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RUTTING PERFORAMCE STUDY OF DENSE BITUMINOUS MACADAM (DBM) GRADE-I & GRADE-II MIX BY USING ROLLER COMPACTOR CUM RUT ANALYZER (RCRA)

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Abstract *—Design of bituminous paving mixes is largely a matter of selecting and proportioning the materials to obtain the desired properties. Here, we are Comparing Rutting performance of Dense Bituminous Macadam Gr- I & Gr-II mix by using Roller Compactor Cum Rut Analyze(RCRA). The overall objective is to compare the Marshall Properties and the Rutting Performance of bituminous mix. By using RCRA instrument Rutting performance of Dense Bituminous Macadam of grade I and grade II for pavement temperature 30°C, 50°C and 70°C are found and compared so as to match the actual pavement temperatures at the Field/ Site.*

Keywords-component: Job Mix Formula, Dense Bituminous Macadam(DBM), Optimum Binder Content, Marshall Stability test , Modified Marshall Stability test, Roller Compactor Cum Rut analyzer (RCRA).

I. INTRODUCTION

Bituminous pavement is commonly used all over the world for the construction of both rural and urban roads. Overloading of commercial vehicles than the prescribed limit and increased traffic volume, higher tyre pressure have caused widespread problems with the performance of the pavement.

The desired mix design is to produce a bituminous mix by proportioning various materials so as to have sufficient bitumen to ensure a durable pavement, strength to resist shear deformation under traffic at higher temperature, sufficient air voids in compacted bitumen so as to avoid Rutting and other parameters which causes pavement deterioration.

The Marshall Stability and flow test provides the resistance of bituminous materials to distortion, displacement, rutting and shearing stresses. 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 of 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.

Rutting is the load induced permanent deformation of bituminous pavements and it can occur in any layer of flexible pavement. Rutting or permanent deformation is one of the common distress which is caused due to the continuous application of axle load in the form of longitudinal depression across the wheel path in flexible pavement.

II. OBJECTIVE OF THE STUDY

- To conduct the basic tests on Materials, to find out the Job Mix Formula and Optimum Binder Content for Dense Bituminous Macadam Grade-I & Grade- II Mix.
- To find out Marshall properties i.e.; Stability, Flow value, VFB, VMA, Percentage of voids for both above mixes.
- To find out the Rutting performance of dense bituminous mix of grade I and grade II mix and plastic at different temperatures such as 30°C, 50°C and 70°C so as to match the actual pavement temperatures at field/Site.
- To compare the Marshall properties and Rutting performance of dense bituminous mix of grade I and grade II mix.

III. LITERATURE REVIEW

Prasad [(1)], studied the importance to add the shredded waste plastic bottles to bituminous concrete (BC) mix and to evaluate the various mix properties like Marshall Stability, flow, bulk density, voids in the mix and VFB in 2012. Also the effect of soaking conditions of the mix was investigated. Indirect tensile strength was investigated for OBC and 8% plastic coated on aggregates which had yielded the highest marshal stability. The optimum plastic content for 60/70 and 80/100 grade bitumen was 8%. For both 60/70 and 80/100 grade bitumen with plastic content 8%, the maximum stability was achieved in 80/100 grade bitumen. Hence there is an increase in stability with the addition of PET (polyethylene terephthalate) plastic in asphalt mix by incorporating dry process this can be used in highway construction for better stability for the appropriate traffic.

Sharma D K [(2)], investigated the use of plastic/polymer as modifiers in 2009. The waste plastic/polymer was added on the aggregate before mixing Optimum Binder Content (OBC) in dry process at 150-160 C temperature. This type of mixing increases the bonding between aggregates coated with plastic/polymer which increases the strength of the bituminous concrete mixes. Stability values and indirect tensile strength values were observed to be more in polymer modified bitumen than in conventional bitumen. Rutting values were also higher in polymer modified bitumen mixes than in conventional mixes.

Nitin Prasad and Nagakumar [(3)] conducted experiment on Performance evaluation of dense bituminous macadam mix a refusal density approach. In their journal, they stated about "refusal density" i,e; after compacting a pavement layer by conventional method, due to heavy traffic the pavement layer can further compacted and it reduces the air voids whichis called Residual Density. So in their study they conduct experiment for Marshall Stability by using Hugo hammers by varying blows.

Sheeb [(4)], concluded that the modified mixture has a higher stability and VMA (Void in Mix Aggregate) percentage compared to the non-modified mixtures (in 2007). This, in returns, would positively influence the rutting resistance of these mixtures. The air void contents of the modified mixtures are not far from that of the non-modified one. Air void proportion around4% is not enough to room for the expansion of asphalt binder to prevent bleeding or flushing that would reduce the skid resistance of the pavement and increase rutting susceptibility. In summary, using the poly-ethylene in asphalt mixtures reduces pavement deformation; increase fatigue resistance and provide better adhesion between the asphalt and the aggregates.

