EXPERIMENTAL INVESTIGATION ON CONCRETE MIXED WITH STEEL SCRAPS AND TIRE WASTE

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ABSTRACT

Concrete is a composite material whose behavior depends on the behavior of its constituent materials. The major components of concrete are cement, water, and aggregates. Depending on the mix proportion of concrete 60-75% by volume and 70 to 85 % by weight is an aggregate. Aggregates are inert granular materials, essential ingredient in concrete. In Ethiopia, concrete with conventional building material are widely used. These materials are costly, which seeks an alternative material for sustainable aggregate. Critical parameters that affect concrete performance with special reference to aggregate have been extensively studied. But in this research, the coarse aggregate was replaced with waste tire aggregate from 5 to 25% in addition to that; steel scraps are added by 5 to 25% by weight of cement. The fresh and hardened properties of concrete are studied with waste tire as aggregate and steel scraps as fibers. The workability of rubberized concrete shows an increase in slump with increase of waste tire rubber content of total aggregate mass.

KEYWORDS: Waste rubber tire aggregate, steel scraps, coarse aggregate, fibers.

I. INTRODUCTION

Waste utilization is an attractive alternative to disposal in that disposal cost and potential pollution problems are reduced or even eliminated along with the achievement of resource conservation. At present the disposal of waste tires is becoming a major waste management problem in the world. It is estimated that 1.2 billions of waste tire rubber produced globally per year. It is estimated that 11% of post consumer tires are exported and 27% are sent to landfill, stockpiled or dumped illegally and only 4% is used for civil engineering projects. Hence effort has been taken to identify the potential application of waste tires in civil engineering projects. In this context, my present study aims to investigate the optimal use of waste tyre rubber as coarse aggregate in concrete composite.

Steel scrap which is a lathe waste is generated by each lathe industry and dumping of such wastes in barren soil causes contamination of soil and ground water, which creates unhealthy environment. A good waste solid management is to find a way to make use of it. In this research an experimental investigation is carried out to study the feasibility of using steel scrap obtained from lathe machine in concrete by checking the mechanical properties of concrete.

II. LITERATURE REVIEW

Toutanji (1996) conducted experiments to investigate the effect of the replacement of coarse aggregate by rubber aggregate. Four different contents of rubber aggregate with a maximum size of 12.7 mm were used to replace the coarse aggregate at 25, 50, 75 and 100% by volume and 23 discovered that the incorporation of the rubber aggregates in concrete produced a reduction in compressive strength of up to 75% and a significantly smaller reduction in flexural strength of up to 35%. The reduction in both strengths increased with increasing the rubber aggregate content. It is observed that the specimens containing rubber aggregate exhibited a ductile mode of failure as compared to the control specimens. Khatib (1999) investigated the workability of TRAC. They observed a decrease in slump with increased rubber aggregate content by total aggregate volume. Their results show that for rubber aggregate contents of 40% by total aggregate volume, the slump was close to zero and the concrete was not workable by hand. Such mixtures had to be compacted using a mechanical vibrator. Mixtures containing fine crumb rubber were, however, more workable than mixtures containing either coarse rubber aggregate or a combination of crumb rubber and tyre chips. Michelle Danko (2006) examined that the tensile strength of rubberized concrete is mostly affected by the size, shape, and textures of the aggregate and the strength of concretes 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. G. Senthil Kumaran (2012), in their study concluded that the reduction of compressive strength and tensile strength can be increased by adding some superplasticizers and industrial wastes as partial replacement of cement will definitely increase the strength of waste tyre rubber modified concrete. Further study is needed to increase performance against fire. Tushar R More (2015) got the conclusions that, addition of recycled crumb rubber aggregates into normal concrete mix leads to decrease in workability for the various mix samples. Flexural strength of concrete decreases about 40% when 3% sand is replaced by crumb rubber aggregates and further decrease in strength with increase of percentage of crumb rubber aggregates. Split tensile strength of concrete decreases about 30% corresponding to 3% sand replaced by crumb rubber and further decreases the strength with increase in percentage of crumb rubber. One of the reasons that splitting tensile strength of rubberized concrete is lower than conventional concrete because of bond strength between cement paste and rubber tire aggregates poor. The rubberized concrete can be used in non-load bearing member's, i.e., lightweight concrete walls, other light architectural units, thus concrete containing fine rubber aggregates could give a viable alternative to where strength is not prime requirements. Experimental results of study show that it is possible to use recycled rubber tyre in terms of aggregates in concrete construction as partial replacement to natural fine aggregates. S.Selvakumar (2015) in their research paper concluded that the compressive strength of crumb rubber concrete with 5% replacement is 38.66 N/mm2; it is higher than the strength of normal concrete (36.73N/mm2) on 28th day. The compressive strength of crumb rubber concrete with 10% replacement, it gives acceptable strength of 33.47 N/mm In splitting tensile strength the strength of crumb rubber concrete is lower than the strength of normal concrete. In the flexural strength test conducted on crumb rubber concrete it shows a decrease in strength when compared to the strength of normal concrete. From the test results, it is found that the crumb rubber possess less bonding ability which has affected on the strength of the concrete.

