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# LABORATORY EVALUATION OF CHEM-CRETE PROCESSED ASPHALT FOR USE WITH MARGINAL CONSTRUCTION MATERIAL

by


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## Preface

The laboratory investigation of Chem-Crete reported herein was requested by Mr. Bill Daley (DAEN-MPO-B), Office, Chief of Engineers. The request for an investigation is in a Memorandum for Record dated 30 January 1980, subject: Visit to Washington, D. C., on 24-25 January 1980, signed by Mr. Ronald L. Hutchinson, Acting Chief, Geotechnical Laboratory, U. S. Army Engineer Waterways Experiment Station (WES). Personnel actively involved in this study were Messrs. E. R. Brown and J. D. Perkins. This report was written by Mr. J. D. Perkins.

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## Introduction

### Background

1. Aggregates for heavy-duty pavements require a significant percentage of sound, durable crushed aggregate. In those areas without high-quality aggregates, paving costs are increased significantly by having to import aggregate with the desired quality. The reason for going to the effort and expense of importing aggregates is that poor-quality, local aggregates such as natural sands and sand-gravels normally will not provide the required level of performance. For example, in a study evaluating the use of marginal-type aggregates in pavement mixtures, the two most significant problems were low stability and water susceptibility. The results of these tests were reported in Technical Report GL-79-21.* A significant cost savings would be realized if an improved asphalt could be used with marginal aggregate to obtain adequate mix performance. Chem-Crete processed asphalt has the potential to improve stability and water resistance of bituminous mixtures produced with marginal materials.

### Objective

2. The objective of this investigation is to evaluate the properties of bituminous mixtures composed of marginal aggregates and Chem-Crete processed asphalt.

### Scope

3. In this study, concrete sand and chert gravel are used for two marginal bituminous aggregate mixtures. The mixtures were prepared with an untreated and Chem-Crete treated asphalt and allowed to cure for various times and conditions. Marshall stabilities and flows are

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* R. W. Grau, "Utilization of Marginal Construction Material for LOC," Technical Report GL-79-21, 1979, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

compared. Water susceptibility of bituminous mix prepared with and without Chem-Crete treatment was also investigated. The test results determined in this laboratory study and recommendations are presented.

## Laboratory Tests

4. The U. S. Army Corps of Engineers uses the Marshall method for the design of bituminous mixtures. This method of mix design involves compacting 4-in.-diam* by 2-1/2-in.-high bituminous mixture specimens with varying amounts of asphalt cement. Physical properties of the mix over the range of asphalt content, such as stability, flow, percent voids total mix, percent voids filled, and density can be plotted. A compaction effort is used that results in a density expected to be reached in the pavement under traffic from either a 100- or 200-psi tire pressure. This is normally accomplished by using a manually operated Marshall compaction hammer, which has a 10-lb sliding weight with an 18-in. drop. A mechanical hammer can be used in lieu of the manually operated hammer to prepare the Marshall cores, but in so doing a correlation between the mechanical hammer and the hand hammer should be established. In this investigation, the mechanical hammer calibrated to equal 50 blows of the hand hammer was used for compaction of the 4-in.-diam specimens.

6. Two types of aggregates were selected for this investigation: (a) 100 percent concrete sand and (b) a blend of crushed chert gravel with 25 percent concrete sand. The gradations of these aggregate blends are shown in Table 1. These aggregates were selected because of their inability to produce a satisfactory bituminous pavement mixture. Generally these materials produce bituminous mixtures that have low stabilities. The chert gravel has a history of stripping in a moisture environment.

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

6. The optimum bitumen content obtained for the concrete sand was 8.5 percent, and the optimum bitumen content obtained for the chert gravel and concrete sand was 7.7 percent. As shown in Table 2, the addition of Chem-Crete modified asphalt had no significant effect on specific gravity of bitumen, voids total mix, voids filled, or density. The physical properties of the AC-20 asphalts are listed in Table 3.

