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Performance Evaluation of Bituminous Mixes with Modified Binders using Roller Compactor cum Rut Analyzer (RCRA)

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Abstract: ***In India majority of roads are being constructed by flexible pavements. But the performance of the pavement largely depends on quality and type of materials used, construction methodology adopted, temperature, climatic conditions etc. Because of these variations in these parameters, pavements undergo distress/ failure. The different types of failure in flexible pavement are Rutting, Shovelling, Edge breaks, Cracks, Slippage etc. Rutting is a common phenomenon which occurs in flexible pavement surface due to overloading of vehicles and repeated application of wheel load. Rutting is defined as channelized depression in the pavement surface along wheel path due to heavy repetitive traffic load. Design of bituminous paving mixes greatly effects the performance of pavements. In the present laboratory research work, conventional bitumen is used in wearing/ surface course and Modified Bitumen is used in binder course of the layer. Pavement layers are constructed/casted in an Indigenously designed, developed and fabricated equipment called Roller Compactor cum Rut Analyzer (RCRA) and Rutting test is performed. The Rutting test is carried out on wearing course of bituminous layer (BC Gr-II with VG-30) and by adopting Binder course layer namely DBM Gr-II prepared with two different types of binders namely VG-30, SBS-70. The overall objective is to compare the Marshall properties of the conventional and Modified Bituminous mix and to study the rutting performance of these bituminous mixes.. Results shows that bituminous mixes prepared with Modified Bitumen/Binders (SBS-70) has a very high Marshall Strength and offers greater resistance to rutting.***

Keywords: Modified Bitumen, Bituminous Concrete (BC), Dense Bituminous Macadam (DBM) , Marshall Stability, Roller Compactor cum Rut Analyzer (RCRA), Styrene-Butadiene-Styrene (SBS).

I. INTRODUCTION

Bituminous pavement is extensively used in India for the construction of both rural and urban roads. Overloading of axles and increased traffic volume in excess of permissible limits and higher tyre pressure, repeated loading has caused widespread problems with the performance of the pavement. Design of bituminous mixes is a very important factor in deciding the Strength, durable and sufficient strength, durability and sufficient strength to resist shear deformation under traffic at higher temperature.

The Marshall Stability is a very important test which is conducted in the laboratory to decidedeciding the quality of bituminous mixes. The stability is derived mainly from internal friction and cohesion. Cohesion is the binding force of binder material while internal friction is the interlocking and frictional resistance offered by aggregates. As bituminous pavement is subjected to severe traffic loads from time to time, it is necessary to adopt bituminous mix with good stability and flow.

It is a common practice in India to use the Modified Bitumen in the wearing course and conventional bitumen in the binder course of pavement layers. But due repeated application of heavy wheel loads, temperature difference between the top and bottom of pavement layers, variations in climatic conditions severely affects performance of pavement .So, in the present laboratory research work, an attempt is made to study the performance of bituminous mixes by using Polymer based modified bitumen namely Styrene-Butadiene-Styrene (SBS-70) in the Binder course of pavement layers. The Rutting test is carried out on wearing course of bituminous layer (BC Gr-II with VG-30) and by adopting Binder course layer namely DBM Gr-II prepared with two different types of binders namely VG-30, SBS-70

II. OBJECTIVES OF THE RESEARCH WORK

1) To conduct the basic tests on Aggregates, Bitumen and Modified Bitumen (SBS-70) in the laboratory as per the relevant IS/ MoRTH standards to ascertain its suitability for the use in research work.
2) Based on the obtained Job Mix Formula (JMF) for different bituminous mixes, Cast and conduct Marshall stability test for bituminous mixes with VG-30 and SBS-70
3) To Conduct the rutting test on casted specimens of bituminous mixes at different temperatures in the laboratory using Roller Compactor cum Rut analyser (RCRA).
4) Comparison of results of Marshall stability and rutting values for the adopted bituminous mixes prepared with VG-30 and SBS-70

III. LITERATURE REVIEW

Veena K et al[1]— The utilization of bitumen along with the admixtures in road construction, generally provides many benefits. Construction of roads is a continuous process, as the necessity of highway pavement plays an important role in transportation industry. The purpose of highway pavement is to provide smooth surface over which vehicles can move smoothly from one place to another. In this contemporary world, with increasing population and rapidly increasing manufacturing of vehicles, rapid increase in number of vehicles it has become much necessary to construct more and more roads, in order to satisfy human life demand. The following report consists of details of stability and flow index of bitumen by conducting Marshall Stability of bitumen by varying the number of blows like 50 and 75 blows for different percentage of bitumen i.e. 3%, 3.5%, 4%, 4.5% and 5%. The following report gives the brief description regarding the comparison between different numbers of blows given to the bituminous samples.

