INVESTIGATION ON STRENGTH PROPERTIES OF SELF COMPACTING CONCRETE WITH COPPER SLAG AS FINE AGGREGATE FOR M25 GRADE CONCRETE

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ABSTRACT— Now a days using of industrial waste materials has more in construction sector for the making of concrete because it contributes to reducing the consumption of natural resources. Self – compacting concrete (SCC) is a high performance concrete which can flow under its own weight and it fills the form work perfectly and self-consolidates without any additional vibration devices. This concrete can accelerate the placement and reduce the labour needs for compaction and finishing. Copper slag is one of the waste materials which can have a hopeful expectation in construction industry as partial or full alternative of fine aggregates. The objective of this work is to study the strength properties of self-compacted copper slag concrete. For this purpose M25 grade concrete was used and test were conducted for various proportion of sand replaced by copper slag at 0%, 20%, 40%, 60%, 80%, 100% and silica fume were used as an admixture to the concrete.

Keywords— SCC, Copper slag, Packing factor, Passing ability, Filling ability.

INTRODUCTION

When more quantity of heavy reinforcement is to be placed in a reinforced concrete member, it is too hard to ensure that the formwork is totally filled with concrete that is, completely compacted without any honeycombs. It is not easy to do the compaction by manual Tamping or by mechanical vibrators in this situation. The common methods of compaction, vibration, generates time delays and extra cost in the projects. This difficulty can now be solved with self-compacting concrete. This type of concrete can flow easily around the reinforcement and into all corners of the formwork. Self-compacting concrete (SCC) means a concrete having the ability to compact itself only by means of its own self weight without the usuage of all mechanical vibrations.The exclusion of vibrating machine enhance the environment on and near construction where concrete is being placed, sinking the coverage of labour to noise and vibration. Self-compacting concrete is also known as self-leveling concrete or Self consolidating concrete. Large amount of industrialized waste mounted annually in the emerging countries. Viability and resource effectiveness are escalated by most important issues in our construction industry. Therefore, these days use of alternate materials is commonly used in construction industry. Copper slag is one of the waste materials which possibly will have a hopeful future in construction field as alternative of either cement or fine aggregates.European Federation of National Associations Representing for Concrete established 1989 (EFNARC) has specification and guidelines for SCC to provide a framework for designing SCC and the use of high quality SCC during the year 2002.The design mix of SCC based on M25 is prepared and studied for various replacements of fine aggregates by copper slag and it is evaluated for its strength properties.

MATERIAL PROPERTIES

Cement :

The cement used in this research is 53 grade Ordinary Portland Cement (OPC).The properties of cement used in this research are given in Table 1.

Table 1: Properties of Cement

S. NO	PROPERTIES	RESULT
1	Specific gravity	3.15
2	Initial setting time	34 Min
3	Final setting time	585 Min
4	Normal Consistency	31.3%
5	Fineness	2%

Coarse Aggregate :

Well grade 16 mm size coarse aggregate were selected for present work. The various properties of coarse aggregates were tabulated in table 2.

Table2 : Properties of coarse aggregate

S. NO	PROPERTIES	RESULT
1	Fineness Modulus	3.46
2	Specific Gravity	2.695
3	Bulk Density	1450 kg/m3
4	Moisture Content	0.25 %
5	Water Absorption	0.4 %

Fine Aggregate :

Fine aggregate used in this research was river sand passing through IS sieves 4.75 mm obtained from a local source. Various properties of fine aggregates are tabulated in table 3.

Table 3: Properties of fine aggregate

S. NO	PROPERTIES	RESULT
1	Fineness Modulus	3.18
2	Specific Gravity	2.624
3	Bulk Density	1500Kg/m3
4	Moisture Content	2.4%
5	Water Absorption	0.8%

Copper Slag:

Copper slag was collected from Sterlite Industries India Limited (SIIL) Tuticorin, Tamil Nadu, India and used in this research. Various physical and chemical properties of copper slag are listed in the table below:

Table 4: Chemical properties of Copper Slag

CHEMICAL COMPOSITION	PERCENTAGE OF CHEMICAL COMPONENT
Fe_2O_3	65.23
SiO_2	23.43
CuO	1.22
Al_2O_3	0.20
TiO_2	0.51
K_2O	0.28
Mn_2O_3	0.25
CaO	0.13
SO_3	0.16
Na_2O	0.52
Insoluble residue	10.22
Sulphide sulphur	0.15

Table 5: Physical properties of Copper Slag.

