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Effects of Recycled Waste Tire Rubber as Coarse Aggregate on the Performance of Concrete

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Abstract:

This paper is the second in the series of publishing papers in our research of sound absorption behavior of rubberized concrete. There are very serious problems with the disposal of waste tires in India and worldwide. Because of environmental problem associated with the disposal of waste automobile tires so we need to find an environment-friendly solution. Then this study explores the possibility of reusing tire waste in concrete engineering applications through enhancing the properties of concrete mix as partial replacement with coarse aggregate to produce ideal concrete mix. In this study, percentage replacement of tire waste with natural aggregate in the concrete mix by weight is 0%, 10%, 20%, and 30% respectively. Chipped type generally square in shape and max 20mm in size are used as coarse aggregate. Tests were conducted to determine slump performance, flexural strength, density calculation, water absorption for control and rubberized concrete mix of M25.

Keywords — **Rubberized concrete, Scrap rubber, chipped shape rubber, recycling, waste management.**

I INTRODUCTION

Every year all over the world, a steady stream of large volume of waste tires is generated due to the continual increase in the number of all kinds of transport vehicles. Since the last two decades in India, transportation vehicles have been increasing tremendously. Tires are bulky, and 75% of the space a tire occupies is void, so that the land filling of scrap tires has several difficulties as whole tire land filling requires a large amount of space. Because of these difficulties and the resulting high costs, tire stockpiles have turned up across the country. These waste tires represent a significant environmental, human health, and aesthetic problem. The unique properties of scrap tires have made the wiping out of waste tire stockpiles difficult. Several of these problems are associated with following.

(i) Toughness (difficult to break down and decompose), durability (difficult to process),
(ii) Shape (large void space, poor space efficiency for storage and transportation)
(iii) Volume (occupies a large volume).

In this regard, the plenty availability of scrap tire rubber could be utilized as an capable replacement for natural rubber compounds which will be beneficial for both saving environment and natural resources.

A. Aim Of This Research

1. Design a standard concrete mix (M25).
2. Replacement of coarse aggregate of standard concrete mix with chipped shape scrap tire waste with wire by weight as 0%, 10%, 20%, and 30% respectively.
3. Investigation of properties of rubberized concrete and comparison with control sample.

II EXPERIMENTAL WORK

A. Materials Properties

In performance of the experiments the raw materials used included portland pozzolana cement, mixture of aggregates (coarse and medium), sand, water and tire waste. Tires from light vehicles, such as cars were used

B. Cement

PPC of grade 43, conforming to Indian Standards (IS): 8112-1989 was used. Specific gravity of cement was found to be 3.15, Normal consistency was 32%, Initial setting time was 42 min and final setting time was 6hours.

C. Fine Aggregate

The fine aggregate (Fig. 1) was natural sand of 10 mm maximum size as shown in fig.1. The properties of the fine aggregate were determined and table (1) presents the properties of the sand, conforming to grading zone II of IS 383-1970. Gradation curve is shown in Fig 2.

Figure-: 1 Fine aggregate

TABLE 1

PHYSICAL PROPERTIES OF FINE AGGREGATES

Properties	**Test Results**
Specific Gravity	2.64
Fineness modulus	2.82
Water absorption	0 .98 %
Silt content	4.6 %

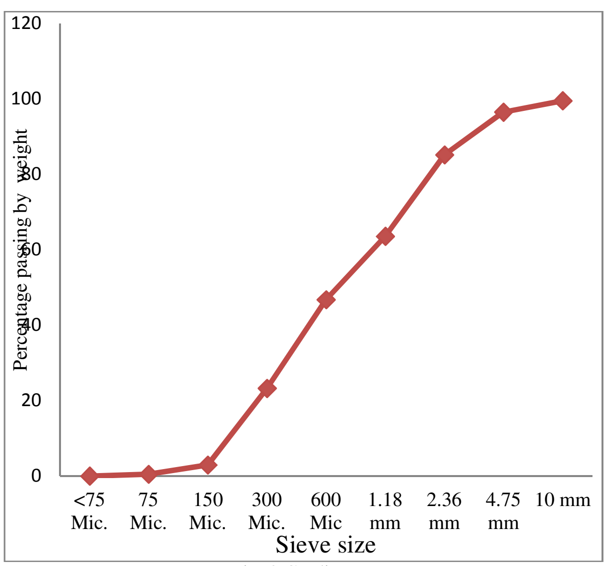

Fig. 2 Grading curve

D. Coarse Aggregate

Natural crushed stone aggregate for maximum size 20mm as shown in fig.(3) The physical properties of coarse aggregate were determined and tabulated in table (2).

Fig. 3 Coarse aggregate

TABLE 2

PHYSICAL PROPERTIES OF COARSE AGGREGATES

Properties	**Test Results**
Specific Gravity	2.77
Water absorption of 20 mm Aggregate	0.94 %
Water absorption of 12.5 mm Aggregate	0.89%
Grading ratio of 20 mm to 12.5 mm	2:1

E. Rubber Aggregate

Waste tire rubbers generally square in shape and, chipped type obtained from local market with max size of 20mm without removing of steel wire was used as rubber aggregate as shown in fig. (4) and the physical properties of rubber aggregate were determined in table (3).

