

Comparison of the Polyethylene and SBS Polymer Modified Bitumen's Effect – A Case Study

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Abstract- The ever increasing road traffic coupled with inadequate degree of maintenance has led to a continuous and accelerated deterioration of road network in various countries across the globe. This amass waste development itself prompted the researchers to go for the modification of the conventional bitumen by mixing it with recycled waste plastic materials like Polyethylene, Polypropylene, Styrene-Butadiene-Styrene, and Polyvinyl Chloride etc. The bitumen mixed with any of the above recycled polymers is often referred to as polymer modified bitumen. In this study two polymers namely Polyethylene and Styrene-Butadiene-Styrene are taken and their effect is studied vis-a-vis against the conventional bitumen with regard to their index and engineering properties by partial replacement of conventional bitumen with the above mentioned polymer modifiers. Findings from this study reveals that the polymer modified bitumen's offer better engineering properties there by increasing the durability of the road to a certain extent and their usage will also serve as a means of managing the waste menace properly.

Keywords- Polymer, Recycled waste, Asphalt Mix, Penetration, Softening point, Ductility, Stability, Flow, Unit weight.

I. INTRODUCTION

To ameliorate the riding quality of the bituminous roads, several construction methodologies were suggested including the Polymer modified bitumen in the recent past. In the wake of waste proliferated from the abundant usage of plastics in this technologically advanced world, man has reached a stage where he cannot sail through even a single day without using the plastic materials which are made up of different

polymers and hence the accumulation of plastic waste in larger quantities. The use of plastic materials from dawn to dusk in various walks of life of a human being has received a great momentum and hence the accumulation of the same as waste in different ways. However their disposal has posed a severe problem. Many of the polymers break down in fire and typically liberate hazardous smoke, ash and toxic fumes. Some of the polymers incineration is highly expensive and hence they were dumped in garbage, which in turn will decay slowly. The mixing up of these waste plastic materials with other bio-degradable organic waste materials in the garbage of the urban areas is another area of concern [1]. As a result more research is needed towards a better way of combating these waste materials, in order to minimize the problems encountered in their disposal.

Asphalt concrete is a composite material commonly used in road projects .It consists of bitumen used as a binder and mineral aggregate mixed together and lay down in layers and compacted [2].

The amount of aggregate in asphalt concrete mix is usually around 90 to 95 percent by weight and 75 to 85 percent by volume and they are basically responsible for the load bearing ability of the pavement [3]. The binder, generally penetration grade bitumen is a viscoelastic material with good mechanical and rheological properties which in turn gives good adhesion properties with aggregates [4].

The performance of the road pavement is strongly influenced by the properties of the bituminous binders as the bitumen is in the deformable phase [5]. However roads laid with bitumen binders are subjected to many harsh field conditions such as heavy traffic loading, ingress of water, chemical attack, and widely fluctuating temperatures [6].

Conventional bitumen often cannot provide the desired resistance to the above mentioned conditions and hence the modification of the same is inevitable. Though there are many grades of bitumen available in the market only a few grades are suitable for paving applications [7].

However, practical experience over the recent past has justified the modification of the asphalt binder with polymer additives will result in numerous benefits like enhanced adhesion and cohesion properties, improved fatigue resistance, thermal stress, decrease in temperature susceptibility and reduction of rutting [8]. As a result, polymer modified bitumen is a common means of providing economically performing pavement [9].

II. MATERIALS USED

A. Aggregates

In the present study Aggregates of different sizes i.e. 20mm, 16mm, 12.5mm, 10mm and 4.75mm are procured from Rapaka village, a place nearer to Rajam town situated in Srikakulam District-Andhra Pradesh-India. They are sieved properly as per their size.

B. Bitumen

Bitumen of 80/100 grade is procured from HPCL Refinery, Visakhapatnam-Andhra Pradesh-India.

C. Polymers

The Polymers used in this study are Polyethylene and Styrene-butadiene-Styrene in powder form. They are procured from RFCL Industry, New Delhi-India.

D. Filler Material

It has been procured from Rapaka village, a place nearer to Rajam town situated in Srikakulam District-Andhra Pradesh-India.

III. METHODOLOGY AND EXPERIMENTATION

The modified bitumen is prepared by mixing the conventional bitumen with the above mentioned polymers by weight of the original bitumen, i.e. Polyethylene and Styrene-butadiene-Styrene are mixed with trials of 0%, 2%, 4%, 6% etc. by weight to the

original bitumen. The mixture is continuously stirred until a uniform blend is achieved. The Tests like Penetration (IS: 1203 - 1978), Softening Point (IS: 1205 - 1978), Ductility (IS: 1208 – 1978) are conducted on the specimens which are prepared as per the specifications laid down by IS on conventional bitumen samples as well as Polyethylene and Styrene-butadiene-Styrene modified bitumen samples.

