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Laboratory Comparative Study on the Performance of Plain Bitumen and Crumb Rubber Modified Bitumen on DBM Grade 2

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Abstract: ***In the present study, the physical properties of aggregates and bitumen were determined. Rothfuch's method is carried out to obtain the proportion of aggregate mixing and Marshall Stability method is adopted for bituminous mix design. Then for the neat bitumen, Marshall Tests were conducted to obtain the OBC for DBM Grade II. The OBC of 5.2% is obtained for the mix. The present study aims in investigating the Mashall properties of the bitumen modified with 15% and 18% of crumb rubber mixed with 500g of bitumen i.e. (75g and 90g crumb rubber) is used for the preparation of CRMB. Two categories of the size of crumb rubber were used, having sieve size (3.35 mm–2.36 mm) and (2.36mm – 1.18mm). Penetration tests and Softening point tests were performed on the modified bitumen using various sizes of crumb rubber modified bitumen. For the molds prepared with CRMB and with neat bitumen, 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),Crumb Rubber , Bitumen and aggregates

1. Introduction

Roads act as a communication link in serving millions of people in every part of the world. The roads serve traffic safely, comfortably and efficiently at an affordable cost. India being a developing country, the flexible pavement forms the major part of the roads in comparison with the use of other roads like Cement Concrete Road, Water Bound Macadam, Gravel road, earthen road, etc. The transportation problems faced by various nations have increased manifold, necessitating the search for alternatives that ensure efficient, feasible and faster means of transport. Over the past two decades, traffic volumes and the percentage of heavy trucks have increased. In recent years due to the heavy magnitude of wheel loads and tire pressure, the severity of rutting is increasing on Indian roads. Due to permanent deformation caused in the sub grade, other layers also contribute to the total permanent deformation. Also, the accumulation of permanent deformation in the bituminous pavement with traffic repetitions increases the roughness of the road surfaces resulting in loss of serviceability of the road. The rainwater accumulated in the ruts can be a cause for an accident. It also reduces the strength of different layers due to the ingress of water into the pavements. For a location where higher temperatures prevail, the rutting of the bituminous layer become more critical especially for pavements with a thick bituminous layer. The rutting mode of distress in bituminous pavement result from both densification and plastic flow caused by repeated application of axial loads. Bituminous pavement can also undergo permanent deformation when subjected to sustained (creep) loading for long periods of time in parking areas, bus terminals, intersections, and loading /unloading yards

1.1 Role of Crumb Rubber in Bituminous Pavements

Use of crumb rubber in road construction is not new. Some aggregates are highly hydrophilic (water loving). Like bitumen crumb rubber is hydrophobic (water hating) in nature. So the addition of crumb rubber to asphalt mix lead to improvement of strength, water repellent property of the mix. Crumb rubber get added to hot bitumen mixture and the mixture is laid on the road surface like a normal tar road. Crumb rubber modification can be considered as one of the solution to improvise the fatigue life, reduce the rutting& thermal cracking in the pavement. Creating a modified bituminous mixture by using recycled tires which enhances properties of HMA mixtures would not only produce a more durable pavement, but also provide a beneficial way of disposal of a large amount of recycled tires.

Figure 1: Shredded Crumb Rubber.

1.2 Objectives of Present Study

Basic intention is to efficiently utilize the waste tires in constructive way so that it can be beneficial to society however main objectives of current project work are:

1) To carry out various tests on aggregate and bitumen binder to decide suitable property.
2) To estimate the proportion of aggregate by using Rothfuch's method.
3) To reuse the waste crumb rubber in the bitumen for the construction of pavement.
4) To prepare a bituminous mix design by using Marshall Method for DBM grade 2.
5) To find the Marshall properties of DBM grade 2 by varying the percentage of Crumb rubber.

2. 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.

1) Collection of materials such as Bitumen (VG30), Aggregate , fine aggregate , filler , Crumb rubber.
2) Tests on aggregate such as Abrasion test , Impact test , Water absorption test, Specific Gravity .
3) Test on Bitumen such as Penetration test , specific gravity test, etc.
4) Mixing of crumb rubber , and bitumen to check the properties of crumb rubber modified bitumen.
5) Mixing of crumb rubber , Aggregate ,Filler and Bitumen by dry process.
6) Test on Crumb rubber modified bitumen to check stability of bituminous mix of various size of crumb rubber by Marshall stability test.

