Antistrip Additives: Background for a Field Performance Study

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Water sensitivity of asphalt concrete pavements is of great importance nationwide. Water-sensitive pavement may suffer damage that leads to reduced pavement life when subject to moisture. To alleviate this problem, various liquid antistripping additives have been developed. In this paper are presented the results of a study on the effectiveness of antistrip additives for materials used in the reconstruction of Nevada State Highway 207. Preconstruction mixtures containing various antistripping additives (liquids and solids), construction mixtures mixed in the field and compacted in the laboratory, and cores taken after construction were subjected to laboratory conditioning using vacuum saturation plus one cycle of freeze-thaw. Test results show that a slight reduction in water sensitivity was obtained in mixtures that contained the liquid antistrip additives in comparison with control mixtures without additives or mixtures containing portland cement as an antistripping material. Results of evaluation of mixtures during the preconstruction phase of the project indicate that mixtures that contain lime slurry exhibited significant reductions in water sensitivity. Test results of field cores show agreement with preconstruction mixtures in the prediction of water sensitivity. Test results of cores also indicate that no significant changes in mixture strength and water sensitivity have taken place during the first year of life. In addition, visual surveys have indicated that test sections that contain either the liquid antistripping additive or portland cement additive have performed well during the first year of pavement life.

Premature pavement distress in the form of raveling and cracking has occurred on several pavements in Nevada in the last several years *(1, 2)*. These types of distress are caused in part by water sensitivity (loss of bond between the asphalt cement and the aggregate or loss of strength in the presence of water, or both) of the paving mixtures.

Several techniques can be used to reduce the sensitivity of an asphalt concrete mixture to water or moisture. Liquid "antistrip" chemicals as an additive to asphalt cement and portland cement or lime as an additive to aggregate (dry or in slurry form) are commonly used throughout the United States as antistrip agents. Paving mixtures that have been designed to account for the effects of water sensitivity by the use of antistripping agents can be cost-effective for governmental agencies. Liquid chemical antistrip agents added to asphalts are preferred by several public agencies and contractors because of their cost advantage and ease of handling during construction. However, research has indicated that several liquid antistrip chemicals used in asphalt cements are not effective over a wide range of material types.

New chemical formulations that show promise for solving difficult stripping problems are being developed. One of these new products is being evaluated in Nevada. In this paper preconstruction, construction, and postconstruction portions of the research study are discussed. Laboratory comparisons of this relatively new product, a conventional liquid antistrip chemical in asphalt cement, portland cement, and lime are presented. A more detailed report of this project can be found elsewhere *(3)*.

DESCRIPTION OF PROJECT

A portion of Nevada State Highway 207 was reconstructed and realigned in 1984 and 1985. The project, locally known as Kingsbury Grade, is located in Douglas County and connects the Carson Valley with US-50 near Stateline, Nevada (Figure 1). The project is approximately 3.8 mi in length. The average daily traffic for 1985 was 14,670 over the length of the project. The projected traffic level for the year 2005 is 27,160 *(4)*. The test section within the project is located at elevations that range from 7,075 to 7,300 ft above sea level. Average annual precipitation for the area is 23 in. during a 70-day period. One hundred forty air freeze-thaw cycles occur annually. Maximum

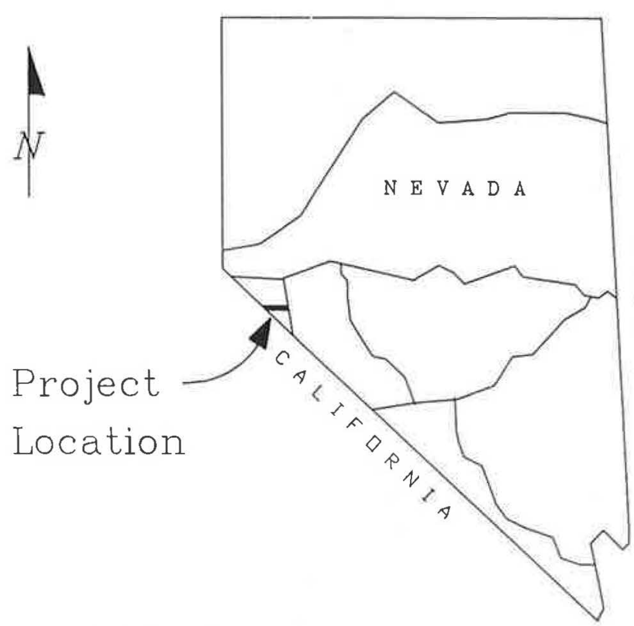

FIGURE 1 Location of project.

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air temperatures rarely exceed 90°F. Typical minimum temperatures are 0°F.

The typical reconstructed cross section of the roadway consists of a 3/4-in. open-graded bituminous wearing surface and 5 1/2 in. of dense-graded Type-2 asphalt concrete over a Type-2 Class-B aggregate base. The Type-2 dense-graded asphalt concrete used on the project contains one of two antistrip agents, portland cement, or a liquid antistrip additive. The open-graded surface layer contains portland cement as an antistrip material. Laboratory preconstruction tests to evaluate water sensitivity were performed on these and several other antistrip agents. Loose samples of field-prepared mixtures and core samples from the in-place pavement were also obtained and subjected to the laboratory testing program.

