INFLUENCE OF CRMB IN SMA BY USING COIR FIBRE – AN EXPERIMENTAL ANALYSIS

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ABSTRACT- *The used rubber obtained from the tyres (Crumb Rubber) of vehicles are playing a vital role in the construction of pavement in recent years. Crumb rubber modification has been proven to enhance the properties of bitumen. Stone Mastic Asphalt (SMA) is a dense wearing course material used as a road surface mix to overcome the issue of rutting due to the action of studded tyres on road surfaces. The mineral aggregate skeleton of SMA is gap-graded and the voids are filled with mastic of fine aggregate, filler, binder and fibre. In this project, coir fibre is adopted in SMA.This project looks at some of the international standards for replacing Crumb Rubber Modified Bitumen (CRMB) in Stone Mastic Asphalt (SMA) pavement and finds the difference in performance of pavement construction. Here, the idea of Crumb Rubber Modified Bitumen in Stone Mastic Asphalt is a new concept in pavement history an attempt has been made to use Crumb Rubber Modified Bitumen for hot climatic conditions. Marshall Method of bituminous mix design was carried out for different percentages of Crumb Rubber and coir fibre in Grade-55 bitumen to determine the different characteristics of mix design. According to the results we obtained, the application of Crumb Rubber Modified Bitumen (CRMB) with Stone Mastic Asphalt (SMA) shows better stability and thus it leads to great performance over other conventional bitumen.*

***Keywords**: CRMB, SMA, Coir Fiber, Marshall Stability*

1. INTRODUCTION

Waste tyres are one of the largest most problematic sources of waste around the world, especially in our country. The availability of scrap tyres at the international level is exceeding rapidly. Annually 300 million tons of scrap tyres are produced worldwide. Proper utilization of scrap tyres in the flexible pavements can promise reduction in the stock of scrap tyres nationally. Tyres are not desired at landfills, due to their large volumes and 75% void space will consume more space.

Crumb Rubber Modified Bitumen (CRMB) is manufactured using finely powdered scrap tyre rubber and processed in a sophisticated reactor at high temperature. The application of CRMB in Stone Mastic Asphalt (SMA) will improve the performance of the pavements strength, elasticity and other beneficial properties to make it better able to withstand high traffic loads, extreme weather conditions and the other forms of stress and also provide low maintenance.

Stone Mastic Asphalt (SMA), otherwise known as Stone Matrix Asphalt is a premium quality bituminous wearing course material having excellent durability and performance properties. It is characterized by a stone-on-stone structure. SMA uses a high proportion of larger stones or aggregate that contacts each other. This skeleton of larger stones resists heavy loads by transmitting them to the pavement below. If the under laying pavement is sufficiently strong then the SMA will resist the heavier loads effectively. The mastic is intended to hold the aggregate in place and to inhibit the ingress of moisture into the pavement and to provide durability. The mastic consists of bitumen and fine aggregate particles; it also includes modified bitumen and filler material to increase the mastic strength. Fibres are also added to stabilize the bitumen and to prevent the binder segregating from the aggregate during transport and placement. It is important that the aggregate material consist of only the larger stones (in the structure) and fines to provide effective mastic.

2. NEED FOR STUDY

- Crumb Rubber Modified Bitumen (CRMB) will lead to Minimization of Environmental Pollution caused by burning of tyre and disposing in landfills and thereby protecting it.
- Stone Mastic Asphalt has proved superior on heavily trafficked roads and industrial applications with high lorry frequency and intense wheel tracking.
- Stone Mastic Asphalt reduces noise emissions. The macro texture of this road surface absorbs traffic noise. Because of this property, the surface is very suitable for access roads in residential areas.

- SMA grades laid in thin layers are used extensively for preventive maintenance and road repair purposes. The stone skeleton matrix can accommodate unevenness of the underlying pavement to improve driving comfort.
- The idea of Crumb Rubber Modified Bitumen in Stone Mastic Asphalt is a new concept in pavement history and thus it leads to great performance over other conventional pavements.

3. LITERATURE REVIEW

Ashish Talati and Vaishakha Talati(2014) suggested that SMA is a potential method that can also be used in India especially for high and increasing traffic in India and they have also said that countries like the United Kingdom has already resurfaced its heavy traffic roads with SMA-Type surface.

Gite B.E. and Momin Soyal (2013) investigate the benefits of stabilizing SMA mixture in flexible pavement with shredded waste plastic and use of bagasse in SMA.

Mishra C. B. and etc [at all] (2014) has accessed the properties of CRMB-55 with and without addition in small doses of Nano-Technology additive to fulfill the basic requirements.

