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Study on the Performance of Crumb Rubber Modified Bitumen by Varying the Size of Crumb Rubber

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Abstract

The abundance and increase of waste tyre disposal is a serious problem that leads to environmental pollution. Crumb rubber obtained from shredding of those scrap tires has been proven to enhance the properties of plain bitumen since the 1840s. It can be used as cheap an environmentally friendly modification process to minimize the damage of pavement due to increase in service traffic density ,axle loading and low maintenance services which has deteriorated and subjected road structures to failure more rapidly. Use of crumb rubber leads to excellent pavement life, driving comfort and low maintenance. The rheology of CRMB depends on the internal factors such as crumb rubber quantity, type, particle size, source and pure bitumen composition , and external factors such as the mixing time, temperature, and also the mixing process(dry process or wet process).

The present study aims in investigating the experimental performance of the bitumen modified with 15% by weight of crumb rubber varying its sizes. Four different categories of size of crumb rubber will be used , which are coarse(2.36 mm- 1.6 mm); medium size(1.6 mm- 1.18 mm); fine (1.18 mm- 600 μm); and superfine (600 μm- 300μm). Common laboratory tests will be performed on the modified bitumen using various sizes of crumb rubber and thus analyzed. Marshal stability method is used for mix design. Finally a comparative study is made among the modified bitumen samples using the various sizes of crumb rubber particles and the best size is suggested for the modification to obtain best results.

Keywords: Crumb Rubber Modified Bitumen (CRMB), Marshal Stability test , crumb rubber

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1. INTRODUCTION

Presently in India bitumen is modified with various types of modifier such as crumb rubber, natural rubber, reclaimed polyethylene and polymers are being used for construction of bituminous roads. A number of products are so available in market, with which bitumen has been modified with able of modifiers..As per IRC: SP:53-2010 the products shall be evaluated for their suitability in an approved laboratory by conducting various test know its properties

The recent study an attempt is made to investigate the influence of mixing temperature on bituminous mixture with different types of bitumen .The basic principle of the arrangement of different layers of adaptable asphalt by carrying out experimental investigation like marshall mix design test , Indirect tensile strength and Fatigue test were carried out using Paving grade (VG-40) and crumb rubber using various size. .

Crumb rubber were extracted by segregation process , cleaning process , shredding process and collection process.

1.Segregation process

Rubber waste collected from various sources must be separated from other waste

2. Cleaning process

Rubber wastes are cleaned and dried properly by suitable method

3.Shredding process

Will be shredded into small pieces in formof aggregate size.

Size varies from4mm to75um

4. Collection process

The rubber pieces is separated by 22.4 mm sieve and retained at5.6 mm sieve and this rubber pieces is blended with the bituminous mix of 10% to 20% by weight of stone aggregate.

2. Materials and Methodology

A methodology based on technically sound information will have to be formulated before collecting the data and its analysis. The various stages are presented below.

Stage 1: Collection of materials such as Bitumen (VG30), Aggregate , fine aggregate , filler , Crumb rubber

Stage 2: Test on aggregate such as Abrasion test , Impact test , Water absorption test

Stage 3: Test on Bitumen such as Penetration test , Softening point values)

Stage 4: Mixing of crumb rubber , and bitumen to check the properties of crumb rubber modified bitumen

Stage 5: Mixing of crumb rubber , Aggregate ,Filler and Bitumen by dry process

Stage 6: Test on Crumb rubber modified bitumen to check stability of bituminous mix of various size of crumb rubber by marshall stability test.

