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An Experimental Study on Partial Replacement of Aggregate by E-Waste for Flexible Pavement

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ABSTRACT

In India, bituminous surfaced flexible pavements comprise of majority of the roads.

Distress symptoms, such as cracking, rutting, etc. are being increasingly caused at earlier stages due to high traffic intensity, over loading of vehicles and significant variations in daily and seasonal temperature of the pavement. Investigations have revealed that modifiers can be used to improve rheological properties of bitumen and bituminous mixes to make it more suitable for road construction.

Bituminous-mix design involves mixing various size aggregate and bitumen contents in optimum proportions. Electronic waste or e-waste are the discarded electrical or electronic items, which are destined for reuse, resale, recycling or disposal. Informal processing of electronic/ electrical waste in developing countries may cause serious health and pollution problems, as these countries have limited regulatory oversight of e-waste processing.

Solid waste management is one of the major environmental concerns in our country now days. The present study covers the use or recycled e-wastes as replacement of coarse aggregates in bitumen. The objective of the study is to investigate the change in mechanical properties of bitumen mix with the addition of e-wastes in bitumen concrete as replacement of aggregate.

***Keywords:** Bitumen, Modifiers, Pavements, Durability, Marshal Stability, VMA, VFB, Air Voids, Density*

INTRODUCTION

In India, bituminous surfaced flexible pavements comprise of majority of the roads. Distress symptoms, such as cracking, rutting, etc, are being increasingly caused earlier by high traffic intensity, over loading of vehicles and significant variations in daily and seasonal temperature of the pavement.

Objectives

- To Study E-waste aggregate on highway bituminous mix for Dense Bitumen Concrete (DBC).

Methodology Adopted

Laboratory experiments were conducted on the conventional bitumen (60/70) and modified bitumen samples. Individual properties (Penetration, Softening Point, Ductility, Flash and Fire, and Specific Gravity) of the sample were determined. Using the Marshal Mix design characterization of conventional bituminous mix (60/70) for dense bituminous mix (DBC) were carried out and comparison was made for conventional bitumen mix properties with modified bitumen. After determining factors to be considered for modeling modified bitumen in bituminous mix, a detailed plan for the experimental program (sample preparation and lists of tests) was developed.

Results

Results of Marshal Mix Design for DBM with ordinary bitumen (60/70 grade):

Following graphs have been plotted to find the optimum binder content

1. Binder content vs Marshal stability (fig. 5.1)
2. Binder content vs flow value (fig. 5.2)
3. Binder content vs Bulk Density (fig. 5.3)
4. Binder content vs Air voids (fig. 5.4)
5. Binder content vs Voids filled with bitumen (fig. 5.5)

