Evaluation of Concrete Using Reshaped Waste Tyre Rubber as Partial Replacement of Coarse Aggregate

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Abstract - The increasing demand of natural resources for the concrete production has created significant impact on the environment and the concern to protect these natural resources is increasing. The conglomeration of waste tyres and their disposal attracts serious attention as their disposal on landfill pollutes the land, ground water and also air when they are incinerated. When water gets stagnated in these waste tyres, they form a breeding platform for mosquitoes and worms which cause dangerous diseases. Various research work had been conducted in the past which had results that showed reduction in the mechanical strength of the concrete. The objective of this research is to use the reshaped waste tyre rubber as partial alteration of coarse gravel in the concrete and to examine the outcome of providing an mooring hole of10mm in dia on the surface of the rubber gravel which will allow the cement paste to form a cylindrical mooring between the gravel and the concrete as well as serves as a reinforcement to the rubber gravel thereby, increase withstanding power to failure under load which simultaneously increase the strength. The partial replacements of coarse aggregates are done at 0%, 5%, 10%, 15% and 20% by volume of coarse aggregate. The resulting concrete specimens are tested for the physical charastrics of concrete such as crushing strength, Spliting strength and bending strength. The crushing strength of the 10% alteration was found to be 32.68N/mm^{2}which was up to 7.92% increase compared to the conventional concrete mix. The Spliting strength of 10% alteration was 3.6 N/mm^2 which was up to 11.80% increase compared to the conventional concrete mix. The Bending strength of 10% was 10.28 N/mm^2 which was up to 7.08% increase compared to the conventional concrete mix. It was concluded that 10% alteration of coarse gravel with reshaped rubber gravel is the optimum replacement percentage that showed promising results and also drilling of hole on the rubber aggregate's surface has proved to be an useful feature that served its purpose on its effect on the strength of the concrete[1].

Index terms- Anchorage hole, Mix proportioning, waste tyre rubber, compressive strength.

I. INTRODUCTION

Numerous researches have been conducted in the past using chipped rubber as partial alteration of coarse gravel which resulted in reduced strength in the mechanical characteristics of the concrete. Though there was reduction in the strength, when the rubber aggregate was pre-treated with some chemicals, the results showed increased mechanical strength of the concrete but the process of pre-treating the rubber aggregate is quite costly. The objective of this research is to study the merit and demerit of introducing a 10 mm diameter anchorage hole on the rubber aggregate surface. This hole is provided to make the cement mix to structure a cylindrical bonding between the rubber aggregate and the concrete mix and also to act as an reinforcement to the rubber aggregate. This concept of formation of cylindrical anchorage increases the ability to resist deformation when load is applied eventually increasing the concrete's mechanical strength.[2]

Purpose of the Study:

Previous investigations have shown that the Tyre Rubber Aggregate Concrete (TRAC) possesses moderate strength but did not show enough strength when compared to ordinary conventional concrete.

This study has the following purposes

1. To increase the physical strength of the Tyre Rubber Aggregate Concrete (TRAC).
2. To analyе the impact of the holes provided on the surface of the rubber gravel on the mechanical characteristics of the concrete.

II. MATERIALS AND METHOD

A. Cement

A binding medium that adheres the other components together in the concrete. This study used OPC 53 grade as per IS code 12269,1987in every experiment.

B. Coarse Aggregates [Natural]

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Fig.1 10 mm diameter hole on the surface of the reshaped tyre rubber

The 20 mm well graded and smaller size were made use in this study. The gravel were tested according to the Indian Standards 383 – 1970.

C. Fine Gravel [M-sand]

The M-sand which was available locally that passed in 4.75mm sieve corresponding to IS 383, 1970 was used as fine aggregate. This fine aggregate satisfies the Zone-II category grouping. Table 1 shows the sensible properties of fine aggregate and coarse aggregate.

Table 1.Sensible Properties of Fine Aggregate and Coarse Aggregate

DESCRIPTION	FA	CA
Specific Gravity	2.64	2.84
Bulk density	1450 kg/m^3	1665kg/m^3

D. Tyre Chipped Rubber

The truck tyres which contained thread fibres in it were shredded to acquire the rubber chips. The tyres are then cut to form small cubes of 20x20x10 mm size. A hole of 10 mm diameter was made on the rubber aggregate's surface.Table 2 represents the physical characteristics of the rubber chips.

