USE OF RUBBER AS AGGREGATE IN CONCRETE

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ABSTRACT

Rubber is produced excessively worldwide every year. It cannot be discharged off easily in the environment as its decomposition takes much time and also produces environmental pollution. In such a case the reuse of rubber would be a better choice. In order to reuse rubber wastes, it was added to concrete as coarse aggregate and its different properties like compressive strength, Tensile strength, ductility etc. were investigated and compared with ordinary concrete. As a result it was found that rubberized concrete is durable, less ductile, has greater crack resistance but has a low compressive strength when compared with ordinary concrete. The compressive strength of rubberized concrete can be increased by adding some amount of silica to it.

In the present experimental study the experimental program was carried out for the partial replacement of natural coarse aggregate by using waste rubber tyre aggregates of maximum size 20mm. In this study the natural coarse aggregates were replaced by rubber tyre aggregates by 5%, 7.5% & 10% by weight of coarse aggregate. The compressive & flexural strength were determined at 7 days and 28 days and the results were compared with ordinary concrete of same grade. A normal concrete of natural aggregate without any replacement with rubber particles is used for the purpose of reference. The concrete of M20 grade has been used.

Keywords: Compressive strength, controlled mix, flexural strength, rubberized concrete, tensile strength.

I. INTRODUCTION

A large variety of waste materials are considered feasible and even much valuable additives for concrete. Some of these materials include cellulose, fly ash, silica fumes and wood particles. Rubber obtained from scrapped tyres is considered as the most recent waste materials that have been examined because of its vital use in the construction field.

Worldwide, the production of rubber increases every year. Different countries of the world has different rate of producing rubber, for instance United States produces 3.6 million tons of rubber per year. Iran produces 100,000 tons of rubber per year; similarly Malaysia produces 200,000 tons of rubber per year. These numbers increases with the increase in the production of vehicles. Investigations have shown that scrapped rubber tyres contain materials that do not decompose under environmental conditions and cause serious problems.

One choice of decomposition is burning, but that would also results in harmful pollutions. Based on these problems, tyres can be used as aggregates in concrete. It is very difficult to manage the waste produced by the rubber-tyre industry and to handle the waste. It is not easily biodegradable waste form. The rubber waste is not easily biodegradable even after a long span passes after the landfill treatment. The rubber tyres shows better performance in concrete when they are cut in the form of normally sized coarse aggregate to take the full advantage of the shape factor of the aggregate. Due to this fact, the compressive strength of the concrete can be made more or less stronger as compared to the aggregate sizes which are not in the proper shape to be incorporated in the concrete.

II. EXPERIMENTAL WORK

The study carried out is totally concerned with the partial replacement of natural coarse aggregate by used rubber tyre aggregates of maximum size 20 mm. In this study the natural coarse aggregates were replaced by rubber tyre aggregates by 5%, 7.5% & 10% by weight of coarse aggregate. The compressive & flexural strength were determined at 7 days and 28 days and the result was compared with ordinary concrete of same grade. A normal concrete of natural aggregate without any replacement (0%) is used for the purpose of reference. The concrete of M20 grade has been used.

2.1 Rubber Aggregates

Tyre aggregates used in this study were made by cutting the scrap tires into maximum sizes of 16mm & 20mm. They were used by mixing them in proportion of 2:3. The cutting of tire was done by labor with chisels & hand cutters. The maximum and minimum size of rubber aggregate used is 20mm and 16mm respectively. The tyres used in the analysis are from the same origin (scrap of APPLO tyre were used).

2.2 Chemical for Surface Treatment

During the initial stage of the study it was observed that the bonding between the rubber particles in concrete was very week. To enhance the bonding between the rubber particle with rest of the materials, surface treatment becomes necessary.

For the purpose of surface treatment we have used NaOH solution. NaOH is a powerful cleansing agent removes the dirt and cleans the surface of rubber which enhances the bonding between the rubber aggregate with the other materials in concrete. The rubber particles were first soaked in the NaOH solution for 24 hours before using. After Subjected to NaOH solution the aggregate were washed with water and cleaned. After the completion of the surface treatment of the rubber aggregates they were allowed to use in the concrete.

