Proc. of Int. Conf. on Current Trends in Eng., Science and Technology, ICCTEST

Study of Crumb Rubber for the Partial Replacement for Bitumen or as an Alternative Material for Bitumen

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***Abstract*—Crumb rubber is recycled rubber from automotive and truck scraps tires. During the recycling process steel and fluff is removed leaving tire rubber with a granular consistency. The Tyres which are obtained from Vehicles and other rubber materials which are available in the places. Now days there are lot of automobiles throughout the world as well as in India also. The waste produced by these is so much it is very difficult to dispose of; hence this is an alternate method in which we can solve the problem. Here the main object of this paper is to bring light on the fact that the waste can be used very effectively for the purpose of road material instead of bitumen as an alternative and also can be used as mixture with certain percentage along with bitumen. In any country transportation by road is a important mode of transport system for the development of country, hence the length of roads are becoming more and more day by day hence it is very much essential to make an alternative for bitumen and also to reduce the amount of usage of bitumen is very much essential, in this direction the study is important. They study involves the characteristics of the crumb rubber when used along with bitumen. The different tests are conducted.**

***Index Terms*— component, formatting, style, styling, insert (key words).**

I. INTRODUCTION

India has a road network of over 4,236,000 kilometres in 2011, the third largest road network in the world. At 0.66 km of roads per square kilometre of land, the quantitative density of India's road network is similar to that of the United States (0.65) and far higher than that of China (0.16) or Brazil (0.20). However, qualitatively India's roads are a mix of modern highways and narrow, unpaved roads, and are undergoing drastic improvement. As of 2008, 49 % – about 2.1 million kilometres – of Indian roads were paved. To improve the properties of bituminous roads certain modifiers are being used. It improves its load capacity. One such additive being used is the Crumb Rubber. Crumb Rubber - Crumb rubber is recycled rubber from automotive and truck scrap tyres. During the recycling process steel and fluff is removed leaving tyre rubber with a granular consistency.

Grenze ID: 02.ICCTEST.2017.1.87

Continued processing with a granulator and/or cracker mill, possibly with the aid of cryogenic or mechanical means, reduces the size of the particles. As of 2012, 24 lakh tons of waste tires are produced in India. 12 lakh tons are used as landfill, remaining 11 lakh tons of tires are recycled for various purposes and among these 1 lakh tons of tires are converted into Crumb Rubber.

II. OBJECTIVES OF THE STUDY

The properties of bituminous mixes get improved and life of pavement gets enhanced, particularly, where high traffic loads are expected. In order to enhance the strength of the bitumen mix Crumbed rubber is used and also to obtain high flow value and high stability of the mix. The different tests will be conducted for testing of different materials used in the construction of road is carried out as per standards and also the used values are as per standards (I.R.C).our main consideration is the usage of crumb rubber.

1) Tests on Aggregates (As per Standard values)
2) Tests on Bitumenous Material

A. Marshall Stability

This is the important test to be conducted for the study of crumb rubber.

TABLE I. PENETRATION VALUE OF BITUMEN

Readings		**Samples**		
Initial Reading	0	0	0	0
Final Reading	70	68	65	66
Penetration Value (mm)	70	68	65	66
Mean value (mm)		67		

B. Recommended Value

Penetration test is a commonly adopted test on bitumen to grade the material in terms of its hardness. 80/100 grade bitumen indicates that its penetration value lies between 80 & 100.Grading of bitumen helps to assess its suitability in different climatic conditions and types of construction. For bituminous macadam and penetration macadam, IRC suggests bitumen grades 30/40, 60/70, 80/100. In warmer regions, lower penetration grades are preferred to avoid softening whereas higher penetration grades like 180/200 are used in colder regions to prevent the occurrence of excessive brittleness. High penetration grade is used in spray application works.

To improve the properties of bituminous roads certain modifiers are being used. It improves its load capacity. One such additive being used is the Crumb Rubber. Crumb Rubber - Crumb rubber is recycled rubber from automotive and truck scrap tyres. During the recycling process steel and fluff is removed leaving tyre rubber with a granular consistency. Continued processing with a granulator and/or cracker mill, possibly with the aid of cryogenic or mechanical means, reduces the size of the particles. As of 2012, 24 lakh tons of waste tires are produced in India. 12 lakh tons are used as landfill, remaining 11 lakh tons of tires are recycled for various purposes and among these 1 lakh tons of tires are converted into Crumb Rubber. The specific gravity of Bitumen is found to be = 1.0343