Table 2.Physical Properties Of Rubber Chips

DESCRIPTION	CA
Specific Gravity	1.11
Bulk density	480

Sample Procedure:

As per the M25 mix design, the cement, fine sand and coarse gravel are weighed and combined to be mixed properly and then gradual addition of water at a ratio of 0.5 was carried out to give a homogenous mixture. If there is any formation of lumps, they are taken out at any phase, broken and added back into the mixture. Then, for the second mixture, the coarse aggregate was partially replaced at 5%, 10%, 15% and 20% by volume of coarse aggregate by the reshaped rubber chips. The standard cube specimens (150x150x150mm), cylindrical specimens (150x300mm) and prism specimens (100x100x500mm) were casted.For optimum moisture retention, the moulded specimens were covered with gunny. After 24 hours, these specimens are taken out of the mould and subjected to curing in a pond of water. In this study, a total of 45 cubes, 30 cylinders and 30 prism specimens were casted.

Curing

The specimens were cured for 7, 14 and 28 days in a pond of water called as the ponding method of curing.

III. RESULTS AND DISCUSSION

A. Compressive strength

The Universal Testing Machine (UTM) was used to perform the crushing test on the cube and cylinder specimens. After 7, 14 and 28 days of curing, the cube specimens of size 150x150x150mm were studied. For each mix and each test, 3 specimens were tested and analysed.The compressive strength was calculated using the formula

$$Fc = P/A$$

Where, Fc is the compressive strength in MPa;P is the applied ultimate load;A is the sectional area in mm^2.

Fig.2.Cube specimen

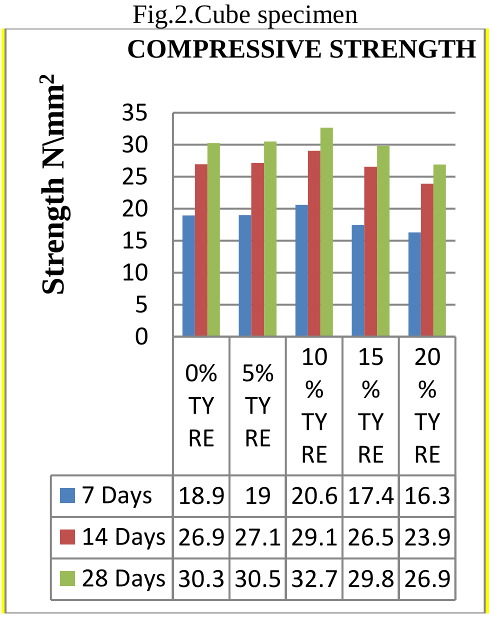

Fig.3.Compressive Strength

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The graph above shows the crushing strength test results. It was seen that the strength had marginal change in 5% rubber tyre replacement, increased in 10% rubber tyre replacement and decreased in the 15% and 20% rubber tyre replacement. At 7 days, the strength of 10% was 20.6N/mm^2 which was up to 8.82% increase related to the normal concrete mix. At 14 days energy of 10% alteration gave more strength. At 28 days, the strength of 10% was 32.68 N/mm^2 which was up to 7.92% increase related to the normal concrete mix.

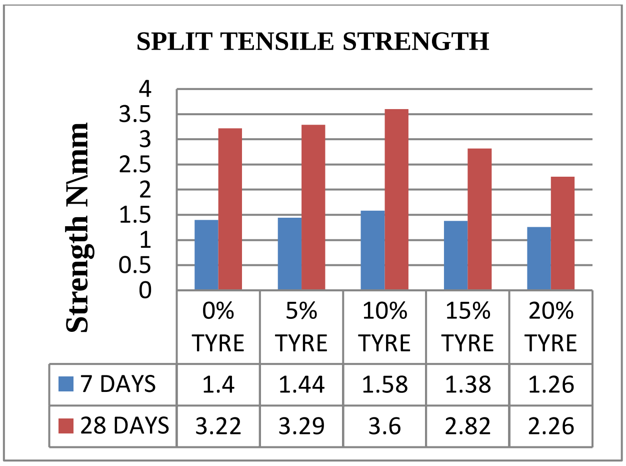
B. Split Tensile Strength

The malleable property of concrete was found out using the spliting strength test. After 7 and 28 days of curing the test was carried out on the cylinder specimens of size 150x300mm respectively using the Compression Testing Machine (CTM). The spliting strength was calculated using the formula

$$F_{ct} = 2P/\pi dl$$

where, F_{ct} is the Split tensile strength in MPa;
P is the Compressive load on the cylinder specimen in N;
l is the length of the circular solid in mm;
d is the diameter of thecylinder in mm.

Fig.4.Cylinder Specimen



	0% TYRE	5% TYRE	10% TYRE	15% TYRE	20% TYRE
7 DAYS	1.4	1.44	1.58	1.38	1.26
28 DAYS	3.22	3.29	3.6	2.82	2.26

Fig.5.Split Tensile Strength

The graph above shows the split tensile strength test results. It was observed that the strength had marginal increase in 5% and 10% rubber tyre replacement and decreased in the 15% and 20% rubber tyre replacement. At 7 days, the strength of 10%was 1.58 N/mm^2 which was up to 12.85% increase related to the normal concrete mix.