2.1 Mixing of Crumb Rubber with Plain Bitumen

In preparing the modified binders, about 500 g of the bitumen was heated to fluid condition in a 1.5 litre capacity metal container. For blending of crumb rubber with bitumen, it was heated to a temperature of 160 °C and then crumb rubber was added. For each mixture sample 15% of crumb rubber by weight of two different sizes is used, which are (3.35 mm – 2.36 mm); (2.36 mm – 1.18 mm). The blend is mixed manually for about 8-10 minutes. The mixture is then heated to 160 °C and the whole mass was stirred for about 30 minutes. Care is taken to maintain the temperature between 160 °C to 170 °C. The contents are gradually stirred for about 35 minutes. The modified bitumen is cooled to room temperature and suitably stored for testing.

2.2 Common tests on the Modified Bitumen

Penetration test and Softening point tests on both the plain and modified CRMB are performed and the results are analyzed for further study.

2.3 Specimen Preparation

Approximately 1200gm of aggregates and filler is heated to a temperature of 175°C to 190°C. Bitumen is heated to a temperature of 121°C to 125°C with the first trial percentage of bitumen (say 3.0 or 3.5% by weight of the material aggregates) to the heated aggregates and thoroughly mixed at temperature of 154°C to 160°C. The mix is placed in a preheated mould and compacted by a rammer with 75 blows on either side at temperature of 138°C to 149°C. The weight of mixed aggregates taken for the preparation of the specimen may be suitably altered to obtain a compacted thickness of 63.5+/-3 mm. Vary the bitumen content in the next trial by +0:5% and repeat the above procedure. Number of trials is predetermined. The prepared mould is loaded in the Marshall Stability apparatus.

Figure 2(a): Preparation of CRMB mix

Figure 2(b): Marshall mould of CRMB

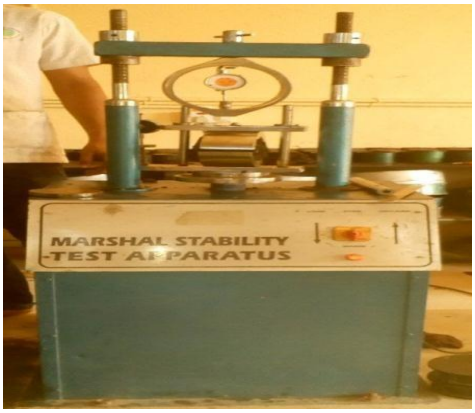

Figure 2(c): Marshall Stability Test Apparatu

2.4 Determination of Density and Void Analysis

1) Theoretical Specific Gravity of the Mix, Gt
2) Bulk Specific Gravity of Mix, Gm
3) Air Voids Percent, Vv
4) Percent Volume of Bitumen, Vb
5) Voids in Mineral Aggregate, VMA
6) Voids Filled with Bitumen VFB

3. Test Results

Table 1: Determination of Optimum Content of Bitumen

Bitumen Content (%)	Unit Weight (g/cm3)	Stability (kg)	Flow Value (mm)	Air Voids (%)	VMA (%)	VFB (%)
4.5	2.48	3293.33	0.9	8.13	16.79	52.58
4.8	2.51	3045.77	3.13	2.67	12.43	78.97
5.1	2.5	3009.73	4.22	1.87	12.41	85.19
5.4	2.58	3964.04	1.57	2.09	13.07	84.46
5.7	2.52	2272.31	0.48	1.23	12.87	90.47

3.1 Marshall Graph Plots

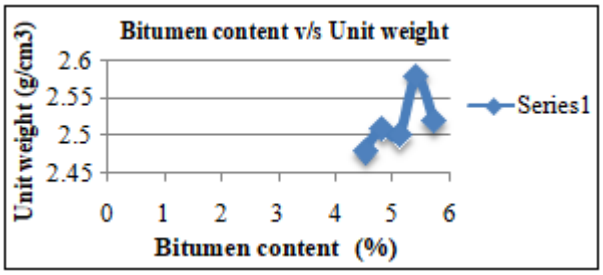

Chart 1: Unit weight (g/cm3) v/s Bitumen Content (%)

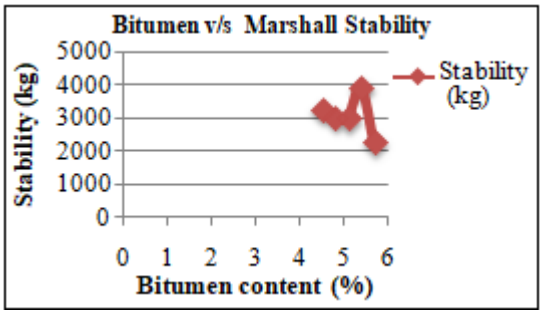

Chart 2: Marshall Stability (kg) v/s Bitumen Content (%)

