American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-03, Issue-12, pp-93-101
www.ajer.org

Research Paper Open Access

Effect of Chipped Rubber Aggregates on Performance of Concrete

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ABSTRACT **:** *Due to rapid growth in automobile industry, use of tyre increases day to day and there is no reuse of the same to decrease the environmental pollution. The decomposition and disposing of waste tyre rubber is harmful to environment. This research reflects the reuse of waste tyre rubber into concrete after observing their properties. In that experimental work chipped rubber aggregates replaced to the natural coarse aggregates by varying percentage of 3, 6, 9 and 12 with comparison of 0% replacement. Silica fume is replaced in 10% with cement for improving the bond properties between cement paste and rubber. In evaluation, test has been carried out to determine the properties of concrete such as workability, unit weight, flexural strength and split tensile strength. The workability of fresh concrete is observed with the help of compaction factor test. From the test of compaction factor, workability is decrease with increasing percentage of chipped rubber. The specific gravity of chipped rubber aggregates is lower as compared to natural aggregates therefore decrease the unit weight of rubber mix concrete. Increasing chipped rubber aggregates as partial replacement into concrete reduces compressive strength. So these can use in non-primary structural applications of medium to low strength requirements. The overall results of study show that it is possible to use recycled rubber tyre aggregates in concrete construction as partial replacement to natural coarse aggregates.*

KEYWORDS: *chipped rubber aggregates, Flexural strength, Natural aggregates, Silica fume, Split tensile strength. unit weight, Workability,*

I. INTRODUCTION

Rapid growth in automobile industry and increasing use of vehicles, production of tyre is also increased which generate waste tyre rubber. Management of waste tyre rubber is challenging to municipalities and burning or biodegradation of waste tyre rubber is harmful to environment. On the other hand, demand of concrete as construction material from society, it is needed to preserve natural coarse aggregate by using alternative material. In this research, reuse of waste tyre chipped rubber in concrete as partial replacement as coarse aggregates. Over the two decades, researchers have underscored to use waste tyre rubbers in concrete and carried out the test on various concrete mixes using rubber aggregate as partial replacement of mineral aggregates [1].

The researchers have studied the Crumb rubber is a material produced by shredding and commutating used tyres and there is no doubt that increasing piles of tyres create environmental concerns [2]. Author studied the product of shredding used rubber tyres as a partial sand replacement in foamed concrete, and investigates the effect of it on some properties of foamed concrete such as, density, water absorption, compressive strength, tensile strength, flexural strength and impact resistance [3]. Recently the flexural strength of normal beam by replacing tension reinforcement as waste tyre is also carried out [4]. Different partial replacements of crumb rubber by volume of fine aggregate are cast and test for compressive strength, flexural strength, split tensile strength and stress strain behavior [5]. An experimental work using recycled rubber tyre aggregates as partial replacement to the coarse aggregates in concrete mix and carried out using tests such as slump, unit weight and compressive strength on different concrete mixes in order to determine properties of concrete [6]. Density and

compressive strength of concrete utilizing waster tyre rubber has been investigated by replacing fine and coarse aggregate with waste rubber tyre by weight along with super-plasticizer using different percentages [7].In this paper, general objective of study is to evaluate some fresh and hardened properties of concrete produced by replacing part of natural coarse aggregates with rubber aggregates collected from locally available waste tyre rubber. The specific objectives of study are i) Observing the physical properties of normal and chipped rubber mix concrete. ii) Study regarding performance of workability of concrete by compaction factor test. iii) Comparison and discussion on results obtained from unit weight, flexural strength and split tensile strength for normal concrete and chipped rubber mix concrete.

II. OUTLINE OF EVALUATION

From the results of physical properties of ingredients, Mix design of M_{25} grade of concrete mixes having water cement ratio 0.5 is prepared. Beam and cylinder specimen is casted in standard size for coarse aggregate replaced by 0, 3, 6, 9 and 12 % of chipped rubber aggregates. The tables and graphs reflect comparisons between normal concrete and rubberized concrete for the various test carried out such as workability by compaction factor, unit weight, flexural test and split tensile test. Tables and graphs are presenting the conclusions and recommendations for the future.

Material properties

Cement : Cement used in this work O.P.C of 53 grades and its properties of cement are determined as per IS 12269:1987.

