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# Louisiana Highway Research

## *EVALUATION OF THE USE OF ANTISTRIPPING ADDITIVES IN ASPHALTIC CONCRETE MIXTURES*

Louisiana Department of Highways – Research & Development Section

# EVALUATION OF THE USE OF ANTISTRIPPING ADDITIVES IN ASPHALTIC CONCRETE MIXTURES

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## SYNOPSIS

Stripping is not a major problem in Louisiana. However there has been isolated instances of stripping occurring within the state and this study was initiated to ascertain if antistripping additives would have any benefical effect in combating stripping.

A preliminary laboratory investigation was conducted on seven different commercially available additives to select one for field use. Based solely on the laboratory tests, Redicote 80-S was selected for field use.

A four mile test section was constructed on State Route La. 3092 in November, 1968. Approximately one mile of this project was constructed with the antistripping additive added to the asphalt cement in the amount of 0.5 percent by weight. The remainder of the project was used as a control section.

Comparative tests were conducted on the asphaltic cement and hot mix with and without the additive to ascertain if the antistripping additive had any effect on the asphalt or hot mix. These tests were:

1. Marshall Immersion
2. Gyratory Shear Stress and Bearing Resistance
3. Roadway Core - specific gravity and percent compaction
4. Asphalt Analysis

The results of these comparatives indicated that the additive had a negligible effect on the properties tested.

In addition to the comparative tests conducted, the control and test sections were visually compared six months and one year after construction to ascertain if any raveling or pitting was occurring in either section.

At the end of the allotted time for study, no raveling or pitting had occurred in either the test or control section. A slight textural difference did develop between the sections in the form of a more open texture in the control section.

Based on this study alone, it is not possible to recommend the use of antistripping additives on a state-wide basis. However it is recommended that additional periodic visual checks be made on this project to ascertain if the slight textural difference that now exists between the test and control section develops into any indication of stripping. If any stripping should occur and the test section indicates that the antistripping additive has had a benefical effect, a supplemental report will be issued.

# INTRODUCTION

"Stripping" or the failure of asphalt cement to completely coat the aggregate in asphaltic concrete mixtures, is largely due to moisture in the aggregate. Stripping results in asphaltic concrete mixtures of low stability, and riding surfaces that are very susceptible to raveling and pitting due to the poor cementing between the asphalt cement and the aggregate.

Stripping is not a major problem in Louisiana. However, there have been isolated instances of stripping occurring within the state.

This study was initiated to combat this moisture problem, which in some cases, causes stripping of the asphalt from the aggregate, and to establish what advantage, if any, antistripping additives could have in solving this problem.

## METHODOLOGY

### Preliminary Laboratory Investigation

Before any attempt at field testing of antistripping additives was undertaken, it was deemed necessary to evaluate the commercial antistripping additives available to ascertain which could be considered the most suitable for use in field testing.

Seven different commercially available additives were selected for laboratory evaluation. Static immersion stripping tests were performed using each of the additives in percentages of 0.3, 0.5, 0.7 and 1 percent to determine which percentage would give the best performance and whether or not a given additive required a higher or lower percentage to give equal performance.

The stripping test consisted of using a 100 gram sample of 3/8 inch to No. 4 size gravel aggregate, heating the aggregate to 300°F, heating the various asphalt additive mixtures to 315°F and mixing approximately three percent by weight of the asphalt additive mixture with the aggregate. After mixing, the coated aggregate was put into a clean 250 ml. beaker and allowed to cool. After cooling, it was submerged into a 160°F water bath for 24 hours. Visual observations were then made as to the amount of stripping obtained.

From the visual observations by several different persons, it was concluded that 0.5 percent additive resulted in the least amount of stripping for all of the additives tested. Therefore it was decided that a comparison of stripping performance between additives be made at a percentage of 0.5 percent.

