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COMPARITIVE STUDY OF BITUMINOUS CONCRETE GRADE-II MIX BY PARTIAL REPLACEMENT OF PLASTIC AGGREGATE

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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 using the Plastic Aggregates in the bituminous concrete mix. The overall objective is to compare the bituminous concrete mix with and without using Plastic Aggregates in BC grade- II. In this work, the task is to compare the Marshall Properties of Bituminous concrete (BC) grade-II mix by using Conventional Aggregate and Partially replacement of Conventional aggregate by Plastic aggregate.

Keywords-component: Job Mix Formula, Plastic Aggregates, Bituminous concrete mix, Optimum Binder Content, Marshall Stability test.

I. INTRODUCTION

Bituminous pavement is extensively used in world 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, have caused widespread problems with the performance of the pavement.

The mix design is to produce a bituminous mix by proportioning various components 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 to avoid flushing and bleeding under traffic load and sufficient workability to provide easy placement without segregation.

The Marshall Stability and flow test provides the performance prediction measure for the Marshall mix design method. It is related to 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.

Waste trash bag plastic are collected from the land fill and from other locations and are used to manufacture light weight aggregates. The plastic waste aggregates are modified by heat treatment (160˚C-200˚C) in plastic granule recycling machine. Then, the hot aggregates are removed from the machine and are allowed to cool at room temperature. And obtained plastic granules are grinded in a grinding mill to a 20mm down size.

II. OBJECTIVE OF THE STUDY

- To conduct the basic tests on Materials, to find out the Job Mix Formula and Optimum Binder Content for Bituminous Concrete (BC) Grade-II Mix.
- To find out Marshall properties i.e.; Stability, Flow value, VFB, VMA, Percentage of voids for conventional and partially replaced aggregates of Bituminous Concrete (BC) Grade-II Mix.
- To compare the Marshall test results of Virgin aggregates and partial replacement of aggregates by plastic aggregate in Bituminous Concrete 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.

Justo [(3)] ,reported the possible use of the processed plastic bags as an additive in bituminous concrete mixes at the Centre for Transportation Engineering of Bangalore University in 2002.The properties of the modified bitumen were compared with ordinary bitumen. It was observed that the penetration and ductility values of the modified bitumen decreased with the increase in proportion of the plastic additive, up to 12 % by weight. Therefore the life of the pavement surfacing course using the modified bitumen is also expected to increase substantially in comparison to the use of ordinary bitumen.

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.

Tayde [(5)] ,intended to find the effective ways to reutilize the hard plastic waste particles as bitumen modifier for flexible pavements. The use of recycled waste plastic in pavement asphalt represents a valuable outlet for such materials. The use of modified bitumen with the addition of processed waste plastic of about 5-10% by weight of bitumen helps in substantially improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous concrete mix, resulting which improves the longevity and pavement performance with marginal saving in bitumen usage. The process is environment friendly. The use of waste plastics in the manufacture of roads and laminated roofing also help to consume large quantity of waste plastics. Thus, these processes are socially highly relevant, giving better infrastructure.

IV. METHODOLOGY

The following steps are adopted for the present study:

- The Basic Properties of the Conventional Coarse Aggregate, Fine aggregate, Plastic 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 Conventional Aggregate and Partially replacing the Conventional aggregate by Plastic aggregate.
- Marshall Stability test is conducted on both the Specimens to find out the Marshall Properties of bituminous mix.

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 (20mm)	Obtained results (12.5mm)	Permissible Limit (as per MoRTH)	Remarks
1	Aggregate impact value	12.54%	14.32%	27%	Satisfactory
2	Los Angeles Abrasion value	16.84%	28.66%	35%	Satisfactory

3	Specific Gravity	2.65	2.67	2.5-3.0	Satisfactory
4	Water Absorption	0.20 %	0.30%	2%	Satisfactory
5	Combined Flakiness & Elongation Index	11.35%	5.18%	35%	Satisfactory
6	Angularity Number	8	10	<11	Satisfactory

TABLE 2: PROPERTIES OF BITUMEN

SL No	Properties Tested	Obtained Results	Permissible limit	Remarks
1	Penetration test	65	40-100	Satisfactory
2	Softening point ^{0}C	46	35-70	Satisfactory
3	Flash and fire point ^{0}C	276 and 300	220 min	Satisfactory
4	Ductility (mm), min	96	50	Satisfactory
5	Specific Gravity	1.02	0.97-1.02	Satisfactory

