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A Laboratory Study on use of Crumb Rubber Waste in Bituminous Mix – Dry Process

Pranay Raj BS[1]

[1]*Assistant Professor, Dept. of civil Engineering, JVIT Bidadi, Bangalore, Karnataka, India.*

Abstract - *As the use of vehicles is expanding day by day this result increases the amount of waste tires. 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 landfilling. In the present study has been trying to check the performance of bituminous mix (BC grade II) (As per MORTH V[TH] revision) with and without adding of crumb rubber, by dry processing. Here an attempt is made to replacing 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 Marshall 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 the replacing fine aggregate by 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% Crumb rubber replacement.*

***Key Words*: Indirect Tensile Strength, Tensile Strength Ratio, Bituminous concrete (BC), Marshall Stability.**

1. INTRODUCTION

The change in expectations for everyday comforts of the general population the utilization of two wheelers and four wheelers has expanded day by day giving ascent in vehicular density on roads. As vehicles are utilized as often as possible the wear and tear of tyres are more, this results decreases the life of tyres and finally it become useless. The dumping of the tyres has become a major issue, it is non-biodegradable in nature causes environmental issue. Crumb rubber is made by shredding of scrap tyre which is specific material free from fibre and steel the rubber particle is graded and found in numerous size and shapes. Crumb rubber are user friendly not eco-friendly. These waste are disposed either by landfilling or incineration as shown in the figure (1&2) both the process are certain impact to the environment. The hazardous waste tyre include air contamination associated with open burning of tyres particular smell, visual effect and other unsafe contaminant such as polycyclic hydrocarbon [1].

It is necessary to find the way for safe disposal of the waste material, recycling is the common solution for the disposal problem. The recent development in technologies and research have been proving there are several successful ways to reuse the waste materials one of the best arrangement being utilization of waste material into the construction of road the utilization of crumb rubber in bituminous mix helps accomplish better execution of wearing courses, lower temperature susceptibility, higher resistance to deformation, better age resistance properties, higher fatigue life, better adhesion between aggregate and bitumen, reducing cracking and reflection cracking[11], reduced traffic noise on the study carried out by united states and India the rubber asphalt road can reduced the noise from 4 decibels to 10 decibels so that it is better to application on roads.[5]

The crumb rubber can be added into bituminous mix using two unique strategies such as wet processing and dry processing. In the wet processing involves mixing of crumb rubber with the hot bitumen during the preparation of mix. In the wet processing crumb rubber/ground rubber acts like a asphalt cement binder where as in dry processing involves mixing of crumb rubber with the hot aggregate prior to bitumen during mixing in both dry and wet process the crumb rubber is some of the time called as CRM.

All though dry procedure exhibits some advantage compare to the wet procedure for the most part concerning the cost included and the larger quantity of rubber to be utilized. Researches throughout the world have focused mostly on the wet procedure. In this present study an attempt been made to use of waste crumb rubber obtained from worn-out vehicle tyres are replaced into fine aggregate (dry process) in bituminous mix. The aim was to use the crumb rubber waste in the bituminous mix and improving the Engineering properties of the bituminous mix.

Fig- 1 Burning

Fig-2 Land filling

1.1 EFFECT OF CRUMB RUBBER WASTE IN BITUMINOUS MIX

The incorporation of crumb rubber waste in the bituminous mixes producing following advantages:

The utilization of crumb rubber waste in the flexible pavement eventually enhance the quality and performance of road.

The fine aggregate used in the bituminous mix can be saved to certain quantity by incorporating crumb rubber waste.

Rubber as property of retaining sound which also helps in minimizing the sound pollution of heavy movement of traffic on roads.

Higher fatigue life of bituminous mix.

Use of crumb rubber waste in the bituminous mix prevents the moisture absorption to nil and lower specific gravity(0.98) and reducing the wear and tear of vehicle tyres this study will have a positive effect on the environment as it will minimize the volume of crumb rubber was to be discarded by incineration and landfilling.

Better age resistance properties.

Use of crumb rubber in bituminous mix has higher resistance to deformation and rutting of pavement.