### Comparison of All Additives to Prevent Stripping

Additional mixtures were made using each of the seven different additives previously mentioned, at a percentage of 0.5. The test procedure was the same as above with the exception that two different size gravel aggregates were used. A large 1 inch to 3/4 inch gravel was used on one set of samples and a smaller 3/8 inch to No. 4 gravel was used on another set of samples.

Table 4 of the Appendix shows the rating of five different observers listed in the order of good to poor results. The various additives are designated by the numbers 1 through 7 for the protection of the manufacturer. Figure 1 gives a comparison of the coatings obtained with the various additives.

Redicote 80-S was selected for the field testing. The evaluation and rating of the various additives were based solely on the modified static immersion test, and the selection of Redicote 80-S should not be construed as an endorsement of the product nor a rejection of the other products.

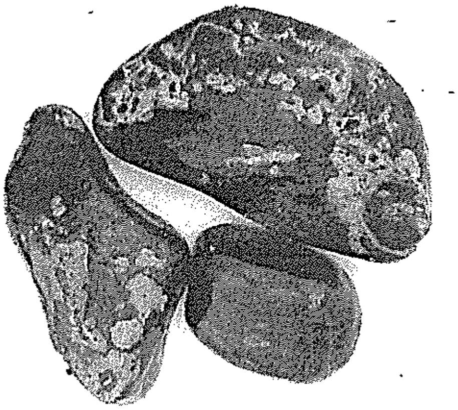

*Fig. 1a*
*Control (No Additive)*

*Fig. 1b*
*Redicote 80-S*

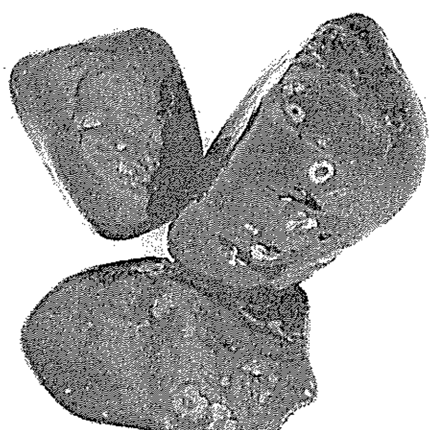

*Fig. 1c*
*Redicote 2323*

*Fig. 1d*
*Pave 100*

*FIGURE 1*

Comparative Photographs of resultant coatings of aggregate with untreated and treated asphalt after static immersion - 160°F for 24 hours

*Fig. 1e*
*Tyfo A-40*

*Fig. 1f*
*Tyfo Amined*

*Fig. 1g*
*Darakote Universal*

*Fig. 1h*
*Nostrip Acra 500*

*FIGURE 1 (CONTINUED)*

Comparative Photographs of resultant coatings of aggregate with untreated and treated asphalt after static immersion - 160°F for 24 hours

An attempt to rate the additives by use of the ASTM test "Proposed Method of Test for Stripping of Bitumen Aggregate Mixtures (Tracer Salt Method)" was tried. However, the results of this test method were discarded due to the inability of the equipment to give similar results upon repetitive testing.

Field Construction of Control and Experimental Sections

The test section was constructed on State Project 810-28-01, State Route La 3092 (Airport Road-Lake Charles Highway). Construction began November 11, 1968. The project consisted of approximately four miles of asphaltic concrete mix Type CS-5 Type 1 Wearing Course. For approximately one mile of this project, Redicote 80S was added to asphalt cement in a quantity of approximately 0.5 percent by weight. The remainder of the project was used as a control section using the same asphalt cement without the additive.

It should be noted that the night before construction was started on this project, a rainstorm wet the stockpiles, thus assuring a valid test of the antistripping additive.

Control During Construction

Two sets of specimens were molded using 75 blows on each face with a standard Marshall hammer. Each set consisted of ten specimens. One set of specimens was molded from the mix with additive and one set from mix without the additive. In addition to the Marshall specimens, twelve roadway cores were taken; six cores from the additive section and six from the control section. The roadway cores were tested for percent of laboratory gravity. The Marshall specimens were tested according to the following procedures:

(1) Specific Gravity determinations of Compressed Bituminous Mixtures --- LDH TR 304.

