EFFECT OF ANTISTRIPPING ADDITIVES ON THE COMPACTION OF BITUMINOUS CONCRETE

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ABSTRACT

The objective of this investigation was to determine the effect of antistripping additives on the compaction of bituminous concrete. To do this, the densities obtained on test sections with and without additive were compared. Comparisons of nuclear densities and the void contents of cores from the pavement revealed no significant differences. Also, there were no significant differences in the optimum numbers of roller passes required to attain maximum density on the sections with and without additive. The properties of the asphalt cement were probably not influenced enough by the additives to affect compaction.

Based on the results of this investigation, the inability to achieve the desired density should not be attributed to the use of antistripping additives.

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PURPOSE AND SCOPE

Some of the most important factors in the attainment of pavement density are ambient temperature, mix temperature, lift thickness, rolling equipment and procedure, and mix components. It is important that these factors be properly considered so that the full service life of the pavement will be realized and no price adjustment for construction will be assessed.

A paving contractor reported an incident where apparently the required density could be obtained only when the antistripping additive specified for the mix was omitted; therefore, a possible additional factor influencing density was identified. Much of the plant mix requires an antistripping additive, and it seemed reasonable that the additive might affect the viscosity of the asphalt cement and thereby result in compaction difficulties. Consequently, an investigation was undertaken to determine the effect of the additive on compaction.

To achieve the objective of the investigation, density was monitored and compared on test sections with and without additive for four paving projects (see Appendix A).

An attempt was made to locate jobs using S-5 mixes with aggregate that was not susceptible to stripping and that were being awarded to contractors who were willing to cooperate.

Three additives and three asphalts were tested in the mix designs shown in Table 1. At least one tanker of asphalt cement with no additive was used on each job. If the contractor had only one tank for storing asphalt cement, the tank had to be emptied completely when a changeover was made from additive to no additive.

Table 1. Materials

Job	Asphalt	Additive	Aggregate
1	Exxon AC-20	Pave Bond 206	50% #8 - Blue Ridge Stone Corp., Lynchburg 35% #10 - Blue Ridge Stone Corp., Lynchburg 15% sand - Staunton River
2	Chevron AC-20	Kling Beta	75% S-5 blend - Jack Quarry, Petersburg 25% Concrete sand - Puddledock Farm, Hopewell
3	Exxon AC-20	Kling Beta	40% #8 - Luck Quarry, Shadwell 30% #10 - Luck Quarry, Shadwell 30% sand - Rivanna River, Charlottesville
4	Fuel Oil & Equipment Co.* AC-20	Pave Bond Special	45% #8 - Medusa Aggregates, Inc., Sylvatus 45% #10 - Medusa Aggregates, Inc., Sylvatus 10% sand - Castle Sand, New Castle

*Brand unknown

TESTING PROGRAM

Field Tests

The optimum number of roller passes was obtained for each of the two mixes in a test section by establishing roller patterns with a nuclear device. The optimum compactive effort was used for the placement of each mix. The roller pattern also indicated whether the compaction characteristics of the mixes were affected by the additive.

Soon after the sections were completed, ten 4-in. cores were obtained for each mix and transported to the laboratory for density determinations. Nuclear densities were also obtained at 20 locations for each mix.

Samples of the plant mixes were obtained for the fabrication of Marshall specimens to be used in laboratory tests.

Laboratory Tests

Density and Void Determinations

When necessary, the surface layer of the cores was separated from the other layers by sawing or chiseling. Then the cores were dried by fan at room temperature overnight. The bulk specific gravity was obtained by ASTM test method D2726; however, no correction was attempted for any moisture that might have remained in the cores.

Several of the cores were combined and the maximum specific gravity was determined by ASTM test method D2041 using a type A container.

The percent air voids was calculated by ASTM test method D3203.

Marshall Tests

Marshall tests were performed according to ASTM test method D1559 on plant mix obtained during construction of the test section. Voids total mix, voids filled with asphalt, and voids in the mineral aggregate were calculated to determine the compactibility of each mix.

Asphalt Cement

Samples of asphalt cement with and without additives were obtained at the hot mix plant during construction of the test sections. Viscosity tests were performed at 140°F and 275°F by ASTM test methods D2171 and D2170, respectively. The penetration of the asphalt cements was measured by ASTM test method D5.

