



ISAET '21

7th International Symposium on Asphalt Emulsion Technology

Full-Depth Reclamation Mix Design

Effect of Sample Size, Conditioning, and Testing Temperature

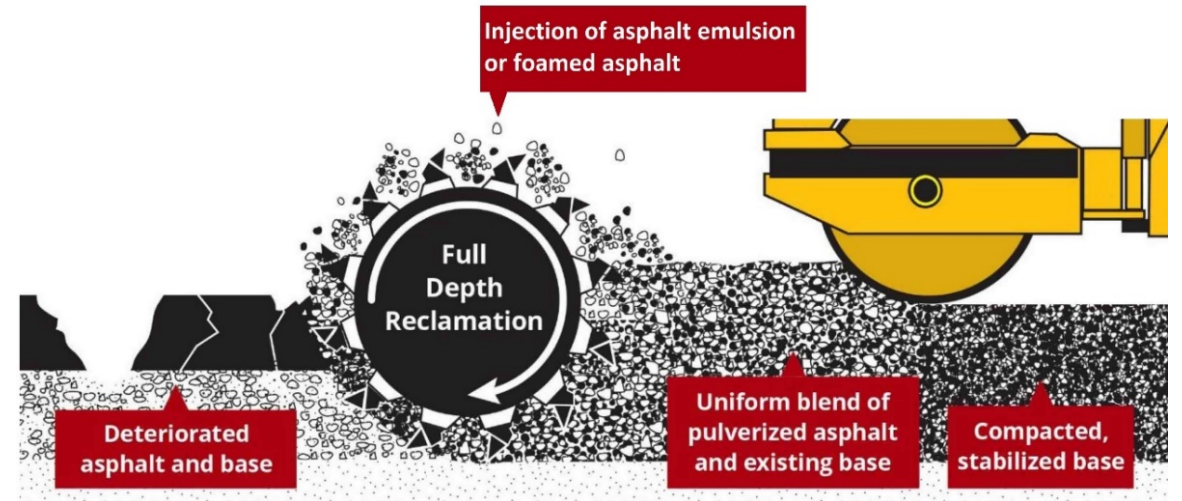
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Introduction - Full Depth Reclamation (FDR)

- Cost-effective
- Maintenance
- Full rehabilitation
- Asphalt bound materials
- Unbound granular materials



Adapted from Asphalt Zipper, Inc., 2013

Introduction - FDR Mix Design



DOTs and Highway Agencies

- Similar procedures for sampling and mixing
 - Different compaction and conditioning procedures
 - Different acceptance criteria
- Tex-122-E (emulsion)
Tex-134-E (foamed asphalt)
 - Superpave Gyrotory Compactor
 - 4 × 2-inch samples
 - 6 × 3.75-inch samples
 - Identical IDT strength acceptance criteria for both sample sizes
 - > 50 psi dry samples
 - > 30 psi conditioned samples

Objectives

1. Differences in IDT strength

- 4-inch vs 6-inch
 - Binder type
 - Binder content
 - Conditioning procedure



2. Propose revised IDT strength acceptance criteria for 6-inch diameter samples.
3. Evaluate the effect of different conditioning and testing temperatures on IDT strength.

Experimental Plan

- Material sources

- Northeast (NE)
- West (W)
- Central (C)



- Binder type and content

- Emulsion — 3.25, 4.0, 4.75%
- Foamed asphalt — 2.0, 2.5, 3.0%

- Conditioning

- Dry
- Soaked
- Vacuum saturated

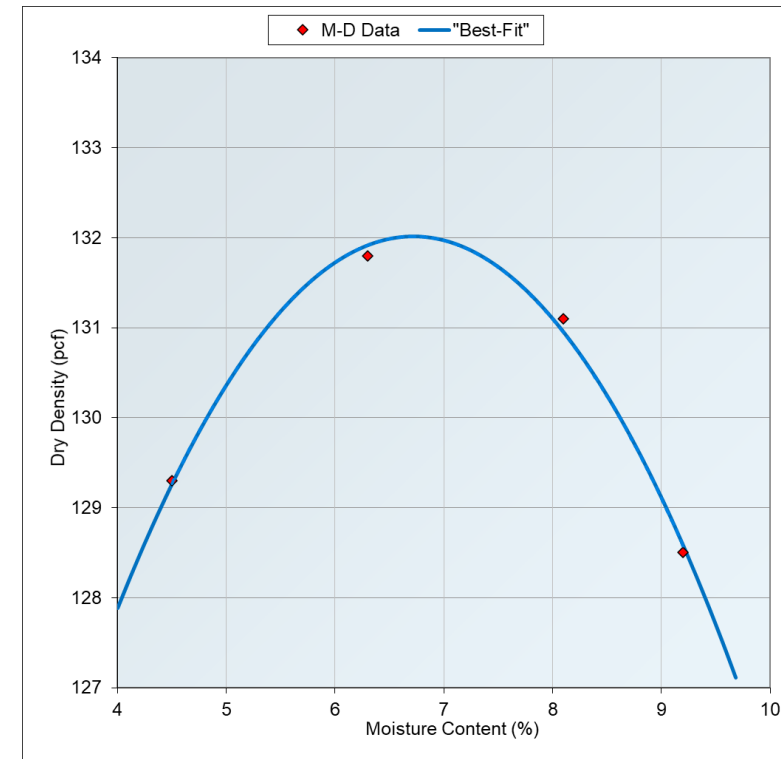
- Sample size

- 4 × 2-inch
- 6 × 3.75-inch



Mix Design and Sample Fabrication

- Optimum Moisture Content
 - Moisture-Density Curve
 - Tex-113-E
 - Foamed asphalt — 100% OMC
 - Emulsion — 70% OMC
- Wirtgen mixer and foaming unit
- 1% cement



Mix Design and Sample Fabrication

Aggregate Gradation

- Min. 20% Passing Sieve #200
- 5-7% Retained on Sieve 7/8”
- 4 × 2-inch samples
 - Remove and replace with 5/8”
- 6 × 3.75-inch samples
 - Remove 7/8” and mix by hand before compaction



Mix Design and Sample Fabrication

Compaction

- Superpave Gyrotory Compactor
- Air Voids per ASTM D 2041



Emulsion	4 × 2-inch samples	6 × 3.75-inch samples
# Gyration	50	55
Air voids%	12.0 - 13.9	12.3 - 14.3

Foamed Asphalt	4 × 2-inch samples	6 × 3.75-inch samples
# Gyration	≈ 60	≈ 70
Air voids%	7.5 - 8.9	7.7 - 8.5

Conditioning and Testing

Curing at 104°F for 72 hrs.