Prevent cracking and reflective cracking of the pavement.

Lower susceptibility to daily and seasonal temperature variation.

1.2 OBJECTIVES OF PRESENT STUDY

The following are the objectives of present study;

To evaluate the physical properties of coarse aggregate, fine aggregate, VG-30 grade bitumen and crumb rubber waste.

To evaluate Variation in properties of coarse aggregate by adding crumb rubber waste.

To evaluate the Optimum Binder Content (OBC) in bituminous mix by marshal stability and flow parameters by varying crumb rubber percentage of 0, 2, 4, 6 & 8.

To find the Indirect Tensile Strength (ITS), and Tensile Strength Ratio (TSR) for an obtained OBC for 0, 2, 4, 6 & 8% of crumb rubber.

To find the Optimum Crumb Rubber Content (OCRC) in the bituminous mix.

2. LITERATURE REVIEW

2.1 GENERAL

The change in expectation for everyday comforts of the general population the utilization of two wheelers and four wheelers has expanded day by day giving ascent in vehicular density on roads. As vehicles are utilized as often as possible the wear and tear of tyres are more, this results decreases the life of tyres and finally it become useless. The waste tyre disposal has become a major issue, it is non-biodegradable in nature causes environmental issue. In order to overcome this issue the concept of crumb rubber [shredding of scrap tyres] blended into the bituminous mix either by dry processing or wet processing. In this chapter an attempt has been made to review the various literatures that use for blending of crumb rubber in the bituminous mixes by dry process, wet process and also case study.

2.2 Effect of Crumb Rubber blended into hot Aggregate prior to Bitumen in Bituminous mix [Dry process].

The study was carried out by **"Niraj D Baraiya"**[1] the incorporation of rubber aggregate in the asphalt mix diminishes the amount of stone aggregate by total volume and improves the flexural quality and flexibility of the carpet layer of highway. In this study the waste rubber tyre were cut into little pieces the rubber pieces were sieved through 22.4mm passing and 5.6mm retains as per mix design specifications. This were included into the bituminous mix of 10 to 20% by weight of stone aggregate the rubber aggregate were blended with stone aggregate and asphalt at temperature between 160^0C to 170^0C for proper blending of asphalt mix. As the waste rubber tyre were thermostatically set they shouldn't liquefy in the bitumen at the time of blending the aggregate. The rubber aggregate solves numerous issues like thermal cracking and permanent deformation are diminish in hot temperature area. The rubberized pavement can also resist the effect of water and also the property of absorbing sound which helps to reduce the sound pollution on heavy traffic roads.

The research work carried out by "**Salim R"et.al** [2] VG30 penetration grade bitumen binder was modified by including Low Density Polyethylene (LDPE) waste 2,4,6,8,10% by weight of bitumen binder by wet processing and the mineral aggregate was altered by including 1,2,3,4,5% of scrap tyre which is free from fiber and steel by volume of mineral aggregate by the dry processing the LDPE altered bitumen binder lab result demonstrates an increase in viscosity, softening point and stiffness of bitumen the altered bitumen was then utilized as a part of preparing bituminous mixtures by marshal design mix procedure. The marshal stability values for mixes containing 2% scrap tyre and 4% LDPE were found to 30% greater than the conventional bituminous concrete mix

2.3 Effect of Crumb Rubber blended into hot Bitumen in Bituminous mix [wet process]

"**Sharma Pavan kumar**" **et.al** [3] carried out the study to accomplish the standard marshal stability i.e. 1200kg by blending distinctive percent of crumb rubber to bitumen (wet procedure). In this study attempt to blend different percentage of crumb rubber into bitumen to accomplish the marshal stability 1200kg. And also various tests on the bitumen i.e. softening point values increases and penetration decreases elastic recovery and marshal stability on account of crumb rubber modified bitumen have been discovered to be with in the required specification. The 12% crumb rubber gives the higher stability in the wet process this experiment won't just productively use the waste tires in road development industry additionally, successfully improve the important parameters which will ultimately have better and living roads.

