# TRANSPORTATION DEPARTMENT
# DIVISION OF HIGHWAYS

LABORATORY TESTING OF MINERAL FIBER
FILLERS FOR ASPHALT CONCRETE

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RESEARCH PROJECT 24
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## MATERIALS and RESEARCH SECTION

# LABORATORY TESTING OF MINERAL FIBER FILLERS FOR ASPHALT CONCRETE

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By

A. F. Stanley
Associate Materials Engineer I

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## ABSTRACT

A short testing program was undertaken to compare rock wool and two other types of glass fiber with asbestos as stabilizing fillers in asphalt paving. The fillers were compared on the basis of cost, Marshall stability, and tensile splitting strength. All three glass fiber fillers gave lower Marshall stabilities than unmodified plantmix, which had lower stability than asbestos filled mix.

## DISCLAIMER

The findings, opinions, conclusions and recommendations contained in this report are those of the author and do not necessarily reflect official policies of the Idaho Department of Highways.


## ACKNOWLEDGMENTS

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Chopped "Glass Roving" fiberglass was furnished by Owens/Corning.

# INTRODUCTION

Asbestos filled asphalt concrete overlays have been specified on several bridge projects where deck sealing membranes were installed. This type of plantmix employs higher than normal asphalt content, so asphalt film thickness is relatively high and air voids are low, which should improve pavement durability. The asbestos fibers help stabilize the mix against bleeding and shoving which often occur in ordinary plantmix with high asphalt content.

The increase in asphalt content and the addition of asbestos raise the cost of asbestos plantmix significantly compared to ordinary asphalt concrete. This additional cost has been considered acceptable for the special application of overlays placed over bridge deck sealing membranes, in view of the expected improvement in overlay durability. Maximum overlay durability is desired, to give the best possible protection to the sealing membrane.

In view of recent publicity about possible health hazards of asbestos particles, consideration has been given to alternate fiber fillers. Several forms of glass fiber are commercially available, and this type of material has fewer handling restrictions than asbestos. This report contains the results of a short testing program comparing fiberglass filled plantmix to asbestos filled plantmix. Three different types of glass fibers were used.

At the beginning of the testing project we intended to investigate the possibility that the asbestos filled asphalt concrete overlay would serve both as wearing surface and sealing membrane. After testing was well underway, we received information from a major asbestos supplier, Johns-Manville Sales Corp., that asphalt content of about 14% and asbestos content of 5% or more are required to make asbestos filled asphalt concrete impermeable to moisture. These values are considerably higher than the ones adopted for this test program. As a result, it was decided to restrict the program to consideration of mixes to be used either in ordinary paving or as wearing surfaces placed atop sealing membranes. Asphalt-asbestos membranes intended to serve both as wearing surface and sealing membrane are not discussed further in this report.

other fillers were selected after reviewing the mix designs. One series of specimens was compacted by the Marshall procedure using 50 blows, and the other series was compacted in the kneading compactor using the procedure specified in Idaho T-9. Marshall and Hveem stabilities were measured on the appropriate specimens, and wet and dry tensile split tests (Idaho T-11) were done to observe the differences resulting from the different types of compaction as well as the differences attributable to the various fiber types.

All specimens were made with Exxon 120-150 asphalt cement, the same grade which has been specified on recent asbestos plantmix jobs in Idaho. Aggregate was from Source No. Ad-104 and gradation was as shown in the table below.

AGGREGATE GRADATION

| Sieve Size | | 3/4 | 1/2 | 3/8 | #4 | #8 | #30 | #200 |
|---|---|---|---|---|---|---|---|---|
| % Passing | This Project | 100 | 91 | 79 | 59 | 49 | 30 | 6.6 |
| | ITD Deck Overlay Spec. | - | 100 | 80-100 | 55-75 | 35-55 | 15-35 | 5-12 |

