FINAL REPORT

USE OF LIMESTONE SCREENINGS IN S-5 SURFACE MIXES

by

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Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

It is often practical to use limestone screenings in non-polishing S-5 surface mixes in some western areas of Virginia. Also, there has been some conjecture that limestone increases the durability of these mixes. Although the fine aggregate usually has a minimal effect on the skid resistance of bituminous pavements, there were no skid data available for S-5 mixes containing approximately 20% limestone screenings. The purpose of this study was to obtain such data and to determine if the limestone affects the durability of the S-5 mix. The durability was assessed by performing stripping tests and Marshall tests on several mixes containing various amounts of limestone screenings.

The results of skid tests indicated that satisfactory skid resistance can be achieved using mixes with moderate levels of limestone screenings. The limestone did not significantly affect the Marshall properties; however, two of the three mixes tested showed an increased susceptibility to stripping. Thus, contrary to the supposition, limestone screenings did not improve the durability of the mixes.

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PURPOSE AND SCOPE

Often it has been the opinion of field engineers that the addition of limestone screenings to S-5 asphaltic surface mixes increases durability and provides fines that are necessary for meeting gradation and density requirements. The Virginia Department of Highways and Transportation does not allow aggregates that polish, such as limestone, in surface mixes because of their adverse effect on the skid resistance of the pavement; however, it was thought that a small amount of limestone screenings would not be detrimental.

One purpose of this investigation was to determine the effect on skid resistance of using limited amounts of limestone screenings in polish-resistant S-5 surface mixes. Also, three mixes containing various amounts of limestone screenings were tested to determine the effect of the limestone on the durability of the S-5 mix.

SKID TESTS

Although limestone is prohibited it has been used several times when non-polishing fines were not readily available. To determine the influence of the limestone screenings on pavement skid resistance, six sections of pavement with S-5 surface mixes that contained from 15% to 20% limestone screenings and that had been subjected to various volumes of accumulated traffic were located and tested with a skid test trailer. The tests were made at 40 mph (64 km/h) with treaded tires (ASTM E274-79).

Since various combinations of limestone and non-polishing aggregates were used in the sections tested, the results were quite variable, as can be seen in Figure 1.

