UPGRADING ABSORPTIVE AGGREGATES BY CHEMICAL TREATMENTS

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ABRIDGMENT

•IN the design of bituminous paving mixtures, it has been generally recognized that absorption of bitumen by the aggregate plays an important role. It is one of the factors that determine the amount of asphalt actually present on the surface of the aggregate particles and available as a binder as well as the voids properties of the mixture. If proper correction of the asphalt absorbed is not made, the mixture may become more susceptible to weathering. For this reason, many aggregates have been classified as unsuitable for highway construction because of their high absorption characteristics.

The main objective of this study is to investigate if it is feasible to reduce the absorptive capabilities of the aggregates by various chemical treatments without detrimentally affecting the aggregates or mixtures, thus making highly absorptive aggregates suitable for use in asphalt paving mixtures.

Materials and Methods

Two Iowa aggregates—one from Menlo quarry in Adair County and one from Cook quarry in Story County—have been studied. Aggregates from Menlo quarry have been classified as magnesium limestone and those from Cook quarry as dolomitic limestone; both are considered unsuitable for asphalt paving mixtures.

The water absorption of graded Cook aggregate was 7.6 percent; the water absorption of graded Menlo aggregate was 2.6 percent. Two asphalt cements were included in this study, one 85-100 penetration and the other 120-150 penetration. The chemicals included are (a) aniline, (b) furfural, (c) Armac T, and (d) methyl methacrylate.

The treatments were made on both graded crushed aggregates and cored rock cylinders. The aggregates were treated and cured separately with the selected chemicals on a bench scale and in accordance with procedures developed during preliminary investigations. The amount of chemicals varied from ½ percent to 9 percent by weight of the aggregate. The following tests were conducted on the treated aggregates: (a) water absorption by ASTM C 127; (b) heat stability at 400 F for 4 hours; (c) asphalt absorption by bulk-impregnated specific gravity method; and (d) mixture evaluation by Marshall method.

Results and Discussions

Aniline-Furfural Treatment—Graded crushed aggregates were treated with aniline-furfural on a 2:1 molar basis. Treated aggregates were cured at 220-230 F for 5 days before absorption tests were run. The results were generally very favorable. Sharp decreases of water absorption and asphalt absorption were found with 3 percent chemical (Figs. 1 and 2).

Rock cores were soaked in 2:1 aniline-furfural for 1 hour and cured at 220-230 F. Results of tests conducted on cores indicated that soaking was more effective than mixing.

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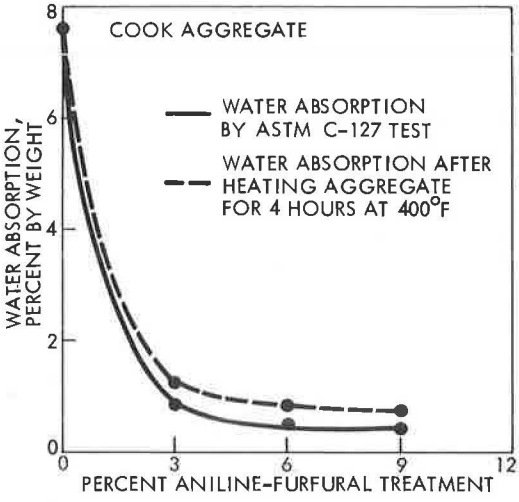

Figure 1. Water absorption of Cook aggregate versus percent aniline-furfural treatment.

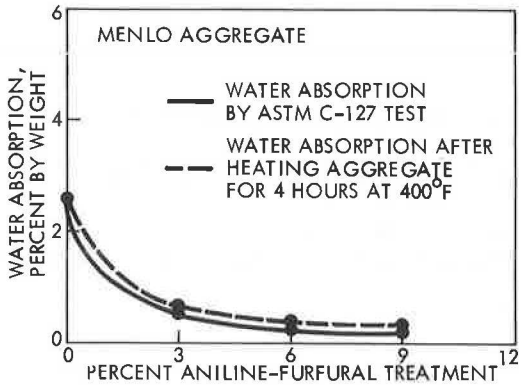

Figure 2. Water absorption of Menlo aggregate versus percent aniline-furfural treatment.

Although standard curing was done at 220-230 F for 5 days, curing curves were also established for two other temperatures, 140 F and 325 F. It was found that curing at 225 and 325 F can be considered complete after 24 hours, whereas curing at 140 F takes about 100 to 120 hours. The effectiveness of aniline-furfural treatment was also dependent on curing temperature; curing at lower temperatures was more effective than at higher temperatures.

Armac T Treatment—Results of tests conducted on the aggregates treated with different percentages of Armac T showed an appreciable reduction in both water and asphalt absorptions with increasing amount of Armac T (Fig. 3).

