EXPERIMENTAL INVESTIGATION ON STEEL FIBER REINFORCED CONCRETE WITH PARTIAL REPLACEMENT OF FINE AGGREGATE BY COPPER SLAG

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Abstract: *The objective of this paper is to investigate workability and strength parameters on concrete of replacement of fine aggregate by copper slag of M25 grade concrete with mix design using IS10262:2019. In this research, the effect of replacement of 40% and 60% copper slag by fine aggregate with 0%,1% and 1.5% of steel fibre on slump cone test for workability, Compression, split tensile and flexural strength of concrete was studied. The experiment test conducted for concrete in 7 days, 21 days, and 28 days for compression test and 28 days for split tensile and flexural test with adding of super plasticizer of 1% of cement as per IS code provision*

Keywords: ***Replacement of fine aggregate by copper slag and adding steel fiber.***

1. INTRODUCTION

Concrete is an engineering materials that stimulates the properties of rock and is a combination of particles closely bound together. It is simple a blend of aggregates, normally natural sand and gravel or crushed rock. Concrete is weak in tension. Microcracks begin to generate in the matrix of a structural element at about 10 to 15% of the ultimate load, propagating into macrocracks at 25 to 30 % of a ultimate load. Different type of fiber which are commercially available, such as steel, glass, polypropylene or graphite. They have proven that they can improve the mechanical properties of the concrete, both as a structure and a material, not as a replacement for continuous-bar reinforcement when it is needed but in addition to it. Concrete fibre composites are concrete elements made from a mixture comprised of hydraulic cements, fine and coarse aggregates, pozzolanic cementitious materials, admixtures commonly used with conventional concrete, and a dispersion of discontinuous, small fibre made from steel, glass, organic polymers or graphite.

Steel Fiber Reinforced Concrete are the most common fiber used in concrete. They may be produced either by cutting wires, shearing sheets or form a hot melt extract. They may be smooth or deformed in a variety of ways to improve the mechanical bond with concrete. Steel fiber have high modulus of elasticity of which is 10 times that of concrete, reasonably good bond and high elongation at fracture. Steel fiber ranges from length from 0.25 inches to 30 inches. Fiber concentrations in concrete mixes generally range from 0.1% to 1% by volume.

In this paper, replacing of the fine aggregate by using of copper slag is implementing in concrete of grade M_{25}.

Grade of concrete used	Percentage of Fiber added	Percentage of replacement of fine aggregate (M-sand)
M_{25} Design mix	0%, 1% and 1.5%	40% and 60%

Table 1. Percentages of replacement of fine aggregate by copper slag

Figure 1.1 Mild Steel Fiber

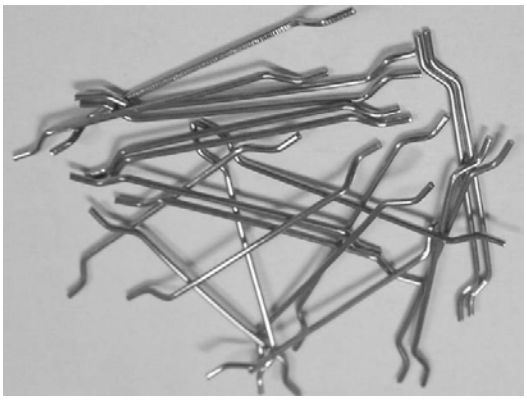


Figure 1.2 Hooked End Steel Fiber

2. LITERATURE REVIEW

2.1 S. Raghu, K. Nehemiya, K. Prasad

Behaviour of copper slag and steel fibers in concrete subjected to destructive and non destructive tests.

International Journal of Technology & Engineering System, Volume: 04 Issue: 08 | Aug -2017

This paper, Copper slag is used in different proportions such as 20%, 30%, 40%, and 50% as a partial replacement of fine aggregate for casting cubes, prisms and beams in order to determine the strength parameters such as compressive, split tensile and flexure (destructive and non destructive tests such as Ultrasonic pulse velocity and Rebound Hammer). From this tests, the optimum percentage of copper slag is determined. Later, the steel fibers of different proportions such as 0.5%, 1%, 1.5% by volume of cement are added to the optimum percentage of copper slag in order to observe its impact on strength thereby calculating the optimum percentage of steel fiber. Using this optimum percentage, beams were casted of size 130cmx20cmx20cm in order to observe the flexural behavior.

2.2. Naveen Kumar, P. Shiva Kumar

Effect of Copper Slag on Steel Fiber Reinforced Concrete and Conventional Concrete.

Journal of applied science and computations.