Mohanlal Chandrawal, et al [2] Rutting is the permanent deformation in pavement usually occurs longitudinally along the wheel path. Permanent deformation or rutting in bituminous mixes depends on numerous factors such as aggregate gradation, shape and size of aggregate, quantity and quality of binder, volumetric properties of mix such as air voids and Voids in Mineral Aggregates (VMA), film thickness, temperature, construction practices and environmental conditions. Rutting resistance potential of any bituminous mix depends on the properties of its constituents. In this study crumb rubber and waste plastic is used to modify constituent's properties. Crumb rubber is used to modify bitumen generally termed as crumb rubber modified bitumen (CRMB). Waste plastic is used to form a coating around aggregates. Bituminous mix with CRMB and plastic coated aggregates having proper proportions of crumb rubber and waste plastic gives better results as compared to mixes having any one of the two waste materials. Thus in the areas prone to high rut depth on DBM, for use mainly, but not exclusively, in base/binder and profile corrective courses, modified bituminous mix (having crumb rubber modified bitumen along with plastic coated aggregates) is more suitable than conventional mix due to its high rut resistance. Plastic coated aggregate – crumb rubber modified mix shown negligible increase in rutting even when significant temperature change occurs. Hence such modified mixes could be used in areas having large temperature variations. Thus modified mix with crumb rubber modified bitumen as binder and LDPE coated aggregate, could be successfully used to replace conventional mix for DBM, with advantage of project cost reduction, improvement in performance and environmental betterment.

Mahesh Kumar A, et al[3] The bituminous mix design aims to determine the proportion of coarse aggregate, fine aggregate, mineral filler and bitumen to produce a mix which is workable, strong, durable and economical bituminous materials are extensively used for roadway construction, because of their excellent binding characteristics and water proofing properties and relatively low cost. Dense Bituminous Macadam is strong enough to handle years of vehicular traffic and is relatively easy to maintain. Bituminous paving is also fully recyclable, though recycled products may not be as strong as conventional materials. Bituminous materials consist of bitumen which is a black or dark coloured semi solid or viscous substance. Design of Dense Bituminous Macadam mix (Grade-II) prepared using VG-30 & PMB-40 was carried out as per MORT&H and IRC SP-53:2010 specifications. Using Marshall Method of mix design, the OBC for DBM Mix was determined. At optimum bitumen content, Marshall Stability test was conducted to determine the Marshall properties of DBM, Indirect Tensile Strength test (ITS),Tensile Strength Ratio (TSR) and Fatigue behaviour are evaluated on Marshall specimens prepared using Stone Dust (2%) and Ground Granulated Blast Furnace Slag (2%) as mineral filler at optimum bitumen content. From the laboratory investigations carried out, it can be concluded that the DBM mix prepared using PMB-40 with GGBS (2%) as mineral filler is superior when compared to that of mix prepared using VG-30 with Stone Dust (2%) & GGBS (2%) as mineral fillers and mix prepared using PMB-40 with Stone Dust (2%) as mineral fillers.

Pranay Raj[4] As the use of vehicles is expanding day by day is resulting in increase of the amount of waste tyres. The crumb rubber obtained from the waste tires of vehicles can be utilize in construction of flexible pavement. This will help to reducing the environmental pollution caused due to burning and land filling. In the present study is to check the performance of bituminous mix (BC grade II) (As per MORTH VTH revision) with and without adding of crumb rubber, by dry processing. Here an attempt is made to replace fine aggregate (4.75mm-0.075mm) by crumb rubber percentage of 0,2,4,6 and 8% .Marshall specimen were prepared by using VG 30 grade bitumen and test were conducted as per ASTM D6927-15, to obtain an Optimum Bitumen Content (OBC). The Indirect Tensile Strength (ITS), Tensile Strength Ratio (TSR) were conducted as per ASTM D6931-12, AASHTO T-283, to obtain the Optimum Crumb Rubber Content (OCRC). The result shows that by replacing fine aggregate with crumb rubber in the bituminous mix there was overall improvement in the engineering properties of the mix and also increase in stability compare to conventional mix and Indirect Tensile Strength (ITS), Tensile Strength Ratio (TSR) also increases up to 4% of Crumb rubber replacement.

