# BASE COURSE STABILIZATION WITH ASPHALT EMULSION
US 131 South of Cadillac (Construction Project F 83031A, C6)

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Research Laboratory Division
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ABSTRACT: Application and mixing of asphalt emulsion into an aggregate base, reportedly low in fines content, is described. The purpose was to stabilize it against the effects of construction traffic and to belp obtain proper density. Base stability and bond with the surface binder course were improved. Maximum density was reduced, but cohesive properties were imparted to the resulting mixture which increased shear strength.

KEY WORDS: bituminous aggregate bases, emulsified asphalts, bituminous stabilization, stabilized base course (materials).

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At the request of the Office of Construction, the Research Laboratory Division studied the application and mixing of asphalt emulsion into the top 4 in. of the 22A aggregate base for the US 131 construction 2-1/2 mi south of Cadillac. The treatment was to stabilize the base sufficiently to prevent shoving and rutting under equipment loads (due to the aggregate's reported low fines content), and to help obtain proper density. It was hoped that elimination of the calcium chloride application, reduction in water required for compaction, and elimination of the bond coat between the aggregate and asphaltic binder course, would compensate for the cost of the asphalt treatment.

Originally, the Research Laboratory was told that the job would not begin for one or two months, allowing time for preliminary study and planning. The work, unfortunately, began almost immediately and the Laboratory had only a few hours notice to prepare for this assignment. The application of emulsion was made during the week of June 13, 1966. Work did not proceed as it was understood it would, in that the area to be treated was already in place and compacted to required density, with calcium chloride included in the mix. Thus, there could be no savings from the elimination of water and chloride on this job. In fact, it was necessary to tear up the area to incorporate the emulsion.

Research Laboratory representatives were present during all phases of the experimental construction and samples of the treated and untreated aggregate were obtained for laboratory test. Samples of the emulsion-treated material were sent to P. J. Serafin for analysis. His findings were reported in a June 30 memorandum to R. L. Greenman (Appendix).

## Project Description

Figure 1 shows the general layout of the US 131 test and control sections south of Cadillac, extending from Stations 1288 to 1312 in the southbound two-lane roadway. Two control sections of normal construction flank the test section. It was planned to treat the test section with 2-percent asphalt emulsion (AE-1S) to a depth of 4 in. The completed lane was to be covered with a 4-1/2 in. asphaltic concrete surface following normal procedures.

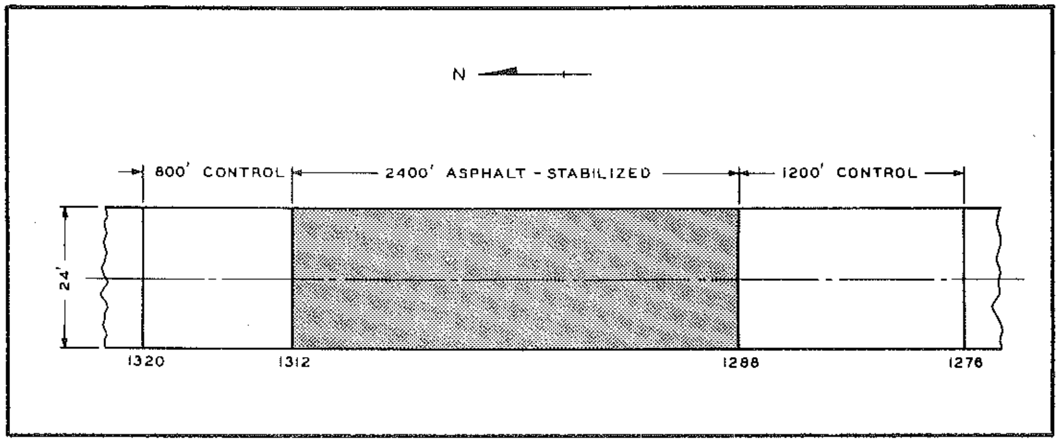



Figure 1. Layout of test area and control sections; southbound US 131 2-1/2 miles south of Cadillac.

## Construction Procedures

The aggregate to be treated was removed to a depth of 4 in. All aggregate on one side of the test section's centerline was trenched out and spread evenly along the adjacent lane. The mixing of emulsion and aggregate was accomplished by alternate asphalt application and blade mixing. About 0.45 gal of emulsion was applied for each pass of the distributor. After each surface application a 1-in. depth of treated material was bladed off into a windrow. This process was repeated until the entire 4-in. depth of aggregate was treated and windrowed. Asphalt was lightly applied to the trenched area's surface as a bond between untreated and treated materials. The windrowed material was then mixed by blading it back and forth, and then it was spread back into its original lane. These operations are shown in Figures 2 and 3.