Because this project is located within a severe climatic area of the state, a test section to evaluate a new antistrip chemical was included within its bounds. The test section was placed during the second year of construction, and the change to include the test section was made after the project was under contract. Because the project was under contract and additional costs associated with test sections needed to be minimized, only one test section was placed although others would normally have been included to better define the field performance of antistrip materials and to provide additional life-cycle cost data on the various additives. Time constraints and equipment availability also severely limited the number of test sections.

MATERIALS

Asphalt Cement

The asphalt cement used for the project was obtained from a San Francisco Bay area refinery. The physical properties of the AR-4000 asphalt cement are given in Table 1.

Aggregate

The aggregate was obtained from a river deposit located near Gardnerville, Nevada, and a decomposed-granite pit located near the junction of US-50 and US-395. The physical properties and specifications of the aggregate are given in Table 2.

Portland Cement

A Type-IP portland cement was used on the project.

Lime

A hydrated high-calcium lime was used in the laboratory portion of the study.

Liquid Antistrip Chemicals

Two proprietary liquid antistrip chemicals were used in the study. Both materials are used as additives to asphalt cements. Liquid Additive 1, the first-generation additive, has been used throughout the United States for a number of years. Liquid Additive 2, a second-generation additive developed more recently, was also studied. Properties of the materials are given in Table 3.

TEST PROGRAM

Laboratory tests were performed on samples prepared before construction, during construction, immediately following construction, and 1 year after construction. Preconstruction sam-

TABLE 1 PROPERTIES OF ASPHALT CEMENT OBTAINED BEFORE CONSTRUCTION

	San Francisco Bay Area AR-4000		
Property	No Additive, Sampled 7/24/84	0.5% Liquid Additive 1, Sampled 11/5/84	0.5% Liquid Additive 2, Sampled 11/5/84
Original			
Viscosity at 140°F (poises)	2263	2280	2540
Penetration at 77°F (dmm)	47	37	36
Penetration at 39.2°F (dmm)		6	10
Viscosity at 275°F (cSt)	340	293	286
Softening point (°F)		125	126
Flash point, COC[a] (°F)	475+	475+	475+
Aged (after RTFOT[b], ASTM D 2872)			
Viscosity at 140°F (poises)	4617	4603	4614
Penetration at 77°F (dmm)	34	24	23
Penetration at 39.2°F (dmm)		3	9
Viscosity at 275°F (cSt)	469	413	406
Softening point (°F)		134	135

[a]Cleveland open cup.
[b]Rolling thin-film oven test.

TABLE 2 PROPERTIES OF AGGREGATE AS COMBINED FOR TYPE-2 GRADATION

	Percent Passing				
Sieve Size	Gradation	Specification	Property	Result	Specification
1 in.	100	100	Specific gravity	2.58	
3/4 in.	98	90–100	Liquid limit	21	35 max
1/2 in.	84				
3/8 in.	74	63–85	Plasticity index	NP	6 max
No. 4	58	45–65			
No. 10	42		Fractured faces (%)	85	50 min
No. 16	34	20–40	Los Angeles, abrasion, 500 rev (%)	23.3	45 max
No. 40	18				
No. 50	13		Surface area (ft^2/lb)	26.8	
No. 100	8				
No. 200	5	3–9	Swell test (in.)	0.003	0.03 max

NOTE: Percentages as combined from pit are as follows:

Size	Percentage
3/4 in.	28.8
3/8 in.	17.6
Natural sand	43.6
Decomposed granite	10

ples were mixed and compacted in the laboratory. The variables considered in this portion of the study included

1. Type and amount of antistrip agent,
2. Asphalt content, and
3. Type and gradation of aggregate.

Table 4 gives the test matrix associated with this portion of the study. Figure 2 shows the test sequence used on the preconstruction samples. Conventional mixture design tests were also performed with various combinations of materials.

Loose samples of asphalt concrete were obtained from behind the paving machine during construction. Conventional quality control tests were performed by the Nevada Department of Transportation (NDOT). Additional tests were performed on laboratory-compacted samples of this loose mixture (Table 4 and Figure 2).

Core samples were obtained a few days after construction and also 1 year after construction. The core samples were obtained with a water-cooled coring unit, wrapped in plastic, and transported to the laboratory. At the laboratory, the cores were removed from the plastic and allowed to air dry for 48 hr before being subjected to the test program shown in Figure 2.

TEST METHODS

Conventional mixture design and quality control tests were performed by NDOT. These tests used standardized AASHTO *(5)* and NDOT *(6)* procedures. Resilient modulus, indirect tensile strength, and modified Lottman water sensitivity tests were performed by the Construction Materials Laboratory, University of Nevada-Reno. These test methods are briefly described.