(2) Stability and Flow of Asphaltic Concrete Mixtures (Marshall Method) --- LDH TR 305.

(3) Shear Stress and Bearing Resistance as obtained by the gyratory testing machine.

Tests on the physical properties of the asphalt, with and without the antistripping additive, were performed to determine whether or not the additive had any definite effect on the test properties.

In addition to the mechanical and physical tests, visual observations were made during construction and six months and one year year after completion.

## DISCUSSION OF RESULTS

### Marshall Immersions

To investigate the possibility of the antistripping additive effecting the resultant stability of an asphaltic concrete mixture containing the additive, the stability and flow of mixes with and without the additive were tested by the Marshall Immersion Method.

A total of twenty Marshall specimens were molded at the plant. Ten of the specimens were molded from the mix containing the additive and ten without. It should be noted that the specimens were molded at the plant, but the testing was conducted at the research laboratory in Baton Rouge.

As can be seen in Table 1, the additive had little or no effect on voids, voids filled, swell, absorption and flow. The additive had its greatest effect upon the stability of the mixes. However, what effect it did have (38 pounds in average stability of the control specimens and 75 pounds in the immersion specimens) can be considered as negligible.

The complete test data on the Marshall Immersions is listed in Tables 5 and 6 of the Appendix.

TABLE 1

COMPARISON OF RESULTS OF MARSHALL IMMERSION TESTS

| | Without Additive | With Additive |
|---|---|---|
| Average Specific Gravity | 2.352 | 2.358 |
| Voids - % | 3.9 | 3.8 |
| Voids Filled - % | 74.8 | 76.2 |
| Average Stability (Control) | 1002 lbs. | 1040 lbs. |
| Average Stability (Immersion) 24 hrs. @ 140°F | 1176 lbs. | 1101 lbs. |
| Average Flow 1/100" (Control) | 9 | 9 |
| Average Flow 1/100" (Immersion) | 8 | 8 |
| % Strength Retained | 117.4 | 105.9 |
| % Swell | 0.23 | 0.00 |
| % Absorption | 0.27 | 0.18 |

Gyratory Shear Stress and Bearing Resistance

An investigation of what effect the antistripping additive might have had on the bearing resistance of the two different mixes was conducted with the Gyratory Testing Machine.

Eight specimens were molded from bin samples and asphalt taken at the plant. Four of the specimens were molded with asphalt containing the additive and the remaining four specimens were molded without the additive.

The shear stress, bearing resistance and percent strain were established for the eight specimens by use of the gyratory formula. Unfortunately, the results of this testing could not be used due to subsequent mathematical changes in the gyratory formula. Re-calibration of the gyratory equipment rendered the results erroneous and no correlation could be established with the old results.

Although the results of the testing were not valid, the values themselves indicated that the additive had a negligible effect upon the bearing resistance of the mix.

Immersion Test of Plant Asphalt

Samples of asphalt with and without the additive were taken from the asphalt storage tanks at the plant. These asphalt samples were then mixed with a bin sample of 3/8 inch to No. 4 aggregate and subjected to static immersion to ascertain if the plant asphalt containing the additive would give the same coating as obtained in the laboratory investigation.

After a static immersion of sixteen hours at 160°F, the two samples were compared. As can be seen in Figure 2a, the untreated asphalt did strip in a manner very similar to the laboratory mix (See Figure 1-C).

Likewise, the aggregate coated with the asphalt containing the additive performed in the same manner as the laboratory mix (see Figure 2b and compare to Figure 1-1).

Roadway Cores

After construction of the control and test sections was completed, twelve roadway cores were taken, as indicated in Figure 3.

