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# Experimental Study on Partial Replacement of Bitumen by Waste Materials for Pavements

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***Abstract*: Dispatching of debris constituents together with waste shape able bags has become a laborious obstruction and waste plastics are scorched for obvious dumping which triggers eco-friendly contamination. Implementation of waste plastic bags in bituminous amalgams has established that these intensify the stage set of the mixture in accretion to sort out the scraping difficulties. Plastic waste which is dressed and is the chip of a size such that it discharges through 2-3mm sieve by means of shredding machine. The aggregate mixture is warmed and the plastic is effectually layered over the aggregate. This plastic waste overlaid aggregate is blended with hot bitumen and the sequenced mixture is used for road development. Bitumen is in the form of sticky, black in colour and highly viscous liquid. The residue or by-product of the fractional distillation of crude petroleum. Grades of Bitumen used for pavement are Grade: 30/40; Grade: 60/70; Grade: 80/100. Asphalt binder 70/80 was used for the investigation in this paper. The contemporary analysis is only pertinent to the mix design of flexible pavement examinations. Polymers main role to improves the fatigue life, cracking due to thermal, recycled plastics to disposal. This paper also includes the results of the various laboratory tests conducted on bitumen and its properties***

***Index Terms*:** *Waste plastic, Aggregate, Bitumen, plastic-bitumen-aggregate mix, Asphalt binder, modified bitumen and plastic modified aggregate*

## I. INTRODUCTION

Bituminous binders are widely used by paving industry to lay roads at low cost. In general, Flexible pavements have low flexural strength and are rather flexible in their structural action under loads. These types of pavement layers reflect the deformation of lower layers on-to the surface of the layer. If the surface course of a pavement is of Plain Cement Concrete then it is called as rigid pavement design and the mix design are two major considerations in case of pavement engineering. In the heavy vehicles on the road which leads to the increases in the drastically and substantially [1, 2]. Render new methods they have designed to improve the effective life of the bitumen's mixer and the higher quality [3, 4].

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To improve the asphalt pavement they have approached the new mixers as stone mastic asphalt (SMA) [4, 5], which increase the durability of the road surfaces [6]. Polymer modification can be considered as one of the solution to improvise the fatigue life, reduce the rutting & thermal cracking in the pavement.

ASTM standard to be considered for the better ductility and durability of the bitumen's [7, 8, 9, 10]. To provide a beneficial way of disposal of a large amount of recycled plastics.

Road paving is mainly used by the bituminous binders with their viscoelastic properties are dependent on their chemical composition. Now-a-days, the increment in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature put us in a situation to think about the improvement of the pavement characteristics and quality by both the strength and economical aspects. Bitumen can be modified by adding additives to achieve the present requirement. One of these additives is the polymers. The residue or by-product of fractional distillation of crude petroleum. Grades of Bitumen used for pavement are Grade: 30/40; Grade: 60/70; Grade: 80/100. Asphalt binder 70/80 was used for the study. In order to evaluate bitumen properties number of laboratory tests have been performed such as

- Ductility test
- Flash & fire point test
- Softening point test
- Penetration test
- Marshall Test.

## II. PROPERTIES OF SPECIMENS

### A. Penetration Test

It determines the hardness or softness of the bitumen by measuring the depth in tenths of millimeter will penetrate vertically in five seconds. Fig. 1 and Table. 1 show the penetration test result for various percentage of plastic added with bitumen is given below.

**Table. 1 Penetration Test Values**

| % of plastic | Penetration | | |
|---|---|---|---|
| | Trail 1 | Trail 2 | Trail 3 |
| 0 | 85 | 87 | 86 |
| 2 | 77 | 75 | 76 |
| 4 | 69 | 70 | 69.5 |
| 6 | 64 | 63 | 63.5 |
| 8 | 63 | 61 | 62 |
| 10 | 59 | 57 | 58 |

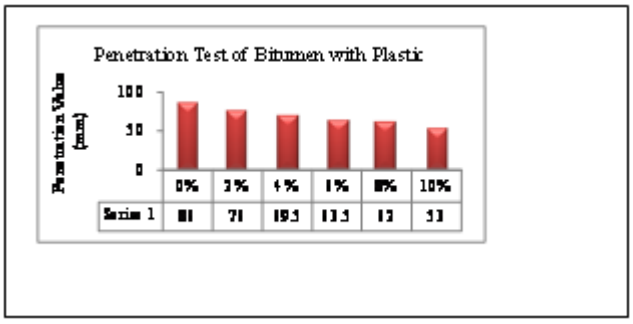


**Fig.1 Penetration value Vs % of Waste plastic**

### B. Ductility Test on Bitumen and Waste Plastic Mix

It is carried out find out the binding property between the bitumen and aggregate. It forms a thin ductile layer around the aggregate. Fig 2 and Table 2 shows the ductility test result for various percentage of plastic added with bitumen are given below