Laboratory study carried out on **"Nabin Rana Magar"et.al** [4] execution of the bitumen altered with 15% by weight of the crumb rubber changing its sizes four distinct classification of size of crumb rubber will be utilized which are coarse (1mm-600µ) medium size (600µ -300µ) fine (300µ-150µ) and super fine (150µ-75µ) usual experimental tests will be done on modified bitumen using different sizes of crumb rubber marshal method of mix design is adopted the result obtained were the sample prepared using crumb rubber size (300µ-150µ) gives the highest stability value of 1597.64kg, minimum flow value, maximum unit weight, maximum air voids and minimum VMA and VFB% values so that best size to be used for crumb rubber modification can be suggested (300µ-150µ).

2.4 Summary

From the literature review, it has been clearly observed that, the no research has been done replacement of fine aggregate (4.75mm passing - 75µ retained) by crumb rubber waste in the bituminous mix. Hence we made an attempt to study the replacement of fine aggregate by crumb rubber by dry process and also a checking the engineering properties of the bituminous mix.

3. METHODOLOGY

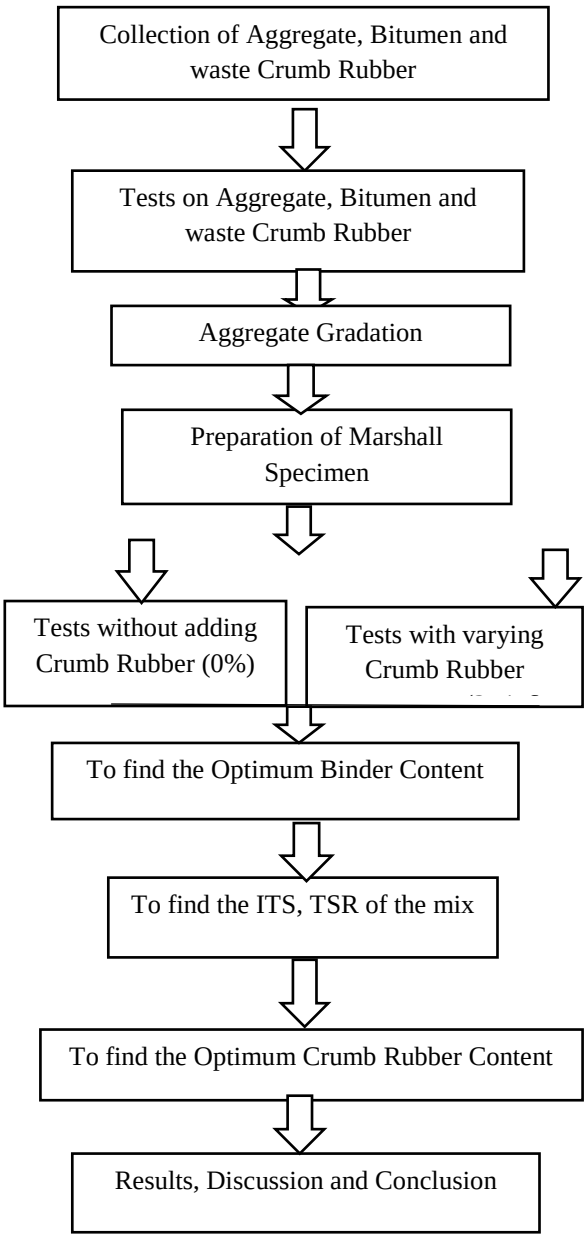

Fig-3 Flow chart of the Research

4. RESULTS

4.1 TESTS ON ROAD MATERIALS

The results of the test conducted on road aggregates are tabulated below

Table -1: Results of Tests on road aggregates

Properties	Obtained	Morth[6] specification table 500-16
AIV%	22.8%	Max 24
SG and water absorption test	2.65 &0.3	
SG for fine aggregate	2.56	
SG for filler material	2.6	
Combined Flakiness and Elongation index %	31.65%	Max 35%
Aggregate crushing value %	25.61%	Max 30%
Los Angeles Abrasion value%	29.05%	Max 30%

Table- 2: variation in properties of coarse aggregate by adding Crumb Rubber waste.