Silica fume : Silica Fume is densified from smoke gray Elkem India Private Limited, Mumbai which is based Micro Silica Grade 920-D is used which is in dry fine powder form. It was available in weight of 25kg bags. The various properties of silica fume is Sio_2 content-85%, Specific Gravity-2.2-2.3, Moisture content-2.8%, Loss in ignition as per mass- 3.6%, Density- 500-700 kg/m^3, Oversize percentage retained on 45 micron IS sieve- 8.56, Compressive strength of 7 day as percent of controlled sample-88.

Coarse and Fine aggregates : Coarse aggregate from a local commercial quarry with a maximum nominal size of 20 mm was used and natural sand of river bed is used confirming to grading Zone –II of table 4 of IS-383-1970 were procured from Nashik city in Maharashtra. For investigation its properties the various tests are performed as (1) Sieve analysis and fineness modulus (2) Specific gravity (3) Moisture content (4) Density. Whereas for coarse aggregates, fineness modulus= 7.51, specific gravity = 2.80, moisture content= 0.39 % and density=1560 kg/m^3.The test results obtained for fine aggregates are, fineness modulus= 2.31, specific gravity= 2.75, moisture content= 0.69 % and density = 1800 kg/m^3

Chipped rubber aggregates : In this research, Scrap truck tyre rubber is collected from remolding shops available at Nashik city in Maharashtra. These scrap tyre rubbers are cut into aggregates with help of shoemaker and cutting to maximum nominal sizes equal to 20mm.

FIGURE 1. Prepared sample of chipped rubber aggregates

To investigate the properties of chipped aggregates, the procedure has been adopted as same as procedure of coarse aggregates. Therefore the test results obtained for chipped rubber aggregates are fineness modulus= 2.39, specific gravity = 1.10, moisture content= 0.0 % and mass density= 778 kg/m^3.

III. EXPERIMENTAL WORK

The various experimental work and test are carried out in the material testing laboratory of K. K. Wagh

Institute of Engineering Education & Research Nashik**.** Concrete mix design are prepared using IS method and total 60 specimens were casted with replacement of chipped rubber in concrete. The specimens were prepared with percentage replacements of the coarse aggregate by 3, 6, 9 and 12 chipped rubber aggregate. For comparative analysis, M_{25} grade concrete mix is prepared with no replacement of chipped rubber aggregate. Replacing the 10 percent cement by silica fume into normal concrete and chipped rubber mix concrete. The mixing process carried out by using machine mixer and after casting of specimens employed tamping rod and table vibrator. In this evaluation, tests are performed as workability by compaction factor test, unit weight, flexural strength, split tensile strength at 7^{th} and 28^{th} days on various concrete mixes.

IV. TEST RESULT AND DISCUSSION

Workability by compaction factor test : The Compaction factor test is carried out to measuring the workability of concrete which is an important aspect of workability. This test works on the principal of measuring the amount of compaction achieved by a standard amount of workdone by allowing the concrete fall through a standard height. This test is more accurate than slump test,especially for concrete to fall through a standard height.The compaction factor test is more popular to determine the workabilty of concrete mix in laboratories. The compaction factor is the weight of partially compacted concrete to the weight fully compacted concrete.IS 5515-1983 is used for the procedure of compaction factor test.

FIGURE 2.Concrete fills in upper hopper

FIGURE 3.Concrete drop in lower hopper

TABLE 1: Test results of compaction factor

Specimen	% rubber	Compaction factor
CR-0	0	0.92
CR-3	3	0.91
CR-6	6	0.90
CR-9	9	0.86
CR-12	12	0.85