III. RESULTS

3.1 Effect on workability

It is noted that by increasing the rubber content in concrete the slump as well as the unit weight decreases. But it still gave a workable mix despite of adding rubber to it when compared with ordinary concrete.

3.2 Effect on Unit weight

The density of rubberized concrete was found comparatively less than ordinary concrete. With the increase in the percentage of rubber in concrete the density of it decreases. The density of concrete greatly depends upon the amount of air entrained or air entrapped, water-cement ratio, which in turn depends upon the size of aggregates. The increase in rubber content in concrete increases the air content which decreases the density (unit weight) of concrete. At about 25% of the content of rubber in concrete, the density decreases to about 90% of the ordinary concrete. However this decrease is very less when rubber content is less than 10-15% of the total aggregate volume.

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3.3. Effect on Compressive Strength

Compressive tests are considered as the most convenient test for evaluating the quality of the Concrete. Various tests on rubberized concrete, having tyre articles and crumb rubber of sizes 36, 24 and 18 mm and found that there is a reduction of 85% in compressive strength and about 50% of reduction in split tensile strength but showed large absorption of energy. As per investigation, that increase in rubber content in concrete decreased the compressive strength. This reduction was due to the presence of entrapped air. Experiments have showed that compressive strength can be increased by adding some de-airing agents into rubberized concrete.

3.3.1 Compressive strength after 7 days & 28 days

Table 1: Table showing compressive strength of concrete at different age

Sl. No.	Sample	Percentage of rubber aggregate	7 days Compressive strength (N/mm^2) [Average]	28 days Compressive strength (N/mm^2) [Average]
1	S_1	0	17.5	26
2	S_2	5	16.5	21.6
3	S_3	7.5	13.8	17.9
4	S_4	10	12.5	15.68

3.3.2 Comparative analysis of the compressive strength at different stages

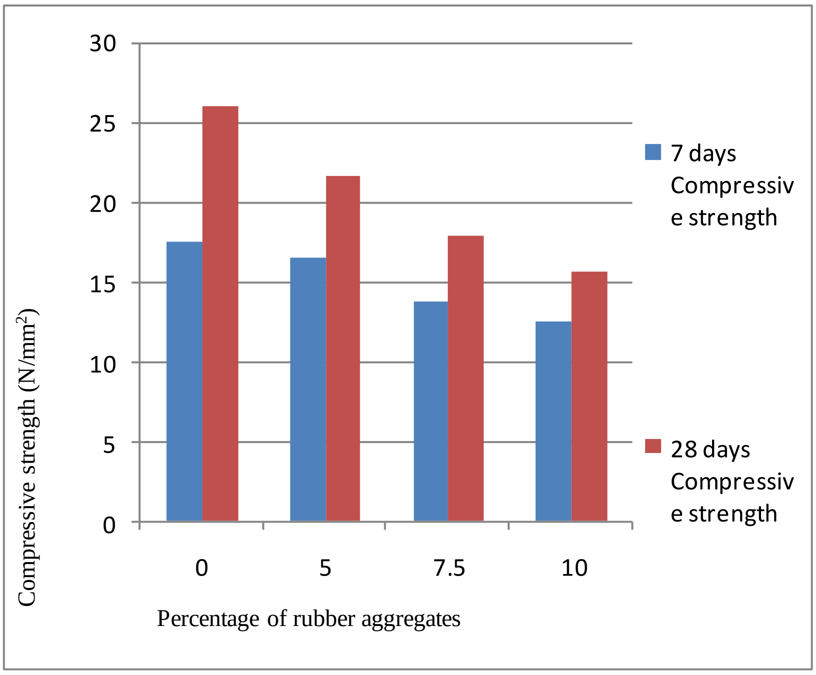

Figure 1: Graph showing variation of Compressive strength for the rubberized concrete at different stages.