Stone aggregates	% of Crumb Rubber	Aggregate Impact value test %	Aggregate Crushing value %	Los Angles Abrasion value %
Without Crumb Rubber	0	22.8	25.61	29.05
With Crumb Rubber	2	22.1	25.3	28.6
	4	21.4	24.6	27.2
	6	20.4	24.1	26.4
	8	19.3	23.6	25.3

Table-3 Tests results of VG-30 Grade Bitumen

TESTS	VG 30	IS 73-2006
Penetration test (mm)	67	60-70
Flash point, ^{o}C	240	Min 220
Fire point ^{o}C	260	

Table-4 Marshall Test results with the addition of Crumb Rubber waste and OBC

Crumb rubber % By weight of fine aggregate	**0**	**2**	**4**	**6**	**8**
OBC %	5.55	5.63	5.70	5.73	5.73
Marshall stability, kN	26.2	27.5	29.5	25.9	25.5
Flow value, mm	3.75	3.7	3.6	3.3	3.1
Theoretical max Density(Gt) g/cc	2.40	2.36	2.32	2.29	2.27
Bulk density (G_m) g/cc	2.302	2.270	2.230	2.210	2.170
Air voids(Vv)%	4.1	4	3.9	3.8	3.8
Voids in mineral aggregates (VMA)%	16.6	16.6	16.3	15.5	15.2
Voids filled with Bitumen (VFB)%	74.5	73.3	72.4	76.5	78.3
Unit weight g/cc	2.293	2.254	2.224	2.19	2.17

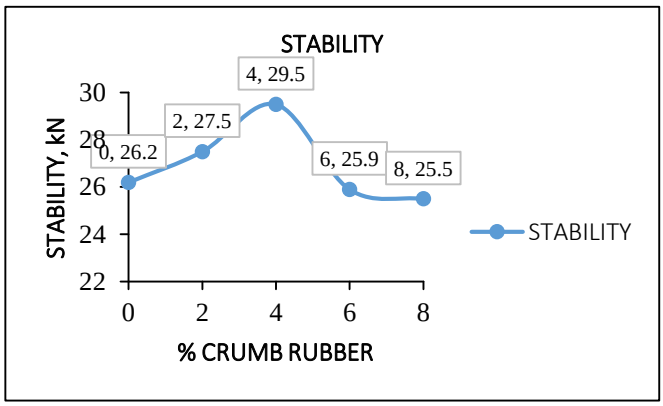

Chart-1: variation of stability by varying % crumb rubber and OBC with addition of crumb rubber waste.

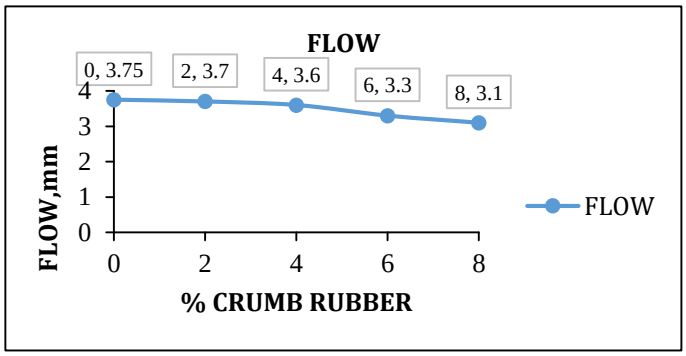

Chart-2: variation of flow by varying % crumb rubber and OBC with addition of crumb rubber waste.

