A Study on the Performance of Crumb Rubber Modified Bitumen by Varying the viscosity grades of Bitumen

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Abstract:

India is a rapid urbanizing country. Due to overall development new roads are being constructed for ever increasing population. Density of vehicular traffic increases day by day. The wear and tear of tyres from these vehicles are undoubted. So, many scrap tires are being generated. Many wastes and worn out tires are 15-20% each year. The abundance and increase of waste tyre disposal are 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 since the 1840s. As a first part of this study, an attempt was made to assess the stabilization of the bitumen by performing basic tests such as Penetration Test, Ductility Test, Softening Point Test. Marshall Values, namely Marshall Stability Value, Marshall Flow Value, Voids present in air, Voids in Aggregates and Voids in Bitumen, determined from Marshall Stability Test, serve as the benchmark values to assess the quality of Bituminous Concrete. The design and performance of Bituminous Concrete mainly depends upon the quality and percentage of binder used. Experimental investigations were undertaken to check the pavement worthiness of these mixes. So, the results show that Penetration values and softening points of plain bitumen can be improved by modifying it with addition of crump rubber. Also, Optimum binder content for conventional bitumen was found to be 4.7% and 4.5% for Grade VG10 and VG20 respectively. Optimum value of crumb rubber in CRMB was found to be 10% for Grade VG10 as well as VG20. Using waste rubber reduces threat to environment and improve the road quality.

Keywords: *Crumb Rubber, Marshall Test, Flexible Pavements, Wet Process, Dry process*

1. Introduction:

In the present scenario disposal of rubber wastes produced from different Industries is a great problem. These materials lead to environmental pollution in the atmosphere nearby locality due non-biodegradable property. Most of the construction materials used for roads are soil, stone aggregate, sand, bitumen, cement etc. The availability of natural materials is declining. Also, cost of extracting good quality of natural material is increasing. To overcome this problem, it is recommended to use alternative materials for highway construction, by which the pollution and disposal problems may be reduced. The need for these solid wastes in India, it was in need to test these materials and to develop specifications for usage of waste tyres in road construction in which it may leads to higher economic returns. The possibility of using these materials should be developed for low volume roads construction in various parts of our country. The necessary specifications should be formulated to maximize the use of solid wastes in different layers of the road pavement.

Rubber tyres are user friendly but not eco-friendly since they are non-biodegradable. The process of disposing waste tyres in landfill and burning in open space is becoming nuisance because of rapid depletion of available landfill sites and clear environment respectively.

The conventional bituminous mix consists of aggregate and 5 to 6 percent bitumen by weight of the aggregate. The tyre rubber scrap can be incorporated into bitumen, which is known as modified bitumen and granulated, or ground rubber or crumb rubber are used as a portion of the fine stone aggregate. The use of waste tyres in hot bituminous mixes enhances the performance of pavement, protect environment and provide economic and long-lasting roads.

2. Literature Review:

Athira R Prasad, Dr Sowmya N.J. (May - Jun. 2015) paper is based on Marshal Stability Value, it is observed that with increase in bitumen concentration the Marshall stability value increases up to certain bitumen content and there after it decreases. Thus, the maximum stability was obtained at 5%. This test is performed on VG 30 grade of bitumen.

Nitu H. Deshmukh, Prof. D. Y. Kshirsagar, (2017) In this paper Penetration test, softening point test, Ductility test were performed on CRMB grading VG 30 with 0%,8%,10%,12% and 14% Crumb rubber which results in enhancement of properties of bitumen.

Nabin Rana Magar(Aug 2014) This paper examines the results obtained by performing penetration test and softening point test on plain bitumen and crumb rubber modified bitumen, it is concluded that the penetration values and softening

points of plain bitumen can be improved significantly by modifying it with addition of crumb rubber which is a major environment pollutant

Rakesh Nagar, Pratiksha Malviya, Vikash Kumar Singh (Jan 2018) It is observed crumb rubber modified bitumen reveals that the Marshal Stability value, which is the strength parameter of bituminous concrete, has shown increasing trend and the maximum values have increased by about 18 % by addition of crumb rubber. This will provide more stable and durable mix for the flexible pavements.

