# INFLUENCE OF HANDLING ON THE EFFECTIVENESS OF ANTISTRIPPING ADDITIVES

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Virginia Highway and Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia
Department of Highways & Transportation and
the University of Virginia)

In Cooperation with the U. S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

August 1980

VHTRC 81-R8

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# SUMMARY

The purpose of this investigation was to determine the influence of the procedures used in handling asphalt-additive blends on the effectiveness of antistripping additives in asphaltic concrete. The additives were blended with the asphalt cements before shipment by tank truck to the hot mix plants. Laboratory tests were performed on samples of the asphalt cement obtained prior to the blending process at the terminal and after blending and shipment by tank truck to the hot mix plant.

Quick bottle tests and infrared spectrophotometer tests were used to determine the presence and approximate amount of additive, respectively. A stripping test was performed to determine the effectiveness of the additive.

The results of this limited investigation indicate that the present procedure of blending asphalt and antistripping additive before shipment to the hot mix plant is satisfactory; however, long periods of storage at high temperatures might cause the additive to lose part of its effectiveness.

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## INTRODUCTION

Stripping in asphaltic concrete pavements is the loss of bond between the asphalt cement and the aggregate surface caused by the presence of moisture. Stripping results in a strength loss and is often evidenced by cracking, raveling, potholing, and, in very severe cases, by disintegration of the pavement. Antistripping additives that function as surface active agents are used to eliminate or reduce stripping failures commonly encountered with bituminous mixes in which siliceous aggregates are used. The additives are usually amine or fatty acid chemical compounds, but hydrated lime has been used with apparent success in several states. Contrary to the experience with siliceous aggregates, stripping in mixes with limestone aggregates is very rare.

The Virginia Department of Highways and Transportation requires that an antistripping additive be used in all hot plant mixes except those containing limestone aggregate. The additives increase the cost of the mixes by approximately $1.00 - $1.25 per ton; however, the overall expense can be greater if the additive is used improperly and the pavement must be repaired or overlaid prematurely. It has been recognized that the practices employed in handling asphalt cement-additive blends can affect the efficacy of the additive. It is essential that the handling procedures be proper so that a durable, non-stripping pavement will be obtained.

## PURPOSE

The purpose of this investigation was to determine the influence of the procedures used in handling asphalt-additive blends on the efficacy of antistripping additives in asphaltic concrete. Samples of asphalt cement with and without additive were obtained during the handling procedure and tested in the laboratory.

# PROCEDURE

## Sampling

The sampling and testing procedures were designed to determine whether the specified amounts of additives were present in the asphalt and effective in preventing laboratory stripping prior to the blend being mixed with aggregate to produce asphaltic concrete. The asphalt cement with no additive was sampled (samples 1, 2, 3, etc.) before shipment by tank truck to the hot mix plant. As the asphalt was being loaded into the tank trailer, the additives were blended in and mixed by natural agitation of the loading and hauling processes. Immediately upon arrival of the tank trailer at the hot mix plant, the asphalt-additive blend was sampled from it (samples 1A, 2A, etc.). Six samples with an additive and six without an additive were taken from each of five brands of AC-20 asphalt at various times during the 1979 construction season. Exxon binder was obtained from two sources. Two brands of additive were used. The combinations of asphalts and additives can be noted in Table 2 presented later under RESULTS.

There were deviations to the above procedure for samples 1A and 6A. Sample 1A was mixed in a tank prior to loading and sample 6A was obtained after the blend had been stored at the hot mix plant at high temperatures for approximately 5 days.

## Testing

The quick bottle test and infrared spectrophotometer were employed to determine the presence and approximate amount of antistripping additive in the asphalt cement-additive blend. The stripping test was used to measure the efficacy of the additive.

### Quick Bottle Test

The quick bottle test has been used by several states to detect the presence of antistripping additives in asphalt cement. In the test, the asphalt cement is mixed with a solvent to form a cutback; Ottawa sand is placed in a bottle and covered with water; the cutback is added to the bottle; and the bottle shaken. If the asphalt coats the sand, an antistripping additive is present. There are several versions of the method in which different types and amounts of solvent are specified and the temperature of the sand-water mixture is varied. The version of the method used in this study is given in Appendix A.

