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Performance Evaluation of Bituminous Concrete with Crumb Rubber of N.H-44 on Hyderbad-Bangalore Section in States of A.P & T.S of India

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Abstract--Increase in environmental concerns has been leading to develop innovative and eco-friendly ideas to re-use the waste byproducts from industries and domestic use. Waste plastic and waste tyres/crumb rubber considered as solid waste in India which causes environmental pollution. These wastes will be disposed by land filling and incineration which are hazardous. Flexible pavements tend to become soft in summer &brittle in winter due to high temperature variation. Also early development of distress symptoms occur due to heavy traffic loads on such roads. In these circumstances ordinary bitumen is not sufficient to overcome these symptoms. CRMB is special type of bitumen whose properties have been improved by addition of crumb rubber & special types of additives like hydrocarbon material, resins etc. Thus altering the physical properties of bitumen making it more resistant to temperature variations, weather &high traffic load, From practical experiences of asphalt binder with crump rubber offer several benefits to enhance various engineering properties many modifiers such as styrene based polymers, Gilsonite and various oils have been used in asphalt. In this process addition of crmb-55 has been done by replacing bitumen by percentage by weight in varying percentage. Marshall Method of bituminous mix design was carried out. Significant improvement in properties like Marshall Stability, retained stability, has been observed in crumb rubber bituminous mix compared to conventional mix.
Keywords: VG-10,CRMB-55, bituminous mix, Marshall Properties, retained stability

I. INTRODUCTION

The growth rate of vehicles is the backbone of economic development of any country. India is the second fastest growing automobile industry in the world. These have brought excitement amongst business leader over the potential enormous vehicle industry and have drawn attention of likely future course of environmentalists and pavement engineers too. Here lies the utmost important responsibility of highway engineer in world to implement sustainable solutions in the road construction industry which is paramount as one of the major research topics. The road needs to be updated to meet the quality and quantity of performance to sustain repeated vehicle loadings, climatic changes and riding quality. Bitumen modification is needed to sustain the stresses of vehicles with other changes in properties. CRMB 55 is a special type of bitumen obtained which is prepared for improving the properties by blending with crumb rubber and special type of additives to make the material resistant to temperature variations, weathering and high traffic loads. CRMB 55 for dense bituminous macadam design is taken into consideration and careful analysis of necessary properties of it.

Crumb rubber is the term usually applied to recycled rubber from automotive and truck scrap tires. During the recycling process steel and fluff is removed leaving tire rubber with a granular consistency. Continued processing with a granulator and/or cracker mill, possibly with the aid of cryogenics or mechanical means, reduces the size of the particles. From physical and chemical interaction of crumb rubber with conventional bitumen Crumb Rubber Modified Bitumen (CRMB) is made. Its advantages are: Lower susceptibility to daily & seasonal temperature variations, higher resistance to deformation at elevated pavement temperature, better age resistance properties, higher fatigue life of mixes, Better adhesion between aggregate & binder, Prevention of cracking & reflective cracking, and Overall improved performance in extreme climatic conditions & under heavy traffic condition.

In this present study comparison has been drawn between the properties of bituminous mix prepared by using penetration grade 80/100 bitumen (VG-10) and commercially available crumb rubber modified bitumen (CRMB-55) by replacing 6%,8%,10%,12%,14% percentage of bitumen

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II. MATERIALS AND METHODS

A. *Materials*

In this study 80/100 penetration grade bitumen (VG-10) and commercially available crumb rubber modified bitumen (CRMB55) from the local manufactures has been used and their properties are given in Table 1

Table 1 : Physical properties of 80/100 bitumen (VG-10) & CRMB 55

Properties	VG-10	CRMB 55
Penetration (mm)	86	55
Softening Point	42	55
Ductility	+75	+100
Specific Gravity	1.03	1.02

Fig.2: crumb rubber

Aggregate from local quarry (Timmapur quarry) (quartzite type) is used for the preparation of bituminous mixes. The results of physical properties of aggregates are given in Table 2.