Because of Rapid growth of technology and population in India, there is a huge demand for construction material mostly for natural sand, of late excessive consumption

of sand caused ecological economical imbalance. To overcome these effects large modifications are being carried out in construction industry, i.e. usage of by products as a replacement of fine aggregate. In the present study to increase the mechanical properties of concrete steel fibers are added to the concrete mix. Experimental investigation was carried out to evaluate the mechanical properties of SFRC and conventional concrete by replacement of sand (F.A.) with copper slag for different grades (M30, M40).Tests are conducted with 1% addition of hooked end steel fiber shaving aspect ratio 60 and replacement of copper slag by 0%, 10%....with increase in 10% up to where optimum strength is obtained.

2.3. D. Sahathi , G.L. Sirisha

STUDIES ON EFFECT OF COPPER SLAG ON STEEL FIBER REINFORCED CONCRETE

International Journal For Technological Research In Engineering Volume 4, Issue 6, February-2017

In the construction industry which involves the use of natural resources for the development of the infrastructure. In order to reduce dependence on natural aggregates as the main source of aggregate in concrete, artificially manufactured aggregates are becoming popular in these days. Artificial aggregates generated from industrial wastes provide an alternative for the construction industry. The Rapid growth of technology and population in India, there is a huge demand for construction material mostly for natural sand, of late excessive consumption of sand caused ecological & economical imbalances. To overcome these effects large modifications are being carried out in construction industry, i.e. usage of by-products as a replacement of fine aggregate. In the present study to increase the mechanical properties of concrete steel fibres are added to the concrete mix. Experimental investigation was carried out to evaluate the mechanical properties of steel fibre reinforced concrete and conventional concrete by partial replacement of Fine Aggregate (F.A.) with copper slag for M30 grade concrete. Tests are conducted with 1% addition of hooked end steel fibres having aspect ratio 60 and replacement of F.A by 0%, 10%, 20%, 30%, 40%, 50%, 60%, copper slag with increase in 10% up to where optimum strength is obtained

2.4. Angadala Sowjanya1 and P. Krishna Prasanna

Effect of Copper Slag on Steel Fiber Reinforced Concrete and Conventional Concrete

International Journal Of Research In Engineering, IT and Social Sciences, Volume 06, Issue 09, September 2016.

apid growth of technology and population in India, there is a huge demand for construction material mostly for natural sand, of late excessive consumption of sand caused ecological economical imbalance. To overcome these effects large modifications are being carried out in construction industry, i.e. usage of by products as a replacement of fine aggregate.In the present study to increase the mechanical properties of concretesteel fibers are added to the concrete mix. Experimental investigation was carried out to evaluate the mechanical properties of SFRC and conventional concrete by replacement of sand (F.A.) with copper slag for different grades (M30, M40).Tests are conducted with 1% addition of hooked end steel fibershaving aspect ratio 60 and

replacement of copper slag by 0%, 10%....with increase in 10% up to where optimum strength is obtained.

3. PROPERTIES OF MATERIALS

3.1. Test for fine and coarse aggregate

TEST	FINE AGGREGATE	COARSE AGGREGATE
Fineness modulus of fine aggregate	2.66	4.06
Specific Gravity	2.64	2.71
Water absorption	0.8%	0.4%

Table 2. Test results for fine and coarse aggregate

3.2. Test for cement

S.NO	PROPERTIES	TEST RESULTS
1	Specific gravity	3.15
2	Initial Setting Time	38 min
3	Final Setting Time	560 min
4	Normal Consistency	34%

Table 3..Test results for cement

3.3. Steel Fiber

PROPERTY	VALUE
Wire Diameter (d)	0.755 mm (± 0.04mm)
Fiber Length (L)	60.0 mm (+2/-3 mm)
Hook Length (l and l')	1 – 4 Hook
Hook Depth (h and h')	1.80 mm (+1/-0 mm)
Bending Angle(α and α')	45° (min 30°)
Aspect ratio (L/d)	80
Tensile Strength of drawn wire	1200 N/mm²

Table 4. Steel Fiber Property

3.4. Super Plasticizers

S.NO	PROPERTIES	VALUES OBTAINED	IS REQUIREMENTS
1	pH VALUE	7.1	6 - 8
2	Chloride ion content	0.07%	0 – 0.2%
3	Specific gravity at 25°C	1.09	1.08 - 1.09

Table 5. Super Plasticizer Properties

3.5 Copper Slag

S.NO	PROPERTIES	PHYSICAL COMPONENTS
1	Grain Shape	Angular and Multi faceted
2	Colour	Black and Glassy
3	Hardness	7 MOH
4	Bulk Density	3.25 x 10^3
5	Specific Gravity	3.5
6	Conductivity	4%
7	Moisture Content	< 0.001%