Md.Saeed and Md.Rehan (2014) concluded in their thesis that the standard requirement of getting satisfied by replacing the Recycled Coarse Aggregates (RCA) in SMA with high caution on size and percentage of aggregate.

Md.Rosli and Haryati Yaacob (2013) concluded that the fatigue life of asphalt mixture was lower at 40°C than at 25°C. They also observed that mixtures with smallest nominal maximum aggregate size had a higher fatigue life.

Qiu Y.F. and Lum K.M. (2016) concluded that SMA mixtures having stone-to-stone contact exhibited excellent rutting characteristics. They also indicated that positive correlation existed between the rutting from wheel tracking tests.

Suhana Koting and etc. [at all] (2013) concluded that CRMB improves the property of bitumen by increasing the storage and loss modulus and enhancing the high and low temperature susceptibility.

4. METHODOLOGY

The initial stage in solving a crisis is, identifying that there is one, and likewise the first step in resolving the pavement distress is to identify the problem and its causes. In this case, a methodology to work out the process is framed and given in the figure below as Figure 1.

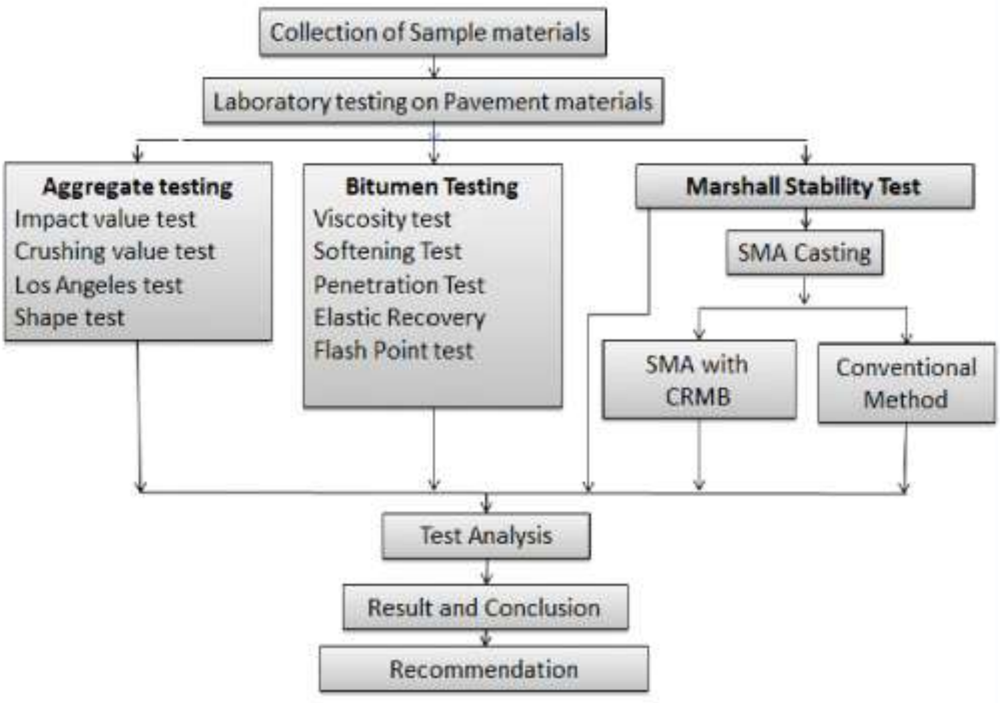


Figure 1: Methodology Chart of the proposed work

5. PAVEMENT MATERIALS

5.1. Crumb Rubber Modified Bitumen (CRMB)

Crumb Rubber Modified Bitumen (CRMB) is a binder obtained through physical and chemical reaction of Crumb Rubber (produced by recycling of used tyres) with bitumen and specific additives. CRMB is generally composed of 25% of Natural Rubber, 75% of Waste Tyre Crumb. The use of alternative materials for bitumen such as Crumb Rubber Modified Bitumen (CRMB), it will definitely be environmentally beneficial, and not only it can improve the bitumen binder properties and durability, but it also has a potential to be cost effective. Various studies are being carried out to improve the performance of the bitumen used for road construction. One of the results such studies introduces Crumb Rubber Modified Bitumen (CRMB).The Crumb Rubber Modified Bitumen shows better properties for pavement construction like friction, skid resistance, durability, maintenance cost, noise generation, load carrying capacity, etc., It is durable and economical solution for new construction and maintenance of wearing courses.

