To Study the Strength Characteristics of Concrete using Combination of Tyre Rubber and Recycled Aggregate

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Abstract— In recent decades, worldwide growth of automobile industry and increasing use of car as a means of transport has tremendously boosted tire production. This has generated massive stockpiles of used tires. Big amounts of used rubber tires accumulate in the world each year-275 million in the United States and 180 million in European Union. India is presently generating construction and demolition waste to the tune of23.75 million tones annually and these figures are likely to double fold in the next 7years.This project is an attempt to design concrete of 25Mpa using natural sand, Conventional sand, Shredded rubber, crumb rubber and recycled aggregate as an alternative source of aggregate in concrete. A comparison with control mix which uses conventional material will allow to assess the difference in the properties of materials or concrete and ultimately the suitability of using shredded rubber, crumb rubber aggregate and recycled aggregate in concrete (probably in percentages) for structural components. Replacement of constant 1% crumb rubber, 1% shredded rubber and variable as 10%, 20%, 30%, 40% replacement of recycled aggregate respectively. By above mix design, investigate the properties of compressive strength, split tensile strength.

Key words: Tire Rubber, Shredded Rubber, Crumb Rubber, Recycled Aggregate, Compressive Strength, Split Tensile Strength, Flexural Strength

I. INTRODUCTION

About 33 million vehicles are being added to Indian roads in last three years. About80 million tires are part of these 33 million vehicles which include two, three, four and six wheelers. After the use of these tires they are thrown away and cause environmental mal-effects. One of the most popular methods of disposal is to pile used tires in landfills, as due to low density and poor degradation they cannot be buried in the landfills. These tires are also been placed in dump, or basically piled in a large hole in the ground. However these dumps serve as a great breeding ground for mosquitoes which cause diseases. In India the usage of tires for burning in cement kilns is up to 20000 tons per year. In industry large amount of waste tires are utilized as fuel, pigment soot, in bitumen pastes, roof and floor covers and for paving industries. One of the where these scrap tires can be used is rubberized concrete. Concrete, though a popular construction material has some limitations. Low tensile strength, low ductility, low energy absorption, and shrinkage and cracking associated with hardening and curing. Several studies performed earlier shows that the application of the recycled tire rubber in concrete might improve these properties. However by use of these granulated rubber crumbs with replacement of fine aggregate can make concrete cheaper and useful for some applications.

Works on recycling have emphasized that if old concrete has to be used in second generation concrete, the product should adhere to the required compressive strength. Literature survey reveals that compressive strength primarily depends upon adhered mortar, water absorption, Los Angeles abrasion, size of aggregates, strength of parent concrete, age of curing and ratio of replacement, interfacial transition zone ,moisture state, impurities present and controlled environmental condition. Some of the studies have suggested the mix design procedure for recycled aggregates in concrete, yet a simple and cost effective method of using demolished concrete, taking into account % adhered mortar and thus calculating mix composition needs to be developed.

II. EXPERIMENTAL MATERIALS

A. Materials

1) Crumb Rubber

Crumb rubbers are obtained by grinding. Crumb rubber- 30 mesh is produced by passing rubber tires through a screen with 30 holes per inch resulting in rubber granulate that is slightly less than 1/30th of an inch.

Fig. 1: Crumb Rubber
Source: Vaibhav Rubbers, Dombivali, Maharashtra.

2) Shredded Rubber

This fine grade reclaim rubber product is manufactured from whole tire scrap. These are the used tires from passenger car used tires, primary shred size of pieces from 30 cm and below is the tires produced by Eldinprimary chopper, container 40 ft. load with 25 tons

Fig. 2: Shredded Rubber
Source: Vaibhav Rubbers, Dombivali, Maharashtra.

3) Recycled Aggregate

India is presently generating construction and demolition waste to the tune of23.75 million tons annually and these figures are likely to double fold in the next 7years. C&D waste and specifically concrete has been seen as a resource in

developed countries. Works on recycling have emphasized that if old concrete has to be used in second generation concrete, the product should adhere to the required compressive strength. Literature survey reveals that compressive strength primarily depends upon adhered mortar, water absorption, Los Angeles abrasion, size of aggregates, strength of parent concrete, age of curing and ratio of replacement, interfacial transition zone ,moisture state, impurities present and controlled environmental condition. Some of the studies have suggested the mix design procedure for recycled aggregates in concrete, yet a simple and cost effective method of using demolished concrete, taking into account % adhered mortar and thus calculating mix composition needs to be developed.