Darshna B Joshi [(5)] conducted tests on finding out of Optimum binder content by Marshall mix design for DBM. Bituminous mix design is done to find out the properties of coarse aggregate, filler and binder materials and also mix should be workable, strong, durable and economical. Aggregate gradation and mix design requirements are primary concern in a asphalt mix. Various volumetric parameter and Marshall Stability is different for different mixes. Material tests should be done to make sure that all material satisfies the Indian standards

IV. METHODOLOGY

The following steps are adopted for the present study:

- The Basic Properties of the Coarse Aggregate, Fine aggregate and Bituminous Binder are found out in the laboratory as per codal provision to check the suitability of aggregates to be used in bituminous mix.
- Job Mix Formula (JMF) and Optimum Bonder Content (OBC) is obtained for Dense Bituminous Macadam (DBM) Gr-I and Gr-II Mix.
- Marshall Stability test & Modified Marshall Stability Tests are conducted on both grades of DBM Mix to find out the Marshall Properties.
- Rutting Test is carried out in the laboratory using Roller Compactor Cum rut analyzer (RCRA) in the Laboratory and the obtained Results are compared.

V. LABORATORY INVESTIGATION

Test results for basic properties of materials are as follows:

TABLE 1: PROPERTIES OF COARSE AGGREGATE

Sl No	Properties Tested	Obtained Results (40mm & 20mm)	Obtained results (12.5mm)	Permissible Limit (as per MoRTH)	Remarks
1	Aggregate impact value	16.32%	12.00%	27%	Satisfactory
2	Los Angeles Abrasion value	14.30%	22.40%	35%	Satisfactory
3	Specific Gravity	2.53	2.60	2.5-3.0	Satisfactory
4	Water Absorption	0.25 %	0.35%	2%	Satisfactory
5	Combined Flakiness & Elongation Index	11.35%	5.18%	35%	Satisfactory
6	Angularity Number	7	10	<11	Satisfactory

TABLE 2: PROPERTIES OF BITUMEN

Sl No	Properties Tested	Obtained Results	Permissible limit	Remarks
1	Penetration test	64.3	40-100	Satisfactory
2	Softening point ^{0}C	48	35-70	Satisfactory
3	Flash and fire point ^{0}C	278 and 300	220 min	Satisfactory
4	Ductility (mm), min	96	50	Satisfactory
5	Specific Gravity	1.00	0.97-1.02	Satisfactory

TABLE 3: JOB MIX FORMULA (JMF) FOR DBM GRADE-II & GRADE-I MIX

Sl No	Job Mix Formula for DBM Gr-II (Percentage Blend)			Job Mix Formula for DBM Gr-I (Percentage Blend)			
1	20 mm & Down Size Aggregate	12.5 mm & Down Size Aggregate	Fine Aggregate (Dust)	40mm & Down Size Aggregate	20 mm & Down Size Aggregate	12.5mm & Down Size Aggregate	Fine Aggregate (Dust)
	5%	**30%**	**65%**	**10%**	**8%**	**24%**	**58%**

TABLE 4: MARSHALL TEST RESULTS FOR DENSE BITUMINOUS MACADAM GRADE- II

Sl No	Percentage of Bitumen	Unit Weight (gm/cc)	Stability (Kg)	Flow value (mm)	Vv(%)	VMA(%)	VFB((%)	Optimum Binder Content % (OBC%)
1	4.0	2.290	945.5	3.09	3.80	15.50	68.10	**5.10%**
2	4.5	2.325	1080.0	3.60	3.65	16.90	70.20	
3	5.0	2.360	1185.0	3.85	3.05	18.50	73.10	
4	5.5	2.345	1230.5	4.40	2.65	19.10	75.50	
5	6.0	2.305	1145.0	4.55	2.10	19.40	77.70	

