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Comparison on Marshall Stability Properties of Plain and Crumb Rubber Modified Bitumen

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Abstract- The abundance and increase of waste tire 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. It can be used as a cheap and environmentally friendly modification process to minimize the damage of pavement due to increase in traffic density, axle loading and low maintenance services which has deteriorated and subjected road structures to failure more rapidly. The use of crumb rubber leads to excellent pavement life and low maintenance. The present study aims in investigating effect of crumb rubber bitumen as a modifier in various proportions. Common laboratory test will be performed on the modified bitumen in various proportion of Bitumen and thus analyzed. Marshall Method is adopted for testing. Finally, a comparative study is made among the plain Bitumen and modified Bitumen by varying the proportions of crumb rubber.

Index Terms- Crumb rubber (CRMB 55), Marshall stability test, Modified Bitumen, Plain Bitumen.

I. INTRODUCTION

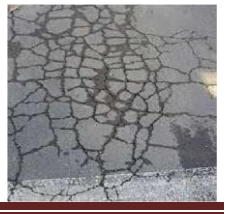
Roads act as a communication link in serving millions of people in every part of the world. The roads serve traffic safely, comfortably and efficiently at an affordable cost. India being a developing country, the flexible pavement forms the major part of the roads in comparison with the use of other 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 subgrade, 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.

In this scenario, it became regular practice to use modifier as additives to strengthen the bitumen for making long lasting bituminous mixes and also reducing the waste tyres across the world. Crumb rubber is a recycled rubber produces from automotive scrap tires which are primarily natural rubbers, synthetic rubbers and carbon black rubbers. During the recycling process, steel and tire lacing are removed, leaving tire rubber with a granular consistency or crack mill process. The scrap tire is shredded into small pieces by the help of crack mill of mechanical blades up to sizes of 1mm to 0.075mm. Scrap tire rubber can be added into bitumen paving mixes using two different methods which are referred as the wet process and the dry process. Addition of crumb rubber to bitumen increases the modified bitumen viscosity, softening point and lower susceptibility to temperature variations, higher resistance to buckling at elevated pavement temperature. This modified bitumen has shown higher durability, better adhesion between aggregate & binder, prevention of cracking, reflective cracking, and overall improved performance in extreme climatic conditions under heavy traffic condition

II. COMMON PROBLEMS IN SURFACING

In bituminous pavements common problems are high susceptibility to temperature variation, tendency to crack, lesser effective service life etc. The problem in the city section is due to heavy intensity of traffic, overloaded trucks and lack of efficient maintenance system. Rutting caused by permanent deformation within the asphalted layer. Bleeding at high temperature and lack of adhesion in the presence of ground water are also common. The most common binder used for road surfacing is bitumen obtained from petroleum sources; bituminous road construction in future will face a setback due to the scarcity of materials. The various





performance reports indicate that useful life of bituminous overlays has declined from average value of 2-4 years in recent years.

III. OBJECTIVES OF THE STUDY

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

1) To study the change in property of bitumen mixes prepared by using crumb rubber modified bitumen and Plain bitumen.
2) To determine the optimum binder content i.e., Optimum binder value shows at which percentage of bitumen gives maximum stability and minimum flow value.
3) To encourage the use of waste material i.e. waste tires mixed with bitumen, which has potential use in Highway and Construction Industry.

IV. MATERIALS AND METHODOLOGY

Materials:

To develop a modified alternative binder, material selection is the most vital part. Materials were selected as per the availability, cost efficiency. Samples were prepared from the mixture of Bitumen, Coarse Aggregates, and Fillers.