The resilient modulus (Young's modulus for viscoelastic materials) was determined by ASTM D 4123 *(7)*. The test

TABLE 3 TYPICAL PHYSICAL PROPERTIES OF LIQUID ANTISTRIP AGENTS

Property	First-Generation Additive	Second-Generation Additive
Active ingredients (%)	100	100
Form	Liquid	Viscous liquid
Color	Dark brown	Dark
Type	Alkaline	Metallo amine complex
Pour point, ASTM D 97 (°F)	20–30	60
Viscosity, ASTM D 445-79 (cSt)		
At 77°F	750–2000	35 000[a]
At 100°F	250–860	–[b]
At 140°F	–[b]	1500[c]
Flash point, ASTM D 92-78, COC (°F)	275 min	375
Specific gravity, 77°F/60°F (U.S.P. method)	1.03	1.10
Weight at 77°F (lb/gal)	8.6	9.18

[a]Plus or minus 15 percent.
[b]Dash = not specified.
[c]Plus or minus 10 percent.

TABLE 4 VARIABLES CONSIDERED IN PROJECT

Amount of Decomposed Granite (%)	Asphalt Content (% by dry weight of aggregate)	Additive Type and Percentage						
		No Additive	1% Portland Cement Applied Dry[a]	1% Lime Applied Dry[a]	1% Lime Applied in Slurry[a]	2% lime Applied in Slurry[a]	0.5% Liquid Additive 1[b]	0.5% Liquid Additive 2[b]
0	6.0		PC	PC	PC	PC		
	6.25							
	6.5	PC					PC	PC
5	6.0							
	6.25							LC
	6.5							
10	6.0	PC	PC	PC	PC	PC	PC	PC
	6.25			LC, CC				LC, CC
	6.5							

NOTE: PC = preconstruction tests, LC = loose mix sampled during construction and completed in laboratory, and CC = cores obtained after construction.
[a]Percent by dry weight of aggregate.
[b]Percent by weight of asphalt.

procedure involves the application of a light repetitive load through a load cell along the vertical axis of the sample. Loads were applied for a duration of 0.1 sec at 3.0-sec intervals.

Resilient modulus values for all samples were obtained at 77°F. Control samples were tested in the dry condition, and samples subject to moisture conditioning were tested under saturated surface dry (SSD) conditions.

Indirect Tensile Strength

Indirect tension was determined by ASTM D 4123 *(7)*. The equipment required and the loading procedure are described in ASTM C 496 *(8)*. A deformation rate of 2.0 in./min was used until sample failure occurred. The calculation of tensile strength at failure is also described in ASTM C 496. It should be noted that tensile strength measurements for core samples taken in May 1986 were taken with a Marshall testing machine as described in ASTM D 1559 *(8)* because the previously used mechanical testing apparatus had suffered flood damage. Measurements of indirect tensile strength were obtained at 77°F in either the dry or the SSD condition.

Lottman Water Sensitivity

The procedure used for moisture conditioning is essentially that used by Lottman *(9)* with slight modification. Specimens were subjected to vacuum saturation at 26 in. Hg vacuum for 2 hr and then the resilient modulus test was performed under the SSD condition. The samples were again subjected to vacuum saturation for 10 min, tightly wrapped in thin plastic, and frozen at −20°F for 15 hr. The frozen specimens were unwrapped and submerged in 140°F water for 24 hr and then submerged in 77°F water for approximately 2 hr. Resilient modulus and indirect tension results were determined at SSD conditions, and these results were compared with the test results for unconditioned samples.

PRECONSTRUCTION TESTS

Mixture Design

A mixture design for the Type-2 dense-graded asphalt concrete was performed by NDOT using the Hveem method. The design

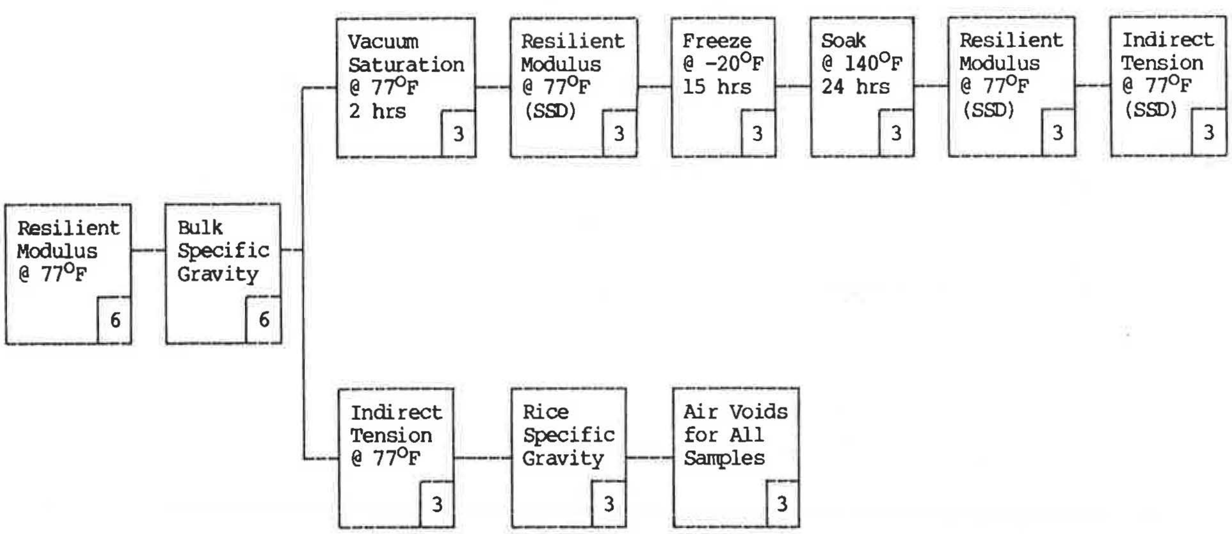

FIGURE 2 Test sequence for samples.

mixture was prepared from aggregates that contained 10.0 percent decomposed granite (DG) and no antistrip chemicals.

