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Strength of Concrete containing Rubber as Partial Replacement of Coarse Aggregate

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Abstract*: *Effective Waste management is the need of the hour in the world. Solid wastes generated by the industries becomes hazardous as days passes by, used tyres are one such waste material that can affect our environment and people. Rubber tyre wastes can be used as partial replacement for the aggregates. In this study, rubber tyre wastes were used as coarse aggregates. And those rubber aggregates are used as partial replacement of coarse aggregates in the cement concrete (5%, 10%, 15%, 20%). The specimens were subjected to different strength tests as per the standards. It is found that the strength of the concrete is greatly reduced as the percentage of replacement of rubber aggregates is increased. Due to their low strength this type concrete cannot be used for load bearing or structural members. However rubberized concrete can be used for non –structural elements and in future a study can be made whether rubber concrete can be used for pavement blocks.

Keywords* : *Rubberized concrete, Concrete using waste, Special concrete, Aggregate replacement

I. INTRODUCTION

In this fast moving world, vehicle has become an inseparable part of the human life. According to Ministry of Statistics and Programme Implementation of India almost 1.98 billion vehicles were registered in India between 2011 and 2016. And each year we tend to generate tyre wastes from the vehicles. India accounts for the 6-7 % of global tyre wastes. We are recycling only about 40% of tyre wastes and 60 % of it are dumped illegally [13]. This dumping leads to many environmental and societal issues. The dumping of tyres affects the land, burning of tyres causes air pollution and the gases release from incinerating the tyre wastes are toxic in nature and water gets stagnated in the tyres and becomes the source of disease spreading flies. Recycling or reuse of these materials conserves valuable natural resources as well as reduces the amount of wastes [9]. Here we have proposed to use chipped rubber tyre wastes as aggregates in the concrete.

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II. PROPERTIES OF RUBBER TYRES

Moisture absorption: Tyres and shreds can trap water on the surface and in irregular contours, but they are relatively impervious to actual absorption. Various studies cited in ASTM D 6270-98 indicate maximum moisture absorption of 2-4% [6].

Unit Weight: Due to the low unit weight of rubber, the weight of the rubberized concrete is less than the conventional concrete [9].
Thermal Insulation: Rubber is a poor thermal conductor, conversely providing a better thermal insulation than soil or aggregate.
Acoustic Insulation: Tyre rubber is a poor acoustic conductor and, therefore a good insulator.

III. CLASSIFICATION OF TYRE SCRAPS

Scrap tyres can be used in different forms as slit tyre, whole tyre, Shredded or chipped tyres, ground or crumb tyre [12]. Chipped tyres were used as aggregates in the concrete [7] and their mechanical properties were checked. The crumb rubber waste was used as a partial replacement for the sand in aggregates [10]. And at the same time crumb rubber and chipped rubber were also used in a concrete mix[14].

IV. EXPERIMENT

A. Materials used

The materials used are: Ordinary Portland cement 53 grade with specific gravity 3.15. Naturally available fine aggregate (river sand) is used for casting specimens. The fine aggregate was passing through 2.36mm sieve and had a specific gravity 2.68. Drinking water is generally fit for making concrete. Water should have pH equal to 7 or greater than that and also free from acids, oils, alkalis and other organic impurities. Aggregates of 20 mm size were used. The aggregates were angular in shape and well graded. Rubber tyre wastes were used for partial replacement of the coarse aggregates. The waste tyre from a lorry was chipped into 20 mm size pieces. Admixture was used for better bonding of the rubber aggregates. As the rubber does not possess the bonding capacity of the normal stone aggregates it becomes necessary to increase the bonding quality of the rubber. Styrene Butadiene Latex seems to possess the nature of improving the bonding capacity of the materials. Before adding the latex with any material it must be ensured that the material is free from dirt, dust, oil, grease, debris, etc,.

B. Mix Design

Concrete mix design in this experiment was designed as per the guidelines in IS 10262-2009. All the samples were prepared using design mix. M20 grade of concrete was used for the present investigation. Table I shows the volume of materials used in this experiment.

Table-I: Volume of materials as per mix design

Material	Volume for 1 m3 of concrete (in m3)
Cement	0.1
Water	0.138
Admixture	0.00134
Volume of Coarse aggregate	0.471
Volume of Coarse aggregate	0.288

The chipped rubber tyre aggregates are partially replaced as coarse aggregates in the concrete mixes for the following percentages: 5%, 10%,15%,20%.

C. Concrete mixing

Utmost care must be taken during the addition of rubber in the cement concrete, because if the rubber aggregates are not uniformly distributed that may result in brittle failure of the cement concrete specimen. Before adding the rubber, the rubber aggregates must be mixed thoroughly with the SBR Latex to improve the bonding capacity of the rubber aggregates. The white coloured highly viscous liquid when added with rubber, it turns the material into blue colour.

