EVALUATION OF TEST METHOD TEX-531-C, "PREDICTION OF MOISTURE-INDUCED DAMAGE TO BITUMINOUS PAVING MATERIALS USING MOLDED SPECIMENS"

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This in-house research study was performed with the help of the Atlanta, Austin, Corpus Christi, Tyler, Wichita Falls, and Yoakum District Laboratories and the MAT Bituminous field laboratories.

16. Abstract

This in-house research project evaluated Test Method Tex-531-C. The objectives of the study were:

1. Evaluate effects of degree of saturation on tensile strength ratio (TSR).
2. Evaluate effects of lime and liquid antistripping agents on TSR.
3. Evaluate effects of water pH on TSR.

Results of this study do not support any changes to the current Test Method Tex-531-C.

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RESEARCH REPORT DHT-38

by

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Texas Department of Transportation

April 1996

INTRODUCTION

In 1995, the Bituminous Section of Materials and Tests Division of TxDOT, in cooperation with the Corpus Christi, Yoakum, Tyler, Wichita Falls, Atlanta, Pharr, and Austin District Laboratories, conducted an in-house research project to evaluate Tex-531-C. The objectives of the study were:

1. Evaluate effects of degree of saturation on tensile strength ratio (TSR).
2. Evaluate effects of lime and liquid antistripping agents on TSR.
3. Evaluate effects of water pH on TSR.

EXPERIMENT DESIGN

Each district laboratory that participated in the study selected one HMAC mixture routinely used in that district. Each laboratory compacted 84 specimens using its selected mix and sent the specimens to the Bituminous Laboratory for further testing. The experiment design is presented in Table 1.

The districts selected the liquid antistripping additive for their mixtures; therefore, the same liquid additive was not used in all cases. The mixtures used by Pharr, Tyler, Corpus Christi, and Atlanta were made with siliceous gravel, while Yoakum, Austin, and Wichita Falls used limestone mixtures. The summary of material types used by each district is shown in Table 2.

TESTING PROGRAM

The primary objective of this study was to determine the effects of the degree of saturation on TSR. For each mixture type, the Bituminous Section used the procedure in Tex-531-C to vacuum saturate the specimens at 60, 70, 80, 90, and 100 percent saturation level. In addition, we vacuum saturated one set for 30 minutes at 28 inches Hg vacuum level. This set in theory would have 100 percent saturation level but is exposed to the vacuum saturation process for an extended period of time. One set was tested dry for reference purposes. After vacuum saturating the molded specimens, the specimens were put in the freezer for 15 hours, then removed from the freezer and thawed in 140°F (60°C) water bath for 24 hours. The specimens were conditioned to test temperature of 77°F (25°C) prior to testing to measure indirect tensile strength.

In a limited study involving two mixtures, we evaluated the effects of changing pH content of water on TSR.

DISCUSSION OF RESULTS

Test results for individual districts are presented in Tables 3 through 9. In each table, the tensile strength values as well as the tensile strength ratios for each saturation level are presented. As shown in the tables, the actual saturation level for the individual specimens was not exactly the same as the target saturation level. This difference is due to the difficulty in attaining a given target saturation level. All actual saturation levels are well within acceptable tolerances of the target saturation levels. In some tables, the tensile strength values are missing for some of the cells. Either the missing cells are from specimens which were damaged during the testing, or the test results were statistically considered to be outliers. The last column in each table contains TSR at various saturation levels.

Tensile strength ratios are plotted versus degree of saturation for each district in Figures 1 through 7.

Data from Atlanta mix is shown in Figure 1. Atlanta District mixture was a Type C siliceous mix. As shown in this figure, TSR values generally decreased with increasing saturation level for untreated and liquid additives. Mixtures treated with lime showed a trend of increasing TSR with increase in saturation level. Both lime and liquid improved TSR for all saturation levels.

Austin District results are shown in Figure 2. The Austin District did not provide mixes with liquid additives, since the district does not use any antistripping additives in its HMAC. In untreated mix, TSR decreased as degree of saturation increased. Lime-treated mixes appear to be unaffected by increases in saturation level.

Data from Corpus Christi is shown in Figure 3. None of the mixtures appear to be significantly affected by saturation level. There is a significant difference between TSR values among untreated, liquid, and lime mixtures. Lime treatment produced the best TSR results.

Tyler data is shown in Figure 4. There is no significant change in TSR with varying saturation level up to 90 percent. At saturation levels of 100 percent or more, some of the test results appear erratic.

Data from Pharr District mixtures is shown in Figure 5. There is no consistent trend in the relationship between TSR and degree of saturation. The untreated Pharr mix showed very low TSR values at all saturation levels.

Both liquid and lime improved this mixture. However, the most improvement resulted from lime.

Wichita Falls data is shown in Figure 6. There is a general tendency for TSR to drop as degree of saturation increases. Both additives improved TSR, with the largest improvement resulting from lime addition.

Data from Yoakum District mix is shown in Figure 7. Untreated mixture shows a general tendency for TSR to drop with increasing saturation level. The liquid- and lime-modified mixes show a general tendency for increase in TSR as degree of saturation increases. Both additives improved TSR values, and the largest increase resulted from addition of lime.

Figure 8 shows the relationship between TSR and saturation level for all unmodified mixtures. Although a unified trend does not exist, there is a general trend of decreasing TSR value as the saturation level increases.

Figures 9 and 10 show the relationship between TSR and saturation level for liquid and lime mixtures, respectively. There is no discernable trend between saturation level and TSR for these mixtures.

EFFECTS OF pH CONTENT

In a limited experiment involving two mixtures, we attempted to evaluate effects of changing the pH content of water on TSR. The Atlanta mix and a limestone mix from Central Texas were evaluated. We changed the pH content of the water that is used in the vacuum saturation, measurement of saturation level, and the conditioning of the specimen in 77°F water bath. Four pH levels of 4, 7, 10, and 13 were used in this study. Results are shown in Tables 10 and 11 for the Atlanta and Central Texas mixtures, respectively. Relationship between TSR and pH content is shown in Table 10 and Figure 11. As shown in this figure, there is no appreciable change in TSR for pH values of 4, 7, and 10. However, at pH of 13 both mixtures stripped severely and fell apart in 140°F water bath. The Central Texas mix is not known to be stripping prone, while the Atlanta mix is known to be stripping prone. Both mixtures failed at pH of 13. Therefore, pH value of 13 is unreasonably high for this test.

CONCLUSIONS

1. There is no uniform trend between saturation level and TSR values. Different mixtures show different trends. In addition, a definite grouping of the data based on aggregate type (i.e., gravel versus limestone) cannot be made. However, both Pharr and Corpus Christi mixes that contain South Texas gravel showed the lowest TSRs.
2. For most mixture types, addition of liquid or lime as antistripping additive improved TSR values. Lime was more effective than liquid additives in increasing TSR. However, both Pharr and Corpus Christi mixes, which contained South Texas gravel, showed the lowest TSRs.

RECOMMENDATIONS

Results of this study do not support any changes to the current Test Method Tex-531-C.

TABLE 1: Experiment design for a single material.

Antistripping Agent	Target Saturation Level (%)	Number of Specimens
None	0	4
	60	4
	70	4
	80	4
	90	4
	100	4
	30 minute vacuum	4
Selected Liquid	0	4
	60	4
	70	4
	80	4
	90	4
	100	4
	30 minute vacuum	4
Lime	0	4
	60	4
	70	4
	80	4
	90	4
	100	4
	30 minute vacuum	4

4 specimens x 7 saturation levels x 3 additives = 84 specimens per district

TABLE 2: Summary of material types.

