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Experimental Study on Rubberized Concrete

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Abstract— Recycling granulated waste tires (crumb rubber) has been widely studied for the last twenty years mostly relating to applications such as asphalt pavement, waterproofing system, membrane liners, etc., Use of alternative material in concrete opens a whole new range of possibilities in the construction industry. Sustainable technologies for concrete construction are not only essential for the development of eco friendly construction but also to manage huge quantity of solid waste disposal without compromising durability. In this study, the use of crumb rubber to replace fine aggregates in concrete was studied. It is believed that concrete acting as a binder mixed with crumb rubber can make concrete more flexible and thus, provide softness to the surface. The objective of this paper is to investigate the mechanical properties of concrete when crumb rubber is used as partial replacement of fine aggregate in different percentage (5%, 10%, 15%, 20% and 25%) by volume. Laboratory trials were conducted to investigate the effect of crumb rubber. A comparison was also made between mixtures containing various percentages of crumb rubber to determine the optimum crumb rubber content and the test results also compared with conventional concrete (without crumb rubber).

Index Terms— crumb rubber, fine aggregate, workability, compressive strength, tensile strength, flexural strength.

1 Introduction

Solid waste management is one most important environmental concern worldwide. The last 30 years many studies have been conducted in order to find the feasibility of utilizing the solid waste materials in civil engineering applications. The main important motivations for such studies are continuous demanding of natural aggregates, ban the disposal of wastes in land and demanded of sustainable development (recycling). [1-3]

In the concrete preparation, the most commonly used coarse and fine aggregate has likely become scarce it is today. Now construction people need the alternatives to natural aggregates. Therefore, finding alternatives to naturally available materials is important to sustaining construction industry. A review of recent research has shown than it is possible to use industrial by products as well as other materials in the concrete preparation as a replacement for cement and aggregates. The waste tire crumb rubber was used as an alternative of river sand and its properties were investigated. So in such cases waste materials are used to modify the mechanical and durability properties of concrete to make it suitable for any situation. This would also additional benefits in terms of reduction in cost, energy savings, promoting ecological balance and conservation of natural resources.[3-7]

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2 Literature Review

Erhan Guneyisi et al. [8] presented the mechanical properties of rubberized concrete. The test results show that reduction in compressive strength and modulus of elasticity with the increase in rubber content 0% to 50%.

T C Ling et al. [9] investigate the potential of using crumb rubber as substitute for coarse sand in the production of concrete paving block. Crumb rubber was treated by using SBR latex. It was concluded that there is a systematic reduction in the density, compressive strength with the increasing in rubber content.

Rana hasshim ghedan and dina mukheef hamza [10] studied the compressive strength and thermal conductivity of rubberized concrete and compared with the traditional concrete. In this study rubber particles were treated by using SICAN of 0.1% of water as coupling agent. The test results show that the adding of rubber particles to the concrete obtains light weight and the compressive strength was reduced

Khalid B. Najim and Mathew R. Hall [11] found that the mechanical and dynamic properties of self compacting rubberized concrete (SCRC). Incorporating rubber aggregates improved the strain capacity resulting in significant reduction in flexural crack mouth open displacement compared to the reference mix. The dynamic modulus and ultrasonic pulse velocity decreased as the proportion of rubber aggregate was increased.

N. ganesan et al. [12] investigates the flexural fatigue behavior of SCRC with and without steel fibres. The addition of scrap rubber to SCC the flexural fatigue strength was increased around 15% and the addition of steel fibres in to SCRC the fatigue strength was increased 25-50%.

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T. Senthil Vadivel et al. [13] finding the behavior of waste tire rubber aggregate concrete (WTRAC) cylindrical specimen under drop weight impact testing method. It was concluded that WTRAC mixture generally reduced compressive strength at the same time it has lower density, higher toughness, higher impact resistance and enhanced ductility compared with conventional concrete.

2 Experimental Works

Experimental program was designed to investigate the mechanical properties of M20 grade concrete incorporating waste tire crumb rubber as fine aggregate. The standard cubical, cylindrical and small beam specimens were cast with and without crumb rubber. A compressive testing machine was used to test the cubical and cylindrical specimens. Flexural strength testing machine was used for the small beam specimens.
The specimens were cast with M20 grade concrete using 0%, 5%, 10%, 15%, 20% and 25% partial replacement of waste tire crumb rubber as fine aggregate.

2.1 Materials

Ordinary Portland cement of 53 grade confirming to IS: 12269-1987 [14] was used for the present investigation. The cement was tested as per the Indian standards IS 4031-1999 [15]. The test results were tabulated in Table 1.
Locally available river sand conforming to grading zone-II as per IS: 383-1970 [16] was used. The sand was screened at site to remove deleterious material. The fineness modulus of sand used is 2.45 and with a specific gravity of 2.65.