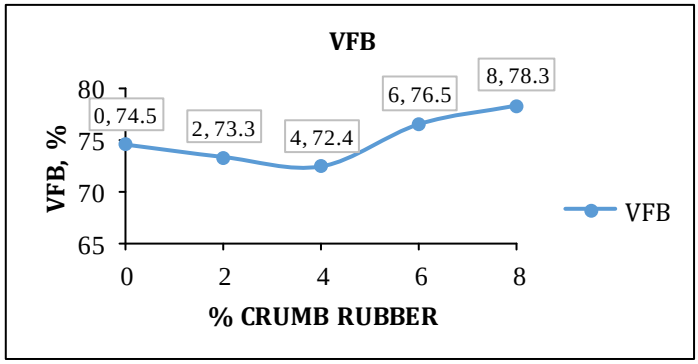

Chart-3: variation of VFB by varying % crumb rubber and OBC with addition of crumb rubber waste

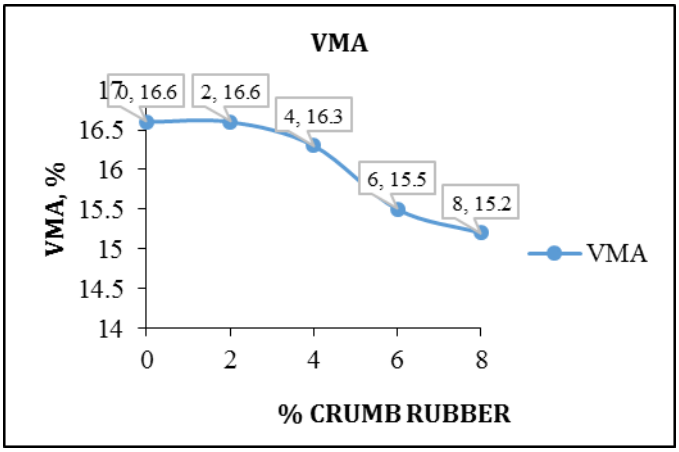

Chart-4: variation of VMA by varying % crumb rubber and OBC with addition of crumb rubber waste.

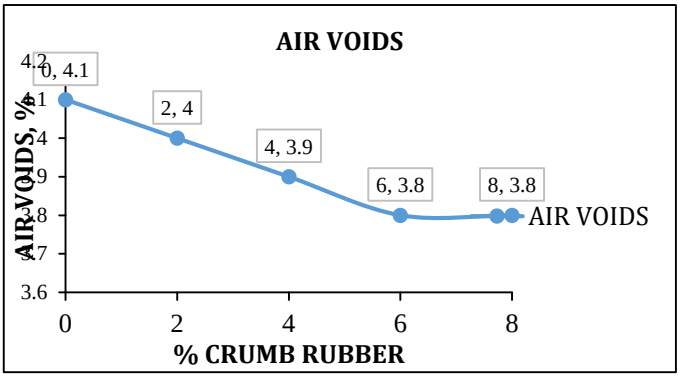

Chart-5: variation of Air voids by varying % crumb rubber and OBC with addition of crumb rubber waste.

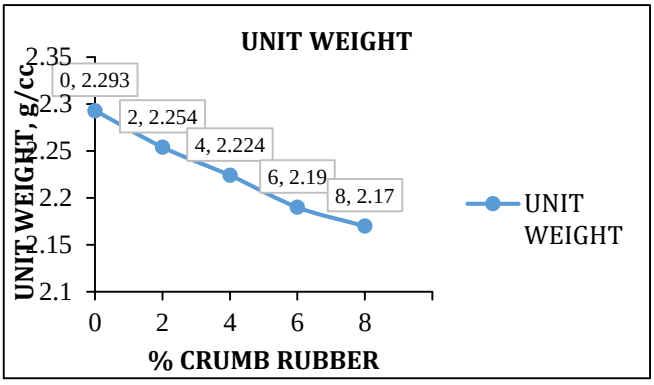

Chart-5: variation of unit weight by varying % crumb rubber and OBC with addition of crumb rubber waste.

4.2 INDIRECT TENSILE STRENGTH

The Indirect Tensile Strength tests were conducted and the results are tabulated in table 5 and chart 6 as shown in below.