3. Test on aggregate

3.1 Impact test:

Sl No.	Aggregate weight(W1)gms	Weight of aggregate passing through 2.36mm IS sieve after 15 blows (W2)gms	Impact value of aggregate =(W2/W1)*100

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1	340	**55**	**16.17%**
2	340	**60**	**17.64%**
3	**340**	**50**	**14.70%**

3.2 CRUSHING TEST

Sl NO	Aggregate weight (W1)gm	Weight of aggregate passing through2.36 mm IS-sieve (W2) gms	Crushing value of aggregate =(W2/W1)*100
1	2560	590	23.04%
2	2560	600	23.04%
3	2560	590	23.04%

3.3 Water absorption test

Sl No	Weight of aggregate W1) gms	Weight of water absorbed by the aggregate after24hours (W2)gms	Absorption value =(W2/W1)*100
1	2000	37	1.86%

4.1 Penetration test:

4. Test on Conventional Bitumen:

Sl No	**Size of crumb rubber in mm**	**Pentration value of conventional bitumen**	**Penetration value of crmb**
1	**2.36-1.36**	**48.23**	**39.36**
2	**1.6-1.18**	**43.96**	**33.82**
3	**1.18-0.6**	**47.38**	**37.56**
4	**0.6-0.3**	**45.04**	**40.17**

4.2 Softening Point test:

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Sl No	Size of crumb rubber in mm	Softening point value of conventional bitumen	Softening point value of crmb
1	**2.36-1.36**	**83^0 C**	**91^0 C**
2	**1.6-1.18**	**85^0 C**	**95.4^0 C**
3	**1.18-0.6**	**84^0 C**	**99^0 C**
4	**0.6-0.3**	**82^0 C**	**90^0 C**

Design of bituminous mix:

The Marshall mix design:

Marshall Mix design method is the suggested method for categorization of bituminous mixes in India. This test was conducted on compacted cylindrical specimen of bituminous mix of diameter The impact compaction due to the absence of Kneading and Shearing 101.6mm and thickness 63.5mm . A low cost option to gyratory compaction was first reported in South Africa. This consists of the modification for the face of the Marshall Hammer by providing indents on the compaction face .In the present investigation, instead of Modified Marshal Hammer only standard Marshall Hammer issued.

Grading for bituminous mixes as per MORT&H

Grading	**2**
Size of aggregate (mm)	**13**
Thickness of pavement(mm)	30-45
IS sieve size (mm)	Cumulative % by weight
19	100
13.2	79-100
9.5	70-88
4.75	53-77
2.36	42-58
1.18	34-48
0.6	26-28

0.3	18-28
0.15	12-20
0.075	4-10
Bitument content	5-7

Marshall properties as per MoRT&H specification

Marshall properties	Specification of MoRT&H
Stability	Min 900kg
Indirect tensile strength value	Min 80%
Flow value	2-4mm
Voids in mineral aggregate	Min 16%
VFB values	65-75%

Test on bituminous mix by Marshall Stability test

1)The mineral aggregate and filler were proportiones as mentioned in table and weighed of 1200gms and kept it into an oven of temperature 175^{0}C to 190^{0}C

2) The viscosity grade 30 bitumen mix is boiled it to 120^{0}C to 165^{0}C temperature

3) The calculated amount of fine crumb rubber is placed into a separate container.

4)The calculated amount of hot bitumen is to be put into the hot aggregate and this substance is blended thoroughly using mechanical stirrer or by manual mixing with the trowel till the aggregate are coated uniformly with bitumen for VG 30 grade bitumen mixing temperature is 160 c

5)The compaction mould assembly is cleaned and oily coated and placed preheated to attain the temperature in the range of 95^{0}C to 150^{0}C

6)The bituminous mix is to be transferred to a pre heated compaction mould and it to be compacted by a mechanical compacted rammer by applying 75 blows on both sides at a compaction temperature of 149^{0}C for VG 30 grade bitumen.

