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EVALUATION OF STRENGTH CHARACTERISTICS OF MODIFIED BITUMEN

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Abstract*:Modified bitumen is emerging as one of the important construction materials for flexible pavements. Use of waste in the construction of flexible pavement is gaining importance because of the several reasons. Here, rubber wastes considered to be a pollution menace, can find its use in this process and this can help solving the problem of pollution because most of the waste is polymers. Use of disposed waste is the need of the hour. In the construction of flexible pavements, bitumen plays the role of binding the aggregate together by coating over the aggregate. It also helps to improve the strength of the road. But its resistance towards water is poor. Anti-stripping agents are being used. A common method to improve the quality of bitumen is by modifying the rheological properties of bitumen by blending with organic synthetic polymers like rubber and plastics. Once used waste materials are thrown out, they do not undergo bio-decomposition. Hence, they are either land filled or incinerated. Both are not eco-friendly processes as they pollute the land and the air. Any method that can use this rubber waste for the purpose of construction is always welcomed. However, in this present work the effectiveness of Crumb Rubber, HIPS (High Impact Polystyrene), PPCP (Polypropylene Copolymer) in bitumen as modified bitumen have been studied thoroughly*

Keywords: modified bitumen, rubber, polymer, flexible pavement, etc

1. INTRODUCTION

In the present scenario disposal of rubber wastes produced from different Industries is a great problem as these, materials are non-biodegradable. Majority of the construction materials used for roads are soil, stone aggregate, sand, bitumen, cement etc. The availability of natural materials is declining day by day. To overcome this difficulty, use alternative materials for road construction is to be given a thought. It is learnt that, usage of waste tyres in road construction in which it may leads to higher economic returns The necessary specifications should be formulated to maximize the use of solid wastes in different layers of the road pavement.

The process of disposing waste tyres in landfills and burning in open space is becoming nuisance because of rapid depletion of available landfill sites and clear environment respectively. The conventional bituminous mix consists of aggregate and 3 to 5 percent bitumen by weight of the aggregate **[1]**Thetyre rubber scrap can be incorporated into bitumen, which is known as modified bitumen and granulated or ground rubber or crumb rubber are used as a portion of the fine stone aggregate. the performance of bituminous pavements is found to be very poor in moisture inducedsituations. Considering this a lot of work has been done on use of additives in bituminous mixtures and aswell as on the modification of bitumen.**[2]**

2. OBJECTIVES OF PRESENT STUDY

- To evaluate properties of the various modified bituminous binders.

- To test typical bituminous mix using the various modifiers
- To study the effect of by varying bitumen content with additives.

2.1 METHODOLOGY

Methodology to evaluate the strength characteristics of modified bitumen using Crum rubber, HIPS (High Impact Polystyrene) PPCP (Polypropylene Copolymer). Assessment of strength characteristics of bitumen includes stages such as assessment of physical properties of bitumen as per respective IS codes to check the suitability of materials then finding optimum bitumen content by performing Marshall's test on prepared specimen which will be used further in study

3.1 MODIFIED BITUMEN

Modified Bitumen is bitumen with additives. These additives help in further enhancing the properties of bituminous pavements. Pavements constructed with modified bitumen last longer which automatically translates into reduced overlays. Flexible pavements containing conventional bitumen do not always perform as expected. In improving the properties of bitumen, several types of modification have been investigated. These include additive modification, polymer modification and chemical reaction modification. Investigations have revealed that properties of bitumen and bituminous mixes can be improved to meet the growing requirements of pavement with incorporation of certain polymers**.[3]**

3.2 TYPES ADDITIVE USED MODIFIED BITUMEN

A variety of additives can be used for modification of Bitumen. The degree of modification depends on type of Modifier, its dose and nature of Bitumen. The most commonly used Modifiers are:

- Crumb Rubber.
- HIPS (High Impact Polystyrene)
- PPCP (Polypropylene Copolymer)

3.3 PREPARATION OF BITUMEN SPECIMEN

Two samples of bitumen are prepared with each admixture viz crumb rubber, HIPS, PPCP .Various Grades of Bitumen used for pavement purpose. Grade: 30/40; Grade: 60/70; Grade: 80/100.Generally in India bitumen used in road construction of flexible pavement is of grades 60/70 or 80/100 penetration grade. For the study purposegrade of bitumen is 80/100 is used.Initially 15 and 50% of crumb rubber was added in two different bitumen samples. Similarly, 5 and 10% of HIPS plastic and PPCP plastic was added in two different bitumen samples.

