Laboratory Tests for Assessing Moisture Damage of Asphalt Concrete Mixtures

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A synopsis of an extensive report prepared for the National Lime Association and FHWA is presented. Field projects originally constructed in the mid-1980s incorporating various methods of adding lime were used as the basis for the research effort. A total of 13 test sections constructed in four states were evaluated. Cores from the test sections and raw materials from the original suppliers for each project were obtained. The pavement condition surveys reported as part of the companion research effort were used to compare laboratory results with pavement performance. Laboratory testing included variations of existing moisture conditioning procedures: (a) no saturation, (b) partial saturation, and (c) full saturation. Results indicate that moisture-sensitive mixtures without lime will be significantly damaged even when the initial saturation step is eliminated. When lime is included in the mixtures, some level of saturation is needed to reduce significantly mixture strength. The increase in the number of freeze-thaw cycles from one to six follows the same trend—that is, mixtures without lime are significantly damaged, whereas mixtures with lime show only a moderate decrease in mixture strength with increasing numbers of freeze-thaw cycles. There is little difference in the mixture properties obtained for a given aggregate source when lime is introduced to either dry or prewet aggregate when preparing laboratory specimens. Little difference is noticed between the introduction of lime to prewet aggregate or lime with the binder inside the drum for field mixtures. The no-initial-saturation option provides the best agreement in relative ranking between conditioned resilient moduli values and the moduli values obtained for the cores. As the level of saturation is increased, the distinction between projects is lost.

The main purpose in assessing the moisture sensitivity of laboratory-prepared samples is to identify asphalt-aggregate mixtures that are susceptible to in-service moisture damage. However, any laboratory assessment of moisture sensitivity assumes that laboratory conditioning of laboratory-prepared samples accurately reflects the in-service environmental conditions and the as-constructed asphalt concrete. Current laboratory test methods have been developed from rational approaches, but little information is available that compares the various approaches and relates them to pavement performance.

This research program was designed to define the relationships between laboratory test method variables and pavement performance.

BACKGROUND

Current laboratory-conditioning procedures have been developed to represent both warm-wet and cold-wet climatic regions of the country. The two most commonly used laboratory simulations of these types of climates were developed by Root and Tunnicliff (*3*) and by Lottman (*4*). Both methods include some level of initial moisture saturation of the sample, followed by freezing (Lottman only), and subsequent warm-water thawing. The inclusion of a freeze-thaw cycle is based on regional climatic conditions. The second main difference between the two procedures is the result of a controversy over methods of saturating the sample before environmental conditioning.

Root and Tunnicliff have hypothesized that saturating samples to more than 90 percent of the sample void space can, by itself, damage the sample by creating excessive internal pressure (*3*). They also mention that saturation levels greater than this range may not be representative of actual field conditions. On the basis of these hypotheses, they have recommended saturation levels between 55 and 80 percent.

Lottman has indicated that damage due to saturation levels greater than 90 percent may be minimal and can be monitored by determining the swell (i.e., increase in sample volume) of the saturated sample (*4*). His procedure recommends a set level of vacuum pressure for a fixed time interval. Experience with this procedure has indicated that the specified 24 in. of vacuum for 30 min results in saturation levels consistently over 90 percent (*5*).

Additional research has indicated that increasing the number of freeze-thaw cycles used also affects test results (*5*). Typically, both mixture strength and retained strength ratios decrease as the number of cycles increases.

The testing program used to evaluate laboratory-prepared specimens was based on these test method variables.

RESEARCH PROGRAM

Objective

The main objective of the research was to establish guidelines for the laboratory assessment of moisture sensitivity of asphalt concrete mixtures. This was accomplished by first comparing test results obtained for the various laboratory test methods and then comparing these results to the fundamental properties (i.e., resilient moduli and tensile strength) of the cores.

Scope

A total of 13 test sections constructed by FHWA in Wyoming, Montana, New Mexico, and Georgia were used as the source

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of raw materials, cores, and estimates of pavement performance for this program (Figure 1). These sections were originally placed in the early 1980s to investigate both methods of adding lime and the benefits of using lime in asphalt concrete (*1*).

Raw materials were used to fabricate samples to the job mix formulas reported in the original FHWA report on the projects (*1*). Variables included in the laboratory assessment of moisture sensitivity included the number of freeze-thaw cycles (zero, one, and six), method of adding lime (dry aggregate, prewet aggregate), level of initial saturation (zero, 55 to 80 percent, and more than 90 percent). These results were then compared with the mixture properties (i.e., resilient modulus and tensile strength) of the cores.

BACKGROUND OF PROJECTS

Both the project descriptions and pavement condition surveys were reported in depth in the FHWA report for this project (*2*). A summary of this information is presented.

Project Descriptions

Wyoming

Two projects consisting of two test sections each were placed in September 1984 in Wyoming; all asphalt concrete was mixed in a drum plant. Project 1 was placed on US-14A between Garland and Byron. This project was new construction consisting of a 6-in. crushed aggregate base and a 3.5-in. layer of asphalt concrete. The top 1.5 in. of the asphalt concrete contained lime and was the test layer under investigation. Section 1 of this project contained lime added with the asphalt cement inside the drum. Section 2 had lime added to damp aggregate. The final surface was fog- and chip-sealed.

Project 2 was also new construction placed on Wyoming State Route 50 between Gillette and Pine Tree Junction. This project consisted of 9 in. of cement-treated base, followed by a 1-in. asphalt cement leveling course and a 2-in. wearing course; the wearing course was the test layer. Section 1 had lime added to damp aggregate, and Section 2 had lime added to dry aggregate inside the drum.

