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

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ABSTRACT

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.

Keywords : SFRC, M30, M40

I. INTRODUCTION

Concrete is one of the world's most widely used construction material. However, since the early 1800's, it has been known that concrete is weak in tension. Weak tensile strength combined with brittle behaviour result in sudden tensile failure without warning. To improve the strength, ductility and post cracking strength of concrete copper slag and steel fibers are added to the concrete. Copper slag can be used in concrete production as a partial replacement for sand. Copper slag is used as a building material, formed into blocks. Such use was common in areas where smelting was done. The granulated slag (<3 mm size fraction) has both insulating and drainage properties which are usable to avoid ground frost in winter which in turn prevents pavement cracks. Steel fibers can be defined as discrete, short length of steel having ratio of its length to diameter (i.e.aspect ratio) in the range of 20 to 100 with any of the several cross-section, and that are sufficiently small to be easily and randomly dispersed in fresh concrete mix using conventional mixing procedure. The random distribution results in a loss of efficiency as compared to conventional rebars, but the closely spaced fibers

improve toughness and tensile properties of concrete and help to control cracking.

II. LITERATURE REVIEW

Dr.T.Ch. Madhavi, Arindam Mallick, Sohail M.B, Soumyadeep Nath, Mohit Jain has investigated "Effect of Copper Slag on Strength of Polypropylene Fiber Reinforced Concrete". In this work copper slag, which is an industrial waste is used as a replacement material for sand and its effect is studied on the strength of concrete. Also, to improve the strength and ductility, polypropylene fibers are added in the ratios of 0.1%, 0.2%, 0.3% and 0.4% content. The effect of copper slag is investigated by replacing fine aggregate in concrete in the proportions of 10%, 20%, 30%, 40%, 50% 60% and 100%. The results obtained are analysed and presented.

S. Raghu, MR.K. Nehemiya, MR.K. Prasad has studied "Behaviour Aspects of Copper Slag and Steel Fibers in Concrete Subjected to Destructive and Non-Destructive Tests". In 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 these 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 behaviour.

Binaya Patnaik, Seshadri Sekhar T and Chandra Sekhar B has investigated "An Experimental Investigation on Strength Properties of Copper Slag Fibre Reinforced Concrete". This paper presents a study of the mechanical properties of copper slag fibre reinforced concrete considering the effect of fibre content (0%, 0.5%, 1%, and 1.5%). Also, an attempt has been made to establish the relationship between different mechanical and non-destructive test properties of concrete. Furthermore, a mathematical model was proposed to determine different strength properties of copper slag concrete with variation of fibre content in it. The suggested model successfully epitomizes the rise of tensile and flexure strength properties of copper slag concrete with increase in fibre content, however a different pattern has been observed in case of compressive strength. In the present experimental investigation, concretes of grade M20 and M30 were used with crimped steel fibres having an Aspect Ratio of 60.

D.Sahathi, G.L. Sirisha has studied "Effect of Copper Slag on Steel Fiber Reinforced Concrete". 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.

III. METHODOLOGY

The methodology we follow for recycling of concrete are as follows

1. Select a grade of concrete for which a conventional mix is to be done.
2. Now, materials required for preparation for conventional concrete must be brought and material testing must be done in the laboratory before mix is prepared.
3. All the physical tests on the aggregates have to be done acc to

IS:2386 (PART I) - Particle size and shape

IS:2386 (PART III) – Specific gravity, Density, Voids, Absorption and Bulking

- Also find the properties of the cement, properties of copper slag, properties of steel fiber's which is used in the mix
- Now, using IS 10262:2009 design the suitable mix for required grade of a conventional concrete by considering the physical properties of the material.
- Using the above mix design prepare the mix and workability test has been done and 6 cubes are casted to find the 3Days, 7 days and 28 days strength of the concrete.
- Now, phase I of the project is completed next phase is preparing the concrete by utilizing copper slag.
- We use copper slag is in this case and accordingly we adjust the water content for the new mix design and we find strength of the concrete by preparing the cubes of different proportions of coarse aggregate and demolished concrete.
- Now, the cubes are tested for compressive strength and compared.
- Now, phase II of the project is completed next phase is preparing the concrete by utilizing steel fibers.
- Now, phase III of the project is completed next phase is preparing the concrete by utilizing steel fibers along with copper slag.
- In this case we use steel fibers and copper slag and accordingly we adjust the water content for the new mix design and we find strength of the concrete by preparing the cubes of different proportions of coarse aggregate and demolished concrete.
- Now, the cubes are tested for compressive strength and compared.