District	Mix Type	Aggregate Type	Liquid Additive	% Lime
Atlanta	C	Gravel	1% Perma-Tac 99	1.5
Austin	C	Limestone	None	1.0
Corpus Christi	D	Gravel	Pavebond Lite	1.0
Tyler	C	Gravel	0.5% Unichem 8161	1.0
Pharr	D	Gravel	Perma-Tac +	1.0
Wichita Falls	D	Limestone	Perma-Tac +	1.0
Yoakum	C	Limestone	0.5% Unichem 8162	1.0

TABLE 3: Atlanta District test data, 531-C research.

No Additives

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		138.8	119.4	138.2	126.4	130.7	
60%	61.3	61.6	62.1	58.5	60.9	103.8	111.6	129.3	118.5	115.8	**0.89**
70%	69.2	72.3	72.3	70.8	71.2	92.9		92.8	100.3	95.3	**0.73**
80%	79.1	82.1	81.5	82.1	81.2	69.5	80.7	101.0		83.7	**0.64**
90%	89.2	89.4	91.3	92.5	90.6	71.2		63.5	87.1	73.9	**0.57**
100%	98.6	97.3	97.0	97.2	97.5	73.6	67.8	69.7	69.9	70.3	**0.54**
30 Minutes	100.0	98.5	100.0	98.5	99.3	80.4	79.7	73.1	77.0	77.6	**0.59**
Dry Boil:	5-7%										

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Liquid Antistrip

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		116.7	112.3		127.0	118.7	
60%	60.9	60.0	62.9	61.5	61.3	123.2	133.8	145.5	136.5	134.8	**1.14**
70%	71.2	70.8	71.2	70.6	71.0	146.1	129.1		109.7	128.3	**1.08**
80%	81.5	82.1	81.3	81.2	81.5	104.5	108.1	112.3	115.9	110.2	**0.93**
90%	89.9	93.2	90.1	87.8	90.3	106.8	102.8		106.7	105.4	**0.89**
100%	97.3	97.2	98.6	98.7	98.0	114.4	112.9	112.5	123.2	115.8	**0.98**
30 Minutes	94.4	95.9	91.7	93.1	93.8	129.4	126.7	118.6	134.3	127.3	**1.07**
Dry Boil:	0-3%										

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Lime Slurry

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		104.1	105.8	104.9	100.0	103.7	
60%	63.5	61.2	61.6	61.3	61.9	89.5	96.5	82.8	98.1	91.7	**0.88**
70%	71.0	70.1	71.8	69.9	70.7	97.2		92.8	96.2	95.4	**0.92**
80%	81.8	82.4	81.7	81.4	81.8	114.1	105.7		104.3	108.0	**1.04**
90%	91.0	91.8	91.7	90.7	91.3	101.9	107.6		105.0	104.8	**1.01**
100%	100.0	98.5	98.5	100.0	99.3	109.9		101.6	103.4	105.0	**1.01**
30 Minutes	90.0	94.0	90.8	87.7	90.6	98.2	104.9		109.0	104.0	**1.00**
Dry Boil:	0-3%										

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

TABLE 4: Corpus Christi District test data, 531-C research.

No Additives

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		127.9	127.3	112.5	117.5	121.3	
60%	61.4	60.7	61.9	59.7	60.9	50.8	48.5	44.7		48.0	**0.40**
70%	71.6	70.0	69.9	69.9	70.4	44.2	48.5	48.0		46.9	**0.39**
80%	82.0	81.8	81.5	80.6	81.5	41.5	32.3	39.0	47.7	40.1	**0.33**
90%	89.7	90.5	89.2	91.2	90.2	47.4	32.3	45.9	35.6	40.3	**0.33**
100%	100.0	98.5	98.4	100.0	99.2	34.6	45.8	52.0		44.1	**0.36**
30 Minutes	100.0	100.0	98.8	98.8	99.4	20.8		26.4	27.3	24.8	**0.20**
Dry Boil:	5-7%										

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Liquid Antistrip

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		124.5	94.6	97.3	84.9	100.3	
60%	61.8	61.3	60.8	59.7	60.9	66.4	65.3	71.3	66.9	67.5	**0.67**
70%	69.5	69.6	70.5	69.9	69.9	61.2		54.7	62.2	59.4	**0.59**
80%	80.5	81.6	80.8	81.8	81.2	52.8	49.2	62.2	65.7	57.5	**0.57**
90%	92.6	92.5	92.4	90.8	92.1	62.6	61.3	74.7	74.1	68.2	**0.68**
100%	100.0	100.0	100.0	100.0	100.0	62.2	63.3	57.8	61.3	61.2	**0.61**
30 Minutes	100.0	100.0	100.0	100.0	100.0	49.6	60.5	55.8	50.2	54.0	**0.54**
Dry Boil:	0-3%										

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Lime Slurry

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		100.9	112.1	99.6	96.8	102.4	
60%	61.4	61.6	60.8	61.1	61.2	89.2		93.1	93.5	91.9	**0.90**
70%	70.3	71.8	71.2	71.2	71.1	96.0	82.8	79.8		86.2	**0.84**
80%	79.4	80.3	79.4	79.7	79.7	109.7	120.5	129.2		119.8	**1.17**
90%	89.6	89.9	90.0	89.0	89.6	84.5		88.8	84.5	85.9	**0.84**
100%	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	**ERR**
30 Minutes	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	**ERR**
Dry Boil:	0-3%										

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

TABLE 5: Pharr District test data, 531-C research.

No Additives

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		102.8	99.7	97.3	88.6	97.1	
60%	60.0	61.1	61.8	61.0	61.0	4.9		5.7	2.3	4.3	**0.04**
70%	70.8	68.9	69.3	70.1	69.8	1.9		3.0	3.8	2.9	**0.03**
80%	78.7	79.5	78.5	80.0	79.2	4.6	3.0	3.8	7.6	4.8	**0.05**
90%	87.5	88.0	88.6	91.1	88.8	11.3	10.6	7.6		9.8	**0.10**
100%	100.0	96.1	96.1	94.8	96.8	5.7	6.1	5.8	9.1	6.7	**0.07**
30 Minutes	97.1	98.5	100.0	97.3	98.2	14.7	17.1	15.7	11.6	14.8	**0.15**
Dry Boil:	5-10%					*100% - Pulled vac for 15 min. 30 min-vac at 28 in.					

Liquid Antistrip

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		43.8	37.7	37.9	45.8	41.3	
60%	62.8	60.3	62.5	61.8	61.9	14.3	10.3	10.7	11.5	11.7	**0.28**
70%	71.2	71.4	71.4	70.3	71.1	18.2	15.3	15.1	15.7	16.1	**0.39**
80%	81.4	81.1	81.5	81.3	81.3	21.3		17.1	18.1	18.8	**0.46**
90%	91.0	90.9	91.4	91.3	91.2	27.9	22.6	27.5	18.1	24.0	**0.58**
100%	97.3	95.4	95.8	94.1	95.7	24.4	28.0	18.9	16.0	21.8	**0.53**
30 Minutes	97.5	96.2	98.4	93.1	96.3	19.2			26.8	23.0	**0.56**
Dry Boil:	3-5%					*100% - Pulled vac for 15 min. 30 min-vac at 28 in.					