Nitish Kumar k, Dr. H N Raja kumara(May-2016) In this paper it is evaluated that the Specific gravity of tyre waste is 1.25 and bitumen is 1.02 but with the addition of rubber the specific gravity of bitumen increases, it is due to the reason that the specific gravity of tyre waste causes the improvement in specific gravity.

3. Experimental Programs:

3.1 Marshal Stability Test

3.1.1 DBM mix preparation

All aggregate required for this indigestion were provided by PMC hot mix plant. Table displace the primary aggregate use in the mix including their percentages of mix type use in the control mix. The precise followed in accordance with the specified standard. For control DBM mix initially, the aggregate was placed in an oven at 105 C for 24 hours to remove any moisture that might be present. After driving the components of the DBM mix the aggregate sand bitumen were placed in an oven along with the testing equipment and heated to 150°Cfor about 1 hour so that they were all at the same temperature. Once all the required material is heated to required temperature, the aggregate was then mix with the bitumen for a mixing time not exceeding more than 3 min. For preparation on control mix only bitumen is added and crumb rubber is added.

Bitumen VG-10 and VG20 grade	4.3% by weight	52 gm
	4.5% by weight	54 gm
	4.7% by weight	57 gm
20 mm aggregate	42% by weight	504 gm
10 mm aggregate	8% by weight	96 gm
06 mm aggregate	8% by weight	96 gm
Crush Sand	40% by weight	480 gm
Filler (Stone Dust)	2 % by weight	24 gm

Table1: DBM proportions

3.1.2 Compaction of DBM sample

After preparing batch of the DBM mix sample, it requires to be compacted before testing. Compaction is done with Automatic Marshal Compactor machine present at the lab at Pune Municipal Corporation, Hot Mix Plant, Yerwada. Sample placed in the mould were compacted in the compaction machine for 75 blows each side. Filter papers were added to the both sides of the mould. The moulds were kept for 24 hours before testing.

Compacted sample were kept for 24 hours in the mould and after that they were used for testing. Testing is done with Marshal Method. Marshal method of testing for stability and flow. The samples were removed from the mould and placed in the water bath at 60 C for 30-40 minutes. They were then assembled in preparation for testing the Marshal stability and flow


Image 1. Automatic Marshall Compactor

3.1.3 Determine Marshall Stability and Flow:

Marshall Stability of a test specimen is the maximum load required to produce failure when the specimen is preheated to a prescribed temperature placed in a special test head and the load is applied at a constant strain (5 cm per minute). While the stability test is in progress dial gauge is used to measure the vertical deformation of the specimen. The deformation at the failure point expressed in units of 0.25 mm is called the Marshall Flow value of the specimen.