Bottle and Stripping Tests

Bottle tests were performed according to Virginia test method #55 to verify the presence or absence of antistripping additives in the field test sections. The test was conducted on asphalt cement sampled at the hot mix plant during the construction of the test section.

Using a modified procedure described in Transportation Research Record 712, stripping tests were performed on cores from all of the jobs and also on samples of plant mix from job #4 to verify the presence or absence of additive and to gather information on predicted performance.* This information will be useful in the implementation of the modified stripping test.

RESULTS

Density and Voids

The optimum number of roller passes required for maximum density was equal for mixes with and without additive on each of the four jobs. None of the mixes displayed any lack of stability during rolling; however, some cracking, apparently caused by the finish roller, was observed in both mixes on job 2.

The pavement densities determined by the nuclear device are listed in Table 2 and the voids of the cores in Table 3. There was not a significant difference at a 95% confidence level between sections with and without additive on any job. The voids total mix were high for all mixes except those on job 4. The plant mix was probably not compactible, with the exception of job 4, as reflected by high VTM, low VFA and high VMA of the Marshall tests reported subsequently.

*Maupin, G. W., Jr., "Implementation of Stripping Test for Asphaltic Concrete", *Transportation Research Record 712*, 1979.

Table 2. Nuclear Densities, lb./ft.^{3}

Job	With Additive	Without Additive
1	135.8	134.7
2	135.7	136.4
3	141.3	142.2
4	137.8	137.8

Table 3. Percent Voids Total Mix

Job	With Additive	Without Additive
1	12.5	11.9
2	10.1	9.4
3	13.8	12.3
4	7.8	8.4

Marshall Tests

The voids and stabilities from Marshall tests on plant mix are listed in Table 4. There was a significant difference in voids total mix between the mixes with and without additive on only job 1, and this difference was attributed to the very low variability in the test results. The voids total mix on jobs 1-3 were outside or very close to the upper specification limit of 6%, and the voids filled with asphalt were below or very close to the lower specification limit of 65%. At the 95% confidence level only job 4 produced a significant difference between the average stabilities of mixes with and without additive.

Table 4. Average Voids and Stabilities

	VTM, %		VFA, %		VMA, %		Stability, lb.	
Job	With Additive	Without Additive	With Additive	Without Additive	With Additive	Without Additive	With Additive	Without Additive
1	7.5*	6.8*	62.7	65.2	20.4	19.8	2,240	2,210
2	4.6	6.5	73.1	65.2	17.1	18.7	2,580	2,170
3	5.6	6.4	70.5	67.8	19.3	19.9	2,270	2,040
4	3.2	3.1	81.3	81.8	17.2	17.0	2,560*	3,020*

*t test indicates significant difference at 0.05 level.

Asphalt Cement

Antistripping additives sometimes cause changes in the original physical properties of the asphalt cement. The properties of the asphalt cements with and without additive are listed in Table 5.

Penetration values were 3 to 9 units higher for the asphalt cements containing additive. The viscosity at 275°F was slightly less for the asphalt cements with additive, and the additive caused the viscosity at 140°F to decrease by 90 to 260 poises. All test values remained within the specification limits for AC-20, and the physical changes caused by the additives would probably not affect the compaction characteristics of the mixes.

Bottle and Stripping Tests

The bottle test should indicate positive results with additive present and negative results when there is no additive. As can be seen in Table 6 all jobs except job 4 yielded such results. The samples of asphalt cements supposedly with and without additive on job 4 all yielded positive results, indicating that additive was present in both cases. It is possible that a small amount of additive was present at the location at which the "no additive" sample was taken or that the storage tank was not emptied completely of the asphalt containing the additive.

According to the results of the stripping tests, given in Table 7, there was a definite improvement of the TSR of the section containing additive over the TSR of the section with no additive on job 4. These results indicate that at least there was more additive in the mix in the additive section than in the mix in the no additive section. The TSR of the sections with additive was significantly greater than the TSR of sections with no additive on jobs 1 and 3, thereby verifying the presence and absence of additive, respectively. The TSR of the section with additive on job 2 was not significantly higher than the TSR of the section with no additive; therefore, there is no definite indication of the presence or absence of additive. It is possible that the additive was present but not effective in this case.

