USE OF FLY ASH IN HOT MIX ASPHALT CONCRETE

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INTRODUCTION

In Sri Lanka, quarry dust is generally used as the mineral filler in hot mixed asphalt concrete. Quarry dust is a byproduct in rock quarries. Fly ash is found in Norochcholai coal power plant as an industrial waste. This paper presents the results of an investigation into the feasibility of using fly ash as a partial substitute for mineral filler in hot mixed asphalt concrete. The results of this study will help reduce the consumption of depleting resources as rock and minimize environmental hazards that occur through disposal of fly ash.

Nearly all main highways and pavements in Sri Lanka are constructed using asphalt pavements which consist of coarse aggregate, fine aggregate, mineral filler and a bituminous binder. The coarse aggregate is crushed stone with particle size ranging from 2.36mm to 19mm. The fine aggregate is sand or quarry dust, in which the size ranges between 0.15mm and 2.36mm. The mineral filler normally used is a quarry dust, 85 percent of which passes the 0.075mm sieve. The aggregate mixture is bound together with bitumen. To replace quarry dust with fly ash firstly, it is required to examine the physical properties, to check samples for conformity. Secondly, the Marshall Test method, which is a widely used test recommended by Asphalt institute and presently used by Road Development Authority of Sri Lanka, is adopted for optimizing the proportioning of the asphaltic concrete mix components and the Marshall properties of the samples are checked for conformity. Marshall Test method on three sets of tests were conducted by replacing mineral filler with fly ash in the percentages of 100%, 58% 42% (12%, 7% and 5% respectively from the total weight of aggregates). The ICTAD specifications were fulfilled only for the replacement of 42% of mineral filler with fly ash (5% from total weight of aggregates).

METHODOLOGY

Sieve analysis was carried out according to ASTM D 3515, on a representative sample of the fly ash. For the determination of specific gravity and fineness of fly ash and quarry dust ASTM D 854 and ASTM C 204 were used respectively. The results of above tests are given in Tables 1, 2 and 3.

Marshal test method was carried out as follows. A filler content consisting of 12% of quarry dust and fly ash combined (5% of fly ash and 7% of quarry dust) was added to 57.5% and 30.5% of coarse and fine aggregates, respectively (Asphalt Institute, 1997). These aggregate proportions are typical of wearing course mixes normally used for main roads in Sri Lanka. Standard Marshall Specimens (63.5 mm height and 101.6 mm diameter) were prepared in the following manner. Weight of bitumen was varied from 3.5% to 6% in steps of 0.5%, resulting in six percentages by weight of bitumen content, and three samples were prepared for each bitumen percentage. The grading and proportions were kept constant for all the mixes by sieving the aggregates to individual sizes and then recombining them in a continuous grading required by the local standards.

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The same quantity of materials was used for each sample in an effort to obtain approximately the same height of the specimens. The mix was first partially compacted using a heated standard rod, fifteen times around the perimeter and five times in the center. The whole mould was then fixed in the Marshall Compaction machine which consists of a 4.5 kg hammer falling from a distance of 457 mm. Both sides of the samples were compacted 75 times. The compacted samples were allowed to cure overnight at room temperature. The density of the samples was then determined by obtaining the submerged weight in water and weighing the samples in air. Samples were then tested at standard temperature (60 ^{0}C) in the Marshall machine and the deformation stability (in kN) and the flow of the samples (in mm) were recorded. The same procedure was repeated for all samples.

RESULTS AND DISCUSSION

In test results of the Tables 1, 2 and 3 represents the particle size analysis, specific gravity and fineness of fly ash respectively.