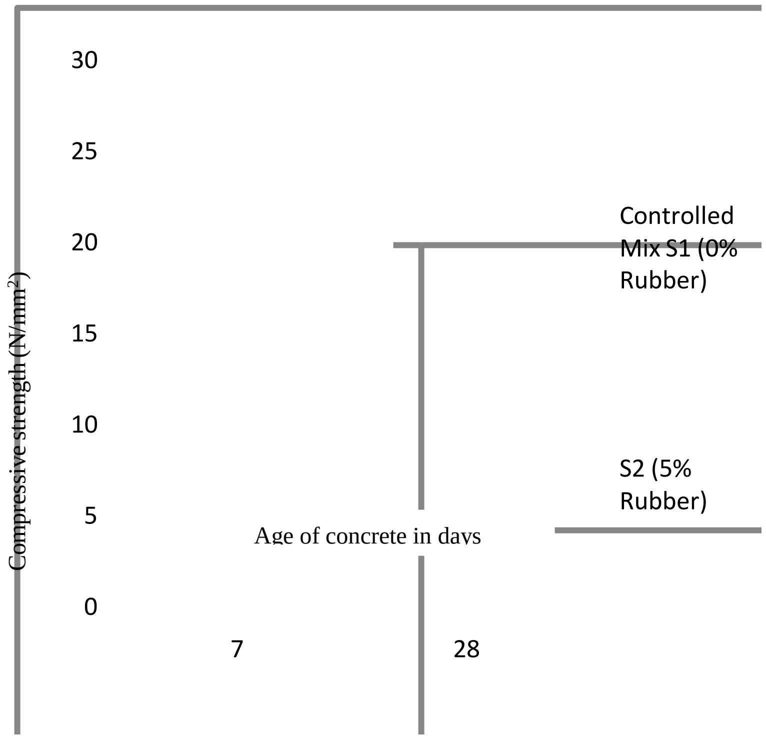

Figure 2: Graph showing decrement of compressive strength of rubberized concrete (S_2) with respect to Controlled mix (S_1)

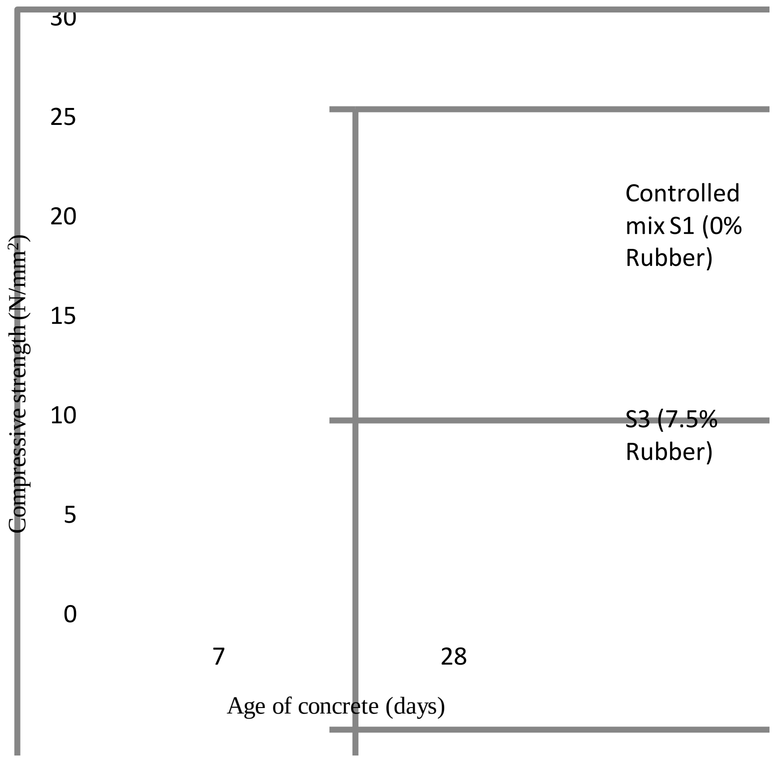

Figure 3: Graph showing decrement of compressive strength of rubberized concrete(S_3) with respect to controlled mix(S_1)

