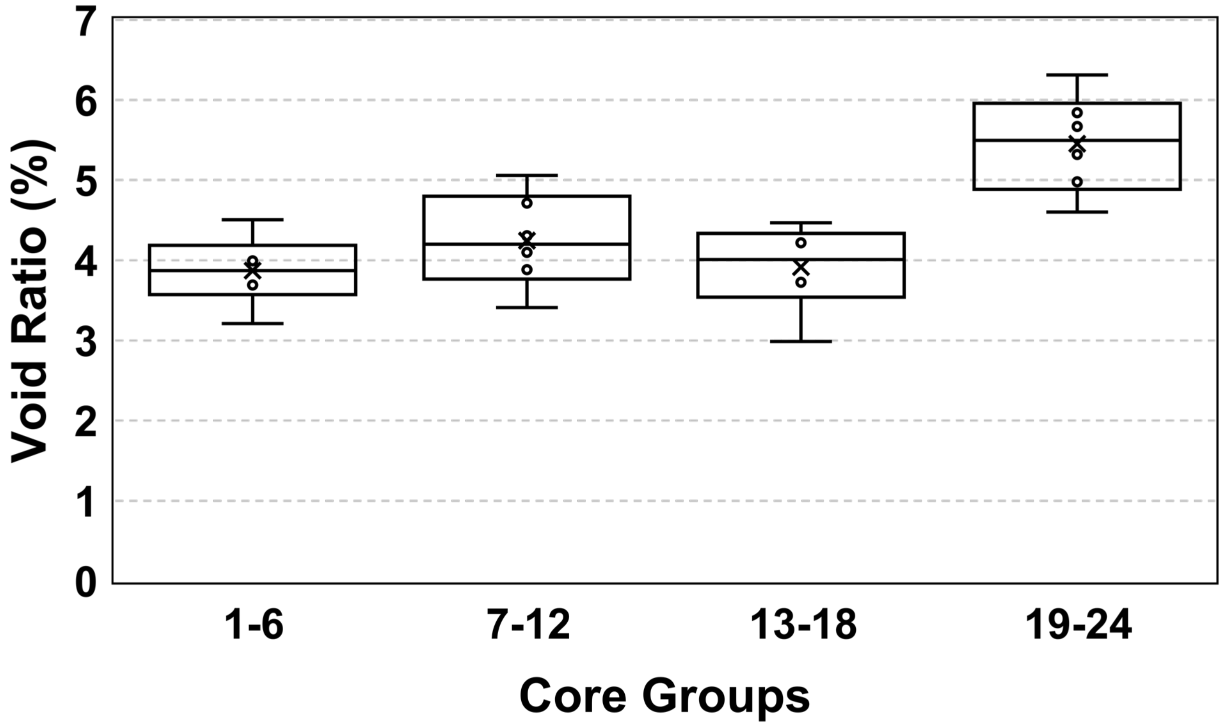
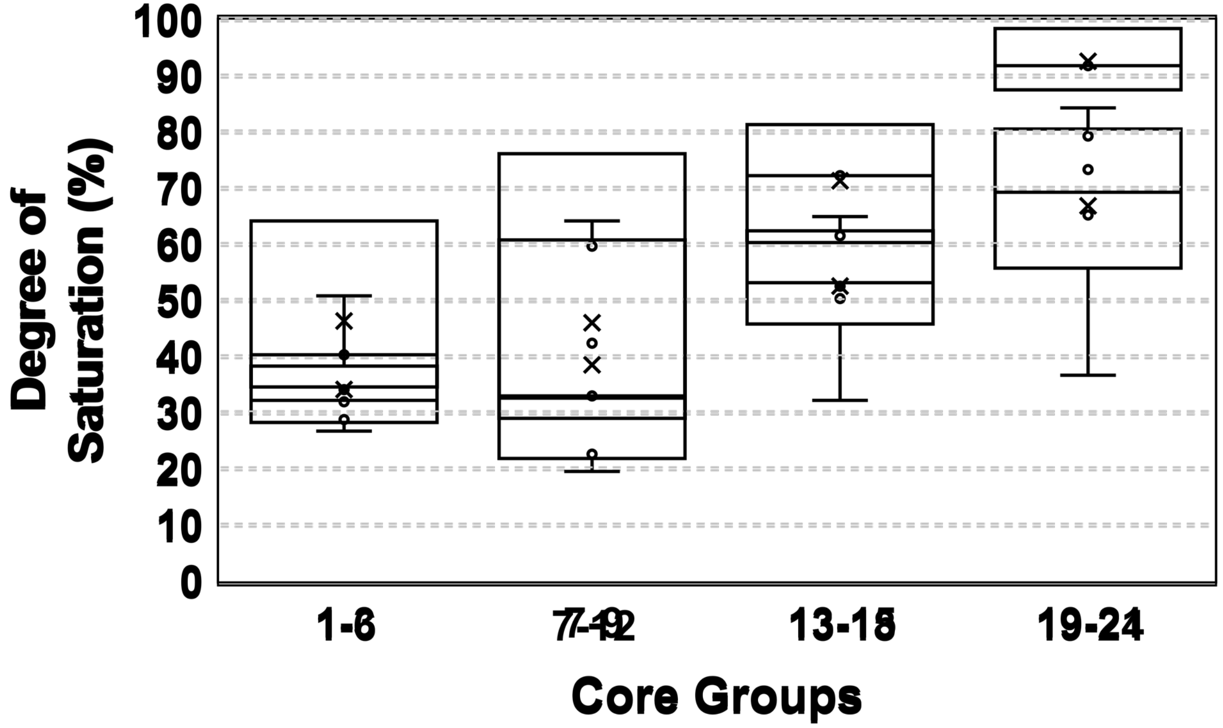
Putman, B. J., and Amirkhanian, S. N. (2006). “Laboratory Evaluation of Anti-Strip Additives in Hot Mix Asphalt.” *South Carolina Department of Transportation*, Report No. FHWA-SC-06-07.