**Table. 2** Result of Ductility Test Values

| % of plastic | Trials 1 | Trails 2 | Mean Ductility Value (mm) |
|---|---|---|---|
| 0 | 140 | 140 | 140 |
| 2 | 137 | 139 | 138 |
| 4 | 134 | 134 | 134 |
| 6 | 129 | 127 | 128 |
| 8 | 119 | 121 | 120 |
| 10 | 115 | 117 | 116 |

The graph is drawn between % of plastics vs ductility values

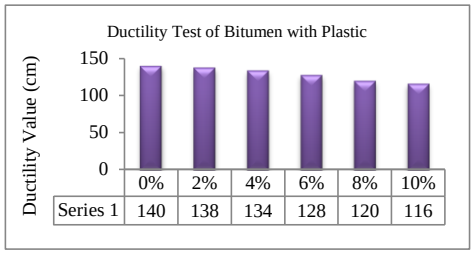


**Fig.2 Ductility value Vs % of Waste Plastic**

### C. Viscosity test on bitumen and waste plastic mix

Generally, viscosity is inverse of fluidity. Viscosity test is carried out to determine the consistency of the material. The table 3 and fig. 3 shows the viscosity test result for various percentage of plastic added with bitumen are given below

**Table. 3** Viscosity Test Values

| % of plastic | Viscosity value (seconds) | | |
|---|---|---|---|
| | Trail 1 | Trail 2 | Trail 3 |
| 0 | 40 | 38 | 39 |
| 2 | 45 | 49 | 47 |
| 4 | 57 | 53 | 55 |
| 6 | 59 | 63 | 61 |
| 8 | 76 | 74 | 75 |
| 10 | 80 | 78 | 79 |

The graph is drawn between % of plastics vs viscosity values

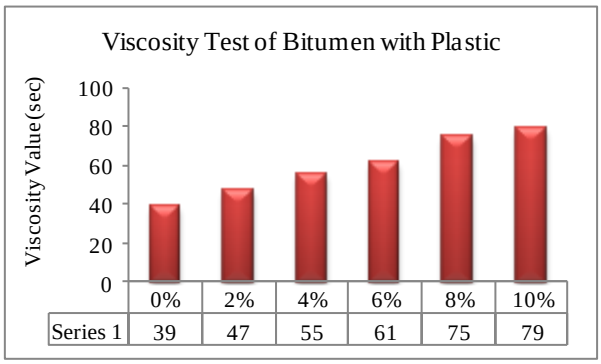


**Fig.3 Viscosity Value Vs % of Waste Plastic**

### D. Softening point test on bitumen and waste plastic mix

Softening point is usually determined using ring and ball test. It is the temperature at which the substance attains softening. The table 4 and fig 4 shows the softening point test result for various percentage of plastic added with bitumen are given below

**Table. 4** Softening Point Test Values

| % of plastic | Viscosity value (seconds) | | |
|---|---|---|---|
| | Trail 1 | Trail 2 | Trail 3 |
| 0 | 46.5 | 47 | 46 |
| 2 | 44.6 | 44 | 45.2 |
| 4 | 44.2 | 44 | 44.4 |
| 6 | 44.1 | 44 | 44.2 |
| 8 | 43.8 | 43 | 44.16 |
| 10 | 43.5 | 43 | 44 |

The graph is drawn between % of plastics Vs softening point values

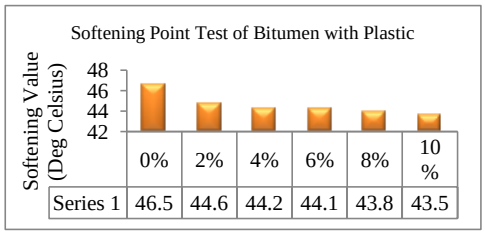


**Fig.4 Softening Point Value Vs % of Waste Plastic**

### E. Flash and fire point test on bitumen and waste plastic mix

Generally, the bitumen leaves the volatile material which is harmful and catches fire with flame. The Table 5 and fig. 5 shows the flash and fire point test result for various percentage of plastic added with bitumen are given below.

**Table. 5** Flash and Fire Point Test Values

| % of plastic | Flash point | Fire point |
|---|---|---|
| 0 | 272 | 286 |
| 2 | 279 | 290 |
| 4 | 283 | 298 |
| 6 | 289 | 306 |
| 8 | 292 | 309 |
| 10 | 298 | 312 |

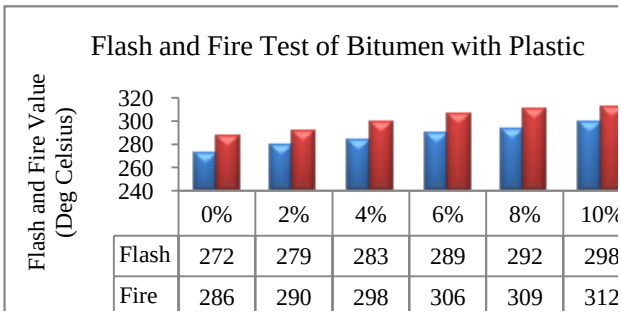


**Fig.5 Flash and Fire Point**

### F. Marshal Stability and Flow Test on Bitumen and Waste Plastic Mix

Marshall Method for designing hot asphalt mixtures is used to determine the optimum bitumen content to be added to specific aggregate blend resulting a mix. The table VI and fig 6 shows the marshal stability test result for various percentage of plastic added with bitumen and table 7 and fig 7 shows the flow test of the marshall.