Lime Slurry

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		150.4	151.8	161.0	164.2	156.9	
60%	63.2	60.6	62.2	61.3	61.8	142.0		131.2	130.8	134.7	**0.86**
70%	69.3	71.2	72.7	72.3	71.4	123.5	142.8	143.2	146.7	139.1	**0.89**
80%	79.1	82.7	80.6	78.5	80.2	96.2		109.6	99.2	101.7	**0.65**
90%	92.4	90.9	91.0	92.2	91.6	132.3		119.1	113.5	121.6	**0.78**
100%	98.4	100.0	98.5	98.4	98.8	105.0	103.4	100.8		103.1	**0.66**
30 Minutes	100.0	98.6	98.5	98.5	98.9	85.3	77.2	91.8	93.8	87.0	**0.55**
Dry Boil:						*100% - Pulled vac for 15 min. 30 min-vac at 28 in.					

Remarks — As-is specimens: After conditioning, specimens were falling apart as they were transferred to tensile machine. Sand appeared to strip in all groups.

TABLE 6: Yoakum District test data, 531-C research.

No Additives

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		118.7	136.5		136.4	130.5	
60%	60.3	60.3	60.6	59.4	60.2	77.6		75.1	74.3	75.7	**0.58**
70%	70.6	71.0	71.6	71.6	71.2	76.1	65.1	66.3	76.7	71.1	**0.54**
80%	80.3	81.5	81.4	78.5	80.4	66.4	76.6	77.0	80.8	75.2	**0.58**
90%	89.2	91.2	91.0	89.2	90.2	79.7	83.3	72.3	82.9	79.6	**0.61**
100%	98.5	100.0	98.4	98.4	98.8	73.4	67.1	75.5	70.6	71.7	**0.55**
30 Minutes	101.5	101.5	102.9	100.0	101.5	51.8	58.4	68.3	52.3	57.7	**0.44**
Dry Boil:	2-5%										

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Liquid Antistrip

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		104.7	92.7	95.4	103.7	99.1	
60%	60.0	61.5	61.5	61.3	61.1	77.7		87.3	87.5	84.2	**0.85**
70%	69.8	68.3	69.2	70.1	69.4	77.7	90.2	92.3	81.1	85.3	**0.86**
80%	80.6	78.5	80.0	80.6	79.9	85.6	102.2	90.7	95.2	93.4	**0.94**
90%	89.6	89.9	89.7	91.0	90.1	84.1	80.7		78.0	80.9	**0.82**
100%	100.0	100.0	100.0	100.0	100.0	116.9	128.6	117.4		121.0	**1.22**
30 Minutes	100.0	98.5	100.0	101.5	100.0	127.1	122.0	125.5	133.7	127.1	**1.28**
Dry Boil:	0-3%										

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Lime Slurry

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		124.0	122.1		118.7	121.6	
60%	61.3	61.3	59.7	60.8	60.8	99.4		100.0	105.1	101.5	**0.83**
70%	71.8	70.9	72.5	70.9	71.5	163.3	162.5		163.0	162.9	**1.34**
80%	79.5	81.3	79.2	80.5	80.1	140.8	156.0	137.5	141.4	143.9	**1.18**
90%	92.0	92.2	93.7	88.6	91.6	164.2		157.4	149.2	156.9	**1.29**
100%	98.7	100.0	100.0	100.0	99.7	158.2	143.2		142.3	147.9	**1.22**
30 Minutes	97.1	97.2	101.5	100.0	99.0	170.3	155.6	169.1	158.3	163.3	**1.34**
Dry Boil:											

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

TABLE 7: Wichita Falls District test data, 531-C research.

No Additives

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		85.7		86.6	83.3	85.2	
60%	62.3	61.1	62.0	62.3	61.9	49.8	58.6	54.9	47.5	52.7	**0.62**
70%	70.6	71.6	69.0	70.8	70.5	50.2	55.3	53.7		53.1	**0.62**
80%	79.4	78.6	78.3	79.2	78.9	50.6	54.8	54.1		53.2	**0.62**
90%	91.7	90.1	89.4	91.3	90.6	32.5	35.9		43.9	37.4	**0.44**
100%	98.5	101.4	98.6	101.5	100.0	34.4	35.6	36.7	38.5	36.3	**0.43**
30 Minutes	98.5	98.5	100.0	101.4	99.6	42.8	41.1	38.7	41.3	41.0	**0.48**
Dry Boil:											

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Liquid Antistrip

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		81.2	81.6	76.0	84.0	80.7	
60%	61.6	62.2	62.5	62.2	62.1	70.2	70.2	70.3		70.2	**0.87**
70%	71.8	70.7	70.7	69.3	70.6	57.0	52.9	52.1	58.7	55.2	**0.68**
80%	79.2	79.7	81.7	81.7	80.6	62.3	63.1	66.7	59.4	62.9	**0.78**
90%	89.9	91.4	90.4	89.3	90.3	61.1	59.8	57.1	54.5	58.1	**0.72**
100%	100.0	91.9	100.0	97.1	97.3	54.2	56.4	52.4	54.6	54.4	**0.67**
30 Minutes	94.5	94.4	100.0	97.2	96.5	54.1	54.3	53.4	50.0	53.0	**0.66**
Dry Boil:											

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Lime Slurry

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		88.3	89.3	94.0	91.9	90.9	
60%	60.3	59.7	60.0	61.5	60.4	97.4		88.1	98.6	94.7	**1.04**
70%	70.1	71.0	69.3	69.3	69.9	91.5	95.1	83.5	85.2	88.8	**0.98**
80%	81.1	80.3	79.7	82.7	81.0	89.8	80.1	79.3	89.0	84.6	**0.93**
90%	90.7	89.2	89.9	89.6	89.9	82.3	77.8	79.6		79.9	**0.88**
100%	100.0	100.0	100.0	100.0	100.0	74.3	72.2	77.0		74.5	**0.82**
30 Minutes	94.0	93.9	100.0	92.5	95.1	75.5		77.1	79.0	77.2	**0.85**
Dry Boil:											

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

TABLE 8: Tyler District test data, 531-C research.

No Additives

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		78.9	73.3	74.9	65.0	73.0	
60%	58.8	62.0	60.0	60.0	60.2	72.2	69.3	76.4	72.3	72.6	**0.99**
70%	69.9	70.3	71.4	71.6	70.8	73.0	73.1	72.6		72.9	**1.00**
80%	81.6	80.5	79.2	80.3	80.4	85.0	78.5	101.8	93.8	89.8	**1.23**
90%	91.8	93.2	92.3	90.0	91.8	95.7	98.0		86.0	89.0	**1.22**
100%	100.0	98.7	98.5	100.0	99.3	37.4		37.4	35.1	36.6	**0.50**
30 Minutes	86.8	89.7	92.4	84.5	88.4	42.9	34.9	46.4	35.9	40.0	**0.55**
Dry Boil:											

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Liquid Antistrip

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		73.1		71.9	71.0	72.0	
60%	61.8	60.6	60.3	61.3	61.0	47.6	48.2	49.7	55.0	50.1	**0.70**
70%	71.9	70.8	70.8	70.6	71.0	43.4	49.2	49.2	48.7	47.6	**0.66**
80%	79.7	80.6	80.0	78.3	79.7	57.0	39.9	49.2	57.8	51.0	**0.71**
90%	91.7	89.6	90.2	90.5	90.5	49.9	39.9	48.0	38.7	44.1	**0.61**
100%	100.0	98.8	100.0	100.0	99.7	45.3	31.1	38.9	45.4	40.2	**0.56**
30 Minutes	98.5	98.6	100.0	98.6	98.9	48.5	65.0	64.1	56.0	58.4	**0.81**
Dry Boil:											