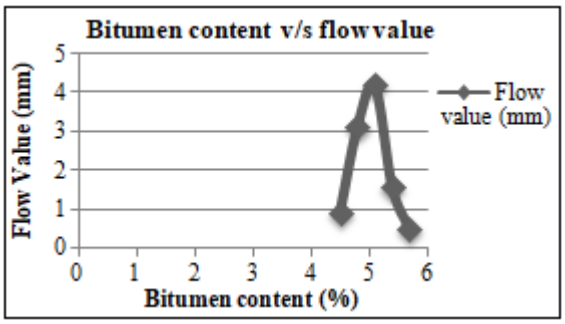

Chart 3: Flow value (%) v/s Binder Content (%)

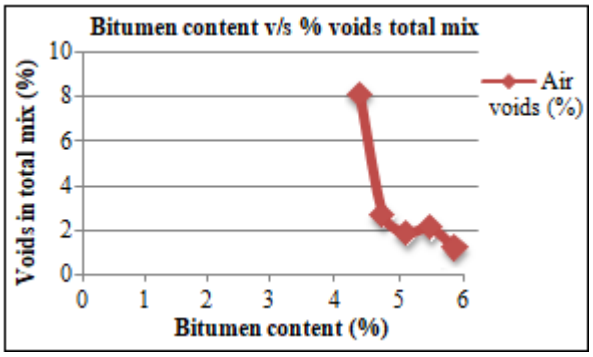

Chart 4: Air voids (%) v/s Binder Content (%)

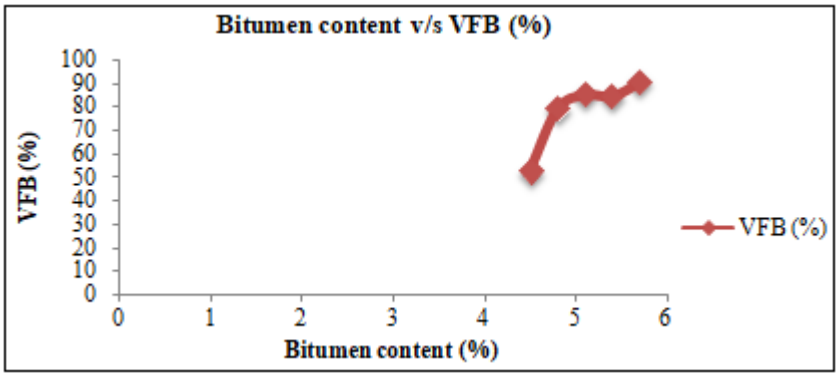

Chart 5: VFB (%) v/s Bitumen Content (%)

Table 2: Comparison of plain bitumen and crumb rubber modified bitumen

Marshall Properties	*Plain Bitumen*	*Crumb Rubber 15%*		*Crumb Rubber 18%*	
		3.35-2.36mm	*2.36-1.18mm*	*3.35-2.36mm*	*2.36-1.18mm*
Stability (kg)	3009.73	3673.74	3042.85	2802.86	3143.2
Unit weight (g/cm3)	2.5	2.48	2.49	2.44	2.46
Flow value (mm)	4.22	2.38	3.55	2.25	2.65
Air voids (%)	1.87	3.24	3.54	1.22	1.23
VMA (%)	12.41	14.22	14.64	12.98	13.70
VFB (%)	85.79	77.96	73.86	89.68	91.18
% of Crumb rubber	-	15 %	15%	18%	18%

4. Conclusions

Based on the laboratory studies for DBM grade 2 mixes with the crumb rubber following conclusions may be drawn,

1) The Optimum Bitumen content obtained is 5.2% and its Marshall Stability value is 3300kg which satisfies the specified value (900kg minimum).
2) By considering Marshall Parameters, we can conclude that we can obtain a more stable and durable mix for the pavements by crumb rubber modifications.
3) The crumb rubber modified bitumen shown improved properties for pavement constructions.
4) By the addition of crumb rubber we can also reduce the amount of rubber waste which otherwise are considered to be a threat to the hygiene of the environment.
5) From this study we can conclude that by the addition of 15% crumb rubber of size 3.35 mm sieve passing and 2.36 mm sieve retaining gives better Marshall properties compared to plain bitumen.

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