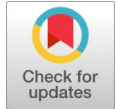


Crumb Rubber: A sustainable road paving material

Minati Mohanty, Sagarika Panda



Abstract: In the Present Scenario, the use of automobiles has increased significantly and due to that the waste or scrap tyres are also increasing day by day. The waste tyres are classified as solid waste. The proper disposal of these waste tyres has become a serious environmental issue as the tyres are manufactured with synthetic rubber. According to the past records, the scrap tyres were used as a common additive to bituminous binders which not only addresses the pavement performance issues but also tackles the problem of disposal of these tyres. Therefore, In this study an attempt is made to know what percentage incorporation of crumb rubber to bitumen upgrade the strength and durability of the pavement and a comparative study has been done using both wet process and dry process on semi-dense bituminous concrete. Efforts are being made to make it a Sustainable road paving material.

Index terms: Bitumen; crumb rubber; Aggregates; SDBC Mix

I. INTRODUCTION

Crumb rubber is usually recycled rubber which is obtained from waste tires. In the recycling process, the steel and the tire cords are removed and tire rubber is separated. This is done either mechanically or by using cracker mill. Crumb rubber is very suitable to be the used as an additive in pavement because it has the characteristic that can support the weakness of asphalt. It not only enhances the properties of bitumen but also addresses serious environmental pollution issues. The basis of this study is to give an overall idea to students regarding waste disposal and how this waste disposal problem can be addressed effectively without harming the environment. Past literatures shows several uses of crumb rubber with bitumen in different ways like Use in open graded wearing course[1], Modification using crumb rubber and mica[7], Experimental study on partial replacement of Bitumen with Crumb Rubber[8], Effect of Used Motor Oil on the Macro and Micromechanical Properties of Crumb Rubber Modified Asphalt[9], But none has done a comparative study of dry process and wet process of bitumen using crumb rubber. The objective here in this study is to find out exactly what percentage of crumb rubber addition to bitumen increases the stability values of pavement and leads to overall improved performance. Moreover, the use of scrap tires can save the cost for the maintenance of roadway pavement because crumb rubber is found to be economical. It is found to be environment friendly and has better age-resistance properties.

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II. RESEARCH METHODOLOGY

A. Marshall mix design

The mixture was prepared using Marshall Method of bituminous mix design. The SDBC mix was prepared with VG-30 bitumen, VG-30 bitumen added with varying percentages of Crumb Rubber. The materials used in this process are: Aggregates(Gradation as per SDBC mix), Bitumen(VG-30), Crumb rubber and stone dust being used as filler. The Marshall Stability and flow test provides the performance prediction measure for the Marshall mix design method. The aggregate gradation chart as per SDBC is presented below

Basically the Bituminous mix design aims to find out the proportion of materials such as coarse aggregates, fine aggregates, bitumen and filler material to produce a mix which is strong, workable, durable and economical. The aggregates should be of good quality and must have sufficient strength to withstand stresses caused due to heavy traffic loading.

Nominal Aggregate Size	13.2 mm	
Layer Thickness	30-40 mm	
IS Sieve (mm)	Cumulative % by weight of total aggregate passing	
	Specified limit	Adopted value
13.2	100	0
9.5	90-100	95
4.75	35-51	43
2.36	24-39	31.5
1.18	15-30	22.5
0.3	9-19	14
0.0075	3-8	5.5

Table 1: Aggregate Gradation for SDBC

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The Different tests on aggregates were performed and the observed values along with their requirements are presented in the tabular form below.

Property	Test	Requirements as per table 500-16 of mort&h specifications (fifth revision) , 2013	Observed Value
Particle Shape	Combined Flakiness and Elongation Indices	Max 35%	27.84%
Strength	LOS	Max 30%	22.08%
	Angeles Abrasion Value	Max 24%	23.56%
	Aggregate Impact Value	Max 30%	20.33%
Crushing Strength			
Water Absorption	Water Absorption	Max 2%	0.72%
Specific Gravity	Specific Gravity	2.7	2.61

Table 2 : Aggregate Properties

Bitumen is basically a black,very stickyand highly viscous liquid, found in some natural deposits. It is also obtained by the by-product of fractional distillation of crude petroleum. Bitumen is composed of highly condensed polycyclic aromatic hydrocarbons, containing 95% carbon and hydrogen, up to 5% sulphur, 1% nitrogen 1% oxygen and 200ppm metals.In this project work VG30 Bitumen is used. The different tests were performed for bitumen and the results are presented below:

Characteristics	Requirements as per IS: SP: 73 - 2013	Observed Value
penetration	50-70	63
Softening point in deg C	47	46.3
Ductility @ 27 deg C (cm)	40	85
Specific gravity	Min 0.99	1.03

Table.3 : Properties of Bitumen

B. Sample Preparation

In this experimental work bitumen VG-30 was taken in percentage 4 %,4.5 % ,5 % ,5.5 % , 6 % and 2 specimens were prepared for each bitumen content and crumb rubber%. The percentage of crumb rubber was taken as 0 % ,4 % ,8% ,12 % ,16 % ,20 % .Total number of samples=2×5×2×6=120. So 60 Samples were prepared through Dry Process. And 60 Samples were prepared through Wet Process. Total 120 samples were prepared in this experimental work.