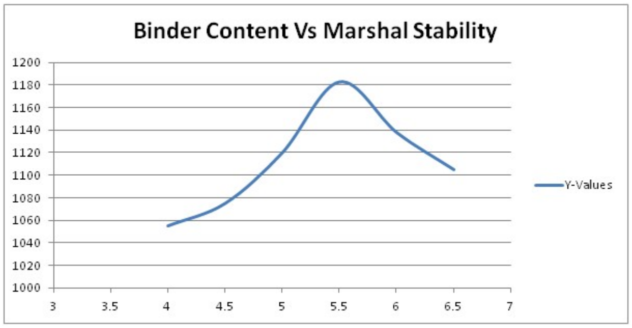

Figure 5.1 Bitumen % Vs Marshal Stability Value

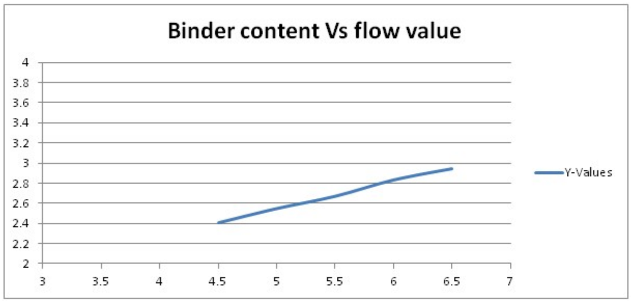

Figure 5.2 Bitumen % Vs Flow value

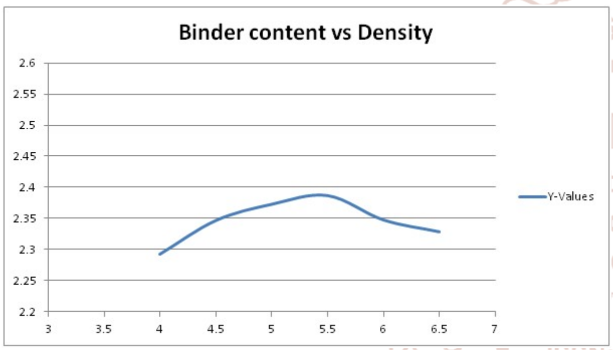

Figure 5.3 Bitumen % Vs Density

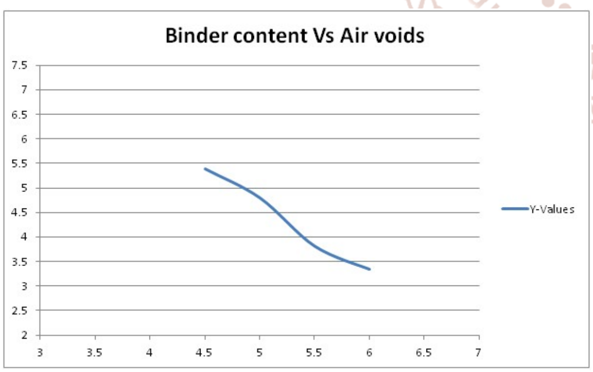

Figure 5.4 Bitumen % Vs Air voids %

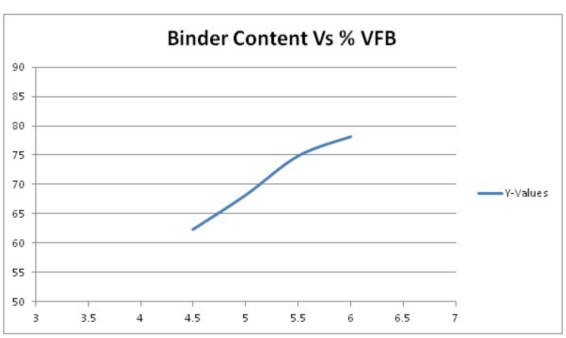

Figure 5.5 Bitumen % Vs Voids filled with bitumen %(VFB)

5.3.2: Results of DBM with E-Waste

By using this optimum binder content (i.e. 5.5%) various samples of varying E-Waste Fiber percentages (4%, 8%, 10%, 12%) were prepared and subsequent tests have been performed, to find properties of modified DBM. The table (5.9) shows the various properties E-Waste modified DBM mix.

The results shows that Marshal Stability increases with the increase of E-Waste Fiber percentage from 6% to 10% but it decreases at higher percentage (i.e. 12%). Also the flow value, Bulk Density, VMA and VFB increases with increase of E-Waste Fiber.

Since DBM shows better properties with 10% E-Waste Fiber Modified Bitumen, the test were performed to find the optimum binder content by fixing the percent of E-Waste Fiber i.e. 10%. Various properties of the mix are shown below in the table.

Following graphs have been plotted to find the optimum binder content with 10% E-Waste

1. Binder content vs Marshal stability (fig. 5.6)
2. Binder content vs flow value (fig. 5.7)
3. Binder content vs Density (fig. 5.8)
4. Binder content vs Air voids (fig. 5.9)
5. Binder content vs Voids filled with bitumen (fig. 5.10)

It is observed from graphs, that maximum marshal value is obtained with 5.25% modified bitumen compared 5.5% ordinary bitumen in DBM.

It is therefore inferred that 10% E-WASTE admixture saves bitumen content, without adversely affecting Marshal Stability Value.

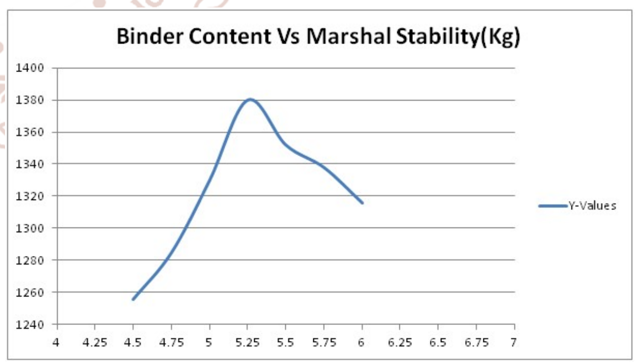

Figure 5.6 Bitumen % Vs Marshal Stability Value (with 10% E-WASTE)

