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Experimental Investigation of Waste Rubber and Steel Fiber Reinforced Cement Concrete

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ABSTRACT

Waste tire rubber is used due to its light weight and elastic properties and steel fiber for its ductile and flexural toughness. In this study, there are two different mixes. M20 mix in which waste tire rubber was replaced at different replacement levels (0%, 10%, 20%, 30% and 40%) and same replacement for M25 mix keeping 2% steel fiber constant in above mix. Mechanical and durability properties were studied. When we compare the strength of above two mixes M25 mix concrete containing 2% steel fiber shows good results as its compressive, tensile and flexural strength increases compared to M20 mix. When replacement of 10% is done there is nearly 27%, 18%, and 13% rise in compressive, tensile, and flexural strength of rubber concrete with 2% steel fiber.

Keywords: Conventional concrete, Waste rubber tire, Steel fiber, Mechanical properties.

1. INTRODUCTION

The country where every budget proposal involves large construction of bridges, roads, residential and educational buildings etc. These construction schemes demand efficient and optimum use of construction resources. Most of the modern heavy constructions require cement and natural resources such as river sand and rock strata. Cost of both the materials rapidly increasing because of rise of transport cost and inadequate raw materials. In this essence the waste tire rubber can be used as an effective replacement for natural aggregate.

Disposal of waste tire rubber has grown to be a major environmental difficulty in all parts of world very serious risk to ecology. The waste tire is a promising product in construction industry due to its light weight, elasticity, power absorption, sound and heat insulating assets. One of the viable solutions for the use of scrap tire rubber is to substitute some of the natural aggregate by waste tire rubber. The rubberized concrete is durable, much less ductile and has greater crack resistance. The abrasion resistance and water absorption (up to 10% substitution) showed good results than that of control mix. Tire shreds can be useful as back fill for walls and bridge abutments. It can be used to build embankments on weak, compressible foundation soils. Extra water is unconfined when sub grade soils in the spring. putting a 15 to 30cm thick shredded layer underneath the road curb prevents sub grade soils from freezing. Scrap tires may be used in land fill capping and closures, and as a material for daily cover.

These were utilized to reinforced brittle material before cement was known since Babylonian and Egyptian civilizations. The main object of fibers is to bridge the cracks that develop in concrete and to expand the ductility of concrete elements. Fibers improvise the pressure at peak load and grant extra additional energy absorption potential of reinforced concrete structures. It was recently researched that they notably improve static flexural strength of concrete as properly as its impact strength, tensile strength, ductility and flexural toughness. Fiber reinforcement is normally randomly distributed throughout the entire element. Besides that, the character of fiber reinforced concrete varies with type of concrete, geometrics, fiber materials, distribution, orientation and volume fraction. The quantity of fibers delivered to a concrete mix is expressed as a proportion of the complete volume of concrete termed as “volume fraction” (Vf). Vf, generally ranges from 0.1 to 3%. The aspect ratio (l/d) is calculated with the aid of dividing the fiber size (l) by its diameter (d). The stitching motion of the fibers throughout the cracks reduces the improvement of macro cracks from micro cracks. They also minimize the permeability of concrete and hence reduce bleeding of water. Fiber reinforced concrete is a concrete containing fibrous material which induces its structural integrity. In recent days fibers are used as a crack arrester and it improves mechanical properties and toughness.

2. EXPERIMENTAL PROGRAMME

2.1 Materials

The cement used was ordinary Portland cement of 53 grade. The tests carried out are specific gravity 3.15, normal consistency 32, initial and final setting time are 48 and 255 minutes as per IS: 2269-2013. Fine aggregate was crushed stone sand confirming to zone II passing through 4.75 mm size sieve and having a specific gravity 2.68 with fineness modulus 2.60, bulk density of 1816 kg/m^3, water absorption 2%. Natural aggregate having 20mm down size, specific gravity 2.68, fineness modulus 4.83, water absorption 0.2%, impact value 27.01% and crushing value 25.28%was used as coarse aggregate.

2.1.2 Rubber tire

Rubber tire obtained from the tire shop. Tire used in this experiment was obtained from Gubbi gate, Tumakuru, Karnataka, India.

Table.1 Properties of Rubber tire

SI No.	Characteristics	Test results
1	Appearance	small pieces (square, diamond)
2	Color	Black
3	Size	4.75-20mm
4	Water absorption	3.8%
5	Bulk density	490 kg/m3

2.1.3 Steel fiber

In this project hooked end fibers are used. The physical properties of this fiber are listed below.

Table.2 Physical properties of steel fiber

SI No.	Characteristics	Test results
1	Steel fiber type	Double hooked end
2	Diameter(mm)	0.75
3	Length(mm)	60
4	Family of fiber	DRAMIX 3D

2.2 Mix Proportion

The Mix Design of concrete as per IS: 10262-2009 has to be done to know the proportions of concrete. The water-cement ratio for M20 is 0.55. Total six different mixtures of concrete were prepared in the laboratory. First is the conventional concrete without any additives. Next with the concrete containing rubber tire in the varying percentages of 0, 10, 20, 30 and 40% replacing coarse aggregates and next water cement ratio of M25 is 0.45 were casted where 2% steel fiber is included in the above replacement. The details of mix proportion of all the concrete are in table 2.