A. Dry

- Store at 77°F for 24 hrs.

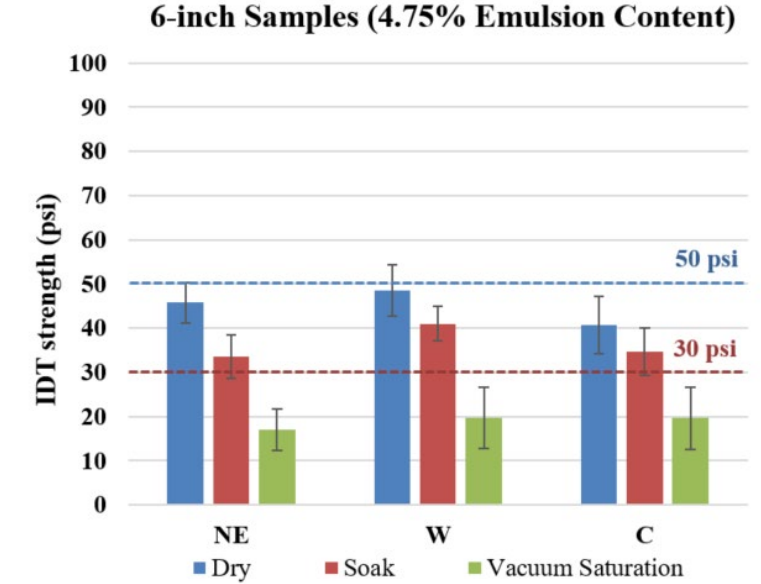
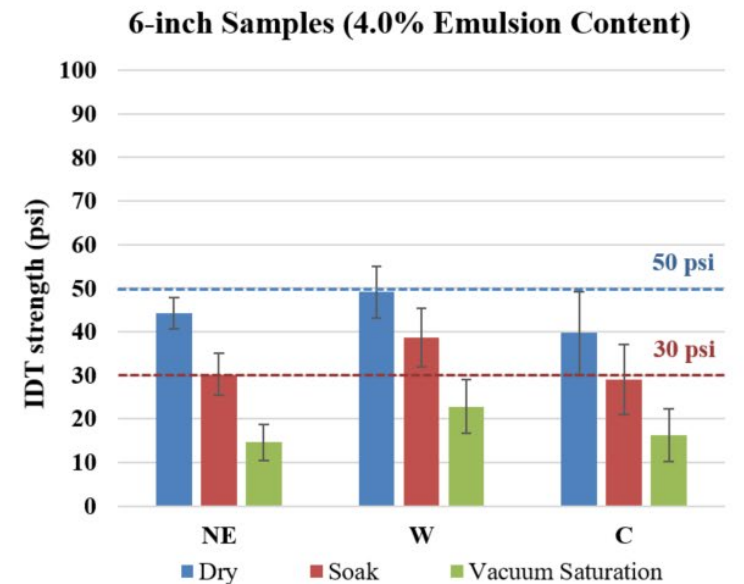
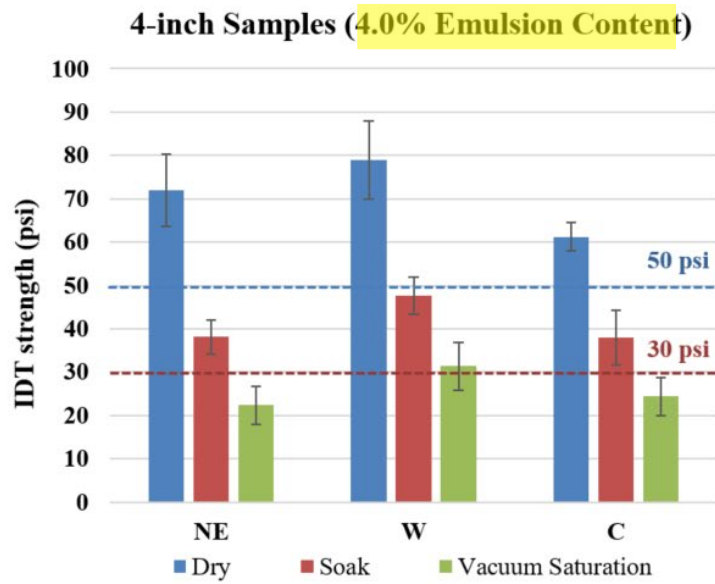
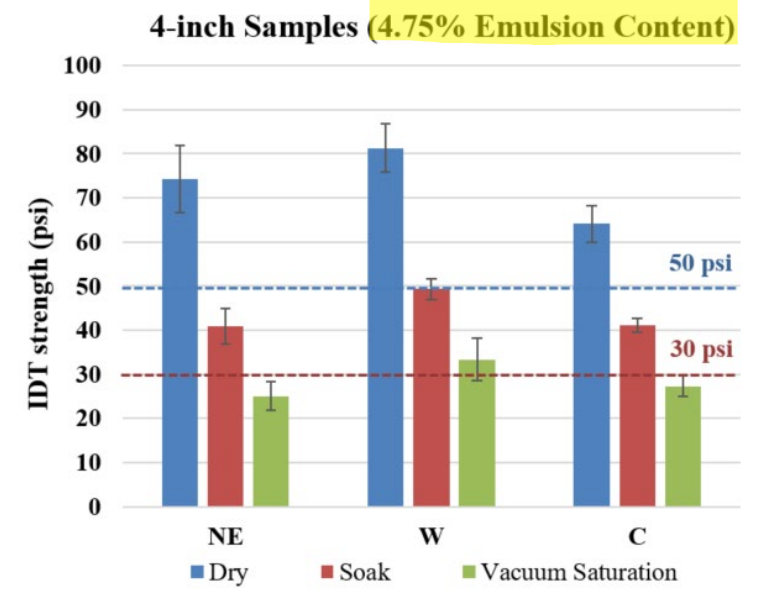
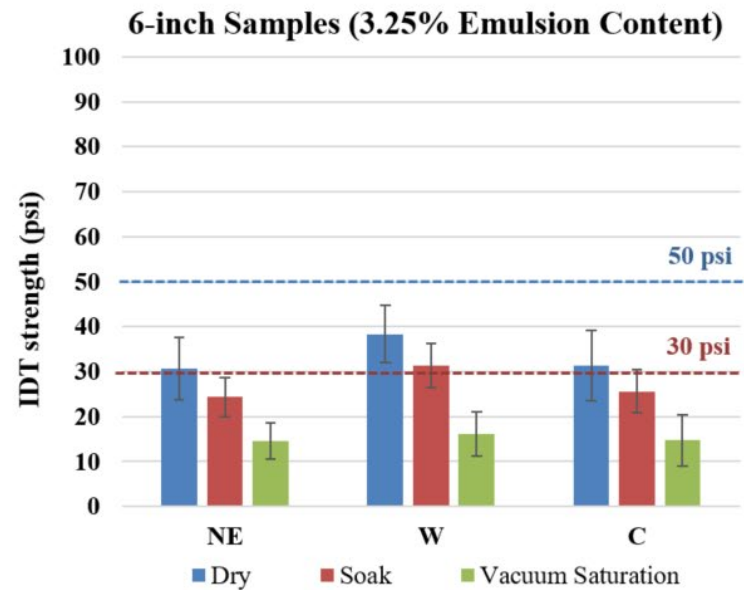
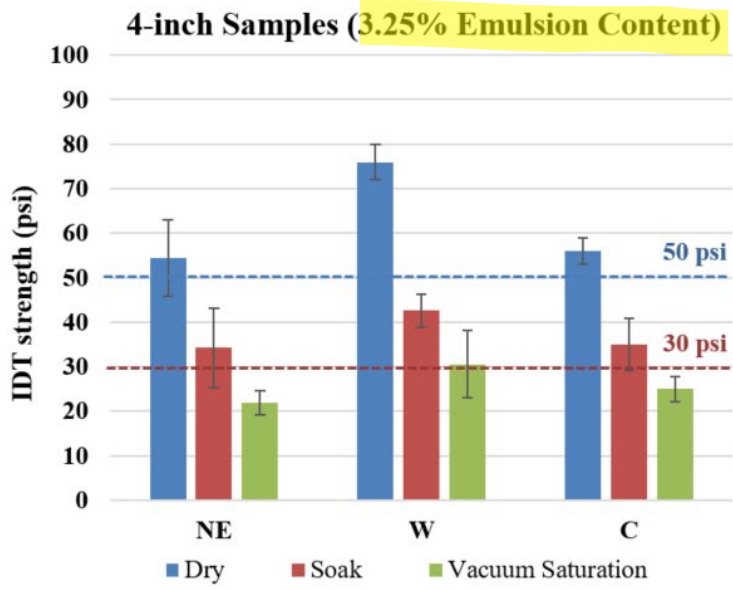
B. Soaked