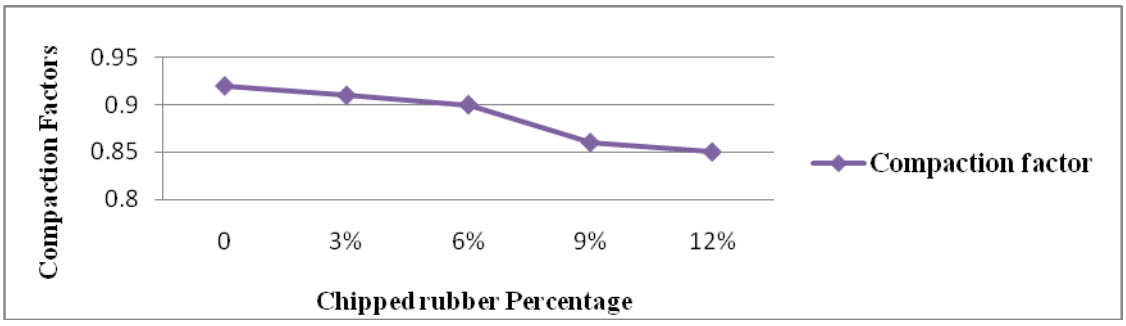

FIGURE 4. Comparison of compaction factor for normal and rubberized concrete

Degree of workability is medium as per IS 456:2000 for normal concrete mix. It is observed the graph, for 0% to 12 % the values of compacting factor are slightly reduce upto 0.9 for the percentage of 6 then after the graphs instantly reduced upto 0.86 for the 9% and again slightly reduce the factor 0.85 for the 12 %. It has to be noted that increasing the percentage of chipped rubber the value of compaction factor is reduce. From

above observation which was also noticed that while casting the rubberized concrete rubber aggregates have a high tendency to come out to the top surface when vibrated by a table vibrator which is due to low specific gravity of rubber aggregate.

Unit weight : Unit weight can be defined as the weight of a given volume of concrete specimen. The specific gravity of the rubber chips are 1.1 which is low as compared to the mineral coarse aggregates is 2.84. From the above observation it has to be noted that increasing the reduction in unit weights of rubberized concrete with increasing chipped rubber percentage into concrete. The loss of unit weight is 9.75 % for 12% replacement of chipped rubber into concrete.

TABLE 2: Unit weights of the normal and rubberized concretes for beams

Specimen	% Rubber aggregates	Av. Unit weight (kg/m^3)	% Unit weight Loss
CHR-0	0	2626	0
CHR-3	3	2540	3.27
CHR-6	6	2510	4.42
CHR-9	9	2428	7.54
CHR-12	12	2370	9.75

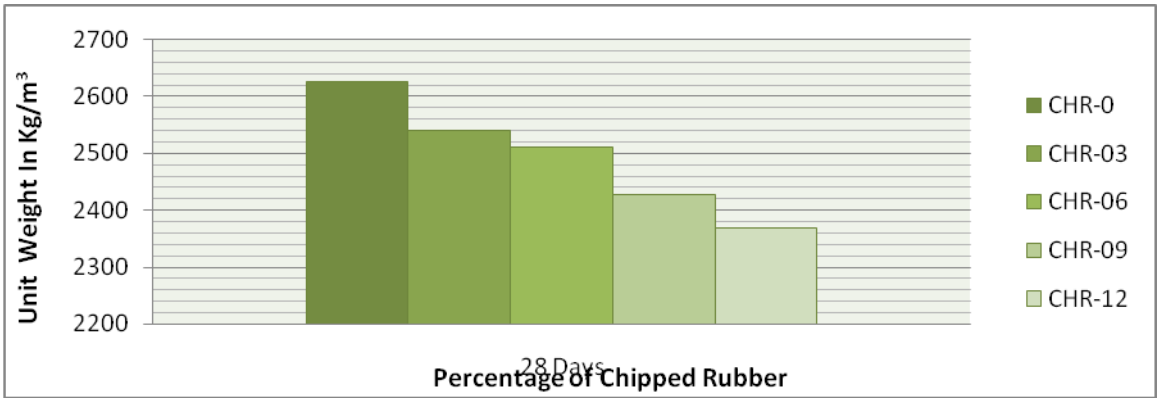

FIGURE 5. Comparisons of unit weight for beam specimens at 7 days

TABLE 3: Unit weights of normal and rubberized concretes for beam cylinders

Specimen	% Rubber aggregates	Av. Unit Weight (kg/m^3)	% Unit Weight Loss
CHR-0	0	2558.5	0
CHR-3	3	2462.3	3.80
CHR-6	6	2424.5	5.24
CHR-9	9	2383	6.83
CHR-12	12	2332.1	8.50