Table 1- Sieve analysis test results for fly ash

Sieve size	Weight retained / (g)	Total weight retained / (g)	% retained	% Passing
2.36 mm	0.64	0.64	0.062	99.938
1.18 mm	4.13	4.77	0.461	99.539
600 μm	10.84	15.61	1.508	98.492
300 μm	25.48	41.09	3.970	96.030
150 μm	414.57	455.66	44.027	55.973
75 μm	363.80	819.46	79.179	20.821
Pan	204.66	1024.12	98.954	1.046

Table 2- Specific gravity of fly ash and quarry dust

Sample No.	Specific gravity	
	Fly ash	Quarry dust
01	2.068	2.429
02	2.044	2.330
03	2.077	2.500
Average	2.063	2.420

Table 3- Specific surface (fineness) of fly ash and quarry dust

Trial	Specific surface	
	Fly ash x *K*	Quarry dust x *K*
01	0.463	0.404
02	0.426	0.416
03	0.474	0.442
Average	0.454	0.421

Figures 1 - 5 illustrates the Marshall properties of the samples. These include the crushing strength or stability, the deformation behavior or flow, as well as the density and voids characteristics of the asphaltic mixes. It is observed that a bitumen content of 5.5% satisfies the Institute of Construction Training and Development (ICTAD) specifications. Figure 1 represents the maximum stability values of the mixes. For bitumen content of 5.5% the stability value was observed to be 8.6 kN. This value was in conformity with the ICTAD specifications. Figure 2 shows the effect of variation of the bitumen content on the Marshall Flow expressed in millimeters.

For the 5.5% bitumen content it can be seen that the mix had the required flow value of 14.41. Figure 3 indicates that the percentage of air voids in the mix decreases as the bitumen content increases. This is expected since the bitumen will fill the voids in aggregate matrix. However, there is a limit on how much the voids can be reduced. If they are too high then deformation and loss of stability is expected in the field, and if they are too low then bleeding and shoving due to expansion occurs because of high temperatures. For a bitumen content of 5.5%, voids in mix lie in the range specified, which 3% to 7% is. Figure 4 shows that the minimum voids in the mineral aggregates are greater than 13%. Figure 5 indicates that for bitumen content of 5.5% the voids filled with bitumen is in the range of 70-85% which is the specified range. Figure 6 indicates the compacted density mix values which are required for calculation of voids

Table 4 summarizes the Marshall properties of the mix determined at an optimum bitumen content of 5.5%, compared with the ICTAD specifications.