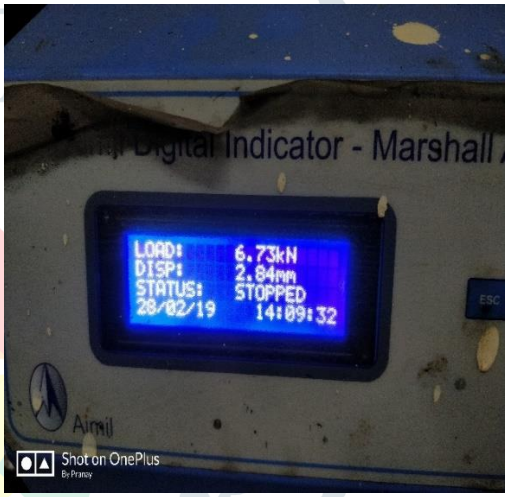



Image 3. Loading Arrangement Image 4. Digital indicator

3.1.4 Marshall Stability Test on CRMB Mixes

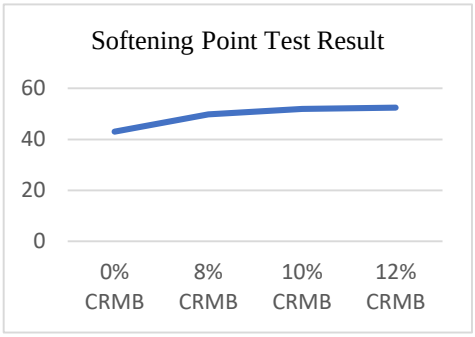
In this process aggregates are heated to 170°C and added crumb rubber with varying percentage of 8%, 10% and 12% of binder content i.e. 4.32 gm, 5.4 gm and 6.48gm and mixed to coat the aggregates. These coated aggregates have been used for the preparation of the bituminous mixes.



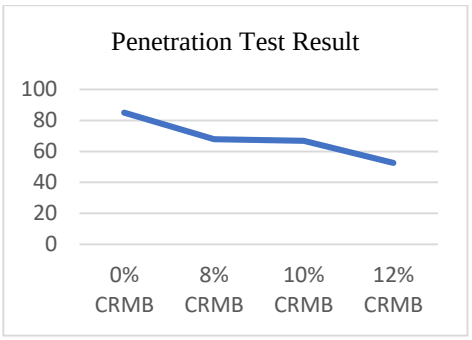
Image 4. Mixing of Rubber Image 5. CRMB Specimen in Water Bath Image 6. Loading Arrangement