III. EXPERIMENTAL INVESTIGATION

The materials used in this investigation are Portland pozzolana cement, natural sand (N.S), 20mm down size coarse aggregate of size 12 to 20mm, waste tire rubber aggregate of size 15 to 25mm and steel scraps. They are shown in the Figure 1 to 5. The material properties are given in Tables 1 and 2.

Figure 1 Cement

Figure 2 Sand

Figure 3 Coarse aggregate

Figure 4 Waste tire rubber aggregate

Figure 5 Steel scraps

Table 1 Properties of Fine, Coarse & Rubber Aggregate

Properties	Fine Aggregate	Coarse Aggregate	Waste Tire Rubber Aggregate
Specific gravity	2.4	2.68	1.1
Dry density	1505 kg/m^3	1515 kg/m^3	709 kg/m^3
Moisture content	0.12%	1.07 %	0

Table 2 Properties of steel scraps

Description	Value
Cross –section	Straight and deformed
Thickness	0.3 - 0.75 mm
Length	10 – 20 mm
Aspect ratio	20 - 50
Specific gravity	7.85
Density	7850 kg/m^3

III. MIX DESIGN

The mix design was prepared for M25 grade concrete with w/c ratio of 0.5. The materials required for 1m^3 of concrete is given in Table 3.

Table 3 Mix proportion for 1m^3 concrete

Specimen ID	Cement (kg)	Sand(kg)	Steel scrap (kg)	Coarse aggregate		W/C Ratio	Water (lit)
				NCA (kg)	RCA (kg)		
WR 0	376.8	753.6	-	1130.4	-	0.5	188.4
WR 5	376.8	753.6	18.84	1073.88	56.52	0.5	188.4
WR 10	376.8	753.6	37.68	1017.36	113.04	0.5	188.4
WR 15	376.8	753.6	56.52	960.84	169.56	0.5	188.4
WR 20	376.8	753.6	75.36	904.32	226.08	0.5	188.4
WR 25	376.8	753.6	94.2	847.8	282.6	0.5	188.4

IV. TESTING DETAILS

Casting of Specimens

All mixtures were mixed in a conventional blade type mixer. The coarse and fine aggregate and cement were loaded in the mixer prior to the addition of rubber aggregate and mixed for 3 to 5 minutes. Rubber aggregate and steel scraps were then added gradually to the mix for a period of 2 minutes to allow the rubber aggregates and steel scraps to get mixed thoroughly. Water was then added gradually to the mix for a period of 2 minutes and followed by mixing for 5 minutes to produce a uniform mix. Standard 150mm size cube, cylinder (150 mm diameter and 300 mm long), beam (100 mm x 100 mm x 500 mm) specimens were prepared to find out the compressive strength, tensile strength and flexural strength of concrete. Moulds were filled with fresh concrete in three equal layers and vibrated on a vibrating table to drive out air trapped in the mix. The time of vibration was judged by the visual appearance of individual mixes to ensure full compaction. After casting, the specimens were then de molded 24 hours later and cured in a water tank.