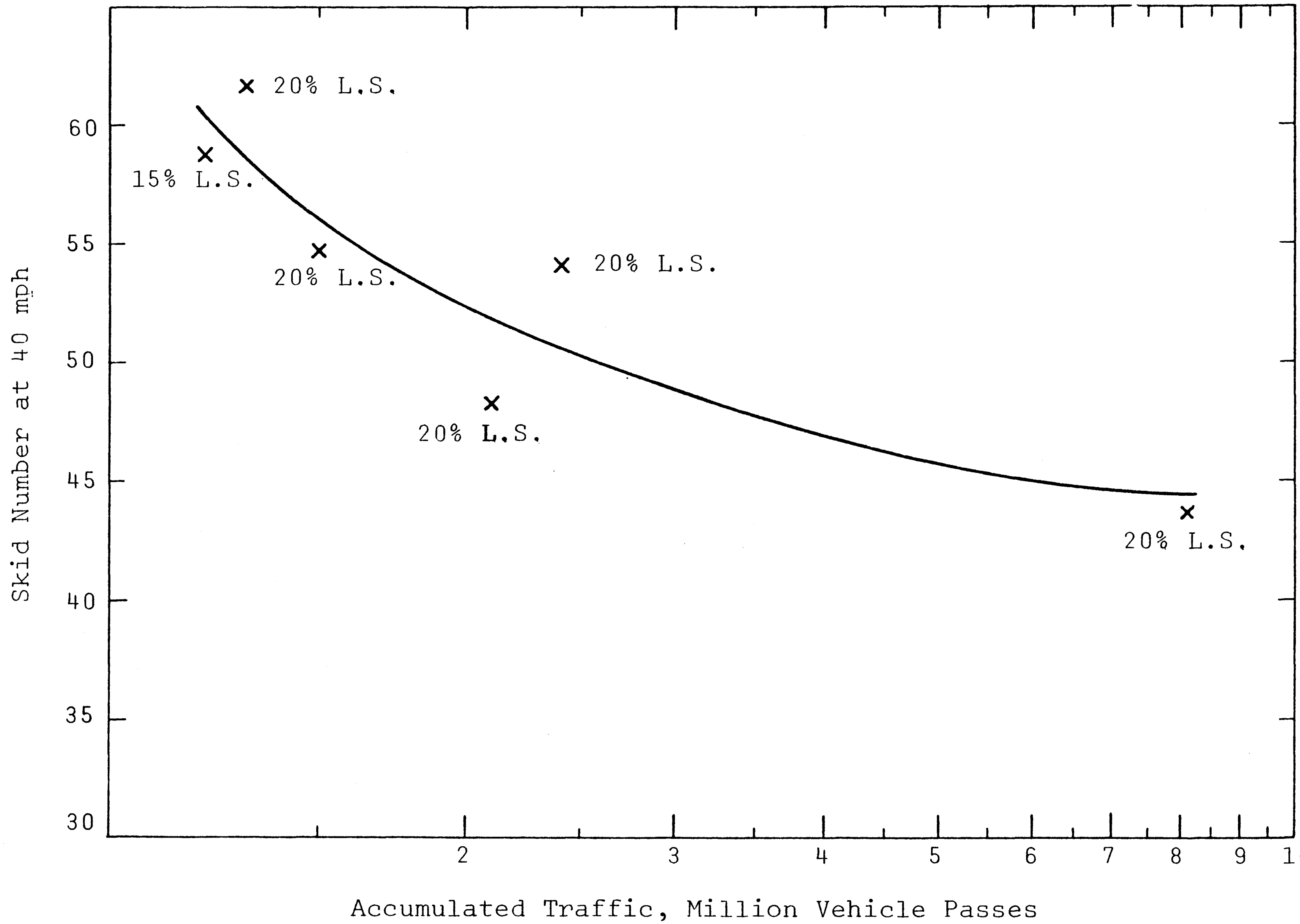

Figure 1. Skid resistance vs. accumulated traffic.

Corrective maintenance is usually perfomed on pavement surfaces with skid numbers less than 30; however, it is desirable to maintain a minimum number of 35 to allow for normal variation. Although the data are limited, it appears that mixes containing a maximum of 20% limestone screenings will maintain satisfactory skid resistance for the expected service life of the pavement. All of the plotted values in Figure 1 are well above the minimum skid number of 35 which is considered adequate by the Virginia Department of Highways and Transportation.

LABORATORY TESTING

To determine the effect of the limestone on the durability of the S-5 mix, Marshall and stripping tests were performed on three mixes containing various percentages of the screenings. The mix designs supplied by district materials labs contained from 20% to 25% limestone screenings and 75% to 80% polish-resistant aggregate. Each mix was tested at three percentages of limestone; viz., the design level, 50% of the design level, and zero.

Materials

The proportions and sources of aggregates for the mixes are listed in Table 1. Exxon AC-20 asphalt was used for all mixes and 0.5% Pave Bond Special antistripping additive was used in the treated design mixes on which stripping tests were performed. Normally antistripping additive would be required; therefore, it was advantageous to determine the potential stripping damage of the design mixes containing limestone and additive. The mix gradation was maintained as constant as possible for the different limestone contents by adjusting the amounts of fine and coarse non-polishing aggregate. The resultant gradations are listed in Table 2.

Marshall Tests

A Marshall mix design was performed on each mix containing zero, 50%, and 100% of the design limestone content. Since 4% voids total mix is the median of the recommended design range, Marshall properties at this value are compared for each mix in Table 3.