IV. EXPERIMENTAL RESULTS

Table 1 : Physical Properties

	Coarse Aggregate	Fine Aggregate	Copper Slag	Cement
Specific gravity	2.7	2.65	2.52	3.2
Water absorption	0.28%	0.35%	-	-
Bulk density	1685.2 Kg/m³	1647.2 Kg/m³	1710.2 Kg/m³	-
Fineness	-	-	-	92.7%
Initial setting time	-	-	-	29min

Table 2: Mix Design for Different Combinations in M30 Replacing copper slag and steel fiber

Mix	Cement	Fine Aggregate	% Replacement Of Copper Slag	Coarse Aggregate	% Addition Of Steel Fibers	Copper Slag	Water
CS0	390	582	0	1298	1	0	175.5
CS1	390	524	10	1298	1	58.2	175.5
CS2	390	465.4	20	1298	1	116.4	175.5
CS3	390	407.3	30	1298	1	174.6	175.5
CS4	390	349.1	40	1298	1	232.7	175.5
CS5	390	290.9	50	1298	1	290.93	175.5
CS6	390	232.7	60	1298	1	349.3	175.5

Table 3 : Mix Design for Different Combinations in M40 Replacing copper slag and steel fiber

Mix	Cement	Fine Aggregate	% Replacement of Copper Slag	Coarse Aggregate	% Addition Of Steel Fibers	Copper Slag	Water
CS0	420	569.5	0	1278	1	0	180.6
CS1	420	512.5	10	1278	1	56.95	180.6
CS2	420	455.6	20	1278	1	113.9	180.6
CS3	420	398.6	30	1278	1	170.9	180.6
CS4	420	341.7	40	1278	1	227.8	180.6
CS5	420	284.7	50	1278	1	284.8	180.6
CS6	420	238.6	60	1278	1	227.8	180.6

Table 4 : Compressive Strength, Flexural Strength and Split Tensile strength Results for M30 Grade Concrete with Copper Slag

	Compressive Strength (N/mm²)		Flexural Strength (N/mm²)	Split Tensile Strength (N/mm²)
Mix Proportions	7 Days Strength	28 Days Strength	28 Days Strength	28 Days Strength
CS0	34	39	C	2.02
CS1	37	41	4.73	2.19
CS2	38	42	4.89	2.2
CS3	40	43	5.33	2.4
CS4	42	44	5.72	2.63
CS5	44	45	6.0	2.87
CS6	39	43	5.8	2.56

Table 5 : Compressive Strength, Flexural Strength and Split Tensile strength Results for M30 Grade Concrete with Steel Fibre and Copper Slag

	Compressive Strength (N/mm²)		Flexural Strength (N/mm²)	Split Tensile Strength (N/mm²)
Mix Proportions	7 Days Strength	28 Days Strength	28 Days Strength	28 Days Strength
CS0 +1%SF	39	43	4.9	3.23
CS1+1%SF	41	46	7.0	3.62
CS2+1%SF	43	48	8.3	3.87
CS3+1%SF	45	48.4	8.79	4.23
CS4+1%SF	47	51.3	9.3	4.95
CS5+1%SF	45	49	6.73	3.7

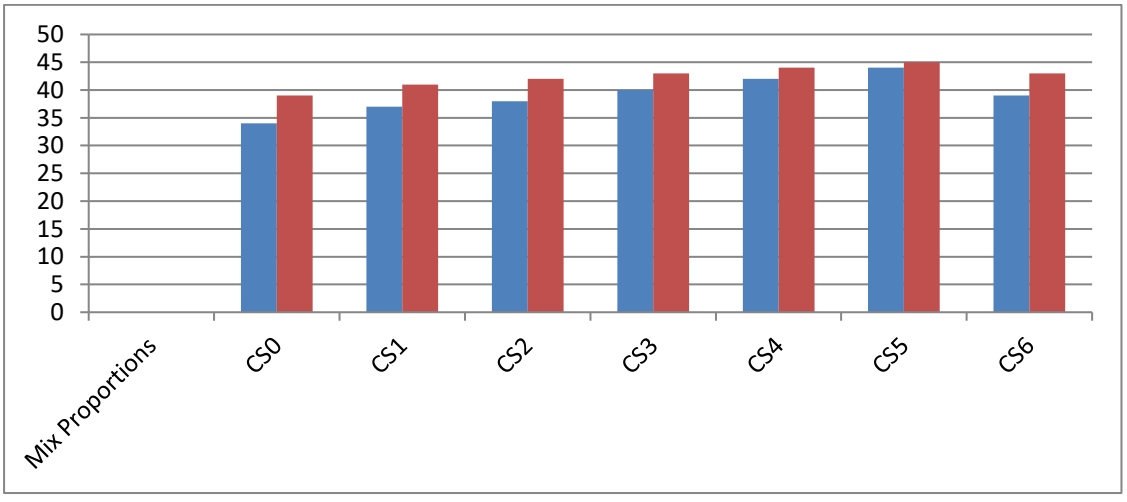
Table 6 : Compressive Strength, Flexural Strength and Split Tensile strength Results for M40 Grade Concrete with Copper Slag