Table 6. copper Slag

4. WORKABILITY OF CONCRETE

Slump test is popular due to the simplicity of apparatus used and simple procedure, unfortunately, the simplicity is also often allows a wide variability and many time it could not provide true guide to workability. For example, a harsh mix cannot be said to have same workability as one with a large proportion of sand even though they may have the same slump. The slump cone experiment is conducted in an apparatus called slump cone. This apparatus essentially consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as under: Bottom diameter: 20 cm, Top diameter: 10 cm, Height: 30 cm and the thickness of the metallic sheet for the mould should not be thinner than 15 mm. The slump of concrete by using of m-sand as fine aggregate is 95mm of water cement ratio 0.5.

PERCENTAGE OF FIBER ADDED	COPPER SLAG	SLUMP RESULTS
0%	0	95 mm
1%	40%	60 mm
1%	60%	50 mm
1.5%	40%	90 mm
1.5%	60%	44 mm

Table 7. Slump Cone Results

The workability of concrete on 1% and 1.5% was is lower since steel fibre has low moisture absorption.

5. TESTS OF HARDENED CONCRETE

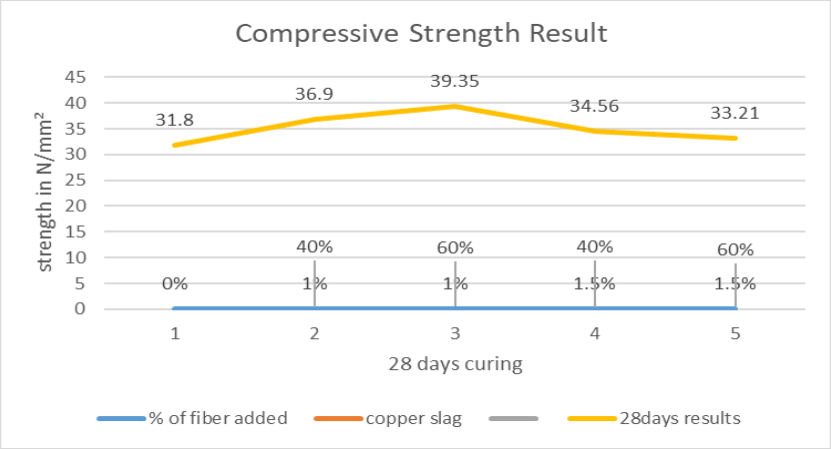
5.1 Compressive Strength of Concrete

Cube size: 150mm x 150mm x 150mm

Curing days: 28 days

Grade of concrete	Compressive strength of conventional concrete "N/mm^2"	% Adding on steel Fiber	% of replacement of fine aggregate by copper slag	Compressive strength of modified concrete "N/mm^2"
M25	28.62	1% 1% 1.5% 1.5%	40% 60% 40% 60%	36.9 39.35 34.56 33.21

Table 8. Compression strength test results of concrete



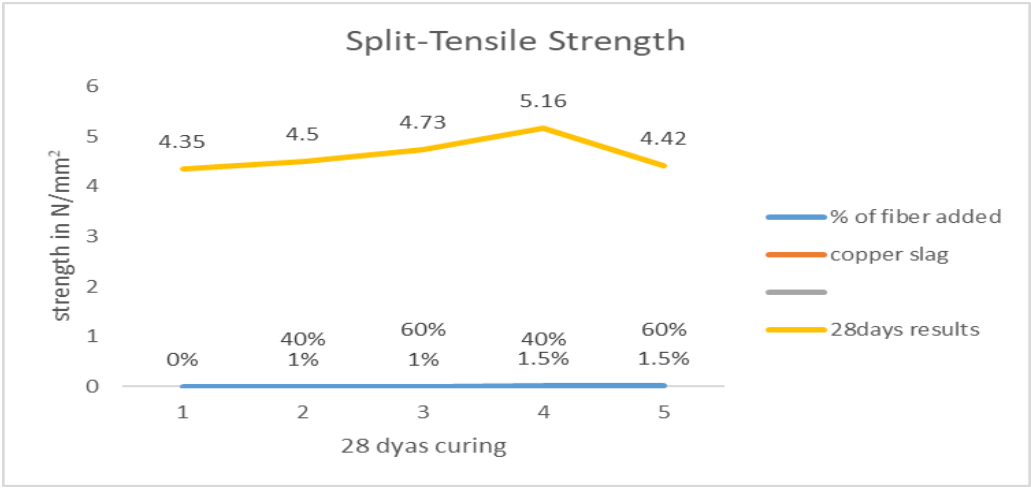
Fibers do enhance the static compressive strength of concrete, with increases in strength ranging from essentially nil to perhaps 24%. Even in members which contain conventional reinforcement in addition to the steel fibers, the fibers have little effect on compressive strength. However, the fibers do substantially increase the post-cracking ductility, or energy absorption of the material.