TABLE II. ADVANTAGES AND DISADVANTAGES OF CRUMB RUBBER SERIAL NUMBER

Sl.No	Advantages	Disadvantages
1.	Adaptability to stage construction.	Higher maintenance costs.
2.	Availability of low-cost types that can be easily built.	Shorter life span when compared to Rigid Pavements.
3.	Ability to be easily opened and patched.	Damage by oils and certain chemicals.
4.	Easy to repair frost heave and settlement.	Weak edges that may require curbs.
5.	Resistance to formation of ice glaze	-
6.	Utilization of waste material	-

Table 4.2 – Ductility test results
The penetration values of various types of bitumen used in pavements construction in our country range between 20 and 225, 30/40 and 80/100 grade bitumen are more commonly used depending on construction type and climatic conditions. In hot climate a lower penetration bitumen like 30/40 bitumen is s

Table 4.3 – Softening Point test Values
The average of the two readings to the nearest 0.5°C is reported as softening point.

Test Values Observed:
Table 4.6 Tabulation of Flash point and Fire point

Summary of tests results conducted on Bitumen –Table 4.7 – Results obtained for 60/70 gradeof Bitumen

C. Preparation of test specimen

The test specimen was prepared using the standard Marshall mould and compacting equipment. The apparatus consists of a cylindrical mould, 10.16cm diameter and 6.35cm height, with a base plate an 4.54kg weight with 45.7cm height of fall. A sample extractor is used to extrude the compacted specimen from the mould.
The step by step procedure for preparation of test specimen is given below:
Step1: 1200gm of aggregate is taken and heated to a temperature of 170 ° C to 180 ° C.
Step 2:. Place the compaction mould, collar and rammer in oven for heating to a temperature of 100°C to 140°C.
Step 3: Required quantity of bitumen is taken and heats it to a temperature of 120°C to 140°C. In case of modified bitumen, modifier is directly added to bitumen when it is attains required temperature and mix it thoroughly to get homogenous mix.
Step 4: Add the bitumen to aggregates, after it attains required temperature and mix it thoroughly till all aggregates coated completely and uniformly.
Step 5: The Crumb rubber measured to the weight of bitumen is added and mixed continuously (Crumb Rubber varies from 2% - 20%)
Step 6: Continue heating of the mix till it attains a temperature of 160°C to 180°C.
Step 7: Place the mould of 10.16cm diameter and 6.35cm height on base plate and transfer the bituminous mix in to the mould and 75 blows are applied on either side of the specimen.
Step 8: After 24 hours, specimen is extruded from the mould and the diameter and mean height of the specimens are measured and then they are weighed in air and also suspended in water. d collar. A compaction pedestal and hammer are used to compact a specimen by

Time, minutes	Temperature, 0^C	Time, minutes	Temperature, 0^C
0	17.5	0	17.4
1	18.0	1	18.0
2	20.7	2	21.0
3	25.0	3	25.2
4	29.0	4	29.3
5	32.7	5	32.6
6	36.3	6	37.0
7	39.8	7	40.0
8	43.7	8	44.5
9	47.9	9	49.0

Sl. No.	Tests	Grade 60/70
1	Penetration Test	67mm
2	Ductility Test	100 cm
3	Softening Point Test	48.45°C
4	Specific Gravity Test	1.0343
5	Flash Point Test	314°C
6	Fire Point Test	324°C

Tests done on Bitumen by using Crumb Rubber –
Table 6.2 Crumb Rubber Modified Bitumen Properties

Characteristics	60/70 grade of Bitumen	Crumb Rubber Modified Bitumen
Penetration test	67	60
Softening Point	48.50C	550C
Flash Point	3140C	2800C






D. Marshall Stability

1. The specimens are kept immersed in water in a thermostatically controlled water bath at 60°C for 30 to 40 minutes.
2. The specimen is taken out and placed in the Marshall Test head to determine Marshall Stability value which is the maximum load in kg before failure and the Flow value which is the deformation of the specimen in 0.25mm up to maximum load.

Marshall Stability Test Specimens in water bath at 60^0C

Graphs obtained for Hot Mix Asphalt mixed with Crumb Rubber – Figure 6.6 Marshall Stability(kg) vs Crumb Rubber (%)

