Effect of Angle of Repose of Aggregates on Strength of Bituminous Mix

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Abstract— The major constituent of bituminous mix are aggregates. The characteristics of bituminous mix are mainly affected by properties of aggregates. Angle of repose of aggregates of different sizes and sources have been designed in the present study. Further an attempt has been made to study the effect of angle of repose to the strength of bituminous mix. Indirect tensile strength has been used as the measure of strength of bituminous mix, subsequently, statistical relationship has been proposed between the overall angle of repose of the aggregates used in the bituminous mix to its indirect tensile strength.

Key words: Bituminous Mix, Aggregates Shape, Indirect Tensile Strength

I. Introduction

Compressive strength of bituminous mix: - Compressive strength of is the capacity of pavement materials to withstand directed compressive forces. Compressive strength of compacted bituminous mixture measures by this test. The test specimen is in the shape of cylinder of the diameter 101.6mm and 2.5 in height. The influence of results of the size of test specimen of compressive strength test. For adding the bitumen binder aggregates is heated above the mixing temperature to allow for dry mixing.

A. Angle of Repose

The angle of repose or critical angle of repose is the steepest angle of granular material of descent or dip. It is relative to the horizontal plane to which a material can be piled without slumping. At this angle, the slope face of material is on verge of sliding. The range of angle of repose can be from 0 to 90 degrees. Angle of repose =tan-(h/r)

B. Measurement

There are various methods for measuring of angle of repose and all give different results. One method is the triaxial shear method, another is direct shear method. The strength of bituminous mixes is measured in terms of compressive strength and marshal stability values. The results show good correspondence between the two mixes, indicating that the angle of repose of aggregates mix can be used to predict the strength of bituminous mix.

For determining the angle of repose there are some other method has given below-TILTING BOX METHOD, FIXED FUNNEL METHOD, and REVOLVING CYLINDER METHOD

C. The Tilting Box Method

This method is good for fined-grained non-cohesive soils materials, which has particle less than 10 mm. The material is placed within a box which has on side transparent for observing the granular test material. The box is tilted slowly until the material begins to slide in bulk and the angle of tilt will be measured.

D. Revolving cylinder method:

The cylinder with at least one transparent face for placing a material. The cylinder is rotated at uniform speed. The observer will watch the material moving within the rotating cylinder. As it flows within the rotating cylinder will be assume a certain angle. The method is recommended for obtaining the dynamic angle of repose.

E. Effect of Aggregates Shape on the Stability of Bituminous Mixes

A laboratory study was made of effects of crushed particle both coarse and fine aggregates, on the stability of bituminous-aggregates mixtures. In the results of this study show that crushed stone coarse aggregates mixture produced greater strength than the mixture which contains any percentage of crushed gravel. However, change in the amount of crushed gravel in coarse aggregates affected mixture strength only in one size, very open mixtures.

II. Results and Discussions

A. Optimum Bitumen Content

Relationship of Marshall Stability and flow with five asphalt content of 5.0, 5.5, 6.0, 6.5 and 7.0% are shown in Figure 1. Stability values increased with the increase of asphalt content up to 6.0% and decreased thereafter, while flow of the mixture increased continuously with the increase of asphalt content as expected. Figure 2 shows the relationship of unit weight and amount of void (%) with varying asphalt content. Both the void (%) in total mix and in mineral aggregate decreased with the increase of asphalt content, however, the unit weight of the mix reached its maximum for asphalt content of 6.5%. Thus, the optimum bitumen content was the average of 6.0 and 6.5 i.e. 6.25. The parameters at optimum bitumen content were Marshall Stability = 407.5 kN, flow = 0.045 in, unit weight = 2.27 gm/cc, void in total mix = 3.47% and void in mineral aggregates = 21.0%. The objective when designing continuously graded mixes is to achieve a dense mix of high stability but with sufficient voids between aggregates particles ensuring that sufficient bitumen is added to achieve flexibility, durability and workability without sacrificing resistance to permanent deformation.

B. Influence of Elongation Index

Stability-flow relationship with varying elongation index is shown in Figure 3. Both stability and flow value decreased with the increase in elongation index. The particle was said to be elongated when its dimension is greater than 1.8 times the mean size. With higher elongation index of the aggregates the total contact surface area between aggregate and binder got reduced and amount of total void in the mix would be increased, which adversely affected the stability of mix. When there were no elongated particles in mix, the

Marshall stability was 589 kN for a fixed flakiness index of 34% at a temperature of 3000F. With a 17% increase in the elongation index the stability got reduced by 12.5%. However, the rate of strength reduction significantly slowed down with further increase in the elongation index. Only a less than 1% more reduction in stability was observed with further increase of elongation index by 10% i.e. at total of 27%.

Under traffic loading the layers of a flexible pavement structure are subjected to continuous flexing. The magnitude of strain was likely to depend on the overall stiffness and nature of the pavement construction. There are two categories of stiffness namely elastic stiffness under conditions of low temperature or short times of loading and viscous stiffness at high temperatures or long times of loadings. The former is used to calculate stains in the structure and the latter is used to assess the resistance of the materials to deformation. To determine the permanent deformation resistance of a bituminous mix, its response at high temperatures or long loading time was analyzed. Marshall Stability at higher mixing temperature (3200F) was decreased linearly with the increase in elongation index. They were about 3% lower than that at temperatures of 3200F. It was reported that when the stiffness of bitumen was less than 5x106 Pa, the mix behavior was much more complex than that in the elastic zone (Ehrola and Turunen, 1995).