TABLE 3

PHYSICAL PROPERTIES OF RUBBER AGGREGATES

Properties	**Values**
Type	Car scarp tire with steel wire
Shape of particle	Chipped type generally square in shape
Size	10-20mm
Specific gravity	1.40
Color	Black
Water absorption 24 Hours (%)	0.01

Fig. 4 Size and shape of rubber aggregate

F. Concrete Mix Design

Concrete strength is greatly affected by the properties of its constituents and the mixture design parameters control concrete mixtures. The mix proportions of different types of percentages of replacement mixes and obtained quantities for mixes were tabulated as below in table (4).

Fig.5 Concrete mixture after replacement by scrap rubber

TABLE 4
CONTROL AND RUBBERIZED CONCRETE MIXTURES AND SAMPLE DESIGNATION

Scrap tire %	W/ C	Materials in Kg/m^3				
		C	W	FA	CA	RA
0	0.5	400	191.6	665.20	1188.20	N.A
10	0.5	400	191.6	665.20	1069.57	60.06
20	0.5	400	191.6	665.20	950.73	120.12
30	0.5	400	191.6	665.20	831.89	180.19

C* CEMENT W* WATER FA* FINE AGGREGATE
CA* Coarse Aggregate RA* Rubber Aggregate

G. Test Specimen

Cube specimens of 150 X 150X 150 mm were casted, The specimens were left in the moulds for 24 hour to attain enough strength so that it does not deform under their own weight and be peeled. After de-moulding, the specimens were kept in a curing tank and tests were performed at the end of curing period. Beam specimens 100 x 100 x 150 mm were casted for flexural strength test and cured for 7 and 28 days. Both cubic and beam specimens were obtained on samples with rubberized concrete mixtures on 0%, 10%, 20%, and 30% replacement by weight and w/c ratio 0.5 is maintained. Each experimental parameter was obtained by averaging the results of three samples.

III EXPERIMENTAL RESULTS AND DISCUSSION

A. Workability

The workability (i.e. consistence) of the concrete was measured immediately after its manufacture in terms of slump in accordance with IS: 7320-1974 for testing fresh concrete.

It is noted that slump has been fall off due to increase in percentage of rubber aggregates at same w/c ratio in control and all replaced samples of concrete mix. In control specimen, slump is seen to 92 mm and when the coarse aggregates are replaced with 30% tire chips then the slump is about 5 mm which becomes about zero slump value. Figure 6 shows the slum values at different values of scrap tyre rubber.

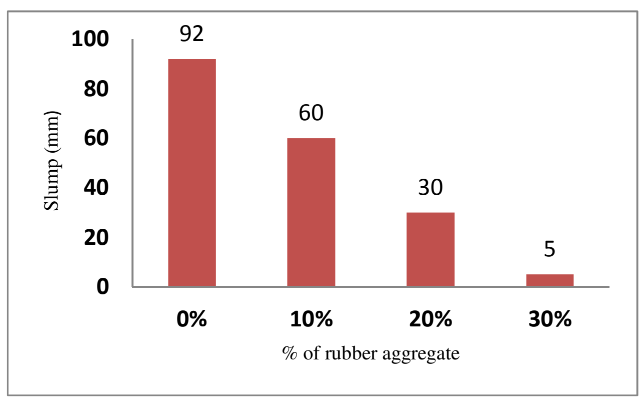

Fig. 6 Slump values for different percentage of rubber aggregate

B. Flexure Strength

Flexural strength is the potential of the beam or slab to resist failure in bending. Flexural strength test is done on beam samples by third point loading system at 7days and 28days as per IS: 516-1959.

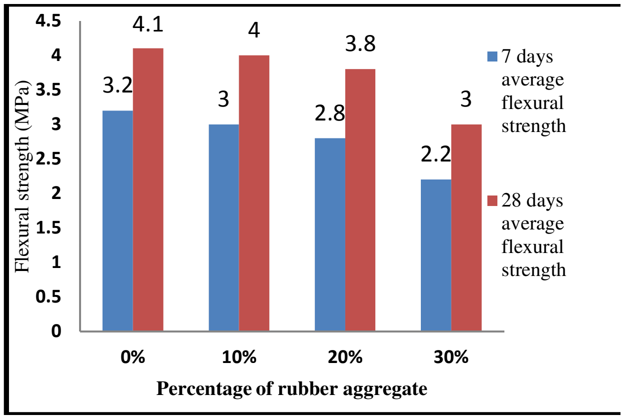

Fig.7 Comparison of 7 days and 28 days average flexure strength for different percentage of rubber aggregate

Flexural strength reduced by increasing replacement of tire rubber aggregate. The variations in flexural tensile strength obtained at 7days and 28days with respect to the 0%, 10%, 20% and 30% replacement of rubber aggregate as shown in fig. 7. At 7days, maximum value (3.2Mpa) of average flexural strength was noticed with control mix at 0% replacement of rubber aggregate and average flexural strength at 30% replacement was minimum value (2.2). At 28 days, maximum value (4.1MPa) of average flexural strength was noticed with control mix at 0% replacement of rubber aggregate and average flexural strength at 30% replacement was minimum value (3.0MPa). Also it was observed that the control specimens with 0% rubber aggregate replacement has brittle failure and was broken into two pieces under loading while the rubberized concrete did not show brittle failure under loading system.