Bitumen: Bitumen is a mixture of organic liquids that is black, highly viscous, sticky product used for paving roads, waterproofing products (used in sealing roofs). It contains around 95% carbon and hydrogen (± 87% carbon and ± 8% hydrogen), and up to 5% sulphur, 1% nitrogen, 1% oxygen and 2000ppm metals. Bitumen are composed mainly of highly condensed polycyclic aromatic hydrocarbons. Here we supplied Plain bitumen from Mugarody RMC and CRMB from HINCOL Mangalore.

a) Plain Bitumen: Plain Bitumen is a common binder used in road construction. It is principally obtained as a residual product in petroleum refineries after higher fractions like gas, petrol, kerosene and diesel, etc. are removed. Here we used Plain bitumen of grade VG40

b) Crumb Rubber Modified Bitumen (CRMB): Crumb Rubber Modified Bitumen (CRMB) is made by the amalgamation of crumb rubber modifier and the chosen bitumen grade. The modifier works as an agent that strengthens the binder from the occurrence of any deformation when trying to maintain during low temperature, fatigue or thermal issues. CRMB is beneficial as it increases the life of a road by 1.5 to 2 times as to using a normal bitumen modifier. Here we used Crumb rubber of grade CRMB55

c) **Basic Tests on Bitumen:** There are many tests which are conducted to check the quality of bitumen. Here we conducted Specific gravity, Softening point, ductility and penetration value test on plain and CRMB. The test results ensure the quality of bitumen is good and is suitable for use in work.

RUTTING POTHOLES CRACKS

Properties	MORTH Specification	Test Result	
		Plain	CRMB 55
Specific Gravity	Min 0.99	1.01	1.03
Softening Point (°C)	49 °C - 55°C	46.5 °C	55°C
Ductility (cm)	75- 100cm	78cm	86cm
Penetration (mm)	60-70	68mm	58mm

Table 1. Basic tests on bitumen

d) **Aggregates:** Aggregates form the major portion of pavement structure and they form the prime materials used in pavement construction. Aggregates have to bear stress occurring to the wheel loads on the pavement and on the surface course they also have to resist wear due to abrasive action of traffic. Therefore, the properties of the aggregates are of considerable significance to the highway engineers. In our present study we use aggregates of size less than 20 mm. The required aggregates sizes are chosen according to fulfil the gradation. We supplied Aggregates from Local RCC Plant.

Basic Test on Aggregates:

Properties	MORTH Specification	Test Result
Impact Value	Max 30%	24%
Abrasion Value	Max 40%	35.2%
Flakiness	Max 25%	13.79%
Elongation	Max 25%	12.24%
Crushing Value	Max 40%	23.9%
Specific Gravity of CA	2.5-3.0	2.52

Table 2. Basic test on Aggregate

Methodology:

Aggregate Gradation as per MORTH:

Sieve sizes in mm	% Passing specified by MORTH
19	100
13.2	79-100
9.5	70-88
4.75	53-71
2.36	42-58
1.18	34-48
0.6	26-38
0.3	18-28
0.15	12-20
0.075	4-20

Table 3. Aggregate Gradation

Batch weight of Aggregates:

Fraction	19mm-14mm	14mm-10mm	10mm-4.75mm	Dust	Lime	Total
19-9.5	144	41.4	-	-	-	185.4
9.5-4.75	-	174.6	36.4	-	-	210.9
4.75-2.36	-	-	131.3	3.4	-	134.7
2.36 down	-	-	36.4	608.6	24	645
Total	144	216	204	612	24	**1200**

Table 4. Batch Weights of Aggregates

Batch weight of Bitumen content:

Bitumen content %	Bitumen Content (gm)	Total Weights (gm)
4	49.9	1249.9
4.5	56.5	1256.5
5	63.2	1263.2
5.5	69.8	1269.8
6	76.6	1276.6
6.5	83.4	1283.4

Table 5. Batch Weights of Bitumen content

Preparation of Specimen and Marshall Testing:

Marshall Test specimens of diameter 63.5mm and 101.6cm height were prepared by adding 4 %, 4.5 %, 5 %, 5.5 %, 6 %, and 6.5 % of Bitumen. Approximately 1200gm of aggregates and filler is heated to a temperature of 175-190℃. Bitumen is heated to a temperature of 121-125℃. With the first trial percentage of bitumen (4% by weight of the mineral aggregates). The heated aggregates and bitumen are thoroughly mixed at a temperature of 154-160℃. The mix is placed in a preheated mould and compacted by a rammer with 75 blows on either side at temperature of 138 to 149℃. The compacted specimens were removed from moulds after 24 hours. The specimens were conditioned by keeping them in thermostatically controlled water bath maintained at 60º C for 30 minutes before testing. The Marshall test consists essentially of crushing a cylinder of bituminous material between two semi- circular test heads and recording the maximum load achieved (i.e. the stability) and the deflection at which the maximum load occurs (i.e. the flow).Vary the bitumen content in the next trial by +0.5% and repeated same procedure. The below figures gives details on specimen casting