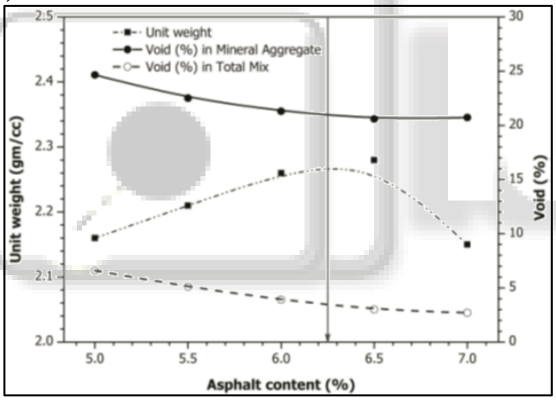

Fig. 1: Optimum Bitumen Content from Stability-Flow Relationship

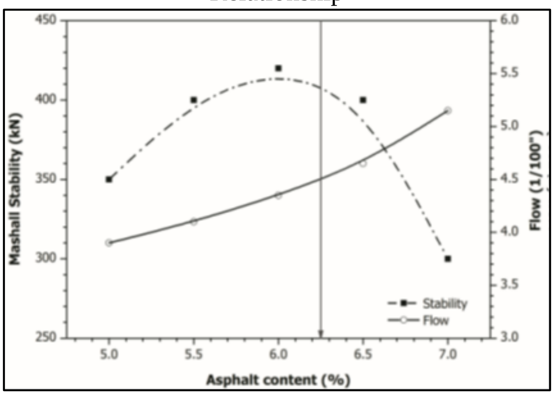

Fig. 2: Optimum Bitumen Content from Unit Weight and Void Ratio (%)

C. Influence of Flakiness Index:

The variation of Marshall Stability and flow for varying flakiness index with a fixed elongation index of 27% is shown in Figure 4. With the increase in flakiness index Marshall Stability of the compact increased steadily. The particle was said to be flaky when its least dimension or thickness was less than 0.6 times the mean thickness. When there were no flaky or elongated particles in the mix the stability values were 438 kN at temperatures of 3000F. When the flakiness index was increased the total contact surface area also increased and amount of total void in the mix would be reduced. A combination of 34% flakiness index and 27% elongation index, as was the natural properties of the coarse aggregates under ABU ZAKIR MORSHED, QUAZI SAZZAD HOSSAIN International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319-5347, Vol. 03, No. 03, July 2014, pp 212-215 study (Table 1), yielded a stability value of 511 kN at 3000F.

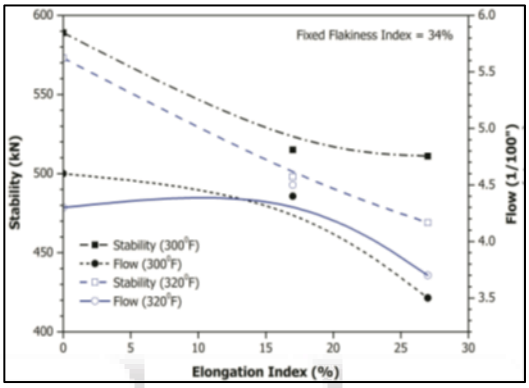

Fig. 3: Marshall Stability and Flow for Varying Elongation Index (%)

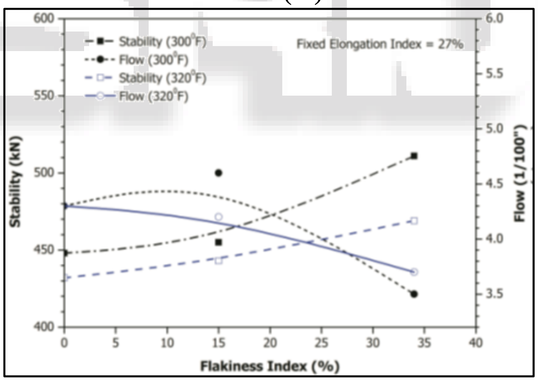

Fig. 4: Marshall Stability and Flow for Varying Flakiness Index (%)

Although it was about 13% less than that produced by the mix with no elongated particles (Figure 3), mixes with abnormally high values of Marshall stability and abnormally low flow values are often less desirable because pavements of such mixes tend to be more rigid or brittle and may crack under heavy volumes of traffic. This is particularly true where base and subgrade deflections are such as to permit moderate to relatively high deflections of the pavement. Stability at 3200F increased linearly with the increase in flakiness index and was consistently 3% lower than that for 3000F up to a flakiness index of 15%. It reached 469 kN at a flakiness index of 34%.

Flow value of the compact increased slightly with increase in the flakiness index of 15% but started to decrease afterwards. As the flow value increased the mix became unstable, but when the flakiness index increased further, the flow value decreased, which was an indication of a stable mix. However, when more flaky particles were present in the mix, the specimen was initially vertically deformed to a certain amount during the blowing (compaction) period. Thus, it is obvious that a certain number of flaky particles were needed to have a stable mix.

III. Conclusion

This paper studied the effect of flaky and elongated coarse aggregates on the strength of bituminous mixes for flexible pavement in terms of Marshall Stability and flow value. The bitumen content was kept same with 3% filler in all mixes, while temperature was varied between 300 and 3200F. The following conclusions are drawn:

– Highest stability of 589 kN was obtained from a combination of 0% elongation index with 34% flakiness index, while lowest flow of 0.035 in. was obtained from a combination of 27% elongation index with 34% flakiness index.
– Increasing elongation indices reduced the stability value up to about 13% for a fixed flakiness index.
– Marshall Stability was found to increase up to about 14% with the increase in flakiness indices by 34% for a fixed elongation index.
– Elongated particles caused more instability than that by the flaky particles in terms of Marshall flow.
– A flakiness index of higher than 15% deemed necessary to have a stable bituminous mix.
– At higher mixing temperature (3200F) didn’t affect the flow value but reduced the stability 3- 8%.

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