- Soak in water at 77°F for 24 hrs.

C. Vacuum Saturation

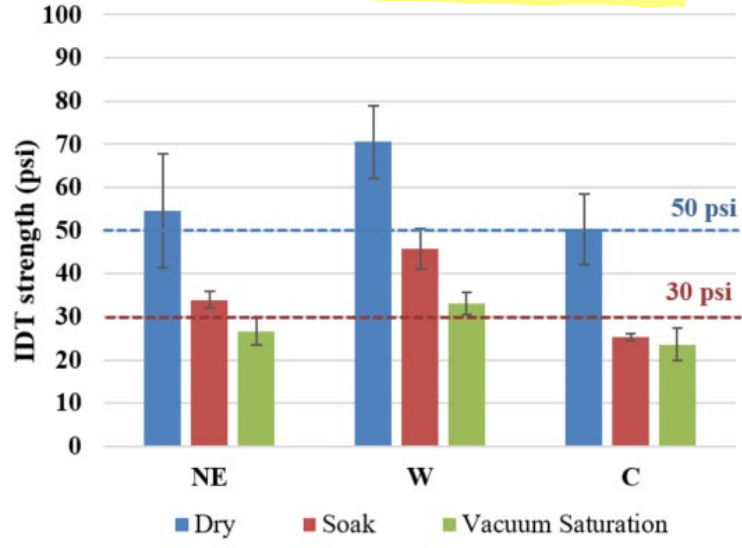
- 55-75% Saturation
- Soak in water at 140°F for 24 hrs.
- Soak in water at 77°F for 1 hr.