TABLE 5: MARSHALL TEST RESULTS FOR DENSE BITUMINOUS MACADAM GRADE- I

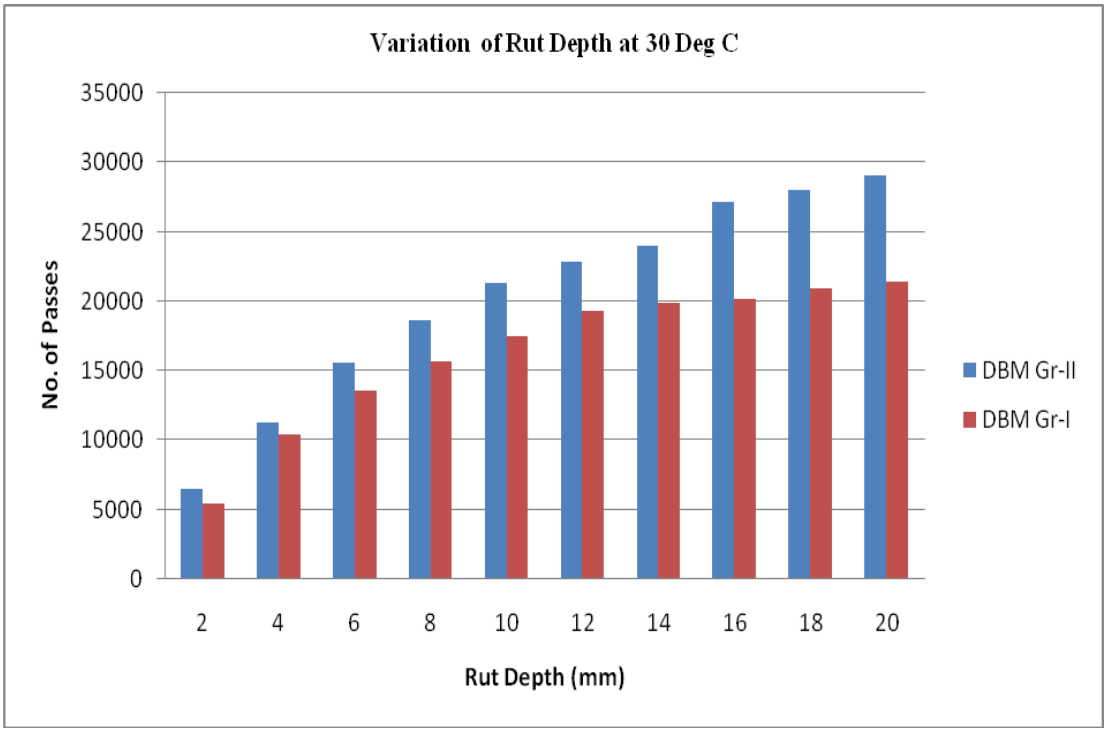
Sl No	Percentage of Bitumen	Unit Weight (gm/cc)	Stability (Kg)	Flow value (mm)	Vv(%)	VMA(%)	VFB((%)	Optimum Binder Content % (OBC%)
1	3.00	2.210	925.0	3.20	4.60	17.50	62.00	
2	3.50	2.240	1005.0	3.55	4.20	18.60	67.50	
3	4.00	2.265	1140.5	3.76	3.90	20.12	72.00	**4.40 %**
4	4.50	2.310	1162.5	4.15	3.65	23.50	74.30	
5	5.00	2.255	1100.0	4.40	3.20	24.60	78.20	

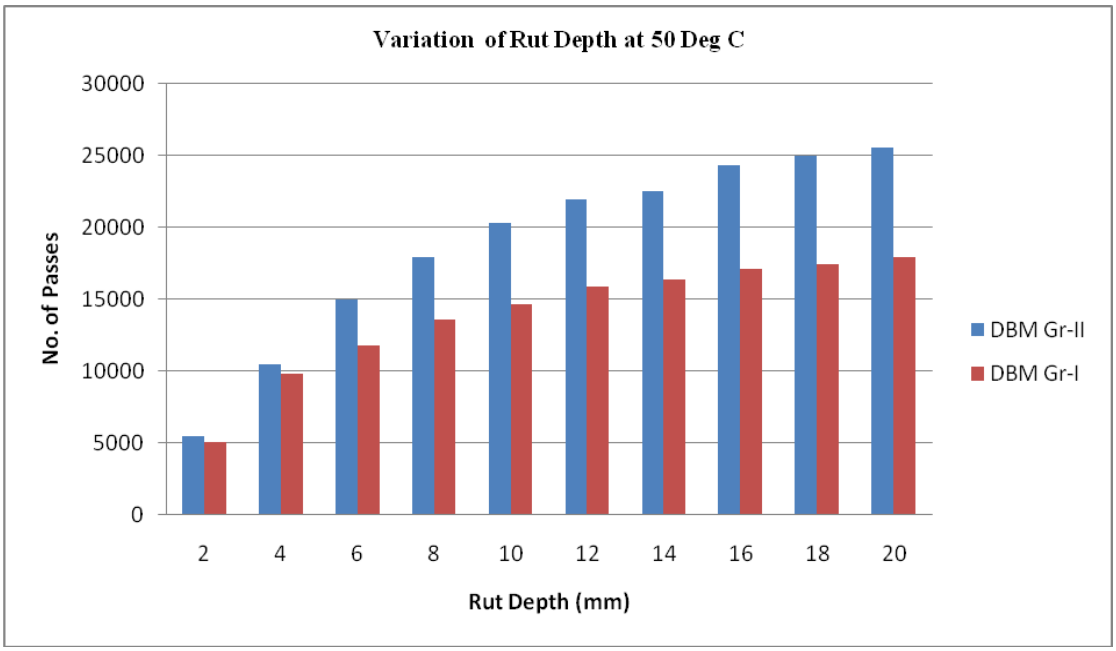
TABLE 6: MARSHALL PROPERTIES FOR DBM Gr-II and Gr-I MIX FOR OPTIMUM BINDER CONTENT (OBC)