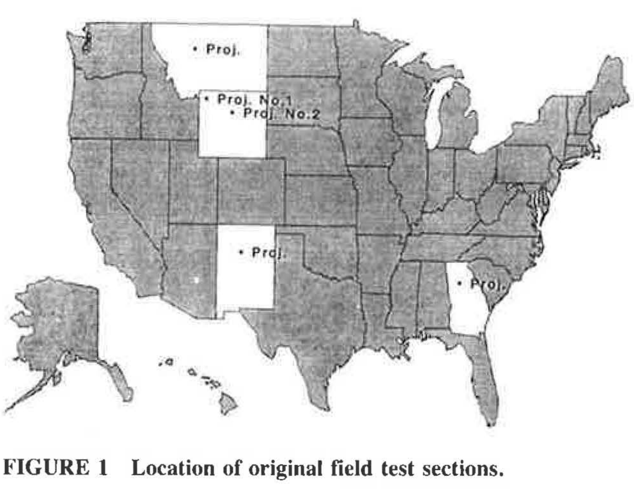


FIGURE 1 Location of original field test sections.

Montana

One overlay project consisting of two test sections was constructed in September 1984 on Interstate 15 between Craig and Cascade; a drum mix plant was used for both sections. The overlay consisted of a 3-in. asphalt concrete layer followed by an open-graded friction course. The top 2 in. of the asphalt concrete layer contained lime and were the test layers. Section 1 was prepared with a quicklime slurry added to the aggregate. Section 2 had lime added with the asphalt cement inside the drum.

New Mexico

One overlay project consisting of two test sections was constructed in July 1985 on New Mexico Route 76 between Truchas and Las Trampas; a drum mix plant was used to construct both test sections. The existing asphalt concrete was overlaid with 2.5 in. of new asphalt concrete containing lime, plus an open-graded friction course. Section 1 had lime added to damp aggregate. Section 2 had lime added with the asphalt cement inside the drum.

Georgia

Two overlay projects, one with a drum plant (Project 1, October 1984) and one with a batch plant (Project 2, September 1985), were constructed on Georgia State Route 20 in Gwinnett County beginning at the intersection with State Route 13. Four sections were constructed for Project 1: Section 1 had lime added to dry aggregate, Section 2 had lime added to damp aggregate, Section 3 had lime added with the asphalt cement inside the drum, and Section 4 had a lime slurry added to damp aggregate. Three additional sections were placed for Project 2: Section 5 had lime added to dry aggregate, Section 6 had lime added to damp aggregate, and Section 7 had a lime slurry added to damp aggregate.

Pavement Condition Surveys

Wyoming

Both sections constructed for Project 1 had a couple of low-temperature transverse cracks and a longitudinal crack at the centerline between two of the westbound lanes. There was no visible evidence of moisture damage. Although generally in good condition, Section 1 of Project 2 showed 12 low-temperature-induced transverse cracks as well as some raveling along the outside edge of the lane-line marker. Section 2 of Project 2 also showed 12 transverse cracks and some longitudinal cracking along the centerline. Surface raveling along the outside edge, along the centerline, and between the wheelpaths was also noted.

Montana

All sections were in excellent condition, except for a couple of thermally induced transverse cracks.

New Mexico

All sections were reported to be in excellent condition, except for a couple transverse cracks in Section 1; Section 2 had no cracks at all.

Georgia

All sections had slight transverse cracking. The alligator cracking in the sections was reported as follows:

- Drum Mix Plants
  - –Section 1: 11 to 15 percent,
  - –Section 2: Less than 10 percent,
  - –Section 3: 26 to 50 percent, and
  - –Section 4: None noted.
- Batch Plants
  - –Section 5: 26 to 50 percent,
  - –Section 6: 51 to 90 percent, and
  - –Section 7: 26 to 50 percent.

TESTING PROGRAM

The testing program used to develop the data presented in this report covers two areas of testing:

1. Assessment of moisture sensitivity of laboratory-prepared samples, and
2. Determination of current in-service mixture properties.

Testing of the laboratory-prepared specimens included various methods of estimating moisture damage; testing of the cores was limited to determining the current in-service mixture properties.

Sample Preparation

The job mix formulas reported during construction of each of the projects were used to prepare the specimens (*1*). Each aggregate source was sieved into 10 individual fractions, then recombined to meet the gradations. The binder content used was the percentage asphalt reported during construction quality-control testing. Samples were mixed and compacted in accordance with ASTM D1561, except that the compactive effort was reduced to produce air voids in the range of 6 to 8 percent. This range was more representative of the actual void contents reported immediately after construction.

Conditioning Procedures

Specimens were compacted and subjected to one of three conditioning procedures:

1. No saturation: Specimens were wrapped in plastic and placed in a 0°F freezer for a minimum of 15 hr. Specimens were then removed from the freezer, unwrapped, and placed in a 140°F water bath for 24 hr. Specimens were cooled to test temperature in a 77°F water bath for 2 hr.
2. 55 to 80 percent saturation: Specimens were partially saturated, and the level of saturation was determined. Once the desired level of saturation was achieved, the specimens were immediately wrapped in plastic and treated as described in the first procedure.
3. More than 90 percent saturation: Specimens were placed in a water bath and subjected to a vacuum of 30 mm of mercury (Hg) for 10 min. Specimens were then wrapped, frozen, and thawed as described.

The no-saturation option coupled with freeze-thaw conditioning was inherently included as a result of all factors' being considered in a full factorial experimental design.

Freeze-Thaw Cycles

One freeze-thaw cycle consisted of a minimum of 15 hr in a 0°F freezer, 24 hr in a 140°F water bath and 2 hr in a 77°F water bath. The time in the 77°F water bath was included in each cycle to minimize damage to the specimens as they were being rewrapped in plastic before their return to the 0°F freezer.

Methods of Adding Lime

Methods of adding lime to laboratory-prepared mixtures are designed to simulate, as closely as possible, the mixing of lime and aggregates during construction. In order to replicate the application of the lime to damp aggregate on the cold feed belt, lime is sprinkled over predampened aggregates, stirred, then used as usual in specimen preparation.

To simulate the injection of lime into the drum, just ahead of the binder, during construction, lime is sprinkled over dry aggregate. Specimens are then prepared as usual.

Measurements of Mixture Strength

Two measurements of mixture strength were determined: resilient modulus and tensile strength. Both tests were performed on the same sample because the first—resilient modulus—is considered a nondestructive test. Briefly, the resilient modulus is a ratio of the applied, repeated stress to the corresponding horizontal recoverable deformation. Testing was conducted at 77°F, 0.33 Hz, and a load duration of 0.1 sec. The tensile strength test subjects the specimen to a constant rate of strain of 2 in./min and measures the maximum stress at failure.