This was repeated for the other lane, using the treated lane as a base for operations. The completed test area with treated aggregate in place before compaction is shown in Figure 4, which also illustrates compaction with rubber-tired and steel wheel rollers. The compacted surface was then broomed to remove loose stones and dirt; Figure 5 shows brooming and the appearance of the surface during application of the bituminous surface course. Surfacing had begun in the other lane.

The control sections were constructed in the normal manner. Unlike the asphalt-treated test sections, however, the compacted untreated aggregate was primed before placing the bituminous concrete binder portion of the surfacing course.

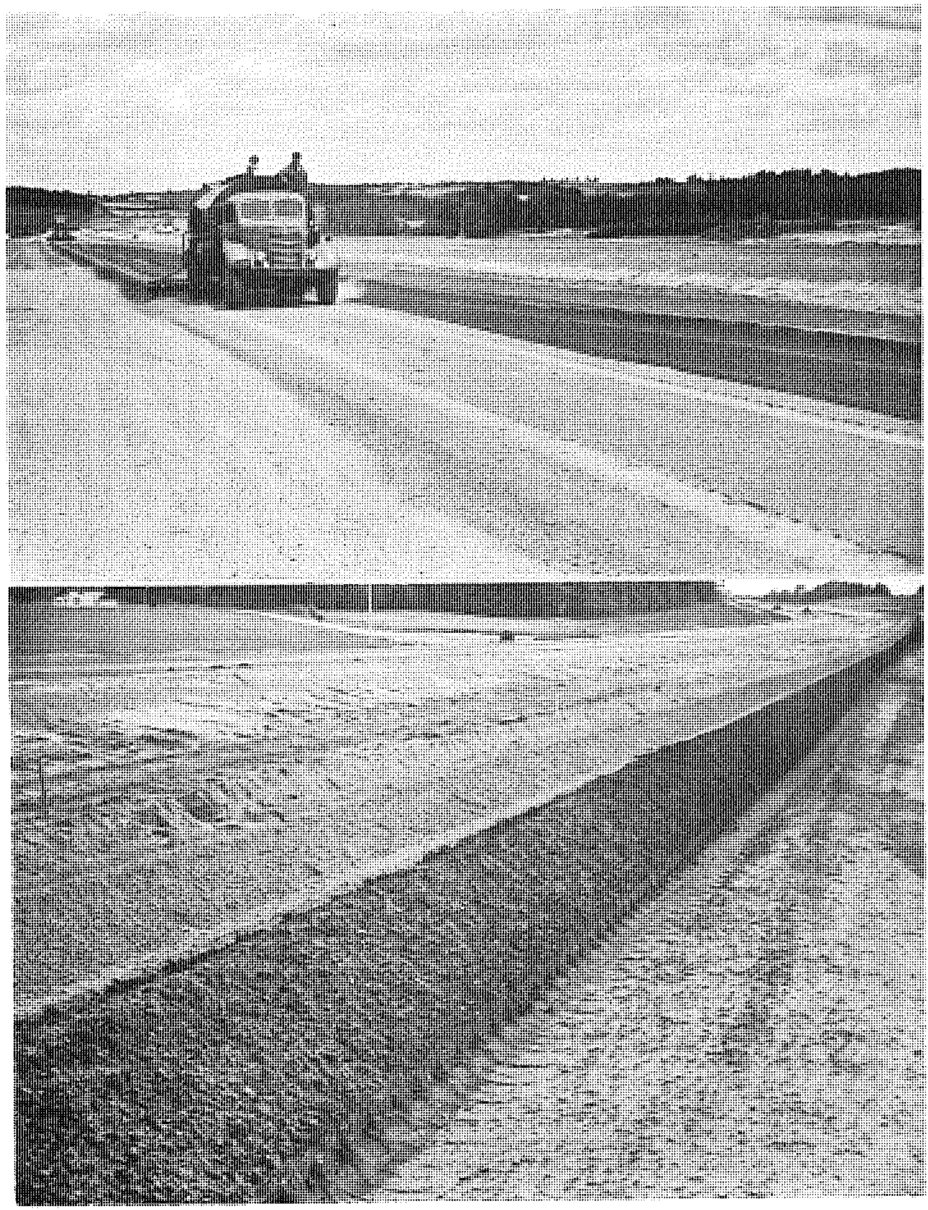


Figure 2. Asphalt emulsion was applied to aggregate removed from the passing lane and spread on the traffic lane (top); material was then bladed into a windrow (bottom) prior to mixing and blending

Figure 3. Treated aggregate was mixed and blended by blading back and forth across the traffic lane (top), and then bladed back into passing lane trench (bottom). Note appearance of AE-S1 primed trench base at right.