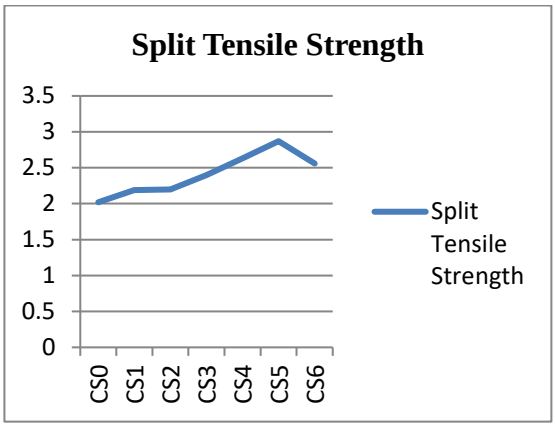
	Compressive Strength (N/mm²)		Flexural Strength (N/mm²)	Split Tensile Strength (N/mm²)
Mix Proportions	7 Days Strength	28 Days Strength	28 Days Strength	28 Days Strength
CS0	44	50	4.9	2.54
CS1	47	52	5.4	2.7
CS2	49	53	5.6	2.86
CS3	51	56	5.9	3.04
CS4	53	58	6.63	3.43
CS5	50.6	55	5.42	2.8

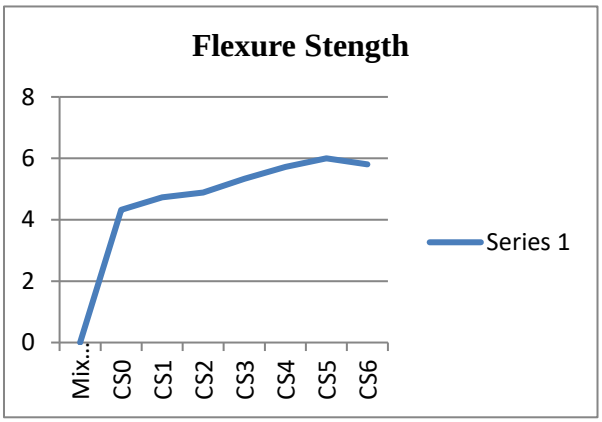
Table 7 : Compressive Strength, Flexural Strength and Split Tensile strength Results for M40 Grade Concrete with Steel Fibre and Copper Slag

	Compressive Strength (N/mm²)		Flexural Strength (N/mm²)	Split Tensile Strength (N/mm²)
Mix Proportions	7 Days Strength	28 Days Strength	28 Days Strength	28 Days Strength
CS0 +1%SF	49	54	6.9	4.09
CS1+1%SF	51	55	7.2	4.72
CS2+1%SF	51	57	8.7	4.95
CS3+1%SF	51	59	9.3	5.23
CS4+1%SF	53	62	10.1	5.94
CS5+1%SF	52.6	57	8	5.63

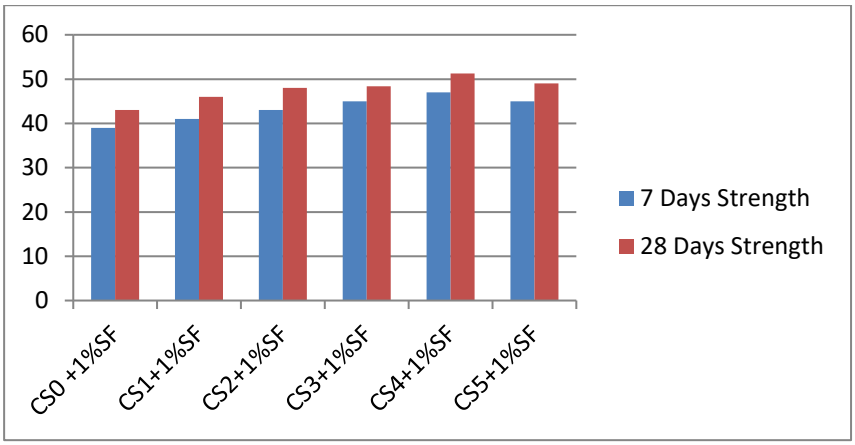
Compressive Strength, Flexural Strength and Split Tensile strength Results for M30 Grade Concrete with Copper Slag