Following tests have been conducted on the modified bitumen and are compared with standard properties of bitumen:

- Penetration test.
- Softening point test.
- Ductility test

3.4 TEST RESULTS:

Penetration test, softening point test and ductility tests are carried out on the modified bitumen and the values are compared with standard values of bitumen. The values of test results are shown in the Table 1, Table 2 and Table 3 respectively.

3.4.1 PENETRATION TEST

A loaded needle, as per BIS standards, is allowed to penetrate down in the bituminous mix for 5 seconds. This process measures the hardness or softness of bitumen by taking into account the depth of penetration of the needle. The test set up and procedure is carried out as per BIS standards at a specified temperature of 25°C. The test results are mentioned in table 1**[6]**

Table 1: Penetration test results on modified bitumen

SN	Admixture	% addition	Result	Standard value	Remark
1	Crumb Rubber	50% 15%	Fail 107mm	80-100	Standard value for Penetration test is taken from IS:73-2000.
2	HIPS	5% 10%	86 mm 81 mm	80-100	
3	PPCP	5% 10%	88 mm 83 mm	80-100	

3.4.2 SOFTENING POINT TEST

The temperature at which bitumen softens under controlled constant heating is termed as Softening point. This parameter is tested using Ring and ball setup. The results are mentioned in table 2**.[7]**

Table 2: Softening point test results on modified bitumen

SN	Admixture	% addition	Result	Standard value	Remark
1	Crumb Rubber	5% 10%	51°C 47.8°C	40°C	Standard value for Softening point is taken from IS:73-2000.
2	HIPS	5% 10%	53°C 51.8°C	40°C	
3	PPCP	5% 10%	58°C 56°C	40°C	

3.4.3 DUCTILITY TEST

Ductility of bitumen is measured as the distance (in cm) up to which it has the tendency to elongate without failure. This test is carried out using Briquette's mould and ductility testing machine. The test observations are recorded at 27oC**.[8]**

Table 3: Ductility test results on modified bitumen

SN	Admixture	% addition	Result	Standard value	Remark
1	Crumb rubber	5% 10%	48 cm 43 cm	70cm	Standard value for Ductility test is taken from IS:73-
2	HIPS	5% 10%	74.6 cm 70 cm	70 cm	

3	PPCP	5% 10%	65 cm 61 cm	70 cm	2000.

The test results for the additive solid waste in conventional bitumen are within standards 80-100 mm penetration value. The value of 40°C for softening point value only for crumb rubber values obtained are not satisfactory that is below 70 cm.

4. MIX DESIGN FOR MARSHAL STABILITY TEST

The wet mix design determines the optimum bitumen content. There are many methods available for mix design which vary in the size of the test specimen, compaction, and other test specifications. Since, Marshall Method of mix design is the most popular it is used in this work.**[9]**

4.1 GRADATION OF AGGREGATES

Gradation of aggregates is one of the most important factors for the design of SMA mixture (Stone Matrix Asphalt). The sieve analysis, blending and the specified limits of the SMA mixture are given in Table 4. It is as per NCHRP - 425,(National Cooperative Highway Research Program)

Table 4: Gradation of Aggregates

Size of aggregate (mm)	Weight of aggregate (gms)
12.5	72
10	312
6.3	84
4.75	200
2.63	204
Filler	350

4.2SPECIMEN PREPARATION

Approximately 1200g of aggregates and filler put together is heated to a temperature of 160-170˚C. Bitumen is heated to a temperature of 160˚C with the first trial percentage of bitumen (say 5% by weight of the mineral aggregates). Then the heated aggregates and bitumen are thoroughly mixed at a temperature of 160 - 170˚C. **[9]**

Fig. 1 Specimen Preparation in present study

The mix is placed in a preheated mould and compacted by a hammer having a weight of 4.5 kg and a free fall of 45.7 cm giving 50 blows on either side

The heights of the samples are measured and specimens are immersed in a water bath at 60˚C for 35±5 minutes. Samples are removed from the water bath and placed immediately in the Marshall loading head .
The load is applied to the specimen at a deformation rate of 50.8 mm/minute. Stability is measured as the maximum load sustained by the sample before failure. Flow is the deformation at the maximum load. The stability values are then adjusted with respect to the sample height (stability corrections). For the proposed design mix gradation, specimens is prepared for each bitumen content within the range of 5 – 7 at increments of 1 percent, in accordance with **[9]** using 50 blows/face compaction standards.