Moisture sensitivity is typically expressed as the ratio of either measurement after environmentally conditioning the specimen to the original strength. The resulting resilient modulus and tensile strength ratios are commonly used to describe the retained strengths of the mixtures.

EVALUATION OF LABORATORY RESULTS

Levels of Saturation

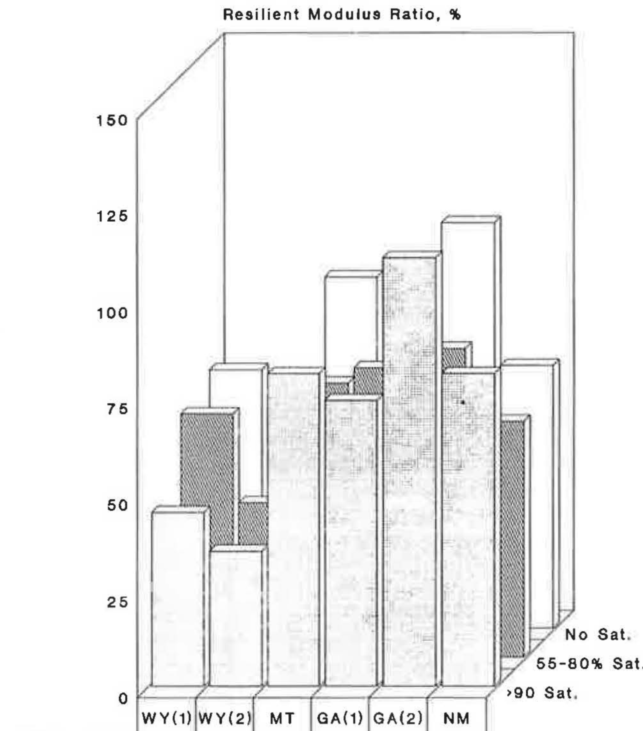
Three saturation levels before subjecting laboratory-prepared specimens to freezing and thawing were investigated: no saturation, 55 to 80 percent saturation, and more than 90 percent saturation. The reader is reminded that although the no-saturation option did not saturate the specimens before freezing, the specimens were soaked and unwrapped, in the 140°F water bath during the thaw portion of the conditioning.

The resilient modulus ratio for no-saturation shows that the strength of mixtures without lime is substantially decreased just by exposure to water during the thaw stage of the conditioning procedure (Figure 2). A general trend for a decrease in resilient modulus ratio with increasing levels of saturation can also be seen.

A value of less than about 70 percent for the resilient modulus ratio, developed for a saturation level of specimens between 60 and 75 percent, has been suggested as an indication of moisture-sensitive mixtures. On the basis of this limit, only the Georgia (Project 1) and New Mexico mixtures would be acceptable as moisture-resistant mixtures without the addition of lime (specimens with 55 to 80 percent saturation).

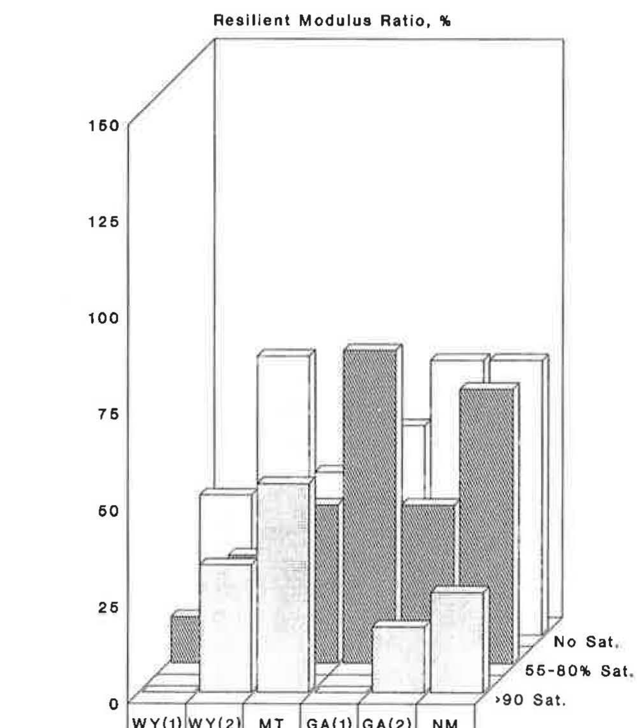
If this same limit was applied to the results for the other levels of saturation, Wyoming Project 2 would be added to the list of acceptable projects for the no-saturation level, and none of the mixtures would be acceptable when saturation levels are greater than 90 percent.

Figure 3 shows that there is much less impact from the saturation level on the resilient modulus ratios for mixtures with lime. In fact, only the Wyoming mixtures showed any decrease in retained strengths when saturation was increased from 55 to 80 percent to more than 90 percent. When lime is added, only one project produced mixtures with a ratio substantially below 70 percent (Wyoming Project 2, 55 to 80 percent saturation).



	WY(1)	WY(2)	MT	GA(1)	GA(2)	NM
No Sat.	67	54	91	75	105	68
55-80% Sat.	63	40	71	75	80	61
›90 Sat.	45	35	81	74	111	81

FIGURE 3 Impact of moisture on resilient modulus ratio for levels of saturation for mixtures with lime added to prewet aggregate (one freeze-thaw cycle).