Table.3 Mix Proportions of concrete for M20

Notation	Constituents (kg/m3)				
	Cement	Fine Aggregate	Coarse Aggregate	Water	Rubber tire
T0(0% rubber tire)	394	726	1090	197	0
T10(10% rubber tire)	394	726	980	197	109
T20(20% rubber tire)	394	726	872	197	218
T30(30% rubber tire)	394	726	763	197	327
T40(40% rubber tire)	394	726	654	197	436

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Table.4 Mix Proportions of concrete for M25

Notation	Constituents (kg/m3)					
	Cement	Fine aggregate	Coarse Aggregate	Water	Rubber tire	Steel fiber
T0(0% rubber tire)	437	675	1106	197	0	0
TS10(8% rubber with 2% steel fiber)	437	675	995.4	197	88.48	22.12
TS20(18% rubber with 2% steel fiber)	437	675	884.8	197	199.08	22.12
TS30(28% rubber with 2% steel fiber)	437	675	774.2	197	309.68	22.12
TS40(38% rubber with 2% steel fiber)	437	675	663.6	197	420.28	22.12

3. RESULTS AND DISCUSSION

3.1 Workability of Concrete

3.1.1 Slump Cone Test

The slump test is carried out for all the different concrete mixtures to know the workability of concrete. The slump test values for different concrete mixture are in table 3.The slump value for control concrete will be slightly higher compared to other mixtures and the degree of workability will be high. The incorporation of both rubber concrete decreases the slump value. As the rubber content Increases the slump value decreases this reduction in slump values are due to rubber contains micro- pores inside and due to its light weight of the material resulting in decrease in free water and lowers the slump value.

Table.5 Results of Slump Test containing rubber tire

Concrete type	Slump (mm)	Degree of workability
T0	95	Medium
T10	85	Medium
T20	75	Low
T30	65	Low
T40	55	Low

Table.6 Results of Slump Test containing rubber tire and 2%steel fiber

Concrete type	Slump (mm)	Degree of workability
TS0	105	High
TS10	95	Medium
TS20	85	Medium
TS30	75	Low
TS40	65	Low

3.2 Hardened Concrete Properties

3.2.1 Compressive Strength Test

In this study, 3 cubes from each mix proportion were tested and average is taken as compressive strength of concrete. There will be a decrease in strength of concrete at 10% replacement of rubber, then compressive strength goes on decreasing gradually as the amount of rubber increases. When 2% steel fiber used the compressive strength of concrete goes on increasing.

Table 7 Compressive Strength test results of rubber concrete

Concrete type	Num of specimens	Compressive strength (Mpa)	
		7 days	28 days
T0(normal concrete)	6	25.08	30.76
T10	6	22.21	24.50
T20	6	18.80	21.51
T30	6	15.30	17.23
T40	6	11.25	13.40

Table 8 Compressive Strength test results of rubber concrete with 2% steel fiber

Concrete type	No. of specimens	Compressive strength (Mpa)	
		7 days	28 days
TS0(normal concrete)	6	28.20	32.60
TS10	6	25.23	26.50
TS20	6	26.20	27.51
TS30	6	18.30	21.23
TS40	6	15.60	18.50