**Table. 6** Marshal Stability Test

| % of plastic | 4.5% bitumen | 5% bitumen | 5.5% bitumen | 6% bitumen |
|---|---|---|---|---|
| | KN | KN | KN | KN |
| 0 | 17.03 | 17.18 | 17.68 | 17.61 |
| 2 | 18.25 | 18.80 | 18.95 | 18.24 |
| 4 | 19.10 | 19.02 | 19.66 | 19.84 |
| 6 | 19.58 | 19.44 | 20.57 | 20.55 |
| 8 | 20.11 | 20.17 | 21.51 | 21.12 |
| 10 | 20.28 | 21.15 | 22.43 | 21.81 |

**Table. 7** Marshal Flow Test

| % of plastic | 4.5% bitumen | 5% bitumen | 5.5% bitumen | 6% bitumen |
|---|---|---|---|---|
| | mm | mm | Mm | mm |
| 0 | 4.08 | 4.23 | 4.40 | 5.10 |
| 2 | 4.27 | 4.25 | 4.63 | 5.11 |
| 4 | 4.36 | 4.26 | 4.71 | 5.12 |
| 6 | 4.44 | 4.38 | 4.86 | 5.13 |
| 8 | 4.53 | 4.64 | 4.95 | 5.14 |
| 10 | 4.57 | 4.82 | 5.05 | 5.15 |

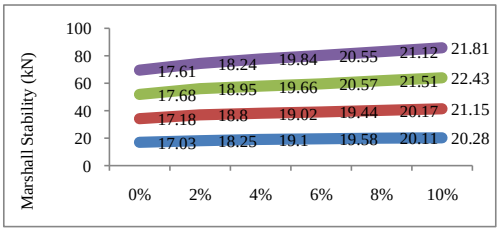


**Fig.6 Stability Values Vs % of Plastic**

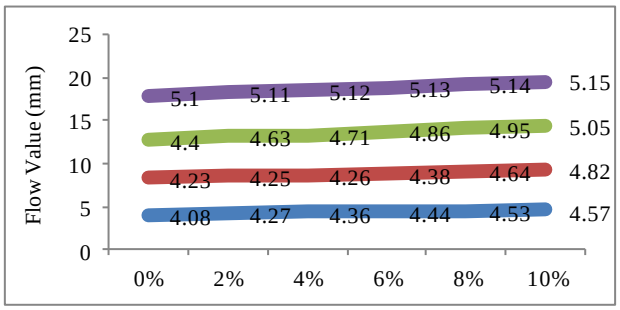


**Fig.7 Flow Values Vs % of Plastic**

## III. ASTM STANDARD SPECIFICATION

The Result is compared with the table 8 of the standard ASTM specifications

**Table. 8** Comparing Results with ASTM Specifications

| Test | Specifications | Results For 8% Plastic | ASTM specification limits |
|---|---|---|---|
| Penetration | ASTM D5-06 | 63.5 | 60-80 |
| Ductility | ASTM D113-86 | 120 | Min 100 |
| Viscosity | ASTM D36-2002 | 75 | Below 80 |
| Softening Point | ASTM D5-07 | 43.8 | 43-52 |
| Flash Point | ASTM D92-02 | 292 | Min 230 degree |
| Fire Point | ASTM D92-02 | 309 | Max 310 degree |
| Stability For 6% Bitumen | ASTM D33-06 | 21.12 | 18-22 |
| Flow Value | ASTM D70 | 5.14 | 5-5.14 |

The comparisons with the ASTM standards we conclude that the modified asphalt mixes with (8 % WPB by OBC weight) have higher stability and stiffness. There was an increase in the air voids and flow ratio in modified asphalt mix exhibited and the density as same. Melted WPB provide a rougher surface texture for aggregate particles in modified asphalt mix that would enhance asphalt mix engineering properties due to improved adhesion between bitumen and WPB coated aggregates.

## IV. CONCLUSION

Based on experimental work results for WPB modified asphalt mixtures compared with conventional asphalt mixtures, the following conclusions can be drawn:

WPB can be conveniently used as a modifier for asphalt mixes for sustainable management of plastic waste. The optimum amount of WPB to be added as a modifier of asphalt mix was found to be (8.0 %) by weight of optimum bitumen content of the asphalt mix. Asphalt mix modified with (8.0 % WPB by OBC weight) has approximately 24% higher stability value compared to the conventional asphalt mix.

Asphalt mix modified with WPB exhibit lower bulk density as the WPB percentage increased.

Asphalt mix modified with WPB exhibit higher flow value as the WPB percentage increased. However, the stiffness got increses due to the modified mix.

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