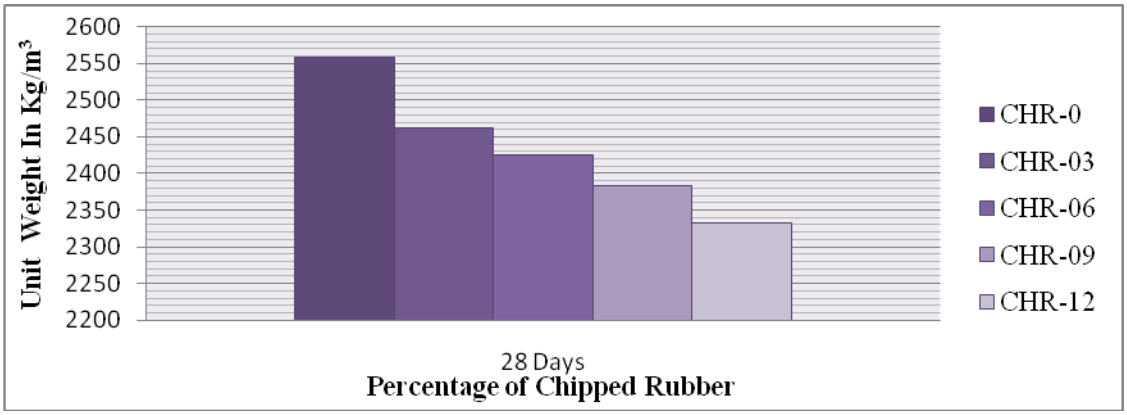

FIGURE 6. Comparisons of unit weights for beam specimens at 28 days

When increasing the percentage of rubber into concrete then reduction in unit weight of cylinder specimen. It is concluded that due to low specific gravity of rubber chips compared with specific gravity of mineral aggregates decrease in the unit weight of the rubberized concrete.

Flexural Strength Test :The test could be performed in accordance with as per code IS: 516 –1959. If the flexural strength would be same as tensile strength then material becomes homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. A simple plain concrete beam is loaded at one third span points. For the test span of beam is three times its depth and for determine strength of specimen of size 100 × 100 × 500 mm are supported. Symmetrically over a span of 400mm and two points load was applied at middle third of span.

FIGURE 7.Flexural test on concrete beams

TABLE 4: Flexural strength test results for concrete mixes

Specimen	% Rubber aggregates	Actual flexural strength (MPa)		Av. flexural strength (MPa)		% Strength loss	
		7 days	28 days	7 days	28 days	7 days	28 days
CHR-0	0	4.00	4.75	4.00	4.88	0	0
		4.25	5.00				
		3.75	4.90				
CHR-3	3	3.00	4.50	3.00	4.55	25	6.76
		2.88	4.65				
		3.10	4.50				
CHR-6	6	2.50	4.25	2.55	4.25	19.5	12.90
		2.00	4.15				
		3.15	4.35				

CHR-9	9	1.38	2.75	1.26	3.10	68.5	36.47
		1.00	3.00				
		1.40	3.50				
CHR-12	12	1.10	2.00	1.00	2.50	75	48.77
		0.90	2.25				
		1.00	3.25				