Fig 2 Setup of Specimen used in present study

All bitumen content shall be in percentage by weight of the total mix. As soon as the freshly compacted specimens have cooled to room temperature, the bulk specific gravity of each test specimen shall be determined in accordance with [9].
The stability and flow value of each test specimen shall then be determined in accordance with .[9]After the completion of the stability and flow test, specific gravity and voids analysis shall be carried out for each test specimen to determine the percentage air voids in mineral aggregate and the percentage air voids in the compacted mix and voids filled with bitumen. The values of bulk specific gravity, stability, flow, VA, (Air voids)VMA (Voids in mineral aggregate) and VFB (Voids filled with bitumen) obtained above are plotted separately against the bitumen content and a smooth curve drawn through the plotted values.

4.3. PREPARATION OF MARSHALL SPECIMENS -

Marshall Stability test is conducted on stabilized SMA in more than 2 samples of 100 mm diameter and 63.5 mm height by applying 50 blows on each face as per ASTM procedure. Bituminous mixes are prepared by mixing the graded aggregates with 80/100 penetration grade bitumen and additives. Three different natural fibres are used as additives in SMA mixture viz., Crumb rubber, HIPS plastic and PPCP plastic. Waste plastics in shredded form are also tried as the additives. The crumb rubber content in this research is taken 5 % by weight of bitumen and the waste plastics content as 5% by weight of bitumen.
The procedure adopted for the preparation of Marshall Specimen is the same as used in control mixtures except, the additives are added in heated aggregate prior to mixing them with heated bitumen (dry blending method). The mixing and compaction temperatures are kept as 150˚C and 165˚C respectively. [9] A total of nine number of Marshall samples have been prepared keeping the percentage of admixture constant and varying the bitumen

percentage as 5 %, 6 %, & 7 %. The admixtures were replaced by replacing the bitumen content in mix to reduce the amount of bitumen by using the solid waste to get optimum results

5. DISCUSSION ON RESULTS

Average of the binder content corresponding to VMA of 17 % and an air void of 4% are considered as the optimum binder content. Stability and Flow values at the optimum bitumen content are then found from the plotted smooth curves and shall comply with the design parameters given in Table

The optimum bitumen content (OBC) for the SMA mixture is determined and is found to be 6.42 % (by wt. of total mix). This SMA mixture without additives is considered as the control mixture for the subsequent studies.

Fig 3. Sample Specimen used in present study

5.1 OPTIMUM BITUMEN CONTENT

The optimum bitumen content been explained in this section.

HIPS-Optimum Binder Content

a) Max stability = 5 percent bitumen content.
b) Max Gm = 6 percent bitumen content.
c) Maximum air void = 5 percent bitumen content.
d) The optimum bitumen extent is the average of above = 5.33 percent.

PPCP- Optimum Binder Content-

a) Max stability = 5 percent bitumen content.
b) Max Gm = 5 percent bitumen content.
c) Maximum air void = 5 percent bitumen content.
d) The optimum bitumen extent is the average of above = 5 percent.

CRUMB RUBBER- Optimum Binder Content-

a) Max stability = 5 percent bitumen content.
b) Max Gm = 6 percent bitumen content.
c) Maximum air void = 5 percent bitumen content.
d) The optimum bitumen extent is the average of above = 5.33 percent.