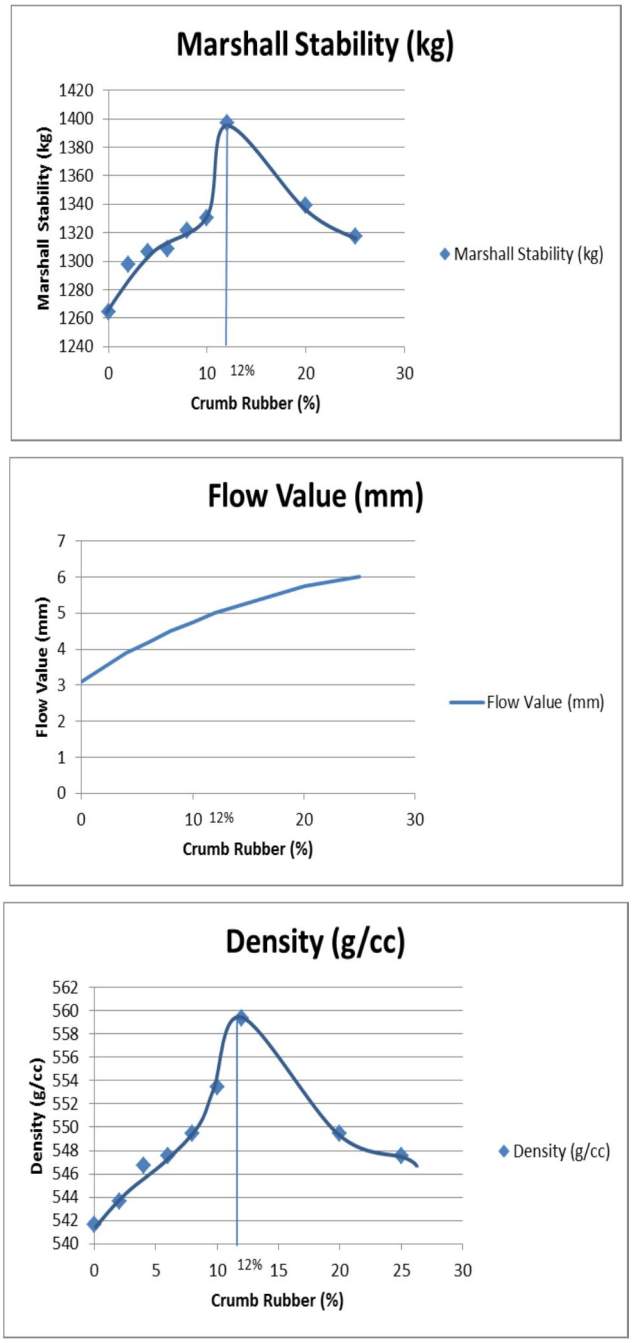

Table 6.1 – Properties of Crumb Rubber

Properties	Crumb Rubber
Specific Gravity, g/cm3	1.041
Moisture content, wt%	0.5
Ash content wt%	3.6
Carbon black content, wt%	32.7
Sulphur content, wt%	1.5

III. SUMMARY

Hot Mix Asphalt was mixed with Crumb Rubber. Optimum percentage of Crumb Rubber that can be used to the weight of Bitumen is 12%. Marshall Stability for 12% was calculated as 1397kg. Marshall Stability Value is 8% higher for Crumb Rubber with Hot mix Asphalt when compared with Conventional Bitumen.

A. Warm Mix Asphalt

General Warm Mix Asphalt is produced by adding zeolites, waxes, asphalt emulsions, or sometimes even water to the asphalt binder prior to mixing. This allows significantly lower mixing and laying temperatures and results in lower consumption of fossil fuels, thus releasing less carbon dioxide, aerosols and vapours. The procedure is same as that of Hot Mix Asphalt. Here the Aggregates are heated up to 1200C and then the additive and bitumen are added and mixed at 1200C. Many additives are used for Warm Mix Asphalt, one of them being Sasobit.

Sasobit – It is a product of Sasol Wax. It is a fine crystalline, long-chain aliphatic polymethylene hydrocarbon produced from coal gasification using the Fischer-Tropsch (FT) process. It is also known as FT hard wax. Sasobit is described as an “asphalt flow improver”, both during the asphalt mixing process and during laydown operations, due to its ability to lower the viscosity of the asphalt binder. Properties of Sasobit are – 1. Flow improvement

2. Low temperature sensitivity
3. Low temperature properties
4. It is added to bitumen or Asphalt mixes at the range 1% - 3% weight of bitumen.

The chemical composition described as fine crystalline materials in long-chain hydrocarbons, produced by means of Fischer-tropsch (F-T) synthesis. It is long chain composed from 40 to 115 carbon atoms. As mentioned from producer the melting point of sasobit additive is 100 °C and it's completely dissolves in bitumen at temperature.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

Sl.No.	Temp. of Bitumen	% of Sasobit	Softening point	Penetration value
1	120°C	1.50%	49.3°C	74
				65
			50.2°C	70
Average				69.67
2	120°C	2.00%	53.2°C	68
				65
			54.1°C	67
Average			53.65°C	66.67
3	120°C	2.50%	59.6°C	62
				63
			60.3°C	60
Average			59.95°C	61.67

B. Procedure for Warm Mix Asphalt

- The aggregates are weighed accordingly and then heated up to 1300C-1400C
- Then Optimum Bitumen is weighed and added with aggregates and heated up to 1400C
- The Crumb rubber measured to the weight of bitumen is added and mixed continuously (Crumb Rubber varies from 5% - 20%)
- It is allowed to cool and brought at temperature 1100C - 1200C
- The mix is placed in the mould and 75 blows are given on one side and repeated on the other side again.
- The sample is kept in the mould for 24hours and then removed from the mould and tested.
- The procedure is repeated for different percentages of Crumb Rubber and tested.

