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Use of Crumb Rubber in Flexible Pavement and Comparison in Strength & Quality

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ABSTRACT: Today disposal of different wastes produced from different Industries is a great problem. These materials pose environmental pollution in the nearby locality because many of them are non-biodegradable, Crumb rubber is one of them. Soil, stone aggregate, sand, bitumen, cement etc. are used for road construction. Natural material are limited in nature, its quantity is decreasing and cost is increasing. Concerned about this, engineers are looking for alternative materials for highway construction, by which the quality of road is increase with low cost. Keeping in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of waste tyres in road making in which higher economic returns may be possible. The waste tyres can be used in the form of aggregate which on mixing with various bitumen in suitable size.

KEYWORDS: Rubber aggregate, flexible pavements, crumb rubber, conventional aggregate, Utilization of waste.

I. INTRODUCTION

Nowadays, the disposing of rubber wastes has become a vast problem. Crumb rubber is a material produced by shredding and commutating used tires. Approximately 60 percent of waste tyres are disposed of via urban and rural areas. This causes various environmental problems including air pollution (due to burning of tyres) and aesthetic pollution which causes severe health related issues These are a biotic, disposable product due to which these materials pose environmental pollution. In recent years, by-products of rubber wastes are being used in road construction with great interest in many developing countries. The selection of these materials in road construction is based on technical, economic, and ecological criteria and is giving a fruit. Every year millions of tons of rubber waste are produce in India. Utilizing these materials in highway road construction, the pollution and disposal problems can be successfully be reduced. Minding the bulk ruse of these wastes in India, it was thought necessary to examine these materials and to develop specifications to increase the use of rubber wastes in road making, in which higher economic returns may be possible. These materials should be used in road construction in each and every part of our country. The waste tyres can be used in the form of aggregate which on mixing with various bitumen in suitable size. This reduces the pollution occurred due to waste tyres as well as minimizes the use of natural aggregate, which help in reducing global warming as well as health problems.

II. RELATED WORK

Prof. Justo et al (2002), after the help of Shankar and Mohd. Imtiyaz, he also uses the crumb rubber in the form of modified bitumen, up to 12% by weight. He preferred crumb rubber modified bitumen (CRMB55) at specific temperature. For the design of modified bitumen, he preferred conventional bitumen 60/70. In the result modified bitumen shows higher resistance to permanent deformation at higher temperature.

Huang et al. (2004) in his report he told that rubberized concrete has very high toughness and strength decreases significantly as the rubber content increases.

Zheng et al. (2008) revealed that strength and modulus elasticity of the rubberized concrete decreased with increasing amount of rubber in concrete. Rosa et al. (2009) found the addition of rubber to concrete should not exceed 10%, due to

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resistance losses verified. Mavroulidou et al. (2010) revealed that the use of rubber 0-10% in concrete gives good results for workability, density, cube compressive strength after 28-days. Beyond that, use of rubber in concrete has negative results.

G. Senthil Kumaran, NurdinMushule and M.Lakshmipathy (2008) use the waste tire in concrete in the form of chips and fibers with different-different sizes. He considered this collaboration as light weight concrete. According to his result it improves the strength of pavement as well as protecting environment.

Sara et al. (2010) study about durability, toughness etc. of rubberized concrete.

Rokade S. (2012) he uses the both waste plastic and waste crumb rubber to build modified bitumen. Because he told that plastic is also non ecofriendly and non-biodegradable. For the study he preferred waste plastic, low density polyethylene (LDPE) and crumb rubber with the specified temperature.

Johnny Bolden, Taher Abu-Lebdeh and Ellie Fini (2013) According to his report we can use the crumb rubber in concrete, grass turf, asphalt mix, embankments, stone cladding, flow able fill and clay composite.

R.K.Kolisetty, H.S.Chore (2013) use the recycled crumb rubber in PCC mixture as crumb rubber aggregate (partially replacing some part of aggregate). He uses rubber aggregates with different-different sizes like 20-10 mm, 10-4.75mm and 4.75 mm according to requirement.

Nabin Rana Magar (2014) use the crumb rubber aggregate in the form of modified bitumen with the four different-different sizes. He replaces crumb rubber with 15% by weight of bitumen. Four different categories of size of crumb rubber will be used, which are coarse (1 mm – 600 μ m); medium size (600 μ m - 300 μ m); fine (300 μ m- 150 μ m); and superfine (150 μ m - 75 μ m).