TABLE 3: JOB MIX FORMULA (JMF) FOR BC GRADE-II BY USING CONVENTIONAL AGGREAGTES

Sl No	Sieve Size, mm	Percentage passing of Material , 20mm Aggregate	Percentage passing of Material , 12.5 mm Aggregate	Percentage Passing of Material, Dust (Fine Aggregate)	Permissible Limit as per MoRTH	Mid Point Gradation	Obtained Gradation
		15%	**22%**	**63%**			
1	19.00	100.00	100.00	100.00	100	100	**100.00**
2	13.20	16.09	99.52	100.00	79-100	89.5	**87.3**
3	9.50	0.14	70.43	100.00	70-88	79	**78.5**
4	4.75	0.00	1.42	98.16	53-71	62	**62.1**
5	2.36	0.00	0.00	77.76	42-58	50	**48.9**
6	1.18	0.00	0.00	57.76	34-48	41	**36.3**
7	0.60	0.00	0.00	50.60	26-38	32	**31.8**
8	0.30	0.00	0.00	37.00	18-28	23	**23.3**
9	0.15	0.00	0.00	23.48	12-20	16	**14.79**

10	0.075	0.00	0.00	7.08	4-10	7	**4.46**

PERCENTAGE BLEND: 15%: 22%:63%

GRAPH 1: GRAPH SHOWING COMBINED AGGREGATE GRADATION

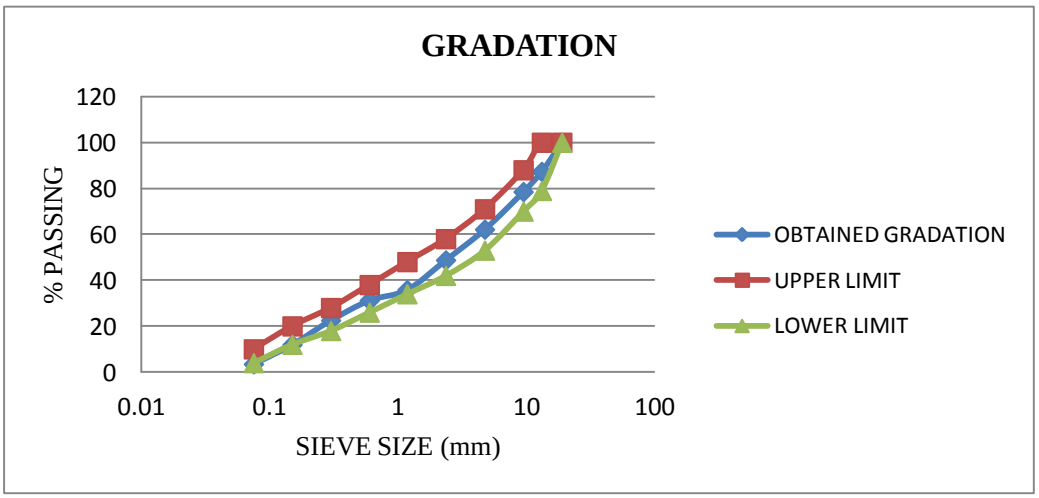
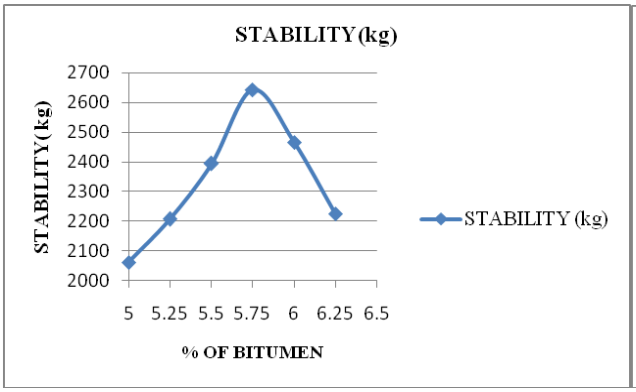


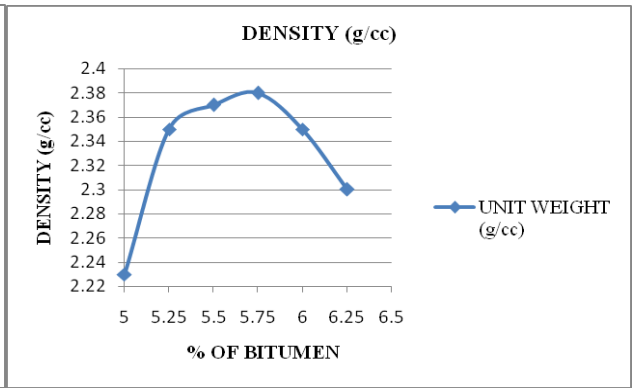
TABLE 4: MARSHALL TEST RESULTS FOR BITUMINOUS CONCRETE GRADE- II

Percentage of Bitumen	Unit weight (g/cc)	Stability (kg)	Flow value (mm)	Vv (%)	VMA (%)	VFB (%)	Average OBC (%)
5.00	2.32	2062	3.30	5.72	16.52	65.36	
5.25	2.35	2207	3.41	4.91	16.31	67.89	
5.50	2.37	2394	3.53	4.01	16.04	71.95	5.60
5.75	2.38	2643	3.62	3.32	15.94	73.15	
6.00	2.35	2466	3.65	3.00	15.63	76.44	
6.25	2.30	2226	3.70	2.67	15.01	78.40	