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Lime Slurry

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		44.1	48.1	45.4	49.3	46.7	
60%	60.0	60.7	61.8	61.5	61.0	45.2	40.6	43.3	41.6	42.7	**0.91**
70%	71.8	69.0	70.5	70.1	70.4	46.9	44.3	50.7	39.7	45.4	**0.97**
80%	80.6	80.0	79.4	79.4	79.9	46.1	47.7	49.9	55.4	49.8	**1.07**
90%	92.5	89.2	90.6	89.2	90.4	51.8	47.0	39.1	48.9	46.7	**1.00**
100%	101.8	100.0	100.0	100.0	100.5	78.3	75.4	74.0	71.8	74.9	**1.60**
30 Minutes	100.0	101.4	101.6	101.3	101.1	76.4	76.8	71.1	72.3	74.2	**1.59**
Dry Boil:											

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

TABLE 9: Austin District test data, 531-C research.

No Additives

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		185.2	193.7	200.7	190.1	192.4	
60%	59.7	60.8	61.0	61.0	60.6	115.7		93.4	127.5	112.2	**0.58**
70%	71.2	72.8	71.4	70.8	71.6	57.9		68.2	67.8	64.6	**0.34**
80%	80.3	81.3	81.3	81.1	81.0	86.1		89.5	99.1	91.6	**0.48**
90%	91.8	91.8	91.6	91.2	91.6	66.3		84.1	49.3	66.6	**0.35**
100%	101.2	101.3	102.6	102.5	101.9	72.1		70.8	81.7	74.9	**0.39**
30 Minutes	112.2	113.4	114.7	114.0	113.6	84.1	78.9		70.1	77.7	**0.40**
Dry Boil:	5-7%										

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Liquid Antistrip

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry											
60%											
70%											
80%											
90%											
100%											
30 Minutes											
Dry Boil:	0-3%										

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

Lime Slurry

Target Saturation	Actual Saturation					Strength (PSI)					TSR Ratio
	1	2	3	4	Avg.	1	2	3	4	Avg.	
Dry	N/A	N/A	N/A	N/A		198.0	198.4		203.9	200.1	
60%	62.5	61.4	60.0	61.2	61.3	192.3		188.9	210.4	197.2	**0.99**
70%	72.7	70.3	71.9	71.7	71.7	202.9		196.4	208.3	202.5	**1.01**
80%	82.4	80.3	80.3	81.0	81.0	173.1	199.3	171.0		181.1	**0.91**
90%	90.2	91.2	92.1	90.0	90.9	179.1	174.3		171.8	175.1	**0.87**
100%	100.0	100.0	100.0	100.0	100.0	180.6	190.3	188.9		186.6	**0.93**
30 Minutes	103.1	100.0	100.0	103.0	101.5	201.5		197.4	190.3	196.4	**0.98**
Dry Boil:	0-3%										

*100% - Pulled vac for 15 min.
30 min-vac at 28 in.

TABLE 10: Effects of pH content of water on TSR – Atlanta mix.

	Saturation Level (%)				Tensile Strength (PSI)				
pH	Sample 1	Sample 2	Sample 3	AVG	Sample 1	Sample 2	Sample 3	AVG	TSR (%)
Dry	00.0	00.0	00.0	00.0	85.2	76.2	86.3	82.6	
4	71.1	71.2	77.2	73.2	79.8	89.6	127.5	99.0	1.2
7	47.9	58.2	64.0	56.7	55.2	95.9	93.9	81.7	1.0
10	63.9	63.6	61.8	63.1	90.7	95.3	102.0	96.0	1.2
13	70.9	66.2	68.0	68.4	00.0	00.0	00.0	00.0	0.0
Note: Conditioned specimens at pH content of 13 stripped severely and fell apart in the 140°F water bath.									

TABLE 11: Effects of pH content of water on TSR – Central Texas mix.

	Saturation Level (%)				Tensile Strength (PSI)				
pH	Sample 1	Sample 2	Sample 3	AVG	Sample 1	Sample 2	Sample 3	AVG	TSR (%)
Dry	00.0	00.0	00.0	00.0	87.4	105.7	109.7	100.9	
4	76.6	74.6	72.4	74.5	55.2	39.7	39.3	44.7	0.4
7	71.0	70.6	68.4	70.0	45.4	41.2	38.9	41.8	0.4
10	72.6	70.0	71.4	71.3	43.6	37.4	37.8	39.6	0.4
13	70.5	68.3	69.6	69.5	00.0	00.0	00.0	00.0	0.0
Note: Conditioned specimens at pH content of 13 stripped severely and fell apart in the 140°F water bath.									

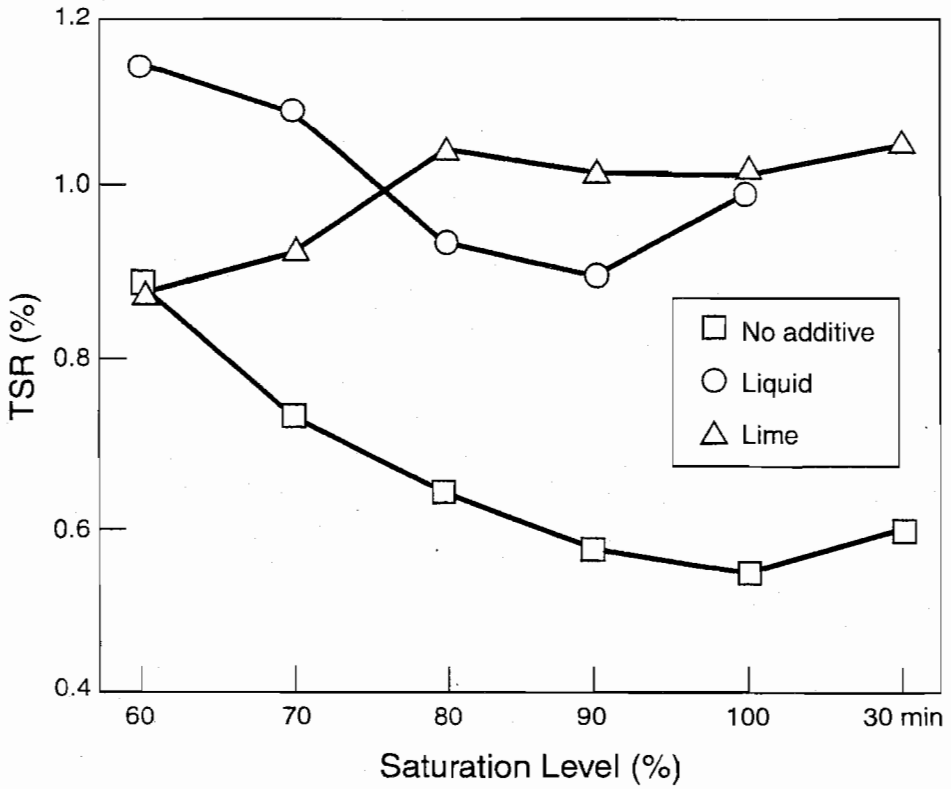

FIGURE 1: Atlanta test results.