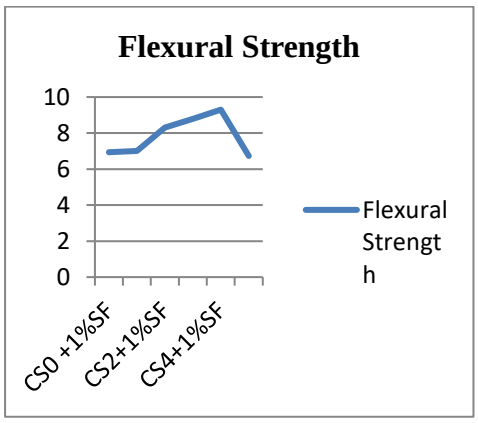


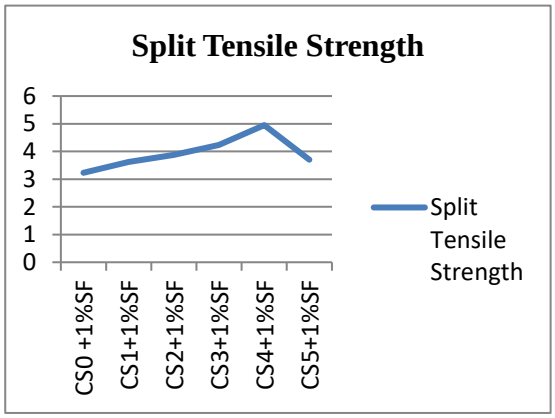




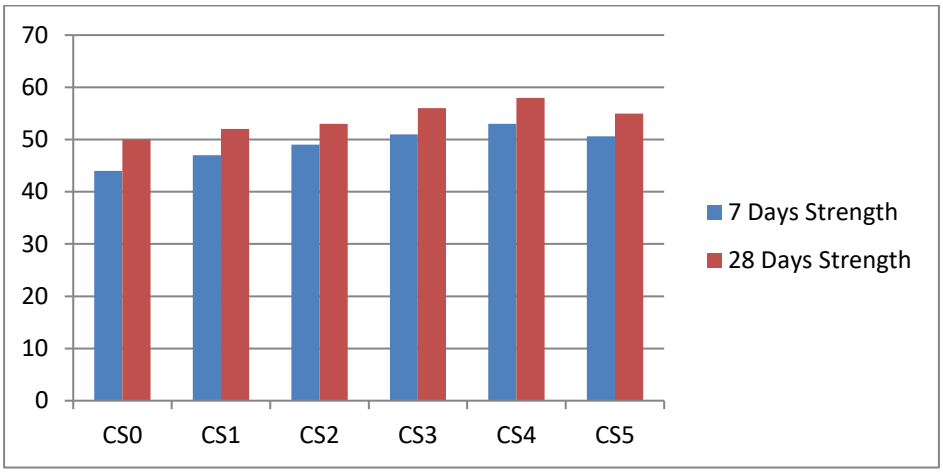
Compressive Strength, Flexural Strength and Split Tensile strength Results for M30 Grade Concrete with Copper Slag and steel fibers

