

Reduction of optimum bitumen content in bituminous mixes using plastic coated aggregates

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Abstract: Use of plastic in road construction is gaining importance these days because plastic roads perform better than ordinary roads and the plastic waste, otherwise considered to be a pollution menace can find its use. This paper deals with the investigations of the use of waste plastic for coating of aggregates in the bituminous mix. Optimum bituminous mixes are designed using ordinary aggregate and plastic coated aggregate. The comparative study of the mixes is also presented.

Keywords: Aggregate, bitumen, optimum bitumen content, mix design

I. INTRODUCTION

Looking forward the scenario of present life style a complete ban on the use of waste plastic cannot be put, although the waste plastic taking the face of a devil for the present and the future generation. But the use of waste plastics in road construction is gaining importance these days because plastic roads perform better than ordinary ones and the plastic waste considered to be a pollution menace, can find its use. This paper investigates the use of waste plastic for coating the aggregates of the bituminous mix to improve its performance characteristics and to design an optimum bituminous mix. Recycled polythene carry bags were shredded into small sizes and is coated on aggregates of the mix at specified temperature. Bituminous mixes were prepared with 60/70 bitumen and plastic coated aggregates/ordinary aggregates with cement as a filler material. Marshall Method is adopted for the mix design.

II. LITERATURE REVIEW

The concept of utilization of waste plastic in the construction of pavements has been done for more than fifteen years. A common method to improve the quality of bitumen is to add polymers at specified temperature to the hot bitumen. Polymer modified bitumen has better resistance to water which reduces the stripping of bitumen from aggregate. Zoorab and Suparna reported the use of waste plastic in plain bituminous concrete. Sabina et al. investigates the benefits of coating the aggregate with waste plastic and it is reported that significant improvements were observed in the performance parameters of bituminous roads with plastic coated aggregates. Bindu et al. explains the benefits of stabilising the stone mastic asphalt mixture in flexible pavement with shredded waste plastic. Amit Gawande et al. investigates the use of waste plastic in road construction as an effective way to reutilise the plastic waste. Again it is reported that in Tamil Nadu lengths of road around 1000m in various stretches were constructed using waste plastic as an additive in bituminous mix under the scheme "1000km plastic tar road" and found that the performance of all the roads are satisfactory. However standard specifications are not available on the use of waste plastic in bituminous road construction. In this regard IRC was specially requested by NRRDA for the preparation of such guidelines for enabling the construction of rural roads under PMGSY using waste plastic.

III. MATERIALS AND PROPERTIES

The materials used for the preparation of mix are

A. Aggregates.

Aggregate was obtained from a local quarry and the physical properties were tested in the laboratory and are given in Table 1. To get the required gradation, three grades (A,B,C) of aggregates were used. The grading curves are shown in Fig 1 to.3

TABLE 1
 PROPERTIES OF AGGREGATES

Sl.No	Property	Test result	Remarks
1	Aggregate crushing value	30.8%	satisfactory
2	Impact value	30%	
3	Specific gravity	2.7	
4	Los Angeles Abrasion value	32.3%	
5	Flakiness Index	13.48%	
6	Elongation index	8.87%	
7	Water absorption	0.4%	
8	Soundness	10%	
9	Stripping value	0%	