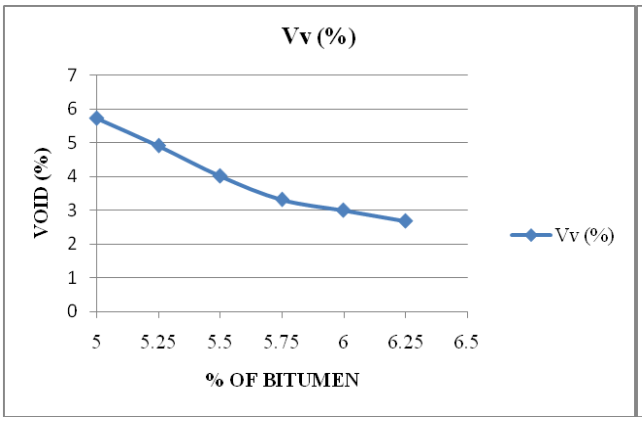
GRAPH 2: GRAPH SHOWING STABILITY VALUES



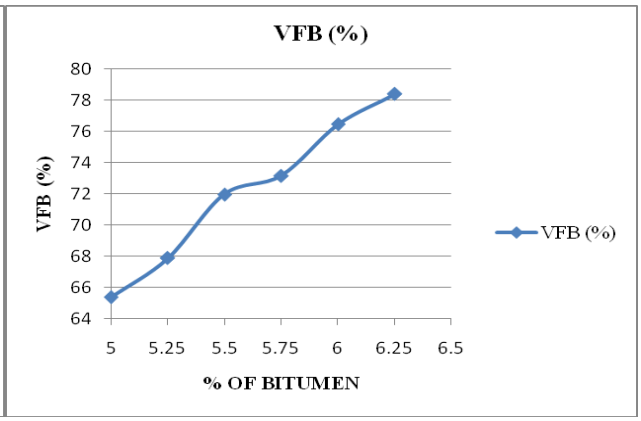
GRAPHS 3: GRAPH SHOWING DENSITY VALUES



GRAPH 4: GRAPH SHOWING % OF VOIDS



GRAPH 5: GRAPH SHOWING % OF VFB



GRAPH 6: GRAPH SHOWING FLOW VALUES

GRAPH 7: GRAPH SHOWING VMA VALUE VALUES

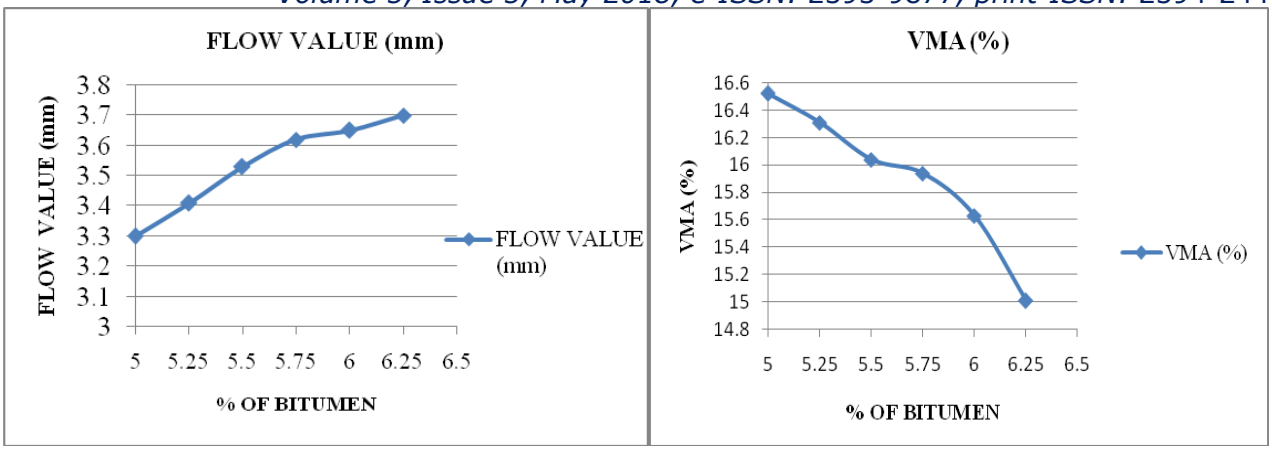


TABLE 5: MARSHALL PROPERTIES OF CONVENTIONAL MIX FOR OBC OF 5.60%

Percentage of Bitumen	Unit weight (g/cc)	Stability (kg)	Flow value (mm)	Vv (%)	VMA (%)	VFB (%)
5.60	2.37	2495	3.56	3.80	16.0	72.5