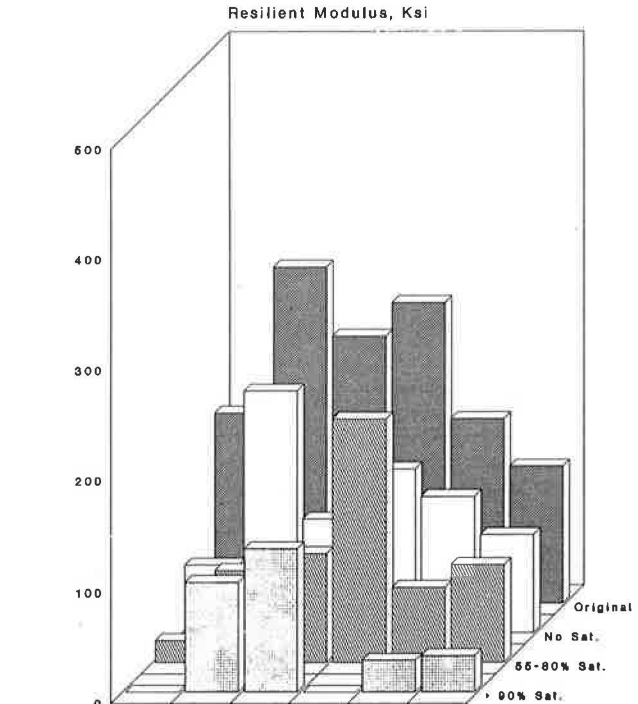
	WY(1)	WY(2)	MT	GA(1)	GA(2)	NM
No Sat.	36	72	42	54	71	71
55-80% Sat.	12	28	41	81	41	71
›90 Sat.	0	33	54	0	17	26

FIGURE 2 Impact of moisture on resilient modulus ratio for levels of saturation for mixtures with no lime (one freeze-thaw cycle).

This generally agrees with the pavement condition survey information noted in the previous section. No evidence of stripping was noticed for any of the projects except Wyoming (Project 2). As mentioned, Figure 3 shows that this was the only project with a resilient modulus ratio (40 percent) substantially below the suggested 70 percent limit. This would indicate that the 70 percent limit for indicating moisture sensitivity could be lowered to include mixtures with ratios in the 60s, and would be applicable to only mixtures tested with an initial saturation level between 55 and 80 percent.

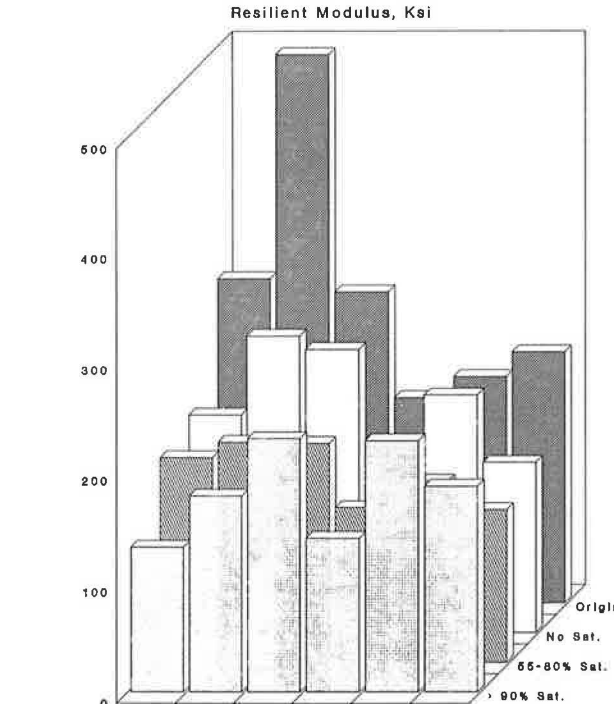
Occasionally anomalies in the ratios are noticed. A comparison of Figures 2 and 3 shows that the ratio for Wyoming Project 2 is 72 with no lime but only 54 with lime (no saturation). If only ratios are considered as indicators of moisture sensitivity, then the mixture with lime would appear to be more sensitive to water. This contradiction of historical experience leads to a closer examination of values used to develop the ratios.

Figures 4 and 5 show that the original resilient modulus of the Wyoming Project 2 mixtures was 303 kip/in² (ksi) without lime and almost 500 ksi with lime, an increase in strength of approximately 65 percent. The wet resilient moduli for these projects were 218 and 267 ksi, respectively (no saturation). The mixture with lime still retains approximately 20 percent more strength than the mixture with no lime. When the wet



	WY(1)	WY(2)	MT	GA(1)	GA(2)	NM
Original	171	303	241	271	166	123
No Sat.	61	218	102	147	122	68
55-80% Sat.	20	83	98	219	66	88
› 90% Sat.	0	99	129	0	29	33

FIGURE 4 Comparison of resilient moduli after moisture conditioning at various levels of saturation conditioning (no lime, one freeze-thaw cycle).



	WY(1)	WY(2)	MT	GA(1)	GA(2)	NM
Original	292	495	260	185	204	226
No Sat.	196	267	255	139	214	153
55-80% Sat.	164	198	197	139	163	137
› 90% Sat.	130	176	228	136	226	165

FIGURE 5 Comparison of resilient moduli after moisture conditioning at various levels of saturation conditioning (lime added to prewet aggregate, one freeze-thaw cycle).

strengths are considered alone, the benefit of adding lime to the mixtures can be seen.

The large initial increase in strength is concealing the benefit of adding lime when only the ratios are considered. For this reason, assessments of moisture sensitivity should include not only limits on the strength ratios, but also minimum values of wet strengths.

Figures 6 and 7 indicate that the tensile strength ratios follow the same trends as the resilient modulus ratios—that is, as the level of saturation increases, the ratios decrease substantially for mixtures without lime (Figure 6). The tensile strength ratio is relatively insensitive to saturation levels when mixtures contain lime (Figure 7).

Number of Freeze-Thaw Cycles

Figure 8 shows typical trends in the resilient modulus ratios that can be expected for mixtures without lime. At six cycles of conditioning, virtually all mixtures have failed.

Figure 9 shows, once again, that the addition of lime significantly improves the moisture resistance of the mixtures. An increase in the number of freeze-thaw cycles from one to six results in only a slight to moderate decrease in resilient modulus ratio.

Not all data are presented in this summary report, but these trends were consistent regardless of the level of saturation for resilient modulus and tensile strength ratios (*6*).