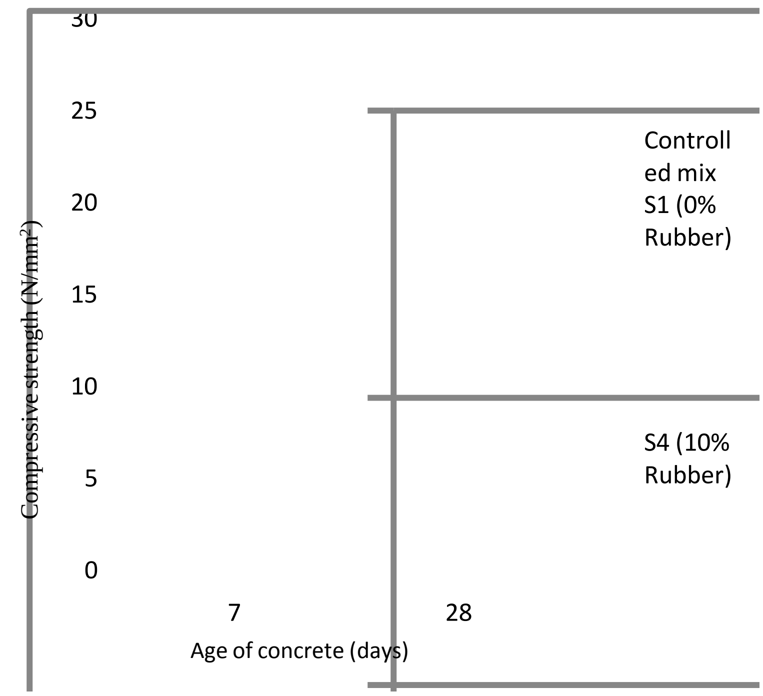

Figure 4: Graph showing decrement of compressive strength of rubberized concrete(S_4) with respect to controlled mix(S_1)

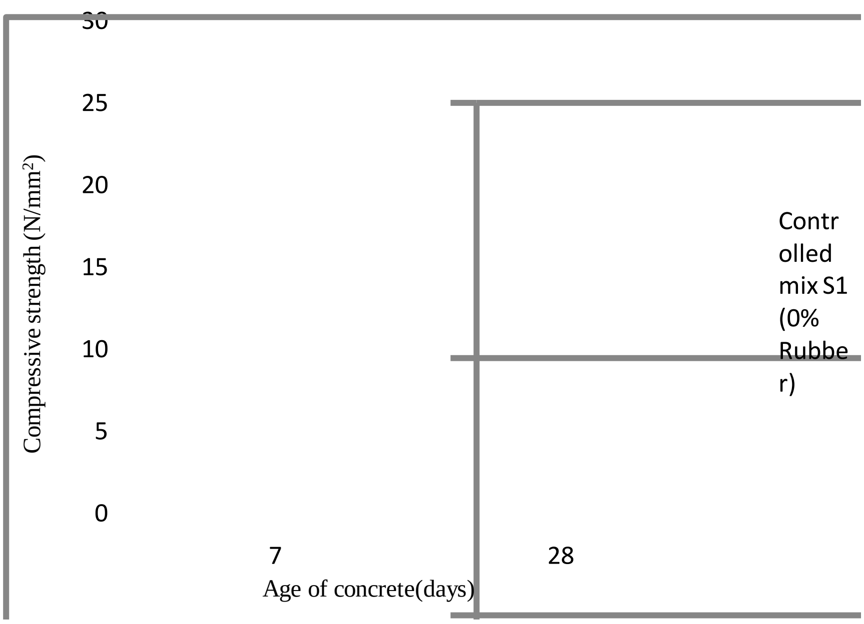

Figure 5: Graph showing decrement of compressive strength of various rubberized concrete with respect to controlled mix(S_1)

3.4 Effect on Flexural strength

The flexure strength of concrete having rubber decreases by increasing the content of rubber in concrete. As per other investigators, the flexural strength was increased by adding rubber in roller compacted concrete. By increasing the content of rubber into concrete the flexural strength and ultimate tension elongation increases when the compressive strength was kept constants for roller compacted concrete.