7. Chem-Crete is a proprietary product manufactured by Chem-Crete Corporation, Menlo Park, California. Two Chem-Crete concentrates were used in this laboratory test study, Chem-Crete Type II and Type III. The Chem-Crete Type III is formulated to give a faster reaction than the Chem-Crete Type II.

8. An AC-20 asphalt was processed with the Chem-Crete Type II concentrate at the Chem-Crete Corporation Laboratory. The supply of AC-20 asphalt prepared with the Chem-Crete Type II concentrate was depleted, and another AC-20 from the same refinery was blended with Chem-Crete Type III concentrate at WES. The Chem-Crete Type III concentrate was heated to $140^{\circ}$F and blended with AC-20 heated to $270^{\circ}$F. One part (by weight) of the concentrate was added to nine parts (by weight) AC-20 asphalt and mixed for 5 minutes.

more oil

9. Bituminous mixture samples with and without Chem-Crete treated asphalt were tested for Marshall stability on a relative basis for similar conditions of cure which included both room temperature cure and $140^{\circ}$F oven cure for various periods of time. Marshall stability and flow were determined according to American Society for Testing and Materials (ASTM) D 1559 with samples being conditioned in a water bath for 30 minutes at $140^{\circ}$F. All results are an average of three samples. Water susceptibility of the chert gravel and concrete sand mix was evaluated using a proposed ASTM test method, "Reduction in Marshall Stability After Vacuum Saturation with Water." This test method is intended to measure the reduction in Marshall stability resulting from the action of water on compacted bituminous mixtures. A numerical index of retained stability is obtained by comparing the stability determined in accordance with ASTM D 1559 and the stability of specimens that have been immersed in water after being evacuated by a vacuum for 1 hour and

then saturated with water at $140^{\circ}F$ for a period of 24 hours. This proposed test procedure is a more severe test than the current immersion-compression test used by the U. S. Army Cops of Engineers.

## Results

10. There was no difference in Marshall stability between treated and untreated sand-asphalt mixes after 1-day and 7-day cures at room temperature (Table 4). However, the samples prepared with Chem-Crete treated asphalt and cured for 7 days and 10 days at $140^{\circ}F$ indicate significantly higher stability than the untreated asphalt samples cured under the same conditions. The samples prepared with Chem-Crete Type II had stabilities 77 percent higher than the untreated asphalt samples after curing for 7 days at $140^{\circ}F$. The samples prepared with Chem-Crete Type III had stabilities 467 percent higher than the untreated asphalt samples after curing for 7 days at $140^{\circ}F$ and 713 percent higher after curing for 10 days.

11. An increase in stability also resulted for the chert gravel mixes prepared with Chem-Crete treated asphalt (Table 5). When cured for 28 days at room temperature, the Chem-Crete treated chert gravel asphalt mix showed a 45 percent increase in stability over the untreated asphalt mix. When the mixes were allowed to cure for 28 days at $140^{\circ}F$, the Chem-Crete treated asphalt mixes showed an increase in stability of 50 percent over that of untreated asphalt mix. In general, there was a slight increase in flow. The increase in Marshall stability is significant, but even more significant is the fact that the index of retained stability after the vacuum saturation immersion test for the Chem-Crete treated samples far exceeds that of the untreated samples. The index of retained stability for the untreated asphalt samples was zero regardless of the cure time. The index of retained stability for the Chem-Crete treated material was zero for 1-day cure at room temperature but increased to 50 percent at 28-day cure at room temperature and 50 percent at 28-day cure at $140^{\circ}F$. Typical samples after the 24-hour soaking are shown in Photo 1. The Chem-Crete treated samples were intact and the untreated samples had disintegrated.

## Conclusions

12. This investigation indicates that Chem-Crete can be used to increase Marshall stability while maintaining the same or slightly increased flow and at the same time decrease water susceptibility of bituminous mixes. This improvement in mix properties could improve performance of mixes produced with marginal paving materials.