Fig. 3: Recycled Aggregate

Properties	Crumb rubber	Shredded rubber	Recycled aggregate
Specific gravity	0.595	0.967	2.82
Fineness modulus	-	4.43	5.58
Bulk density	0.59 kg/lit	0.49kg/lit	1.48 kg/lit
Crushing strength	-	-	-
Water absorption	-	1.74%	4.65%

Table 1: Properties of Materials

4) Cement

The most common cement used is an ordinary Portland cement. The Ordinary Portland cement (Brand-Ultratech cement) of 53 grade conforming to IS: 8112-1989 is being used. Many tests were conducted on cement; some of them are consistency tests, setting tests, etc.

Sr. No.	Physical Properties of Ultratech OPC 53 Grade	Result	Requirement As Per IS: 8112-1989
1	Specific gravity	3.14	3.10-3.15
2.	Standard Consistency (%)	31.7%	30-35 mm
3.	Initial Setting Time	85 min.	30 min.
4.	Final Setting Time	212Min.	600 min.

Table 2: Properties of Cement

5) Aggregate

Aggregates are the main ingredient in concrete. Aggregates provide body to the concrete, reduce shrinkage and effect economy. The most prime factor is Good gradation of aggregates, it is very important for producing workable concrete. Acceptable grading means that a sample fractions of aggregates in required proportion such that the sample having least voids. Samples of the well graded aggregate having least voids need minimum paste to fill up the voids in the aggregates. Minimum paste means minimum quantity of cement and minimum quantity of water, which are further mean raised economy, higher maximum strength, minimum shrinkage and greater maximum durability.

6) Coarse Aggregate

Locally available coarse aggregates having the maximum size of 20 mm were used in the present work. Testing of coarse aggregates was done as per IS: 383-1970. The material which is retained on 4.75mm sieve is called as coarse aggregate. The 20mm aggregates used were first sieved through 10mm sieve and then through 4.75 mm sieve and 20mm aggregates were firstly sieved through 20mm sieve. They were then washed to remove dust and dirt and were dried to surface dry condition.

Sr. No.	Characteristics	Value
1	Maximum size	20 mm
2.	Specific gravity	3.06
3.	Impact value	11.82
4.	Crushing Strength (N/mm^2)	24.6
5.	Fineness modulus	6.46

Table 3: Properties of Coarse Aggregates

7) Fine Aggregate

The sand used for the experimental analysis was locally buy up and Adapt to grading zone II as per IS: 383-1970.The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and then was washed to clear of the dust.

Sr. No.	Characteristics	Value
1	Specific Gravity	2.75
2	Absorption %	0.40%
3	Moisture content %	0.90%
4	Fineness Modulus	2.6

Table 4: Properties of Fine Aggregate

8) Water

Water is a prime element of concrete as it actually take part in the chemical reaction with cement. As it helps to from the strength giving cement gel, so quality of water is needed to be looked into very carefully.

III. Mix Design

A mix M25 grade was designed as per Indian Standard method and the same was used to preparethe test samples.The design mix proportion is done in Table 5.

Grade of Concrete	Cement	Fine Aggregate	Coarse Aggregate	Water
M25	320 kg/m^3	737.35 kg/m^3	1236.2 kg/m^3	176 kg/m^3
	1	2.3	3.86	0.55

Table 5: Design Mix Proportion for (M25)

IV. Experimental Set Up Experimental Methodology

With the help of concrete testing we can evaluate Used Foundry Sand for use as a replacement of fine aggregate material. Concrete contains cement, fine aggregate, coarse aggregate and water. With the replacements of constant 1% Crumb Rubber, 1% Shredded Rubber and 10%, 20%. 30%, 40% Replacement of the recycled aggregate with Natural

Coarse aggregate, the data from the combination of rubber and recycled aggregate is compared with data from a conventional concrete. Six cube samples and six cylinder and beams were cast on the mould of size 150*150*150 mm for each 1:2.3:3.86 concrete mix with partial replacement of coarse aggregate with w/c ratio as 0.55 were also cast. After about 24 h the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7and 28 days for compressive strength and Split tensile strength.