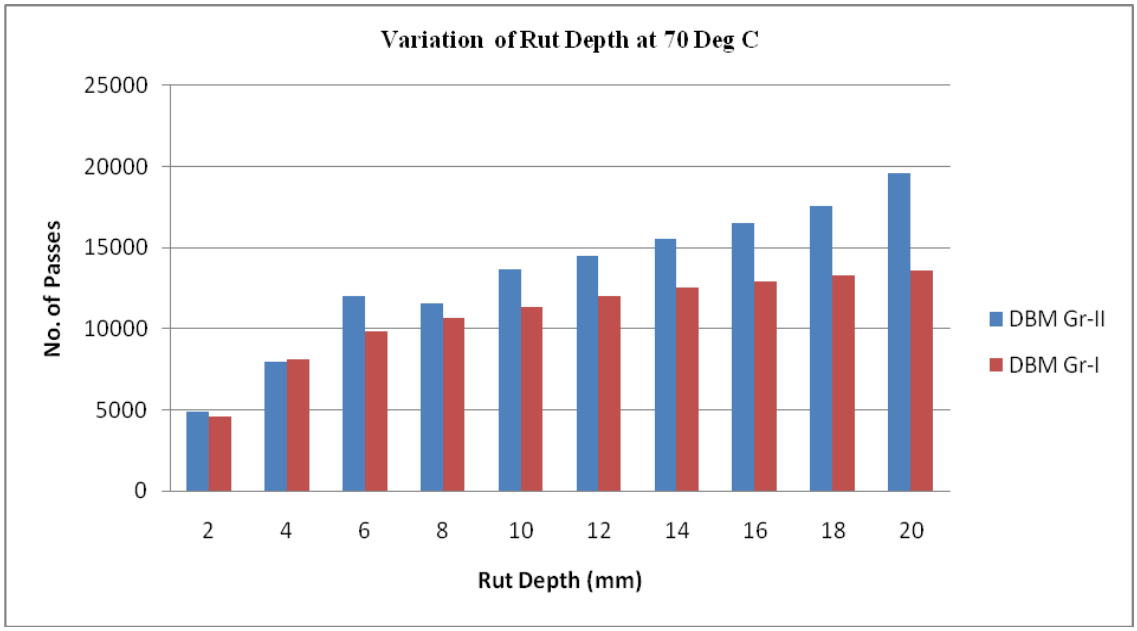
Type of DBM	OBC (%)	Unit weight (g/cc)	Stability (kg)	Flow value (mm)	Vv (%)	VMA (%)	VFB (%)
DBM Gr- II	5.10 %	2.360	1190.0	3.85	3.05	18.50	73.0
DBM Gr-I	4.40%	2.295	1158.0	4.15	3.65	23.40	72.8