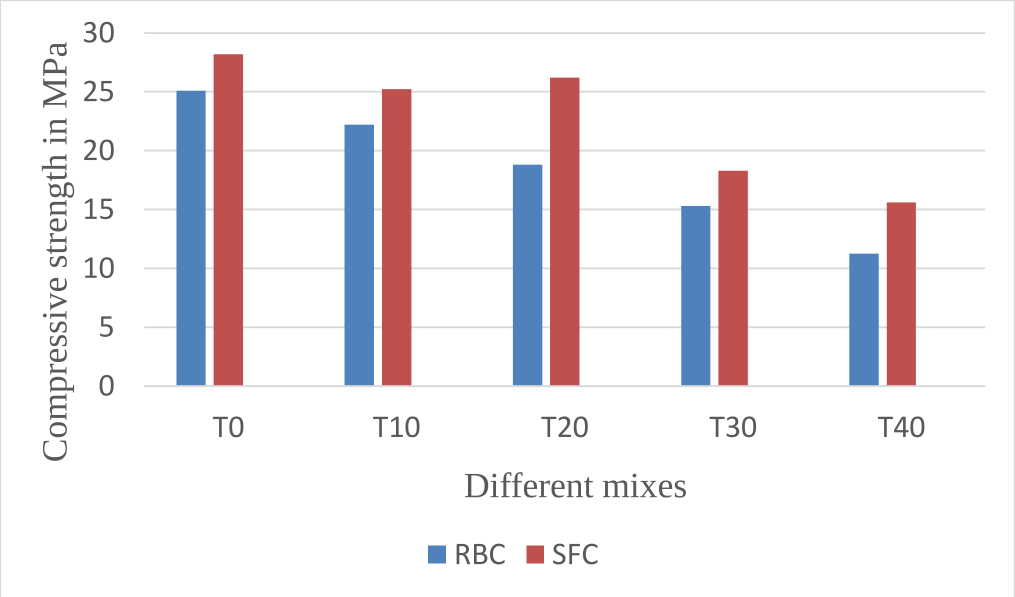

Figure.1 Graph indicating the compressive strength for 7 days

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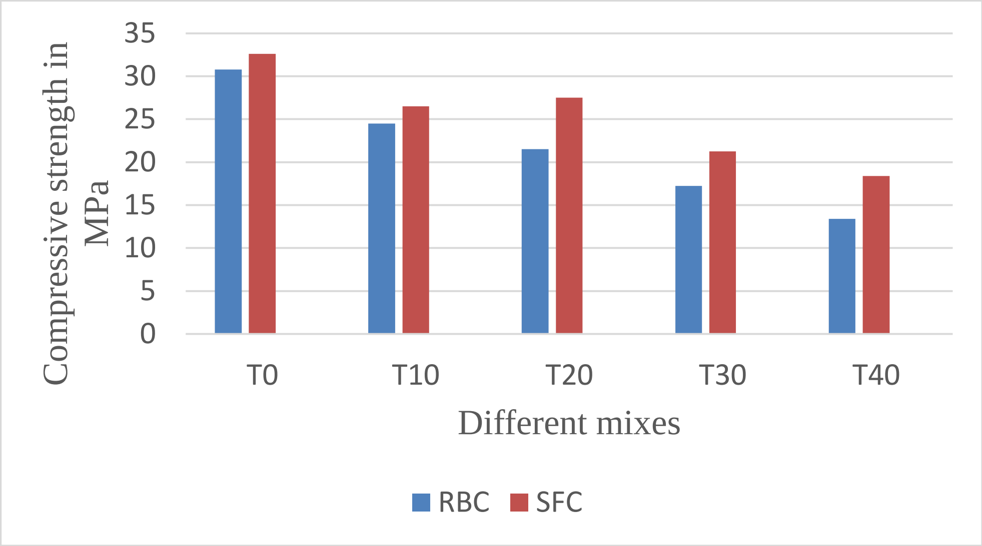

Figure.2 Graph indicating the compressive strength for 28 days

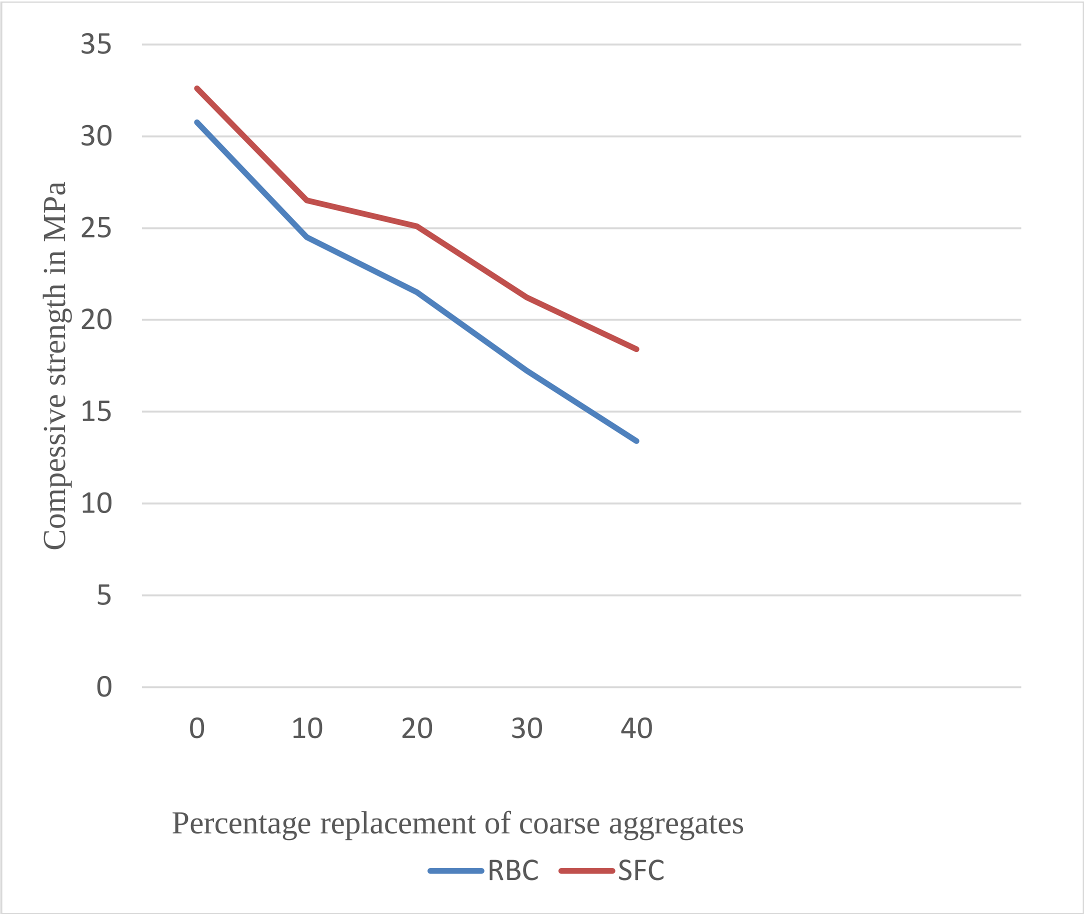

Figure.3 Increase in compressive strength of rubber concrete with 2% steel fiber (SFC) compared to rubber concrete (RBC) for 7 days

