# General Discussion

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•THE PROJECT is located on a short spur connecting US 1 in Madawaska, Maine, with the Canadian border town of Edmundston, New Brunswick. The following statements describe essential features of the road:

1. The project was approximately 900 ft long and consisted of a 42-ft wide roadway.
2. The asbestos pavement was placed on 24 in. of gravel.
3. Approximately one-half of the project was on a 14.5 percent grade.
4. A paper mill is located on both sides of the street, and as a result, heavy trucks are being loaded 24 hr a day.
5. The hilly section of the project has one-way traffic going down, but the lower, flat half of the project has two-way traffic.

The ADT for 1960 was 3,685. Estimated ADT for 1980 is 5,160. A generalized cross-section is shown in Figure 1.

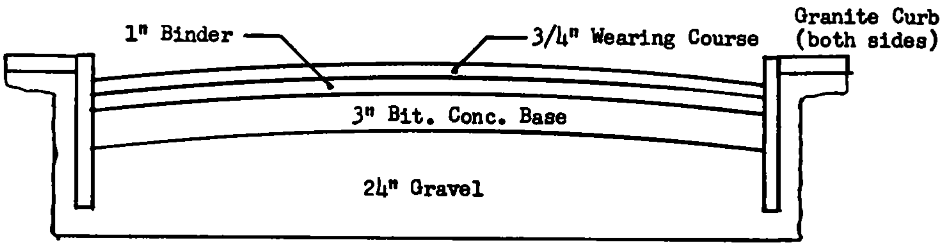


Figure 1.

Background of Paving Difficulties

Cracking. — Dense, flexible pavement surfaces placed in Aroostook County tend to crack and deteriorate excessively. The cracking generally begins to develop during the first winter. The cracking pattern begins with transverse cracks breaking the pavement into slabs about 100 ft long. Longitudinal cracks also appear along the center of the road, but not necessarily on the construction joint. These cracks continue breaking the pavement into smaller chunks as time progresses. This cracking is attributed to deep frost penetration in the underlying soil. The freezing index in the Madawaska area is approximately 3,000 degree-days.

Disintegration of Aggregate. —Engineers have been trying for years to overcome the extreme deficiencies of the local aggregate in Aroostook County. Fine aggregate that would normally be used as a blend sand is also almost nonexistent in this area. The sand is either too coarse and clean or too fine with too much clay material.

The aggregate in this area is described as subangular, angular, and flat, composed of approximately 50 percent quartzite and sandstone, and 50 percent shale. The percentage loss by the Los Angeles abrasion test method (AASHO: T-96-60) is 20 to 23 percent. This is misleading because the durability or soundness is very low. When tested for soundness by the magnesium sulfate method (AASHO: T-104-57) the sands have a loss of approximately 15 percent. The coarse aggregate has an even higher loss of over 20 percent. The aggregate passing the ¼-in. and retained on the ⅛-in. screen has a loss of approximately 40 percent.

Absorption.—There are also indications that disintegration ties in with the moisture in the aggregate at the time of mixing.

In previous years the local hot mix plants were equipped with two dryers; but recently, with the development of more efficient dryers, contractors have attempted to do the work with one dryer.

The absorption of this aggregate is between 1.5 and 2.0 percent and thorough drying is very difficult to obtain even when the stockpiles are relatively dry. It is believed that the moisture in the mix causes the unsatisfactory performance of mixtures produced during periods when the moisture content of stockpiles is high.

Serviceability.—In Aroostook County, partial failure of a bituminous concrete pavement, due to either progressive cracking or to disintegration of aggregate, does not constitute a complete loss of serviceability of a newly constructed highway. There is, however, considerable increase in maintenance cost.

In spite of the difficulties encountered, bituminous concrete seems to be the most favorable type of road as it is more dense than macadam and, along with other advantages, tends to keep water from penetrating to the subgrade. Chip sealing when necessary provides further waterproofing.

## Methods Used to Improve Wearing Course Durability

Because the only aggregate readily available within 100 mi has the deficiencies previously described, it was necessary either to upgrade or otherwise to improve the bituminous concrete wearing course. The following changes were made to correct their corresponding deficiencies:

1. The larger stone (½ in.) maximum size, which showed the most disintegration on the road, was reduced to a maximum size of ⅜ in.
2. To upgrade the general durability of the coarse aggregate, 50 percent crushed ledge rock was added.
3. A finer gradation was used to reduce water infiltration into the coarse aggregate.
4. To get a better type of filler and replace the existing poor blend sand, ground limestone normally produced for use as land lime was added.
5. To remove all moisture, double drying of all aggregate in the wearing course was specified.
6. To insure high densities, a pneumatic roller was specified in addition to the two usual steel rollers.