At 28 days, the strength of 10% was 3.6 N/mm^2 which was up to 11.80% increase related to the normal concrete mix..

C. Flexural Strength

The flexural energy of the concrete was found out by conducting the flexural energy test. The prism specimens of size 100x100x500mm cured for 7 and 28 days are tested in this experiment. The bending strength of the prism specimens was found using the two point loading method after 28 days of curing. The bending strength is determined using the formula

$$F_b=PL/bd^2$$

Where F_b is the flexural strength in MPa;

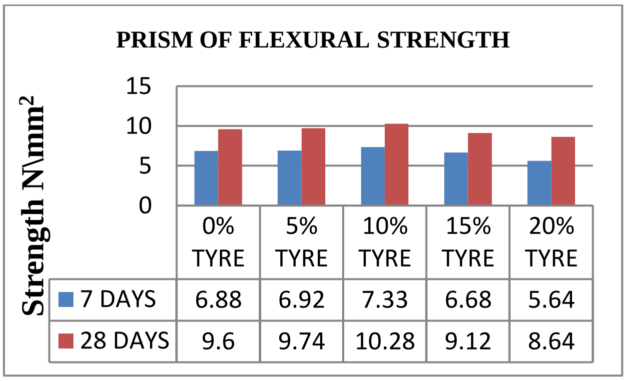
P is the ultimate load applied;

L is the length of the span in mm;

b is the breadth of the specimen in mm;

d is the height of the specimen inmm;

Fig.6.Prism Specimen



	0% TYRE	5% TYRE	10% TYRE	15% TYRE	20% TYRE
7 DAYS	6.88	6.92	7.33	6.68	5.64
28 DAYS	9.6	9.74	10.28	9.12	8.64

Fig.7. Flexural Strength

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The graph above shows the Flexural strength test results. It was observed that the strength had marginal increase in 5% rubber tyre replacement, increased in 10% rubber tyre replacement and decreased in the 15% and 20% rubber tyre replacement. At 7 days, the strength of 10%was 7.33N/mm^2 which was up to 6.54% increase related to the normal concrete mix.. At 28 days, the strength of 10% was 10.28 N/mm^2 which was up to 7.08% increase related to the normal concrete mix.

D. Findings of the study

From this study, it was found that the optimum percentage of the chipped rubber aggregates that yielded the maximum strength was 10% and had the following results.

Table 4. Results Of 10% Rubber Replacement

Mechanical Properties	7 days (N/mm^2)	28 days (N/mm^2)	% increase in strength as compared to the conventional concrete.
Compressive Strength	20.6	32.68	7.92
Split Tensile Strength	1.58	3.6	11.80
Flexural Strength	7.33	10.28	7.08

It can be inferred that 10% reshaped rubber tyre replacement has given the increase in strength as compared with the conventional concrete mix and other replacement percentages. Thus 10% can be regarded as the optimum percentage for using the reshaped rubber chips as partial replacement of aggregates in the concrete mix which gives promising results.

IV. CONCLUSION

The general purpose of this study is to examine and analyze the mechanical characteristics of the concrete which was prepared by partially replacing the coarse aggregate by locally available reshaped rubber chips in various percentages. The following inferences were obtained from the results of the various tests performed on the concrete specimens.

It can be inferred from the results that

- 10% replacement of coarse aggregate by reshaped rubber chips resulted in increase in the crushing strength of the concrete as related to the normal concrete mix..
- The split tensile strength is increased in 10% coarse aggregate replacement with reshaped rubber chips when related to the normal concrete mix.
- The 10% replacement of coarse gravel with reshaped rubber chips also showed increase in the flexural energy of the concrete specimens as related to the normal concrete mix.
- The hole made on the surface of the reshaped rubber showed promising results on the mechanicalcharacteristicsof the concrete.

V. FURTHER RESEARCH RECOMMENDATIONS

Proper studies have to be conducted to investigate the chemical reactions that might take place among the ingredients of the concrete to prevent unwanted outcomes such as alkali-carbonate reactions and alkali-silica reactions.

This research made use of single graded reshaped rubber chips of size 20 mm. Studies on the consequences of different sizes of aggregates and different % alterations have to be carried out in the upcoming experiments in addition to those analyzed in this study. Addition of steel and glass fibers can be attempted to increase the strength of the concrete when higher proportions of reshaped rubber chips are added to the concrete mix.

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