7) The compacted specimen along with mould is kept it cool for room temperature of 24hrs

8) The compacted specimen is to be extracted from the mould with the help of extractor

9) The compacted specimen are to be weighted

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1	4.5	6.8	10	534.14	124	712	2.34	2.51	6.37	10.06	16.43	61.25	2.4	2304
2	4.5	6.8	10	534.14	122	698	2.31	2.51	7.62	9.93	17.55	56.57	2.6	1395.2
3	4.5	6.8	10	534.14	123	711	2.34	2.51	6.34	10.07	16.41	61.35	2.9	1536
1	5.0	6.9	10	541.99	124	718	2.35	2.49	5.33	11.23	16.56	67.78	2.8	2304
2	5.0	6.9	10	541.99	123	709	2.34	2.49	5.71	11.18	16.89	66.19	3.1	2080
3	5.0	6.8	10	534.14	125	728	2.37	2.49	4.58	11.32	15.89	71.21	2.9	1971.2
1	5.5	6.8	10	534.14	124	710	2.32	2.47	5.87	12.19	18.06	67.49	3.8	1504
2	5.5	6.8	10	534.14	125	726	2.37	2.47	4.14	12.41	16.56	74.97	3.5	1792
3	5.5	6.8	10	534.14	125	728	2.37	2.47	3.89	12.45	16.33	76.20	3.2	2080
1	6.0	6.7	10	526.28	126	732	2.36	2.45	3.52	13.53	17.05	79.35	4.9	2336
2	6.0	6.7	10	526.28	125	728	2.38	2.45	2.88	13.62	16.50	82.56	4.65	1504
3	6.0	6.7	10	525.28	125	696	2.25	2.45	8.27	12.87	21.13	60.89	4.4	1939.2
1	6.5	6.7	10	526.28	124	706	2.31	2.44	5.03	14.33	19.36	74.01	5.8	1472
2	6.5	6.6	10	518.43	125	718	2.33	2.44	4.32	14.44	18.75	76.98	4.25	1600
3	6.5	6.6	10	518.43	125	720	2.34	2.44	3.65	14.54	18.19	79.92	4.5	1536

in air and in water finally weighted into saturated surface dry and it is noted down

10) The specimen are kept in thermostatically controlled water bath of temperature 60^0C for period of 30minutes

11) After this the specimen is taken out and placed in marshell test head for testing. The load is applied at a uniform rate of 51mm/ minute , the load and deformation reading are to note down.

Determination of Optimum Bitumen Content (OBC)

For the determination of OBC, graphs are plotted with bitumen content on the X-axis and following values on the Y-axis

- Marshall Stability values
- Flow values
- Unit weight or Bulk Density(G_b)
- Percent air voids in total mix(V_V)
- Percent voids filled with bitumen(VFB)

Design of Volumetric properties for determining the OBC Content for Bituminous Concrete-II mix usingVG–40

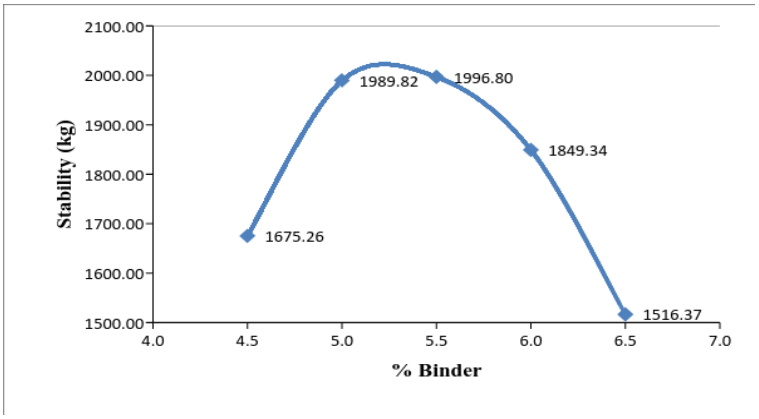

Figure4.1:Binder content(%)VsStability(kg)VG–40

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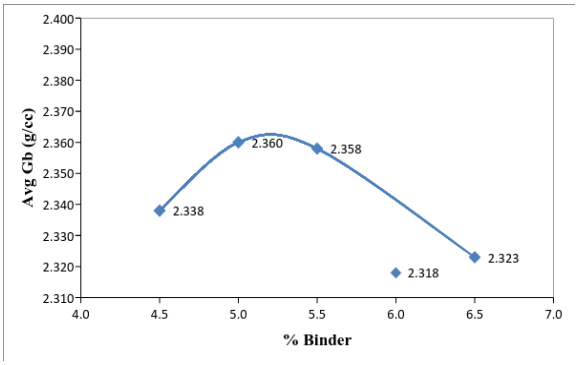