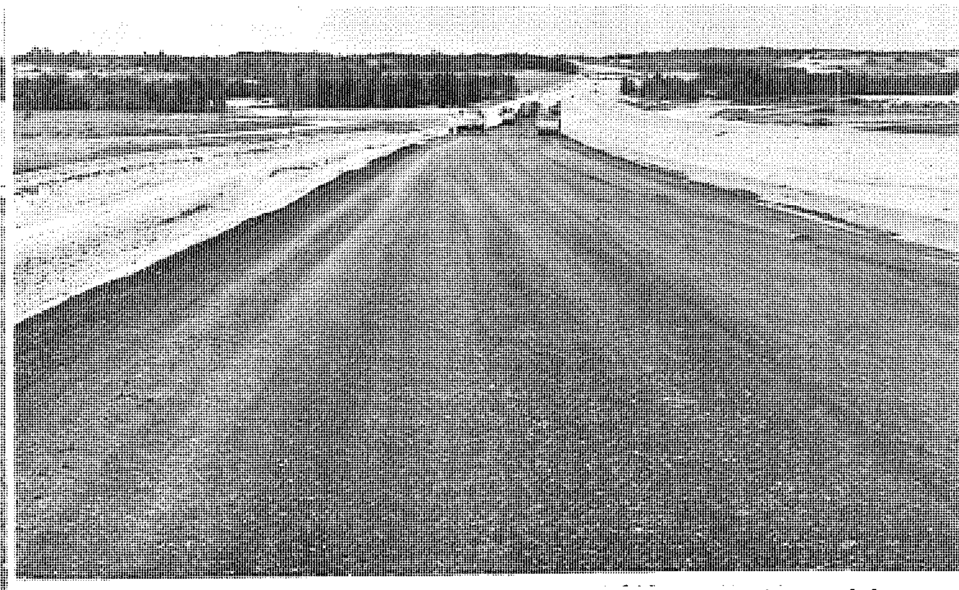


Figure 4 (left and right). Stabilized material back in place before and during compaction.

Figure 5 (left and right). Stabilized surface during and after brooming to remove stones and dirt. Note surface course in adjoining lane.

## Field Observations

No great problems were encountered in placing the asphalt-treated base course. The maximum density for the treated section was 135.0 pcf, as compared with 140.1 pcf for the untreated aggregate, but there was no problem obtaining desired density in either case. Some difficulty was experienced in fine grading the asphalt-treated materials when the grader tended to cut too deeply. Land planing also was more difficult and required two passes of the equipment to obtain the desired profile. These difficulties decreased as experience was gained in handling the asphalt-treated materials.

During surface course construction it was noted that the primed base of the untreated control sections was being rutted by truck traffic (Fig. 6). This condition was not observed on the test section. It was also noted that there was very poor bond between the prime and surface of the control section. Figure 7 shows how easily the primed section could be removed with a pencil point, and by contrast Figure 8 shows how the treated section was quite firm and difficult to pick apart.

During paving, the paver tended to chatter, jerk, and dig into the untreated control section, and it was reported by the inspector that the equipment was stuck at least once in these areas. None of these problems were encountered in the asphalt-emulsion-treated base.

Measurements of the bituminous concrete surface indicated that it tended to thin out at the outside edges of the untreated control sections, indicating low shear strength of the base near the edges. This condition is shown in Figure 9 where the edge thickness of the 230-lb asphalt binder course measured only 1-3/8 in. A full 2-1/2-in. depth was obtained on the edges of the treated base.

## Laboratory Test Results

The grain size distribution curves (Fig. 10) show no significant difference in gradation of the treated and control sections. In the region of the No. 30 sieve size, however, both areas exceeded projected specification limits. Tests by the Bureau of Public Roads* indicated the aggregate in that area was "hump graded," making it susceptible to reduction in shear strength when asphalt-treated, and presumably when untreated.

*Aggregate Gradation for Highways. U. S. Dept. of Commerce, Bureau of Public Roads (1962).