## Reasons for Use of Asbestos

With the previously mentioned difficulties that had to be overcome, a mix with an "excessive" amount of asphalt would be desired. If ample asphalt were available then the double-dried stone would in turn be able to absorb part of the asphalt and yet there would be enough asphalt remaining to provide the required cementing action.

Asbestos appeared to be the natural material to use to make a pavement that will have durability, high asphalt content, high stability, high density, and above all, high flexibility.

Tests by Johns-Manville Research Department had shown that, although asbestos improves the qualities of the wearing course, it has even more pronounced effects on open-graded mixes such as binder and bituminous concrete base courses. As asbestos is almost a native material, the decision to use it in all three courses was made.

# DESIGN OF MIXES

## Base Course

No laboratory design of the bituminous concrete base was made. The gradation was a typical one as used in the State of Maine except that 2 percent by weight of short asbestos fiber was used. The asphalt content was increased by 1 percent over the usual specified amount.

## Binder Course

No laboratory design of the binder course was made. This gradation was also a typical one such as used throughout the State with the exception that it also had 2 percent by weight of asbestos fiber. The amount of asphalt was increased by 1 percent over the amount normally specified.

## Wearing Course

A complete laboratory design was made of the wearing course. For comparison purposes test series were run using both 2 percent asbestos and no asbestos. The aggregate used was a double-dried material collected from the hot bins of the same plant that did the actual mixing. The results using the Hveem method of mix design are shown in Figures 2, 3, and 4. The gradation used in the laboratory-designed mix was very nearly the same as that actually used on the roadway. After analyzing the results of the design tests it could be seen that 8.0 percent asphalt based on percentage of aggregate was the optimum. However, to allow ample asphalt for absorption, additional asphalt was recommended. The same results were obtained independently by Johns-Manville engineers using the same basic gradation and aggregate.

# GRADATIONS AND RESULTS TAKEN FROM PROJECT

## Asphalt Cement

The asphalt used was shipped from Everett, Mass., to Caribou, Maine, by tank truck. It was 85-100 penetration grade. The average results of the asphalt tests are shown below:

| | |
|---|---|
| Penetration at 77 F, 100 g, 5 sec | 92 |
| Flash point ($^{0}$F) | 537 |
| Ductility at 77 F, 5 cm/min | 110+ |
| Loss on heating, 325 F, 5 hr | .29 |
| Penetration of residue at 77 F | 75 |
| Solubility (%) | 99.4 |
| Ash (%) | 0 |

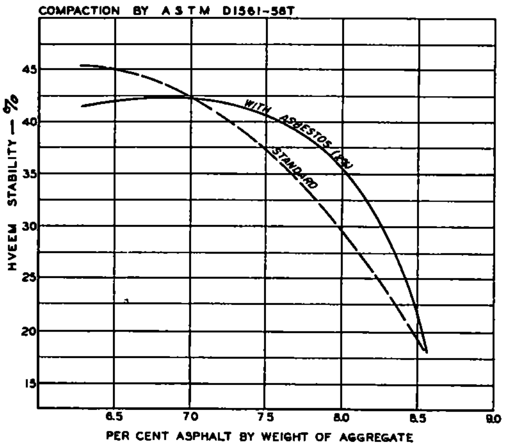


Figure 2. Stability values vs asphalt content.

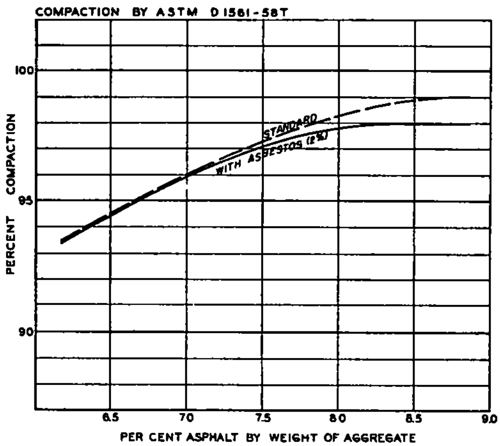


Figure 3. Percent compaction vs asphalt content.

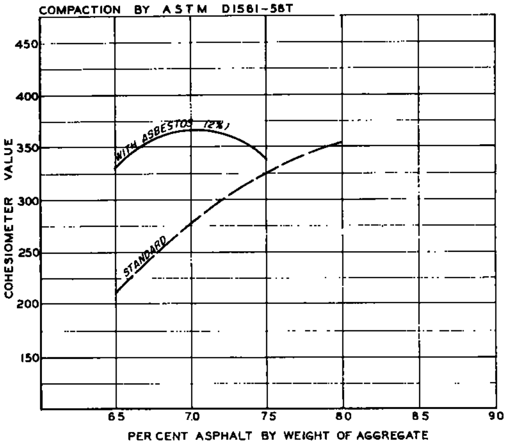


Figure 4. Cohesiometer values vs asphalt content.