Figure4.2: Bindercontent(%) Avg. Vv(%)VG–40

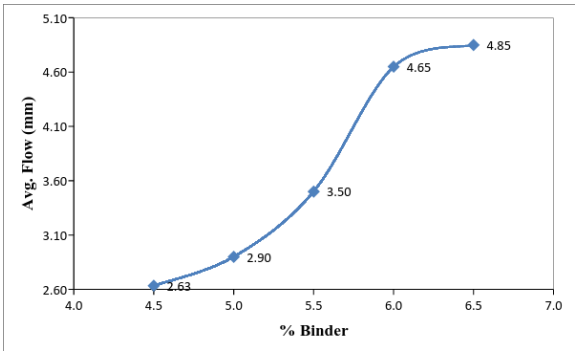

Figure4.3: Binder content(%)VsAvg.VFB(%)VG–40

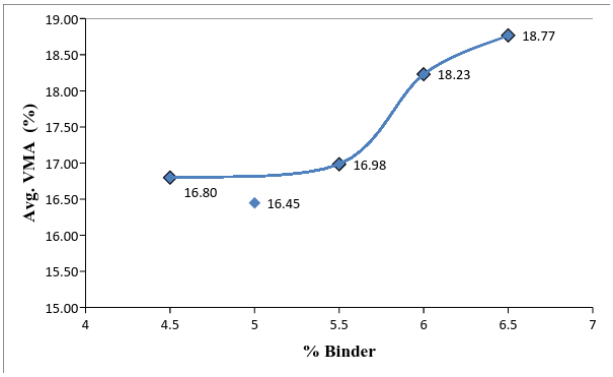

Figure4.4: Binder content(%)VsAvg. VMA(%)VG–40

MARSHALL STABILITY VALUES OF CRUMB RUBBER MODIFIED BITUMEN

The present study had undertaken to determine a effect of different sizes of crumb rubber on the physical properties of bituminous mixes. Improper sizes of mix may affect its performance. Thus this study was envisaged to bring about awareness in the field engineers about the following temperature time line sand its effect on deterioration in stability and other physical properties. Accordingly crumb rubber sizes was varied at predetermined OBC i.e Marshall Specimens were prepared at 170°C for the types of binder sand tested for Marshall Stability. Marshall stability test is conducted on each specimen and the mean of Marshall stability value(after applying the correction factor if any, for thickness value so the than 63.5mm)and the flow value for specimens prepared using different binder contents are tabulated. Graphs is plotted with content of bitumen on the X-axis and i) density ii)Marshall Stability iii)flow value iv) air voids vs VFB on the y-axis. Individual values of optimum bitumen contents are obtained considering i) maximum density ii)maximum stability iii) midrange of recommended flow value iv) midrange of recommended voids content.

Conclusions

1. All the values obtained from the physical test on aggregates (impact test,crushing test, water absorption test)are within the limits given by the MoRT&H requirements.
2. The values obtained from the physical test on bitumenVG-40(penetration test, softening point test, ductility test) are within the limits specified by IRCSP:53-2002andIS:73-2000.
3. Addition of crumb rubber waste generally improves the properties of bituminous mix
4. The sample prepared by using crumb rubber size(600µm-300µm) gives the highest stability value minimum air voids and minimum VMA and VFB% values. So the best size to be used for crumb rubber modifications.

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