## Infrared Spectrophotometer Test

Infrared spectra were measured between 2,000 $cm^{-1}$ and 1,400 $cm^{-1}$, and the absorbance of bands between 1,640 $cm^{-1}$ and 1,660 $cm^{-1}$ was measured and correlated to the concentration of the additive. The procedure detects amido-amine additives, which have strong absorbance bands in the 1,640 $cm^{-1}$ to 1,660 $cm^{-1}$ region; it does not detect the fatty triamine additives, which lack absorbance in this region. The accuracy of the test has not been verified, but experience indicates that results should be within 0.1% of the additive content. The detailed test procedure is given in Appendix B.

## Stripping Test

Stripping tests were performed on a common aggregate (Table 1) using the asphalt cements with and without additive. The stripping test was a modified version of the procedure developed under NCHRP Project 4-8(3).(1,2) In it, the indirect tensile strength was measured on a set of dry specimens and a set of specimens that had been subjected to a preconditioning designed to simulate stripping damage occurring in the field. The ratio of preconditioned strength to dry strength, the tensile strength ratio (TSR), was calculated and used to predict the stripping susceptibility of the mixture. An acceptable TSR was considered to be one greater than 0.7. Tests were performed on samples with and without additive so as to be able to determine the improvement due to the use of additives and to separate the influence of the brand of asphalt cement.

Table 1

S-5 Mix Design and Sources of Aggregates

| Sieve | % Passing |
|---|---|
| 1/2 | 100 |
| 4 | 63 |
| 30 | 22 |
| 200 | 4 |

6% Asphalt cement computed by total weight of mixture

80% Crushed stone — Richmond Crushed Stone, Rockville, Virginia

20% Concrete sand — Warren Brothers, Henrico Pit

# RESULTS

## Bottle Test Results and Infrared Measurements

The results of all bottle tests on asphalt cements containing no additive were negative (no coating) and the results of all bottle tests on asphalt cement with additive were positive, as expected. A positive result indicates only that an additive is present; no quantitative values are obtained. It is possible that a positive result could be obtained for asphalt containing only 0.1% additive, which may be an insufficient amount to prevent stripping in a pavement.

The infrared determinations of the amount of additive agreed reasonably well with the amount of additive that was blended with the asphalt cement (Table 2). The results are within the testing accuracy with the exception of sample 6, in which the infrared was much lower than the amount thought to have been introduced. The low value for sample 6A might be attributable to its extended storage of several days at high temperatures. There is some evidence that additives may combine with or be absorbed by the asphalt cement and become ineffective after long periods of storage at high temperatures.(3)

Sample 4A demonstrated an infrared absorbance of some unidentified bands, thus indicating that a contaminant or unknown substance was present.

## Stripping Test Results

The stripping test results indicate the effectiveness of the various additives in lowering the susceptibility of a mix to stripping. The tensile strength ratio (TSR) is used to predict the stripping susceptibility. As mentioned previously, a TSR greater than 0.7 indicates a mixture that should perform satisfactorily in the field.

The small range of values for TSR of 0.51 to 0.64 for mixtures without an additive indicates an insignificant influence of the type of asphalt cement on stripping. All asphaltic concrete mixtures without an additive were unacceptable, being less than 0.7. With the inclusion of an additive, all of the mixtures had an acceptable TSR; however, there appeared to be less improvement for sample 2A. In summary, all additives were potentially effective in preventing stripping; therefore, it was concluded that the blends were mixed sufficiently and contained sufficient amounts of additive.