C. Density

Tests were conducted to find out the dry density of newly made concrete samples as per IS: 2572. Densities were influenced by the constant w/c ratio and the amount of scrap rubber replacement. The density shows a downward trend as shown in fig. 8 The density of the concrete ranged from 2505 to 22230 kg/m3, depending on rubber aggregate percentage. The apparent density of the 10%, 20% and 30% replaced concrete mixes were reduced by 3.4%, 7.9% and 10.97%, respectively, compared to concrete with control specimens.

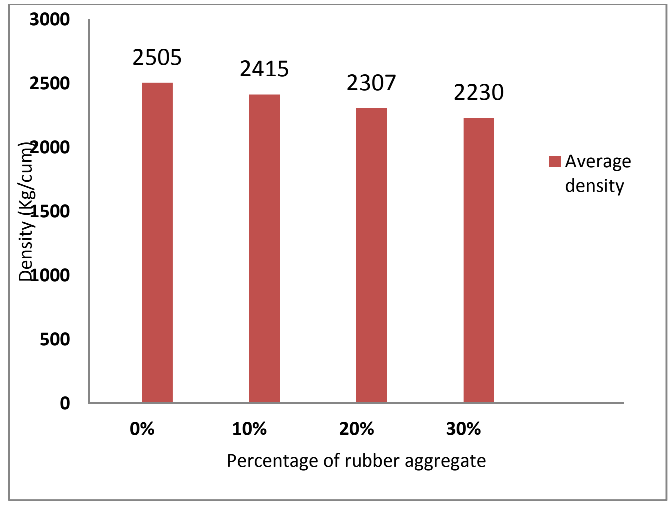

Fig. 8 Density calculation

D. Water Absorption

ASTM C642-81 explains the method to determine water absorption in concrete. Cubes (150mm x150mm x150 mm-set of 3 samples each) were casted and cured.

Water absorption test carried out on concrete cubes and it was found that it will be increases by increasing the content of scrap tire rubber in place of coarse aggregate to 30% because the weak bond between the cement paste and the rubber aggregate as a result the vacuums will be increases this leads to the water to penetrate through the interface zone of cement matrix and rubber aggregate. Also, formation of internal voids due to rubber replacement causes water absorption. At the age of 28days, the amount of water absorption for control mix was found 1.22% as shown in figure 12. Percentage increase at 10%, 20%, and 30% replacement of rubber aggregate by control specimen was found 36%, 105% and 162% respectively.

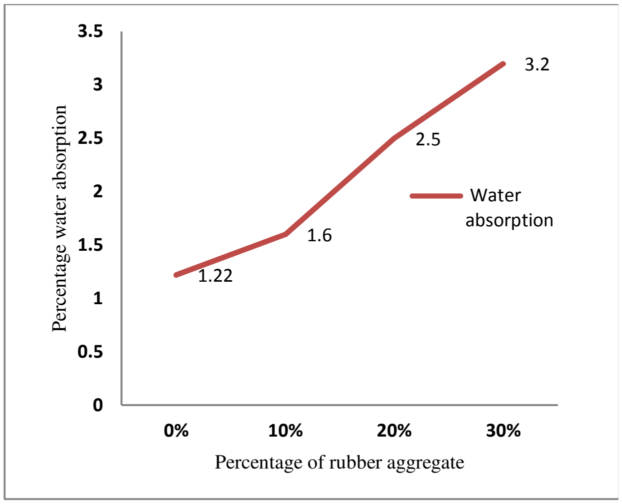

Fig.9 Water absorption values for different percentage of rubber aggregate

IV CONCLUSION

Based on the experimental investigation, the following can be concluded:

1. The study illustrate that it is possible to design rubberized concrete with varying percentage of scarp rubber by coarse aggregate such as 0%, 10%, 20%, 30%.
2. Higher content of waste tire rubber (chipped shape) produces the light weight concrete.
3. Introduction of recycled rubber tires into concrete mix leads to decrease in slump and workability for the various mix samples.
4. Minor decrease in flexural strength was observed on using waste rubber as coarse aggregate. The highest reduction was related to 30% replacement of rubber used. The reduction in flexural strength at 28 days of age was about 26.83%
5. Density decreases as the percent of rubber aggregate increases, for various percentages of mixes. Water absorption increases as percentage of rubber aggregate content increases. It is observed that the specific gravity and bulk density of rubber aggregates are less as compared to natural coarse aggregates.
6. Rubberized concrete can be used in non-load bearing members with medium strength requirement.

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