A. Compressive Strength

Compression testing machine were used to find Compressive strength using cube samples. Three cubes per batch were tested with the average strength values reported in this paper. The comparative analysis were made on their characteristics for concrete mix ratio of 1:2.3:3.86 with partial replacement of 2% rubber with fine aggregate and 0%, 10%, 20%, 30% and 40% of recycled aggregate with used natural coarse aggregate.

Fig. 4: Setup of Compressive Strength Testing Machine

1) Compressive Strength of Cubes (150X150X150) for M25 Mix at 28 Days

Cube No.	Density (kg/m^3)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	2545.88	30.94	30.87
2	2543.96	30.66	
3	2544.76	31.02	

Table 6: Compressive Strength for conventional concrete

Cube No.	Density (kg/m^3)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	2555.61	28.77	28.84
2	2554.60	28.35	
3	2551.43	29.42	

Table 7: Compressive Strength for 2% rubber and 10% replacement of Recycled aggregate

Cube No.	Density (kg/m^3)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	2542.43	27.81	27.78
2	2542.6	27.95	
3	2555.09	27.60	

Table 8: Compressive Strength for 2% rubber and 20% replacement of Recycled aggregate

Cube No.	Density (kg/m^3)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	2541.98	26.09	26.84
2	2540.08	27.11	
3	2543.09	27.33	

Table 9: Compressive Strength for 2% rubber and 30% replacement of Recycled aggregate

Cube No.	Density (kg/m^3)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	2485.87	22.97	22.38
2	2448.26	23.06	
3	2544.30	21.18	

Table 10: Compressive Strength for 2% rubber and 40% replacement of Recycled aggregate

B. Split Tensile Strength

The tensile strength of concrete is almost 10% of its compressive strength. As per IS: 5816-1999 tensile splitting strength of concrete specimen were determined. The specimens were tested after curing of 28 days for tensile strength using a calibrated compression testing machine of 2000KN capacity.

Fig. 5: Setup of Tensile Strength Testing Machine

Sr. No.	Weight (Kg)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	13.370	3.31	3.53
2	13.554	3.88	
3	13.406	3.42	

Table 11: Split Tensile Strength of conventional concrete (28-Days)

Sr. No.	Weight (Kg)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	13.404	3.96	3.86
2	13.214	3.76	
3	13.302	3.87	

Table 12: Split Tensile Strength of 2% rubber and 10% replacement of recycled aggregate (28 -Days)

Sr. No.	Weight (Kg)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	13.23	4.12	4.22
2	13.40	4.45	
3	13.16	4.09	

Table 13: Split Tensile Strength of 2%rubber and 20% replacement of recycled aggregate (28 -Days)

Sr. No.	Weight (Kg)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	13.136	4.37	4.65
2	13.246	4.83	
3	13.185	4.76	

Table 14: Split Tensile Strength of 2% rubber and 30% replacement of recycled aggregate (28 -Days)

Sr. No.	Weight (Kg)	Strength (N/mm^2)	Average Strength (N/mm^2)
1	13.070	4.34	4.45

2	13.054	4.56	
3	12.866	4.45	

Table 15: Split Tensile Strength of 2% rubber and 40% replacement of recycled aggregate (28 -Days)

C. *Flexural Strength Test*

Flexural strength of concrete is another strength property of concrete which have ability of the beam to resist failure in bending. After 28 days of curing samples were tested for flexural strength. Flexural strength of concrete is measured by concrete beam (150x150x700 mm) with a span approximately 5 times the depth. Universal Testing machine (UTM) was used for testing the specimens.