Testing of Specimens

Workability Test

Slump test was made on fresh concrete to measure the effect of change in ingredients on workability according to the addition of crumb waste tires. The mold for the slump test is in the form of a frustum of a cone, which is placed on top of a metal plate. The mold is filled in three equal layers and each layer is tamped 25times with a tamping rod. Surplus concrete above the top edge of the mold is struck off with the tamping rod. The cone is immediately lifted vertically and the amount by which the concrete sample slumps is measured. The value of the slump is obtained from the distance between the underside of the round tamping bar and the highest point on the surface of the slumped concrete sample. The types of slump i.e. zero, true, shear or collapsed are then recorded.

Compressive Strength Test

The compressive strength of concrete cube was determined based on IS: 516 –1959. Three cubes were tested for each trial mix combination at the age of 7, 14 and 28 days of curing using a compression testing machine.

Splitting tensile strength Test

The common method of estimating the tensile strength of concrete is through an indirect tension test. Splitting tensile strength was determined in accordance with IS: 5816-1970. The test was carried out by placing a cylindrical specimen horizontally between the loading surface of a compression testing machine and the load was applied until the failure of the cylinder, along the vertical diameter.

Flexural strength test

Flexural strength was measured by the prism with two point loading as per IS: 516-1959. Three prisms were tested for each trial mix combination at the age of 7, 14 and 28 days of curing using a flexural testing machine.

V. RESULTS & DISCUSSION

Workability

The slump value is given in Figure 6.

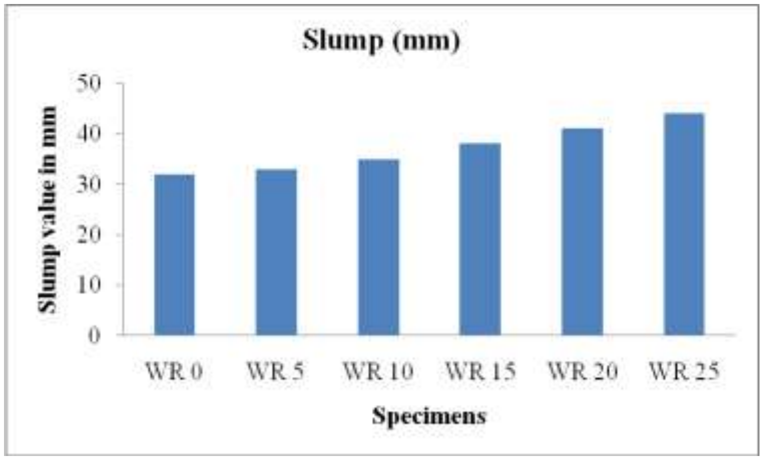

Figure 6 Slump values of concrete

From Figure 6, it is noticed that the workability of rubberized concrete shows an increase in slump with increase of waste tire rubber content of total aggregate mass. This may be due to the low water absorption of the waste tire rubber aggregate.

Compressive strength

The compressive strength of the concrete is illustrated in Figure 7.