Lokesh Gupta, et al[5] A good bituminous mix design is anticipated to produce a mix which is supposed to be sufficiently sturdy, long-lasting, resistive.DBM is used as a binder course in the highway pavement. Binder is a prime material in the bituminous mix. Marshall properties of bituminous mix varies from binder to binder. In this work an effort has been made to evaluate the Marshall properties of dense bituminous macadam prepared using VG-30 and CRMB-55 as binder materials. DBM mix is prepared using 2% lime as filler material and VG-30, CRMB-55 as binder material. Marshall method of bituminous mix design is adopted to decide the optimum bitumen content (OBC) and Marshall properties were determined at optimum bitumen content. On the basis of limited laboratory studies carried out, it is conclude that CRMB-55 is superior binder material in terms of Marshall properties.

IV. METHODOLOGY

The following methodology is adopted in the present research work:

1) The methodology includes conducting the Basic tests on the materials used in the research work such as aggregate, bitumen, modified bitumen binders as per the relevant IS/MoRTH Codal standards
2) Conducting Marshall Stability test on the Prepared Specimens.
3) Preparing the specimens for Rutting and conducting rutting test by Roller Compactor cum Rut analyser (RCRA) at different temperatures with VG-30 and Modified Bitumen (SBS-70).

V. LABORATORY TEST RESULTS

The laboratory investigation/tests were carried out on different materials used in the research work and the obtained results are as follows:

Table 1
Tests on Aggregates

Sr No	Properties of aggregate	Obtained Test Results	Method adopted	Permissible Limit as Per IS/ MoRTH	Results
1	Cleanliness	3	IS 2386-Part-I	Max, 5% passing 0.075 mm sieve	Satisfactory
2	Specific Gravity	---	IS 2386 Part-III	2.5-3.0	Satisfactory
	Coarse Aggregate	2.70			
	Fine Aggregate	2.64			
3	Water absorption, %, max	0.25	IS 2386 Part-III	2	Satisfactory
4	Impact Value, %, max	16.32	IS 2386 Part-IV	27	Satisfactory
5	Abrasion Value, %, max	14.30	IS 2386 Part-IV	35	Satisfactory
6	Flakiness and Elongation Index, %, max	11.35	IS 2386 Part-I	35	Satisfactory
7	Plasticity Index, (Fine Aggregate)	2.5	IS 2720 Part-V	Max, 4 passing 0.075 mm sieve	Satisfactory

Table 2
Tests on Bitumen and Modified Bitumen

Sr No	Name of the test	Obtained Test Results		Method adopted	Permissible Values as per IS/ MoRTH	Remarks
		VG 30	SBS 70			
1	Specific Gravity, min	1.00	1.15	IS:1203-1978	--	---
2	Penetration test at 25 ^{0} C, 0.1 mm, 100g, (mm), min	64.3	67.0	IS:1203-1978	45	Satisfactory
3	Softening point, (R&B) ºC, min	48	66.5	IS:1203-1978	47	Satisfactory
4	Flash and Fire point, ºC, min	278 & 300	275 & 300	IS:1203-1978	220	Satisfactory
5	Ductility, ºC, min at 27^{0}C, min, cm	86..0	76.0	IS:1208-1978	75	Satisfactory

Table 3
Job Mix Formula (JMF) and Optimum Binder Content (OBC)

Sr No	Type of Bituminous Mix	Bitumen/ Modified Bitumen used	Percentages of Aggregate to be used as per Job Mix Formula (JMF)			OBC obtained based on Marshall Stability Test (%)
			Material A (26.5 mm down)	**Material B** (13.2 mm down)	**Material C** (4,75 mm down)	
1	BC Gr-II	VG-30	15	22	63	5.60
2	DBM Gr-II	VG-30	5	30	65	5.10
		SBS-70	5	30	65	

Fig: Roller Compactor cum Rut Analyzer (RCRA)

Table 4
Results of Marshall Stability Test

Sr No	Marshall Property	BC Gr-II with VG-30	DBM Gr-II	
			VG-30	SBS-70
1	Optimum Binder Content (OBC), %	5.60	5.10	5.10
2	Marshall Stability, kg	2490	1190	1802
3	Flow Value, mm	3.57	3.85	4.10
4	Bulk Density, gm/cc	2.32	2.36	2.35
5	Volume of Voids, %	3.73	3.05	5.10
6	Voids in Mineral aggregate , VMA, %	15.99	18.50	18.18
7	Voids filled with Bitumen, VFB, %	72.43	73.0	60.2

TABLE 5
Rutting Test Results at Different Temperatures for Pavement Layers, using BC GR-II with VG-30 as Wearing Course and DBM GR-II AS Binder Course with VG-30 and SBS-70.