5.2. Aggregates

The aggregates used for flexible pavements include crushed stone, gravel and sand. These aggregates must satisfy IRC specifications for the constructional purposes. The aggregates must be strong and durable. In order to select the best class of aggregates we need to carry out different tests.

5.3. Coir Fibre

Coir, or coconut fibre, is a natural fibre extracted from outer husk of coconut and used in products such as floor mats, doormats, brushes and mattresses. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Other uses of brown coir (made from ripe coconut) are in upholstery padding, sacking and horticulture. White coir, harvested from unripe coconuts, is used for making finer brushes, string, rope and fishing nets. It has the advantage of not sinking, so can be used in long lengths on deep water. This fibre is so strong that it can be used as ropes which can carry very heavy weights. In our project, we have adopted brown coir of length 5 mm.

6. EXPERIMENTAL TESTING AND ANALYSIS

Pavement material analysis is an important factor for cost efficient, durable and safe transportation system. Through the analysis process only we came to know about the characteristics of the pavement materials in terms of quality.

6.1. Bitumen Test

The method used for testing the bitumen IS: 1203-1209-1978. The following tests are done and the results are obtained. Penetration value of crumbed rubber modified bitumen is 45 mm, softening point crumbed rubber Modified bitumen is 55◦c respectively, Ductility value of crumbed rubber modified bitumen is 59 cm. Bitumen test result shown in table 1.

Table-1: Results obtained on conducting various tests on CRMB

S. No.	Description of Test	Unit	Specification limit as per IS : 15462-2004	Results obtained for CRMB
1	Penetration value	mm	<60 mm	45 mm
2	Softening point	°C	51°C- 59°C	55°C
3	Flash point & Fire point	°C	Min- 220°C	240°C & 430°C
4.	Ductility(25°C)	cm	>55 cm	59 cm

The above Table-1 shows the results of various tests conducted on CRMB and the result shows that the CRMB can be used for laying surface coarse.(As per IS:15462-2004)

6.2. Aggregate Test

The method used for testing the aggregate is IS-2386 (P1 – P4). The following tests are done and the results are obtained. Impact value test – 14.3%, Flakiness and Elongation index test – 21.9% & 29.53%, Los Angeles Abrasion test- 21%, Water Absorption test – 1.1%.Aggregate test results shown in table 2.

Table-2: Results obtained on conducting various tests on the coarse aggregate

Sl. No.	Description Of Test	Specification As Per MORTH Table (500-35)	Test Method	Test Result
1.	Aggregate Impact Value (%)	< 18 %	IS-2386 (P 4)	14.3 %
2.	Los Angeles Abrasion (%)	< 25%	IS-2386 (P 4)	21 %
3.	Flakiness And Elongation Indices	< 40%	IS:2386 (P 1)	21.9 % & 29.53 %
4	Water absorption Test	<2%	IS:2386	1.1%

As shown in Table-2, the result of the various tests on aggregate shows that the aggregates can be used for laying surface coarse. (As per IS: 2386).

6.3. Marshall Mix Design

The samples are tested with different proportions which have various amounts of fibre content of 0.4%, 0.5% and 0.6%.

The mix design that we adapted by using MORTH specification is shown in table-3.

Table-3: Marshall mix design of SMA-CRMB mix

S.NO	SIZE OF AGGREGATE (mm)	WEIGHT OF AGGREGATE IN GRAMS FOR 1200 MIX AT BINDER CONTENT		
		6.5%	7%	7.5%
1.	13.2	60	60	60
2.	9.5	390	390	390
3.	4.75	462	462	462
4.	2.36	48	48	48
5.	1.18	36	36	36
6.	0.6	24	24	24
7.	0.3	42	36	30
8.	0.075	60	60	60
9.	Binder content	78	84	90
	Total	1200	1200	1200

6.4. Marshall Test Results and Analysis

Table-4: Stability values of conventional specimens for respective CRMB contents

Bitumen content	6.5%	7%	7.5%
Stability value	952 kg	1079 kg	937 kg
Flow value	3.72 mm	3.96 mm	4.25 mm