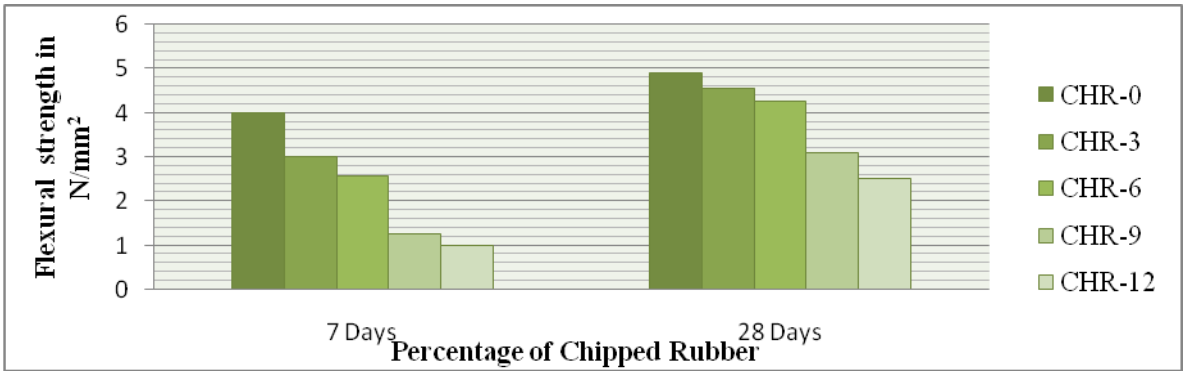

FIGURE 8. Comparison of flexural Strength of various concrete at 7 and 28 days

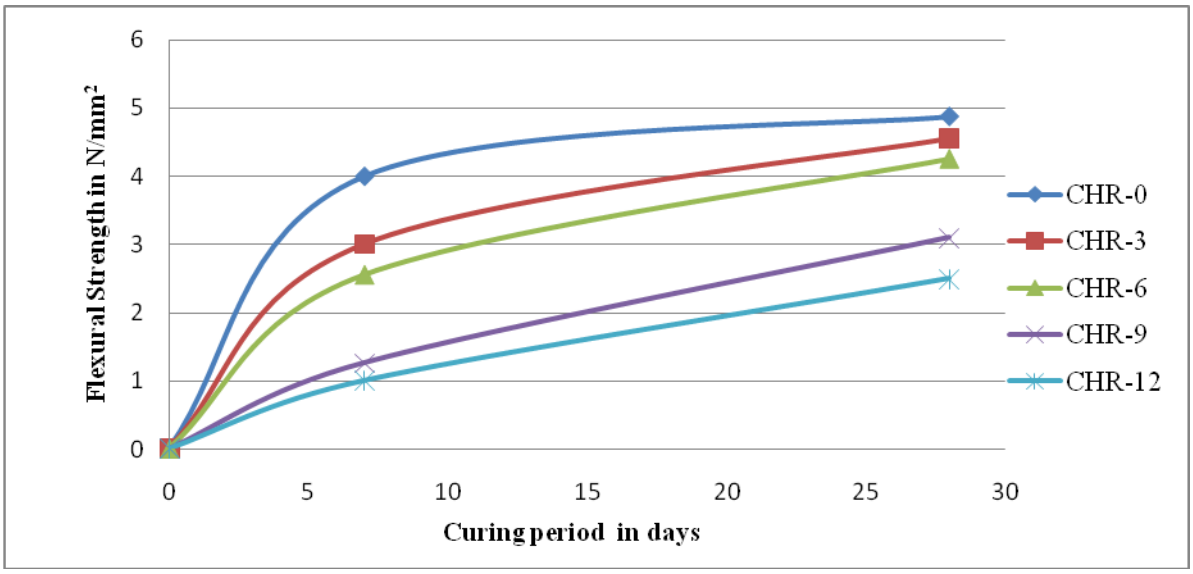

FIGURE 9. Flexural strength of various percentage of crumb rubber containing concrete

The results and graphs shows, when the percentage of chipped rubber aggregates increases into concrete then flexural strength of beam decreases. Soft nature of rubber particles creates the maximum voids into concrete and crushing strength of rubber aggregates is low as compared to mineral aggregates.

Split tensile strength test : It is the standard test; to determine the tensile strength of concrete in a direct way and test has been performed in accordance with IS 5816-1999. A standard test cylinder of concrete specimen (300mmx150mm) is placed horizontally between loading surfaces of compression testing machine. The compression load is applied uniformly along the length of cylinder until the failure of cylinder along the vertical diameter. The concrete cylinders split into two halves along vertical plane due to indirect tensile stresses generated by poison's effect.

FIGURE10. Beam cylinder before failure **FIGURE 11. Beam cylinder after failure**

TABLE 5: Test results of split tensile strength of various concrete mixes

Specimen	% Rubber aggregates	Actual Flexural Strength (MPa)		Av. Flexural Strength (MPa)		% Strength Loss	
		7 days	28 days	7 days	28 days	7 days	28 days
CHR-0	0	2.34	2.66	2.11	2.39	0	0
		2.07	2.15				
		1.92	2.35				
CHR-3	3	1.44	2.16	1.47	2.31	30.33	3.35
		1.46	2.46				
		1.50	2.30				
CHR-6	6	1.45	2.15	1.42	2.19	28.91	8.37
		1.39	2.23				
		1.43	2.20				
CHR-9	9	1.11	1.74	1.19	1.83	43.60	23.43
		1.26	1.84				
		1.21	1.91				
CHR-12	12	1.24	1.87	1.14	1.67	45.97	30.13
		1.15	1.63				
		1.03	1.56				