Sr No	Rut Depth (mm)	Number of passes in Roller Compactor Cum Rut Analyzer at different temperature ranges					
		VG-30			SBS-70		
		30 ^{0}C	50 ^{0}C	70 ^{0}C	30 ^{0}C	50 ^{0}C	70 ^{0}C
1	0	0	0	0	0	0	0
2	2	6456	5459	4902	7965	6105	5105
3	4	11322	10458	7952	13400	12010	8956
4	6	15598	15006	12005	18006	16002	11520
5	8	18659	17956	11551	21670	18597	13780
6	10	21322	20300	13658	23045	20890	15550
7	12	22869	21986	14520	25650	22110	16023
8	14	24005	22568	15569	27989	24240	18145
9	16	27120	24355	16520	30768	26010	21890
10	18	28004	25010	17589	33890	27990	23980
11	20	29100	25542	19602	35980	31050	28115

VI. DISCUSSIONS

A. The basic properties on aggregates, bitumen and modified binders are carried out in the laboratory and the materials satisfies the requirements as per the relevant IS / MoRTH standards.

B. The optimum binder Content (OBC) for BC Gr-II with VG-30 is found to be 5.6%, DBM Gr-II with VG-30 is 5.1% and DBM Gr-II with SBS-70 is 5.1% respectively.

C. The stability value of Binder course (DBM Gr-II) with SBS-70 is 52 % higher than VG-30.

D. The Wearing course (BC Gr-II) and Binder Course (DBG Gr-II) prepared with VG-30 at 30^0C shows, 14% and 48% higher resistance to rutting than at 50^0 C and 70^0C respectively.

E. The Modified Bitumen (SBS-70) shows 23%, 22%, 44% higher resistance to rutting at 30^0C, 50^0C, and 70^0C respectively, when compared at respective temperatures with VG 30.

VII. CONCLUSIONS

From the present research work, it can be concluded that:

1) The modified binders shows a higher Marshall stability value when compared with VG-30 bitumen.

2) The use of modified binders (SBS-70) in the binder course layer of pavement shows a high resistance to rutting when compared with VG-30. The percentage of higher resistance is upto 44%.

3) Modified Binders can also be used in Binder course of pavement. The use of modified bitumen makes the structural layer of pavement to have more stability and greater resistance to rutting.

4) As the temperature increases from 30^0 C to 70^0C, the resistance of the pavement layers to rutting also decreases to the extent of 44%.

5) The temperature significantly affects the rutting in pavement. The pavement undergoes higher rutting with increase in temperature.

VIII. ACKNOWLEDGEMENT

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REFERENCES

[1] Veena K, Hema H, Y Aneesha, Sagar I M, Vinod Kumar, Hemanth Prasad G, “Comparative Study of Marshall Stability Test on Dense Bituminous Macadam Layer by Varying number of Blows” International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Volume 8, Issue 6, Page No 732-737, (2019)