## Recommendations

13. This initial laboratory study addressed asphalt mixes that might be categorized as worst-case asphalt mixes and as such demonstrates the potential benefits of Chem-Crete to reduce water susceptibility and increase stability of asphalt mixes. It is recommended that additional laboratory tests be conducted to determine tensile strength as well as fatigue characteristics of Chem-Crete asphalt mixtures. Positive demonstration of improvement with these additional tests would justify a recommendation to install test sections for evaluation of performance under traffic.

Table 1

Gradation

| Sieve Size | Chert Gravel Percent Passing | Concrete Sand Percent Passing |
|---|---|---|
| 3/4 in. | 100.0 | 100.0 |
| 1/2 in. | 88.8 | 100.0 |
| 3/8 in. | 82.2 | 100.0 |
| No. 4 | 66.5 | 97.0 |
| No. 8 | 53.5 | 88.0 |
| No. 16 | 42.4 | 82.0 |
| No. 30 | 34.2 | 67.0 |
| No. 50 | 19.4 | 14.0 |
| No. 100 | 11.5 | 3.0 |
| No. 200 | 4.4 | 1.0 |
| AGGREGATE BLEND SPECIFIC GRAVITY | 2.63 | 2.65 |

Table 2

Bituminous Mix Properties of Blend

| Bitumen | Aggregate | Percent Bitumen Used | Specific Gravity of Bitumen | Percent Voids Total Mix | Percent Voids Filled | Density lb/cu ft |
|---|---|---|---|---|---|---|
| AC-20 asphalt No. 1 | Chert gravel | 7.7 | 1.035 | 4.1 | 80.2 | 140.8 |
| AC-20 asphalt No. 1 and Chem-Crete Type II | Chert gravel | 7.7 | 1.036 | 4.2 | 80.0 | 140.8 |
| AC-20 asphalt No. 1 | Concrete sand | 8.5 | 1.035 | 9.1 | 65.7 | 132.7 |
| AC-20 asphalt No. 1 and Chem-Crete Type II | Concrete sand | 8.5 | 1.036 | 9.2 | 65.5 | 132.6 |
| AC-20 asphalt No. 2 | Concrete sand | 8.5 | 1.028 | 11.1 | 60.7 | 129.7 |
| AC-20 asphalt No. 2 and Chem-Crete Type III | Concrete sand | 8.5 | 1.028 | 11.2 | 60.5 | 129.7 |

Table 3

Properties of AC-20 Asphalt Cement

| Property | Test Results | |
|---|---|---|
| | Asphalt No. 1 | Asphalt No. 2 |
| Viscosity, 60°C (140°F), poises | 1779 | 2118 |
| Viscosity, 135°C (275°F), Cs | 442 | 422 |
| Penetration, 25°C (77°F), 100 g, 5 sec | 91 | 78 |
| Flash point, COC, C (F) | 299 | 282 |
| Solubility in trichlorethylene, percent | 99.70 | 99.75 |
| Tests on residue from thin-film oven test: | | |
| Viscosity, 60°C (140°F), poises | 2907 | 9267 |
| Ductility, 25°C (77°F), 5 cm/min, cm | 150 | 100+ |
| Spot test, standard naphtha solvent | Negative | Negative |
| Specific gravity, 25°C (77°F) | 1.035 | 1.028 |

Table 4

Summary of Marshall Stability and Flow Properties Using Concrete Sand

| Cure | Properties | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 8.5 Percent AC-20 Asphalt No. 1 | | 8.5 Percent AC-20 Asphalt No. 2 | | 8.5 Percent AC-20 Asphalt No. 1 Chem-Crete Type II | | 8.5 Percent AC-20 Asphalt No. 2 Chem-Crete Type III | |
| | Stability lb | Flow 0.01 in. | Stability lb | Flow 0.01 in. | Stability lb | Flow 0.01 in. | Stability lb | Flow 0.01 in. |
| 1-day cure (room temp) | 261 | 17 | 40 | 9 | 305 | 18 | 30 | 8 |
| 7-day cure (room temp) | 302 | 14 | -- | -- | 348 | 14 | -- | -- |
| 7-day cure (140°F oven temp) | 641 | 7 | 112 | 12 | 1133 | 11 | 635 | 10 |
| 10-day cure (140°F oven temp) | -- | -- | 111 | 11 | -- | -- | 902 | 12 |