Table: 5 Indirect Tensile Strength with varying percentage of Crumb Rubber and OBC

% Crumb Rubber	OBC %	Diameter in mm	Height in mm	P in kN	ITS in N/mm^2
0	5.55	100.1	63.5	13.9	1.39
2	5.63	100	64	14.47	1.44
4	5.70	100.1	63.5	14.97	1.50
6	5.73	100.1	64.3	14.73	1.45
8	5.73	100.1	63.5	14.1	1.41

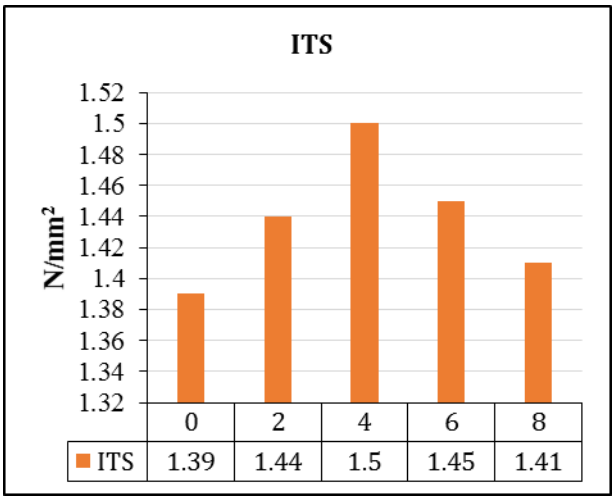

Chart-6: Variation of ITS Values with varying % Crumb rubber and OBC

4.3TENSILE STRENGTH RATIO (TSR)

The Tensile Strength Ratio tests were conducted and the results are tabulated in table 6 and chart 7 as shown in below.

Table: 6 Tensile Strength Ratio varying percentage of Crumb Rubber & OBC

% Crumb Rubber	OBC%	Unconditioned ITS (kN)	Conditioned ITS (kN)	TSR%
0	5.55	11.50	9.82	85.39
2	5.63	11.62	10.12	87.09
4	5.70	12.43	11.15	89.7
6	5.73	12.12	10.76	88.7
8	5.73	11.96	10.52	87.9

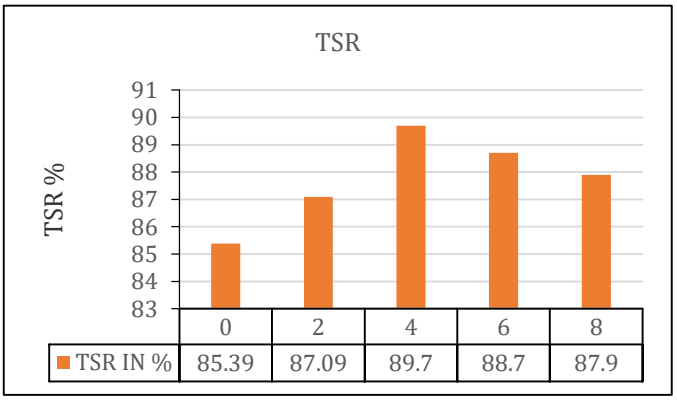

Chart-7: Variation of TSR Values with varying % Crumb rubber and OBC

5. CONCLUSION

It can be conclude that the addition of crumb rubber waste generally improve the properties of bituminous mix. Also the Indirect tensile strength and Tensile strength ratio have increased with the addition of crumb rubber waste. For the material selected in the present study the optimum percentage of crumb rubber waste was obtained as 4% by weight of fine aggregate. This also solve the problem of disposal of crumb rubber waste certain extent.

5.1 SCOPE FOR FURTHER STUDIES

1. Further tests on rutting and fatigue behavior of Bituminous concrete Grade II using crumb rubber waste can be carried out.

2. Investigation can be done on the effect of crumb rubber waste on other mixes such as Stone Matrix Asphalt (SMA), Dense Bituminous Macadam (DBM).

3. Field performance of pavements constructed using crumb rubber waste can be carried out.

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AUTHOR BIOGRAPHY

Pranay Raj BS B.E., M.TECH., (PhD) Received Bachelor of Engineering in Civil Engineering from PES college of Engineering Mandya in 2014. And also received Master of Technology in Transportation Engineering from Reva Institute of Technology Bangalore in 2016. At presently working as an Assistant Professor, Department of Civil Engineering JVIT, Bidadi, Bangalore.