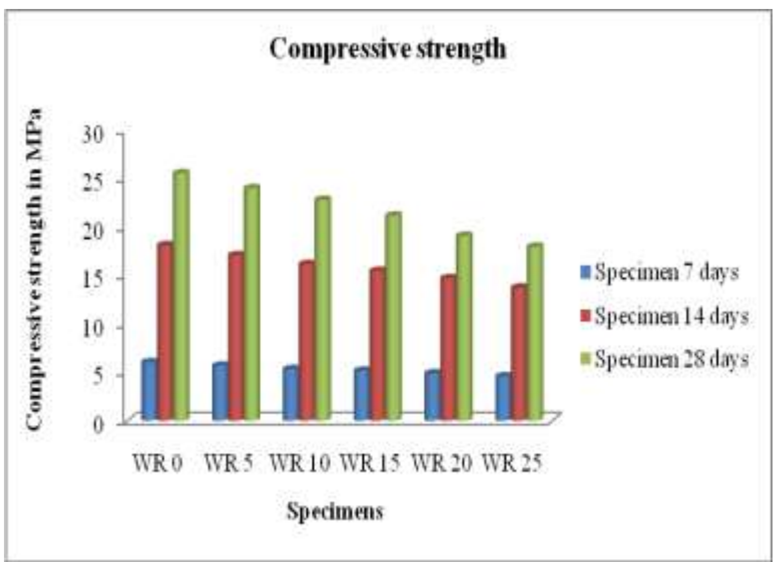

Figure 7 Compressive strength of the concrete

The compressive strength is decreased, while increasing the proportions of waste tire rubber aggregate. This is due to the softer surface texture of rubber aggregate didn't create better bonding between the cement paste.

Split tensile strength

Tensile strength of the concrete is shown in Figure 8.

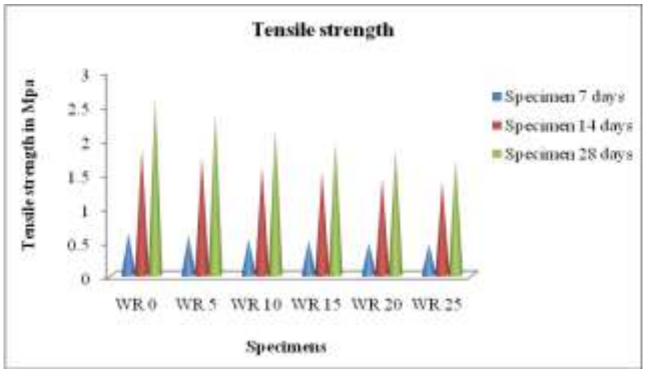

Figure 8 Tensile strength of the concrete

The split tensile strength is reduced, while increasing the proportions of waste tire rubber aggregate due to the soft rubber aggregate created voids in the concrete mix.

Flexural strength

Flexural strength of the concrete is shown in Figure 9.

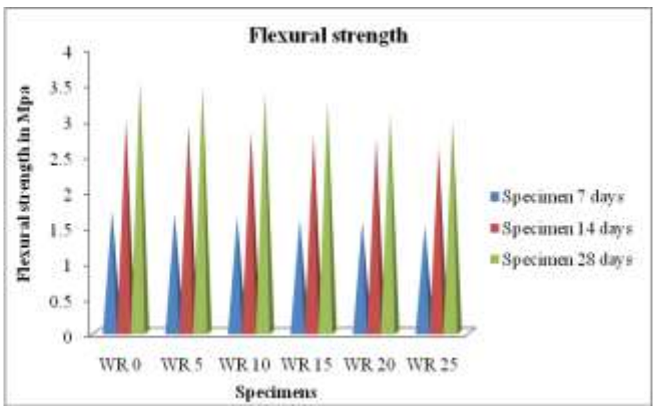

Figure 9 Flexural strength of the concrete

Flexural strength is decreased, while increasing the proportions of waste tire rubber aggregate due to the poor bonding between the rubber aggregate and cement paste.

VI. CONCLUSION

The introduction of recycled rubber tires into concrete significantly increased the workability. It was noted that the slump has increased as the percentage of rubber was increased. Compressive strength decreases as the percentage of waste rubber replacement increases for C25 concrete mix. Splitting tensile strength decreases as the percentage of waste rubber replacement increases. The overall results of this study show that it is possible to use recycled rubber tires in concrete construction as a partial replacement for coarse aggregates. However, the percentage replacement should be limited to specify amounts as discussed above.

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