Traditionally Aggregate gradation requirements are so broad which will make use of different sizes of aggregates either Coarse or Fine. As per MORTH, different combinations of sieve sizes are specified in order to control specific grading ranges. The Coarse and Fine Aggregates of specified sizes are taken along with stone dust which is used as a filler material. The sieve analysis is carried out using a mechanical shaker. The sieve size range is orderly arranged and the weight retained on each sieve is measured. Percentage passing through each sieve is measured and calculated. Trial mixes are made to combine the coarse and fine aggregates in order to obtain all-in combined grading which satisfies the MORTH specification.

The performance of the asphalt mixture is based on the determination of the correct proportion of aggregate and bitumen. To determine the optimum bituminous binder content that would produce the asphalt concrete mixtures with strength and other durability properties which in turn meet the standard specifications, a few samples each of with a height of (63.5+/-0.5 mm), aggregate with 1200 grams in weight is taken and to that required quantity of first trial percentage of bitumen is added to the heated aggregate and the specimens are prepared according to the required design mix. The values of Marshall Parameters like Stability, Flow and unit weight are determined.



Fig. 3.1 Testing of casted mould with Marshall Stability Testing Machine

IV. RESULTS AND DISCUSSIONS

The following are the results obtained for the tests conducted in the present study.

A. Index & Engineering Properties

S.No	Properties	Influence of PE				Influence of SBS			
		0%	1 %	2 %	3 %	0 %	1 %	2 %	3 %
1	Penetration @ 25°C, 5 Sec, 100 gms in mm	94	78.3	73.3	65.5	93.30	81.6	78.3	69.1
2	Softening Point in °C	44.25	49.50	56.75	61.0	44.2	58.0	61.0	65.0
3	Ductility @ 27 °C in mm	905	841	735	602	780	715	522	396

B. Marshall Stability Test

S.No	% of BC	Influence of PE				Influence of SBS			
		% of PE	Stability in kN	Flow in mm	Unit weight in kN/m ³	% of SBS	Stability in kN	Flow in mm	Unit weight in kN/m ³
1	4.0	0	11.70	2.81	25.27	0	21.52	2.52	28.68
		2	12.93	2.64	25.29	2	22.46	2.40	28.72
		4	14.13	2.42	25.31	4	23.15	2.38	28.82
		6	14.01	2.20	25.25	6	22.92	2.31	28.80
2	4.5	0	12.76	3.04	25.28	0	22.97	2.91	28.70
		2	13.78	2.97	25.30	2	23.45	2.88	28.74
		4	14.70	2.65	25.33	4	24.24	2.76	28.76
		6	14.59	2.54	25.31	6	24.15	2.64	28.73
3	5.0	0	13.50	3.64	25.30	0	23.42	3.04	28.76
		2	14.36	3.40	25.31	2	24.28	2.98	28.78
		4	15.18	2.97	25.35	4	25.15	2.87	28.79
		6	15.84	2.75	25.33	6	24.98	2.78	28.73
4	5.5	0	13.22	4.12	25.31	0	23.20	3.54	28.80
		2	13.57	3.84	25.33	2	23.98	3.35	28.82
		4	13.90	3.57	25.36	4	24.34	3.25	28.83
		6	15.32	3.40	25.37	6	24.10	3.20	28.79
5	6.0	0	12.11	4.70	25.25	0	22.95	4.10	28.96
		2	12.91	4.42	25.28	2	23.16	3.95	28.98
		4	13.42	4.21	25.32	4	23.36	3.85	28.99
		6	14.81	3.97	25.33	6	23.25	3.70	28.92