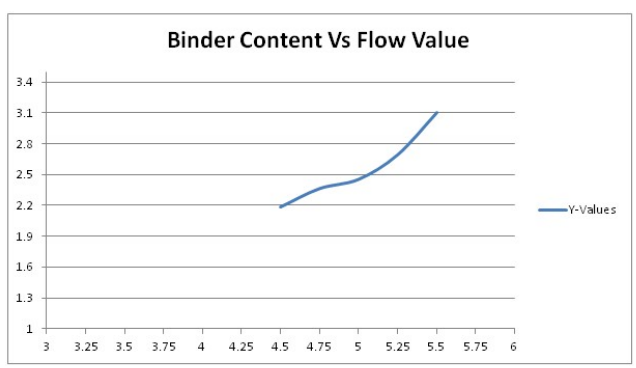

Figure 5.7 Bitumen % Vs Flow value (with 10% E-WASTE)

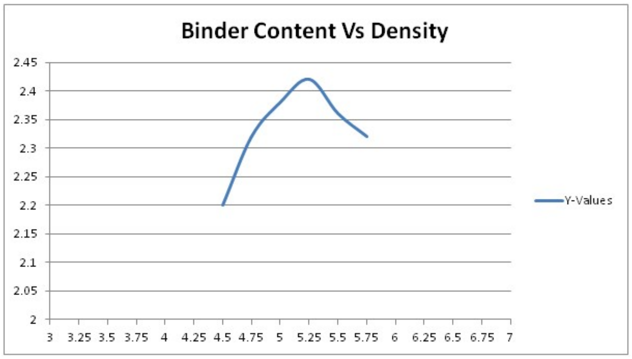

Figure 5.8 Bitumen % Vs Density (with 10% E-WASTE)

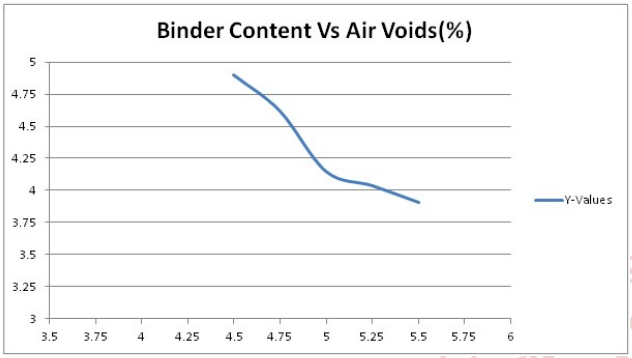

Figure 5.9 Bitumen % Vs Air voids % (with 10% E-WASTE)

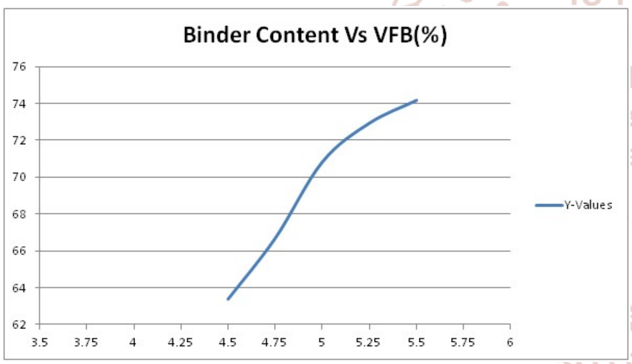

Figure 5.10 Bitumen % Vs Voids filled with bitumen %(VFB) (with 10% E-WASTE)

CONCLUSION

It has been observed when the E-WASTE is mixed with bitumen with varying % (4, 8, 10, and 12) properties of bitumen like penetration value, ductility, flash and fire point, specific gravity and softening point change. As discussed earlier in chapter 5 it is observed experimentally that the penetration, ductility decreased and softening point and specific gravity values are increased as the % of E-WASTE increases. While in the case of flash and fire point values first increases (with 4, 8 and 10%) and then decreases at 12% of E-WASTE. significant change in properties of DBM was observed as per follows.

FUTURE SCOPE OF WORK

- In future, the similar study can be done on different grade of Bitumen Mix.
- In future, the similar study can be done on Semi Dense Bituminous Mix (SDBM) to get enhanced properties.

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