Effect of Density On Marshall Stability Of Hot-Mix Asphaltic Concrete

OBJECTIVE

The Iowa D.O.T. specifications do not require 100 percent of 50 blow Marshall density (generally 94%) for field compaction. However, stabilities are determined in the Laboratory on specimens compacted to 100 percent of Marshall density. The purpose of this study is to determine the stabilities of specimens compacted to various densities which are below 100 percent of the 50 blow Marshall density.

MATERIALS

Ten different asphaltic concrete mixes were tested in this investigation. Four of these were proportioned and mixed in the Laboratory from aggregate and asphalt cement currently in stock. The remaining six mixes were the retained excess materials from field samples. Each mix contained different aggregates and gradations, but all complied with our specified particle size distribution and asphalt content. Different sources and penetrations of asphalt cement were used but the only grade was AC-10

PROCEDURE

By varying the number of blows, five different compactive efforts were made on the specimens. After some exploratory work, it was found that 50, 32, 18, 12 and 7 blows to each side of the specimens would result in the range of densities that was

desired (93 to 100% of Marshall density). The 50 blows resulted, of course, in 100 percent of the Marshall densities, and the densities obtained by each of the lesser compactive efforts were computed as a percent of this figure.

Three specimens were required for each compactive effort resulting in 15 specimens from each mix or a total of 150 specimens molded and tested from the ten mixes. The specimens were all molded at 275°F. Standard Marshall compaction equipment and procedures were used, and also standard density and stability equipment and procedures were employed.

REPORT

The various stabilities that were obtained at the different densities were tabulated (Appendix A). Each is an average of three determinations. The densities were computed as a percentage of the 50 blow Marshall density. The stabilities were computed as a percentage of the stability obtained from the 50 blow Marshall specimens. These percentages of density were plotted against the percentages of stability in the graph.

Appendix B includes the work tickets showing the individual results of each specimen tested as well as the averages. It also includes the flow results of each specimen, the penetration of the asphalt cement used in each mix, and the proportions of aggregates and the asphalt cement contents of the mixes made in the Laboratory. It does not include an aggregate gradation of the individual mixes, but this can readily be obtained by

referring to the test report identified by the Laboratory number.

Appendix C is composed of copies of the actual print-out from the stability apparatus, showing graphically the changes in stabilities and flows corresponding to the changes in densities. The mix numbers and the number of blows for each compactive effort are shown at the top of each sheet.

CONCLUSIONS

The conclusion that can be drawn, and which is readily apparent, from this investigation is that the stability of a hot mix decreases dramatically with a slight decrease in the density. When a density was obtained which was 94 percent of the 50 blow Marshall density (the minimum generally specified in D.O.T. specifications) then the stabilities of all ten mixes tested were below 43 percent of the Marshall stability obtained on specimens compacted to 50 blow Marshall density. Excluding one mix, this percentage drops to less than 35 percent.

The graph of the stabilities versus densities shows the following:

Percent Marshall Density	Percent Marshall Stability
99	all ten mixes < 90
98	" " " < 75
97	" " " < 61
96	" " " < 56, 9 mixes < 51
95	" " " < 50, " " < 42
94	" " " < 43, " " < 35

The same graph shows that to obtain 75 percent of 50 blow Marshall stability a density greater than 98 percent was required for all ten mixes. To obtain 50 percent of 50 blow Marshall stability then a density equal to or greater than 96 percent was required for nine of the ten mixes tested.

The mixes tested had a range of 1282 to 3048 pound 50 blow Marshall stabilities, so they were all within the normal testing range of mixes used in construction.

It was also surprising that only seven blows to each side of the specimens resulted in a density average of 94.5 percent of the 50 blow densities for the ten mixes.

Stability testing is normally performed on specimens compacted to 100 percent of Marshall densities and not at the lesser densities obtained by field compaction. When a field mix is compacted to the minimum of 94 percent of Marshall density, most of the stability that was designed into the mix has been lost.

If the stability of a hot mix is important in the functioning of the finished roadway, then it adds emphasis to the necessity of keeping the densities as high as possible.