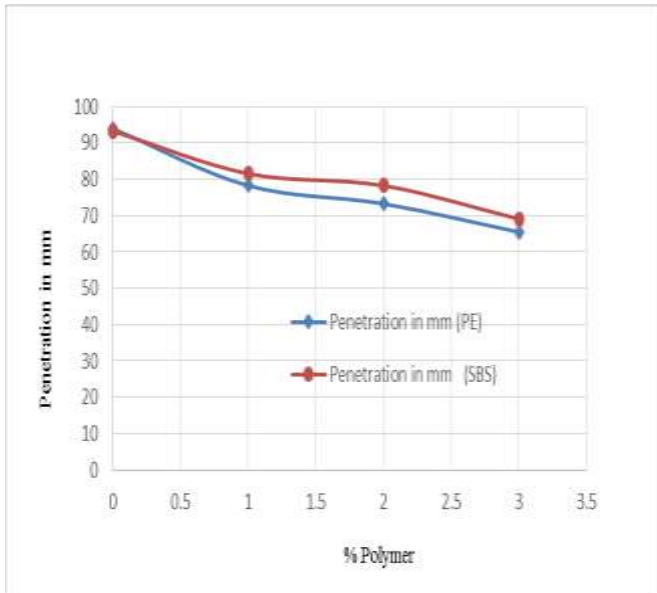


Fig. 4.1 % Polymer Vs Penetration in mm for PE & SBS

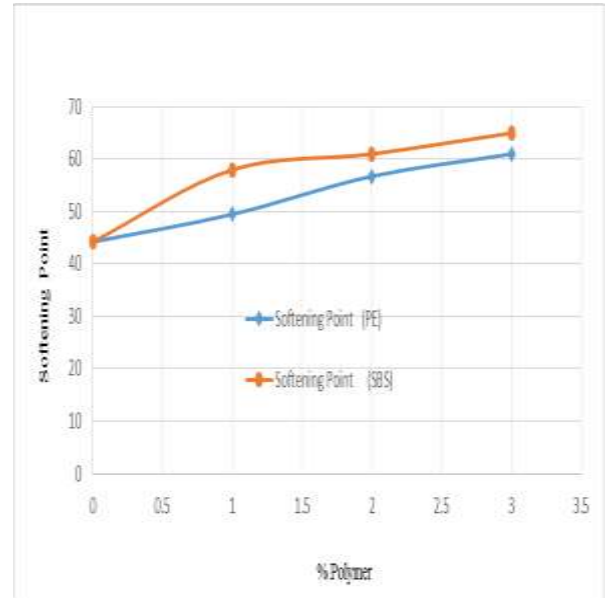


Fig. 4.2 % Polymer Vs Softening Point for PE & SBS

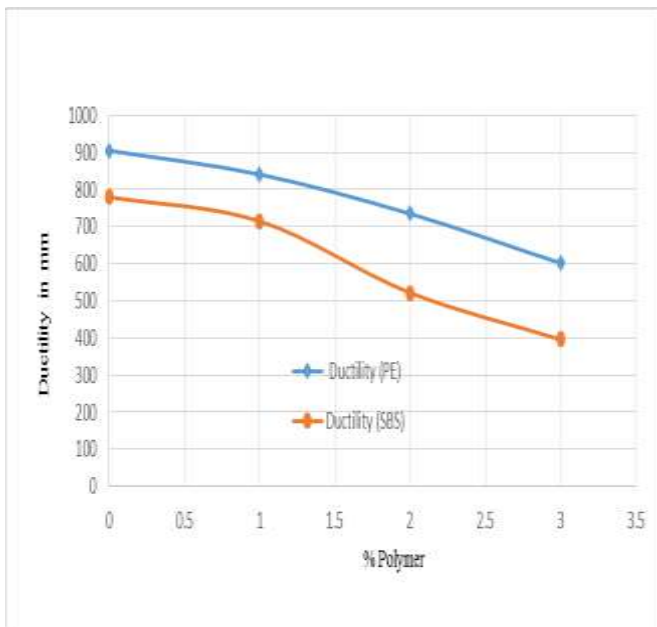


Fig.4.3 % Polymer Vs Ductility in mm for PE & SBS

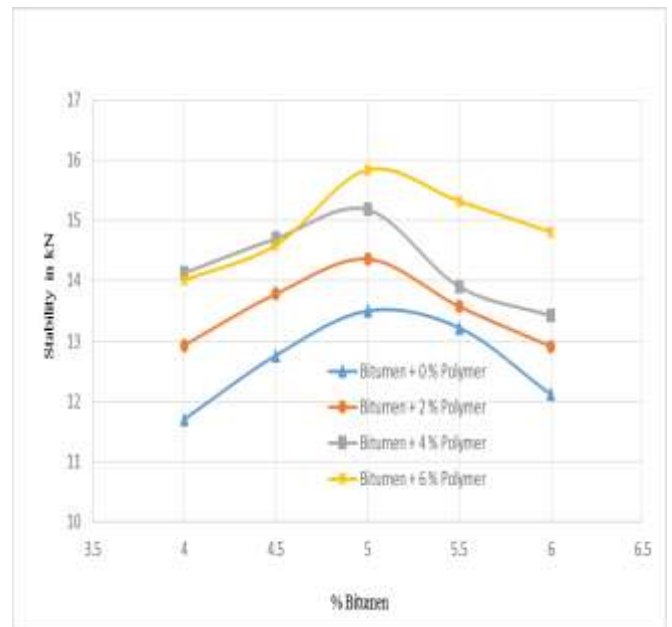


Fig. 4.4 % Bitumen Vs Stability for PE & SBS

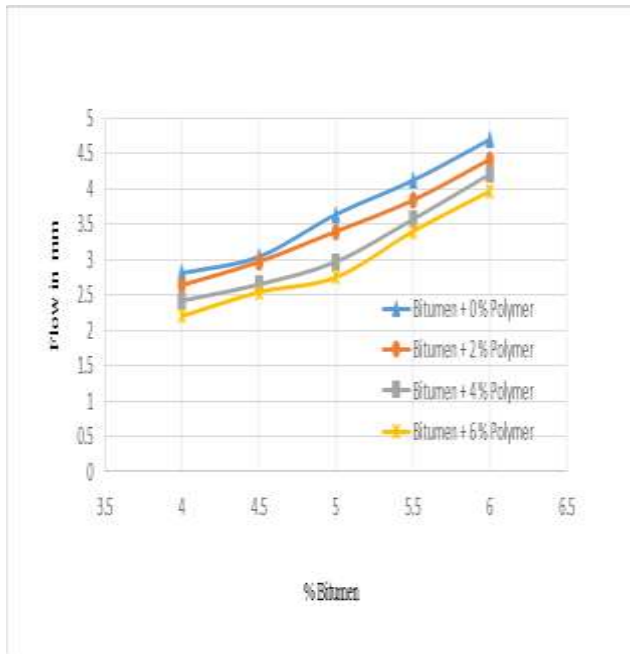


Fig. 4.5 % Bitumen Vs Flow for PE & SBS

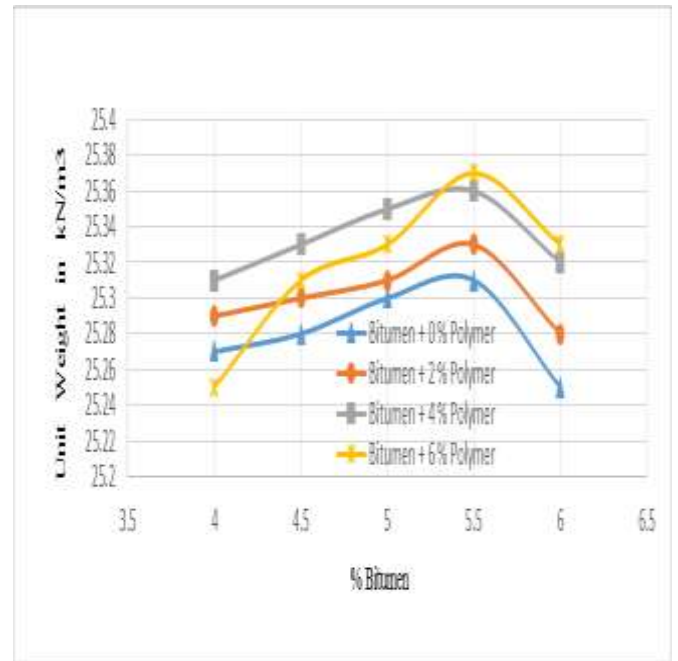


Fig. 4.6 % Bitumen Vs Unit weight for PE & SBS

C. Effect of Polymers on Bituminous Concrete

A Few samples are casted to test the effect of polymer addition with the mix. For all the polymer percentages, the stabilities may be attributed to higher cohesion of the binder and improved internal friction. For all polymer percentages, the flows of the modified bituminous concrete mixtures are lower than that of the conventional bitumen. This may be attributed to the reduction in the viscosity of the binder which will further have the increase internal friction of the concrete. The general trend shows that the flow decreases with increasing polymer content.

V.CONCLUSIONS

For investigating the effect of polymers, the conventional bituminous concrete is mixed with Polyethylene and SBS and the modified ones are subjected to Index properties and Engineering properties tests. Testing and observation of the modified bituminous concrete concludes that

- The Penetration Value of SBS Polymer modified bitumen is promisingly improved in comparison with Polyethylene modified bitumen.
- The Softening Point Value of SBS Polymer modified bitumen is reasonably improved in comparison with Polyethylene modified bitumen.
- The Ductility Value of SBS Polymer modified bitumen is improved in comparison with Polyethylene modified bitumen.
- The Marshall Stability value of the SBS modified bitumen is higher than that of the Polyethylene bitumen.
- The Marshall Flow value of the SBS modified bitumen is lower than that of the Polyethylene bitumen.
- The improvement in Unit Weight of the SBS modified bitumen is higher than that of the Polyethylene modified bitumen due to increase in adhesion and cohesion properties of the binder.

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