In summary, the results indicate additive was present when claimed, and that possibly a very small amount was present in the section "without additive" on job 4.

Table 5. Physical Properties of Asphalt Cement

Job	Penetration, 0.1 mm		Viscosity at 140°F, P		Viscosity at 275°F, cSt	
	With Additive	Without Additive	With Additive	Without Additive	With Additive	Without Additive
1	85	78	1,800	1,910	380	398
2	88	79	1,770	2,030	389	414
3	88	85	1,790	1,880	389	404
4	98	99	2,000	2,000	442	451

Table 6. Results of Bottle Tests

Job	With Additive	Without Additive
1	Positive	Negative
2	Positive	Negative
3	Positive	Negative
4	Positive	Positive

Table 7. Results of Stripping Tests

	Tensile Strength Ratio	
Job	With Additive	Without Additive
1 (cores)	0.88	0.72
2 (cores)	0.53	0.46
3 (cores)	0.88	0.78
4 (cores)	0.96	0.84
(plant mix)	0.94	0.72

CONCLUSIONS

1. There was no significant difference in densities of mixes with and without additives.
2. The presence of additive did not influence the optimum number of roller passes required for maximum density.
3. The properties of the asphalt cements were probably not influenced enough by the additives to affect compaction.

RECOMMENDATION

The inability to achieve the desired density of bituminous concrete should not be attributed to the use of antistripping additives. Attention should be focused upon the effects of aggregate type, mix design, and compaction procedures.*

*Maupin, G. W. Jr., "Problems in Achieving Density in Asphaltic Concrete", Virginia Highway and Transportation Research Council, Charlottesville, Virginia, February 1979.

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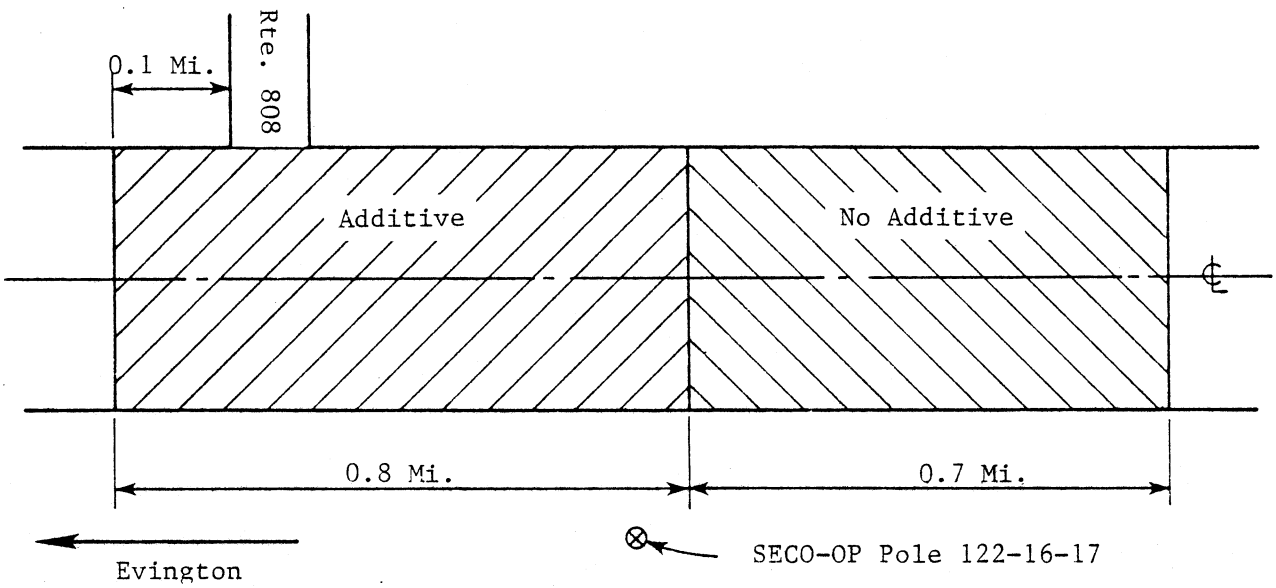
Appreciation is expressed to Virginia Department of Highways and Transportation personnel in the Culpeper, Lynchburg, Richmond, and Salem districts for helping to arrange the test sections, obtaining cores, performing field tests, and providing traffic control. Also, thanks are extended to the contractors for cooperating in construction of the test sections.