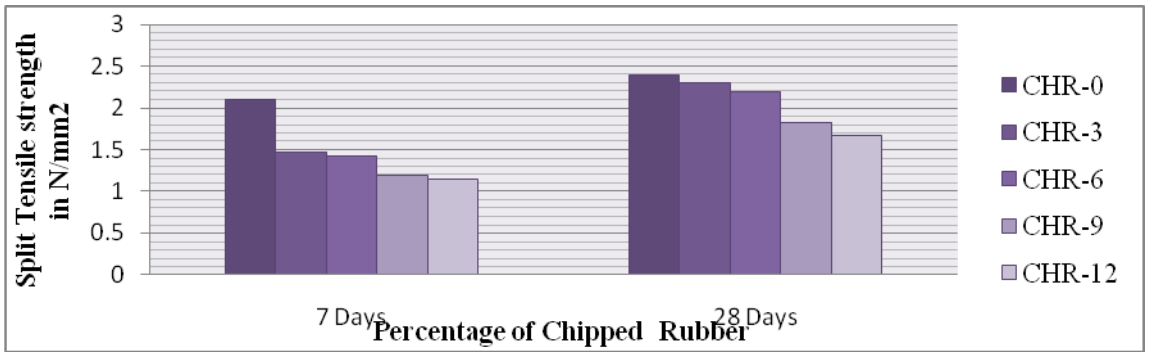

FIGURE 12. Comparison of split tensile strength of diff. concrete mixes at 7 and 28 days

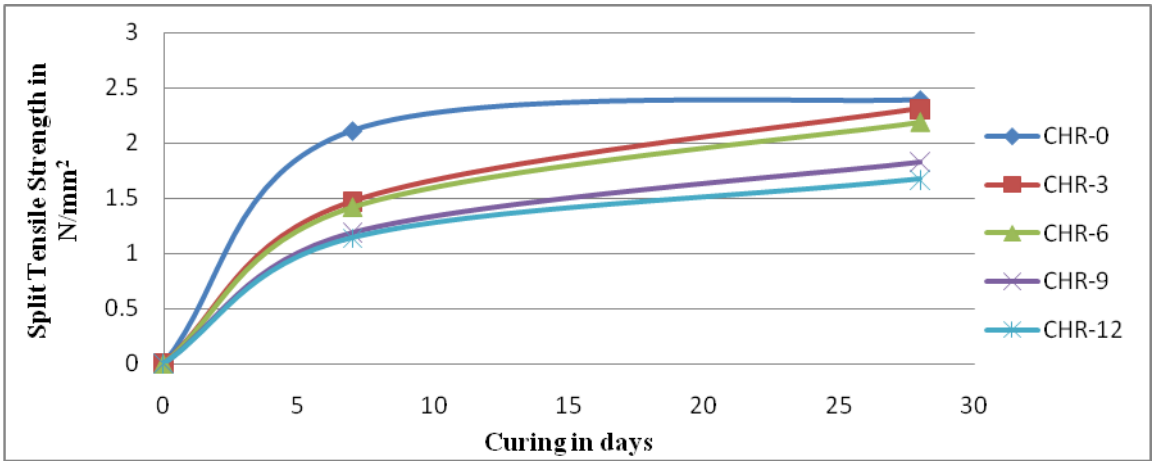

FIGURE 13. Split tensile strengths for various percentage of chipped rubber concrete

Observing from the above results, percentage of chipped rubber increased then split tensile strength is reduced. Bond Strength between cement paste and rubber tire is poor then splitting tensile strength of the chipped rubber mix concrete is lower than normal concrete.

V. CONCLUSIONS

From the test results of various mix samples, the following conclusions are drawn

[1] From the practical evaluation, replacement of chipped rubber at varying proportion in concrete, then workability of fresh concrete is decreasing with increase in percentage of chipped rubber.

[2] From the observations, it is noted that unit weight of beam and cylindrical specimen's has been reduced upto increasing the percentage of chipped rubber into concrete. From this test it has to be concluded that rubberized concrete is used in the light weight structures and restricted to the structural application.

[3] Reduction of solid load carrying material in rubberized concrete is directly affects to reducing the strength of concrete. It can be concluded that as the amount of rubber content increases then there is reduction in flexural strength.

[4] The results of splitting tensile strength test shows that, there is a decrease in strength with increase in rubber aggregate content like reduction observed in the flexural strength tests. One of the reasons that split tensile strength of rubberized concrete is lower than the normal concrete is that the bond strength between cement paste and chipped rubber aggregates is poor.

[5] The crack patterns observed during test on rubberized concrete which does not exhibit typical compression failure behavior. The normal concrete shows a clean split of sample into two halves, whereas rubber aggregate tends to produce a less well defined failure. This may be an indication more ductility in rubberized concrete than the normal concrete.

Acknowledgements : The author would like to the principal and head of the civil engineering department, K.K.Wagh Institute of engineering education and research center, Nashik, Maharashtra for the facility to avail the laboratories for this experimental work

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