Mixtures with Antistrip Chemicals

Laboratory mixed and compacted samples were prepared at the University of Nevada and NDOT to determine the effectiveness of various types of antistrip agents. The type and quantities of antistrip agents used are listed next and are given in Table 4.

1. 1.0 percent portland cement (by dry weight of the aggregate) added dry to the aggregate,
2. 1.0 percent lime (by dry weight of the aggregate) added dry to the aggregate,
3. 1.0 percent lime (by dry weight of the aggregate) added as a slurry to the aggregate,
4. 2.0 percent lime (by dry weight of the aggregate) added as a slurry to the aggregate,
5. 0.5 percent (by weight of asphalt cement) Liquid Additive 1 (a first-generation liquid antistrip additive) added to the asphalt cement, and
6. 0.5 percent (by weight of asphalt cement) Liquid Additive 2 (a second-generation liquid antistrip additive) added to the asphalt cement.

These preconstruction mixes were prepared at 6.0 and 6.5 percent asphalt cement by dry weight of aggregate and at 0.0 and 10.0 percent decomposed granite (Table 4).

Test results are given in Tables 5 and 6 and shown in Figures 3–6. Properties of the mixtures before exposure to water are given in Table 5. A comparison of all antistrip agents investigated in this study is possible with mixtures containing 6.0 percent asphalt cement and 10.0 percent decomposed granite. Mixtures that contain either Liquid Additive 2 or slurried lime have the highest resilient modulus and tensile strength. This difference among types of antistrip agents is also evident for mixtures that contain 6.0 and 6.5 percent asphalt with no decomposed granite (Table 5, Figure 5). Note that the laboratory compaction effort was adjusted to provide air voids in the range of from 8 to 10 percent. This compactive effort was used to match the air voids obtained during laboratory measurements of initial field cores.

A comparison of properties of mixtures before and after they were subjected to the action of water is given in Table 6 and Shown in Figures 3–6. Figures 3 and 4 show comparisons of original resilient modulus, resilient modulus after soaking the sample with use of a vacuum, and resilient modulus after subjecting the sample to a freeze-thaw cycle (Lottman). Retained strength ratios as measured with resilient modulus and tensile strength after the Lottman tests are shown in Figures 5 and 6. A comparison of all antistrip agents investigated in this study is possible with mixtures containing 6.0 percent asphalt cement and 10.0 percent decomposed granite (Table 6, Figures 4 and 6). Retained resilient moduli after vacuum saturation only are at levels greater than 70 percent (Figure 4). After Lottman freeze-thaw conditioning, all mixtures except those that contained slurried lime were below the 70 percent retained strength level (Figure 6).

CONSTRUCTION TESTS

Quality Control Tests

Conventional quality control tests were performed by NDOT during the construction of the project. A complete review of the data is found elsewhere *(3)*. The data are summarized here.

Asphalt Cement Properties

Original and laboratory-aged viscosity and penetration data for the asphalt cement sampled during construction were obtained from samples with and without the liquid antistrip chemicals. The original and aged viscosities and penetrations were not found to be substantially affected by the liquid antistrip chemical.

TABLE 5 AVERAGE TEST RESULTS BEFORE MOISTURE CONDITIONING (preconstruction)

Sample Identification	Resilient Modulus (ksi)	Indirect Tension (psi)	Air Voids (%)
6.0% AC, no DG			
1.0% PC	408	115	10.9
1.0% lime (dry)	500	121	10.4
1.0% lime slurry	679	180	8.4
2.0% lime slurry	624	169	8.8
6.5% AC, no DG			
No additive	470	131	10.7
0.5% Liquid Additive 1	480	127	9.3
0.5% Liquid Additive 2	556	159	9.7
6.0% AC, 10% DG			
No additive	424	119	10.1
0.5% Liquid Additive 1	461	124	9.5
0.5% Liquid Additive 2	672	161	10.1
1.0% PC	456	129	9.3
1.0% lime (dry)	476	126	8.6
1.0% lime slurry	658	170	8.9
2.0% lime slurry	556	150	9.5

TABLE 6 AVERAGE TEST RESULTS FOR MOISTURE-CONDITIONED SAMPLES (preconstruction)