TABLE 1

# SUMMARY OF TEST RESULTS

Preliminary Mix Properties
(Hveem Stability = 30)

| Filler | Comments on Filler | % Asphalt On Dry Aggregate Basis / % Air Voids | | | |
|---|---|---|---|---|---|
| | | * 0% Filler | 1/2% Filler | 1% Filler | 2% Filler |
| None | - - - - | 6.2 / 3.2 | - | - | - |
| Asbestos | Johns-Manville 7M | - | - | - | 6.6 / 4.8 |
| Rock Wool | Clumps Reduced by Hand to Approx. 1/8" - 1/4" Size | - | - | 5.0 / 6.0 | 6.5 / 2.9 |
| Insulation Grade Fiberglass | Clumps Reduced by Hand to Approx. 1/8" - 1/4" Size | - | 6.5 / 2.3 | 5.9 / 4.7 | All Stabilities Below 30 |
| Chopped Fiberglass | Bundles of Straight Fibers 1/2" Long-Owens/ Corning Type K-832 | - | 6.3 / 3.7 | All Stabilities Below 30 | All Stabilities Below 30 |

TABLE 2

* Filler percentages are based on total weight of aggregate including filler weight.

For each glass fiber type, the percent of filler giving lowest voids was selected for tensile split testing, giving the results shown below.

Tensile Split Test Results
(Hveem Stability = 30)

| Filler / Asphalt Content | Dry or Wet | Splitting Tensile Strength PSI, Average of 3 | Tensile Strength Ratio, Wet/Dry |
|---|---|---|---|
| None / 6.2% | Dry | 57 | 1.16 |
| | Wet | 66 | |
| Asbestos 2% / 6.6% | Dry | 27 | 2.19 |
| | Wet | 59 | |
| Rock Wool 2% / 6.5% | Dry | 24 | 2.75 |
| | Wet | 66 | |
| Insulation Fiberglass 1/2% / 6.5% | Dry | 45 | 1.78 |
| | Wet | 80 | |
| Chopped Fiberglass 1/2% / 6.3% | Dry | 24 | 2.33 |
| | Wet | 56 | |

TABLE 3

For the next test series, using the higher asphalt content of 8%, the percentages of the two types of fiberglass filler were increased to 1%. In the case of insulation grade fiberglass, the extra filler was added to keep air voids from dropping too low at the higher asphalt content. In the case of chopped fiberglass, the mix design data for 1% filler had a flatter stability curve than the design using 1/2% filler. Therefore 1% filler was chosen in an effort to obtain the highest stability at the higher asphalt content.

TENSILE SPLIT RESULTS, STABILITY AND AIR VOIDS

(Asphalt Content = 8%)

| | | HVEEM METHOD | | | | MARSHALL METHOD | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Filler % of Dry Agg. Weight | Dry or Wet | Splitting Tens. Strgth. PSI, Avg. of 3 | Tens. Strgth. Ratio, Wet/Dry | Hveem Stability | Air Voids % | Splitting Tens. Strgth. PSI, Avg. of 3 | Tens. Strgth. Ratio, Wet/Dry | Marshall Stability | Flow .01 in. Units | Air Voids % |
| No Filler | - | - | - | - | - | 16 | 1.06 | 1690 | 19 | 1.2 |
| | - | | | | | 17 | | | | |
| Asbestos 2% | Dry | 21 | 1.50 | Excessive Displace-ment | 0.8 | 19 | 1.32 | 1810 | 18 | 1.2 |
| | Wet | 32 | | | | 25 | | | | |
| Rock Wool 2% | Dry | 23 | 1.43 | Excessive Displace-ment | 0.9 | 16 | 1.44 | 1140 | 17 | 2.9 |
| | Wet | 33 | | | | 23 | | | | |
| Insulation Fiberglass 1% | Dry | 18 | 1.50 | Excessive Displace-ment | 0.3 | 13 | 0.92 | 1240 | 18 | 3.0 |
| | Wet | 27 | | | | 12 | | | | |
| Chopped Fiberglass 1% | Dry | 20 | 1.20 | 18 | 2.3 | 8 | N.A. | 340 | 25 | 10.9 |
| | Wet | 24 | | | | Specimens Swelled & Cracked in Water Bath | | | | |

TABLE 4

## DISCUSSION OF RESULTS

As noted in Table 1, aggregate gradation used for these tests does not correspond exactly to that ordinarily specified for bridge deck membrane overlays. This factor should have no effect on the comparisons to be drawn among the various fiber types. The gradation difference may slightly reduce the confidence with which the test results might be applied to the design of 1/2" mixes. It should be borne in mind however, that a limited preliminary investigation of this kind is very unlikely to produce detailed design recommendations under any circumstances.