TABLE 6: PROPERTIES OF PLASTIC COARSE AGGREGATE

SL No	Properties Tested	Obtained Results (on 20mm aggregate only)	Permissible Limit (as per MoRTH	Remarks
1	Aggregate impact value	4.5%	27%	Satisfactory
2	Los Angeles Abrasion value	8.5%	35%	Satisfactory
3	Water Absorption	0.2%	2%	Satisfactory
4	Combined Flakiness & Elongation Index	9.50%	35%	Satisfactory
5	Angularity Number	3	<11	Satisfactory

TABLE 7: JOB MIX FORMULA (JMF) FOR BC GRADE-II BY PARTIALLY REPLACMENT OF CONVENTIONAL AGGREAGTES BY PLASTIC AGGREAGTES

Sl.no	Sieve size (mm)	Percentage passing of material A	Percentage passing of material B	Percentage passing of material C	Permissible limits as per morth	Midpoint gradation	Obtained gradation
		15%	**17%**	**68%**			
1	19.00	100.00	100.00	100.00	100	100	**100.00**
2	13.20	75.14	99.52	100.00	79-100	89.5	**96.19**
3	9.50	16.38	70.43	100.00	70-88	79	**82.43**
4	4.75	0.86	1.42	98.16	53-71	62	**67.12**
5	2.36	0.28	0.00	77.76	42-58	50	**52.92**
6	1.18	0.20	0.00	57.76	34-48	41	**39.31**
7	0.60	0.16	0.00	50.60	26-38	32	**34.43**
8	0.30	0.12	0.00	37.00	18-28	23	**25.18**
9	0.15	0.08	0.00	23.48	12-20	16	**13.94**
10	0.075	0.04	0.00	7.08	4-10	7	**4.82**

PERCENTAGE BLEND: 15%: 17%:68%

TABLE 8: MARSHALL PROPERTIES OF PLASTIC AGGREGATES FOR OBC OF 5.60%

Percentage of Bitumen	Unit weight (g/cc)	Stability (kg)	Flow value (mm)	Vv (%)	VMA (%)	VFB (%)
5.60	1.74	4800	12.6	4.02	12.37	67.50

VI. CONCLUSION

Following conclusions are drawn on the basis of laboratory investigation.

1. Basic properties of coarse aggregates, fine aggregate, plastic aggregates and bituminous binders are tested to satisfy the Requirements as per MoRTH.
2. The Obtained Job Mix Formula (JMF) for the BC Grade-II (using conventional aggregates) is **15%:22%:63%** and the Optimum Binder Content(OBC) is **5.60%**.
3. The Obtained Job Mix Formula (JMF) for the BC Grade-II (using Plastic aggregates) is **15%:17%:68%** and the Optimum Binder Content(OBC) is **5.60%**.
4. It is observed that the Marshall Stability value increases by **92.38%** (1.92 times), Flow Value increases by **353.9%** (3.53 times) when Plastic aggregates are used.
5. Also there is Slight increase in the Volume of Voids (Vv) by 5.79% when plastic aggregates are used.
6. It can be concluded from the above Test Results that there is a significant increase in the Marshall Stability and Flow Value which greatly enhances the resistance of the Bituminous mix against the Pavement Deterioration .

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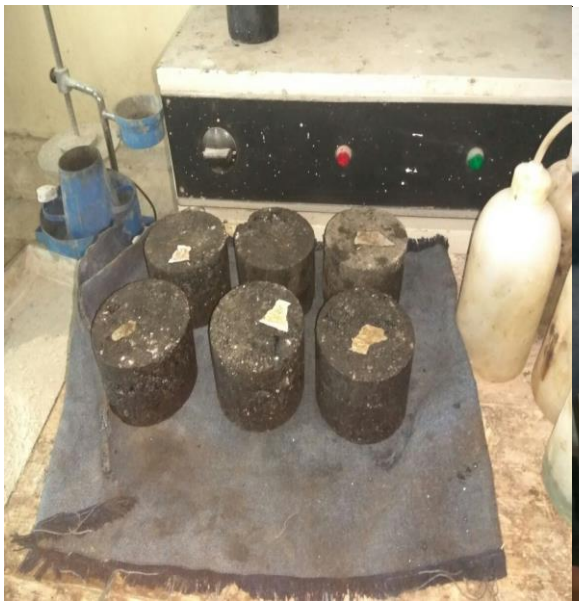
1. Specific Gravity Test Conducted For Aggregate

2.Sieve Analysis

4. Plastic Aggregates

5. Prepration of Marshall Specimens



6. Casted Marshall Specimens

7. Marshall stability test