	Resilient Modulus				Tensile Strength	
Sample Identification	After Vacuum Saturation (ksi)	Retained Strength (%)	After 1 Cycle Lottman (ksi)	Retained Strength (%)	After 1 Cycle Lottman (psi)	Retained Strength (%)
6.0% AC, No DG:						
1.0% PC	405	99	80	20	25	22
1.0% Lime (dry)	486	97	77	15	23	19
1.0% Lime slurry	637	94	437	64	151	84
2.0% Lime slurry	610	98	606	97	155	92
6.5% AC, No DG:						
No additive	405	86	82	17	24	18
0.5% Liquid Additive 1	398	83	132	28	38	30
0.5% Liquid Additive 2	692	124	293	53	60	38
6.0% AC, 10% DG:						
No additive	328	77	55	13	18	15
0.5% Liquid Additive 1	374	81	84	18	28	23
0.5% Liquid Additive 2	701	104	195	29	52	32
1.0% PC	487	107	68	15	22	17
1.0% Lime (dry)	557	117	54	11	16	13
1.0% Lime slurry	530	81	469	71	152	89
2.0% Lime slurry	641	115	558	100	161	107

Asphalt Content

Asphalt content was determined by both tank measurements and mixture extraction tests. Reported average asphalt cement contents were slightly lower than the target value.

Aggregate Gradation

Aggregate gradation was determined on residual aggregate from the extraction of plant mix used for asphalt content determination. Gradation data showed substantial compliance with Type-2 specifications.

Mixture Placement Conditions

The specified job mix formula range of temperature for dense-graded asphalt cements was 255°F to 325°F for the completed mixtures in the haul vehicles just before they left the plant *(10, 11)*. All reported values are within the specified range. Requirements for open-graded mixtures were 255°F to 290°F *(10, 11)*. Some values exceeded the desired range.

Special Laboratory Tests

Loose samples of the dense-graded mixtures were obtained during construction and compacted in the University of Nevada

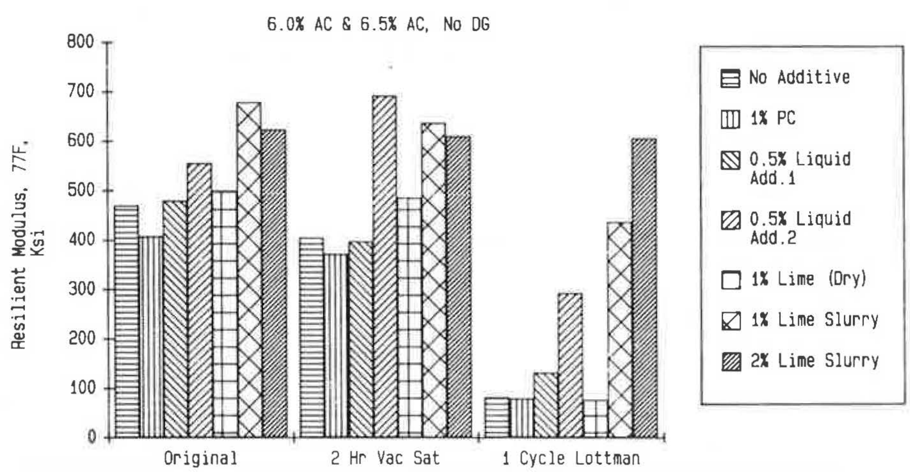

FIGURE 3 Resilient modulus through conditioning cycle, no DG (preconstruction).

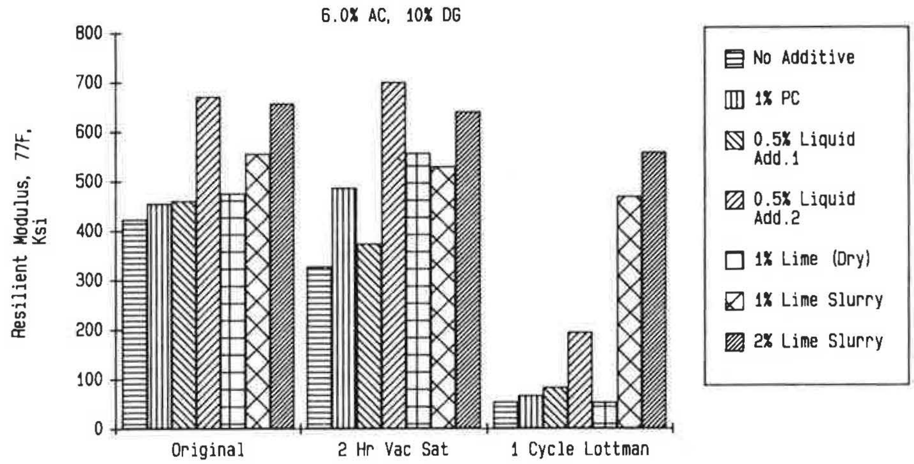

FIGURE 4 Resilient modulus through conditioning cycle, 10% DG (preconstruction).