Mr.Nirajkumar Gupta, Prof.Dhananjayadhav (2016) the waste problem considered as one of the most crucial problems facing the world as a source of the environmental pollution. During last recent years, many improvements in India have occurred in all parts of life such as social, industrial, economical etc., this will lead to generate new ways of living and increase the human requirements and will also increase types and quantities of the waste in India, without any active processes to provide solution to this problem. Waste rubber tires cause serious environmental problems all over the world. And he uses the crumb rubber in pcc.

Naveen Sheoran& Ravi Kumar (2017) study on the use of waste tires in the form of coarse aggregate in road construction. Basic mechanical and physical test have been carried out on aggregates. The strength and durability characteristics of concrete mixtures have been computed in the present work by replacing 0%, 5%, 10%, 15% and 20% of coarse aggregates with the waste tyre rubber.

III.METHODOLOGY

Waste rubber tyres were collected from roads sides, dumpsites and waste-buyers. The collected waste tyres were sorted as per the required sizes for the aggregate. The waste tyres were cut in the form of aggregate of sizes ranging from 22.4 mm to 6.00 mm (as per IRC-SP20) in the tyre cutting machine. The waste rubber tyres can be managed as a whole tyre, as slit tyre, as shredded or chopped tyre, as ground rubber or as a crumb rubber product. The rubber of tyre usually employed in bituminous mix, in the form of rubber particles are subjected to a dual cycle of magnetic separation, then screened and recovered in various sizes and can be called as Rubber aggregate. It was cleaned by de-dusting or washing if required. The rubber pieces (rubber aggregate) were sieved through 22.4 mm sieve and retained at 5.6 mm sieve as per the specification of mix design and these were added in bituminous mix, 10 to 20 percent by weight of the stone aggregate. These rubber aggregates were mixed with stone aggregate and bitumen at temperature between 1600c to 1700c for proper mixing of bituminous mix. As the waste rubber tyres are thermodynamically set, they are not supposed to melt in the bitumen, at the time of mixing of rubber aggregate, stone aggregate and bitumen in hot mix plant.

IV. EXPERIMENTAL SETUPS

Experimental setup is an approach of considering the essential set of experiments suitable and useful for the testing of the materials. There are some certain tests for aggregate, bitumen, rubber waste, etc. By the test, strength, durability and lots of factors will be justified. Before the testing of material, there should be proper selection of appropriate

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material for the research so that proper experiment should be carried out. In this research methodology, deals with the explanation of all the experiments required for our research. The testing methodology will consist of the following step:

- a. Selection of material
- b. Material Processing
- c. Material Testing
- d. Observations & Calculations
- e. Result & Discussion

V. EXPERIMENTS & RESULTS

1. Sieve Analysis of Aggregates

This test is use to determine the particle size distribution of the coarse and fine aggregates as shown in Table 1. This test is works as per IS: 2386 (Part I) – 1963.

Test Result

Table 1 Sieve Analysis Report

Sieve Size	Mass Retained (g)	Percentage Retained	Cumulative Percentage Retained	Cumulative Percentage Passing
13.20 mm	0	0	0	100
9.50 mm	371.8	18.6	18.6	81.4
6.70 mm	392.5	19.6	38.2	61.8
4.75 mm	222.1	11.1	49.3	50.7
2.36 mm	387.5	19.4	68.7	31.3
1.70 mm	97.9	4.9	73.6	26.4
1.18 mm	109.1	5.5	79.1	20.9
425 µm	170.8	8.6	87.7	12.3
300 µm	45.8	2.3	90	10
150 µm	76.7	3.8	93.8	6.2
<150 µm	123.0	-	-	-
Total	1997.2	100	-	-

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2. Specific Gravity & Water Absorption Test

To determine the specific gravity and water absorption of aggregates by using aggregate.

Test Result

Material	Specific gravity	Apparent S.G.	Water Absorption
Aggregate	2.64	2.70	0.92
Rubber Aggregate	1.96	2.01	1.22

3. Aggregate Impact Value Test

This test is help to determine the aggregate impact value of aggregate as per IS: 2386 (Part IV) – 1963.