Fig. 6: Setup of flexural strength on UTM

Sr. No.	B x D (mm)	Length (mm)	Load (kN)	PL/BD^2 (N/mm^2)
1	150x150	700	28.84	6.02

Table 16: Flexural Strength (Conventional concrete)

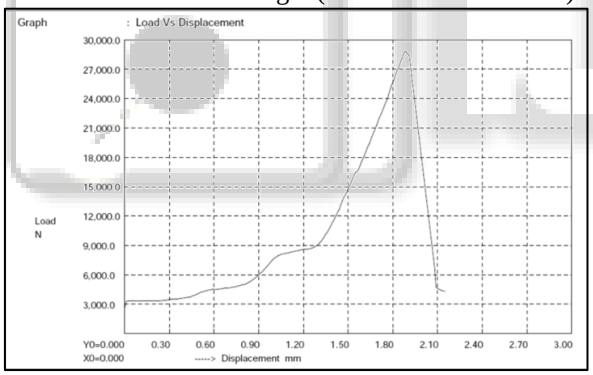

Fig. 7: Load Vs Displacement of Conventional concrete.

Sr. No.	B x D (mm)	Length (mm)	Load (kN)	PL/BD^2 (N/mm^2)
1	150x150	700	25.52	5.29

Table 17: Flexural Strength of 2% Rubber (1% crumb, 1% shredded rubber) and 10% recycled Aggregate

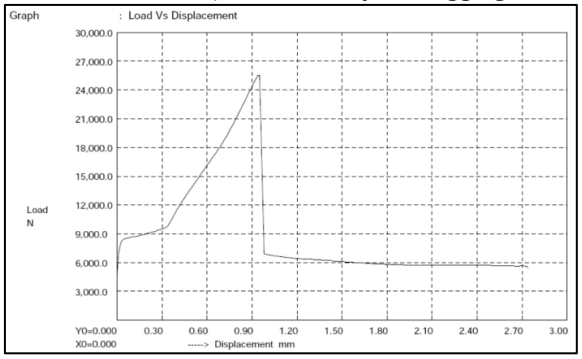

Fig. 8: Load Vs Displacement of 2% Rubber and 10% Recycled Aggregate

Sr. No.	B x D (mm)	Length (mm)	Load (kN)	PL/BD^2 (N/mm^2)
1	150x150	700	25.44	5.27

Table 18: Flexural Strength of 2% Rubber (1% crumb, 1% shredded rubber) and 20% recycled Aggregate

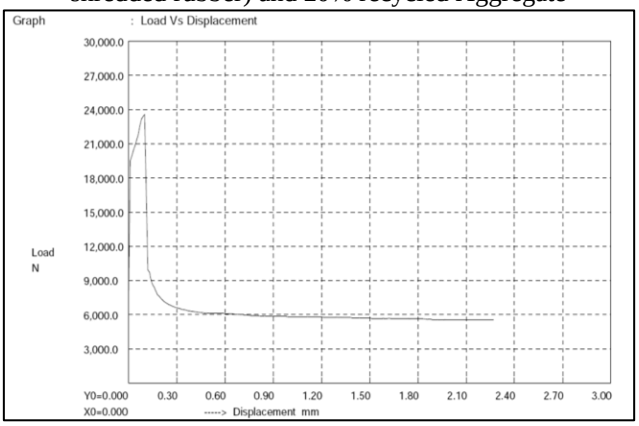

Fig. 9: Load Vs Displacement of 2% Rubber and 20% Recycled Aggregate.

Sr. No.	B x D (mm)	Length (mm)	Load (kN)	PL/BD^2 (N/mm^2)
1	150x150	700	19.70	4.08

Table 19: Flexural Strength of 2% Rubber (1% crumb, 1% shredded rubber) and 30% recycled Aggregate

