

# International Journal of Innovative Research in Science, Engineering and Technology

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## Experimental Study on Self Compacting Concrete Using Copper Slag as a Partial Replacement of Fine Aggregate

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**ABSTRACT:** In this experimental work, the M25 grade Self Compacting Concrete using copper slag as fine aggregate was studied. The percentage of fine aggregate replaced by copper slag as 10%, 20%, 30%, 40% & 50% to study the fresh concrete properties, Slump Flow, V-Funnel and L-Box test were carried out. Strength properties such as Compressive Strength, Split Tensile Strength and Flexural Strength were evaluated experimentally. The obtained results were compared with the control self-compacting concrete. The results indicated that the strength was increased up to 40% replacement of fine aggregate.

### I. INTRODUCTION

Concrete is one of the major construction materials being used worldwide. Self Compacting Concrete or self-consolidating concrete (SCC) is a type of concrete that has the capacity to consolidate under its own weight. The usage of mineral admixtures in the production of SCC not only provides economical benefits but also reduces heat of hydration. These materials are also used to prevent segregation, bleeding, and increase flow ability. Copper slag has excellent soundness characteristics, good abrasion resistance and good stability. Copper Slag has a lower water absorption capacity when compared with Sand. Copper Slag behaves similar to River Sand. Replacement of Copper Slag as fine aggregate in concrete mixes reduces the cost of concrete production.

#### Self-compacting concrete

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The use of SCC in concrete structures increasingly has become prevalent in recent years

#### Copper slag

Copper slag is an industrial by-product material produced during the process of manufacturing of copper. Some of the industrial by-products have been used in the construction industry for the production of concrete. Copper slag is one of the materials that is considered as a waste material which could have been used in construction industry as partial replacement of either cement or aggregates.

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**Objective of this study** In this experimental work, an extensive study using copper slag has been carried out to investigate the following.

1. To find out the optimum proportion of copper slag that can be used as a replacement/ substitute material for fine aggregate in SCC.
2. To study Slump flow, V-funnel and L- Box test.
3. To find compressive strength, split tensile strength and flexural strength.

## Scope of this study

The scope of this project can be summarized as follows,

1. The M25 grade concrete is used.
2. The fine aggregate is replaced by copper slag of various proportions (10%, 20%, 30%, 40% & 50%)
3. Mix design for SCC with water cement ratio of 0.48 is to be proposed.
4. Self Compact ability is to be checked by various flow tests of slump flow, V- funnel and L- Box tests.

## II. REVIEW OF LITERATURES

The literature review clearly indicates that the SCC having benefits in the Performance, strength, quality & durability etc. In the most of the test data evaluated that the design methods developed to predict the characteristics of SCC is based on different Mix proportions, materials & on experimental work. From the above literatures we came to know that, Up to 40% fine aggregate replacement, using copper slag the compressive strength of concrete increased. Addition of copper slag in Concrete increases the density. Polycarboxylate based super plasticizer was used.

## MATERIALS

### Cement

Cement is the well-known building material with adhesive and cohesive properties, which is capable of binding mineral fragment into compact mass. There are several types of cement. The most popular Ordinary Portland cement (OPC-53) is used in this study.

Table 1 Properties of Cement

Sl.No	Properties	Result
1	Specific Gravity	3.13
2	Fineness Modulus	2.6 %
3	Standard Consistency	31 %
4	Initial Setting Time	36 minutes
5	Final Setting Time	300 minutes

### Fine Aggregate

Ordinary river sand conforming IS 383-1970 was used in this project.

### Coarse Aggregate

In this project, 10 mm size coarse aggregate was used. Table 2 shows the various properties of fine and coarse aggregate.

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**Table 2** Properties of Fine and Coarse Aggregate

Sl. No	Properties		Fine Aggregate	Coarse Aggregate
1	Specific Gravity		2.47	2.74
2	Fineness Modulus		2.99	7.34
3	Bulk density (Kg/m <sup>3</sup> )	Loose State	1542	1426
		Compacted state	1701	1706
4	Water absorption (%)		1	0.5
5	Moisture content		NIL	NIL

### Fly ash (Class –F type)

Fly ash is an industrial by-product, generated from the combustion of coal in the thermal power plants. Components of the mix in suspension in order to maintain a homogeneous material. Fly ash is used as a filler material. The flow ability of self compacting concrete depends on the powder and paste content. Hence, in order to increase the flow ability, mineral admixtures such as fly ash has been used.

**Table 3** Properties of Fly ash

Sl. No.	Description	Test Results
1.	Fineness Modulus	2.98
2.	Specific Gravity	2.36
3.	Water Absorption	1.5%
4.	Moisture Content	Nil

### Copper slag

Copper slag is a by-product obtained during matte smelting and refining of copper. The slag is a black glassy particle and granular in nature and has a similar particle size range like sand. It has good pozzalonic properties. The copper slag was brought from Sterlite Industries Ltd (SIL), Tuticorin, Tamil Nadu, India

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**Table 4** Properties of Copper Slag

Sl. No.	Description	Test Results
1.	Fineness Modulus	5.23
2.	Particle size of Copper Slag	0.075 mm to 4.75 mm
3.	Specific Gravity	4.04
4.	Water Absorption	0.14%
5.	Moisture Content	0.1%
6.	Appearance	Black & Glassy

### Super plasticizer

Super Plasticizer is a chemical admixture used in concrete to give workability to SCC. Since water a cement ratio is reduced. Use in concrete Super Plasticizer is a low cost water reducer which can be used to get one or a combination of benefits. Conplast SP 430 was used in this experimental study.