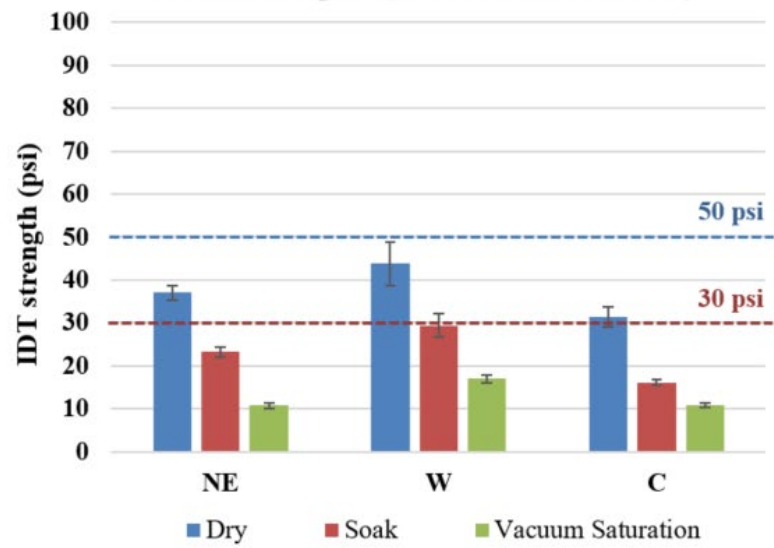


IDT Strength Test Results – Emulsion

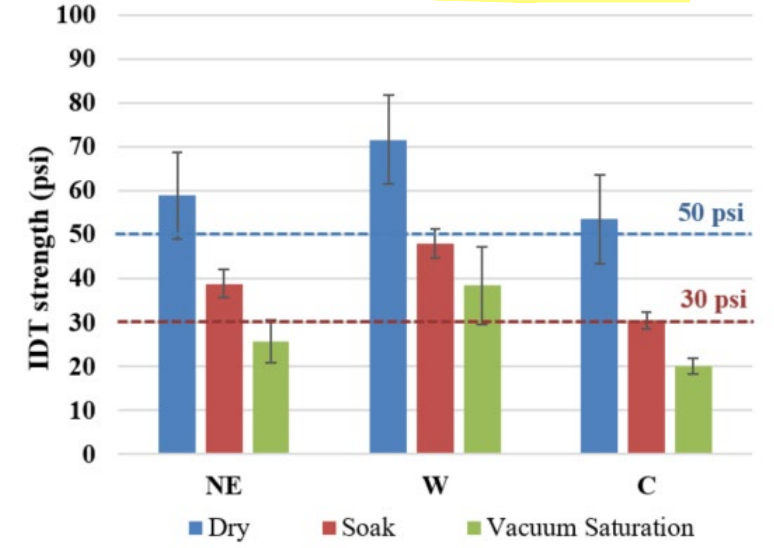
4-inch Samples (2.0% Foam Content)



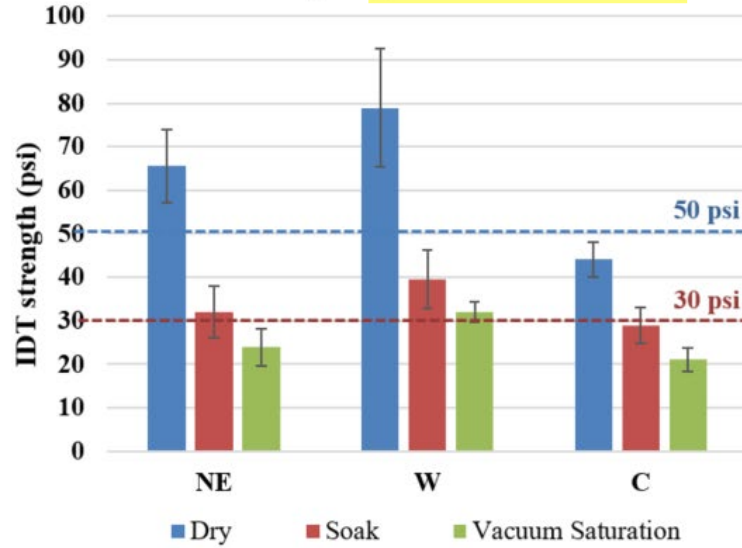
6-inch Samples (2.0% Foam Content)



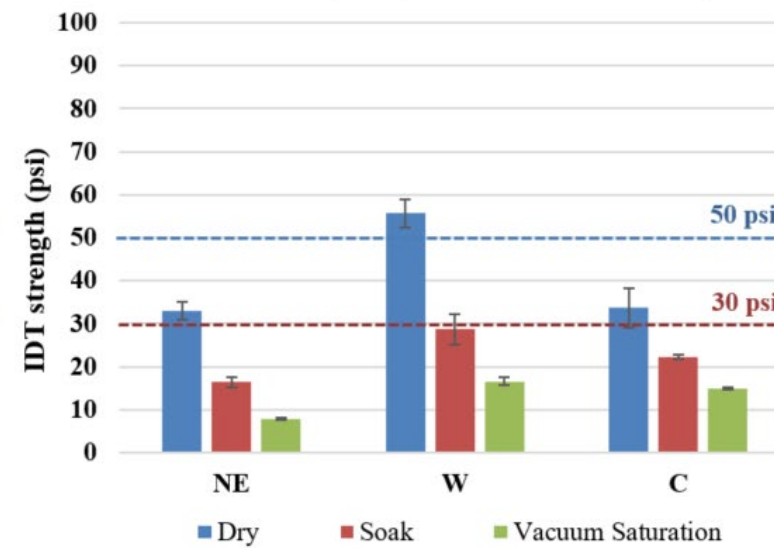
4-inch Samples (3.0% Foam Content)



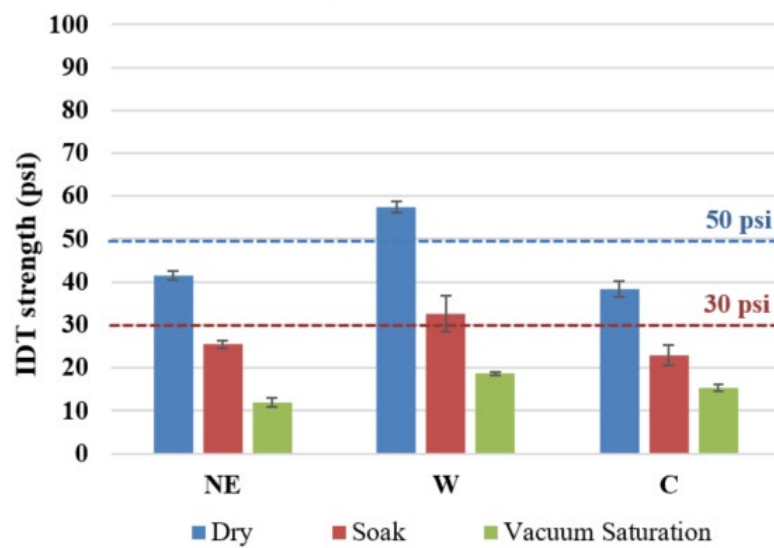
4-inch Samples (2.5% Foam Content)