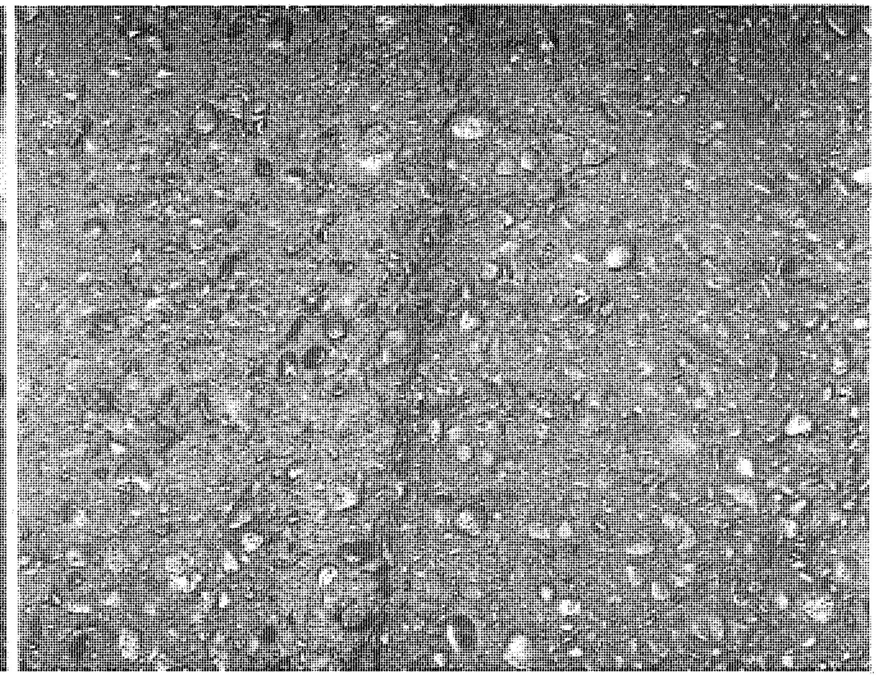
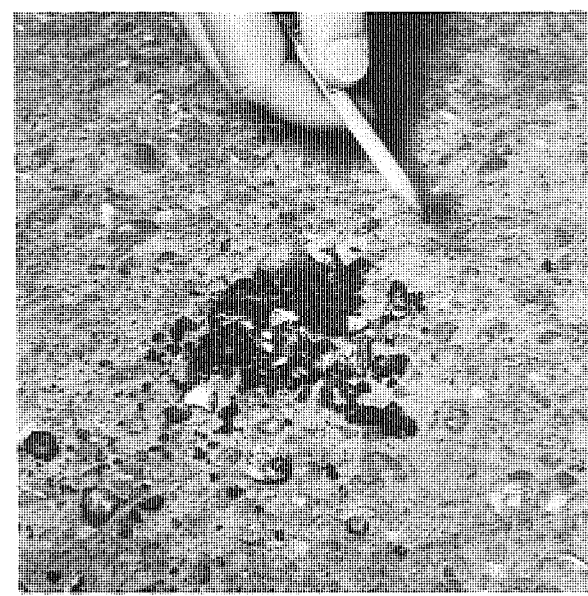


Figure 6 (above). Unstabilized, primed base before application of binder course (left) displayed some rutting, also shown in close-up at right.

Figure 7 (left). Poor bond between prime and surface of unstabilized aggregate.

Figure 8 (right). Firm surface of stabilized base, which was difficult to pick apart.