Void Ratio and Degree of Saturation of the samples

Richford-Jay Project





Double Cycle of Wet Conditioning

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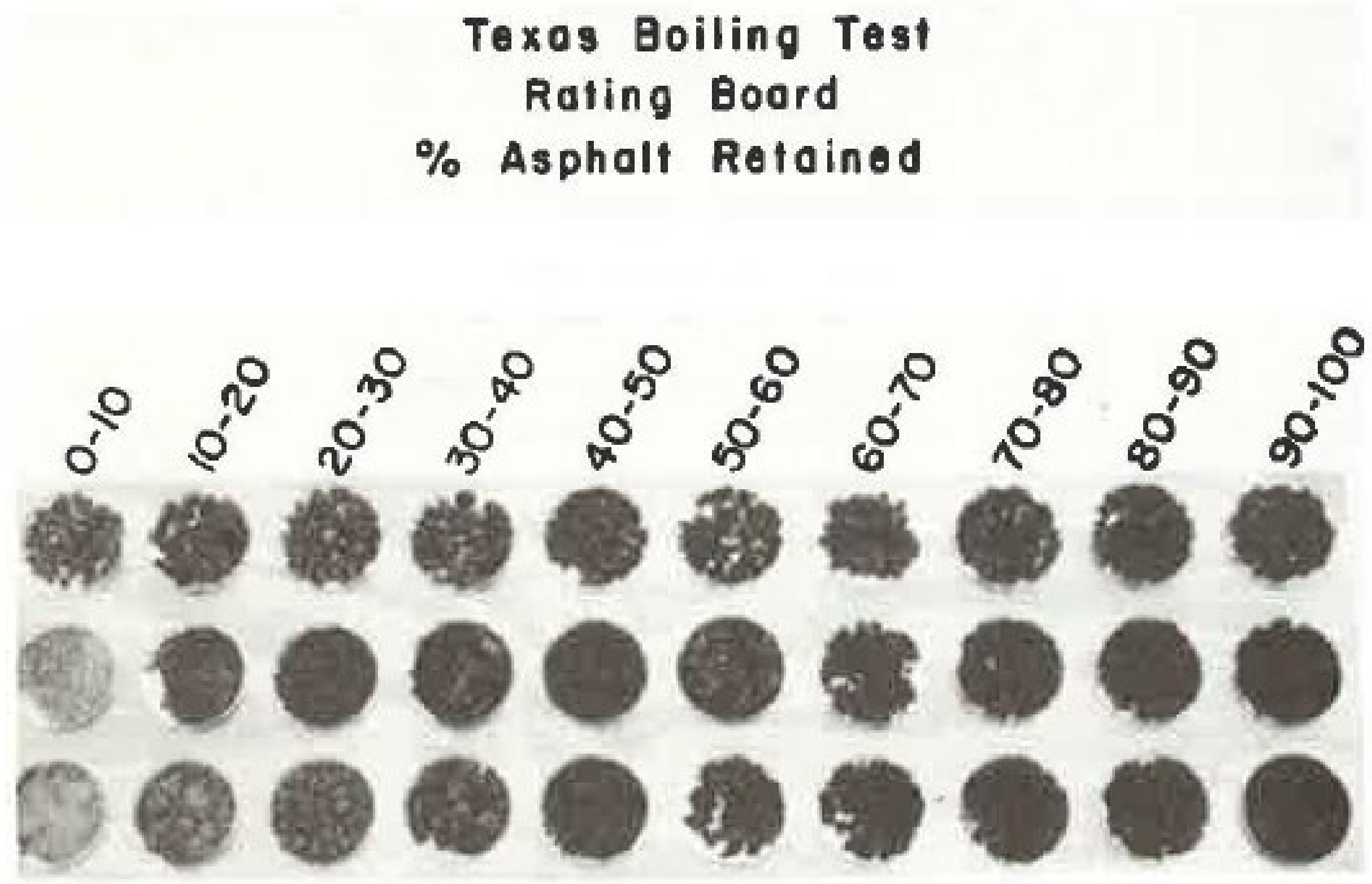
Texas Rating Board