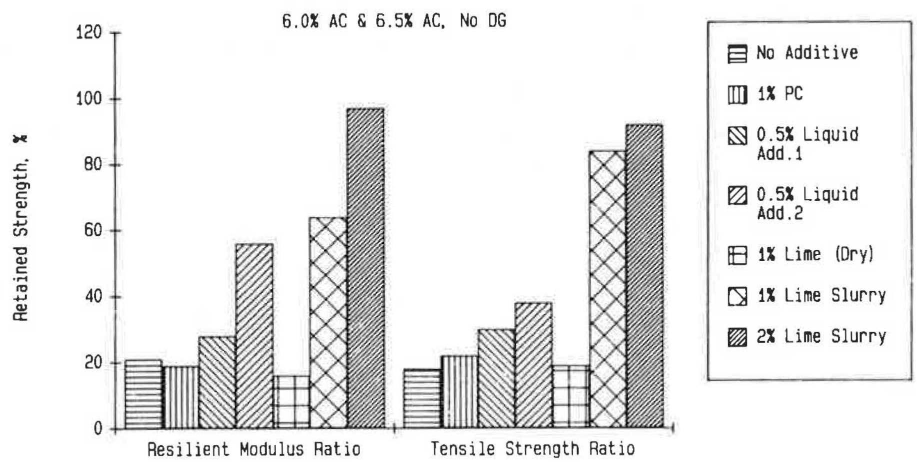

FIGURE 5 Resilient modulus and tensile strength ratios, no DG (preconstruction).

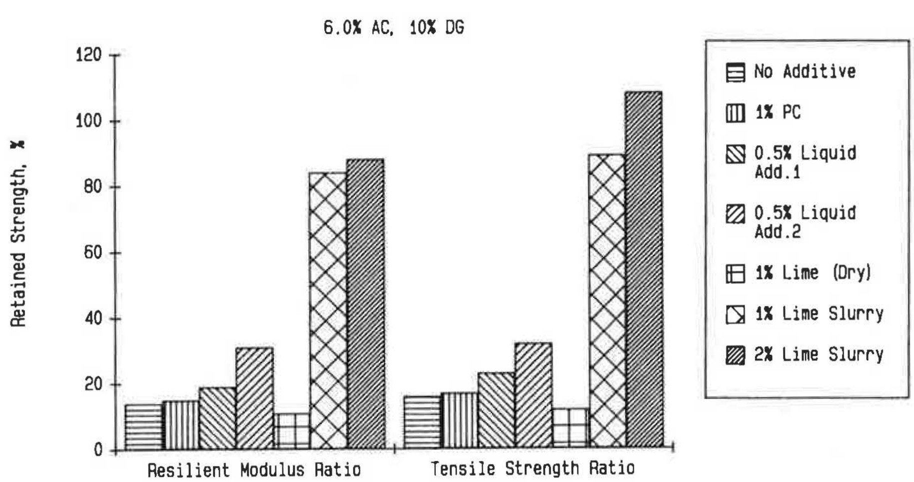

FIGURE 6 Resilient modulus and tensile strength ratios, 10% DG (preconstruction).

TABLE 7 AVERAGE TEST RESULTS BEFORE MOISTURE CONDITIONING (loose field mix and core samples)

Sample Identification	Resilient Modulus (ksi)	Indirect Tension (psi)	Air Voids (%)
Loose field mix samples			
1.0% portland cement	440	119	9.9
0.5% Liquid Additive 2, 5% DG	388	126	10.5
0.5% Liquid Additive 2, 10% DG[a]	345	111	11.2
0.5% Liquid Additive 2, 10% DG[b]	343	101	10.7
Cores taken July 1985			
1.0% portland cement	136	100	11.1
0.5% Liquid Additive 2, top lift	212	135	9.2
0.5% Liquid Additive 2, bottom lift	337	134	8.3
Cores taken May 1986			
1.0% portland cement	283	71	10.7
0.5% Liquid Additive 2, top lift	270	81	10.6
0.5% Liquid Additive 2, bottom lift	488	105	9.4

[a]Location 1.
[b]Location 2.

Construction Materials Laboratory. The samples were subjected to the test program shown in Figure 2. Test results are given in Tables 7 and 8 and shown in Figures 7 and 8. Portland cement and Liquid Additive 2 were used as antistrip agents in the field mixtures. The majority of the field mixtures contained 10.0 percent decomposed granite with a target asphalt content of 6.25 percent by dry weight of aggregate. A control section without antistrip agents was not placed on the project.

Slightly higher resilient modulus at 77°F and tensile strength were noted for the mixtures that contained portland cement (Table 7). The portland cement may be acting as a mineral filler and increasing the stiffness of the asphalt cement.

Retained resilient modulus and tensile strength after Lottman test are uniformly low for the various mixtures (Table 8, Figure 8). Note that the laboratory compaction effort was adjusted to produce samples with air voids in an 8 to 10 percent range to simulate air void measurements obtained from initial field cores (Table 7).

POSTCONSTRUCTION TESTS

Core samples of dense-graded mixtures were obtained a few days after construction (July 1985) and again 1 year after construction (May 1986). The cores were subjected to the test program shown in Figure 2. Test results are given in Tables 7 and 8 and shown in Figures 9 and 10.