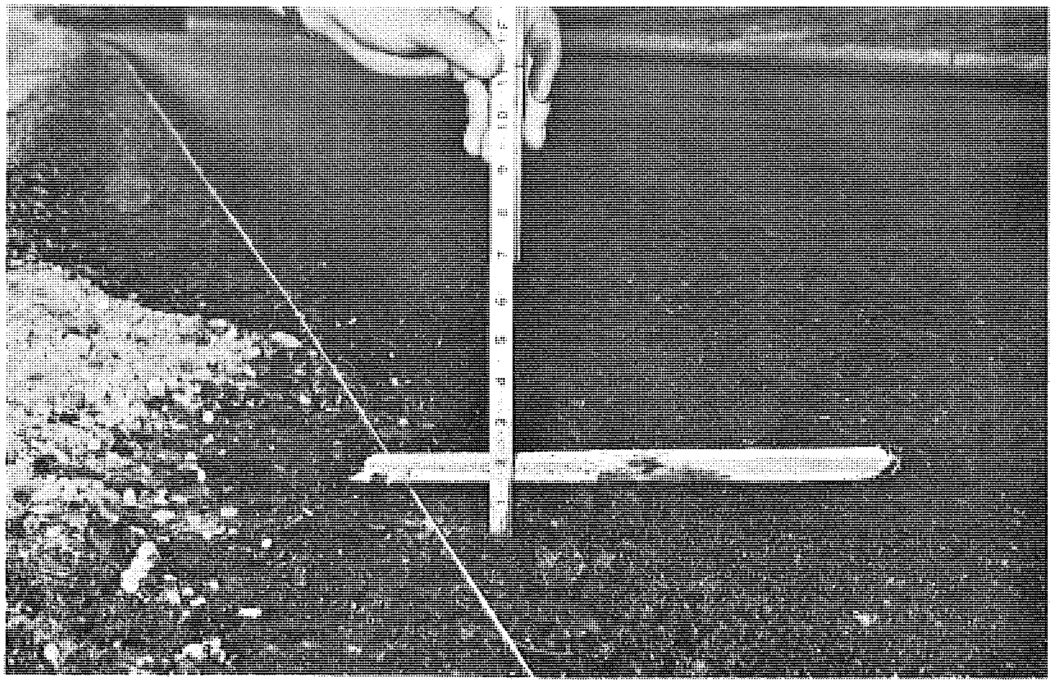


Figure 9. At edge of unstabilized base, 2-1/4 in. binder course measured only 1-3/8 in. thick.

The gradation of this aggregate, furthermore, is near the upper fineness limits of the Department's specifications and, within specification limits, is about as far as possible from the Bureau's established maximum density and stability gradation for 1-in. top-sized aggregate. From a gradation standpoint, therefore, this could not be considered an optimum mix.

Laboratory density determinations were made by T-99 compaction tests. For the untreated aggregate, a maximum density of 136 pcf was obtained as compared with 140 pcf obtained with the cone in the field. The asphalt-emulsion-treated aggregate yielded a maximum density of only 122 pcf as compared with 136 in the field. This significant difference could be due to setting of the emulsion during the time between field sampling and laboratory testing.

Because the laboratory samples were much less dense than the field samples, no significant comparison between shear strength of treated and untreated samples can be made until field-compacted cores are obtained. Preliminary shear tests, using the Hveem Stabilometer, show greater stability for the higher density untreated aggregate, but this may be due to difference in density. The asphalt emulsion increased the cohesive properties of the aggregate.