Table 1

Mix Designs

Mix 1

50% 1/2 in. crusher run - Shenandoah Sand and Gravel, Harriston
25% #8 - West Sand and Gravel, Lynwood
25% #10 - Elkton Limestone Co., Elkton

Mix 2

40% #8 - West Sand and Gravel, Lynwood
40% #10 - West Sand and Gravel, Lynwood
20% 1/4 in. special limestone dust - Frazier Quarry, Harrisonburg

Mix 3

50% #8 - Medusa Aggregate, Sylvatus
30% #10 - Medusa Aggregate, Sylvatus
20% #10 limestone - Appalachian Stone, Pearisburg

1 in. = 25.4 mm

Table 2

Gradation of Mixes

Mix	Limestone percent	Asphalt[a] percent	Percent Passing 1/2 in.	#4	#30	#200
1	0	6.5	100	56	23	4.0
	12.5	6.4	100	56	21	4.1
	25[b]	6.5	100	61	20	3.8
2	0	6.5	100	64	23	5.1
	10	6.5	100	64	23	5.1
	20[b]	6.5	100	64	23	5.1
3	0	5.7	100	65	19	5.5
	10	5.7	100	65	19	5.5
	20[b]	5.8	100	65	19	5.5

[a]Used for stripping tests
[b]Mix design by district labs

1 in. = 25.4 mm

Table 3

Marshall Properties at 4% Voids Total Mix

Mix	Limestone Content, percent	Asphalt Content, percent	Voids Filled With Asphalt, percent	Voids in Mineral Aggregate, percent	Flow, 0.01 in.	Stability, lb.
1	0	6.5	78	18	10	2,310
	12.5	6.4	78	18	11	2,330
	25[a]	6.6	77	19	10	2,130
2	0	6.9	79	19	11	2,180
	10	6.9	79	19	11	2,210
	20[a]	6.5	78	19	12	2,200
3	0	5.7	76	18	12	2,050
	10	5.7	76	17	12	2,060
	20[a]	5.8	75	17	12	2,050

[a]Design limestone content
1 in. = 25.4 mm
1 lb. = 4.448 N

There was no significant difference in the stability, voids in mineral aggregate, and voids filled with asphalt between mixes with different limestone contents. There was no significant difference in the asphalt content demand at 4% voids total mix for mixes 1 and 3. The asphalt content demand for mix 2 was 0.4% lower at the design limestone content than at both zero and 50% limestone. The limestone dust probably functioned as an asphalt extender, replacing asphalt that normally provides flexibility to the pavement. In this particular instance, the limestone might decrease the durability of the pavement.

These results indicate that limestone has no significant effect on the Marshall properties that affect durability when the mix gradation is maintained constant. However, the addition of limestone screenings would probably improve the gradation and durability if there is not a sufficient quantity of non-polishing fines available.

Stripping Tests

Stripping tests were performed at various limestone contents using a modified version of the test method reported in NCHRP Report 192.* In Figure 2, the percent limestone is plotted against the tensile strength ratio (preconditioned strength/dry strength) to illustrate the effect of the limestone on stripping of the mixes. Preconditioning involves vacuum saturation, freezing and storage for 24 hours in a 140°F (60°C) water bath. As can be seen, the addition of limestone had a detrimental effect on mix 2 and mix 3. The tensile strength ratio was decreased significantly when 10% and 20% limestone screenings were used. The tensile strength ratio of mix 1 with no limestone was very low, and the addition of limestone had no effect. All of the mixes with the design limestone content were satisfactory when antistripping additive was used. Additive would normally be used in the field installation of this type of mix; therefore, stripping should not be a problem.

In summary, limestone did not increase the stripping resistance of any of the mixes; rather it decreased the resistance of two of them.