Test Result

a. Impact test on Aggregate-

Weight of empty cylinder = 1401 gm
 Weight of aggregate sample (W1) = 577 gm
 Weight of aggregate after impact (W2) = 511 gm
 (W3) = W1 – W2 = 66 gm
 Impact value = $66 / 577 * 100 = 11.43 \%$

b. Impact test on (Aggregate + Rubber) –

Weight of empty cylinder = 1401 gm
 Weight of (aggregate + rubber) sample (W1) = 563 gm
 Weight of (aggregate + rubber) after impact (W2) = 522 gm
 (W3) = W1 – W2 = 41 gm
 Impact value = $41 / 563 * 100 = 7.282 \%$

4. Aggregate Crushing Value Test

This test is use to determine the aggregate crushing value of aggregates in Table 2 as per IS: 2386 (Part IV) – 1963.

Test Result

Table 2 Aggregate Crushing Value result

Sr.No.	Net Weight (g) (A)	The fraction		Aggregate Crushing Value (%) =(B*100)/A
		passing through 2.36mm Sieve (g) (B)	Retaining on 2.36mm sieve (g) (C)	
1	3230 (Aggregate)	302	2928	9.34 %
2	3500 (Aggregate + Rubber)	0	3500	0 %

5. Abrasion in the Los Angeles Machine

The Los Angeles test is use to determine abrasion or attrition.

Test Result

a. Abrasion test on Aggregate –

Size of aggregate = 40mm to 50mm
 Weight of sample (W1) = 5000gm
 Weight of sample of abrasion after sieving by 1.7mm sieve (W2) = 384gm

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Abrasion value of aggregate = $384 / 5000 * 100 = 7.68\%$

b. Abrasion test on Crumb rubber –

Weight of sample (W1) = 5000gm

Weight of sample of abrasion after sieving by 1.7mm sieve (W2) = 15gm

Abrasion value of crumb rubber = $15 / 5000 * 100 = 0.3\%$

6. Abrasion test on (Aggregate + Crumb rubber) –

Weight of sample (W1) = 5000gm

Weight of sample of abrasion after sieving by 1.7mm sieve (W2) = 46gm

Abrasion value of (Aggregate + Crumb rubber) = $46 / 5000 * 100 = 0.92\%$

SUMMARIZED RESULT

Table 3 Tests on Aggregates

Sr.No.	Aggregate Test	Test Result Obtained
1	Crushing value %	9.34
2	Impact value %	11.43
3	Los Angeles abrasion value %	7.68
4	Combined index %	29
5	Water absorption %	0.92
6	Specific gravity of coarse aggregate	2.64
7	Specific gravity of fine aggregate	2.37
8	Specific gravity of filler	2.5

Table 4 Tests on Crumbed Rubber

Sr. No.	Rubber Test	Test Result Obtained
1	Crushing value %	0
2	Los Angeles abrasion value %	0.3
3	Water absorption %	1.22
4	Specific gravity	1.96

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Rubber has an elastic property, so we can say that addition of waste tyres as rubber aggregate modifies the flexibility of surface layer. The test result on crumbed rubber is shown in Table 4. According to test result optimum content of waste rubber tyres to be used is between the ranges of 10% to 13% with different-2 size in different-2 layers. Rubber is a flexible material, so it decreases the vertical strain on top of subgrade. And because of this deformation in subgrade is also decreases. Rubber has property of absorbing sound, which also help in reducing the sound pollution of heavy traffic roads. According to our test results, test values of crumb rubber (Impact value, abrasion value, crushing value, etc.) are less than test values of aggregate. We can be save a certain quantity of natural stone aggregate. Table 3 shows the summarized results of various tests conducted on aggregates.

VI.CONCLUSION

In the present study, the importance was to add the shredded waste crumb rubber to aggregate and to evaluate the various mix properties like Impact value, abrasion value, crushing value, etc. And also, to check the property of Crumb rubber aggregate. To check the coating property of rubber aggregate with adhesive materials. To check crumb rubber material properties through both laboratory and field evaluation. Develop test data for specification for non-structural / low loading usage. To evaluate the properties of rubber resistance against cracking, fatigue and rutting. Making environment less harm from rubber waste.

So in the end of this we get outcomes which are satisfying all the objectives, like: It modifies the flexibility of surface layer. Waste rubber tyres to be used is between the ranges of 5% to 20%. Problem like thermal cracking (Fatigue) and permanent deformation (Rutting) are reduce in hot temperature region. Rubber has property of sound absorption, which also help in reducing the sound pollution of heavy traffic roads. The use of rubber can improve the quality and performance of road. We can be save a certain quantity of natural stone aggregate.

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