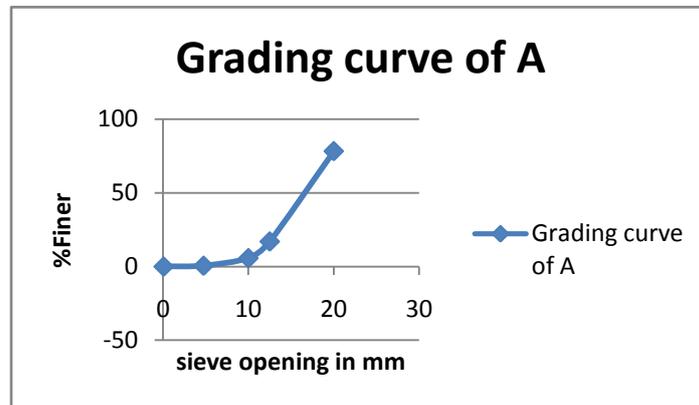


Fig. 1 Grading curve of aggregate A

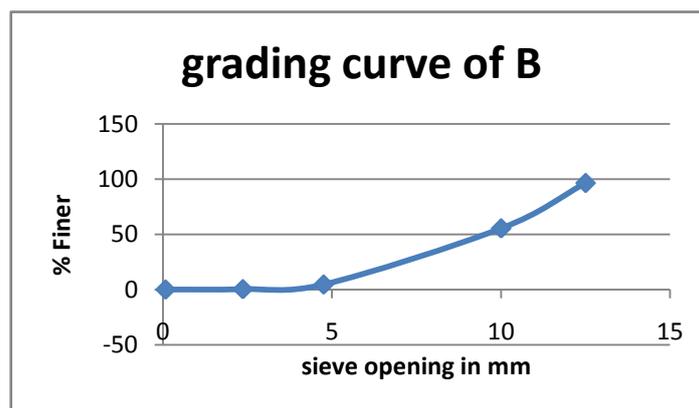


Fig. 2 Grading curve of aggregate B

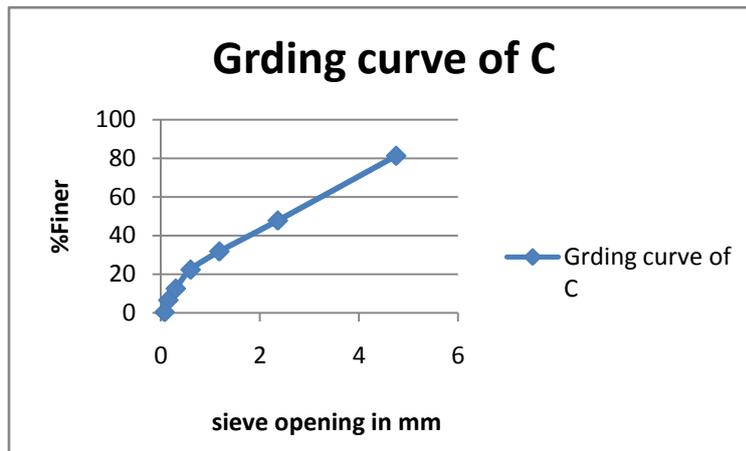


Fig. 3 Grading curve of aggregate C

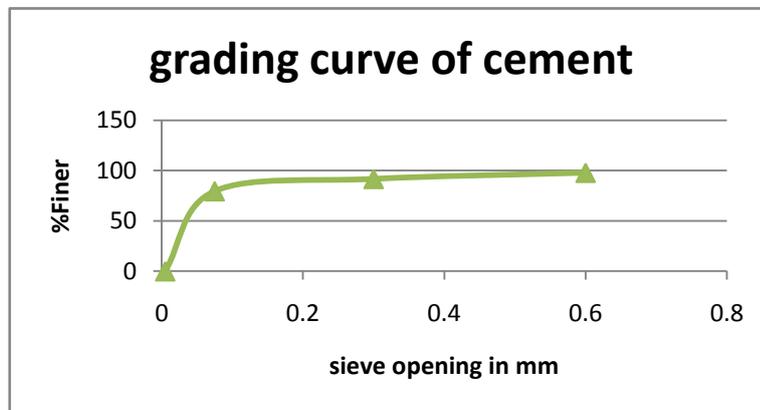


Fig 4. Grading curve of cement

B. Bitumen.

60/70 bitumen was obtained from Cochin refineries Ltd. The physical properties of this bitumen are shown in Table 2.

C. Plastic.

The waste plastic used was polythene carry bags (less than 30microns) collected from the nearby locality. It was shredded in a shredding machine (particle size 2-3mm).

D. Filler.

Ordinary Portland cement was used as the filler material. The gradation of cement is shown in Fig 4.