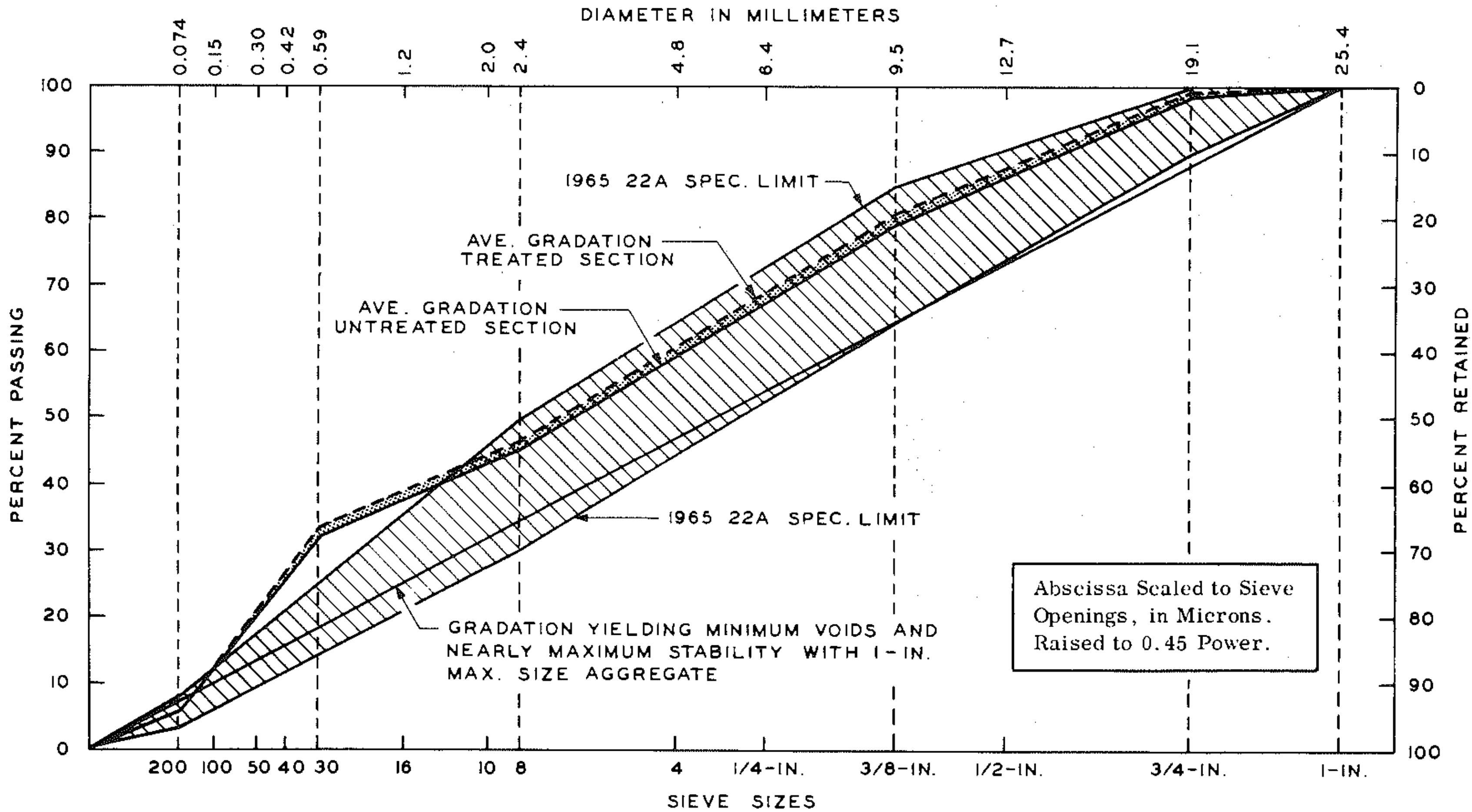



Figure 10. Grain size distribution of untreated aggregates on test and control sections.

## Cost of Operations

The following costs of the asphalt-emulsion stabilized section were furnished by M. L. Luse, Project Engineer:

### Cost

| | |
|---|---|
| 11,666 gal AE-1S @ $0.21 per gal | $2,449.86 |
| Intermixing asphalt emulsion @ $20.00 per station | 480.00 |
| Total | $2,929.86 |

### Savings

| | |
|---|---|
| MC-1 for prime--1,666.7 gal @ $0.155 per gal | $ 258.34 |
| Calcium Chloride (not normally required in asphalt stabilization)--12.685 tons @ $40.00 per ton | $ 507.40 |
| Total Saving | $ 765.74 |
| Total Net Cost (26 Sta.) | $2,164.12 |
| Extra Cost, per Station | $ 90.17 |

There was no appreciable difference in cost of compacting the base course in either case.

## Conclusions

Although time did not permit more thorough research, the following conclusions were reached:

1. Use of asphalt emulsion improved the stability of the 22A aggregate used in this project during construction operations.

2. Problems reported with untreated aggregates during construction appeared to be due to "hump grading" around the No. 30 sieve size and a general gradation on the higher fines side of specification limits.

3. Better bonding between the surface binder course and base was indicated in the stabilized area.

4. The additional cost of asphalt stabilization was about $90 per station. There was no significant difference in compaction costs for the two areas.

5. Lower maximum density was obtained when the aggregates were treated with asphalt. Such reduced density was reflected in lower shear strength values in laboratory tests.

6. Asphalt addition imparts cohesive properties to the resultant mixture, increasing shear strength at such low confining pressures as might be encountered at pavement edges.

7. Prior to addition of the asphalt emulsion the aggregate had been treated with calcium chloride. The effect of such treatment on performance of the asphalt stabilization is unknown.

8. Periodic observations and roughness measurements for this project will be made by the Research Laboratory.

APPENDIX

# OFFICE MEMORANDUM

**MICHIGAN**
**STATE HIGHWAY DEPARTMENT**

COPY

June 30, 1966

**To:** R. L. Greenman, Assistant Testing and Research Engineer
Office of Testing and Research

**From:** Paul J. Serafin

**Subject:** Experimental AE-1S Emulsion Black Base
Control Project No. F 83031 A C6

Per your request on June 17, 1966, Mr. Carl Mainfort submitted six samples of AE-1S emulsion black base mixture from Project No. F 83031 A C6 (US-131 from M-115 south 0.5 miles).