*FIGURE 2a*

Stripping of Untreated Plant Asphalt From 3/8 inch to No. 4 Aggregate After Static Immersion at 160°F for 16 Hours

*FIGURE 2b*

Stripping of Treated Plant Asphalt From 3/8 inch to No. 4 Aggregate After Static Immersion at 160°F for 16 Hours

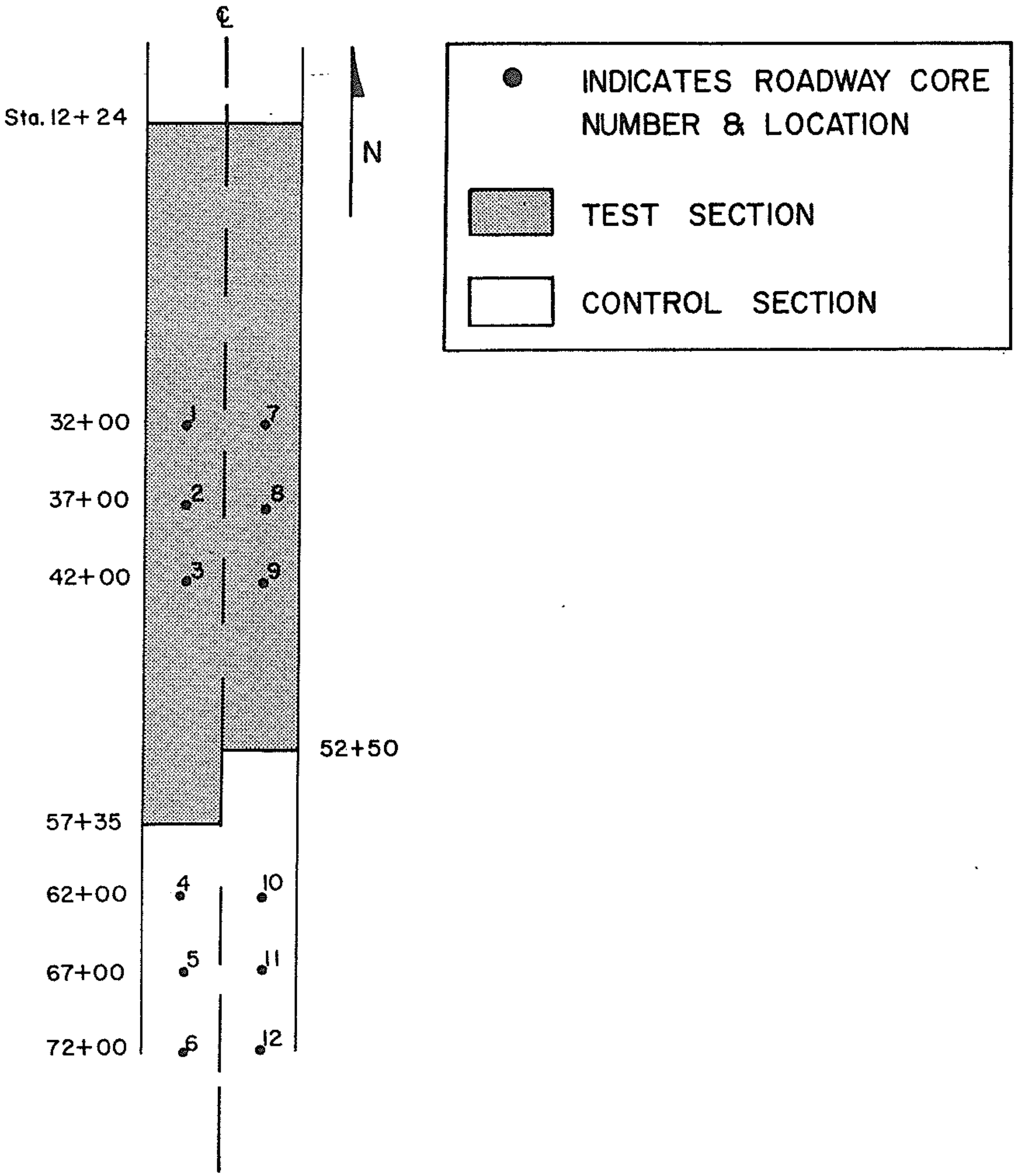


*FIGURE 3*

Location of Roadway Cores Taken

The cores were tested in the laboratory. A comparison of these test results can be seen in Table 2.