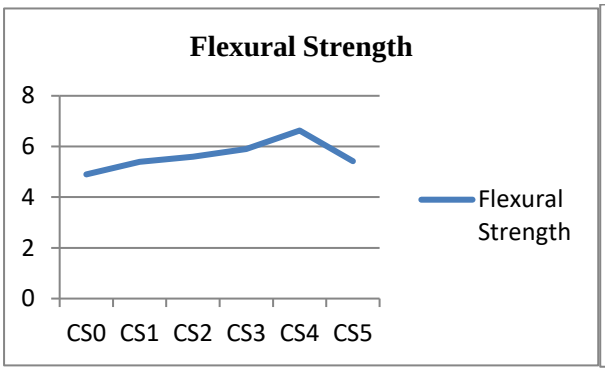


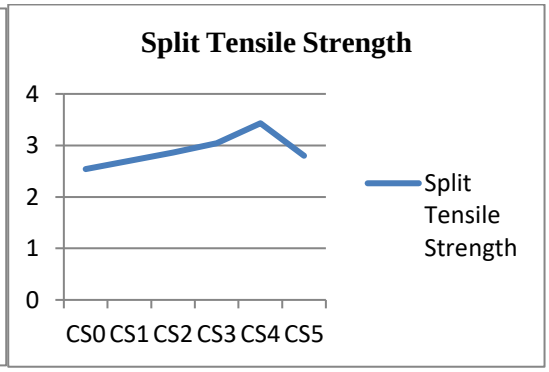




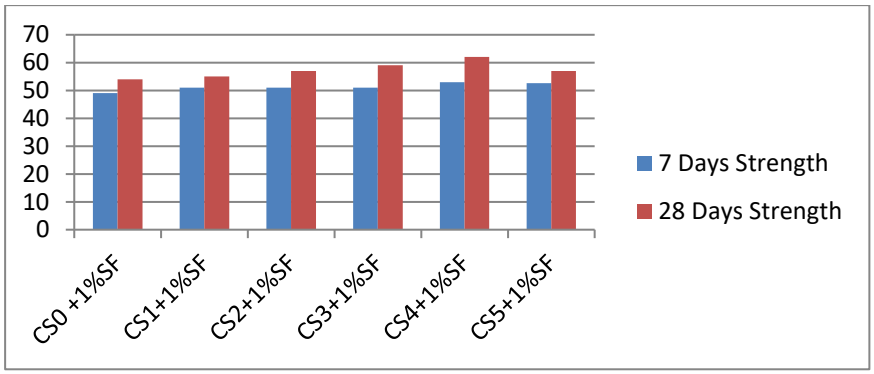
Compressive Strength, Flexural Strength and Split Tensile strength Results for M40 Grade Concrete with Copper Slag

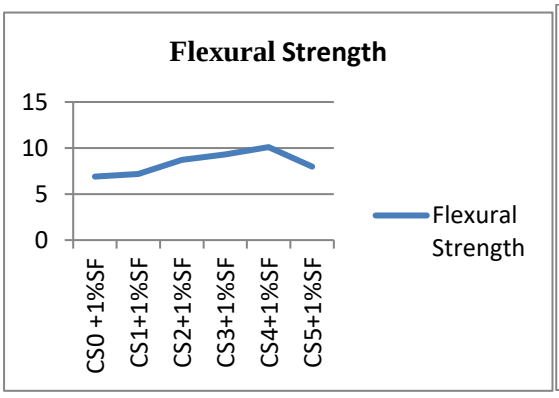


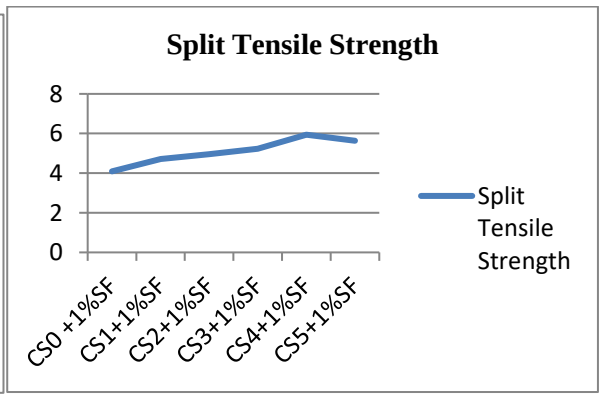




Compressive Strength, Flexural Strength and Split Tensile strength Results for M40 Grade Concrete with Copper Slag and steel fibers







V. CONCLUSION

1. The optimum strength for M30&M40 grade concrete is observed at 50%&40% replacement of copper slag with fine aggregate.
2. Due low water absorption nature copper slag there is a increase in the workability of conventional concrete when compared with steel fiber reinforced concrete due addition of hooked end steel fibers.
3. Maximum percentage increase of compressive strength for conventional concrete is 29.4where as for steel fiber reinforced concrete is 34.28% for M30.
4. Maximum percentage increase of compressive strength for conventional concrete is 20.5% whereas for steel fiber reinforced concrete is 23%for M40.
5. Steel fiber reinforced concrete is having an increase in compressive strength is 70%, Flexural strength is 50%, Split tensile strength is 68%when compared with conventional concrete.
6. So addition of hooked end steel fibers increases mechanical properties of concrete and also provides superior resistance to cracking.
7. While testing the specimens, the plain cement concrete specimens have shown a typical crack propagation pattern which leaded into splitting of member in two-piece geometry. But due to addition of steel fibers in concrete cracks gets ceased which results into the ductile behaviour of SFRC.
8. Increase in replacement of copper slag with F.A beyond the optimum percentage causes increase in workability and causes strength reduction. Increase in fiber content can result in balling effect and reduces workability according to ACI544 (3R-08) it is advisable up to 0.5%-1.5%. Further researches can be carried out to improve the strength and acid resistance by the addition of some admixtures.

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