6-inch Samples (2.5% Foam Content)



6-inch Samples (3.0% Foam Content)



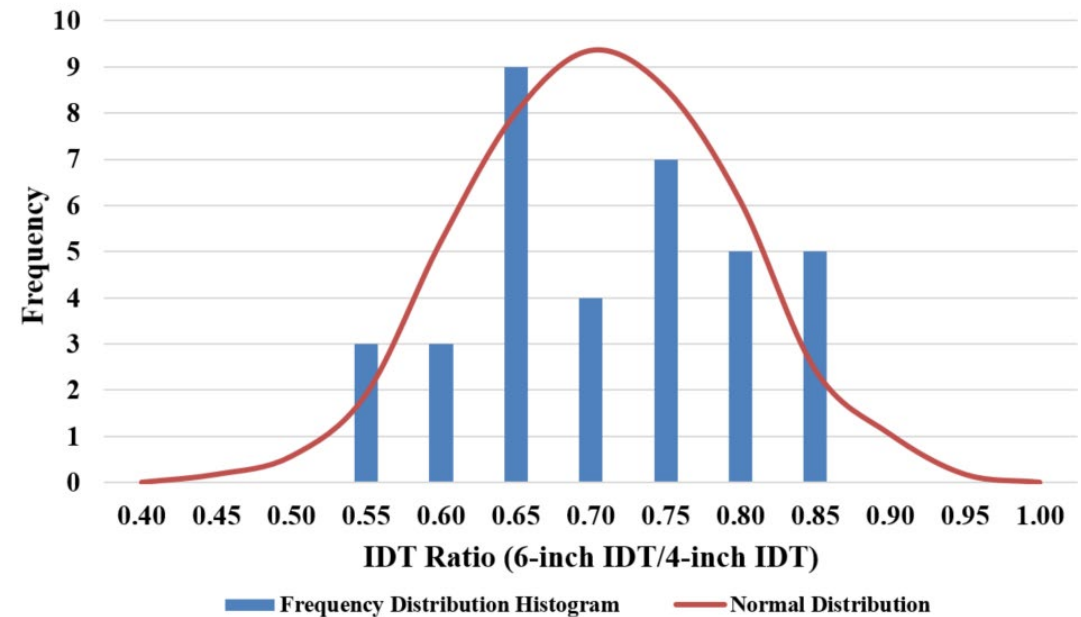
IDT Strength Test Results – Foamed Asphalt

Threshold Adjustment - Method A

IDT Strength Ratio 6-inch/4-inch

Current 4-inch Criteria Dry (Soaked)	Revised 6-inch Criteria Dry (Soaked)
50 (30) psi	34 (20) psi

*Average IDT Strength ratio = **0.68***



Threshold Adjustment - Method B

Receiver Operating Characteristic (ROC)

● **Green markers** —4-inch samples met the min. dry & soaked IDT requirement

● **Red markers** —4-inch samples didn't meet the min. dry & soaked IDT requirement

True Positive: lab results < thresholds & not meeting thresholds (50 psi and 30 psi);

False Positive: lab results < thresholds & meeting thresholds (50 psi and 30 psi);

True Negative: lab results > thresholds & meeting thresholds (50 psi and 30 psi);

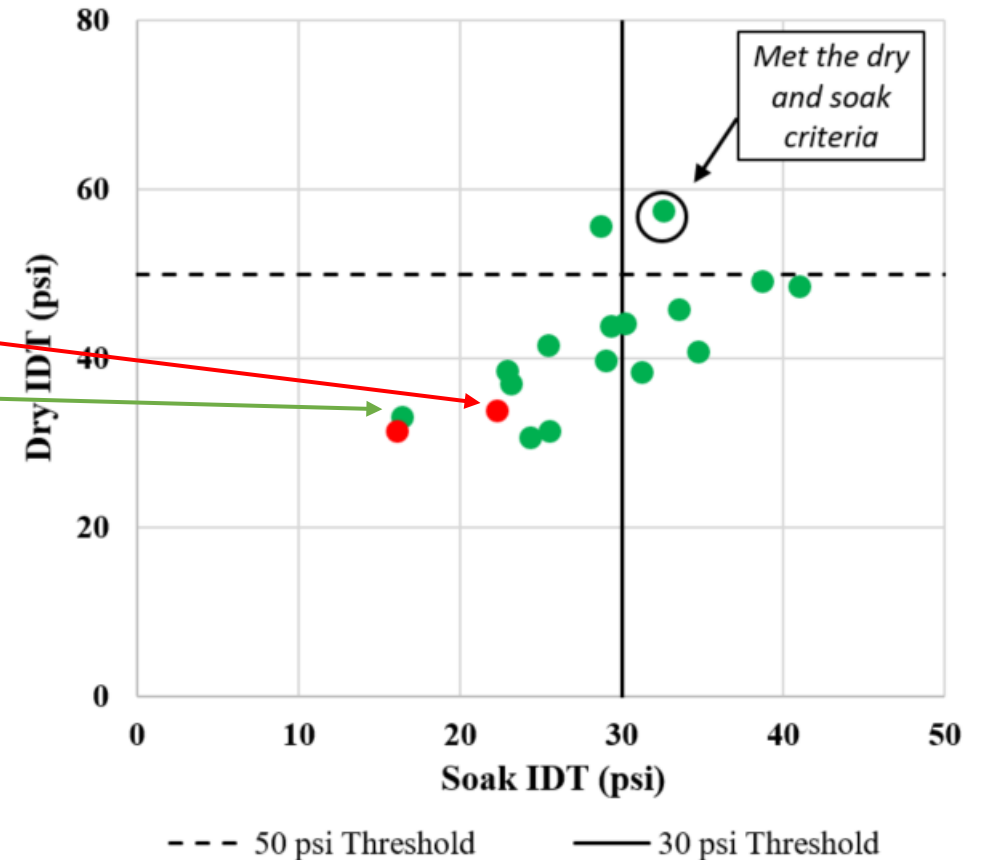
False Negative: lab results > thresholds & not meeting thresholds (50 psi and 30 psi)