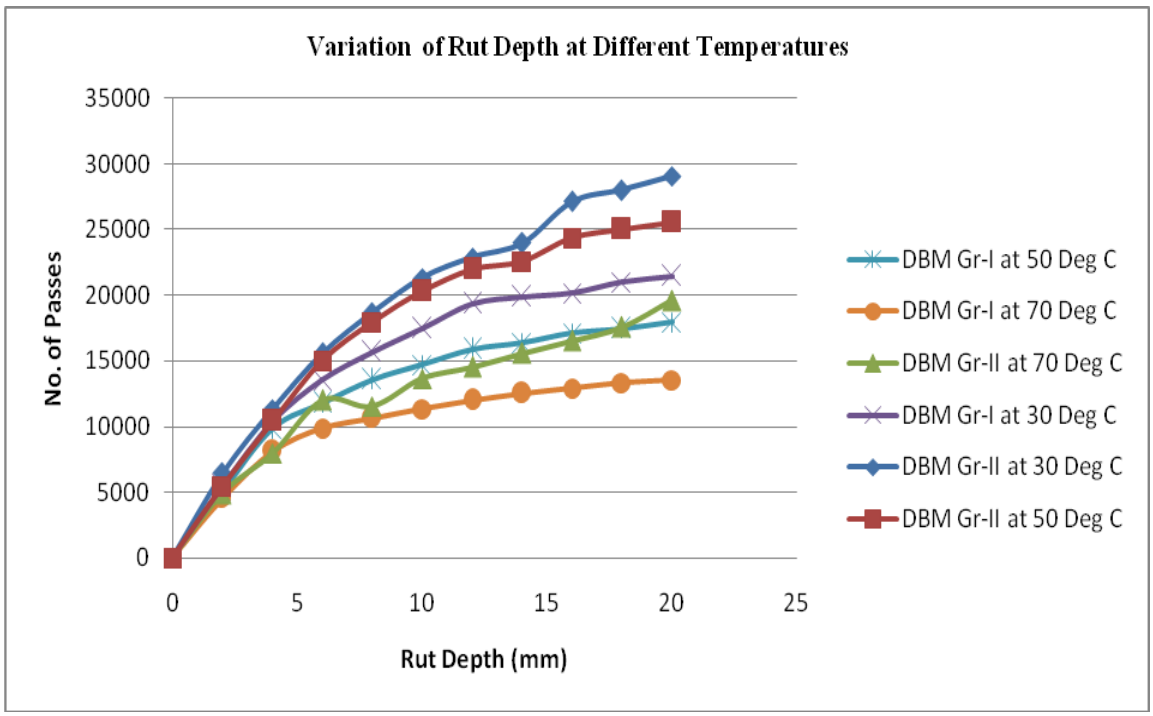
TABLE 7: RUTTING TEST RESULTS FOR DBM GR-II & GR-I AT DIFFERENT TEMPERATURES

Sl No	Rut Depth (mm)	Number of passes required in Roller Compactor Cum Rut Analyzer at different temperature ranges					
		DBM GR-II			DBM GR-I		
		30^0C	50^0C	70^0C	30^0C	50^0C	70^0C
1	0	**0**	**0**	**0**	**0**	**0**	**0**
2	2	6456	5459	4902	5489	5102	4550
3	4	11322	10458	7952	10421	9865	8123
4	6	15598	15006	12005	13556	11775	9863
5	8	18659	17956	11551	15698	13569	10658
6	10	21322	20300	13658	17453	14710	11338
7	12	22869	21986	14520	19335	15890	11989
8	14	24005	22568	15569	19865	16358	12530
9	16	27120	24355	16520	20156	17102	12896
10	18	28004	25010	17589	20985	17450	13325
11	20	29100	25542	19602	21465	17950	13556









VI. CONCLUSION

Following conclusions are drawn on the basis of present investigation studies:

1. Basic properties of coarse aggregates, fine aggregate and bituminous binders are tested and the Materials satisfy to satisfy the Requirements of MoRTH.
2. The Obtained Job Mix Formula (JMF) for DBM Grade-II is **05%: 30%: 65%** and the Optimum Binder Content(OBC) is **5.10%**.
3. The Obtained Job Mix Formula (JMF) for the DBM Grade-I is **10% :08%: 24%: 58%** and the Optimum Binder Content(OBC) is **4.40%**
4. It is observed that the Maximum Marshall Stability value increases for DBM Gr-II is 1190 kg and Density of 2.36 gm/cc, and for DBM Gr-I , it is 1158 kg and Density of 2.295gm/cc. Hence it can be concluded that DBM Gr-II offers higher stability and Density than DBM Gr-I Mix.
5. DBM Gr-II has a less flow Value (mm) and Volume of Voids (%) than DBM Gr-I Mix
6. The Rutting occurs 12% faster at 50^0 C and 32.6% faster at 70^0 C when Compared with 30^0c to cause a 20 mm Rut depth in DBM Gr-II Mix.
7. The Rutting occurs 16..4% faster at 50^0 C and 36.8% faster at 70^0 C when Compared with 30^0c to cause a 20 mm Rut depth in DBM Gr-I Mix.
8. It can be Concluded that DBM Gr-I deteriorates in the form of Rutting at a faster rate of 26.2%, 29.2% and 30.8% than DBM Gr-II at 30^0C, 50^0C and 70^0C respectively.
9. It can be Concluded that the increase in Pavement temperature severely effects/increases the Rutting on the pavement Surface.

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1. Marshall Specimens

2.Rutting Specimen

3. Roller Compactor Cum Rut Analyzer (RCRA) Machine