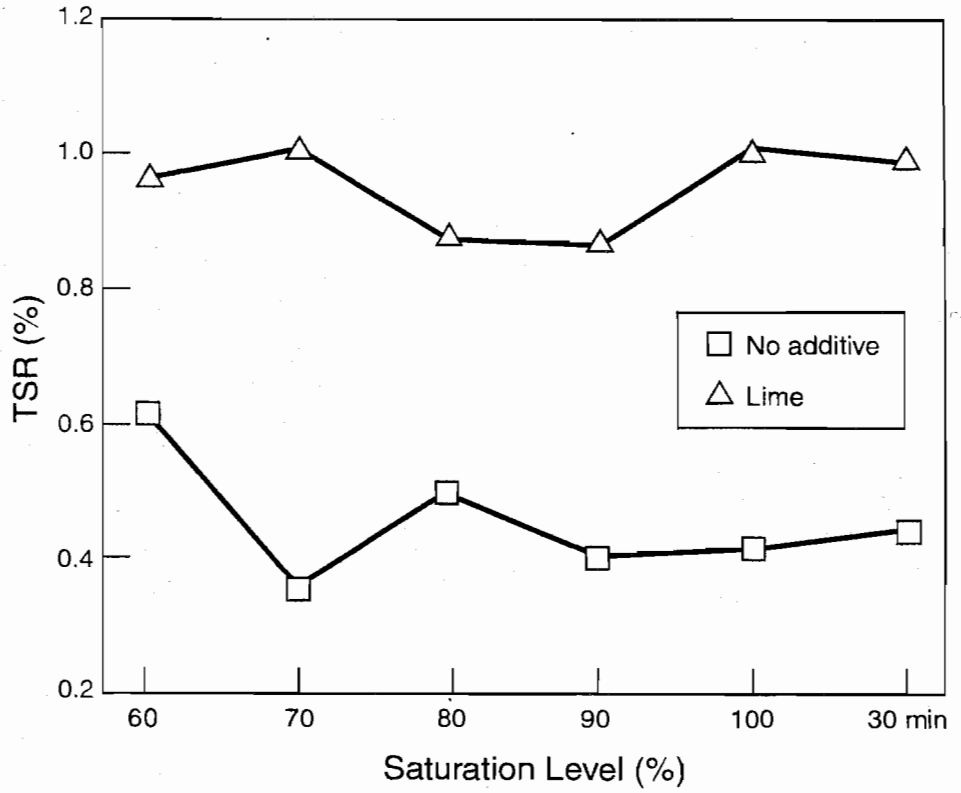

FIGURE 2: Austin test results.

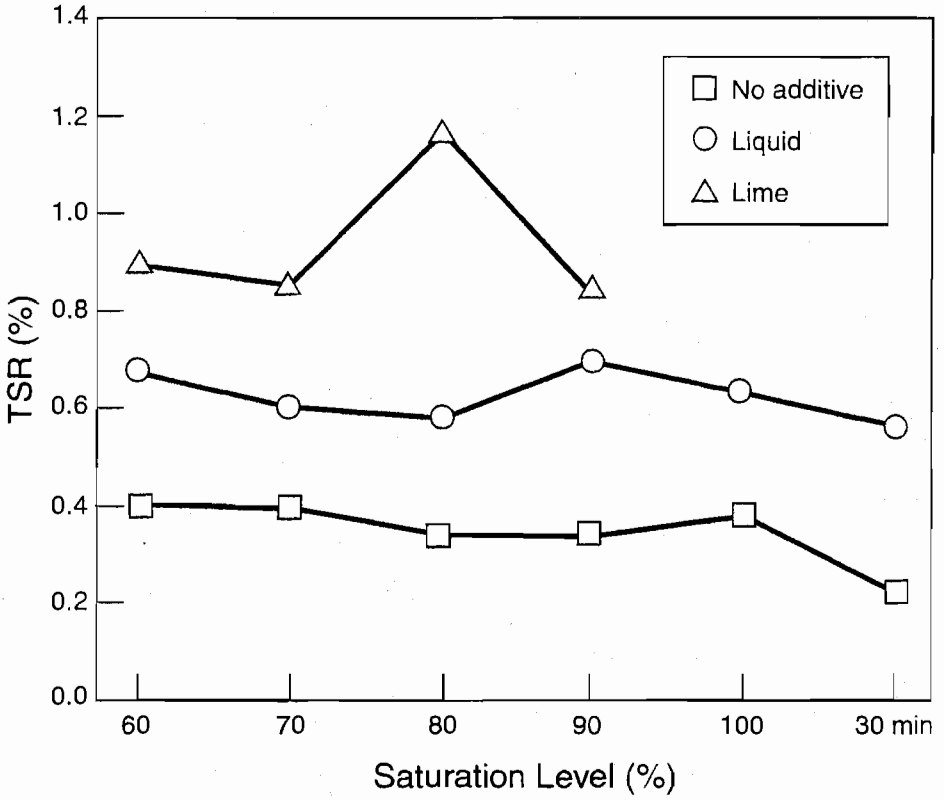

FIGURE 3: Corpus Christi test results.

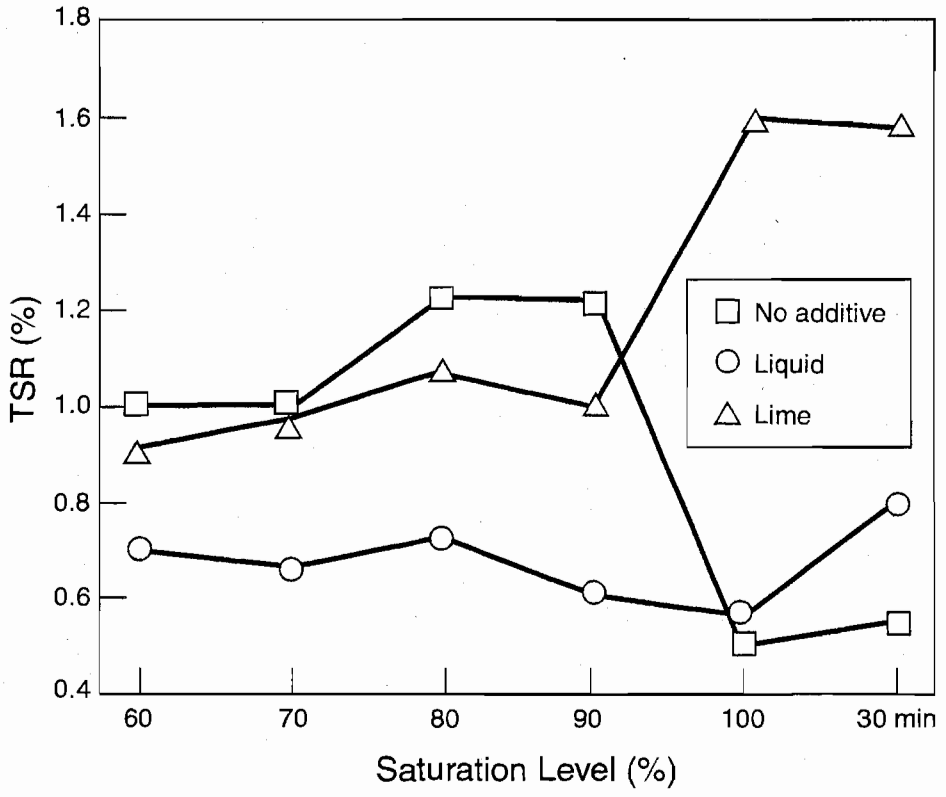

FIGURE 4: Tyler test results.