True Positive Rate (TPR) = True Positive / (True Positive + False Negative);

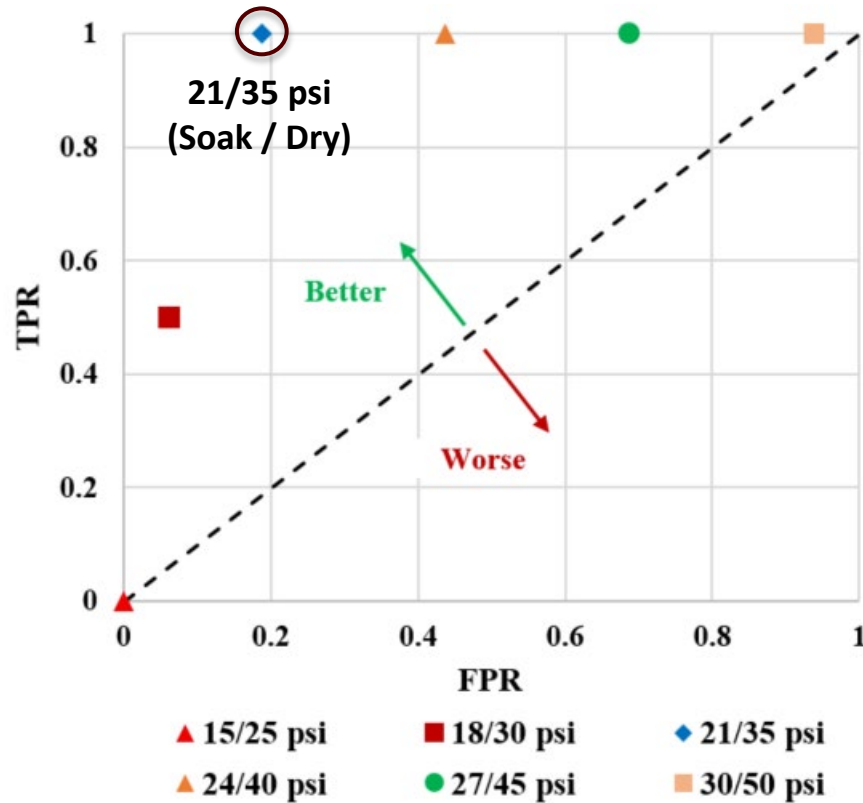
False Positive Rate (FPR) = False Positive / (False Positive + True Negative);

Accuracy = (True Positive + True Negative) / Total Population.

6-inch sample results

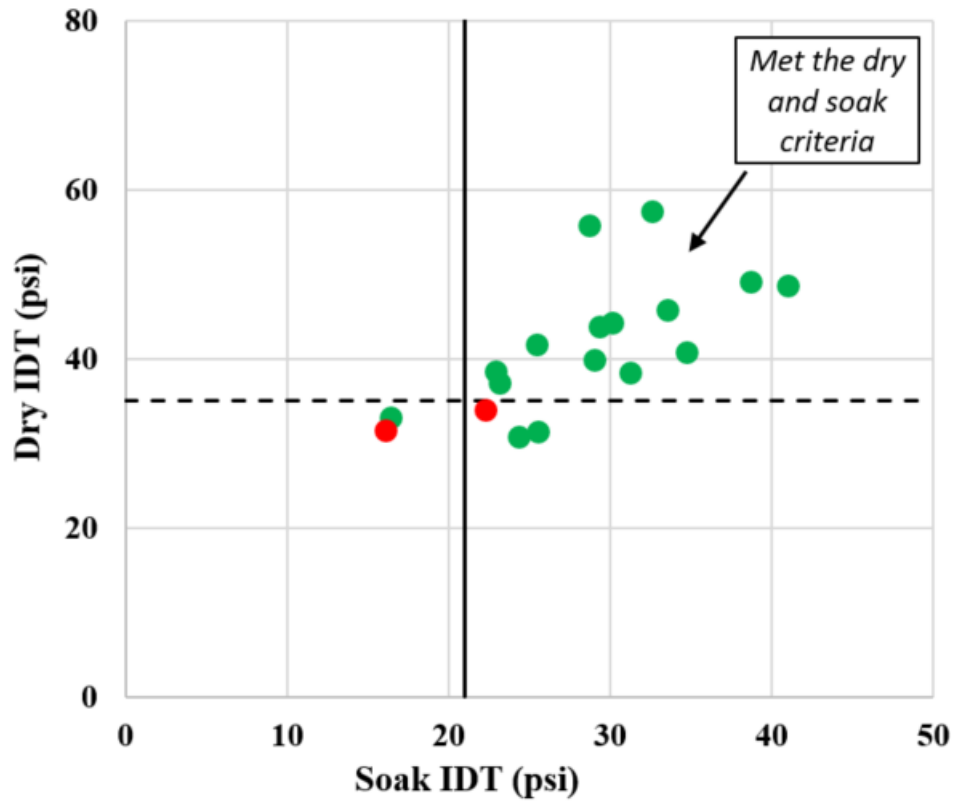


Threshold Adjustment - Method B



ROC Parameter	Soaked/Dry IDT Thresholds					
	15/25 psi	18/30 psi	21/35 psi	24/40 psi	27/45 psi	30/50 psi
True Positive	0	1	2	2	2	2
False Negative	2	1	0	0	0	0
False Positive	0	1	3	7	11	15
True Negative	16	15	13	9	5	1
Total	18	18	18	18	18	18
TPR	0	0.5	1	1	1	1
FPR	0.00	0.06	0.19	0.44	0.69	0.94
Accuracy	0.89	0.89	0.83	0.61	0.39	0.17

