Dominant Effect of Fine Aggregate on Strength of Dense-Graded Asphalt Mixes

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•IN TWO TEST SECTIONS at the U. S. Army Engineer Waterways Experiment Station (WES), tests were conducted on a sand-asphalt mix and on mixes made with two different coarse aggregates and the same fine aggregate used in the sand asphalt. Although the optimum asphalt content varied with the different mixes, all mixes at optimum showed essentially equal performance in resisting the stresses induced by traffic. These tests convincingly showed that the fine aggregate dominates the strength characteristics of dense-graded mixes. Although these tests were made years ago, it is believed that a review of the data is in order.

In the first section, the tires of the vehicles used were inflated to approximately 100 psi; in the second section, the tires were inflated to approximately 200 psi. Because the tests with 100-psi tires are more applicable to highway conditions and because these tests have been reported in detail (1, 2), only the data from the first section are reviewed.

The mixes were made with four aggregates and mineral filler. Gradation curves of the aggregates are shown in Figure 1 and descriptions of the aggregates are given in the following:

1. Crushed coarse aggregate—Crushed limestone from Dolcito Quarry Company, Birmingham, Alabama.
2. Uncrushed coarse aggregate—Washed, subrounded gravel, primarily chert, from St. Catherine Gravel Company, Natchez, Mississippi.
3. Sand—Washed siliceous sand from the St. Catherine Gravel Company, Natchez, Mississippi.
4. Fine sand—Siliceous sand from a Mississippi River bar near Vicksburg, Mississippi.
5. Filler—Commercial limestone dust from Dolcito Quarry Company, Birmingham, Alabama.

These aggregates were used, with 120 penetration asphalt cement, to produce a sand asphalt, an asphaltic concrete with crushed limestone, and an asphaltic concrete with uncrushed gravel. Three filler contents were used in each case; but because the performance was the same, only the mixes with intermediate filler content are used in this discussion. Figure 2 shows average gradation curves for the three mixes.

Figure 3 shows the gradation curves for the fraction passing the No. 10 sieve. Curves for mix 11 and mix 14 were computed from the curves shown in Figure 2 by increasing the percentage passing each sieve by the ratio required to result in 94 percent passing the No. 10 sieve, which was the percentage passing the No. 10 sieve in the sand-asphalt mix.

The tests at WES were designed primarily to develop procedures for designing mixes so that they would be capable of withstanding the stresses induced within the mix. Because asphalt mixes are weakest at high temperatures, the traffic was applied in the summer.

Each of the mixes was placed at a range of asphalt contents and subjected to traffic as described previously. Mixes placed at high asphalt content shoved out from under the path of the traffic and bulged up on the sides, thus providing evidence of plastic deformation, which in turn is lack of adequate strength to resist the stresses induced by traffic. Mixes placed at low asphalt content showed no plastic deformation or lack of strength but tended to ravel under traffic. Mixes at optimum asphalt content showed no plastic deformation or raveling, thus indicating adequate strength to resist the stresses

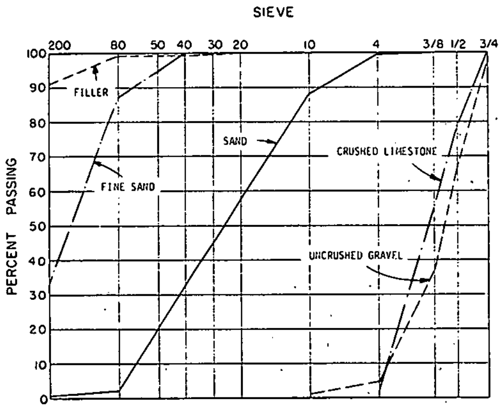

Figure 1.

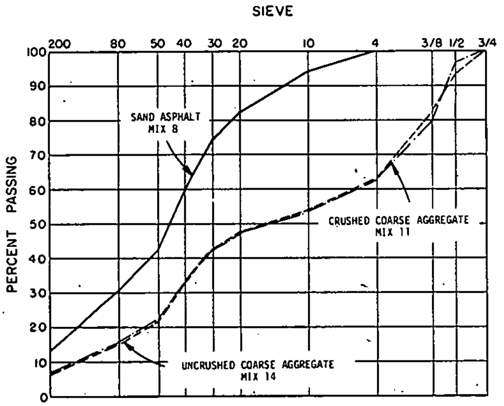

Figure 2.

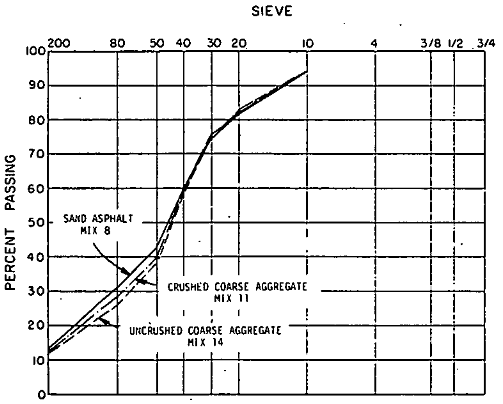

Figure 3.

induced by traffic. The optimum-content mixes that contained coarse aggregate showed no better performance than that of the sand asphalt, and the mix containing crushed coarse aggregate showed no better performance than that of the mix containing uncrushed aggregate. In these tests, the fine aggregate controlled the capacity of the mix to resist the stresses induced within the mix. Observations of the performance of pavements since then support the conclusion that the true capacity of dense-graded mixes to resist traffic-induced stresses is controlled by the characteristics of the fine aggregate.

A feature clearly reported in the WES data, but apparently often overlooked, is that the Marshall stability number did not rate mixes on their capability to withstand stresses induced within the mix. A test section is not needed for this purpose. A simple look at the curve of Marshall stability versus asphalt content shows that it peaks at optimum. This means that the Marshall stability number obtained for a lean mix, which has ample capacity to resist stress, will be the same as that obtained for a rich mix, which will shove out from under the traffic.

An asphalt mix must also be capable of spreading the stresses so that the underlying layer is not overstressed. The WES tests did not include the variables necessary to establish the effect of aggregate type on this feature. The tests did show, however, that asphalt over high-quality base courses need have very few stress-distributing qualities. In addition, there was a trend for higher stability mixes to be better stress distributors, although the effect of stability was not as pronounced as the effect of thickness. Stress-distributing capability is related to the modulus of elasticity at low strains. There have been no controlled traffic tests with the necessary variables to evaluate the effect of aggregate type on stress-distributing capabilities. The author's judgment plus observations of pavements on highways are that a mix with coarse aggregate would normally have stress-distributing capabilities better than those of a fine mix, and a mix with crushed coarse aggregate would have capabilities better than those of a mix with uncrushed aggregates. These differences would not, however, be large.

REFERENCES

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