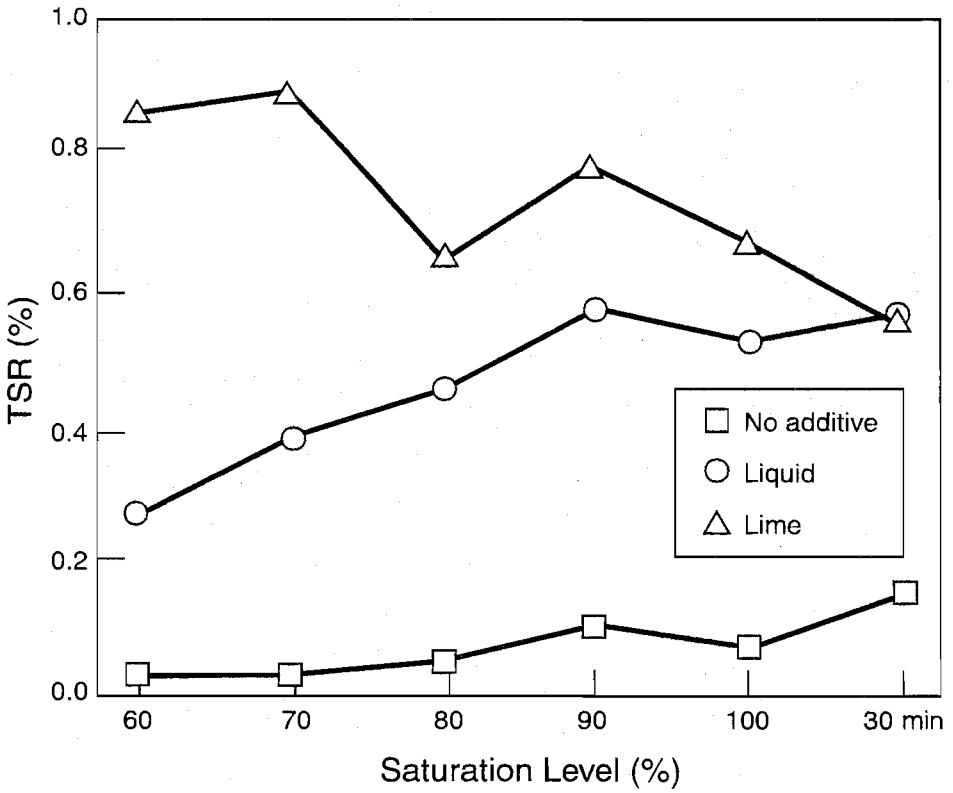

FIGURE 5: Pharr test results.

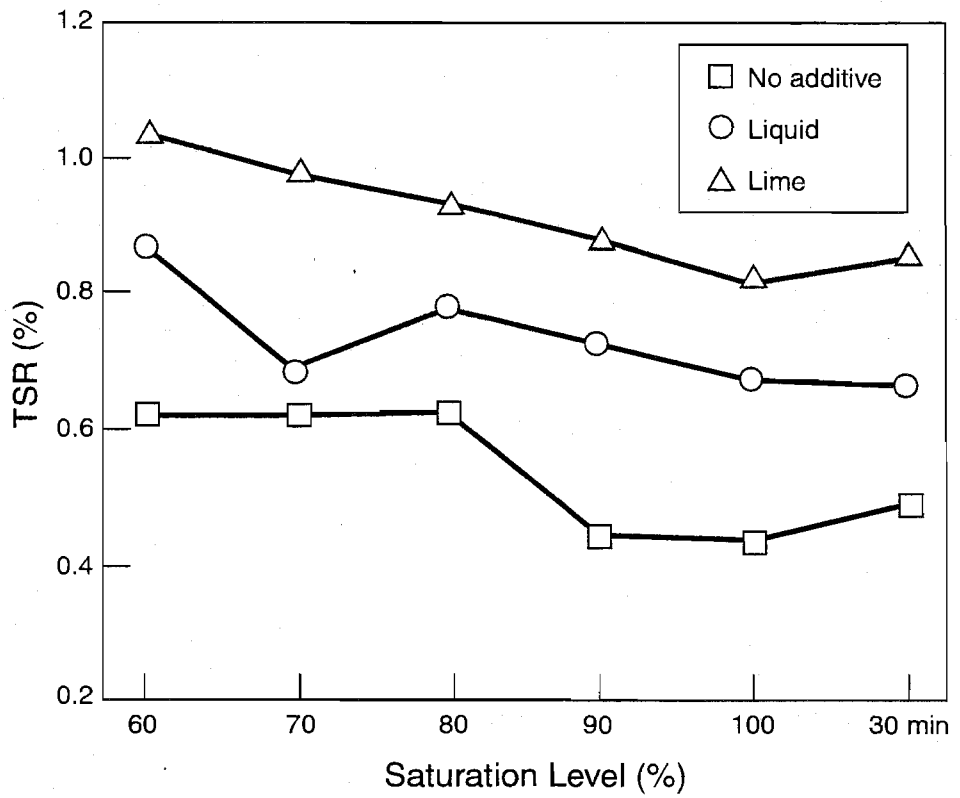

FIGURE 6: Wichita Falls test results.

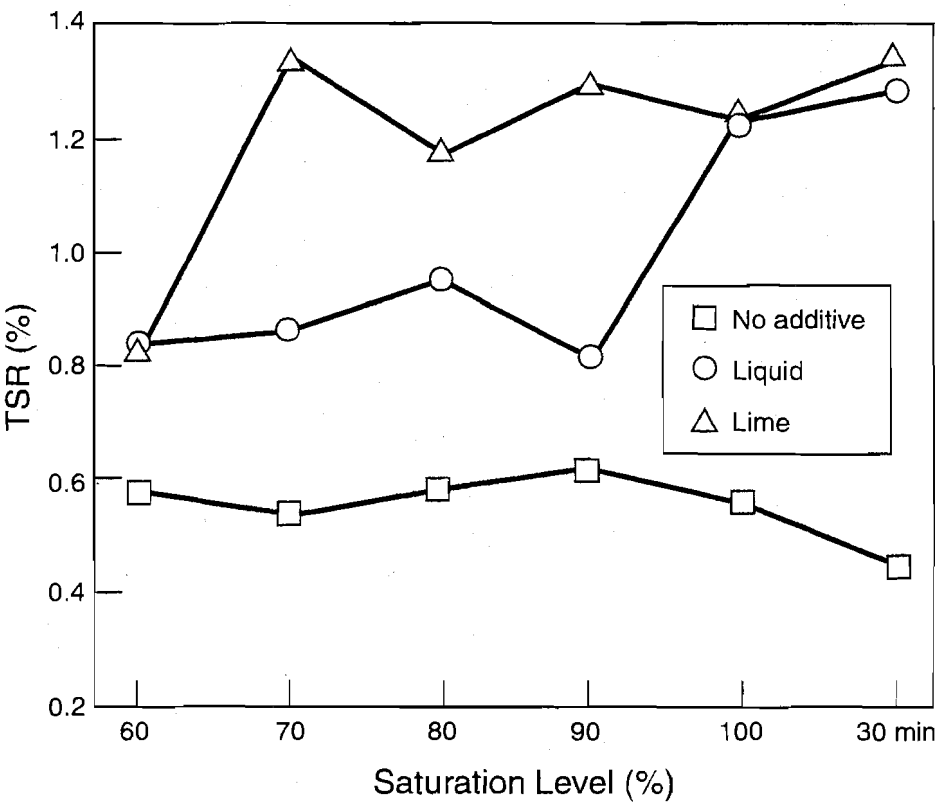

FIGURE 7: Yoakum test results.