3.4.1. Flexural Strength after 28 Days

The results obtained for flexural strength after 28 days are tabulated as follows:

Table 2: 28 days Flexural Strength of Rubberized Concrete

Sl. No.	Sample	Percentage of rubber aggregate	Average load (KN)	Flexural strength (N/mm^2)
1	S_1	0	9.1	3.68
2	S_2	5	11.65	4.7
3	S_3	7.5	16.45	6.62
4	S_4	10	14.73	5.92

3.4.2. Comparative analysis on flexural behavior of Rubberized Concrete

A comparative graph can be drawn between the variations in flexural strength of rubberized concrete at varying composition of tyre aggregates with the flexural strength requirement of the ordinary concrete of same grade as per Indian Standards.

The graph shows increase in the flexural strength of rubberized concrete.

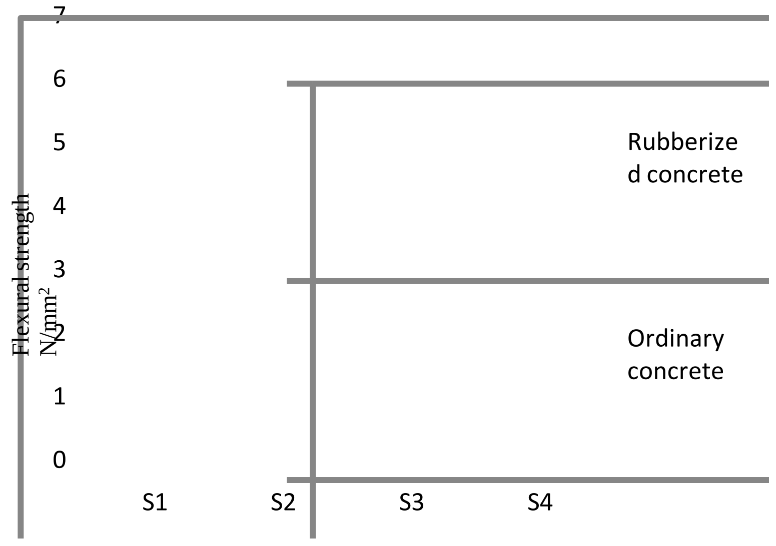

Figure 6: Graph showing increase in flexural strength of rubberized concrete.

3.5 Effect on Tensile Strength

As of investigation, the tensile strength of rubberized concrete is mostly affected by the size, shape, and textures of the aggregate and the strength of concrete decreases as the volume of rubber aggregate increases. The tensile strength of rubberized concrete decreases but the strain at failure increases correspondingly. Higher tensile strain at failure is indicative of more energy absorbent mixes. Tests conducted on the behavior of rubberized concrete containing tyre chips and crumb rubber as a replacement of aggregates having sizes 38, 24 and 19 mm showed reduction in tensile strength by almost 50% but also showed maximum energy absorption during tensile loading.

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3.6. Water Absorption

The water absorption of the concrete cube specimen containing used rubber tyre aggregates was determined by placing the cube specimen in the water for 24 hrs just after the removal from the casting mould, wiped with the dry cloth and then weighed in the surface saturated dry condition (W_{ssd}). The cube specimen was then placed in hot oven for 24 hrs maintaining the temperature of 105±5º C. The cube specimen was then weighed (W_{od}).