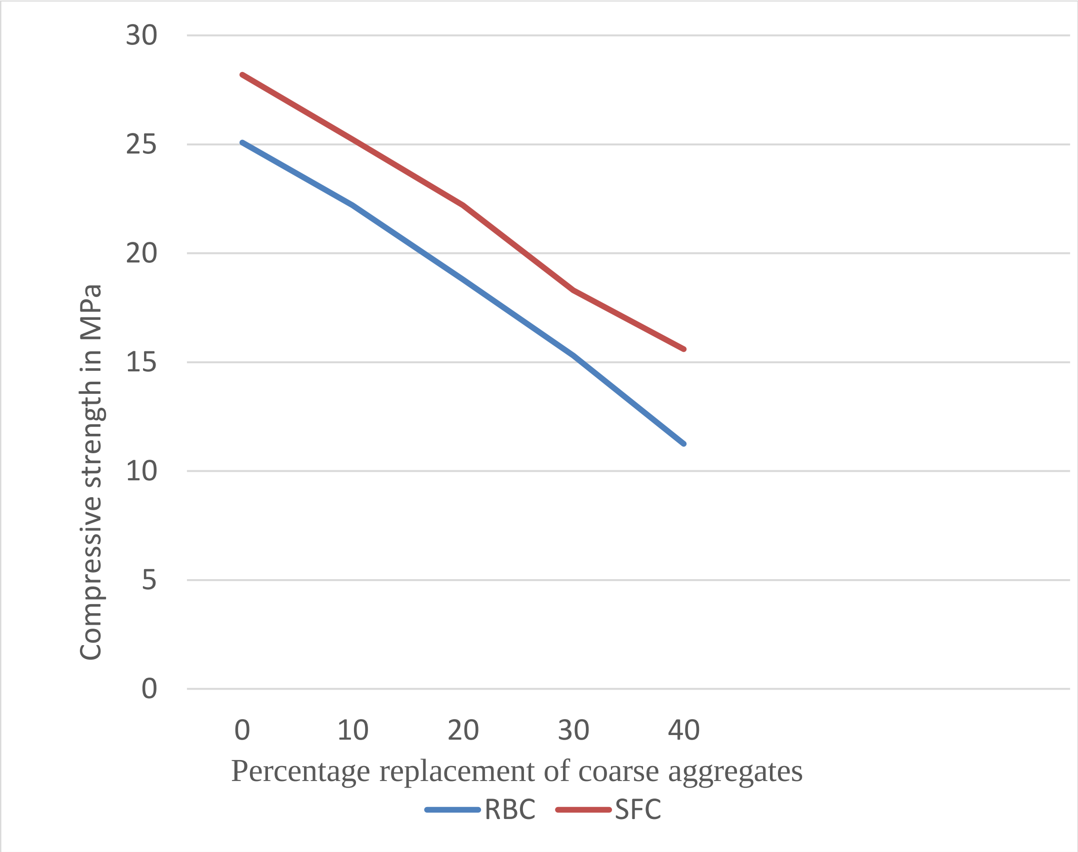

Figure.4 Increase in compressive strength of rubber concrete with 2% steel fiber (SFC) compared to rubber concrete (RBC) for 28 days

3.2.2 Split Tensile Strength Test

The test was conducted on a 150mm*300mm cylinder at the age of 7 and 28 days. The results are in the below table

Table 9 Split tensile Strength test results of rubber concrete

Concrete type	Num of specimens	Split tensile strength (Mpa)	
		7 days	28 days
T0(normal concrete)	6	1.60	1.95
T10	6	1.51	1.83
T20	6	1.34	1.67
T30	6	1.10	1.36
T40	6	0.90	1.28

Table 10 Split tensile Strength test results of rubber concrete with 2% steel fibr

Concrete type	Num of specimens	Split tensile strength (Mpa)	
		7 days	28 days
TS0(normal concrete)	6	1.73	2.15
TS10	6	1.63	1.95
TS20	6	1.45	1.73
TS30	6	1.30	1.54
TS40	6	1.10	1.32

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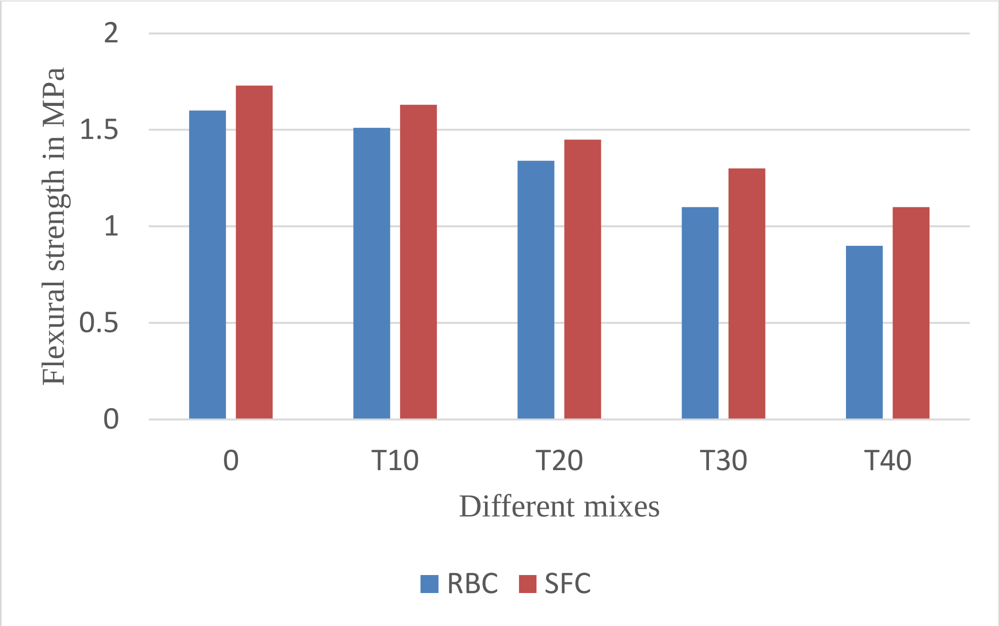