5.2 Split-tensile Strength of Concrete

Diameter of the concrete specimen = 150mm
Length of the specimen = 300mm

Grade of concrete	Compressive strength of conventional concrete "N/mm^2"	% Adding on steel Fiber	% of replacement of fine aggregate by copper slag	Compressive strength of modified concrete "N/mm^2"
M25	4.35	1% 1% 1.5% 1.5%	40% 60% 40% 60%	4.5 4.73 5.16 4.42

Table 8. Split tensile strength test results of concrete



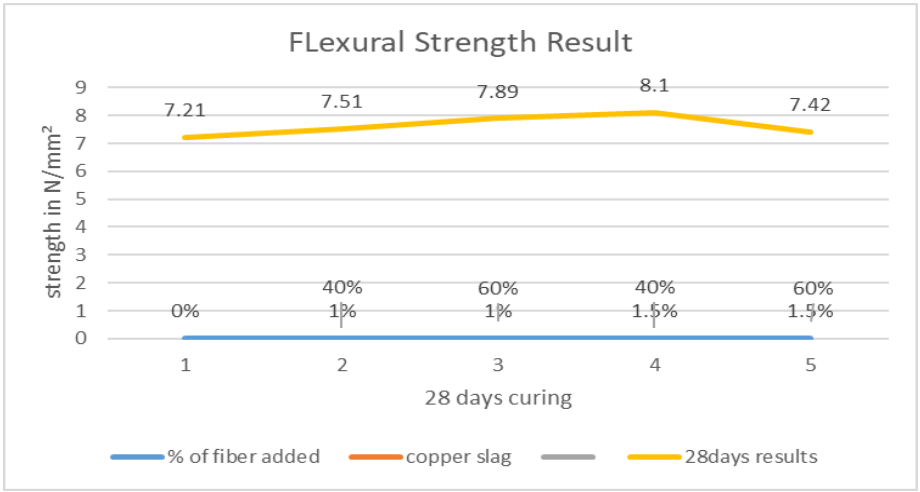
Fibers aligned in the direction of the tensile stress may bring about very large increases in direct tensile strength, as high as 28% for straight steel fibers. However, for more or less randomly distributed fibers, the increase in strength is much smaller, ranging from as little as no increase in some instances to perhaps 40%, with many investigations indicating intermediate values. Splitting-tension do lead to major increases in post-cracking beaviour or toughness of the composites.

5.3 Flexural Strength of Concrete

Width of the concrete specimen = 100mm
Depth of the concrete specimen = 100mm
Length of the specimen = 500mm
Loading distance (a) = 133mm

Grade of concrete	Compressive strength of conventional concrete "N/mm^2"	% Adding on steel Fiber	% of replacement of fine aggregate by copper slag	Compressive strength of modified concrete "N/mm^2"
M25	7.21	1% 1% 1.5% 1.5%	40% 60% 40% 60%	7.51 7.89 8.1 7.42

Table 8. Flexural strength test results of concrete



Steel fiber are generally found to have aggregate much greater effect on the flexural strength of SFRC than on either the compressive or tensile strength, with increase of more than 33.14% having been reported. The increase in flexural strength is particularly sensitive, not only to the fiber volume, but also to the aspect ratio of the fibers, with higher aspect ratio leading to larger strength increase. For all of the empirical measures of toughness, fiber with better bond characteristics give higher toughness values than do smooth, straight fiber at the same volume concentrations.

6. CONCLUSION

In the light of the preceding results and discussion, the following can be concluded:

a) The addition of steel fiber effects on the compressive strength has increasing by 24.15% with 1.5% of fiber than start increasing and then decreases by with increase the fiber quantities.

b) The results of the splitting tensile strength tests show that, there is a increase in strength by increasing fiber. It was found that highest splitting tensile strength was achieved by 15% of steel fibers, which was found about 5.16N/mm² compared with other mix. The load carrying capacity is increased to 28.02% compared with the conventional specimen.

c) Based on the experimental test result there is an improvement in flexural strength of the 1.5% mix is higher at age of 28 days respectively compared to all other mixers.

d) That improves the tensile and cohesion of concrete.

e) The fiber concrete fails in more ductile mode opposite the plain concrete that shattering into pieces.

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