Threshold Adjustment - Method B



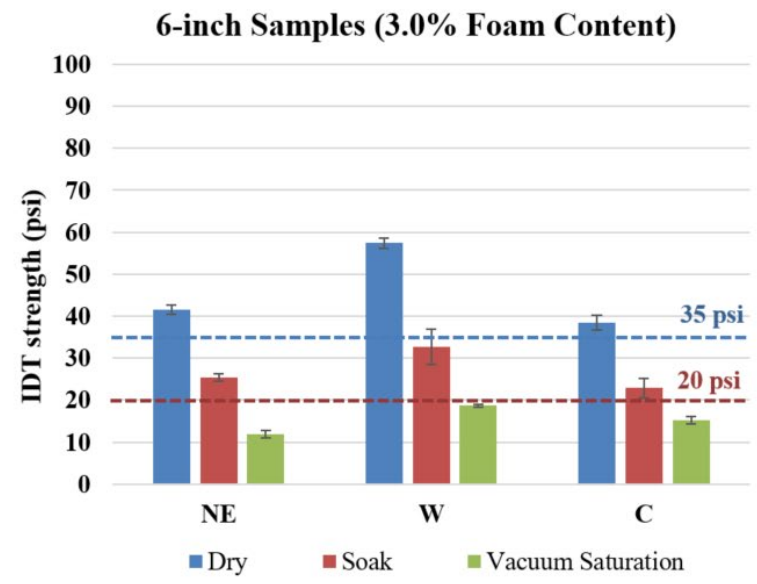
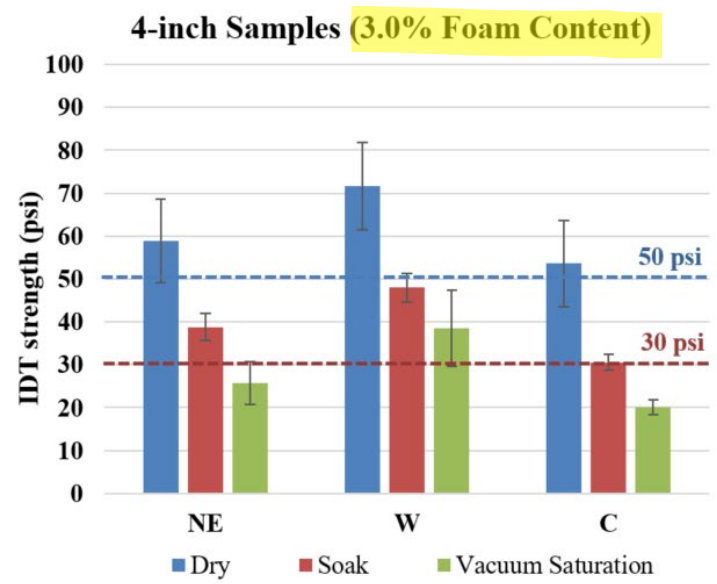
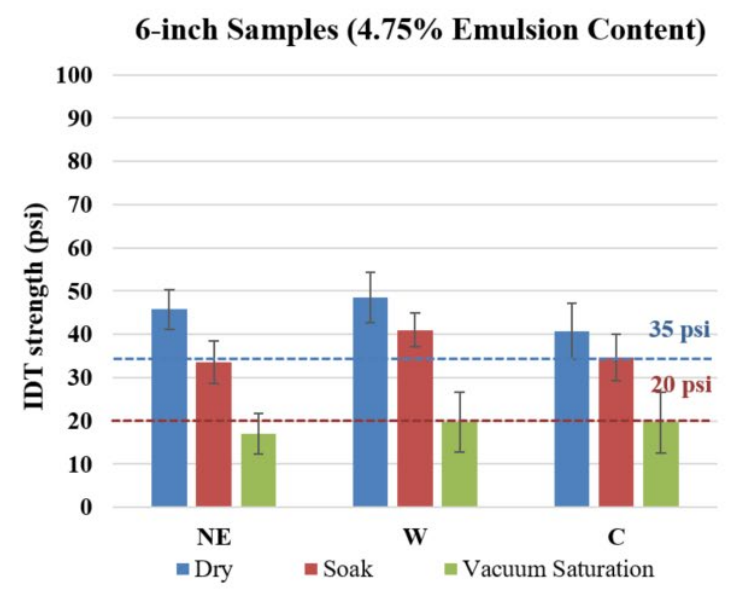
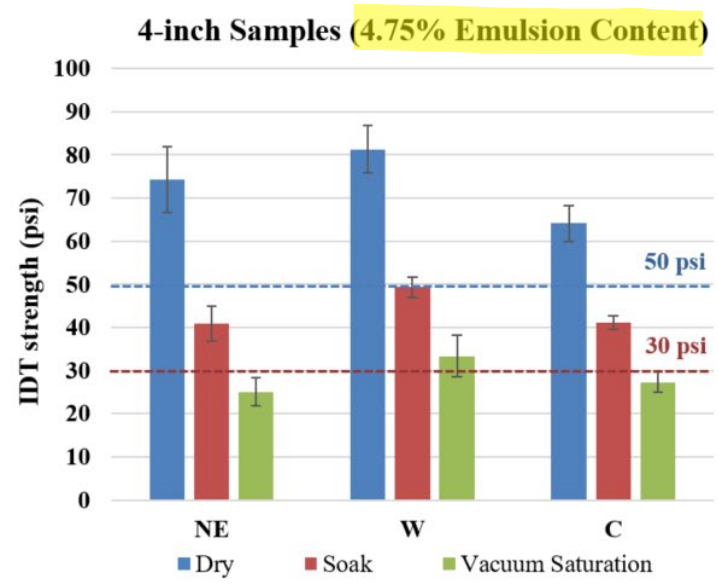
--- 35 psi "Revised" Threshold — 21 psi "Revised" Threshold