Methods of Adding Lime

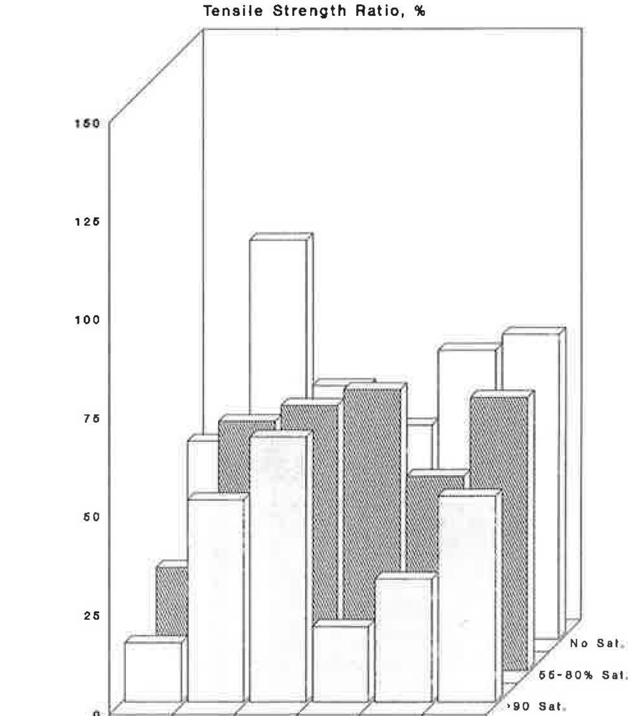
Figure 10 shows that the addition of lime, in any manner, produces essentially the same wet resilient modulus values after one freeze-thaw cycle. There is, again, a substantial improvement over mixtures without lime. Figure 11 shows that this is also true when the number of freeze-thaw cycles is increased to six. The mixtures without lime have essentially failed; those with lime, added by either method, still have substantial wet strengths.

COMPARISON OF LABORATORY RESULTS WITH CORES FROM PROJECTS

Both the levels of saturation and methods of adding lime will be compared in this section. From the laboratory comparison of test results, one freeze-thaw cycle was considered adequate to indicate any substantial changes in mixture properties and will not be considered as a comparison variable in this section.

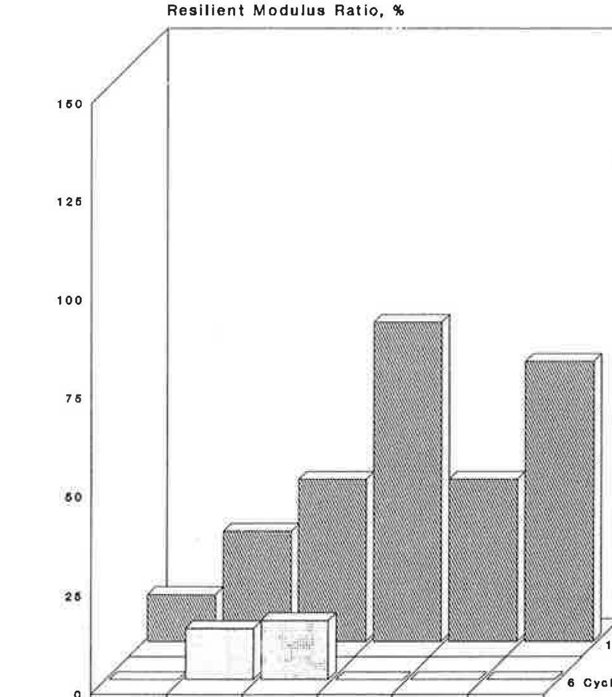
Levels of Saturation

Both resilient modulus and tensile strength values were obtained for cores from all of the field sections. A direct comparison between laboratory test results and core properties



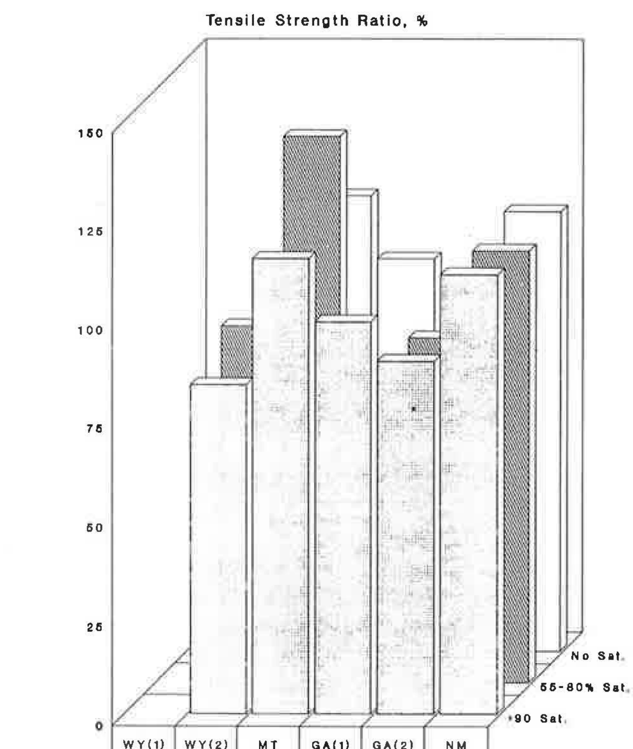
	WY(1)	WY(2)	MT	GA(1)	GA(2)	NM
No Sat.	50	101	64	54	73	77
55-80% Sat.	26	63	67	71	49	69
>90 Sat.	15	51	67	19	31	52

FIGURE 6 Impact of moisture on tensile strength ratios for various levels of saturation for mixtures with no lime (one freeze-thaw cycle).