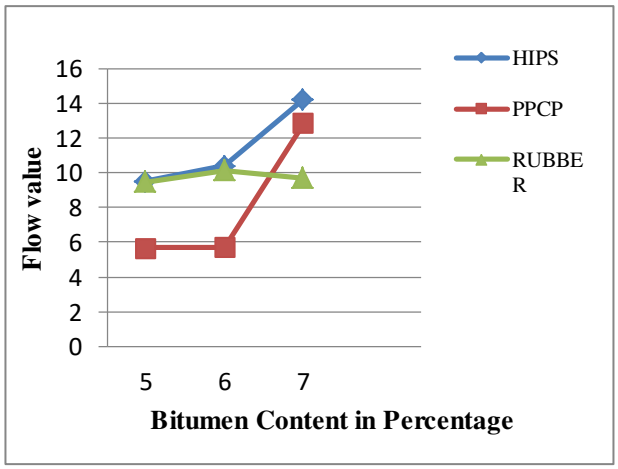

Fig. 3 Bitumen content vs Flow value

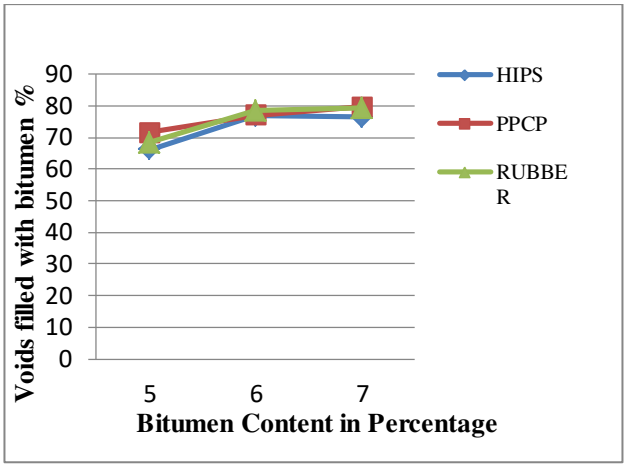

Fig. 4 Bitumen content vs VFB

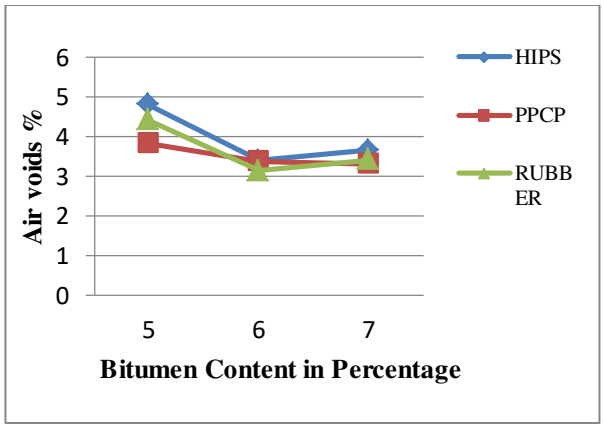

Fig. 5 Bitumen content vs Air voids

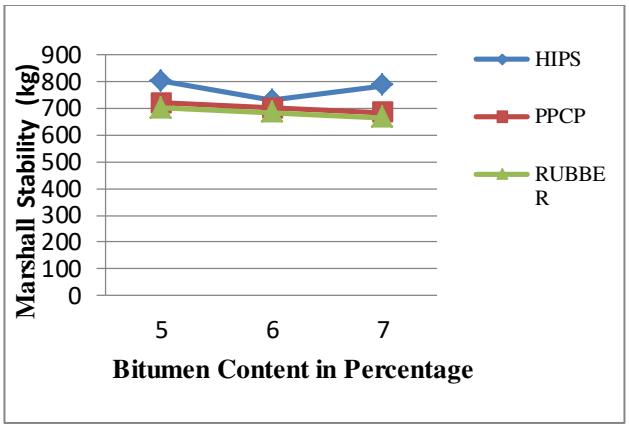

Fig 6 Bitumen content vs Marshal Stability

6. CONCLUSIONS

Based on result of laboratory investigation in present study, following conclusions are drawn:

- Softening point values and ductility value of plain bitumen can be improved significantly by modifying it with addition of different solid wastes which is a major environment pollutant.
- The values obtained from the physical test on bitumen (Penetration test, softening point test, ductility test) are within the limits specified by IRC SP:53-2002 and IS :73-2000.however the results obtained for ductility for crumb rubber is not satisfactory .
- The results of penetration, softening point, ductility shows that the shredded solid waste can be used as modifier in hot mix bitumen to improve resistance to rutting and produce pavement with better durability.
- The optimum bitumen content for HIPS and Crumb rubber is 5.33 %. And for PPCP plastic waste the optimum bitumen content is 5 %.
- As, the solid waste percentage goes on increasing beyond 5 % decrease in stability is observed clearly indicating negative results from excess use of solid waste.

- The presence of solid waste reduces the air voids which prevents the moisture absorption and also prevents oxidation of bitumen due to entrapped air. This result shows enhancement of Marshall Stability value and other design parameters and this may prevent formation of potholes.
- Hence, it is concluded that the added solid waste (Crumb rubber, HIPS, PPCP) to the asphalt mixture with fine particles size, increases the Marshall stability more than the conventional mix.

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