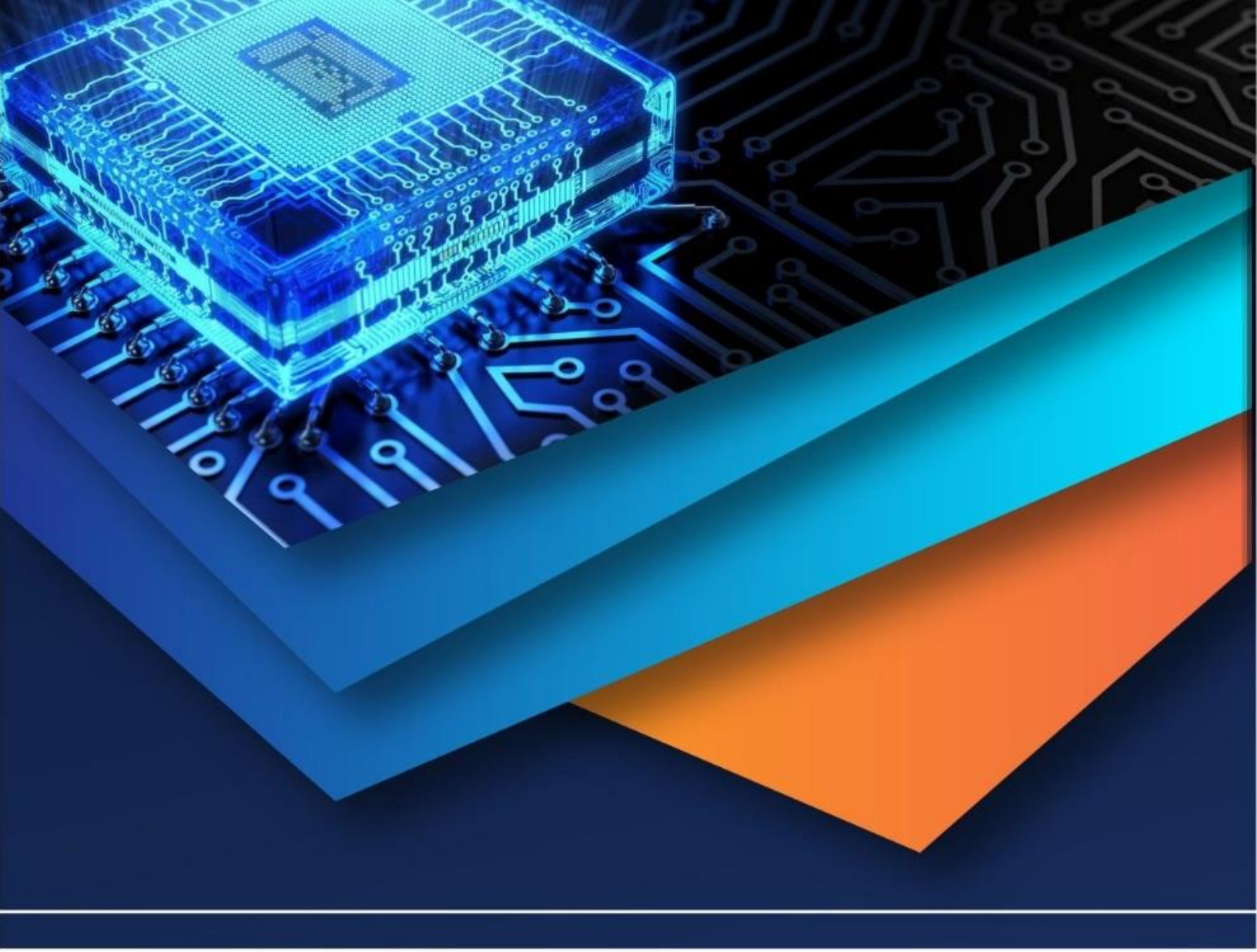
[2] Mohanlal Chandrawal, Goutam Verma, Kapil Kushwah, Vishwajeet Kumar Sharma, “An Experimental Study of Rutting on Dense Bituminous Macadam of Grading-I (Middle) using Crumb Rubber Modified Bitumen and Waste Plastic Coated Aggregates”, International Journal of Research and Scientific Innovation (IJRSI)ISSN: 2321-2705, Volume 3, Issue 12, page No 99-1077, (2016)

[3] Mahesh Kumar B, Dr Manjesh L, “A Comparative Laboratory Studies on the Behaviour of Dense Bituminous Macadam (Grading II) Mix Prepared Using Different Binder and Mineral Fillers” International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056, Volume: 08 Issue: 03, Pg No 767-772, (2021).

[4] Pranay Raj B S, “A Laboratory Study on use of Crumb Rubber Waste in Bituminous Mix – Dry Process”, International Research Journal of Engineering and Technology (IRJET), Volume: 08 Issue: 03, e-ISSN: 2395-0056, Pg No 226-232, (2021)

[5] Lokesh Gupta, “A study on the marshall properties of DBM mix prepared using VG-30 and CRMB-55 as binder materials” International Journal of Research in Engineering and Technology, Volume 05 Issue 03, eISSN: 2319-1163, (2016)

[6] S.K. Khanna, C.E.G. Justo and A. Veeraragavan, “Highway Materials and Pavement Testing.”



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