TABLE 2

COMPARISON OF ROADWAY CORES

| | Roadway Cores without Additive | Roadway Cores with Additive |
|---|---|---|
| Average Actual Specific Gravity | 2.279 | 2.273 |
| Laboratory Specific Gravity | 2.352 | 2.358 |
| Percent Compaction | 96.9% | 96.4% |

The complete test data on the roadway cores is listed in Table 7 of the Appendix.

<u>Analysis of Asphalt</u>

Samples of the asphalt cement used at the plant were taken. One sample representing the asphalt cement without the additive, and a sample representing the same asphalt cement with the antistripping agent added. The physical properties of these samples were tested to see if the additive had any effect on the physical properties of the asphalt.

The most noticeable changes in the physical properties of the two asphalts were in viscosity and penetration. As can be seen in Table 3, the viscosity of the asphalt treated with the antistripping additive decreased by 9 Saybolt Furol seconds and 296 poises on the absolute viscosity. Likewise, the penetration at 39.2°F and 77°F increased by 3 and 10 respectfully.

Again, these differences in viscosities and penetrations can be considered as negligible.

A comparison of all the tests performed on the two asphalts is listed in Table 8 of the Appendix.

TABLE 3

COMPARISON OF ASPHALT TESTS

| Properties Tested | Asphalt without Additive | Asphalt with Additive |
| --- | --- | --- |
| Saybolt Furol Sec. @ 275°F. | 238 | 229 |
| Absolute @ 140°F, Poises | 2346 | 2054 |
| Penetration @ 39.2°F, 200G., 60 sec. | 39 | 41 |
| Penetration @ 77°F. 100G., 5 sec. | 87 | 97 |

Visual Observations

After being exposed to traffic for approximately six months, the control and test sections were checked and visually compared to ascertain if any raveling and/or pitting had occurred. After a complete inspection of the control and test sections, no visual difference was noted.

The test sections were visually compared again after one year of service. At the time of this observation, there appeared to be a slight textural change between the test sections. The control section (the section without the antistripping additive) appeared to have a more open surface texture (i.e., the aggregate appeared to be more exposed) while the additive section seemed to have a finer surface texture. However, it should be noted that the textural difference was so slight and inconsistent that no definite comparison or conclusion could be reached. Figure 4 shows the slight textural differences.

*FIGURE 4a*

Texture of Control Section (without additive)

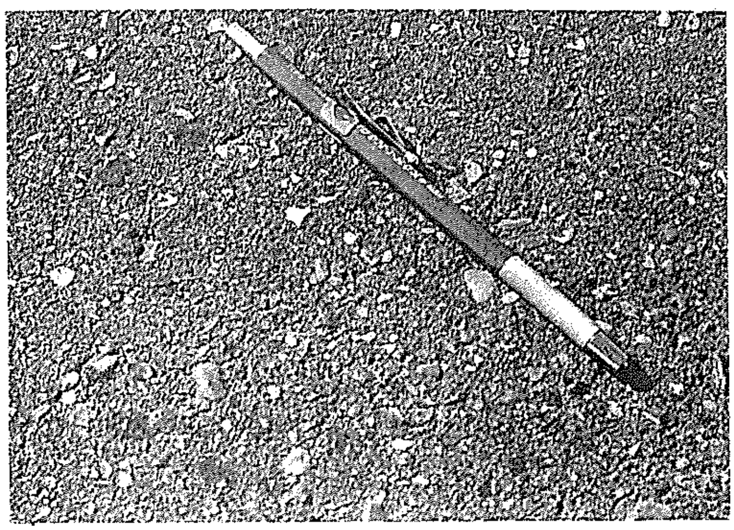

*FIGURE 4b*

Texture of Test Section (with additive)

## CONCLUSIONS AND RECOMMENDATIONS

Based on the laboratory and field results of this project, the antistripping additive did lower the viscosity of the asphaltic cement thus providing a slightly more workable mix. However the benefits to be derived by the use of antistripping additives are so slight that they should be considered as negligible.