Slightly higher resilient modulus and tensile strength values

TABLE 8 AVERAGE TEST RESULTS FOR MOISTURE-CONDITIONED SAMPLES (loose mix and core samples)

	Resilient Modulus				Tensile Strength	
Sample Identification	After Vacuum Saturation (ksi)	Retained Strength (%)	After 1 Cycle Lottman (ksi)	Retained Strength (%)	After 1 Cycle Lottman (psi)	Retained Strength (%)
Loose Mix Field Samples:						
1.0% PC	185	42	52	12	18	15
0.5% Liquid Additive 2, 5% DG	210	54	63	16	21	17
0.5% Liquid Additive 2, 10% DG (1)	253	73	44	13	22	20
0.5% Liquid Additive 2, 10% DG (2)	132	38	48	14	25	25
Cores Taken July 1985:						
1.0% PC	127	94	31	23	13	13
0.5% Liquid Additive 2, top lift	231	109	80	38	32	24
0.5% Liquid Additive 2, bottom lift	315	93	112	33	45	34
Cores Taken May 1986:						
1.0% PC	227	80	42	15	16	23
0.5% Liquid Additive 2, top lift	270	100	65	24	28	35
0.5% Liquid Additive 2, bottom lift	536	110	146	30	46	44

(1) Location 1
(2) Location 2

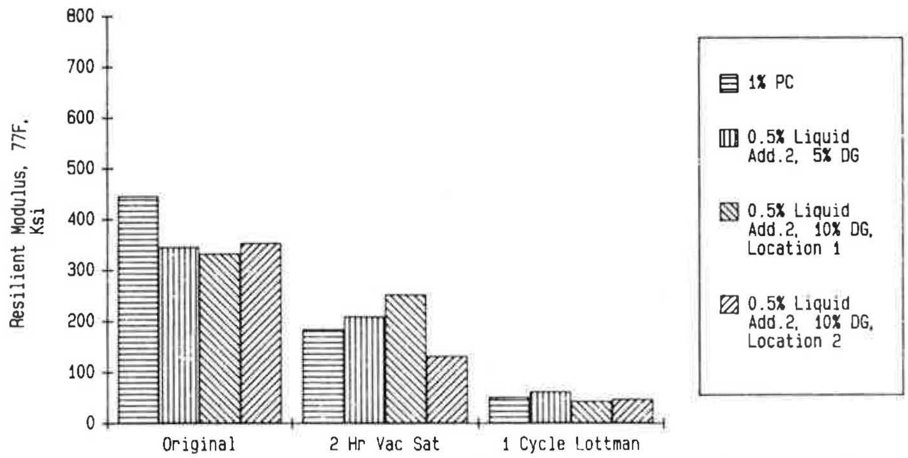

FIGURE 7 Resilient modulus through conditioning cycle (loose field mix).

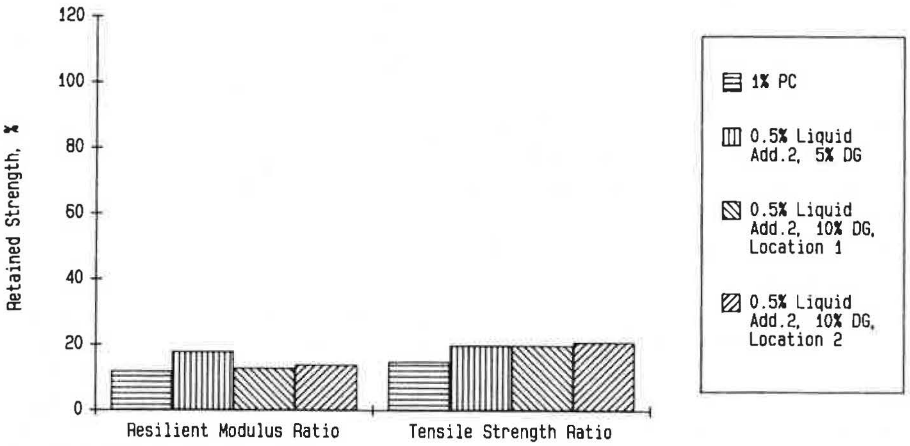

FIGURE 8 Resilient modulus and tensile strength ratios (loose field mix).

were obtained with the liquid antistrip additive (Table 6) for cores taken in July 1985. Part of this difference is associated with the higher air void content of the mixtures that contained portland cement.

Retained resilient modulus and tensile strength values after the Lottman test are low (Table 8, Figures 9 and 10). The mixtures that contained the liquid antistrip agent had slightly higher retained properties than did those mixtures that contained portland cement (Figure 10). Note that the field compaction procedure produced in-place air voids in the range of from 8 to 11 percent (Table 7).

Resilient modulus values for cores taken during May 1986 show an increase in stiffness over those taken in July 1985 (Table 7). The top lift, which contains portland cement, has

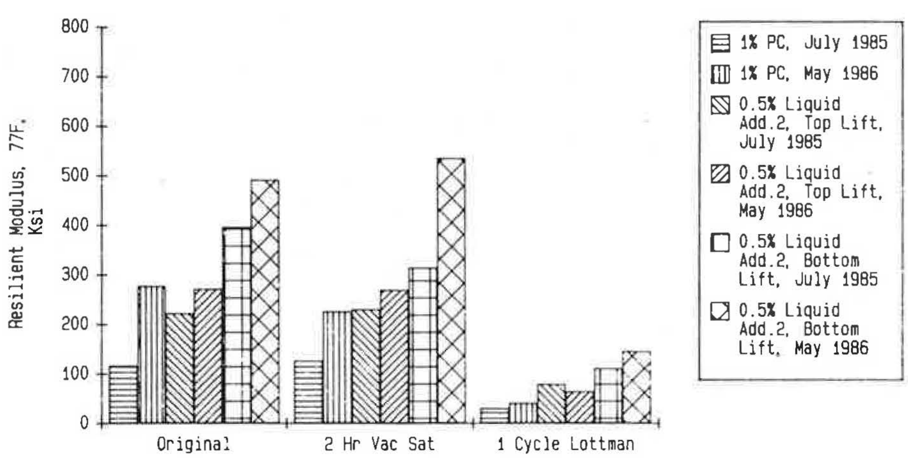

FIGURE 9 Resilient modulus through conditioning cycle (cores).