Recommendations

- Due to inaccuracy of MRD-1 and MRD-10 tests, other tests such as boiling water tests), modified Lottman test, Hamburg wheel tracking (AASHTO T 324), MiST etc. are recommended.
- Other quantifying techniques such as image processing, color analyzing methods of pre- and post-boiled samples.
- More testing, especially quantitative tests such as modified Lottman test, Hamburg wheel tracking test, is required to justify the use of 30% RAP in the HMA mixtures.
- More testing under laboratory conditions to determine the minimum number of lottman conditioning is recommended to develop a robust specification for testing moisture susceptibility of the HMA mixtures.
- The joint cores showed lower compaction level and hence lower tensile strength than the regular cores. More compactive effort on joints is recommended.

Schedule of Deliverables

Project Start Date: 7/27/2020 End Date: 6/30/2022

Period	Deliverables	Status
Aug. -Sept. 2020	Deliverable 1 – literature review to identify a quantitative measure to improve the effectiveness of the ASTM D3625 anti-strip test	**Delivered**
Oct.-Dec. 2020	Deliverable 2 – Preliminary report on progress of preparing different mixes	**Delivered**
Jan.-March 2021	Deliverable 3 – Preliminary report on progress of stripping resistance evaluation according to ASTM D3625 testing procedure	**Delivered**
April-June 2021	Deliverable 4 – Preliminary report on stripping risk posed by using RAP and emulsion in the mix design	**Delivered**
July-Sept. 2021	Deliverable 5 – 5.1 –Report on assessment of stripping potential and ASA performance supplied by different HMA producers, evaluation of the ASTM D3625 for use in Vermont, and required updates to current VTrans testing procedure	**Delivered**
Oct.-Dec. 2021	5.2 – Preliminary report on the impact of wet versus extended wet conditioning on peak strength and TSR	**Delivered**
Jan.-March 2022	5.3 – Preliminary report on the trends of variation of tensile strength values with density for cores subjected to wet versus extended wet conditioning	**Delivered**
April-June 2022	Deliverable 6 – Technology Transfer deliverables: draft final report including benefits quantification and implementation guidelines, final poster and fact sheet, final presentation to the TAC, and final report including any TAC comments.	**Delivered**