IV. Results and Discussions

The use of Crumb Rubber in Flexible Pavements has a lot of advantages when compared to the disadvantages. The use of Sasobit in Warm Mix
Asphalt as an additive too has its advantages. General DiscussionsThe use of Warm mix asphalt (WMA) over Hot mix asphalt (HMA) has clearly shown that the cost can be significantly bought down.By using Crumb rubber modified bituminous pavements over conventional bitumen pavements has shown that the load carried by CRMB pavements is 9% higher than that of theconventional bituminous pavements and by adding crumb rubber to the bituminous pavements the waste tires which are used as landfill can be significantly bought down. By adding crumb rubber to thebituminous pavements the voids present in the aggregates are better filled and thus yield better results. By adding crumb rubber the life cycle of flexible pavements can be increased to 2 to 2.5 yearswith constant maintenance. The maintenance includes periodical checking of roads for potholes and filling them if there is any and checking whether there are any hair line cracks due to temperaturevariation. This can be fixed by adding seal coat of 5mm which also contains crumb rubber and thus adding to its life.Comparisons between bituminous pavements and concrete pavements are done and the Life cycle analysis of CO2 emitted for both have been compared.Concrete pavements produce 27% more CO2 than bituminous pavements. Similarly other comparisons are also done like bituminous pavements and fly ash concrete pavements. Though Fly Ash is said toreduce 20% of CO2 emissions when compared with bituminous pavements they show that concrete pavements produce 9% more CO2 than bituminous pavements. Likewise CRMB (Crumb RubberModified Bituminous pavements) of Hot Mix Role of Crumb Rubber in Flexible Pavements for a Sustainable Future
Asphalt (HMA) emit 28% less CO2 than concrete pavements. Similarly CRMB (HMA) and fly ash concrete pavements are compared and this shows 6% of CO2 is less produced by CRMB (HMA) compared to fly ash pavements.
WMA i.e. Warm Mix Asphalt was also prepared by reducing the temperature by 400c to 500c compared to Hot Mix Asphalt. Concrete pavements produced 25% more CO2 than CRMB of Warm Mix Asphalt. Also Fly Ash concrete pavements produced 6% more CO2 compared to CRMB of Warm Mix Asphalt.
Another benefit of Warm Mix Asphalt is it reduces emission b 25 to 30%. The fumes from hot mix asphalt are known to be potential health hazards, especially for the construction workers. Reduced temperature of the mix avoids this health hazard.
Technical Advantages of Warm Mix Asphalt -

- Lower Mixing Temperature reduces the oxidation and ageing of Bitumen and thereby giving longer lasting pavement by delaying fatigue cracking.
- Reduced rate of cooling of the mix permits longer haul distance from the plant to work sites and better cold weather construction opportunities.

Cost savings is achieved through reduced fuel consumption, longer life of pavement and use of recycled material. Even though the cost of Crumb Rubber Modified roads increases, the property of crumb rubber improves its durability, stability and increases its life.

V. Conclusions

- Use of Crumb Rubber in Bituminous Pavements will increase Marshall Stability by 8% for Hot Mix Asphalt and 9% for Warm Mix Asphalt
- The Optimum percentage of Crumb Rubber is found to be 12% to the weight of the Bitumen.
- The Maximum load obtained for Hot Mix Asphalt mixed with Crumb Rubber is 1397kg.

- The Maximum load obtained for Warm Mix Asphalt mixed with Crumb Rubber is 1418kg.
- It is seen that Warm Mix Asphalt produces 6.4% less CO2 emissions when compared to Fly Ash Concrete Pavements.
- Increase in the cost of construction of Crumb Rubber Modified Bituminous Roads was seen by 6% than the cost of normal Bituminous Roads.
- Crumb Rubber Modified Roads of Warm Mix Asphalt can be preferred over Concrete roads and as well as Fly Ash Concrete Pavements.

ACKNOWLEDGMENT

The work described in this paper is supported by President and Secretary and Principal Jyothy institute of technology, Bangalore, India. Authors would like to thank Dr. Sandeep Shastri, Pro-Vicechancellor, Jain University, Bangalore for providing a strong platform for research work.

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