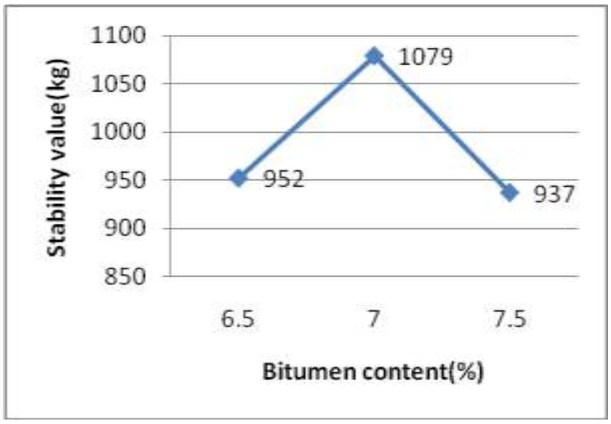


Figure-2: Change in stability value for conventional mix

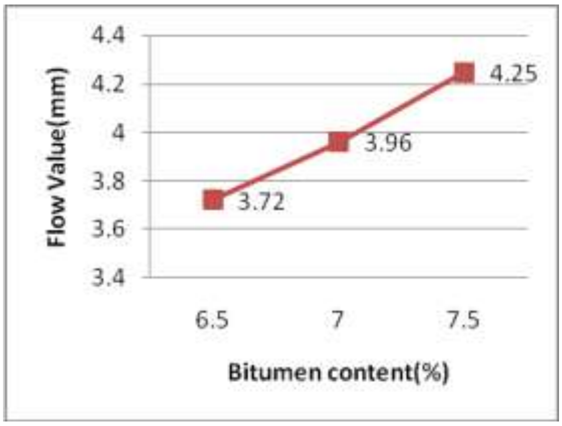


Figure-3: Change in flow value for conventional mix

On examining figures 2 and 3 it is observed that, the stability value of the samples peaks at bitumen content of 7% and decreases in the samples with bitumen content of 7.5%. However, the flow value increases gradually with the increase in bitumen content.

Table-5: Stability values of 0.4% coir fibre specimens for respective CRMB contents

Bitumen content	6.5%	7%	7.5%
Stability value	1121 kg	1208 kg	1096 kg
Flow value	3.69 mm	3.83 mm	4.06 mm

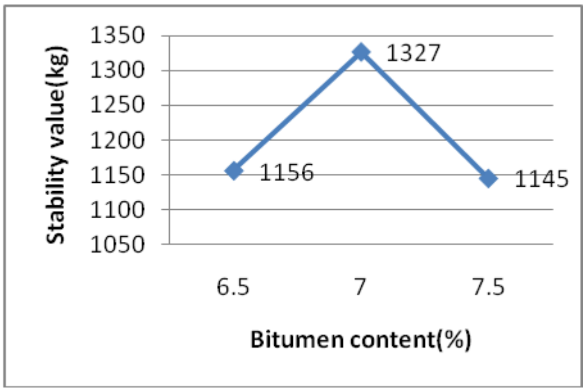


Figure-4: Change in stability value for 0.4%coir

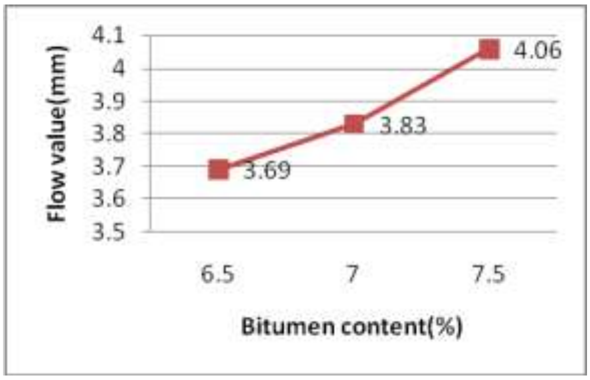
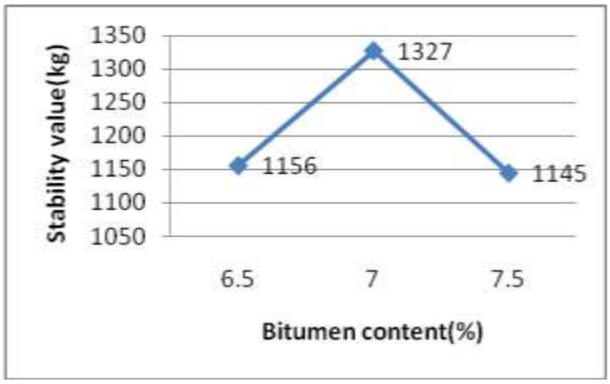


Figure-5: Change in flow value for 0.5%coir

On examining figures 4 and 5 it is noticed that, the samples exhibits the same behavior as the conventional mix since the stability value of the samples peaks at bitumen content of 7% and decreases in the samples with bitumen content of 7.5%. However, the flow value increases gradually with the increase in bitumen content.