## Gradations

Table 1 gives extractions and bin analyses, taken at the project site. It also includes gradations taken by independent testing laboratories.

## Results

Samples of the mixes were taken by Highway Commission forces from the roadway and stabilities were run, but the results were so questionable they have been omitted.

The results of tests made at the request of Johns-Manville Co. by the Chicago Testing Laboratory Inc., Report 06470, are given in Table 2. Recovered asphalt was determined by ASTM D-1856-61T on sample cut from roadway.

| | | |
|---|---|---|
| Penetration at 77 F | 100/5 | 57 & 59 |
| Ductility at 77 F | 5/60 cm | 110+ 110+ |
| Ash (%) | | 2.5 2.2 |

## OBSERVATIONS AT PLANT

The mix was produced in a 4,000-lb Hetherington and Berner batch plant at Caribou, Maine, and then hauled over 40 mi to the project.

Normal batching procedure was followed with the exception that the asbestos blocks were cut into 80-lb blocks and pushed into the pugmill by means of a chute. The asbestos was added first so the paddles would disintegrate the block. The dry mixing cycle was also increased a few seconds to assure good dispersion of the fibers.

When making the base course, the fluffing and bulking of the mix appeared most noticeable. Also the plant indicated the greatest strain when mixing this course.

## Base Course

When the batch was dropped into the truck, the mix stood upright and had the appearance of black cotton due to the bulking. This black cotton appearance decreased as the later mixes became finer and more densely graded.

TABLE 1

EXTRACTIONS AND BIN ANALYSIS

| Course | Cumulative Percent Passing Screen | | | | | | | | | | AC Mix | | Extraction (No.) | Bin Analysis (No.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1¼ In. | ¾ In. | ½ In. | ⅜ In. | No. 4 | No. 10 | No. 20 | No. 40 | No. 80 | No. 200 | % | Temp. (° F) | | |
| Base | 100 | 76 | 49 | 44 | 38 | 29 | 20 | 11 | 3 | 2 | 6.4[a] | 340[b] | | |
| Binder | | 100 | 78 | 65 | 42 | 31 | 20 | 12 | 5 | 2 | 6.2[c] | 335[d] | 9 | 1 |
| Wearing | | | | 100 | 84 | 56 | 33 | 21 | 11 | 5 | 8.8[e] | 340[b] | 7 | 1 |

[a]Obtained from extractions; plant actually put in 5 percent.
[b]At plant.
[c]Plant supposed to put 6.0 percent asphalt.
[d]When leaving plant.
[e]Material double-dried. Trouble occurred with asphalt meter which allowed too much asphalt in mix; consequently, content varies from 7.5 to 10.5 percent—8.5 percent was recommended.

TABLE 2

MARSHALL TESTS: ASTM D-1559-60T

| Property | Asbestos Base | Standard Binder | Asbestos Binder | Asbestos Wearing Course |
|---|---|---|---|---|
| Sp. gr. at 77 F | 2.33 | 2.30 | 2.32 | 2.36 |
| Max. theor. sp. gr. | 2.39 | 2.45 | 2.42 | 2.41 |
| Air voids (%) | 2.5 | 6.1 | 4.1 | 2.1 |
| Stability at 140 F (lb) | 1,690 | 1,030 | 1,695 | 2,140 |
| Flow at 140 F, (0.01 in.) | 26.0 | 12.0 | 14.5 | 23 |

## Binder Course

The same procedure of adding the asbestos was used when binder course was made. Observation showed that mixing effort was about equal to the base course, but the bulking effect was less. The "cottony" appearance was also less noticeable.

## Wearing Course

The wearing course which contained the lime in addition to the asphalt had a very thick coating of asphalt. This was a desired feature. The loads looked rather wet but not excessively so. Experience has taught that this appearance should not fool the inspector because the absorption process immediately begins to soak up the asphalt. As a result, the wet load is often very dry in appearance by the time it arrives at the paver.

Trouble occurred during the mixing of the wearing course because the lime tended to hang up in the storage bin. It was also discovered later by extraction and a gallonage check that the asphalt meter was not working properly. It was for these two reasons that the wearing course presented so much difficulty.

# STREET OBSERVATIONS

## Equipment

The bituminous concrete mixes were placed on a gravel base compacted to 100 percent of Proctor density, AASHO T-99. It was placed with a Barber-Greene 879-A paver and compacted with an 8- to 10-ton tandem, 12- to 16-ton tandem, and a light pneumatic roller.

## Mixes

Base Course.—This course was placed in two 1½-in. layers for a total thickness of 3 in. The author observed that the asbestos fibers tend to increase the softening point of the asphalt. With this increased viscosity, the cohesiveness was also increased. As a result, the asbestos made the asphalt act less like a fluid and behave more as a very viscous cement. With this altered physical property, the knock-down roller was able to get onto the mat and roll it immediately. The aggregate did not push and shove around as might be expected if no asbestos had been used even though the temperature of the mat was 320° ±. One pass with the knock-down roller compacted the pieces of aggregate into their proper positions and further rolling merely increased the density.