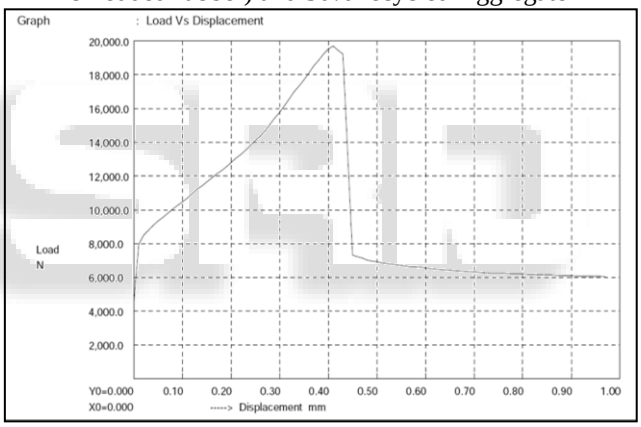

Fig. 10: Load Vs Displacement of 2% Rubber and 30% Recycled Aggregate

Sr. No.	B x D (mm)	Length (mm)	Load (kN)	PL/BD^2 (N/mm^2)
1	150x150	700	28.78	5.97

Table 20: Flexural Strength of 2% Rubber (1% crumb, 1% shredded rubber) and 40% recycled Aggregate

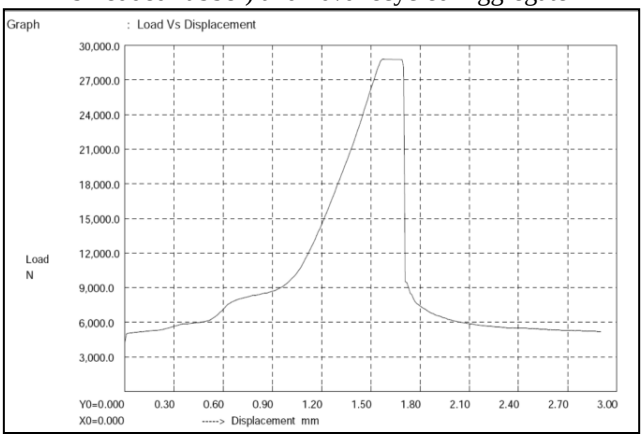

Fig. 11: Load Vs Displacement of 2% Rubber and 40% Recycled Aggregate

V. CONCLUSION

[1] According to experimental analysis by partial replacement of Rubber and Recycled Aggregate. Following observations of Compressive Strength, Tensile strength are observed-
[2] By the replacement of rubber and recycled aggregate the density of concrete becomes less and lightweight concrete is prepared.
[3] As the percentage of recycled aggregate is increasing tends to slightly decrease in compressive strength.
[4] Due to replacement of rubber in concrete, the split tensile strength of concrete is increasing compared to split tensile strength of conventional concrete.
[5] Because of rubber content, the failure pattern of concrete is non-disintegrated.
[6] The slump value is decreasing as the percentage replacement of recycled aggregate increasing.
[7] From the results, highest flexural strength occurs for mix E(replacement of 2% Rubber and 40% recycled aggregate).corresponding load is 28.78kN with deflection 2.90mm.
[8] Eco- friendly concrete by using waste product as Rubber and Recycled Aggregate.

REFERENCES

[1] Gintautas Skripkiunas, AudriusGrinys, Benjaminas Cernius, (2007)" Deformation Properties of concrete with rubber waste additives", Materials Science , Vol: 13, No: 3, pp-219-222]
[2] Nimesh Sharma, (March 2010),"Tyre Recycling: The new business on block" http://dare.co.in/opportunities/manufacturing/tyrerecycling:the new business on block.
[3] KerseviciusV (2002),"Rubber waste-Raw materials for building: Technical and economical accept of utilization", Environmental Research, Engineering and Management, Vol:3 No:31,Pp-72-77.
[4] Skripkianas G,Grinys A,(2005)," Using tire rubber Waste for modification of concrete properties ",Architecture Proceedings of conference ,Kaunas Technology,Pp-132-137.
[5] Eshmaiel Ganjian, Morteza Khorami, Ali Akbar Maghsoudi, (2009), "Scrap-tyre rubber replacement for aggregate and filler in concrete" Construction and Building materials, Vol 23,pp-1828-1836]
[6] G.SenthilKumaran, NurdinMushule and M. Lakshmipathy,(2008)," A review on construction technologies that enables environmental protection: Rubberized Concrete", American journal of Engineering and Applied sciences,Vol:1,No: 1 Pp- 40-44]
[7] Experimental investigation on strength characteristics of concrete using tyre rubber as aggregates in concrete, Vol.4.