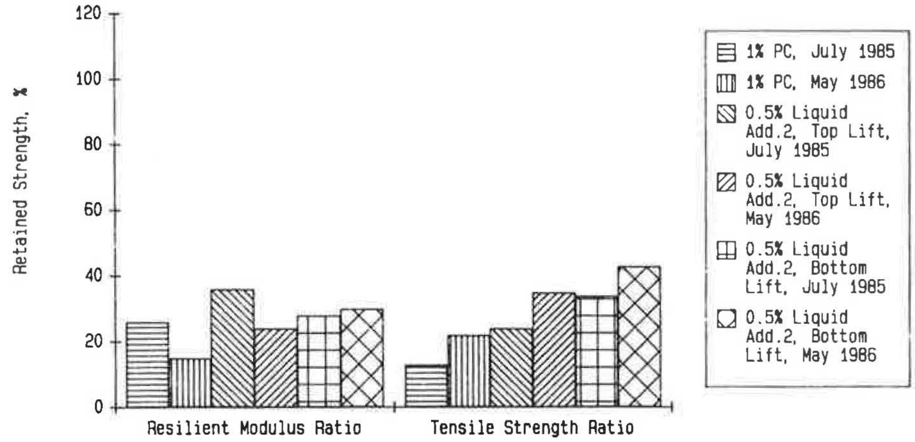

FIGURE 10 Resilient modulus and tensile strength ratios (cores).

stiffness values that have increased significantly relative to the stiffness increase for the top lift of Liquid Additive 2. Resilient modulus measurements on the top lifts of cores sampled during May 1986 show that stiffness values for cores that contain portland cement are quite similar to stiffness values obtained with Liquid Additive 2 (Table 7). Tensile strength values have decreased somewhat. Note that tensile strength values for cores sampled during May 1986 were obtained with a different testing apparatus than were the values reported for July 1985 cores. Resilient modulus values after moisture conditioning did not change significantly during this time (Table 8, Figure 9). Retained strength ratios show no definite trends between these two dates (Figure 10).

A visual survey of the construction project was made during November 1986. A roadway section representing the liquid antistripping agent and a section representing portland cement additive were selected for the survey. Both sections of the roadway appear to be in good condition. There were no occurrences of cracking, rutting, raveling, or bleeding evident in either section. The open-graded layer contains 1.0 percent portland cement as an antistripping agent and was placed over all portions of the project.

CONSTRUCTION PROBLEMS

During the placement of the mixture that contained the liquid antistrip additive, "tenderness" was noted during rolling. "Shoving" and "checking" were noted during steel breakdown rolling. Checking was more severe for downgrade rolling than for upgrade rolling. Only one pass of breakdown rolling was used because two passes proved detrimental to the mat. The temperature was reduced to 180°F for this pass to control the shoving associated with tenderness. Secondary rolling was performed with a pneumatic roller. Pneumatic rolling was performed at a temperature as low as 140°F. A steel-wheeled tandem roller was used for finish rolling.

The cause of the tenderness problem is not known at this time. Asphalt cement tests suggest no significant change in viscosity at compaction temperatures with or without the liquid antistrip additive in the binder. A review of aggregate gradations (although limited) suggests a slight change in gradation with and without the liquid antistrip additive.

This is the first U.S. project that contained the liquid antistrip to be reported as "tender" during construction. An investigation is under way in the manufacturer's laboratory to define the probable cause or causes.

CONCLUSIONS

Preconstruction Samples

Less sensitivity to water was obtained in the mixtures that contained the liquid antistrip chemicals than in control mixes without additives. This improved behavior did not reach the level of performance obtained by lime slurry (Figures 4 and 6).

No significant reduction in water sensitivity was noted with the use of dry portland cement and dry lime compared with control mixes without additive (Figures 4 and 6).

A significant reduction in water sensitivity was noted with the addition of lime slurry (Figures 4 and 6) to the mixtures. The mixtures that contained 2 percent lime slurry showed a slight improvement in resistance to water damage over those that contained 1.0 percent lime slurry.

Construction and Postconstruction Samples

A slight increase in resistance to water damage was obtained in the mixtures that contained the liquid antistrip additive compared with the mixture that contained dry portland cement (Figures 8 and 10). The desired level of improvement was not obtained.

No significant changes in moisture-conditioned mixture strength and water sensitivity occurred between July 1985 and May 1986 (Figures 9 and 10).

Visual surveys indicate that pavement sections with either the liquid antistrip agent or portland cement additive have performed well during the first year of pavement life.

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