Table 2: Physical properties of aggregate

Properties	Value
Impact Value (%)	22.96
Crushing Value (%)	21
Specific Gravity	2.665
Water Absorption	0.3

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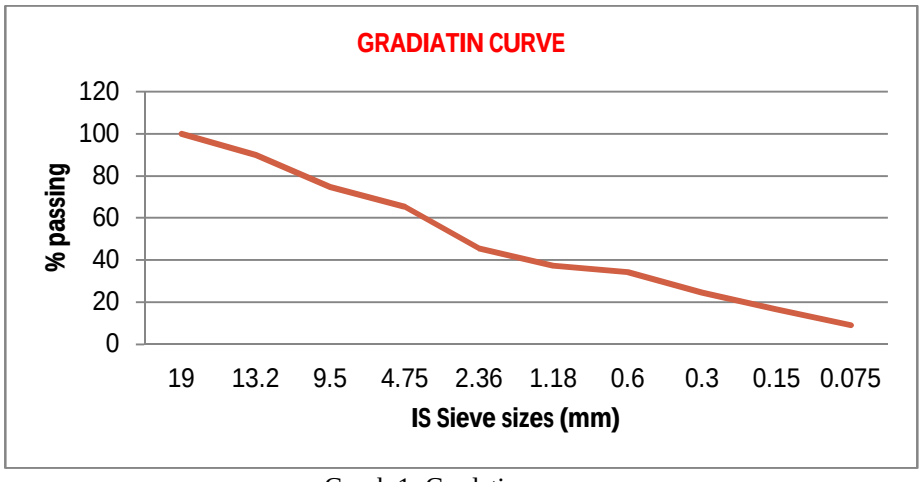
Fig.1: Grading of aggregate

Grading of aggregate as per Ministry of Road Transport and Highways Specification (MoRT&H) for bituminous concrete (Grading 2) The selected gradation and specification limits are shown in Table 3 and graph. 1.

Table.3 : Aggregate Gradation as per MORT&H Specification for Bituminous Concrete Mix

IS Sieve size (mm)	%passing adapted	% Passing Specifications
19	100	100
13.2	89.8	79-100
9.5	74.6	70-88
4.75	65.33	53-71
2.36	45.5	42-58
1.18	37.29	34-48
0.6	34.4	26-38
0.3	24.6	18-28
0.15	16.6	12-20
0.075	9.1	4-10



Graph.1: Gradation curve

B. Methods

Bituminous mixes for this study were prepared in a mixing pan. For preparation of mixes, aggregate was heated to 175°C and bitumen to 160°C. Aggregate was taken in a pan and requisite quantity of bitumen was then added to heated aggregate and both the ingredients were mixed vigorously using a spatula. For bituminous mix prepared using CRMB 55 binder as per IRC-SP-53-1999 the binder should be heated to1700-1800 C.

Bitumen is prepared by adding crumb rubber in various percent to VG-10 in addition to it Gilsonite is add to the mix for

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homogeneous mixture of material and also add anti stripping oil (if necessary) which are use to avoid stripping of modified bitumen to the aggregates

Table.4: Temperature of bitumen

Specific use	
Mixing / Coating	170 - 185 ^{0}C
Laying	150 - 170 ^{0}C
Beginning of compaction	Over 140 ^{0}C
End of compaction	110 - 120 ^{0}C

Fig.3: mixing of bitumen concrete

C. Testing Of Mixes

The properties of Marshall Specimens as per MORT&H are given in Table 5. For testing of stability, flow, indirect tensile strength (ITS), marshall specimen of 101.3 mm diameter and 63.5 mm height using 75 blows on both sides were prepared by standard rammer at 155°C as per procedure described in ASTM D 1559. The optimum binder content for both mixes are determined and the properties of mixture at OBC is given in Table 6. The results of stability, flow, Marshall quotient (stability/flow) along with methods of test adopted are given in Table 6. Volumetric and engineering properties of mixes at varying crumb rubber content are given in Table 6. Retained stability test was conducted on Marshall samples of conventional bituminous mix as well as modified mixes at 25ºC.

Fig.4: Air Voids determination setup

Fig.5: Marshall Stability Test Setup

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Table 5: MORT&H Specification

Properties of Marshall Specimens	Specification Limits
Marshall Stability value (kg)	Min 900
Marshall Flow value (mm)	2-4
Air Voids in total mix (Va %)	3-6
Voids filled with Bitumen, (VFB %)	65-75
Voids in Mineral aggregate	Min 14

Table 6: Properties of mixtures at OBC

Binder	80/100	CRMB 55
OBC	5.2	5.12
Density (gm/cc)	2.371	2.373
Va %	4	4
VFB %	16.11	16.04
VMA%	74.3	74.7
Flow (mm)	3.9	3.6
Stability (Kg)	1180	1370