Figure.5 Graph indicating the split tensile strength for 7 days

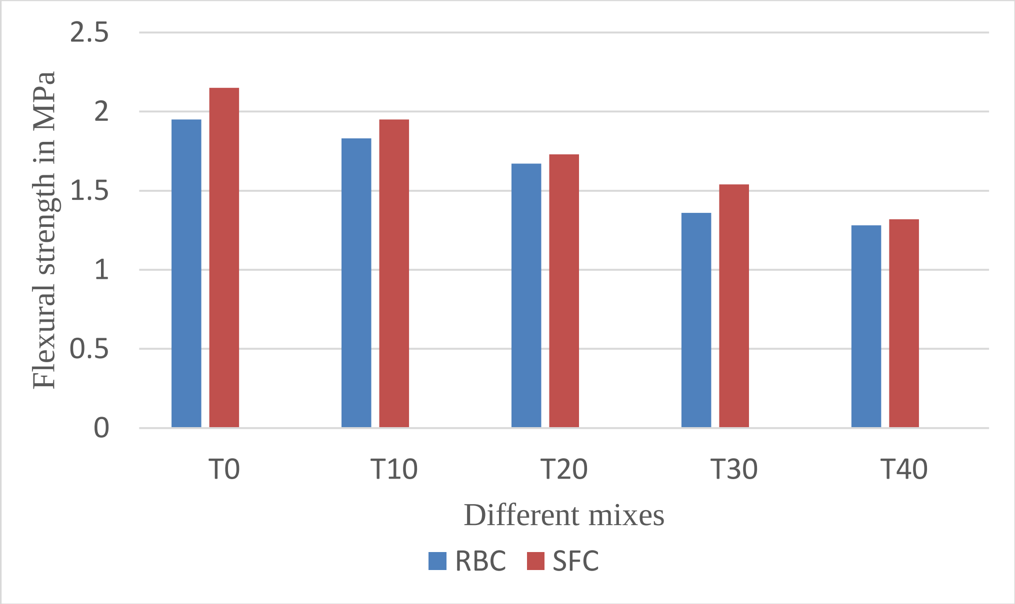

Figure.6 Split tensile strength of concrete for 28 days

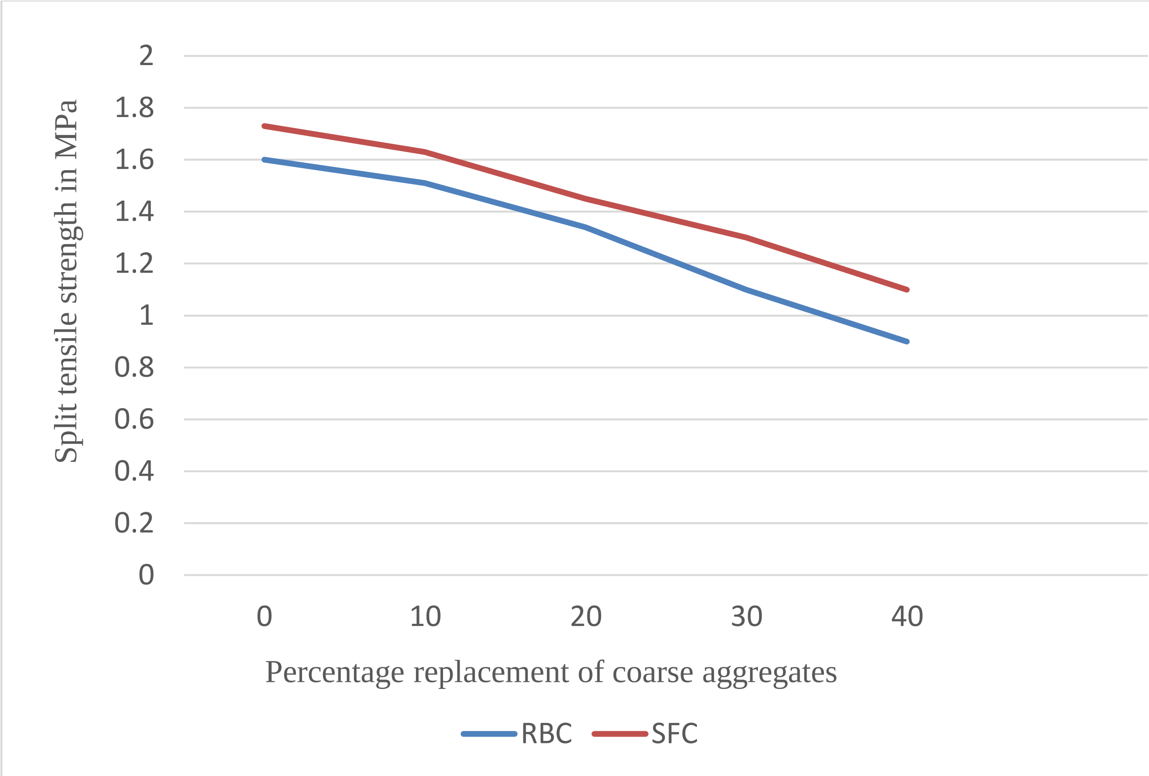

Figure.7 Increase in split tensile strength of rubber concrete with 2% steel fiber (SFC) compared to rubber concrete (RBC) for 7 days