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

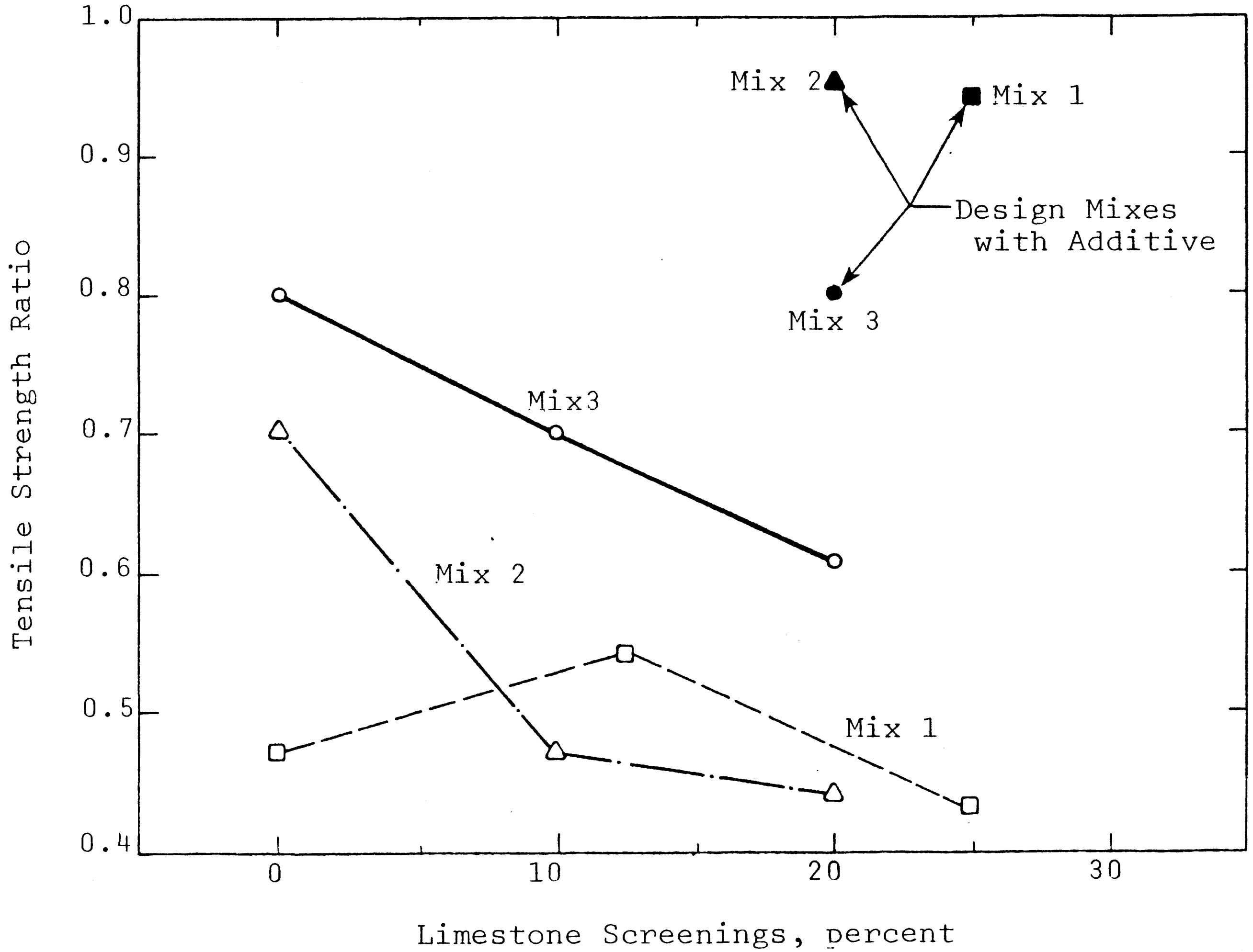

Figure 2. Tensile strength ratio vs. percent limestone screenings.

CONCLUSIONS

1. Pavements containing up to 20% limestone screenings appear to be maintaining satisfactory skid resistance.

2. When the gradation was held constant, limestone screenings did not affect the Marshall properties of the mixes tested.

3. Limestone screenings decreased the resistance to stripping for two of the three mixes tested; however, the use of antistripping additive increased the stripping resistance to an acceptable level.

4. Unless the addition of limestone screenings is economically beneficial, little advantage can be gained from their use.

ACKNOWLEDGEMENTS

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