The water absorption of the concrete was determined by using following formula:

$$\text{Water absorption} = \frac{Wssd - Wod}{Wod} * 100$$

Table 3: Water absorption of rubberized concrete

Sl. No.	Sample	Weight (SSD) (in Kg)	Weight (Oven Dry) (in Kg)	Water Absorption (%)
1	S_1	7.717	7.453	3.5
2	S_2	7.650	7.403	3.33
3	S_3	7.470	7.309	2.20
4	S_4	7.595	7.315	3.8

The results can be represented graphically as follows:

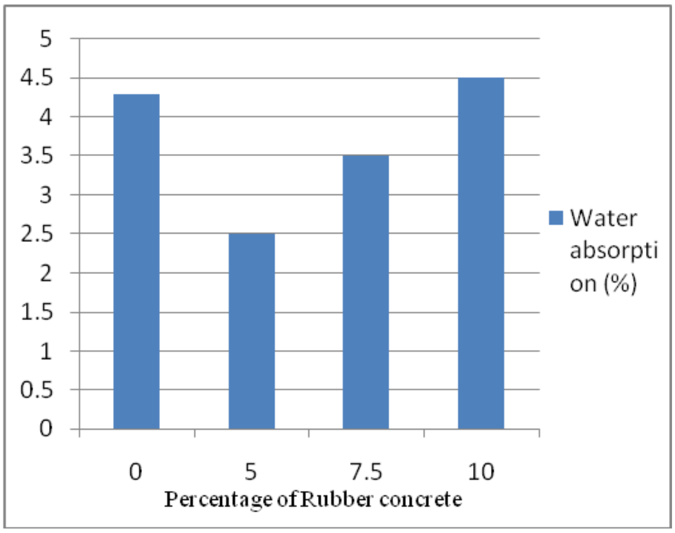

Figure 7: Graph showing water absorption variation in tyre rubberized concrete.

3.7 Effect on Workability of concrete

The workability of concrete was determined using Slump Test of freshly prepared concrete mix. The results observed for the slump test are tabulated below:

Table 4: Slump for rubberized concrete.

Sl. No.	Sample	Percentage of Rubber aggregate	Slump (in mm)
1	S_1	0	85
2	S_2	5	35
3	S_3	7.5	20
4	S_4	10	10

IV. DISCUSSIONS

The results for the test conducted in the present study and the variation observed in compressive strength, flexural strength & Water absorption of thr Rubberized concrete are as follows:

- From the graphical analysis (fig 1) that the compressive strength decreases with the increase in rubber content.
- We can also observe from comparative analysis that, the compressive strength of rubberized concrete is less than the compressive strength of controlled mix (fig. 5).
- The flexural strength of rubberized concrete at 28 days first showed increment up to 7.5% rubber content and then slight decrease in flexural content was observed for 10%. The decrement in flexural strength is still greater than the required flexural strength.
- It is observed that the water absorption of rubberized concrete decreases up to 7.5% rubber content and then increases suddenly at 10% rubber content.
- The workability of rubberized concrete decreases with increase in rubber content.

V. CONCLUSIONS

[1] The decrease in compressive strength may be due to weak bonding between rubber particles and cement paste. i.e., weak interfacial transition zone.

[2] With increase in the rubber aggregates content in rubberized concrete, the compressive strength decreases significantly & the flexural strength first increases (up to 7.5%) and then it gradually decreases.

[3] The water absorption of the rubberized concrete first decreases (up to 7.5%) with increase in rubber aggregates, and then with the further increase in rubber content, water absorption increases. The increase in water absorption may be due to the increase in voids in the rubberized concrete.

[4] The workability of rubberized concrete decrease with increase in rubber content which could be compensated by increasing the dosage of the chemical admixtures.

[5] From the above discussions of results which are obtained it can be concluded that rubberized concrete has limited application in load bearing structure due to reduction in compressive strength but it can be used in non-structural structures.

[6] It is recommended to use rubberized concrete small structures like road curbs and non–bearing walls etc.

VI. FUTURE SCOPE OF THE WORK

1. Studies on freezing and thawing resistance of rubberized concrete need to be conducted.
2. Studies related to the dynamic and static behavior on rubberized concrete is required to be observed.

3. Behavior of rubberized concrete at varying dosage of chemical admixtures is required.
4. Use of mineral admixtures such as Silica flumes and Alco fines may also be needed to study.
5. Microscopic study of concrete microstructure is also required for better observations and for the conclusions.
6. Other properties of concrete should also be part of the study.

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