The preliminary mix data in Table 2 are presented for background information only and require little discussion. The comments in Table 2 regarding rock wool and insulation grade fiberglass are worthy of emphasis, because these materials require mechanical processing before they can be used in asphalt paving mixes. In the bulk form as received from the supplier, these products consist of large clusters of intertwined fibers. These must be reduced to smaller clumps to insure uniform fiber distribution in the plantmix. The clusters were pulled apart by hand for this laboratory work, but a mechanical method of breaking them down would be necessary for field use.

The tensile split tests done under conditions giving Hveem stability of 30 (Table 3) illustrate some effects of the various fibers. First, all the fiber filled specimens exhibited lower dry splitting tensile strengths than the plain specimens. Wet splitting tensile strengths were also lower for most fiber mixes than for the plain mix, but the wet strength reductions were not as great as the dry strength reductions. Because of this, the tensile strength ratios for all fiber mixes were greater than for the plain mix. This indicates that all the fiber mixes tested exhibit better water resistance than the plain mix. None of the glass fiber mixes could be said to be significantly inferior to the asbestos mix on the basis of these tensile split tests.

The tensile strength ratios (TSR) are consistently greater than one. This is unusual, since wet strength is ordinarily lower than dry strength due to the stripping action of water. Some potential causes for TSR greater than one are the following: First, Reference 1 indicates TSR may be greater than one if air voids are less than approximately 3%. This does not seem to offer a complete explanation in the present case because some specimens with TSR considerably above one had air voids approaching 5%. A second possibility is that the fibrous mixes depart significantly from the assumptions on which the tensile split theory is based. A third possible contributor is the conditioning of the wet specimens before splitting. As mentioned previously, these tests were done under the old test method which did not include a freeze-thaw cycle. For this reason, the wet strengths may be unrealistically high. A thorough investigation of these factors was considered to be outside the scope of the test program, so no testing was done to try to isolate the true reasons for the unexpectedly high tensile strength ratios.

The final series of tests (Table 4) was run at 8% asphalt content to simulate more closely the relatively high asphalt content being specified for asbestos-filled deck overlays. Striking differences are noted between the results given by the Hveem method and those of the Marshall method. In every case, tensile splitting strength is higher and air voids lower for Hveem specimens than for corresponding Marshall specimens. This is a result of the greater compactive effort associated with the Hveem design procedure. The extreme example is the mix containing chopped fiberglass, where Hveem compaction yielded 2.3% air voids whereas Marshall compaction gave 10.9% air voids.

Stability comparisons are also interesting. Under our usual minimum Hveem stability criterion of 30, none of the mixes would be acceptable. Under the Marshall criteria given in Reference 2 (Min. Stability = 500, Max. Flow = 18) all fibrous mixes except the one containing chopped fiberglass would be acceptable. It is noteworthy, however, that the mixes using rock wool and insulation fiberglass showed somewhat lower stability numbers than the plain mix, which in turn exhibited lower stability than the asbestos-filled mix. This behavior indicates that rock wool and insulation fiberglass are not as effective as asbestos in maintaining pavement stability at high asphalt content. Moreover, it indicates rock wool and glass fiber to be detrimental rather than beneficial, at least from the standpoint of Marshall stability.

Reference 5 indicates a modified Marshall method is appropriate for designing asbestos plantmix. The test results from our project support the use of a Marshall approach in preference to the standard Hveem procedure, since in most cases no numerical Hveem stabilities could be obtained due to excessive displacement of the mix during the stabilometer test. The Marshall method, on the other hand, yielded stability numbers for all mixes.

The fact that low Hveem stabilities are associated with these fibrous mixes might cause concern in view of our usual minimum acceptable Hveem stability of 30. Despite the low Hveem stability associated with this type of mix, several pavement installations have shown good performance for asbestos-filled plantmix using high asphalt content (Ref. 3,4,6). I have been unable to locate any reports discussing field performance of glass fiber-filled plantmix.