PROPERTIES	COPPER SLAG
Particle shape	Irregular
Appearance	Black and Glassy
Specific gravity	3.93
Bulk density	1900 Kg/m3
Percentage of voids	34 %
Moisture content	0.13 %
Water absorption	0.18 %
Fineness Modulus	3.28

Silica Fume:

Silica fume can be added to Portland cement concrete to extend its properties; especially it improves better compression and bonding strength, and gives more abrasion resistance. Silica fume is very fine non crystalline silica is produced in electric arc furnace as a derivative of the production of elemental silicon or alloys having silicon. It is usually grey color powder, somewhat similar to Portland cement. Silica fume of specific gravity is 2.2 which is used in this research. Because of its intense fineness and high silica content, silica fume acts as a very effective pozzolanic material.

Super plasticizer:

The use of super-plasticizers in concrete is a mile stone in the advancement of concrete technology. Some high range water reducing admixtures can retard final set by one to five hours and if prolonged setting times are not convenient, the admixture can be combined with an accelerating admixture to reduce the retarding tendencies or even to provide some setting on some acceleration. In this present research super plast 840 super plasticizer is used to make concrete more workable with the self compacting charecteristics.

Water:

Water is an important ingredient in concrete. Practically all natural water that is safe to drink and has no distinct taste or smell which can be used for mixing water in making concrete. Some water which may not fit for drinking may also still be harmless for mixing concrete. Potable water available from the local source was used in the work.

MIX PROCEDURE

By varying the volume of fine aggregate and coarse aggregate several trail mixes are carried out according to the limitation given in the EFNARC guidelines to satisfy fresh properties. Based on this optimum design mix is determined. Mix design calculations are based on several characteristic properties like packing factor, bulk density aggregates, specific gravity, etc. Packing factor is the ratio of mass of aggregates of tightly packed state in SCC to loose state in air. Packing Factor of 1.12 is taken on trial basis. Quantity of cement and water required for cement mixing is calculated as per ACI method. The Quantity of other materials is calculated by Nansu tool for mix design (2001). The percentage of fine aggregate is replaced by 0%, 20%, 40%, 60%, 80%, and 100% in the obtained optimum mix and checked for their fresh and hardened properties. Fresh properties, typical acceptance criteria and mix proportions of the self compacting concrete are tabulated in Table 7,Table 8 and Table 9.

Table 7: Fresh Properties of SCC

Mix	Slump (mm)	Slump 50 (sec)	V funnel (sec)	J Ring (mm)	Remark
0 %	700	2	6	2	Satisfied
20 %	700	2	7	3	Satisfied
40 %	700	2	8	4	Satisfied
60 %	680	3	11	8	Satisfied
80 %	480	Not Satisfied			

Table 8: Typical Acceptance Criteria for SCC

S. No	Method	Unit	Typical Range	
			Minimum	Maximum
1	Slump flow test (Filling ability)	mm	600	800
2	T 50 Cm slump flow (Filling ability)	sec	1	4
3	V- funnel test (Filling ability)	sec	7	11
4	J-ring (Passing ability)	mm	0	10

Table 9: Mix Proportion

Mix	Cement (Kg/m3)	Fine Aggregate (Kg/m3)	Copper Slag (Kg/m3)	Coarse Aggregate (Kg/m3)
0%	295	873	-	547.04
20%	295	681	247	547.04
40%	295	482	493	547.04
60%	295	287	542	547.04
80%	295	97	683	547.04

HARDENED PROPERTIES

Hardened concrete properties are as Compressive strength, Spilt tensile strength and Flexural strength are tested in Universal Testing Machine. For that 3 cubes of size (150*150*150 mm), 3 cylinders of size (300*150 mm) and 3 prisms of size (500*100*100 mm) are cast for each trial mixes of copper slag replacement and tested after 7, 14 and 28 days of curing. Test results are listed in Tables 10, 11 & 12.

Table10: Compressive Strength

Specimen	Compressive Strength (N/mm^2)		
	7th day	14th day	28th day
CS 0	24.78	27.7	30.55
CS 20	26.11	29.5	32.7
CS 40	28.78	32.44	37.8
CS 60	30.56	35	40.3
CS 80	21.67	25.6	28.5

Table11: Split Tensile Strength

Specimen	Split Tensile Strength (N/mm^2)		
	7th day	14th day	28th day
CS 0	1.23	1.25	1.31
CS 20	1.41	1.48	1.52
CS 40	1.59	1.65	1.71
CS 60	1.72	1.75	1.82
CS 80	1.32	1.36	1.4

Table12: Flexural Strength.