Method B : ROC

Current 4-inch Criteria Dry (Soaked)	Revised 6-inch Criteria Dry (Soaked)
50 (30) psi	35 (21) psi

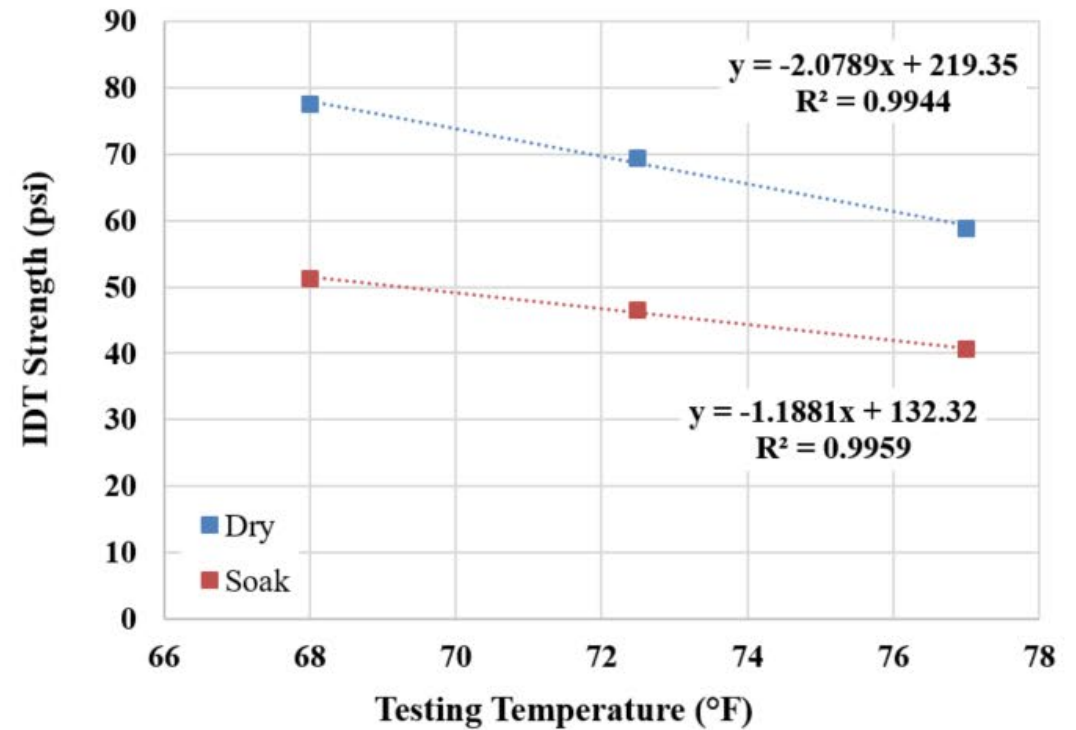
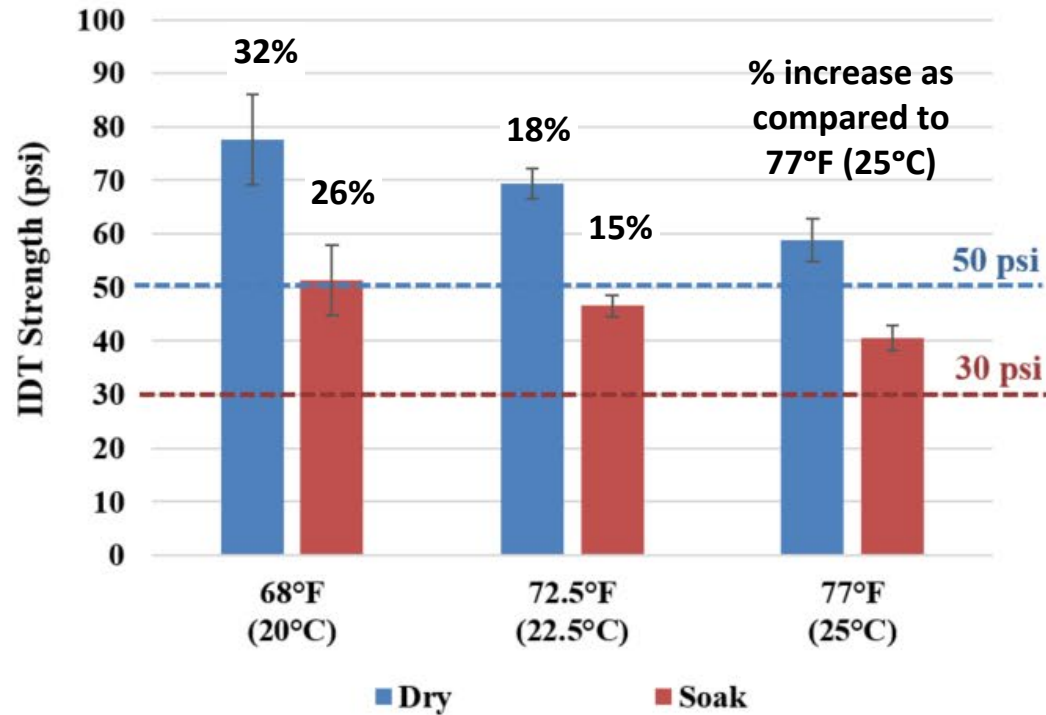
Method A: IDT Strength Ratio

Current 4-inch Criteria Dry (Soaked)	Revised 6-inch Criteria Dry (Soaked)
50 (30) psi	34 (20) psi



Threshold Adjustment

IDT Strength Test Temperature



Conclusions

- Current TxDOT IDT strength thresholds for 4 × 2-inch samples
 - Validated via multiple FDR projects
 - Minimum dry = **50 psi**
 - Minimum soaked = **30 psi**
- IDT strengths were lower for 6 × 3.75-inch samples
 - Proposed revised IDT strength thresholds
 - Minimum dry = **35 psi**
 - Minimum soaked = **20 psi**
- IDT Strength test temperature must be specified





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