Fig.1 : Crumb Rubber



Fig. 2: Mixture for Mould Preparation



Fig. 3: Moulds after Hammering



Fig. 4: Demoulded Marshall Samples

III. RESULT AND DISCUSSION

This chapter deals with the test results and analysis of Marshall Test carried out in the previous chapter. In this chapter, VA%, VMA%, VFB% and optimum binder content has been found out for each bitumen content. Comparative study of Dry process and Wet process is being done.

Sl. no	Properties	Bituminous mix with crumb rubber % of bitumen					
		0%	4%	8%	16%	12%	20%
1.	Marshall Stability	1636	1342	1426	1566	1462	1284
2.	Flow(mm)	1636	1342	1426	1566	1462	1284
3.	Bulk Density	3.8	3.2	3.3	3.5	3.1	3.0
4.	VA(%)	2.19 2	2.12 0	2.16 0	2.16 0	2.14 2	2.14 0
5.	VMA	3.48	3.52	3.52	3.68	4.10	3.81
6.	VFB	15.1 0	14.7 8	14.3 2	14.6 6	14.3 8	14.4 8
		76.9 5	76.1 8	75.4 1	74.8 9	72.1 0	73.3 1

Table.4 :Optimum Binder Content (Dry Process)

The principle of designing the optimum amount of bitumen or binder content is to mix sufficient amount of bitumen so that the aggregates are fully coated with bitumen and the voids within the bituminous material are sealed up.

The test results for wet process is given below:

Sl. no	Properties	Bituminous mix with crumb rubber % of bitumen					
		0%	4%	8%	16%	12%	20%
1.	Marshall Stability	1543	1498	1528	1690	1560	1676
2.	Flow(mm)	3.6	3.4	3.6	3.7	3.5	3.3
3.	Bulk Density	2.18 8	2.14 2	2.16 8	2.13 5	2.15 8	2.14 6
4.	VA(%)	3.45	3.65	3.78	3.54	3.76	3.98
5.	VMA	15.0 2	14.7 0	14.5 6	14.6 0	14.5 2	14.6 5

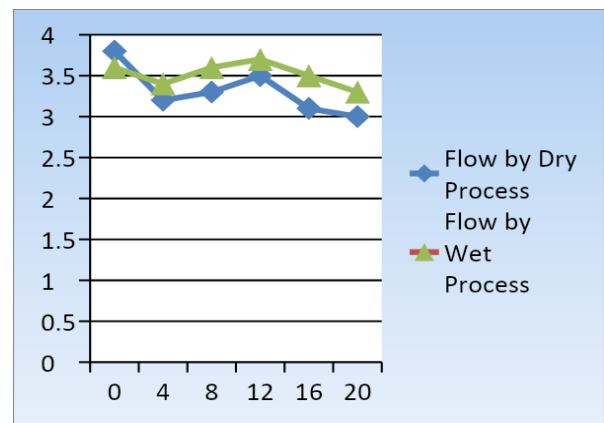
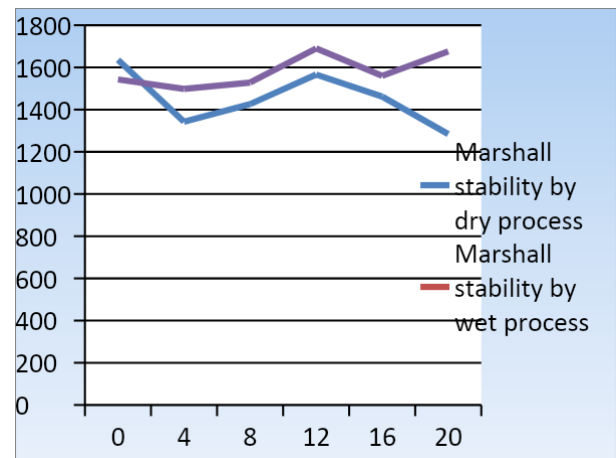
6.	VFB	75.4 3	75.1 7	74.0 3	75.7 5	74.1 0	72.8 3
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Table.5 :Optimum Binder Content (Wet Process)