On June 20, 1966, Carl Mainfort and the writer made an inspection of the compacted black base and obtained an additional sample of the mixutre from the roadway after it had been weather cured for several days.

Attached are the laboratory test results on these samples (Tables I and II). Because the Marshall specimens exhibited low stabilities, they were not tested at the conventional 140 F but were tested at 120 F which is the trend for black base Marshall tests. Even at 120 F it will be noted that the stability values are low, ranging from 90 to 250 pounds.

The six samples originally submitted by Mr. Mainfort were taken from the roadway after road mixing and placed in plastic bags to retain the moisture from the emulsion. This was to enable the laboratory to compact the specimens under similar conditions as was performed in the construction of the roadway. The compacted specimens were cured at room temperature in the laboratory for four days, and then the Marshall testing was performed. The seventh sample was taken from the compacted roadway and recompacted in the laboratory at room temperature. It will be noted that this specimen had a stability of 90 pounds which is lower than that obtained from the other six samples which were compacted from the uncured mixtures.

Also attached is a copy of Laboratory Report No. 66B-1969 and 1970 showing the test results on the AE-1S emulsion which was approved for use on the above project (Table III). It will be noted that the float test on this is 3600 plus seconds, while the float test on the bitumen recovered from the mixes is in the range of 87 5-106.5. The reason for this difference is that the emulsion residue on the original sample is tested on the "so called" jelled conditions as specified by Mr. K. E. McConnaughay, while the residue from the mixture obtained by the recovery procedure requires reheating which apparently destroys this "jelling" condition.

OFFICE OF TESTING AND RESEARCH

Paul J. Serafin
Bituminous Engineer
Testing Laboratory Division

PJS:pl
Attachments
cc: W. W. McLaughlin
C. J. Olsen
Carl Mainfort

TABLE I
PROPERTIES OF ASPHALT EMULSION STABILIZED BASE SAMPLES
(Obtained During Construction)

| | | | | | | |
|---|---|---|---|---|---|---|
| Laboratory No. 66B- | 2260 | 2261 | 2262 | 2263 | 2264 | 2265 |
| Station No. | 1290 | 1296 | 1300 | 1304 | 1308 | 1310 |
| Mixture Proportions, % | | | | | | |
| Retained No. 8 Sieve | 53.2 | 52.3 | 51.5 | 53.4 | 52.6 | 55.1 |
| Passing No. 8 Ret. No. 200 | 39.9 | 40.2 | 42.2 | 40.2 | 40.3 | 37.8 |
| Passing No. 200 Sieve | 3.2 | 2.8 | 3.2 | 3.4 | 4.0 | 4.5 |
| Bitumen | 3.7 | 3.7 | 3.1 | 3.0 | 3.1 | 2.6 |
| Aggregate Gradation | | | | | | |
| Cuml. % Passing Basis | | | | | | |
| 3/4 inch | 100 | 100 | 100 | 100 | 98 | 100 |
| 1/2 inch | 89 | 89 | 90 | 88 | 91 | 88 |
| 3/8 inch | 80 | 79 | 84 | 81 | 83 | 78 |
| No. 4 | 57 | 56 | 60 | 58 | 59 | 57 |
| No. 8 | 45 | 45 | 47 | 45 | 46 | 43 |
| No. 16 | 40 | 40 | 41 | 39 | 41 | 38 |
| No. 30 | 35 | 34 | 35 | 33 | 35 | 33 |
| No. 50 | 16 | 16 | 15 | 15 | 17 | 16 |
| No. 100 | 6.0 | 5.1 | 5.5 | 5.6 | 6.5 | 6.8 |
| No. 200 | 3.4 | 2.9 | 3.3 | 3.5 | 4.2 | 4.6 |
| Moisture, % by Weight (1)* | 0.9 | 1.9 | 0.69 | 0.90 | 0.98 | 0.80 |
| Tests on Recovered Bitumen (2) | | | | | | |
| Float Test 60C, sec. | 87.5 | 101.5 | 105.8 | 106.5 | 99.4 | 95.5 |
| Ash, % by Weight | 0.19 | 0.00 | 0.47 | 0.00 | 0.46 | 0.50 |
| Marshall Test Results (3) | | | | | | |
| Actual Specific Gravity | 2.290 | 2.269 | 2.237 | 2.225 | 2.245 | 2.240 |
| Theoretical Max. Spec. Grav. | 2.406 | 2.406 | 2.406 | 2.406 | 2.406 | 2.406 |
| Air Voids, % | 4.8 | 5.7 | 7.0 | 7.5 | 6.7 | 6.9 |
| Voids Filled with Bitumen, % | 64 | 60 | 50 | 47 | 51 | 46 |
| Voids in Mineral Aggregate, % | 13.3 | 14.2 | 14.0 | 14.2 | 13.7 | 12.8 |
| Stability, Pounds | 220 | 250 | 170 | 160 | 200 | 180 |
| Flow, inches x 0.01 | 10 | 8 | 8 | 8 | 9 | 8 |