Table 5

Summary of Marshall Stability and Flow Properties Before and After Vacuum Saturation Using Chert Gravel

| Cure | Properties: 7.7 Percent AC-20 Asphalt No. 1 — Stability lb | Properties: 7.7 Percent AC-20 Asphalt No. 1 — Flow 0.01 in. | Properties: 7.7 Percent AC-20 Asphalt No. 1 Chem-Crete 0.2 — Stability lb | Properties: 7.7 Percent AC-20 Asphalt No. 1 Chem-Crete 0.2 — Flow 0.01 in. |
|---|---|---|---|---|
| 1-day cure (room temp) | | | | |
| Standard (140°F water temp, 30 min) | 1152 | 10 | 1520 | 12 |
| Vacuum saturation immersion | * | * | * | * |
| 28-day cure (room temp) | | | | |
| Standard (140°F water temp, 30 min) | 1152 | 8 | 1671 | 12 |
| Vacuum saturation immersion | * | * | 837 | 14 |
| 28-day cure (140°F oven temp) | | | | |
| Standard (140°F water temp, 30 min) | 1737 | 10 | 2603 | 10 |
| Vacuum saturation immersion | * | * | 1291 | 17 |

* Samples disintegrated in water bath.

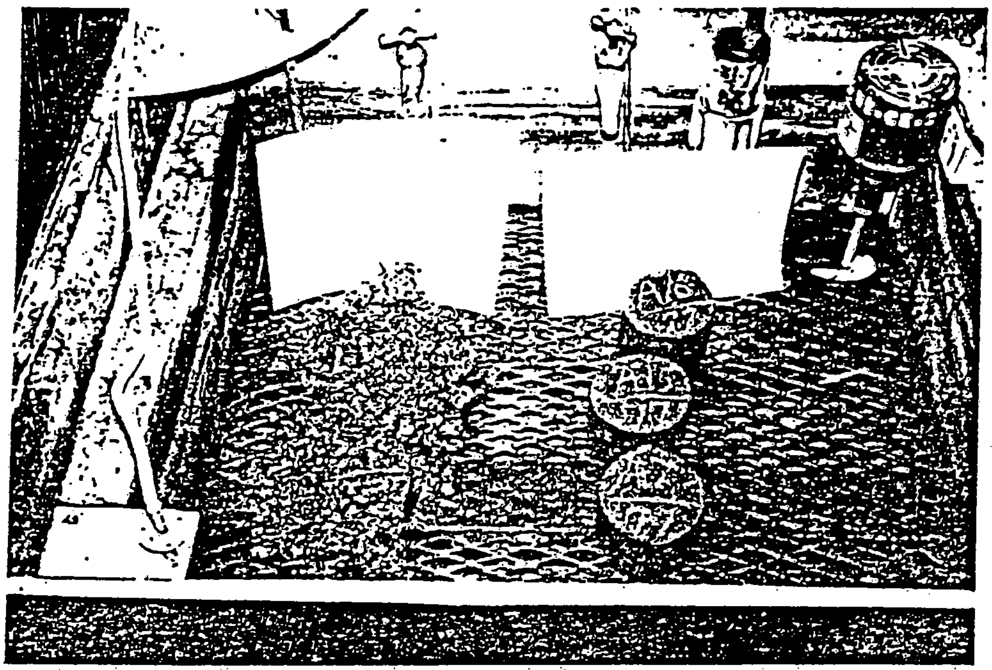

Photo 1. Chert-gravel-compacted bituminous cores after after 28-day/140°F oven temperature test and after vacuum saturation stability test. The condition of the AC-20 asphalt cores are on the left and the condition of AC-20 asphalt and Chem-Crete 0.2 cores are on the right.