Curing curves for graded aggregates treated with Armac T were determined at 140 F, 225 F, and 325 F. It was found that the required curing time was dependent on curing temperature,

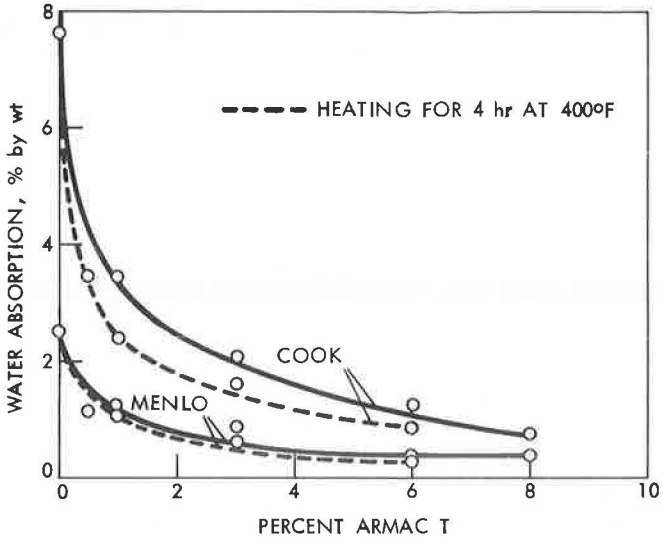

Figure 3. Water absorption versus percent Armac T treatment.

percentage of chemical, and type of aggregate. Except for 140 F curing, which required 100 to 120 hours, curing can be considered complete within 24 hours. Curing at higher temperature decreases the effectiveness of absorption reduction.

Monomer Treatment—Rock cores were first impregnated by soaking in the liquid monomer consisting of 90 percent methyl methacrylate plus 10 percent trimethylolpropane trimethacrylate. They were then polymerized by two methods, cobalt gamma radiation and thermal catalytic technique. The same degree of improvement in the reduction in water and asphalt absorption properties of the rock cores was obtained in both cases. Absorption was reduced to near zero percent for both aggregates with either polymerization technique.

Graded crushed aggregates were impregnated with the monomer and then thermally polymerized at 185 F. Drastic reduction in both asphalt and water absorption resulted. Heat stability of monomer-treated aggregates was excellent. No change in absorption values was found due to heating at 400 F. This is mainly due to the cross-linking of the monomer with trimethylolpropane trimethacrylate, one of the functions of which is to increase the softening point of the monomer solution.

Asphalt Concrete Mixture Evaluation—To determine the performance of the chemically treated aggregates in asphalt paving mixtures, asphalt concrete mixtures using treated and untreated aggregates were prepared.

Mixtures were prepared with untreated aggregates from Cook and Menlo quarries with 6 to 9 percent of 120-150 penetration asphalt cement. In both cases agricultural lime passing the No. 8 sieve was added so that the combined gradation met the Iowa Type A mix gradation. On the basis of tests conducted on Marshall specimens, it was found that a 7.5 percent asphalt by weight mix was necessary for both aggregates. It was also found that for an asphalt content of 7.5 percent the resistance of bituminous mixtures to the detrimental effect of water, as expressed by percentage of retained strength, were of the order of 74 and 77 percent for mixtures containing Cook and Menlo aggregate respectively.

Bituminous mixtures were made with aggregate treated with 2:1 aniline-furfural using the same asphalt cement and Marshall specimens. It was found that for aniline-furfural-treated aggregates, the optimum asphalt content for mixtures containing Cook aggregate was reduced to 5.5 percent and for those containing Menlo aggregate, 4.8 percent. The percentage of retained strength of the mixtures at optimum asphalt contents was 83 and 82 percent respectively (Fig. 4).

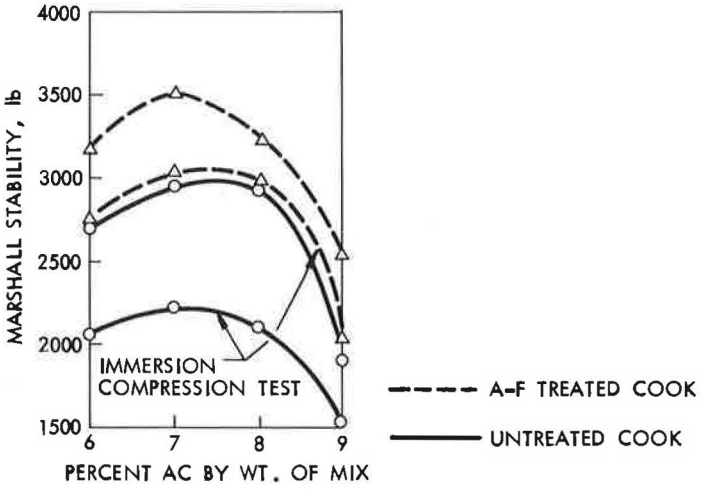

Figure 4. Marshall stability and immersion compression of mixes containing treated and untreated Cook aggregates.

Bituminous mixtures were also prepared aggregates treated with Armac T. Optimum asphalt content for mixtures containing Cook aggregate was 5.6 percent, for those containing Menlo aggregate, 5 percent. The percentage of retained strength of the mixtures at optimum asphalt content was 81 and 84 percent respectively. The lowering of the optimum asphalt content and considerable increase in the percentage of retained strength of the chemically treated aggregate bituminous mixtures can be attributed to the effective chemical treatment of these aggregates.

Conclusions

From the evaluation and analysis of tests conducted on the treated and untreated absorptive limestones, the following conclusions may be drawn:

1. Three to 6 percent of 2:1 aniline-furfural or Armac T could reduce water and asphalt absorption appreciably.
2. Impregnation of cylindrical cores and graded crushed aggregates with methyl methacrylate plus 10 percent trimethylolpropane trimethacrylate and polymerized by either radiation or thermal catalytic techniques substantially reduced water and asphalt absorptions.
3. Tests of asphalt paving mixes with treated and untreated aggregates show that a considerable saving in asphalt requirement in paving mixtures can be effected by chemical treatment.
4. A considerable increase in the percentage of retained strength of the asphalt concrete mixtures made with the chemically treated aggregates was obtained.

Acknowledgment

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