Specimen	Flexural Strength (N/mm^2)		
	7th day	14th day	28th day
CS 0	3.43	3.82	4.2
CS 20	3.9	4.26	5.14
CS 40	4.56	4.96	5.86
CS 60	5.2	5.78	6.39
CS 80	3.54	4.08	4.9

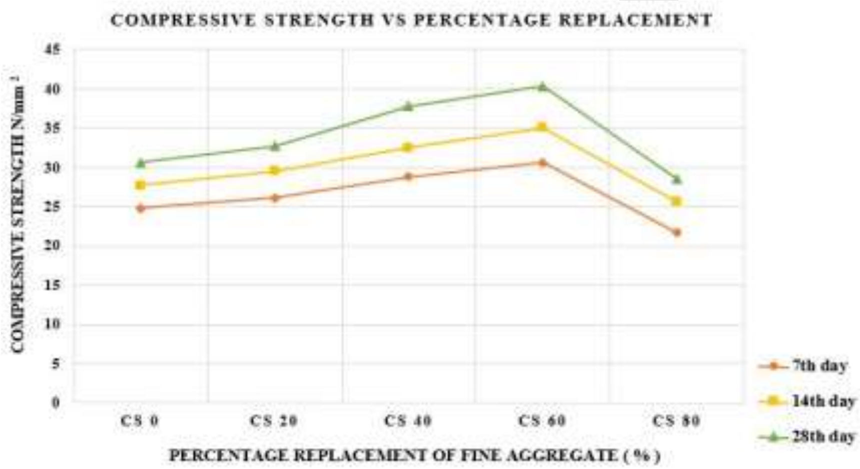

Figure 1 Compressive Strength Vs Percentage Replacement

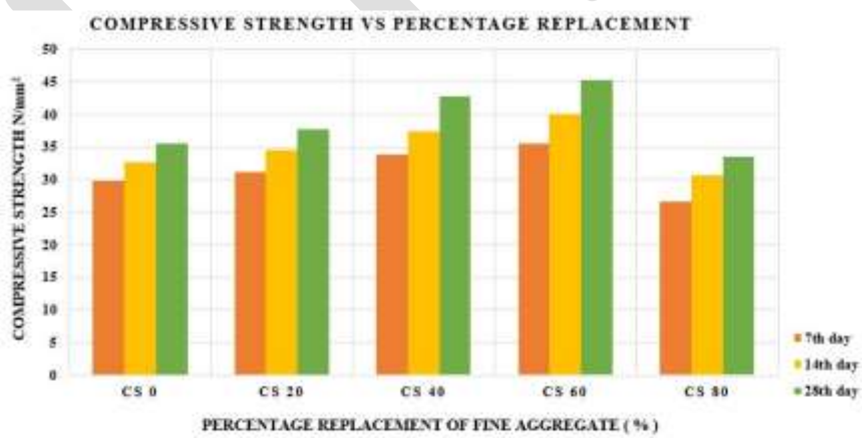

Figure 2 Compressive Strength Vs Percentage Replacement

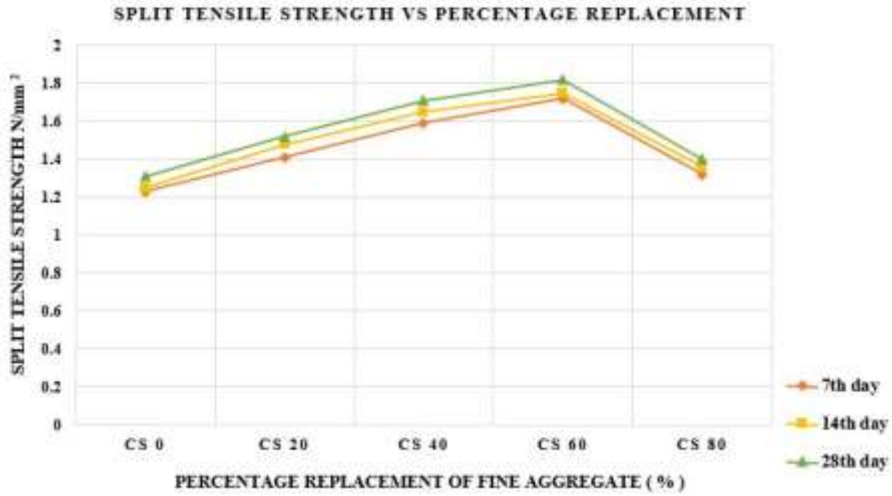

Figure 3 split tensile strength vs percentage replacement

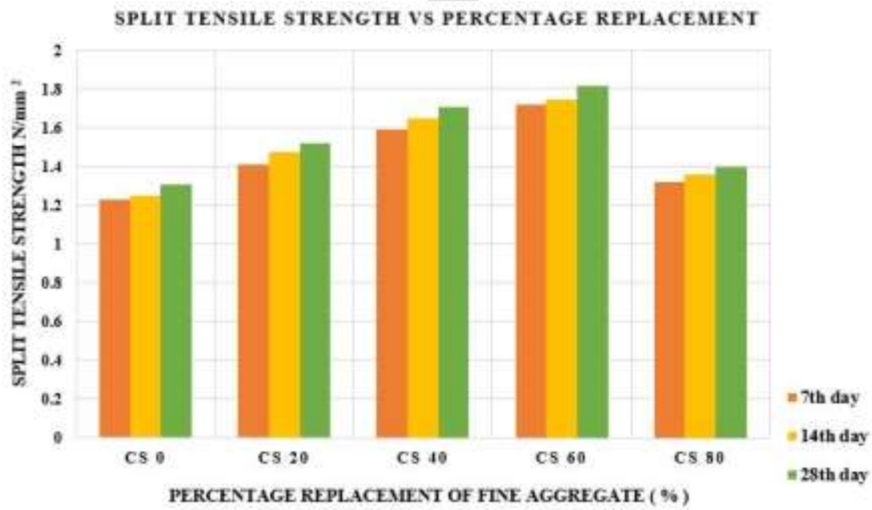

Figure 4 split tensile strength vs percentage replacement

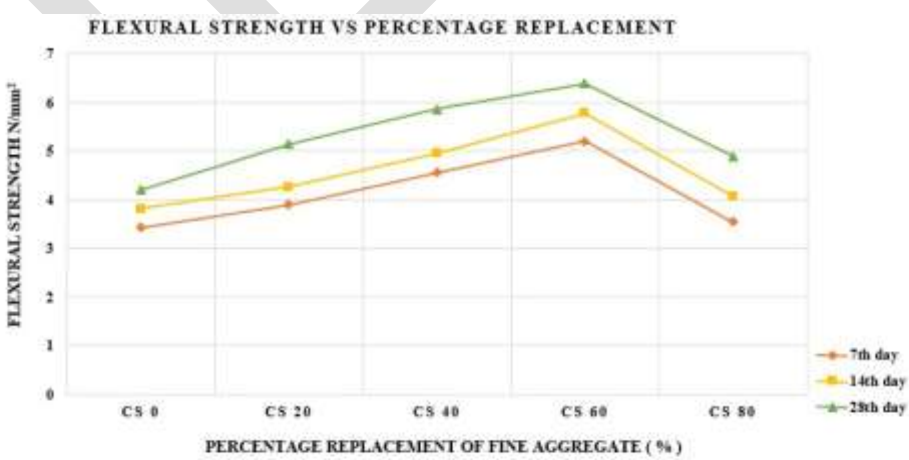

Figure 5 flexural strength vs percentage replacement

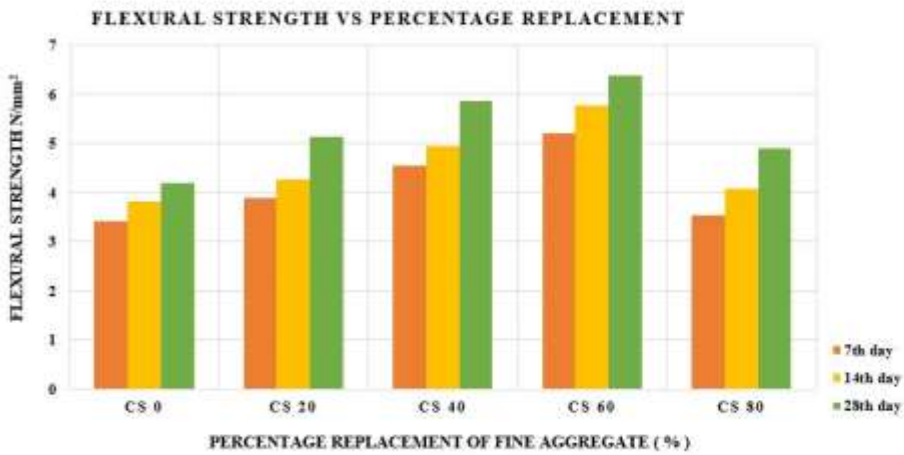

Figure 6 flexural strength vs percentage replacement

From figure 1 to 6, the results clearly show that the self compacting concrete with 60% copper slag is replaced for fine aggregate has optimum results in compressive, split tensile and flexural strength. At 60% Copper slag replacement, the compressive strength, split tensile strength and flexural strength hence an improvement of 24%, 28% and 34% respectively to that of the strengths of control concrete.

CONCLUSION

1. From the experimental results, it was observed that the compressive strength, split tensile strength and flexure strength of concrete can be improved by partial replacement of fine aggregate with copper slag and was found that 60% replacement gives optimum results.

2. The highest compressive strength obtained was 40.3 MPa (60% replacement @ 28 days) which is higher than that of the corresponding strength for control SCC 30.56 MPa.

3. The percentage of increase in the compressive strength is 24.19% after a span of 28 days by replacing 60% of fine aggregate with copper slag.

4. The percentage of increase in the split tensile strength is 28.02% after a span of 28 days by replacing 60% of fine aggregate with copper slag.

5. The percentage of increase in the flexural strength is 34% after a span of 28 days by replacing 60% of fine aggregate with copper slag

6. Further detailed research work is needed to explore the effect of copper slag as fine aggregates.

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