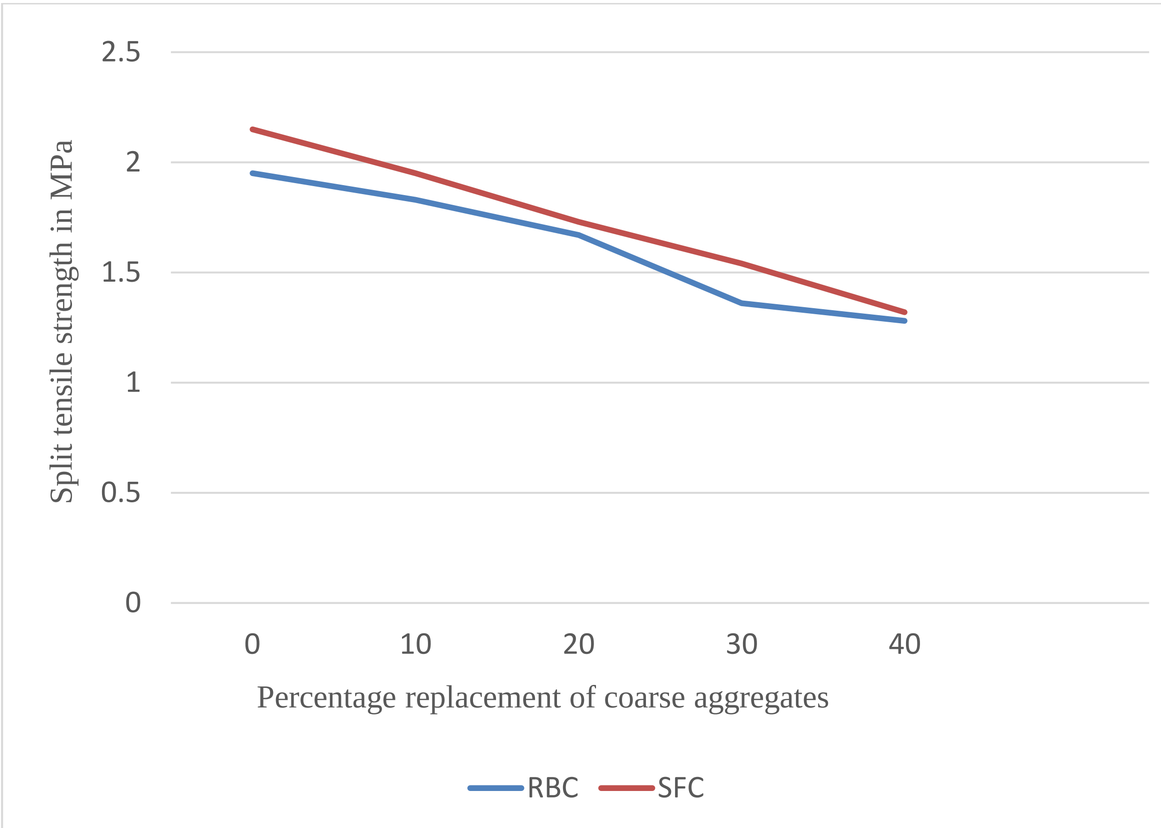

Figure.8 Increase in split tensile strength of rubber concrete with 2% steel fiber (SFC) compared to rubber concrete (RBC) for 7 days

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3.2.3 Flexural Strength Test

The strength of the specimen is calculated by using two-point loading method with the help of a hydraulic testing machine.

Table 9 Flexural Strength test results of rubber concrete

Concrete type	Num of specimens	Flexural strength (Mpa)	
		7 days	28 days
T0(normal concrete)	6	2.87	3.13
T10	6	2.12	2.59
T20	6	2.20	2.20
T30	6	2.10	2.10
T40	6	2.04	2.04

Table 10 Flexural Strength test results of rubber concrete with 2% steel fiber

Concrete type	Num of specimens	Flexural strength (Mpa)	
		7 days	28 days
TS0(normal concrete)	6	3.02	3.60
TS10	6	2.70	3.20
TS20	6	2.50	2.76
TS30	6	2.10	2.34
TS40	6	1.80	2.06

