

## Replacement of Bitumen with Crumb Rubber in Flexible Pavement

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### ABSTRACT:

*The main aim of this study was to determine an alternative for bitumen which will satisfy the physical and binding properties of bitumen in terms of strength, endurance, and flexibility. The asphalt market is looking for alternative sustainable binders that can fractionally replace the bitumen in terms of environmental sustainability and which may also augment the availability of binders. In this research study, crumb rubber has been consumed in bituminous mixes and its optimum content percentage is found, the crumb rubber is used in powdered form and that amount has been replaced from the quantity of bitumen. Standard Marshal Mix design and Penetration test and Ductility test were performed. The various percentages of crumb rubber (from 2% to 10% by the weight of bitumen) were used to prepare the samples, with optimum value of bitumen content (5%). It was observed that crumb rubber at 6% (by weight of bitumen) and at 5% Optimum Bitumen Content came out to be optimum percentage of crumb rubber. The test results shows that stability of the modified bitumen mix was increased as compared to the plain bitumen mix. The physical properties of modified bitumen were also improved, with the help of penetration test it was observed that the modified bitumen was harder consistency and was less flexible as per ductility test.*

### 1. INTRODUCTION

The paving of flexible pavement comprises of a sizeable part of bitumen and mixing it with aggregate. Crumb rubber is available in large quantities and is procured from recycled rubber of waste automobiles tires. The generation of waste tire has become a major concern as they not only acquire large area in our landfills but also effects our health and environment associated with their disposal. Therefore their use in the modification of bitumen will not only augment the availability of bitumen but also helps in incrementing the properties of plain bitumen and provides a better way of disposal of waste tires. By using crumb rubber in the construction of road will be beneficial economically as well as environmentally. The use of crumb rubber gives better strength and durability to the road. The size of crumb rubber used in the sample preparation was taken to be 300 $\mu$ m-150 $\mu$ m. The gradation of aggregate was taken according to the norms of IS: 107-2386 Part 1 (Wet gradation method) and specification of Ministry of road transport and highway (MORTH, 2013) for a layer thickness of 50 mm and nominal aggregate size of 19 mm. The calculation of the optimum value of bitumen and crumb rubber are found with the help of Marshall Test, to determine the values of Marshal Parameters (stability, flow value) and Volumetric Parameters (voids in mineral aggregates (VMA), voids filled with bitumen (VFB) and air content (VA)).

### 2. Materials and Methods

The bituminous blend samples were formed using coarse and fine aggregates. The gradation of aggregate was taken according to the norms of IS: 107-2386 Part 1 (Wet gradation method) (Table 1). The specific gravity of coarse and fine aggregates found out to be 2.6 and 2.55, respectively. The specific gravity of stone dust was found out to be 2.42.

**Table 1 Gradation of aggregate as per MORTH specification**

Sieve size	Passing %	% Quantity of aggregate
26.5 mm	100	
19 mm	90-100	9
13.2 mm	59-79	12
9.5 mm	52-72	15
4.75 mm	35-55	10
2.36 mm	28-44	10
1.18 mm	20-34	11
600 $\mu$ m	15-27	9
300 $\mu$ m	10-20	10
150 $\mu$ m	5-13	5
75 $\mu$ m	2-8	4
filler	5	5



Materials used in the study aggregates of specified quantity.



Crumb rubber

## 2.2. Bitumen and Crumb Rubber

The samples were made using VG-30 grade bitumen and the physical properties of asphalt such as penetration grade, softening point and ductility.

## 2.3. Methodology

Mix design is used to calculate that content of bitumen or any other material that will provide maximum strength and durability as economical as possible. Marshall Mix design was used to determine the optimum percentage of bitumen and crumb rubber. 1200 g of aggregate along with 5% filler (stone dust) by weight of aggregate and various percentages of bitumen were taken to determine the optimum value of bitumen.

## 3. TEST AND RESULTS

### 3.1. Marshall Stability Test

Marshall Stability test is of vast importance and significant in the field of highway engineering. This test is used to calculate stability value and flow value for various bitumen content. In this study ASTM-D, 1559 has been used for testing of bituminous mixes.

In this study the criterion followed to calculate optimum content is to have maximum corrected stability value, flow value under accepted range, percentage of air voids in accepted range and values of VFB, VMA in accepted range and Marshall Quotient set according to IS- MORTH

### 3.2. Penetration Test

The simplicity of this test makes it the most common and widely accepted test of asphalt to obtain the grade of the material in terms of its hardness. In this experimental study penetration value at different crumb rubber percentages is determined and it was observed that with increase in the percentages of crumb rubber the penetration value is reduced shown in table below. The decrease in penetration value shows that consistency of bitumen changes and becomes harder and hence making it better by addition of crumb rubber.

Percentage of Crumb Rubber at 5% B.C	Penetration at 25°C 0.1mm,100gm, 5sec
0%	60
2%	57
4%	54
6%	47
8%	45
10%	40

Penetration values

### 3.3. Ductility Test

During the construction of flexible pavement, it is desirable that bitumen is able form a thin films around the aggregates. This test measures the tensile properties of bituminous materials. In this lab study ductility value at different percentages of crumb rubber is determined and it was found that with the increase in the quantity of crumb rubber in bitumen the ductility value decreases. The reduction of ductility value shows the reduction of flexibility of bitumen

#### Ductility Values

Percentage of Crumb Rubber at 5% B.C	Ductility at 25°C, (cm)
0%	38
2%	36
4%	33.5
6%	32.7
8%	31
10%	30

#### **4. CONCLUSION**

In this laboratory study, the crumb rubber has been used as bitumen replacement by weight. Marshall Tests are carried out on the bituminous samples to found out the optimum value of crumb rubber. And tests such as Penetration test and Ductility tests were also accomplished to evaluate the physical properties of modified bitumen.

- Through Marshall Properties it was observed that the use of crumb rubber in bituminous mixes makes it more stable. According to the Marshall Properties the use of 6% crumb rubber at 5% bitumen content was found out to be optimum percentage. The use of crumb rubber also increases the percentage of air voids than conventional mix.
- By the use of crumb rubber in road construction also solves the problem of waste tire disposal and prevent environmental problems.
- The physical properties such as penetration and ductility of modified bitumen were also improved, the modified bitumen was found out to be of harder consistency making it more rutting resistant and less flexible.

#### **REFERENCES**

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