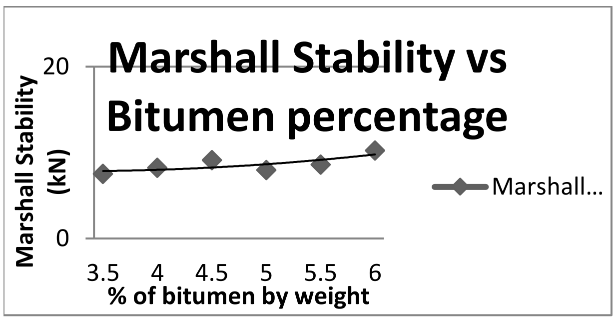

Figure 1 Effect of fly ash on the Marshall stability of Asphaltic concrete

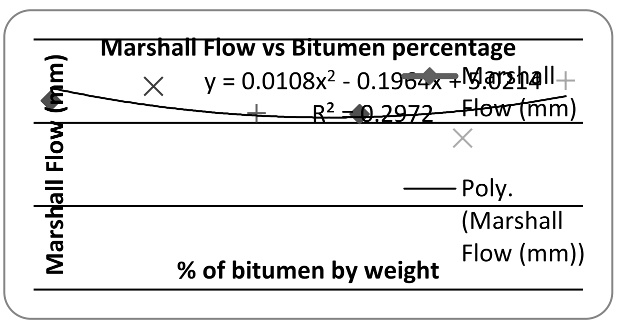

Figure 2 Effect of fly ash on the Marshall flow of asphaltic concrete

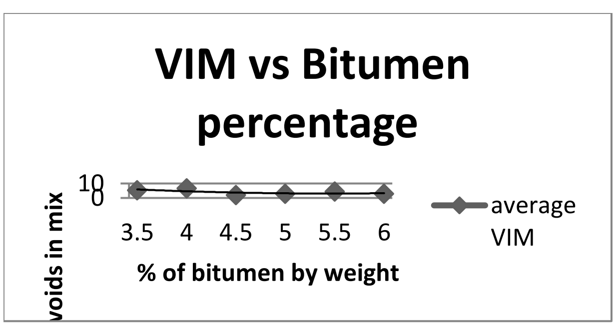

Figure 3 Effect of fly ash on voids of asphaltic concrete

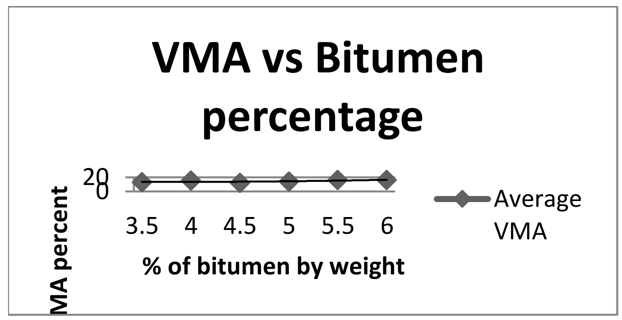

Figure 4 Effect of fly ash on voids in aggregate of asphaltic concrete

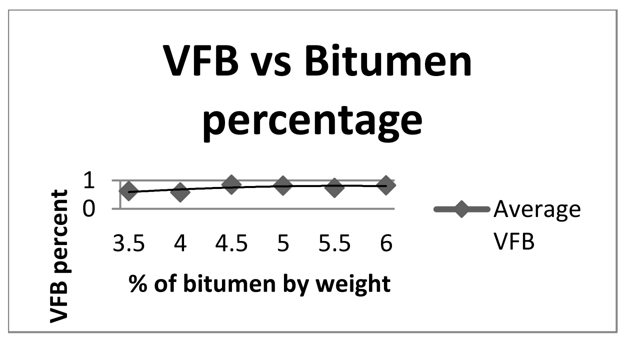

Figure 5 Effect of fly ash on voids filled with bitumen of asphaltic concrete

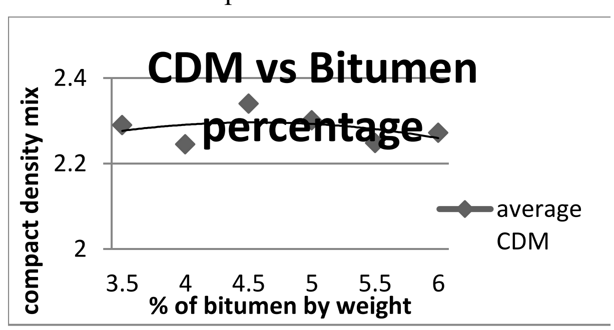

Figure 6 Effect of fly ash on the compacted density of asphaltic concrete

Table 4 Marshall Properties of asphaltic mix at bitumen content of 5.5% compared with ICTAD specifications

Marshall parameter	Value at 5.5% bitumen content	ICTAD Specification limit
Marshall Stability in kN	8.6	Not less than 8
Marshall Flow in(0.25 mm)	14.51	8 to 16
Air voids in Mix (%)	4.44	3 to 7
Voids in Mineral Aggregates (%)	16.56	Not less than 13
Voids Filled with bitumen (%)	73.4	70 to 85

CONCLUSIONS

From the results and preceding discussion, the following can be concluded:

- Results conforming to specifications were obtained by replacing 5% of mineral filler from the total weight of aggregates with Fly ash.
- The stability value of replacing 5% of mineral filler from total weight of aggregates with fly ash was well above the minimum (8 kN) criteria in ICTAD specification.
- The optimum bitumen content by weight of the aggregates was 5.5% which satisfied the ICTAD specifications.
- The fly ash can be utilized as a partial replacement for the mineral filler in hot mix asphalt concrete wearing courses used in Sri Lanka.

REFERENCES

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