D. Slump Test

Slump value is determined to find the workability of the concrete. It is determined using the slump cone apparatus. The concrete is filled in three layers and tamped heavily manually. Once it is filled the cone is removed and the difference between the cone height and the resulting specimen height gives the slump value. For our rubber concrete it is found that the value of the slump found to be inversely proportional to the rubber content (Table-II). This denotes that increasing the rubber content decrease the workability of the concrete.

Table-II: Slump value with different proportion of rubber

Percentage of rubber in concrete (% with respect to aggregate)	Slump value in mm
5	70
10	40
15	35
20	15

E. Compressive strength test

The concrete specimens were tested for both 7-day and 28-day strength. The results of the compressive strength test for all the concrete specimens having different proportion of rubber aggregates are presented in Fig. 1. Though 28 day compressive strength is greater than the 7 day strength, decline in the compressive strength with increasing replacement of aggregates is observed.

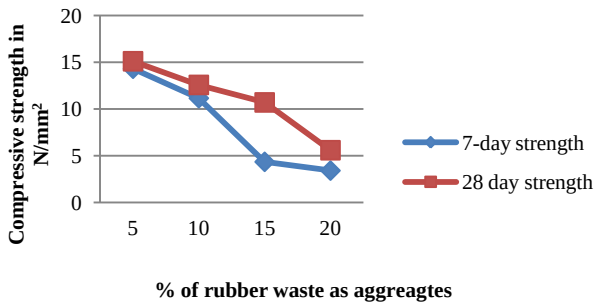

Fig. 1 Result of compressive strength test

F. Flexural strength test

The prism shaped specimens were subjected to flexural test and the result observed in the compressive strength test was repeated. The strength decreased with increase in rubber content (Fig. 2).

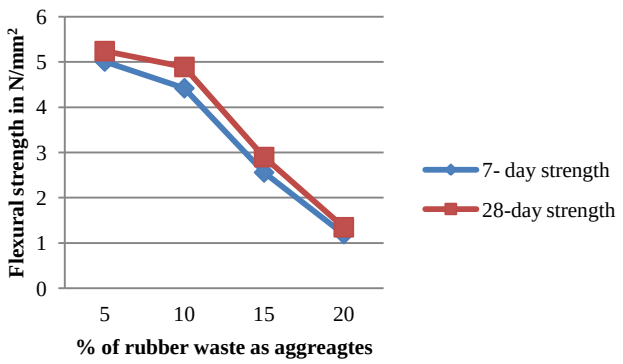

Fig. 2 Result of flexural strength test

G. Split tensile strength test

The same result was once again seen in the split tensile strength test also which was made with a cylindrical concrete specimen as shown in Fig. 3. The split tensile strength decreased with increase in the percentage of rubber aggregates.

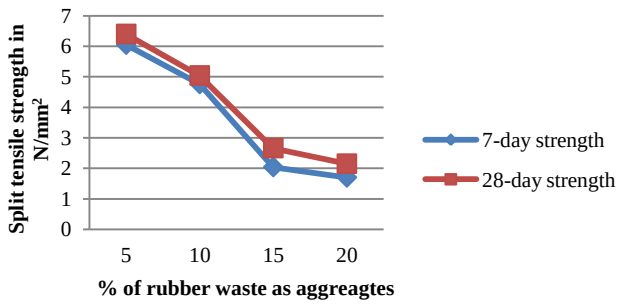

Fig. 3 Result of split tensile strength test

V. Result and Conclusion

From the study we could observe that compressive, flexural and split tensile strengths are found to be decreasing with increase in the rubber proportion.

And also we are not able to attain the actual strength that need to be attained by a M20 grade concrete. The reasons for reduction in strength are- non-uniform distribution of Rubber, lack of proper bonding (though the latex is added), lower stiffness of rubber .

Though this Rubberized concrete exhibits many negative results; it does not exhibit a brittle failure. From the observed results, it could be concluded that this type of concrete cannot be used for load bearing members. However they shall be used for non-structural members like compound walls, shed slabs, pavements in the walking zone and aesthetic members. For improving the strength, further research must be done on the ingredients added in the mix to improve the bonding strength of the concrete with rubber.

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Sakthi Murugan.S has completed his under graduate in Civil Engineering at Kongu Engineering College, Perundurai and post graduate M.E Infrastructure Engineering and Management at Thiagarajar College of Engineering, Madurai. He has done his under graduate thesis on "Study on usage of rubber tyre wastes as aggregates in the concrete" and post graduate thesis on "Management of Non-Revenue water in a water distribution system". He was a member of the team which was selected for National level concrete canoe competition conducted by IIT-Madras. He has also published a paper titled, "Assessment of Non-Revenue water in a water distribution system and strategies to manage the water supply" in International Research Journal of Engineering and Technology. He is currently working as Assistant professor in Sri Ramakrishna Institute of Technology, Coimbatore.

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