In the present study a locally available coarse aggregate (20 mm) from quarry was used. The specific gravity of coarse aggregate is 2.72 and fineness modulus of 3.84.

Table 1

Physical Properties of Cement

Sl. No	Property	Results
1	Normal consistency	31%
2	Specific gravity	3.11
3	Initial setting time and final setting time	85 min 280 min
4	Fineness of cement (by 90 micron sieve)	5.9% retained
5	Compressive strength 7 days (N/mm^2) 28 days (N/mm^2)	21.30 28.56

The crumb rubber was passed through 4.75mm IS sieve and its specific gravity should be in the range of 1.14 to 1.27.
Portable water confirming to IS 456-2000 [17] was used for both mixing and curing.

3.2 Mix proportioning

The M20 grade concrete had cement, fine aggregate, in the ratio 1:1.89:2.88. The water cement ratio was 0.5. Assuming the quality control norms between good and very good following IS 10262 [18], the value of standard deviation was taken as 4.0. Therefore, the target strength was found to be 26.60MPa.

3.3 Casting and curing of test specimens

The ingredients for various mixes were weighed; required water was added and mixed by using pan mixture. Three specimens for each mix were cast in steel mould and compacted on a table vibrator, using standard cubes (150mm X 150mm X 150mm), standard cylinders (150mm diameter with 300mm height) and standard beams (100mm X 100mm X 500mm) were cast for the determination of compressive strength, split tensile strength and flexural strength respectively. The specimens were demoulded and placed immediately in water tank for curing.

Table 2 gives the details of various mixes prepared by replacing sand by waste tire crumb rubber. The water cement ratio as 0.5 in all the mixes was maintained.

3 Results and Discussions

3.1 Workability test

The workability of concrete was measured using slump cone. The slump values are given in Table 3.

Table 3

Slump Values

Sl. No	Mix designation	Slump value in 'mm'
1	R0	48
2	R5	50
3	R10	52
4	R15	56
5	R20	61
6	R25	69

The crumb rubber in the concrete has less absorption capacity when compared to the river sand, so workability of the concrete is increasing as the percentage of crumb rubber content increases. When compared to the conventional concrete, its workability increases from 4 to 44%.

3.2 Compressive strength

This test was carried out in accordance with IS 516 – 2004 [19]. The cubes were casted to the size of 150mm. the specimens were prepared with varying proportions of waste tire crumb rubber to 0%, 5%, 10%, 15%, 20% and 25% were tested. The test results are shown in figure 1.

Table 2

Details of specimens prepared by replacing fine aggregate by waste tire crumb rubber

Sl. No	Designation	Details of replacement	Ratio C: S: CA: CR
1	R0	Conventional concrete	1:1.87:3.15:0.00
2	R5	5% fine aggregate replaced by waste tire crumb rubber	1:1.8:2.88:0.04
3	R10	10% fine aggregate replaced by waste tire crumb rubber	1:1.72:2.88:0.08
4	R15	15% fine aggregate replaced by waste tire crumb rubber	1:1.64:2.88:0.12
5	R20	20% fine aggregate replaced by waste tire crumb rubber	1:1.56:2.88:0.16
6	R25	25% fine aggregate replaced by waste tire crumb rubber	1:1.48:2.88:0.20

Note: C – Cement, S – sand, CA – Coarse aggregate and CR – Crumb rubber

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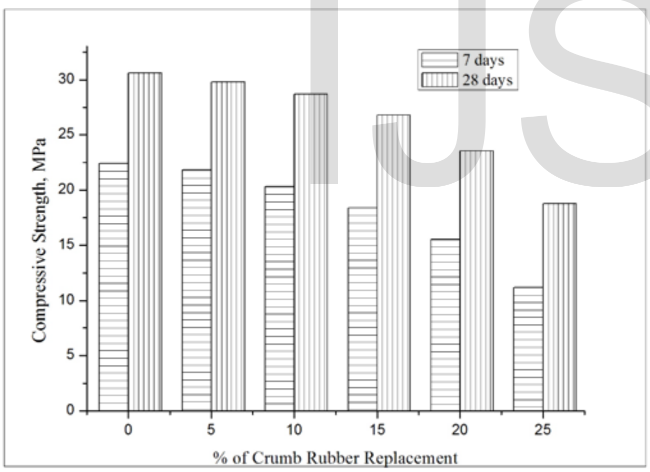

Fig 1. Compressive Strength of Various M20 Grade Concrete Mixes

The decrease in compressive strength of M20 grade concrete with addition of 5%, 10%, 15%, 20% & 25% waste tire crumb rubber was observed to be 2.67%, 9.37%, 17.85%, 30.80% and 50% at 7 days and 2.61%, 6.21%, 12.41%, 23.20% and 38.56% at 28 days respectively when compared to conventional concrete (without rubber).