The test and control sections have yet to show any definite indications of raveling or pitting. Due to this lack of any raveling or pitting in either section, it is not possible to recommend the use of antistripping additives on a state-wide basis based on this study alone.

It should be noted that a slight textural difference has developed between the control and test sections. The control section has a more open texture than the test section. It is therefore recommended that additional periodic visual checks be made on this project to ascertain if this slight textural difference develops into any form of stripping. In the event stripping should occur and the test section indicates that the antistripping additive has had a benefical effect. A supplemental report will be issued.

APPENDIX

TABLE 4

RATING OF ADDITIVES TO PREVENT STRIPPING STATIC IMMERSION 160°F FOR 24 HOURS SMALL AGGREGATE 3/8" - NO. 4 - 0.5% ADDITIVE

| OBSERVER | A | B | C | D | E | CONCENSUS | |
|---|---|---|---|---|---|---|---|
| | Did Not rate this group | 1 | 4 | 1 | 4 | 1 | best |
| | | 4 | 1 | 6 | 1 | 4 | |
| | | 3 | 6 | 4 | 6 | 6 | |
| | | 6 | 2 | 3 | 3 | 3 | |
| | | 5 | 3 | 5 | 2 | 2 | |
| | | 2 | 5 | 7 | 5 | 5 | |
| | | 7 | 7 | 2 | 7 | 7 | worst |

Large Aggregate 1" - 3/4"

| OBSERVER | A | B | C | D | E | CONCENSUS | |
|---|---|---|---|---|---|---|---|
| | 1 | 1 | 1 | 1 | 1 | 1 | best |
| | 4 | 4 | 4 | 6 | 4 | 4 | |
| | 6 | 6 | 6 | 5 | 6 | 6 | |
| | 5 | 5 | 5 | 4 | 5 | 5 | |
| | 2 | 2 | 7 | 7 | 7 | 7 | |
| | 7 | 7 | 2 | 2 | 2 | 2 | |
| | 3 | 3 | 3 | 3 | 3 | 3 | worst |

TABLE 5

RESULTS OF MARSHALL IMMERSION TESTS ON SPECIMENS MOLDED WITH UNTREATED ASPHALT

| Specimen Number | Voids | Voids Filled | Unit Weight Lbs/cu.ft. | Stability | Flow 1/100" |
|---|---|---|---|---|---|
| 1 (Control) | 3.8 | 75.2 | 146.9 | 1043 | 10 |
| 2 | 3.8 | 75.2 | 146.8 | 1246 | 9 |
| 3 | 3.9 | 74.7 | 146.7 | 1304 | 9 |
| 4 (Control) | 4.2 | 73.2 | 146.3 | 1027 | 8 |
| 5 (Control) | 3.9 | 74.7 | 146.7 | 1054 | 9 |
| 6 | 3.6 | 76.3 | 147.3 | 1233 | 7 |
| 7 | 4.2 | 73.2 | 146.3 | 1086 | 7 |
| 8 (Control) | 4.0 | 74.2 | 146.6 | 918 | 7 |
| 9 (Control) | 3.7 | 75.7 | 147.0 | 970 | 10 |
| 10 | 3.8 | 75.2 | 146.9 | 1011 | 8 |

| | |
|---|---|
| Average Specific Gravity (Control) | 2.351 |
| Average Specific Gravity (Immersion) | 2.352 |
| Average Stability (Control) | 1002 |
| Average Stability (Immersion) | 1176 |
| % Swell | 0.23 |
| % Absorption | 0.27 |
| % Strength Retained | 117.4 |