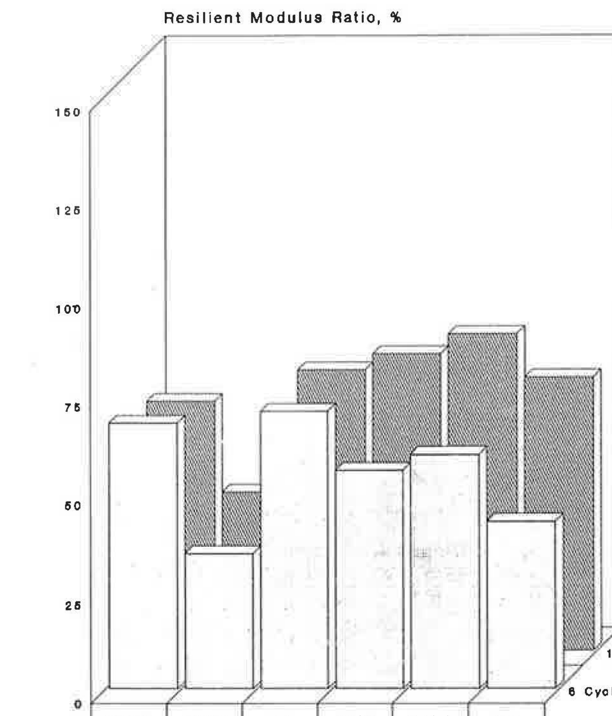
	WY(1)	WY(2)	MT	GA(1)	GA(2)	NM
1 Cycle	12	28	41	61	41	71
6 Cycles	0	13	15	0	0	0

FIGURE 8 Impact of number of freeze-thaw cycles on resilient modulus ratio (no lime, 55 to 80 percent saturation).



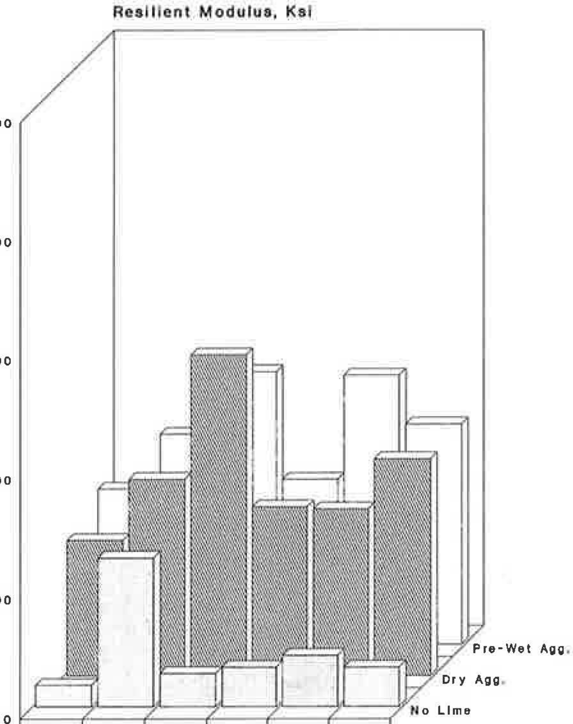
	WY(1)	WY(2)	MT	GA(1)	GA(2)	NM
No Sat.	NA	83	115	99	89	111
55-80% Sat.		90	136	68	87	109
>90 Sat.		83	115	99	89	111

FIGURE 7 Impact of moisture on tensile strength ratio for levels of saturation for mixtures with lime added to prewet aggregate (one freeze-thaw cycle).



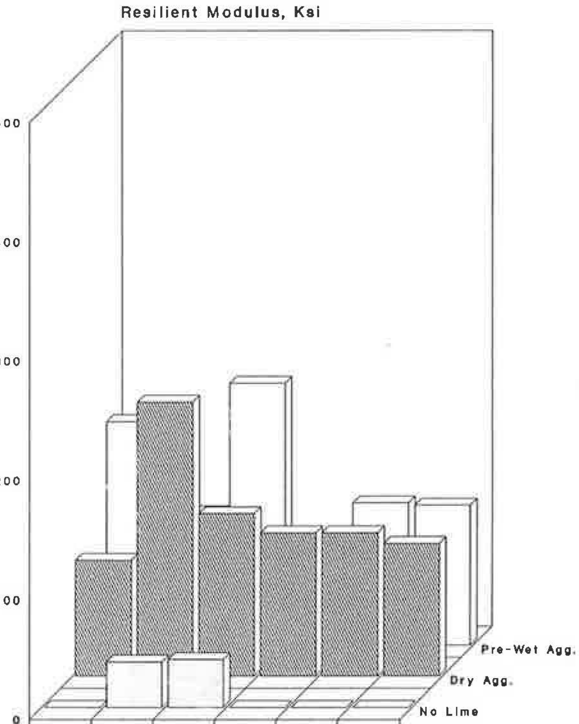
	WY(1)	WY(2)	MT	GA(1)	GA(2)	NM
1 Cycle	63	40	71	75	80	69
6 Cycles	67	34	70	55	59	42

FIGURE 9 Impact of number of freeze-thaw cycles on resilient modulus ratio (lime added to prewet aggregate, 55 to 80 percent saturation).



	WY(1)	WY(2)	MT	GA(1)	GA(2)	NM
Pre-Wet Agg.	130	176	228	168	225	184
Dry Agg.	113	164	268	141	139	181
No Lime	18	124	28	33	43	33

FIGURE 10 Impact of various methods of adding lime on moisture sensitivity of mixtures (55 to 80 percent saturation, one freeze-thaw cycle).



	WY(1)	WY(2)	MT	GA(1)	GA(2)	NM
Pre-Wet Agg.	167	111	219	83	119	117
Dry Agg.	97	229	136	120	120	111
No Lime	0	38	40	0	0	0

FIGURE 11 Impact of various methods of adding lime on moisture sensitivity of mixtures (55 to 80 percent saturation, six freeze-thaw cycles).

can be made for 9 of the 13 sections constructed. This reduction in the data base is because neither the particular lime slurry nor the lime blended with the binder could be reproduced in the preparation of laboratory specimens.

In theory, if the laboratory estimate of moisture damage is accurate, conditioned resilient modulus and tensile strengths should be reflected by the core properties several years after construction. Figures 12 and 13 show that this is true for these sections. What is interesting is that the results for the no saturation and 55 to 80 percent saturation reflect the core properties. In fact, the no-saturation option appears to best reflect the discrete differences between the projects. As the levels of saturation increase to above 90 percent for the laboratory-prepared specimens, the differences between the projects become less evident.

This leads to the conclusion that each mixture has a unique affinity for water, and hence subsequent moisture damage. All that is required to induce moisture damage is to expose the compacted specimen to warm water after it has been frozen. This affinity for water can be accentuated if the specimens are initially saturated; however, the subtle distinctions between projects can be camouflaged by high levels of saturation.