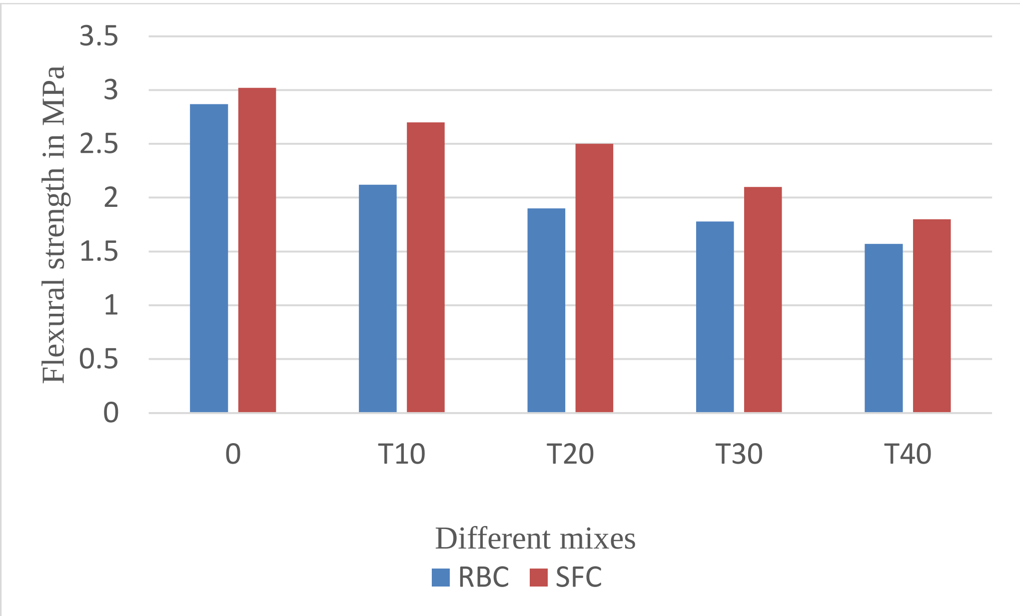

Figure.9 Graph indicating the split tensile strength for 7 days

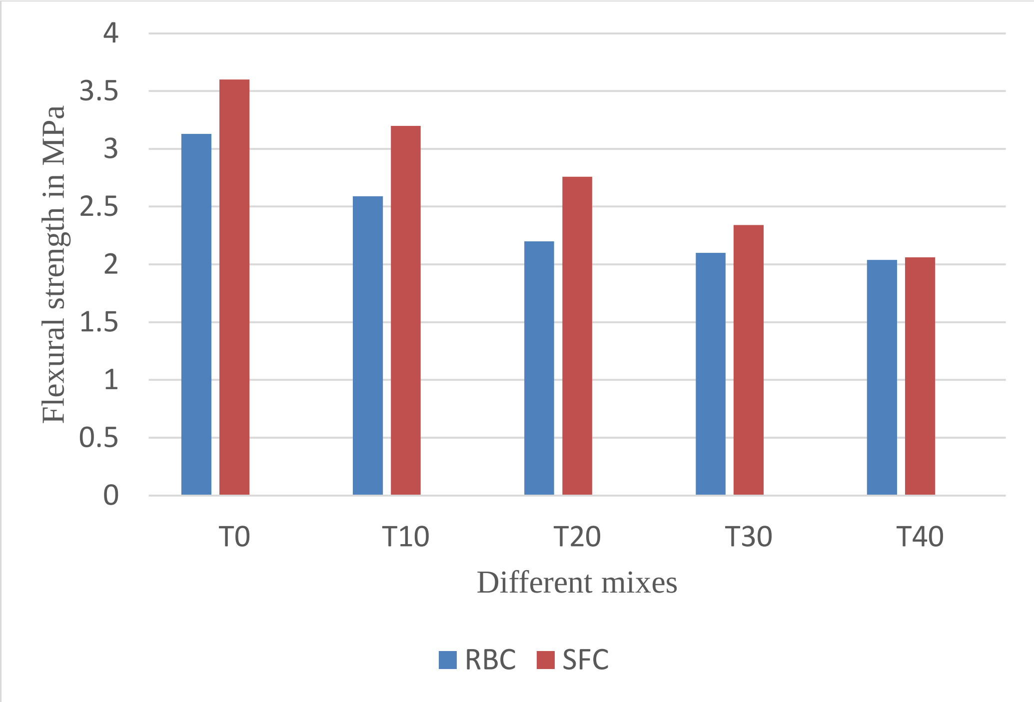

Figure.10 Graph showing flexural strength for 28 days

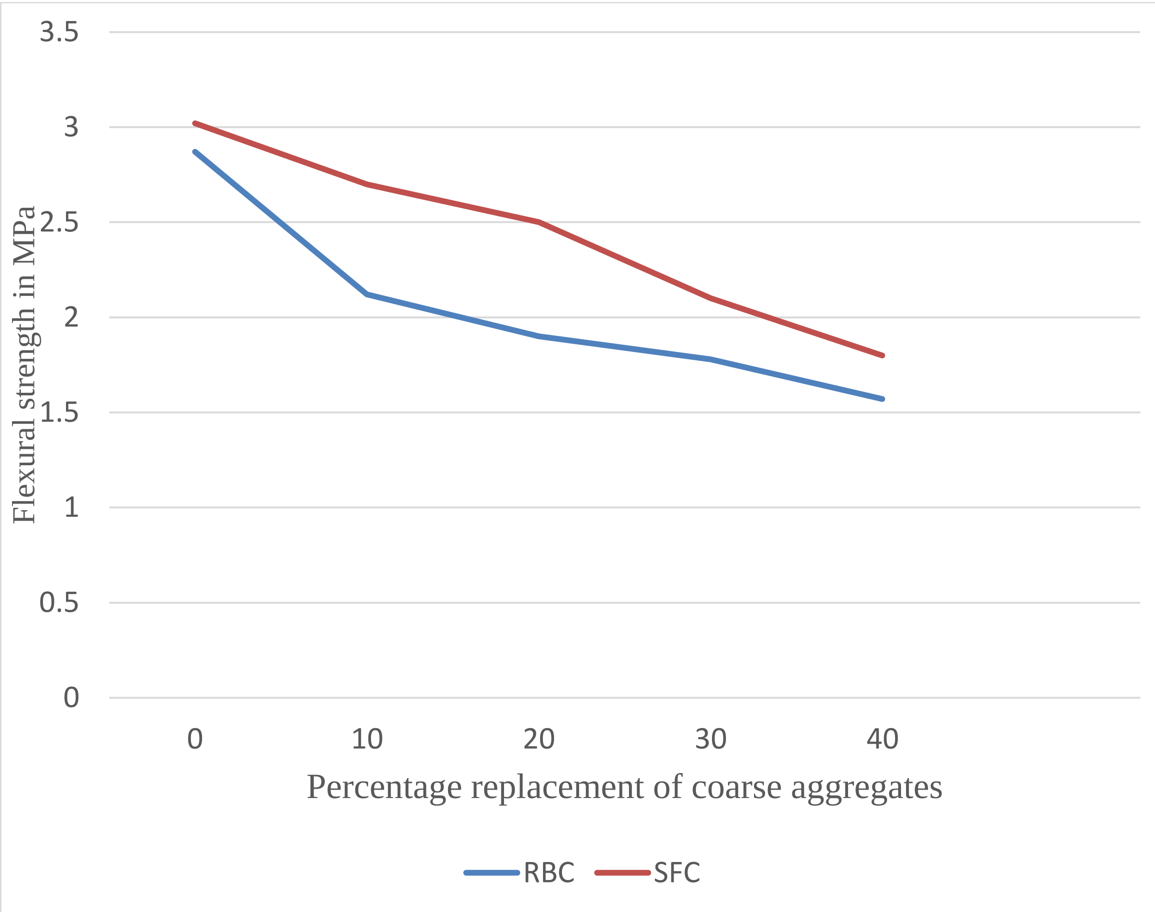

Figure.11 Graph showing flexural strength for 28 days

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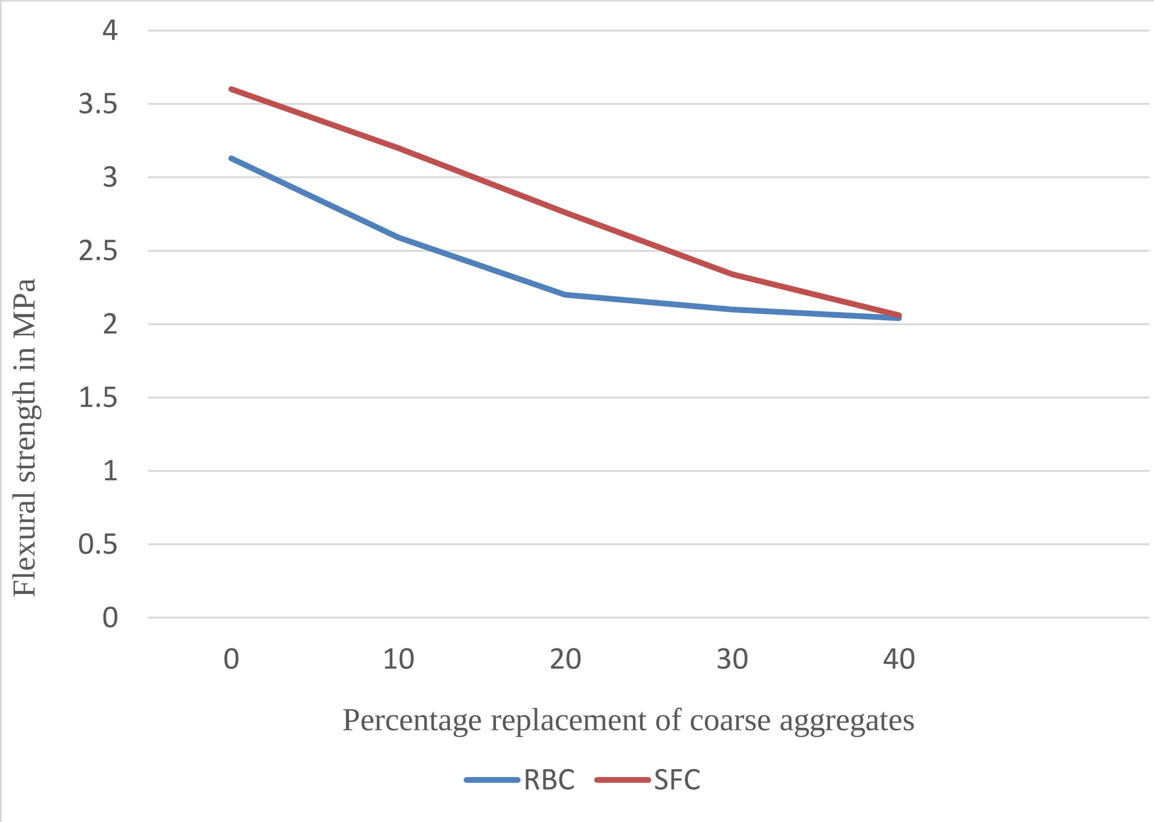

Figure.12 Graph showing flexural strength for 28 days

4. CONCLUSIONS

1) The properties of tire rubber make it proper ingredient for the problem of disposal and for preparation of concrete.

2) There is a decrease in density of concrete when replacement of rubber is increased, so it can be used as a light weight aggregate

3) Replacement of RBC and SFC made very good effect on the mechanical properties of this concrete. Therefore the following conclusion:

a. The compressive strength, split tensile strength and flexural strength of steel fiber concrete and rubber concrete goes on decreasing as the replacement of rubber increased.

b. when replacement of 10% is done there is nearly 27% rise in compressive strength of rubber concrete with 2% steel fiber when compared to rubber concrete for 7 and 28 days.

c. Split tensile strength of rubber concrete with 2% steel fiber also increases by nearly 18% when compared to rubber concrete when replacement of 10% for 7 and 28 days.

d. Rubber concrete with 2% steel fiber accounts for 13% increase in flexural strength compared to concrete with 10% replacement of rubber for 7 and 28 days.

e. There is no drastic changes in compressive, split tensile and flexural strength of rubber concrete with 2% steel fiber as constant for 20%, 30% and 40% replacement of rubber for 7 and 28 days

4) Applications of waste tire rubber are:

a. Pedestrian, foot path blocks

b. For load bearing walls or partition walls

c. Floor concrete as shock absorbing material

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