TABLE 6

RESULTS OF MARSHALL IMMERSION TESTS ON SPECIMENS MOLDED WITH TREATED ASPHALT

| Specimen Number | Voids | Voids Filled | Unit Weight Lbs/cu.ft. | Stability | Flow 1/100" |
|---|---|---|---|---|---|
| 1 (Control) | 3.3 | 77.9 | 147.6 | 1120 | 10 |
| 2 | 3.4 | 77.3 | 147.5 | 1255 | 7 |
| 3 (Control) | 3.6 | 76.3 | 147.3 | 1071 | 9 |
| 4 | 3.6 | 76.3 | 147.1 | 960 | 8 |
| 5 | 3.4 | 77.3 | 147.5 | 1091 | 8 |
| 6 (Control) | 3.8 | 75.2 | 146.8 | 902 | 8 |
| 7 | 3.7 | 75.7 | 147.0 | 1065 | 7 |
| 8 (Control) | 3.6 | 76.3 | 147.1 | 1044 | 11 |
| 9 (Control) | 3.8 | 75.2 | 147.0 | 1062 | 8 |
| 10 | 4.0 | 74.2 | 146.6 | 1134 | 9 |

| | |
|---|---|
| Average Specific Gravity (Control) | 2.358 |
| Average Specific Gravity (Immersion) | 2.358 |
| Average Stability (Control) | 1040 |
| Average Stability (Immersion) | 1101 |
| % Swell | 0.00 |
| % Absorption | 0.18 |
| % Strength Retained | 105.9 |

TABLE 7

RESULTS OF MARSHALL IMMERSION TEST ON ROADWAY CORES

| Core Number Test Section (with additive) | Station Number | Voids | Voids Filled | Unit Weight Lbs/Cu.ft. |
|---|---|---|---|---|
| 1 | 32+00 | 6.4 | 62.8 | 137.8 |
| 2 | 37+00 | 4.5 | 71.0 | 140.5 |
| 3 | 42+00 | 2.3 | 83.1 | 143.8 |
| 7 | 32+00 | 3.0 | 78.9 | 142.8 |
| 8 | 37+00 | 3.6 | 75.6 | 141.8 |
| 9 | 42+00 | 1.9 | 85.6 | 144.3 |
| **Core Number Control Section (without additive)** | | | | |
| 4 | 62+00 | 3.8 | 74.5 | 141.2 |
| 5 | 67+00 | 4.2 | 72.4 | 140.5 |
| 6 | 72+00 | 3.7 | 75.0 | 141.3 |
| 10 | 62+00 | 2.3 | 83.1 | 143.5 |
| 11 | 67+00 | 2.7 | 80.6 | 142.8 |
| 12 | 72+00 | 1.8 | 86.3 | 144.1 |

| | |
|---|---|
| Average Specific Gravity (with) | 2.273 |
| Average Specific Gravity (without) | 2.279 |
| Average % Compaction (with) | 96.4 |
| Average % Compaction (without) | 96.9 |

TABLE 8

REPORT OF TESTS OF ASPHALTS

| | Without Additive | With Additive |
|---|---|---|
| Specific Gravity 77°F | 1.018 | 1.018 |
| Specific Gravity 60°F | 1.021 | 1.021 |
| Wt. per Gallon @ 60°F, Lbs. | 8.512 | 8.512 |
| Flash Point, C.O.C., °F | 625 | 610 |
| Viscosity | | |
| Saybolt Furol sec. @275°F | 238 | 229 |
| Absolute @ 140°F, Poises | 2346 | 2054 |
| Penetration @39.2°F, 200G., 60 sec. | 39 | 41 |
| Penetration @77°F, 100G., 5 sec. | 87 | 97 |
| Thin Film Oven Test | | |
| Loss% @ 325°F, 5 hours | 0.00 | 0.00 |
| Penetration of Residue @ 77°F | 60 | 76 |
| Residue Penetration, % of original | 69 | 78 |
| Ductility of Residue @ 77°F | 100+ | 100+ |
| Solubility in $CS_2$, % | 99.92 | 99.89 |
| Homogeniety | Negative | Negative |