Table 2

Summary of Results

| Sample | Type Additive | Specified Amt. of Additive % | Type Asphalt | Pen. at 77°F, (25°C) mm | Vis. at 140°F, (60°C) P | Vis. at 275°F, (135°C) cS | VTM, % | TSR | Quick Bottle Test | % Additive by Infrared |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | — | 0 | Exxon Richmond | 82 | 1,938 | 421 | 6.3 | 0.64 | Negative | — |
| 1A | Pave Bond Special | 0.25 | Exxon Richmond | 85 | 1,752 | 402 | 6.1 | 0.85 | Positive | 0.26 |
| 2 | — | 0 | Chevron | 78 | 1,754 | 388 | 6.3 | 0.58 | Negative | — |
| 2A | Kling Beta XP 251 | 0.5 | Chevron | 81 | 1,628 | 368 | 7.1 | 0.77 | Positive | 0.44 |
| 3 | — | 0 | Fuel Oil & Equip[a] | 74 | 1,841 | 422 | 7.8 | 0.51 | Negative | — |
| 3A | Pave Bond Special | 0.5 | Fuel Oil & Equip[a] | 75 | 1,833 | 402 | 7.5 | 0.94 | Positive | 0.60 |
| 4 | — | 0 | ARCO | 60 | 1,829 | 382 | 7.0 | 0.52 | Negative | — |
| 4A | Pave Bond Special | 0.5 | ARCO | 59 | 1,874 | 383 | 7.3 | 0.91 | Positive | 0.62 |
| 5 | — | 0 | Exxon, Fuel Oil & Equip | 77 | 2,000 | 409 | 7.9 | 0.52 | Negative | — |
| 5A | Pave Bond Special | 0.5 | Exxon, Fuel Oil & Equip | 76 | 2.075 | 408 | 7.6 | 0.88 | Positive | 0.51 |
| 6 | — | 0 | Shell | 60 | 2,205 | 391 | 7.7 | 0.51 | Negative | — |
| 6A | Pave Bond Special | 0.5 | Shell | 59 | 2,470 | 403 | 8.0 | 0.86 | Positive | 0.25 |

[a] brand unknown supplied by Fuel Oil & Equipment Co.
1 P = 0.1 Pa.s; 1 cS = $10^{-6}$ $m^2/s$

## Viscosity and Penetration Results

The change in asphalt viscosity at 140°F (60°C) caused by the additives ranged from -9.6% to +12.0%, and similar changes in the viscosity at 275°F (135°C) ranged from -5.2% to +3.1%. These changes are probably not of sufficient magnitude to cause difficulties in construction, and all samples met the Virginia viscosity specification for AC-20, with the exception of sample 6A. There was not a significant difference in the penetration values of the samples with and without additive. Samples 4A and 6A had a penetration of 59mm, which is less than the minimum of 60 mm allowed in the Virginia specification.

## DISCUSSION OF RESULTS

The results indicate that the specified amount of anti-stripping additive was present in 5 of 6 samples. It is possible that the longer storage time for sample 6A contributed to the low results; however, storage times of this magnitude are probably frequent in production because of rain, delays caused by plant breakdowns, and other miscellaneous factors. Even though the amount for sample 6A was only 0.25%, the stripping test result was satisfactory. It is possible that only 0.25% was necessary to prevent stripping for this particular combination of aggregate, asphalt, and additive.

The results of this study are limited, and should be applied to only those mixing and blending situations described here. The results indicate that the procedure in which the additive and asphalt are blended when being loaded into the tank trailer and the blend is mixed naturally during loading and transporting was satisfactory in the instances investigated. However, there is limited evidence that storage at high temperatures may cause some of the additive to be absorbed by the asphalt cement.

There are other situations in which the additive is put in the storage tank or added directly to the asphalt line between the storage tank and weigh bucket at the hot mix plant. These situations should be evaluated on an individual basis to ascertain that proper mixing and blending procedures are being used.

## CONCLUSIONS

1. The present procedure of blending asphalt and antistripping additive before shipment to the hot mix plant was satisfactory in this limited investigation.

2. Long periods of storage at high temperatures might cause part of the additive to become ineffective.

## REFERENCES

1. Maupin, G. W., Jr., "Implementation of Stripping Test for Asphaltic Concrete", Transportation Research Record 712, 1979, pp. 8-12.

2. Lottman, R. P., "Predicting Moisture-Induced Damage to Asphaltic Concrete", Report prepared for National Cooperative Highway Research Program, February 1974.