Table 7 Volumetric and mechanical properties of mixes at varying CRMB55 content

Properties	CRMB-55 (%)						
	0	4	6	8	10	12	14
Bulk density,	2.372	2.371	2.37	2.371	2.374	2.373	2.372
(Va), %	4	4.13	4.16	4.13	4.01	4.15	4.08
(VMA),%	16.06	16.1	16.13	16.1	16	16.12	16.06
(VFB), %	74.55	74.32	74.15	74.31	74.89	74.22	74.55
Marshall stability Kg, 60°C	1177	1252	1297	1315	1370	1325	1306
Marshall flow, mm at 60°C	3.8	3.9	3.7	3.9	4	4	4
Marshall quotient,	310	321	339	338	343	332	327

D. Retained Stability

The Marshall Immersion test was done to evaluate the resistance of mixtures against water. Specimens were made at their optimum asphalt content and immersed in the water bath for 24 hours at 600C and some other specimens were immersed in the water bath for 30 minutes at 60^0C too. The Index of Retained Strength (IRS) was then calculated using equation: the higher stability compare to the other two mixes. The retained stability indicates the strength of the mix which is adversely soaked for about 24 hours. It is given in Table 8.

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$$\text{IRS} = \frac{S2}{S1} * 100$$

Where;

S1= Marshall Stability for specimens immersed in water bath for 30 minutes

S2 = Marshall Stability for specimens immersed in water bath for 24 hours

Fig 3 :moulds immersed in water bath for 24 hours

III. RESULTS AND DISCUSSIONS

The behavior of the crumb rubber shows the softening temp is about 120-160^0 C and it doesn't liberate any toxic gases in that temperature hence it can be used . Marshall mix design was conducted on conventional mixes to arrive optimum bitumen content using 80/100 bitumen(VG-10) and CRMB 55. For the conventional mix using 80/100 bitumen, optimum binder content obtained was about 5.2% and the Marshall stability obtained for corresponding OBC were 11.8KN. For CRMB-55 mix the obtained OBC also 5.1%, but there was an increase in Marshall stability from 12.5 to 13.7 KN compare to the conventional mix .also the Marshall flow which indicates the deformation had been gone down to 3.6 mm from 3.9 mm and the remaining volumetric properties were within the satisfactory range and it was given in Table 6.

Retained stability test was done to evaluate the resistance of mixtures against water. crumb rubber modified mix showed the higher stability compare to the normal mix. The retained stability indicates the strength of the mix which is adversely soaked for about 24 hours. It is given in Table 8.

Table 7: Mix Design

Properties	
Bin G3(19mm-13.2mm)	10%
Bin G2(13.2mm-6mm)	31%
Bin G1(6mm-75micron)	52%
Bin F1(Crusher fines)	5.0%
Bin F2(Hydrated lime)	2.0%
Bitumen Content(by Wt of mix)	5.13%

Table 8: Retained stability

Binder Type	S1	S2	Retained stability (%)
80/100 Bitumen (VG-10)	1180	990	83.89
CRMB 55	1350	1205	89.26

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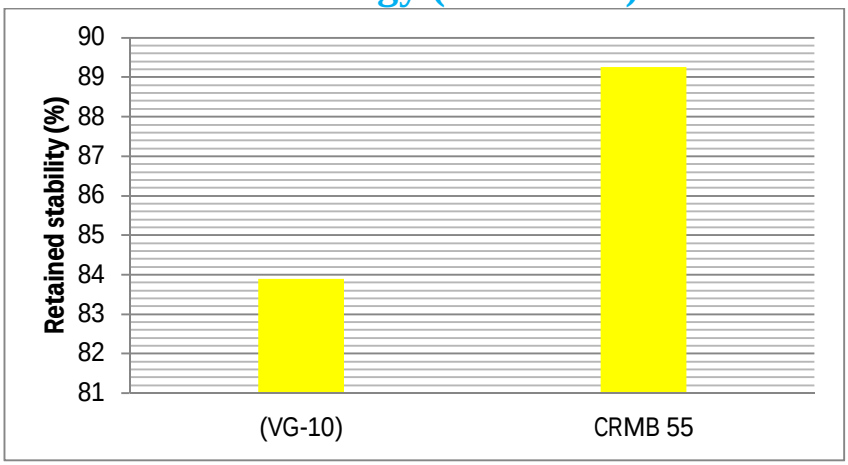

Graph 1 Retained stability of mixes

IV. CONCLUSION

Optimum binder content of the mix reduced from 5.2% to 5.1%, i.e. binder content reduced about 0.1%.Reduction in bitumen required leads to the saving of bitumen hence also the cost of construction will also decreases. Increase in the stability from 12.5KN to 13.7KN. There is 8-12% by weight bitumen with CRMB-55 can preferred to bituminous concrete. However CRMB mix showed a marginal increase in tensile strength compare to that of plain bituminous concrete. It helps in substantially improving the stability or strength, and other mechanical properties of bituminous concrete mix even under adverse water logging conditions. Therefore the life of the pavement surfacing course using the crumb rubber modified bituminous mix is also expected to increase substantially in comparison to the use of conventional bituminous mix.