3.3 Split Tensile Strength

The split tensile strength test was conducted as per IS 516 – 2004. The cylinders of 150 mm diameter with 300 mm height were casted and tested. The test results are shown in figure 2.

The decrease in Split tensile strength of concrete with addition of 5%, 10%, 15%, 20% and 25 % waste tire crumb rubber was observed to be 1.87%, 7.12%, 15,35%, 24.72% and 44.94% at 7 days and 1.01%, 5.78%, 10.19%, 18.45% and 32.50% at 28 days respectively when compared to conventional concrete

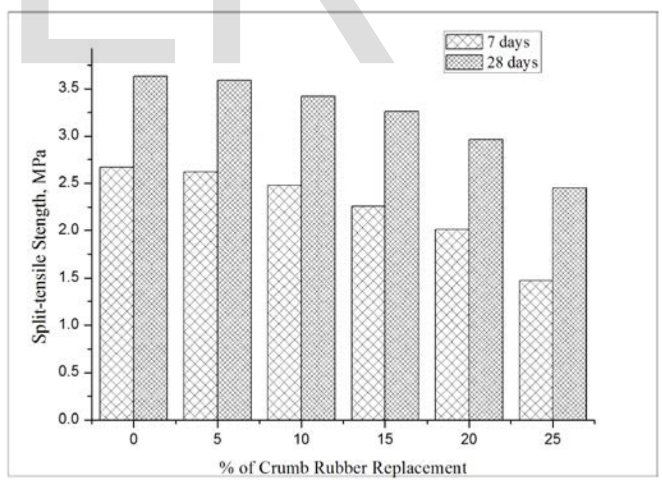

Fig 2. Split Tensile Strength of Various M20 Grade Concrete Mixes at 28 days

3.4 Flexural Strength

The flexural strength was conducted as per IS 516 -2004. Two point loading was applied to the beam specimens and the breaking load for the specimens were measured. From the breaking load the flexural strength of the specimen calculated. The variations of test results are shown in figure 3.

The flexural strength of rubberized concrete was increased up to 15% crumb rubber replacement. More than 15% crumb rubber replacement reduced the flexural strength. The increase in strength of concrete with the addition of crumb rubber 5%, 10% and 15% was recorded 5.12%, 10.24% and 11.74% at 7 days and 4.19%, 9.49% and 11.04% at 28 days respectively. The decrease in strength of concrete with the addition of crumb rubber 20% and 25% was noticed 1.84% and 6.92% at 7 days and 1.76% and 7.06% at 28 days respectively.

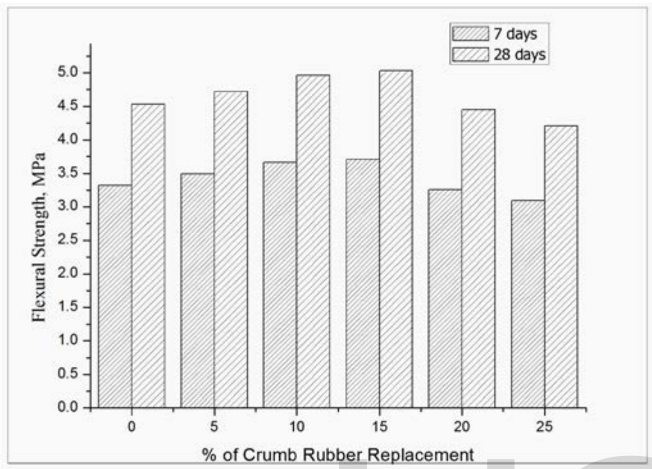

Fig 3. Flexural Strength of Various M20 Grade Concrete Mixes at 28 days

4 Conclusions

The waste tire crumb rubber is incorporated 5% to 25% in to concrete in place of river sand. It gives acceptable mechanical and durability properties such as compressive strength, split tensile strength, flexural strength, water absorption, sulphate resistance, acid resistance and chloride resistance up to 15% replacement. Hence 15% rubber content is to be considered as the optimum amount. Though the compressive strength of concrete is reduced, it has few desirable characteristics such as low density, high flexural strength, high durability etc. Crumb rubber added to concrete gives better resistance to acid and sulphate attack. These properties can be advantages of waste tire crumb rubber concrete in construction applications.

The reduction in compressive strength of concrete is mainly due to the low adhesion between crumb rubber particles and other concrete materials. So we should improve the adhesion, as it gives better bonding between the rubber particles and other concrete materials, thereby significantly improving the strength of concrete.

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