Table-6: Stability values of 0.5% coir fibre specimens for respective CRMB contents

Bitumen content	6.5%	7%	7.5%
Stability value	1156 kg	1327 kg	1145 kg
Flow value	3.66 mm	3.89 mm	4.38 mm



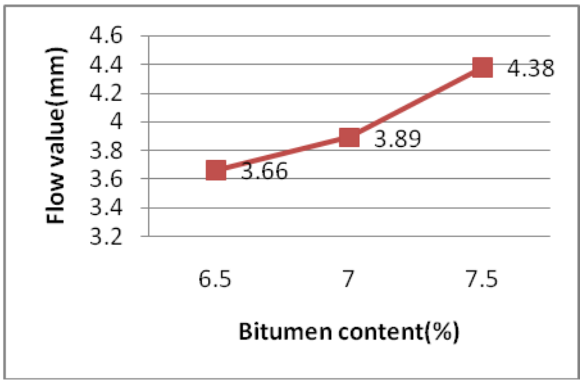
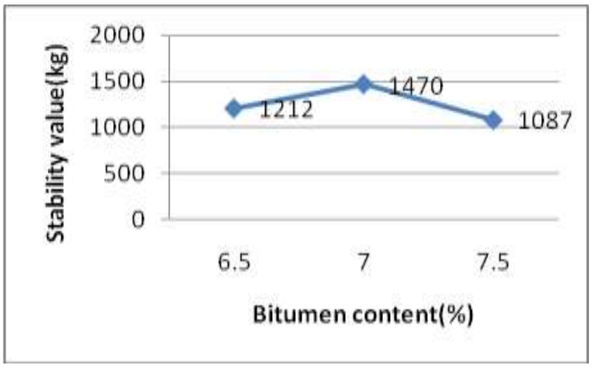


Figure-6: Change in stability value for 0.5% coir **Figure-7:** Change in flow value for 0.5% coir

On examining figures 6 and 7 it is noticed that, the samples exhibits the same behavior as the conventional mix since the stability value of the samples peaks at bitumen content of 7% and decrease in the samples with bitumen content of 7.5%. However, the flow value increases gradually with the increase in bitumen content.

Table-7: Stability values of 0.6% coir fibre specimens for respective CRMB contents

Bitumen content	6.5%	7%	7.5%
Stability value	1212 kg	1470 kg	1087 kg
Flow value	3.76 mm	3.98 mm	3.86 mm



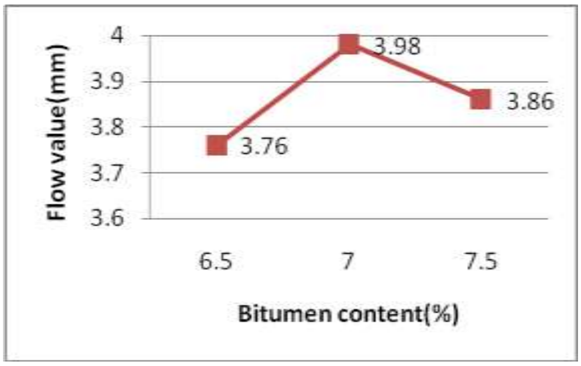


Figure-8: Change in stability value for 0.6%coir **Figure-9:** Change in flow value for 0.6 %coir

On examining figures 8 and 9 it is observed that, the stability value of the samples peaks at bitumen content of 7% and decreases in the samples with bitumen content of 7.5%. Also, it is seen that the flow value drops at the bitumen content of 7.5%.

From the above results, we can infer that, comparatively among the three proportions, SMA – CRMB with 0.6% fibre gives the best result. Much greater stability of 1470 kg is obtained when only 0.6% of fibre is being used. Conclusively, it is found that 7% is optimum for this proportion. Also, the samples start losing their stability from the bitumen content of 7.5%.

7. CONCLUSIONS

By analyzing the test results from the laboratory, Crumb Rubber Modified Bitumen (CRMB) introduced with Stone Mastic Asphalt (SMA) it is concluded that this method was comparatively more stable than the conventional method.

Stability is improved by adding Crumb Rubber Modified Bitumen (CRMB) binders to Stone Mastic Asphalt (SMA) as better adhesion is developed. In comparison to the conventional mix over SMA introduced with CRMB, the values of Marshall Stability were generally higher.

When compared, the most appropriate amount of the added CRMB was found to be 7% by weight of bitumen with 0.6% of Coir Fibre in SMA results are in the maximum level of stability and flow.

Also, the Flow value of 3.98 mm is obtained with the CRMB content of 7% and coir fibre of 0.6% which is acceptable for a CRMB-SMA mix.

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