3. WCTG Panel Meeting at Western User-Producer Conference at Casper, Wyoming, March 1978.

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# APPENDIX A

## Quick Bottle Test

1. Obtain 100 grams of asphalt and form a cutback by adding 18 cc of white gas, mixing thoroughly. Asphalt should be at approximately 100°F (38°C) when white gas is added.
2. Place 50 grams of 30-50 Ottawa sand in a 2 oz. glass jar and add tap water to a level 1/2" to 3/4" above sand.
3. Add 1 gram of cutback prepared in step 1 to the bottle, cap the bottle, and shake vigorouly by hand for approximately 30 seconds.
4. Pour out water, place sand on paper towels, and visually evaluate the degree of asphalt coating on the sand.
5. If the sand is completely coated, an antistripping additive is assumed to be present in the asphalt. If the coating is nonuniform, it is assumed no additive is present.

# APPENDIX B

## VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION

METHOD # ________
Date: 9-10-79

PRODUCT: Antistripping Compounds in AC-20

REFERENCES: None

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SUMMARY: A sample of AC-20 plus additive is heated and dissolved in naphtha and then methanol is added. The mixture is centrifuged and the top layer collected. The solvent is driven off and the additive residue is dissolved in chloroform. An infrared spectra is run between 2000 cm$^{-1}$ and 1400 cm$^{-1}$ and the absorbance of bands between 1640 cm$^{-1}$ and 1660 cm$^{-1}$ is measured and related to concentration.

The analysis is applicable to amido-amine type additives with strong absorbance bands in the 1640 cm$^{-1}$ to 1660 cm$^{-1}$ region, but not to the fatty tri amine additives which have no absorbance in this region.

Sampling must be done as soon as possible after the additive is mixed with the AC-20. The quantitative recovery of the additive becomes more improbable with time and heat.

SAMPLING: For most accurate results the laboratory should be furnished samples of:

1 — AC-20 without additive (quart)

2 — Additive (½ pint)

3 — AC-20 with additive (quart)

The following information should be furnished with the sample:

1 — Type additive used.

2 — Amount of additive used.

3 — Time lapse between sampling and mixing.

4 — Temperature conditions under which the additive was stored.

5 — Temperature conditions of mixture.

6 — Place from which sample was drawn.

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METHOD: Heat the quart cans of AC-20 and AC-20 + additive in an oven at 275°F for one hour or until the samples can be readily mixed with a stirring rod. (Do not mix vigorously so that excess bubbles are formed.)

To an 800-ml beaker (with magnetic stirring bar) transfer by difference sufficient additive to approximate the weight of additive in a 200-gm sample of AC-20. Mark this beaker "STD".

Transfer 200 gm of the heated AC-20 to the "STD" beaker and 200 gm of the sample (AC-20 + Additive) to a second 800-ml beaker. Put these back in the oven and heat at 275°F for 30 minutes, stirring every 10 minutes.

Remove from oven and add 300 ml of boiling naphtha (make certain the asphalt is at 85°C before adding the naphtha) and stir on a magnetic stirrer until temperature reaches 65°C. Add 300 ml of boiling methanol and stir moderately for 30 seconds. DO NOT STIR VIGOROUSLY.

Let the mixture settle for 15 minutes and transfer to four 250-ml centrifuge tubes. Balance the tubes and spin for 10 minutes at 3,000 - 4,000 RPM. Draw off as much of the top layer as possible from each tube without getting any of the bottom layer. Transfer the combined top layers to an 8-oz. metal container.

Drive off the solvent on a hot plate until no bubbling is noticed. (DO NOT OVERHEAT.) Heat in an oven at 95°C for 30 minutes. Dissolve in 10 ml of spectrograde chloroform and transfer to a 25-ml volumetric flask. Wash can with 10 additional ml of chloroform and transfer to the same flask until it is filled to the mark. Mix well.

Run an infrared absorbance spectra from 2000 $cm^{-1}$ to 1400 $cm^{-1}$ in a 0.1 mm NaCl cell (or KBr) with chloroform in the reference beam in a matching cell. Measure the absorbance of the sample and "STD" at the peak which occurs between 1640 $cm^{-1}$ and 1660 $cm^{-1}$ (different for each additive using 0 abs at 2000 $cm^{-1}$ as the baseline).

The absorbance vs concentration of the "STD" is a direct ratio to the absorbance vs concentration of the unknown since:

1 — The sample sizes are the same

2 — The chloroform dilution factor is the same

3 — The same cell is used for standard and sample

4 — It has been shown that under ideal conditions these additives exhibit a relatively straight-line plot of absorbance vs concentration.