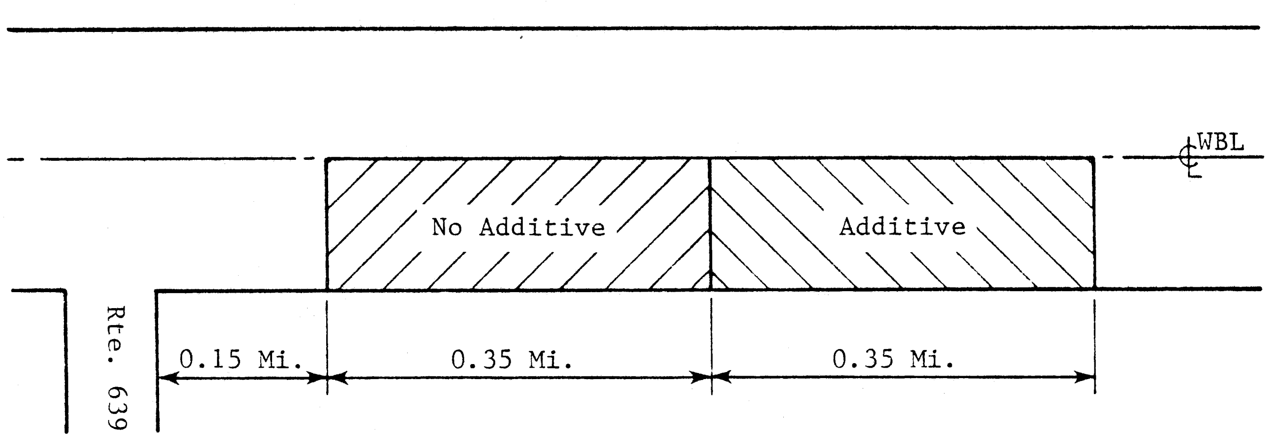
APPENDIX A

Job Locations

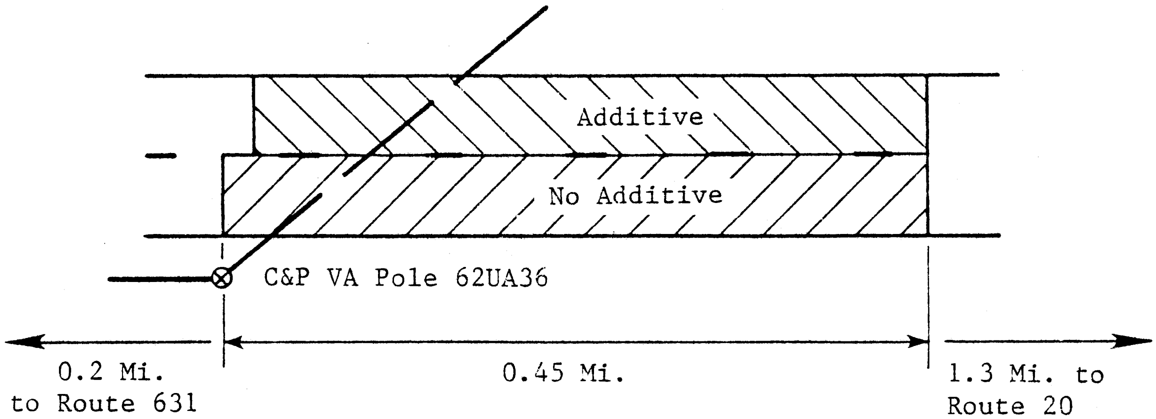
Job #1 - Route 24, Campbell Co., July 1978



Job #2 - Route 460, Dinwiddie Co., Sept. 1978



Job #3 - Route 612, Orange Co., Oct. 1978



Job #4 - Route 460, Blacksburg Bypass
Montgomery Co., Sept. 1981