In the case of chopped fiberglass, comparison between Hveem and Marshall results provides useful information. As mentioned previously, the Marshall specimens containing chopped fiberglass had very high void content. Visually, it was obvious the specimens were not adequately compacted. During water soak, the specimens swelled and cracked. The Hveem (kneading compaction) specimens performed much better than Marshall specimens in the tensile split and stability tests. The greater compactive effort of the Hveem procedure gave a particularly striking difference in mix properties in this case, and part of the reason is probably the special characteristics of the chopped fibers. This filler consists of 1/2" long bundles of straight fibers bonded together by silane sizing. These straight bundles are quite stiff compared to the individual curly fibers in rock wool and insulation type fiberglass. Apparently the stiff fiber bundles interfered with compaction in the Marshall specimens. The higher compactive effort characteristic of Hveem design was evidently sufficient to partly overcome the resistance of the stiff fiber bundles. Even so, the Hveem chopped fiber specimens had higher void content than any of the other Hveem specimens, which reinforces the contention that the short straight fiber bundles interfere with compaction.

A comparison of materials costs provides an additional basis for judging the relative merits of the various fillers. Current prices* are: Johns-Manville 7M asbestos, 9¢/lb.; bulk glass wool, 13-17¢/lb. depending on grade; mineral wool insulation (blowing wool), 10¢/lb.; chopped fiberglass strand, 40-50¢/lb. Chopped strand is much more costly than the other glass fibers

* These prices were obtained 1-20-75. They do not include shipping cost.

because its manufacture involves more steps and more equipment than the others. It is a much more precisely controlled product than the insulation grades of fiberglass or rock wool.

Asbestos, glass wool and rock wool each have additional costs associated with their use, not included in the purchase prices given above. These costs are partly for respirators or other protective equipment and partly for equipment modifications for handling the fibers and delivering them to the mixing chamber. In the case of rock wool or glass wool, a device would be required to break up the fiber clumps into smaller size before mixing.

## CONCLUSIONS

Glass wool insulation, mineral wool insulation and chopped fiberglass strands similar to Owens/Corning K-832 are not as effective as short asbestos fibers for maintaining plantmix stability at high asphalt content.

At asphalt content of 8% and fiber loadings of 1 to 2% by weight of dry aggregate, plantmix containing rock wool, insulating fiberglass, or chopped fiberglass similar to Owens/Corning K-832 has lower Marshall stability than unmodified plantmix.

Plantmix containing chopped fiberglass similar to Owens/Corning K-832 would be difficult to install in the field because the short, stiff, bonded fiber bundles interfere with compaction of the mix.

Asbestos is the lowest priced fiber tested in this program, disregarding differences in handling costs and safety-related costs at the job site. No attempt was made in this study to estimate the handling and safety costs associated with any of the fiber types.

## RECOMMENDATIONS

It is recognized that this study is not a comprehensive treatment of mix design possibilities using various types of glass fiber. Nonetheless, the relatively poor performance of glass fiber mixes compared to asbestos mix and unmodified mix leads to the following recommendations:

Glass fiber should not be specified as a substitute for asbestos filler in asphalt concrete paving mix.

Further investigation into the use of a glass fiber as a substitute for asbestos in plantmix would be justified only in the event of major changes in price, regulations, or product properties. Situations which might justify further investigation would be a dramatic increase in asbestos price, a severe restriction on asbestos usage due to future Federal regulations, or development of an inexpensive specialty grade of glass fiber for plantmix.

## REFERENCES


1. Lottman, R. P., "The Moisture Mechanism That Causes Stripping in Asphaltic Pavement Mixtures", University of Idaho, 1971

2. "Mix Design Methods For Asphalt Concrete", Manual #MS-2, The Asphalt Institute, March 1974

3. Kietzman, J. H., et al, "Performance of Asbestos-Asphalt Pavement Surface Courses With High Asphalt Contents", Highway Research Record #24, 1963

4. Willis, L. F. and Rodier, C. E., "Asbestos Fibre Asphalt Mixes: Their Performance and Evaluation", 14th annual conference of the Canadian Technical Asphalt Association, 1969

5. "Modified Marshall Design Procedure for Asbestos-Asphalt Pavements (Tentative)", Johns-Manville Research and Engineering Center Report #E4111-842.

6. Wortham, G. R., and Hatch, L. M., "Asbestos Fiber as a Filler in a Plantmix Pavement", Idaho Department of Highways, 1969