REMARKS:

Tested for information

SC Samples obtained during construction from roadway from Control Project No. F 83031 A C6.

*(1) Moisture determined on sample as received in sealed plastic bags.

(2) Recovered material too soft for penetration or ductility test.

(3) Average of two specimens. Specimens compacted at room temperature immediately as received by Laboratory. Stability and Flow values Tested at 120F.

TABLE II
PROPERTIES OF ASPHALT EMULSION BASE SAMPLES
OBTAINED FROM THE TEST SITE FOUR DAYS AFTER COMPACTION

| | |
|---|---|
| Laboratory No. 66B- | 2327 |
| Mixture Proportions, % | |
| Retained No. 8 Sieve | 53.1 |
| Passing No. 8 Ret. No. 200 | 39.7 |
| Passing No. 200 Sieve | 4.3 |
| Bitumen | 2.9 |
| Aggregate Gradation | |
| Cuml. % Passing Basis | |
| 3/4 inch | 99 |
| 1/2 inch | 89 |
| 3/8 inch | 80 |
| No. 4 | 57 |
| No. 8 | 45 |
| No. 16 | 39 |
| No. 30 | 34 |
| No. 50 | 17 |
| No. 100 | 6.9 |
| No. 200 | 4.5 |
| Moisture, % by Weight (1)* | 0.14 |
| Tests on Recovered Bitumen (2) | |
| Float Test 60C, sec. | 105.3 |
| Ash, % by Weight | 1.79 |
| Laboratory No. 66B- | 2327 |
| Marshall Test Results (3) | |
| Actual Specific Gravity | 2.208 |
| Theoretical Max. Spec. Grav. | 2.406 |
| Air Voids, % | 8.2 |
| Voids Filled w/Bitumen, % | 44 |
| Voids in Mineral Aggregate, % | 14.6 |
| Stability, pounds | 90 |
| Flow, inches x 0.01 | 10 |

REMARKS:

Tested for information

SC Sample obtained from roadway after curing for 4 days in compacted condition from Control Project No. F 83031 A C6.

*(1) Moisture determined on sample as received

(2) Recovered material too soft for penetration or ductility test.

(3) Average of two specimens. Specimens compacted at room temperature immediately as received in Laboratory. Stability and Flow values tested at 120F.

TABLE III

TEST REPORT OF ASPHALT EMULSION (AE-1S) PROPERTIES

| Laboratory Number 66B- | 1969 | 1970 | Average |
|---|---|---|---|
| VISCOSITY, SAYBOLT FUROL | | | |
| @ 25 C, seconds | 693 | 779 | 736 |
| @ 50 C, seconds | | | |
| Settlement, 5 days, per cent | | | 1.4 |
| DEMULSIBILITY | | | |
| 35 ml 0.02 N $CaCl_2$, per cent | | | |
| 50 ml 0.1 N $CaCl_2$ per cent | | | |
| Sieve Test, per cent | | | 0.0 |
| Miscibility Test | | | |
| Stone Coating Test | | | Passes |
| DISTILLATION TO 260 C | | | |
| Residue, per cent by weight | | | 73.5 |
| Oil Distillate, per cent by weight | | | 2.0 |
| TESTS ON DISTILLATION RESIDUE | | | |
| Penetration @ 25 C, 100 g, 5 sec, dmm | | | 300+ |
| Float Test, 60 C, seconds | | | 3600+ |
| Ductility @ 25 C, 5 cm/min, cm | | | |
| Solubility in $CS_2$, per cent | | | |
| Ash Content, per cent | | | |
| Specific Gravity, 25/25 C | | | 1.004 |
| Weight per Gallon, lb | | | 8.37 |
| Seal No. | | | V 1023 |

REMARKS: Approved

Laboratory Numbers 66B-1969 and 1970 samples from top and bottom of tank, respectively, and combined for all tests except viscosity.