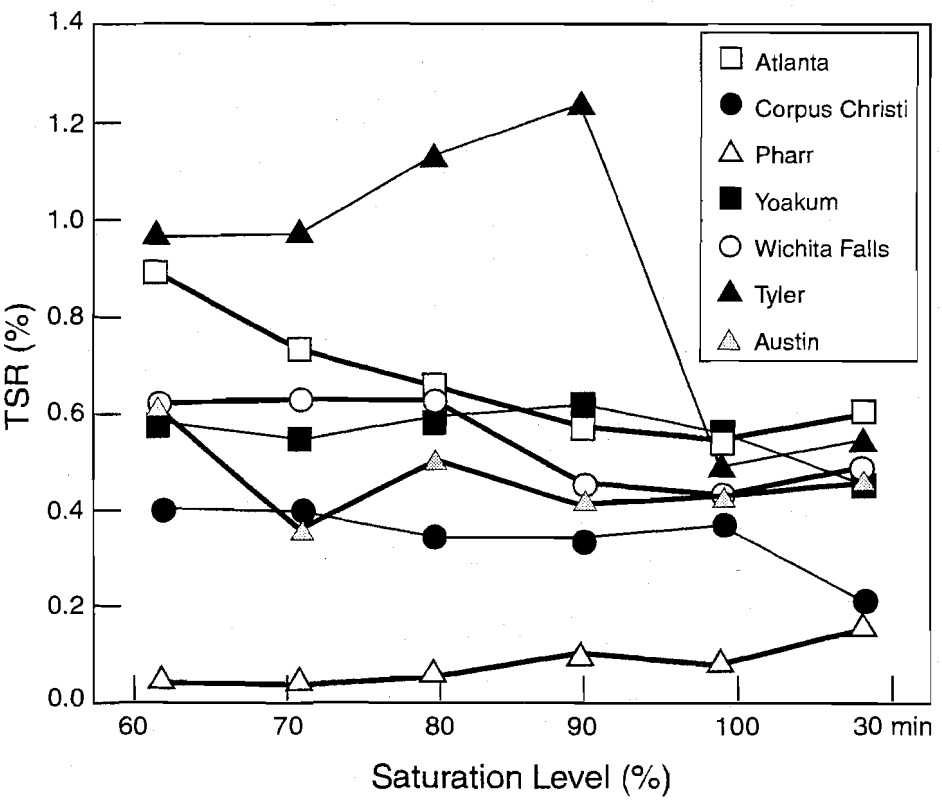

FIGURE 8: No additive.

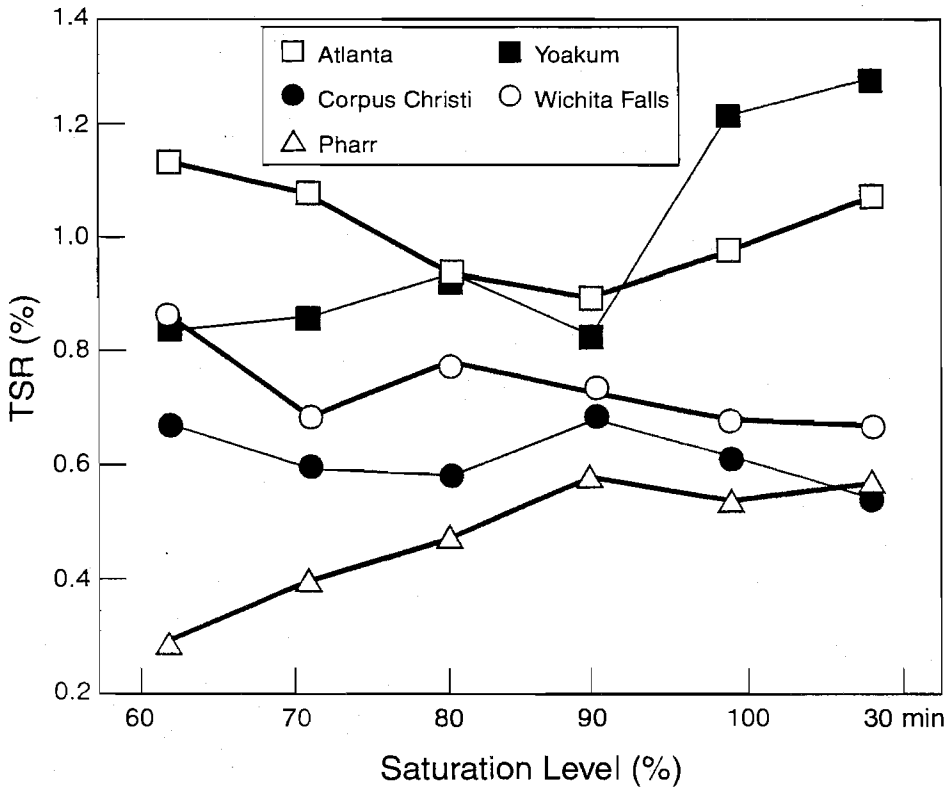

FIGURE 9: Liquid antistripping additives.

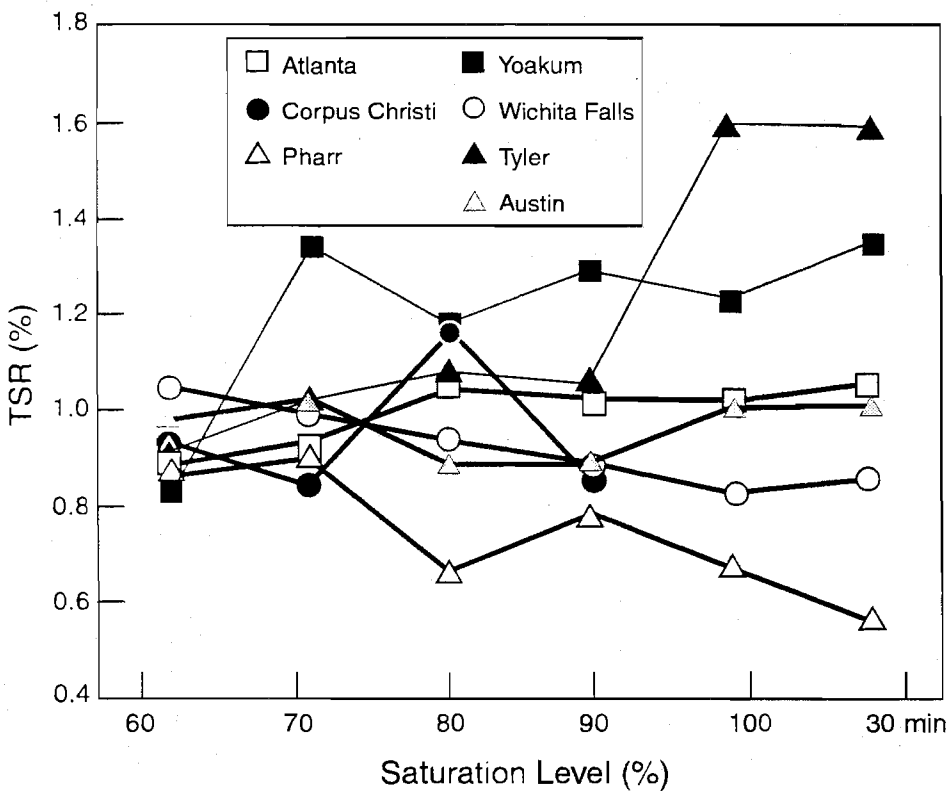

FIGURE 10: Lime.