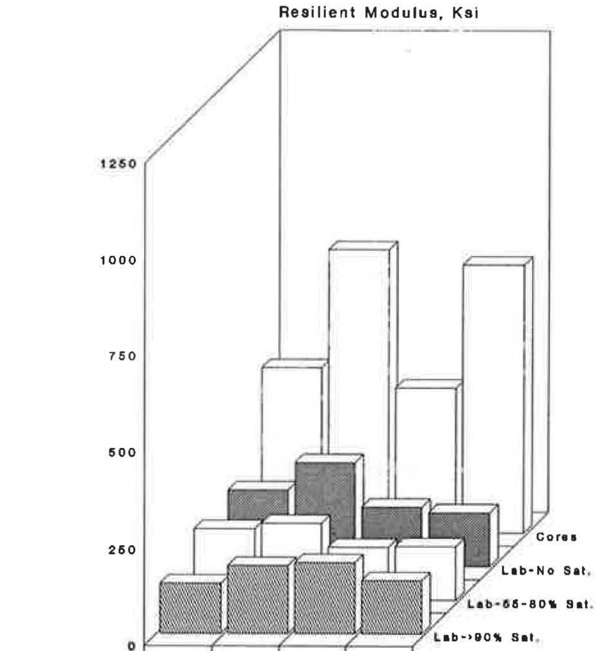
Methods of Adding Lime

These figures also provide a means for comparing methods of adding lime. Figure 12 presents data for both laboratory-prepared specimens and cores for mixtures with lime added to prewet aggregate. The first fact that is obvious is that the cores produce stiffer mixture properties than the laboratory specimens. The higher core stiffness is, as expected, attributable to the decrease in air voids (known to increase resilient moduli) from traffic and stiffening of the binder due to oxidation and ultraviolet light. The second fact is that the trend (or ranking) shown by the core properties is evident in the laboratory-prepared specimens when either the no-saturation or the 55-to-80-percent-saturation option is used. This would indicate that the laboratory method of introducing lime into the laboratory samples reasonably represents field conditions.

Figure 13 provides the same comparison for mixtures with lime added to dry aggregate. Again, the same trends as discussed are apparent.

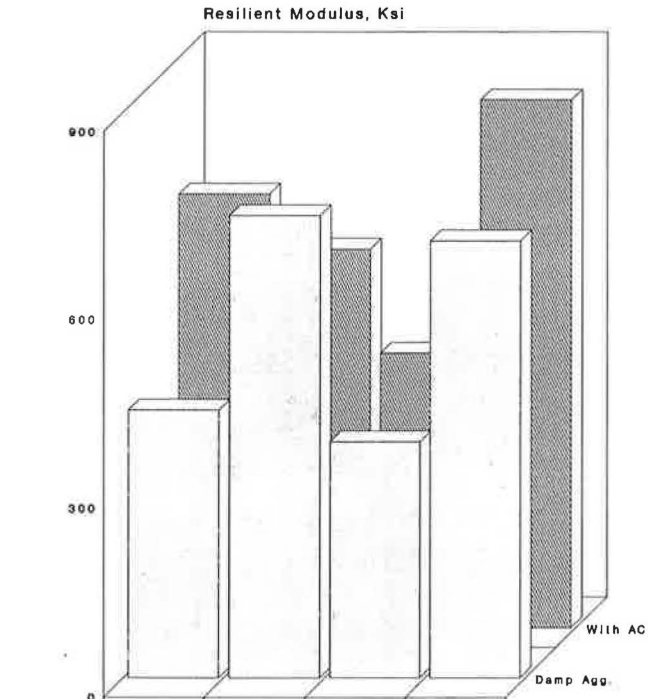
Four of the 13 field sections can provide a direct comparison of methods of adding lime in the field. Figures 14 and 15 show a comparison of resilient modulus and tensile strengths, respectively, for lime added in the drum with the binder and lime added to damp aggregate on the cold feed belt. The data show that both methods of introducing the lime during construction generally produce mixtures with similar properties; this is generally more true of the tensile strengths than of the resilient modulus. In one case there is little impact on the moduli, in two cases lime added with the binder produced significantly higher moduli, and in another case the moduli increased when the lime was added to damp aggregate.

The use of either a drum or batch plant does not appear to alter this conclusion. Figure 16 shows that the Georgia



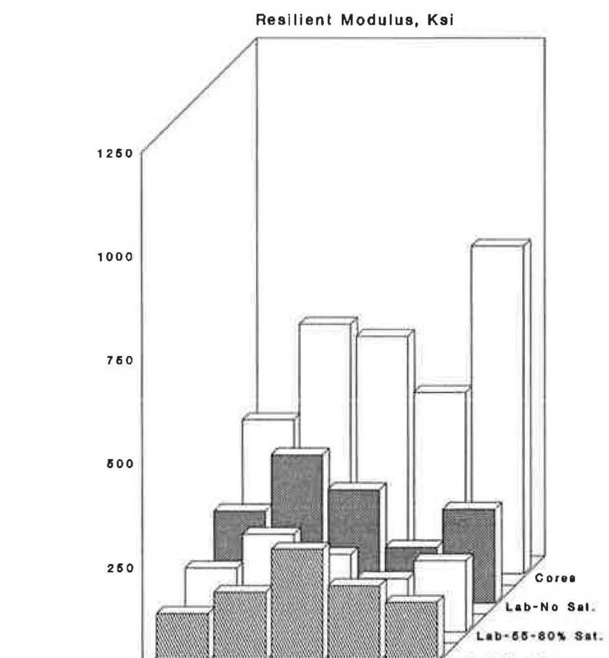
	WY(1)	WY(2)	NW	GA(1)
Cores	425.4	733.8	374.2	694.2
Lab-No Sat.	196	267	153	139
Lab-55-80% Sat.	184	196	137	139
Lab->90% Sat.	130	176	184	136

FIGURE 12 Comparison between cores and lab estimate of resilient modulus after moisture damage (lab samples: one freeze-thaw cycle, lime added to prewet aggregate; cores: unconditioned value, lime added to damp aggregate).