TABLE.2
PROPERTIES OF BITUMEN

Sl.No	Property	Test result	Remarks
1	Softening point of bitumen	41 ⁰ C	satisfactory
2	Ductility Value	82cm	
3	Specific gravity of bitumen	1.0	
4	Penetration Value	65	
5	Viscosity of bitumen	72sec	

E. Plastic coated aggregates.

The aggregate was heated to a temperature 140-150°C. The shredded plastic was added to the hot aggregate with constant mixing to have a uniform distribution. The plastic softened and coated over aggregate. Its properties were tested and are given in Table 3.

TABLE 3: PROPERTIES OF PLASTIC COATED AGGREGATE

Sl.No	Property	Test result	Remarks
1	Aggregate crushing value	29.8%	satisfactory
2	Impact value	27%	
3	Specific gravity	2.73	
4	Los Angeles Abrasion value	31.3%	
5	Flakiness Index	12.48%	
6	Elongation index	9.87%	
7	Water absorption	0%	
8	Soundness	3%	
9	Stripping value	Nil	

F. Marshall method of mix design

The mix design should aim at an economical blend, with proper gradation of aggregates and adequate proportion of bitumen so as to fulfil the desired properties of mix.

1) Proportioning of aggregates.

It is done by Rutherford method and different proportions are shown below:

Aggregate A- 15%

Aggregate B- 32%

Aggregate C- 51%

Cement- 2% (filler)

The final gradation of the mix with the requirement of MOST (Ministry Of Surface Transport) is shown in Table 4

TABLE 4: RESULTING GRADING

Sieve opening(mm)	% Finer	MOST specifications	Remarks
26.5	100	100	satisfactory
19	97	90-100	satisfactory
9.5	71	56-80	satisfactory
4.75	41	35-65	satisfactory
2.36	24	23-49	satisfactory
0.3	5	5-19	satisfactory
0.075	3	2-8	satisfactory

2) Preparation of Test Specimen

The standard specimens were prepared with ordinary aggregate and plastic coated aggregate at different percentages of bitumen as per specifications. Three specimens of each were prepared and tested.

3) Properties of Compacted specimens.

The various properties tested are specific gravity, percentage air voids (V_v), percentage Voids in Mineral Aggregate(VMA), percentage Voids Filled with Bitumen(VFB) and bulk density. The variations of these properties with %bitumen are shown in Fig 5 to 9. The test results for different specimens are shown in Table 5.

TABLE 5
MARSHALL PROPERTIES

Bitumen by weight of mix(%)	Bitumen by weight of aggregate(%)	Specific gravity		Volume % total			Voids %		
		Bulk average	Theo.m ax.	Bitumen	Aggregate	Voids	VMA	VFB	Vv
4	4.2	2.43	2.53	10.206	86.22	3.574	14.156	69.99	3.95
4-plastic	4.2	2.3	2.53	9.66	81.61	8.73	18.75	51.52	9.09
4.5	4.7	2.46	2.508	11.23	84.33	3.97	15.93	70.49	2.7
4.5-plastic	4.7	2.39	2.508	11.23	84.35	3.97	15.93	56.3	4.9
5	5.3	2.355	2.488	12.48	82.6	4.92	17.83	72.09	5.35
5-plastic	5.3	2.22	2.488	11.77	77.86	10.37	22.54	64	10.77

1) Determination of Optimum bitumen content.

Marshall Stability test was conducted for different percentages of bitumen on ordinary aggregate mix and plastic coated aggregate mix .The results are shown in Table 6

IV. TEST RESULTS AND ANALYSIS.

The physical properties of plastic coated aggregates are shown in Table 6. It is seen that the properties like water absorption, stripping value and soundness are improved using plastic coated aggregate. The optimum bitumen content is calculated based on the graphs plotted with bitumen content on X-axis and the values of the following parameters on Y-axis(Fig 5 to 9)