Apprehension mounted as the paver started up the 14.5 percent grade, but no trouble occurred. Again the important fact was that the rollers had no trouble with the mix pushing. On the first strip, the knock-down roller rolled from the top of the hill down but after that first pass it made no difference in rolling. The cohesion of the asbestos-asphalt to the aggregate was enough to prevent any tendency for displacement.

After rolling it was noticed that the bulking effect was very evident. In fact, the bulking was sufficient so that even when the next layer was placed thicker to compensate, the total thickness of the course was less than the desired thickness by about ¼ in.

Binder Course.—This binder was the paving crew's idea of a perfect mix. It went down and went into place like "Scotch Tape." This course was placed 1 in. thick. After one pass with the roller no further movement of the particles appeared to take place. There also was no tearing, pushing, or hairchecks. The increase in the viscosity of the asphalt due to the asbestos fibers again was the underlying factor for this. No trouble was encountered in rolling on the hill except at one spot where the drive wheel spun on the binder because of lack of friction. Yet no pushing developed.

Bulking was not as noticeable in this course as in the base course.

After rolling was complete it was noticed that this course had a hard, smooth-polished looking surface even though the texture was typical for this type gradation.

Wearing Course.—When the wearing course was applied, the following detrimental things occurred:

1. The plant ran out of double-dried aggregate prematurely.
2. The asphalt metering device became stuck and would not always shut off at the proper gallonage content. (Visual inspection did not detect this error.)
3. This course laid very poorly at the project site because it pulled and tore excessively.

The poor workability was apparently a characteristic of this fine-graded mix. Another project placed a year earlier with this same type mix except without asbestos had this same poor workability. The lime filler has such an adhesive characteristic on the asphalt and aggregate that it would tend to "ball" in the mix. The addition of the asbestos fiber merely aggravated this problem more. This increased property was desired but apparently it was in excess.

Although the asbestos fibers did not help in respect to the laying properties, it prevented the wearing course from becoming a failure due to the excessive asphalt. The asphalt content in some loads was as high as 10 percent by weight. Yet the asbestos was able to absorb this asphalt to a large extent although it did lose its optimum stability.

The two loads of wearing course placed without asbestos at the request of the Bureau of Public Roads flushed badly even though the asphalt content was reduced to compensate for the lack of asbestos.

This wearing course in spite of the troubles encountered still did not push and shove when being rolled. As might be expected the densities were 98 to 99 percent of theoretical maximum density.

The finished texture of the wearing course was dense, as desired, but it also had what appeared to be a polished hard surface. Needless to say, it was entirely waterproof.

## Incidental Notes

The adhesive force in the wearing course was amazingly strong. Normally when a crack or area with an open texture needs sanding, a shovel full of mix is spread on it and raked with a lute. This rubs the sand particles off and corrects the situation. With the asbestos added, the sand particles would not leave the stone regardless of the amount of raking back and forth. It was for this reason that asbestos fiber was left out when the handwork was done.

## Observations, October 1961

In October 1961, three months after the pavement had been placed, the project was revisited and the visual results were favorable. The pavement has been able to tolerate the excessive asphalt with no particular difficulty. The two loads placed without the asbestos have flushed and some displacement in the form of ruts have appeared. These are not serious and will probably not give any trouble in the future. The remainder of the roadway was very watertight and still did not have the usual grittiness. If any trouble should develop, it probably will be slipperiness on the 14.5 percent grade.

The abrasive action of snow plows, salt, and one winter's weather should help cure this smoothness.

## SUMMARY AND CONCLUSIONS

In conclusion the following statements should be mentioned:

1. The advantages of asbestos fibers seem more pronounced in open-graded mixes such as base and binder. The short fibers tend to increase the viscosity of the asphalt which in turn allows the mix to be rolled when hot (325 F plus) without displacement.
2. Two percent asbestos by weight will allow the asphalt content to be increased safely by 1.0 percent. On this project the wearing course was able to tolerate 2 percent or more.
3. The bulking effect is most noticeable in open-graded mixes; and the larger the maximum size of aggregate, the more the apparent bulking.
4. The use of asbestos greatly increases the adhesive forces in the mix. It increases this force sufficiently so that it is not particularly advisable to use it when handwork is done with a mix of this particular gradation and material.
5. In a dense, well-graded mix the fibers and asphalt produce a hard, polished riding surface.
6. Higher temperature and consequently better drying of the aggregate is required for the mix to be workable.
7. It is the author's observation that 2 percent asbestos by weight is too much fiber for this particular type gradation. It is believed that 1 to 1½ percent would provide all the desired features and possibly eliminate the disadvantages.