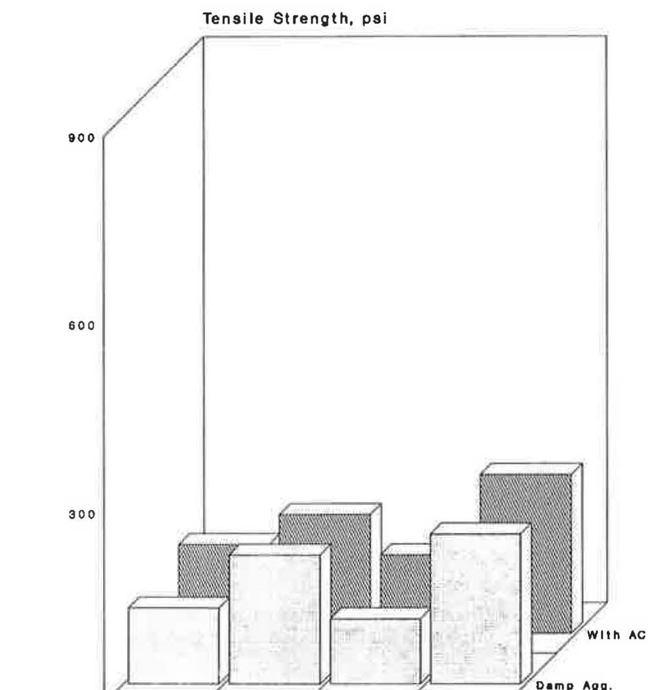
	WY(1)	WY(2)	NM	GA(1)
With AC	689	601	436	840
Damp Agg.	425	734	374	694

FIGURE 14 Comparison of methods of adding lime for field sections.



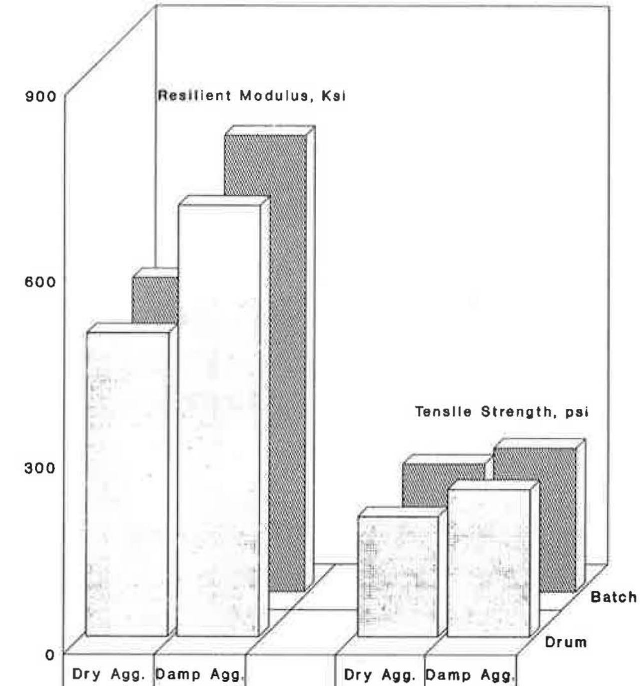
	WY(1)	WY(2)	MT	NM	GA(1)
Cores	369.8	601.2	571.8	436.2	788.8
Lab-No Sat.	220	354	271	134	224
Lab-55-80% Sat.	153	234	186	129	171
Lab->90% Sat.	113	164	266	181	141

FIGURE 13 Comparison between cores and lab estimate of resilient modulus after moisture damage (lab samples: one freeze-thaw cycle, lime added to dry aggregates; cores: unconditioned value, lime added to asphalt concrete).



	WY(1)	WY(2)	NM	GA(1)
With AC	141	188	124	251
Damp Agg.	120	204	103	237

FIGURE 15 Comparison of methods of adding lime for field sections.



	Dry Agg.	Damp Agg.		Dry Agg.	Damp Agg.
Batch	504	734		204	230
Drum	488	694		194	237

FIGURE 16 Comparison of resilient modulus and tensile strength between drum and batch plants (Georgia cores).

projects constructed with both plants show virtually no difference in either resilient modulus or tensile strength.

SUMMARY

The following conclusions can be drawn from the data presented in this paper:

1. Mixtures without lime will exhibit a significant loss of both resilient modulus and tensile strength even though the initial saturation step is eliminated.
2. Mixtures with lime require some level of initial saturation in order for the resulting impact of moisture on resilient modulus and tensile strength to be significant.
3. When the number of freeze-thaw cycles is increased from one to six, mixtures without lime generally do not survive the testing sequence. The impact of the increased numbers of cycles is substantially reduced for mixtures with lime.
4. Lime added to either dry or prewet aggregate for laboratory-prepared specimens produces mixtures with similar resilient moduli values for a given aggregate source.
5. Laboratory methods of adding lime to either prewet aggregate or to dry aggregate appear to reasonably simulate the field application of lime to damp aggregate on the cold feed belt and lime added with the binder in the drum, respectively.
6. When laboratory test results after various methods of moisture conditioning are compared to moduli (unconditioned) cores obtained from in-service pavements, the following conclusions can be drawn: (a) the relative ranking of the resilient moduli values for the various projects is consistent between test methods using no initial saturation and 55 to 80 percent saturation—there is less agreement for the more-than-90-percent-saturation option because of the decrease in differences evident between the projects; and (b) as the level of initial saturation is increased, the distinction between the various projects is reduced. The no-initial-saturation option best replicates the distinction observed between the projects.
7. Using one freeze-thaw cycle for conditioning laboratory-prepared specimens reflects pavement performance when either no or 55 to 80 percent saturation is used.
8. A limited comparison of methods of adding lime during construction indicates mixtures with either lime added to prewet aggregate or lime added with the binder inside of the drum produce mixtures with similar properties. No difference was noticed between either drum or batch plants.

RECOMMENDATIONS

From the findings presented in this report, the following recommendations are made:

1. The initial saturation level step can be eliminated when specimen is frozen before the warm-water soaking.
2. If initial saturation is used, saturation levels should be no more than 80 percent.
3. One freeze-thaw cycle is sufficient for estimating pavement performance.

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