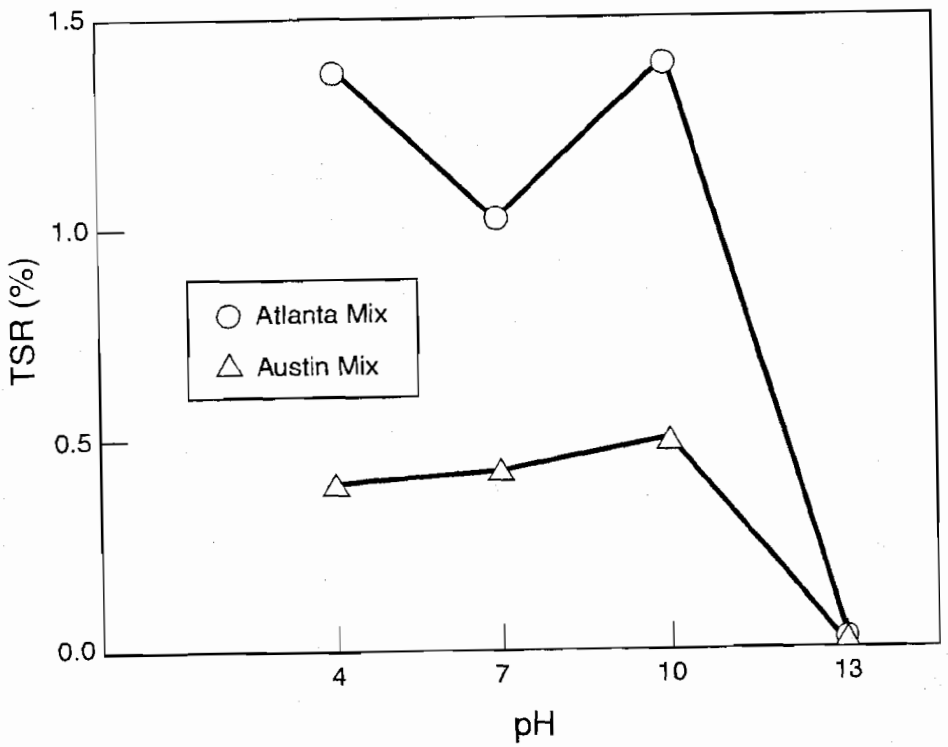

FIGURE 11: Effects of pH on TSR.

APPENDIX A:

TEX-531-C
PREDICTION OF MOISTURE-INDUCED DAMAGE TO BITUMINOUS PAVING MATERIALS USING MOLDED SPECIMENS

PREDICTION OF MOISTURE-INDUCED DAMAGE TO BITUMINOUS PAVING MATERIALS USING MOLDED SPECIMENS

This test method describes a stripping test utilizing molded Hveem specimens of complete mix. It is identical to AASHTO Designation T 283, except for the five following notations.

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1 - Section 6.4 of the AASHTO procedure calls for 72 to 96 hours of storage at room temperature. This method requires only 24 hours of room temperature storage.

2 - Section 9.2 calls for a minimum of 2 hours equilibration in a 25 °C (77 °F) water bath. This method requires three to four hours equilibration.

3 - Compactive Effort Determination Procedure: The following procedure may be used to determine the necessary compactive effort to achieve the required density.

Step	Action
1	Mix 4 trial specimens.
2	Mold the 4 specimens using 2, 4, 6, and 8 sets of gyrations at 345 kPa (50 psi) loading and a 6895 kPa (1000 psi) level-up load.
3	Determine the density of these trial specimens.
4	Determine the compactive effort (i.e., number of gyrations) needed to achieve 93 ± 1% density for the test specimens by interpolating between the density data points obtained.

4 - For Hot Mix-Cold Laid (HMCL) material, the AASHTO T 283 mixing and molding procedures are amended as follows:

Step	Action
1	Mix the design aggregates and the asphaltic material (asphalt primer blend [no water], emulsion, or cutback asphalt) according to Test Method Tex-205-F.
2	Cool at room temperature for 2.5 hours.
3	Cure the mix a minimum of 15 hours at 60 °C (140 °F) or until constant weight is attained.
4	Heat mix specimens at 38 ± 2.5 °C (100 ± 5 °F) for two hours, and mold at that temperature.
NOTE:	Plant mixes may be tested by this procedure, starting with Step 3.

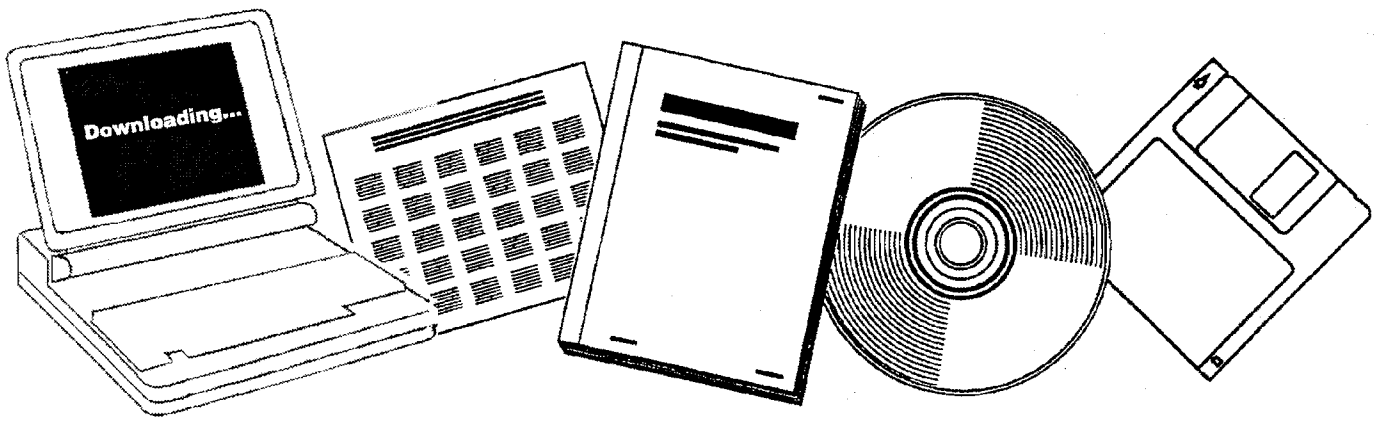
5 - Hot Mix-Hot Laid (HMHL) plant mixes may be tested using AASHTO T 283 by starting at the molding section, providing representative samples of the plant mix are weighed to produce mix specimens.

DHT-38

EVALUATION OF TEST METHOD TEX-531-C, 'PREDICTION OF MOISTURE-INDUCED DAMAGE TO BITUMINOUS PAVING MATERIALS USING MOLDED SPECIMENS'

TEXAS DEPT. OF TRANSPORTATION, AUSTIN

APR 1996



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