With this rutt depth is also decreased and failures on the surface of the pavement decreases it is used to bear heavy traffic loads. It increase service period of the road.

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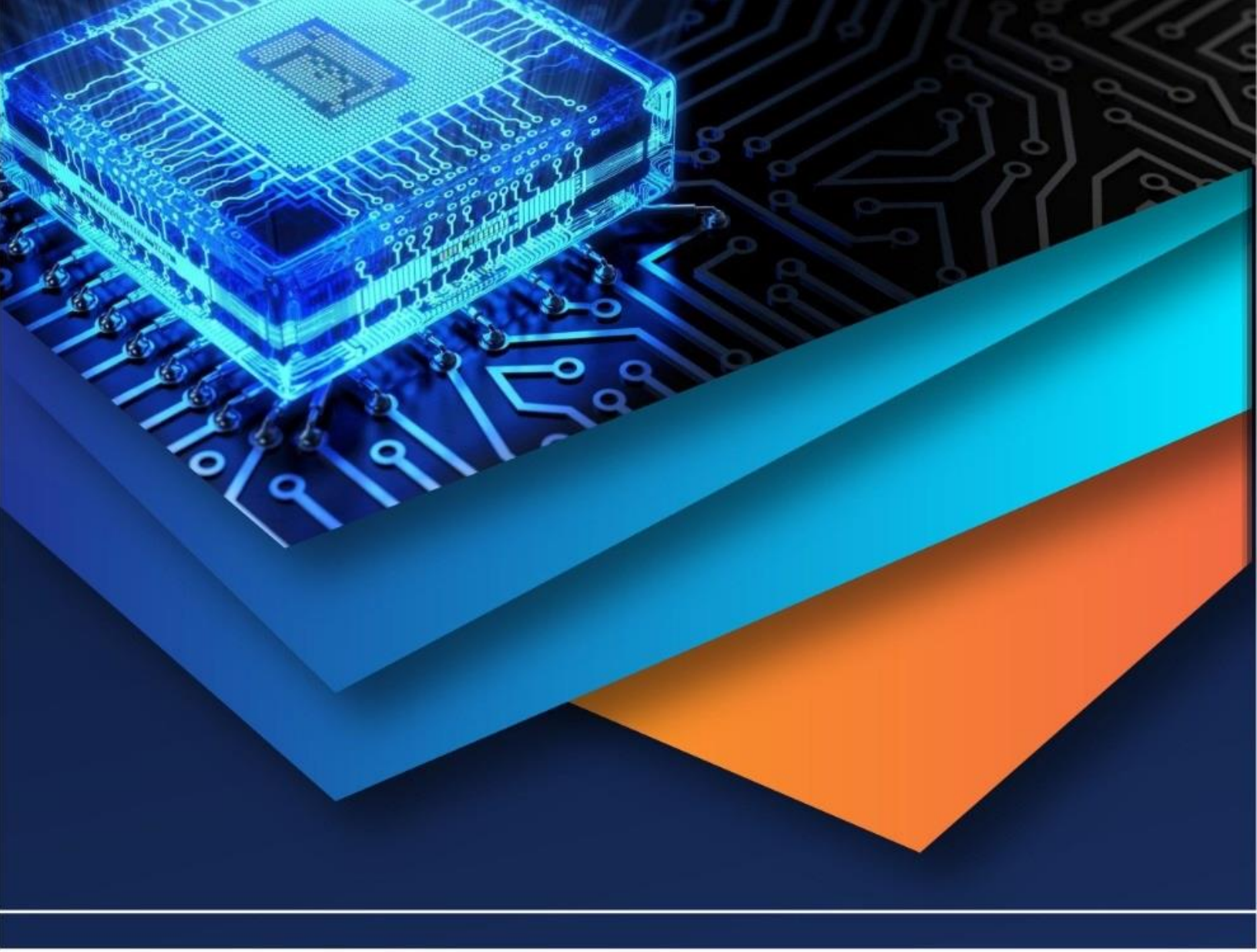

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