TABLE 6: MARSHALL TEST RESULTS

Bitumen by wt. Of mix	Bitumen by wt. Of aggregate	Marshall stability value	Flow value (mm)
4	4.2	1135.78	2.283
4-plastic	4.2	2299.488	3.7
4.5	4.7	1450.444	3.86
4.5-plastic	4.7	2737.008	5.10
5	5.3	906.315	5.15
5-plastic	5.3	2091.59	6.0

- %voids in total mix
- Unit weight
- %voids Filled with Bitumen (VFB)
- Marshall stability value
- Flow value

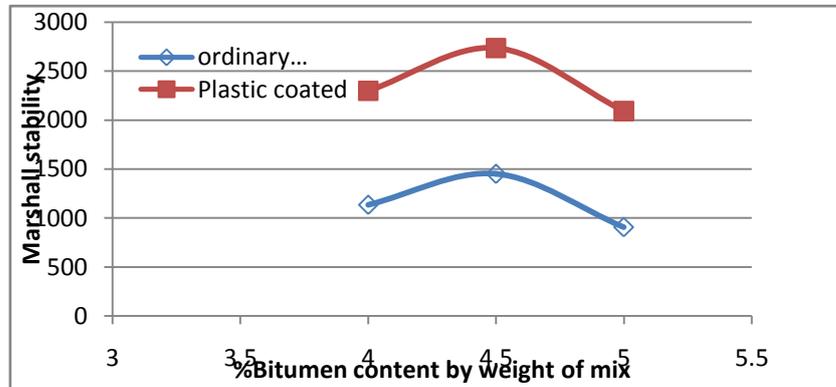


Fig. 5 Variation of Marshall Stability with % bitumen content

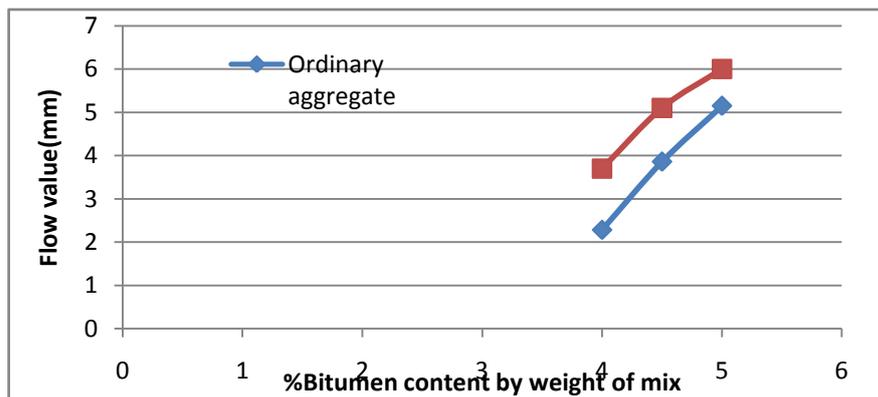


Fig. 6 Variation of flow value with % bitumen content by weight of mix

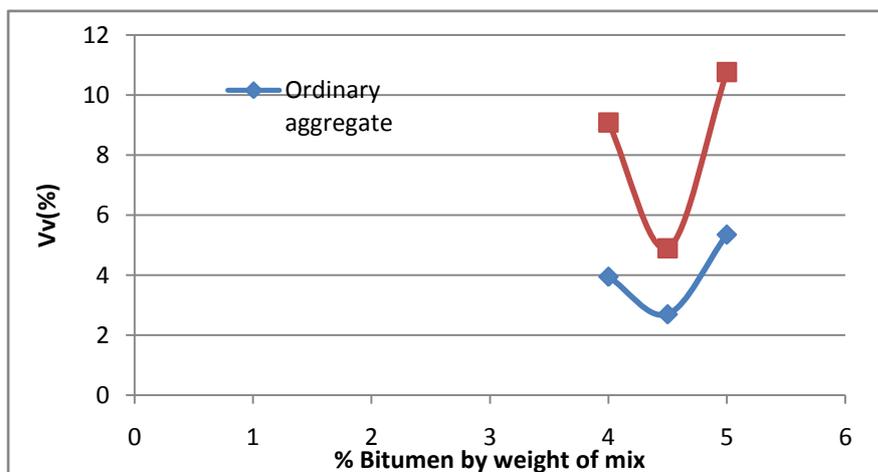


Fig.7 variation of % Vv with % bitumen content

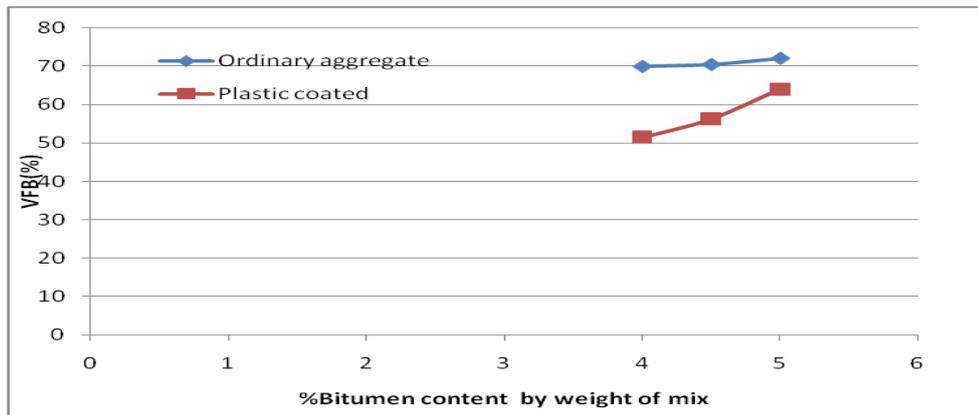
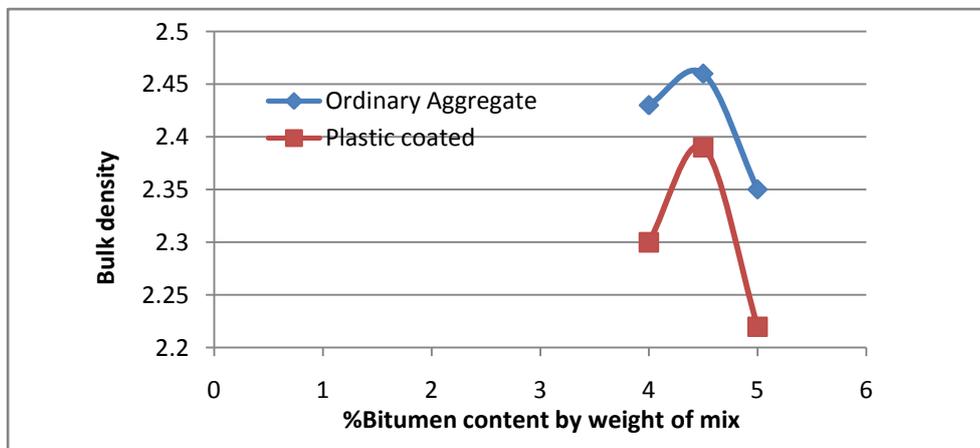


Fig.8 Variation of % VFB with % bitumen content by weight of maix



The optimum bitumen content is calculated by taking the average of the following bitumen contents found from the respective graphs.

- Bitumen content corresponding to maximum stability
- Bitumen content corresponding to maximum unit weight
- Bitumen content corresponding to the median of designed limits of percentage voids (V_v) in the total mix.

The value of optimum bitumen content is :

- ❖ Ordinary aggregate mix 4.658%
- ❖ Plastic coated aggregate mix 4.583%

V. CONCLUSION

With a view to improve the pavement characteristics of the flexible pavement using plastic coated aggregates, the following conclusions are made.

- The properties of aggregates which mainly cause rutting action are improved using plastic coated aggregates.
- Considerable increase in Marshall Stability value.
- The optimum bitumen content is reduced.
- Above all the waste plastic which is a pollution menace can find its use in road construction and thereby solving the problem of pollution to a certain extent.

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