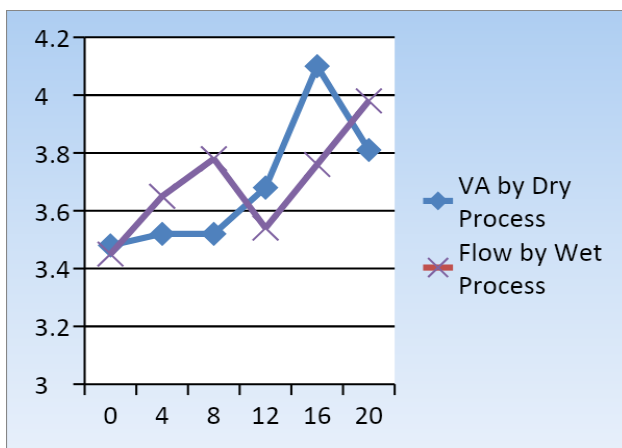
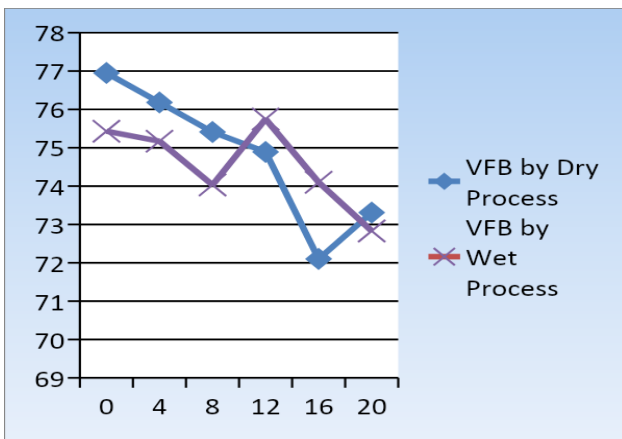
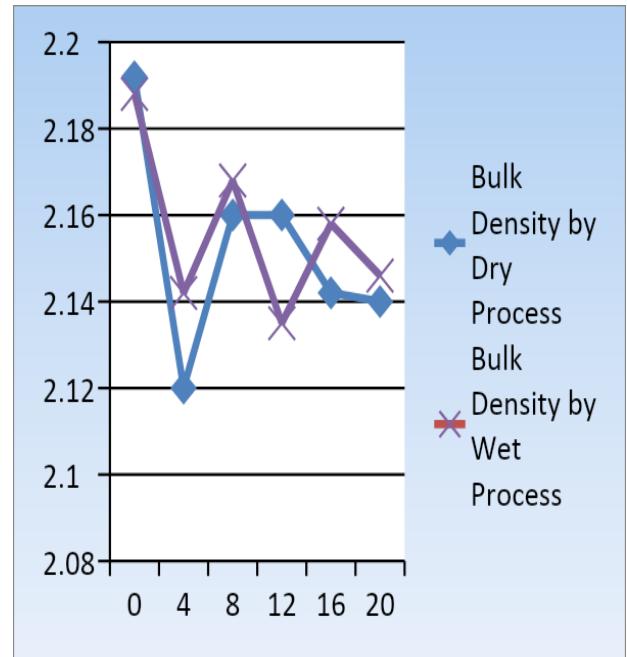
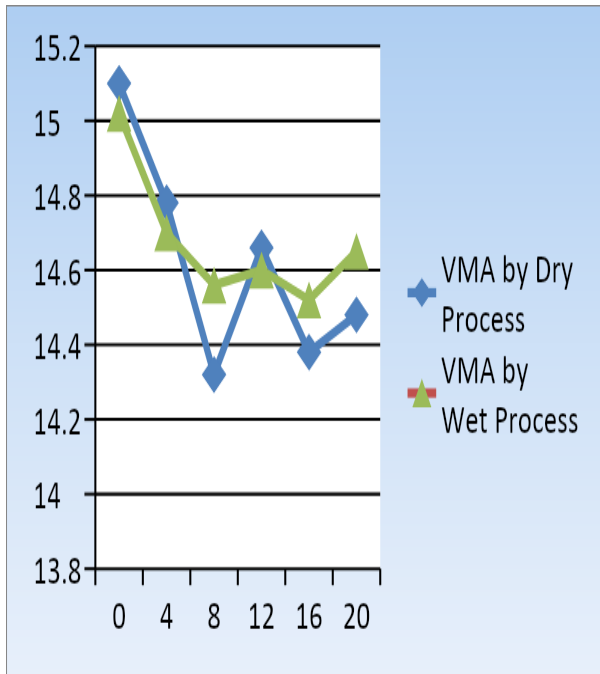
The Requirements of the properties as per MORT&H Specifications is tabulated below:

Sl.no	Properties	Requirements as per MORT&H 2013
1.	Marshall stability Test	9-12
2.	Flow (mm)	2-5
3.	Bulk Density	-
4.	VA(%)	3-5
5.	VMA	14-16
6.	VFB	60-70

Table.6 : Requirements as per MORT&H Comparison Graphs Between Two Process:



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IV. CONCLUSION

This paper presented the overall effect of crumb rubber on semi-dense bituminous concrete using both dry process and wet process. It showed improvement in strength and stability values are showing an increasing trend till 12percent addition of rubber content. Addition of 12% crumb rubber to 5% bitumen content gives satisfactory results and can be used for construction of road pavements. As per the comparative study of the two processes It can be concluded that dry process method gives better performance results as compared to Wet process. Overall waste rubber tyre was not only economical but it proved to be a sustainable road paving material.

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