Determination of Optimum bitumen content (OBC) :

After preparing specimens of different proportions the specimens. They are tested on Marshall testing machine so, we got Marshall Stability and flow value (deformation). The principle of designing the optimum amount of binder content is to include sufficient amount of binder so that the aggregates are fully coated with bitumen and the voids within the bituminous material are sealed up. To find out the OBC we did trial and error method on mixes. In that which Percentage maximum stability value and less flow value that is suitable for Pavement. Here we got 5.1% for Plain bitumen and 5.5% for CRMB. The graph (1&2) plotted by considering % of bitumen on X-axis and Marshall Stability (Kg) on Y-axis and graph (3&4) plotted by considering % of bitumen on X-axis and Flow value in mm on Y-axis

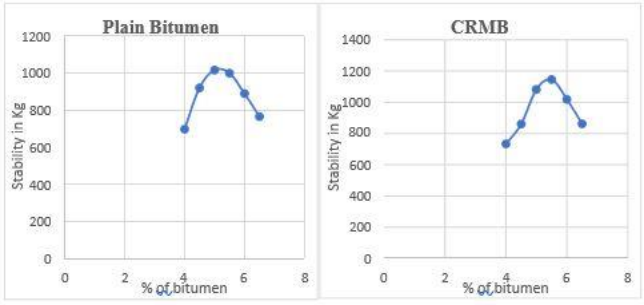


Chart 1: Percentage of bitumen vs Stability

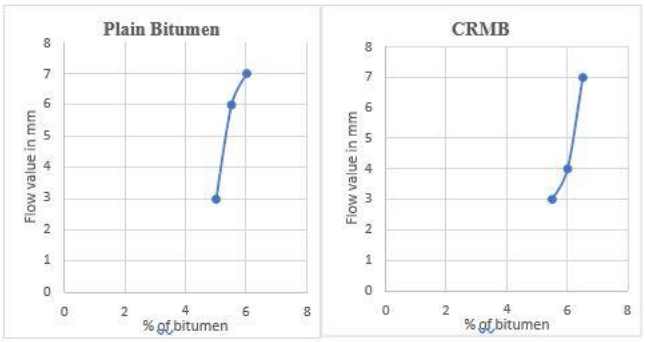


Chart 2: Percentage of bitumen vs flow value

V. RESULTS AND DISCUSSION

After getting Optimum bitumen content (OBC) i.e., for plain bitumen 5.1% and CRMB 5.5%, we prepared 3 moulds of each for Plain and CRMB and conducted tests over that. Afterwards we compared the tests results of plain and CRMB. The results clearly says that there is change in property of mix they are-

- Marshall Stability Value and Flow value decreases
- Increases Elastic nature which increases resistance of road in cold climatic areas and recover the road from cracking
- Increases softening property to increase the longevity of road in hot climatic areas.
- The road life of rubber Bitumen is 2 to 3 times more than the normal bitumen road.
- So, it is very necessary to change Bitumen roads to CRMB for higher resistance, smooth drive, comfort and safety. Choose the best CRMB manufacturer and get the product at an affordable price.

MARSHALL PROPERTIES	PLAIN BITUMEN	CRMB
Stability in Kg	1060.05	1146.6
Flow Value in mm	4	3

Table 6 Marshall Properties

VI.

VII. CONCLUSION

Crumb rubber modifications of bitumen have been proven to improve characteristics of bituminous binder. The optimum dose of the found to be 5.1% and 5.5%. From the Marshall Test results, it is concluded that the Marshall Stability value increases up to OBC, then on increase in bitumen content Marshall Stability value decreases. From an environmental and economic stand point, the use of waste Rubber, as a bitumen-modifying agent may contribute to solving a waste disposal problem and to improving the quality of pavements. The properties of bitumen can be enhanced by adding small amounts of the modifier. Therefore, modified bituminous mix can bring real benefits to highway construction, maintenance, in terms of better and longer lasting roads, and savings in total road life costing.

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