4. Results and Discussions:

4.1 CRMB (VG10) Test Result

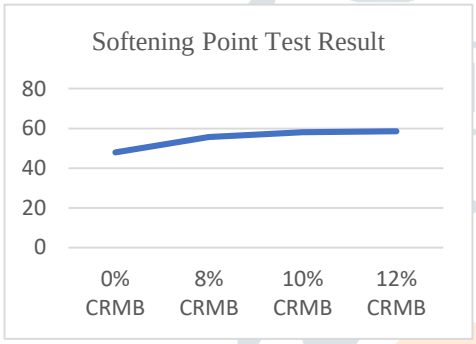


Graph 1- Softening Point Test Result

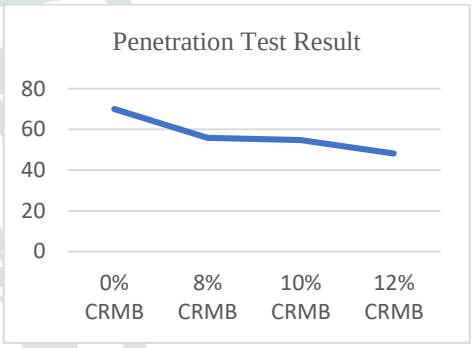


Graph 2- Penetration Test Result

4.2 CRMB (VG20) Test Result

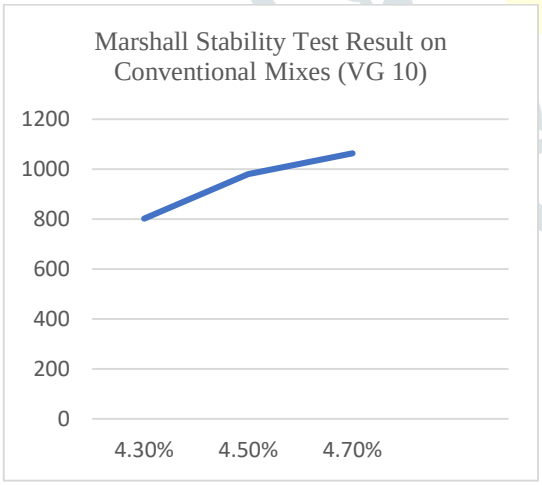


Graph 3- Softening Point Test Result

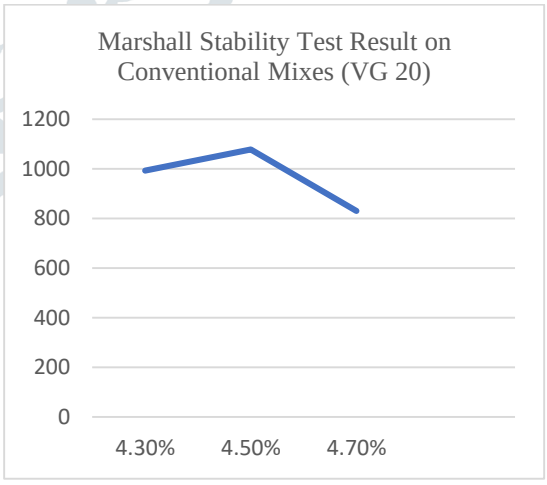


Graph 4- Penetration Test Result

4.3 Marshal Stability Test Result on Conventional Mixes

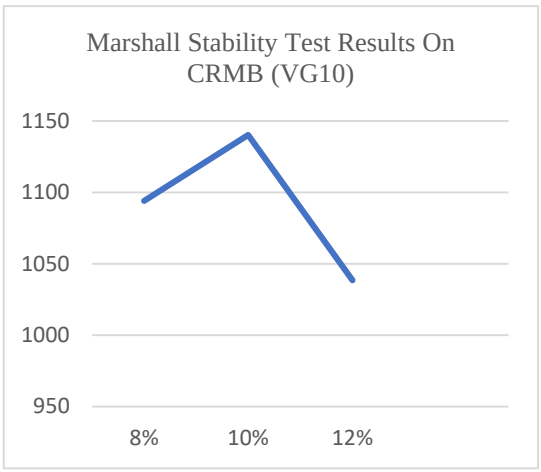


Graph 5- Marshall Stability Test Result on Conventional Mixes (VG 10)

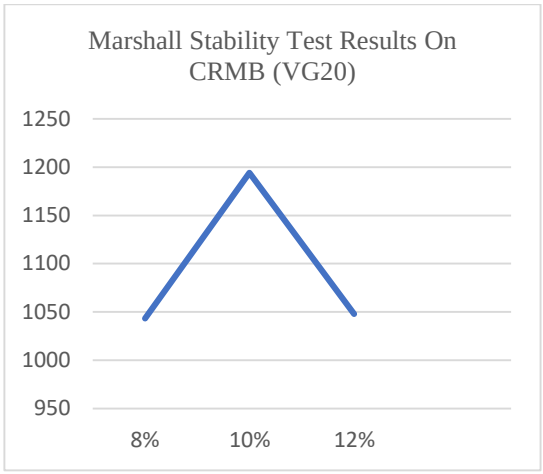


Graph 6-Marshall Stability Test Result on Conventional Mixes (VG20)

4.4 Marshal Stability Test Result on CRMB



Graph 5- Marshall Stability Test Result on CRMB (VG 10)



Graph 6-Marshall Stability Test Result on CRMB(VG20)

Crump Rubber %	Stability (Kg)	Average	Flow(mm)
8%	1150.7	1093.9	4.5
	1007.3		3.5
	1123.8		4
10%	1178	1140.26	4
	1095.2		4
	1147.6		3.5
12%	1102.4	1038.46	4
	1034.7		4.5
	978.3		5

Table 2: Marshal Stability Test Results on CRMB (VG10)

Crump Rubber %	Stability (Kg)	Average	Flow(mm)
8%	1201.47	1043.22	3.5
	1048.56		4
	1179.63		4
10%	1223.3	1194.13	3.5
	1157.7		4.5
	1201.4		4
12%	1157.7	1048	4.5
	1092.2		4
	1004.8		6

Table 3: Marshal Stability Test Results on CRMB (VG20)

5. Conclusion:

- Penetration values and softening points of plain bitumen can be improved by modifying it with addition of crumb rubber.
- Optimum binder content for conventional bitumen was found to be 4.7% and 4.5% for Grade VG10 and VG20 respectively.
- Optimum value of crumb rubber in CRMB was found to be 10% for Grade VG10 as well as VG20.
- Using waste rubber reduces threat to environment and improve the road quality.

6. References:

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