**Table 5** Properties of Super Plasticizer

Sl. No.	Description	Results
1.	Type	Conplast SP-430
2.	Appearance	Brown liquid
3.	Specific gravity	1.18 at 20°C
4.	Chloride content	Nil to BS 5075
5.	Air entrainment	less than 2%
6.	Alkali content	less than 72g

### MIX DESIGN

In this experimental work, M25 grade self compacted concrete with w/c ratio of 0.48 was used. In this experimental study, totally 72 numbers of specimen were cast. The specimen consisted of 36 numbers of 150mm cube, 18 numbers of 150mm diameter and 300 mm length cylinder and 18 numbers of 500x100x100 mm size prisms.

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**Table 6 Mix Ratio**

Cement	Fine Aggregate	Coarse Aggregate	Water
1	1.44	1.7	0.48

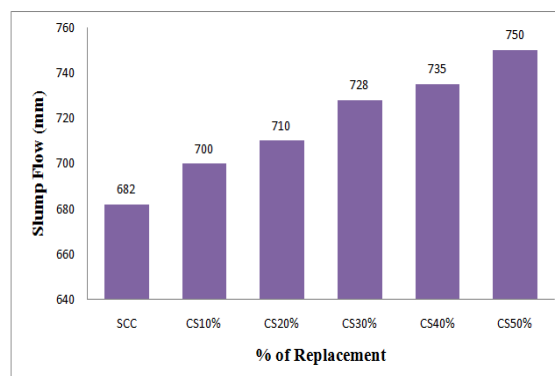
### III. RESULTS

#### Tests on fresh concrete

Fresh concrete or plastic concrete is a freshly mixed material which can be molded into any shape. The following Table 7 shows the results of various workability.

**Table 7 Fresh Concrete Properties**

Specimen description	Slump (mm)	V-Funnel (sec)	L-Box		
			H <sub>1</sub> (mm)	H <sub>2</sub> (mm)	H <sub>2</sub> /H <sub>1</sub>
SCC	682	12.2	82.40	65.90	0.80
CS10%	700	11.5	104.76	88	0.84
CS20%	710	10.25	105.88	90	0.85
CS30%	728	9	102.27	90	0.88
CS40%	735	8.5	105.55	95	0.90
CS50%	750	8.2	96.50	93.60	0.97



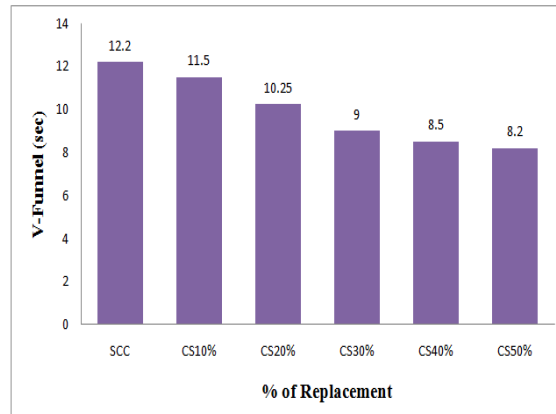
**Fig 1 Slump Value**

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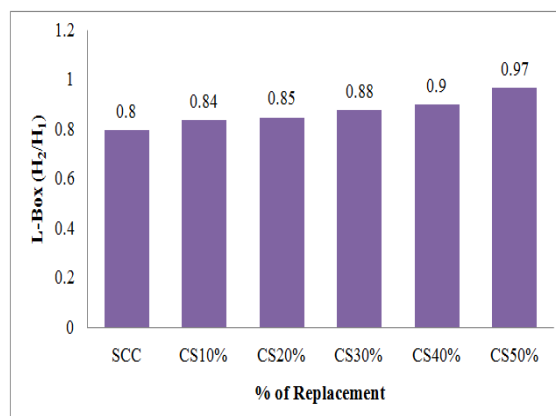
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**Fig 2** V-Funnel Value



**Fig 3** L-Box Value

### Test on hardened concrete

One of the purposes of testing for hardened concrete is to confirm that the concrete used at site has developed the required strength. Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. The test methods should be simple, direct and convenient to apply. The concrete specimens were casted and cured. The tests for hardened concrete such as compressive strength, split tensile strength and flexural strength were conducted and the values are shown in table 8.

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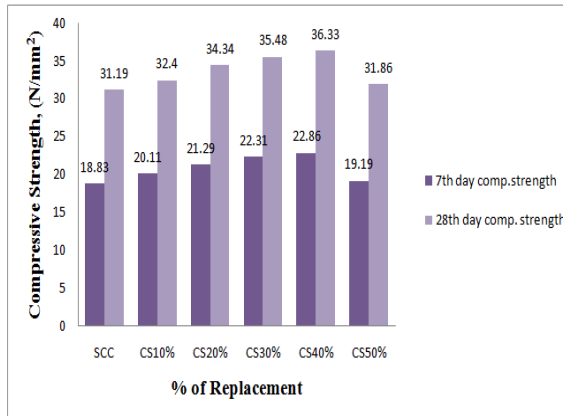
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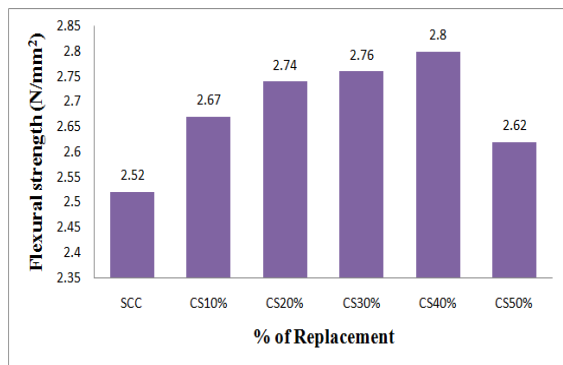
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**Table 8 Various Strength of concrete**

SI. No	Specimen Details	Compressive Strength (N/mm <sup>2</sup> )		Tensile Strength (N/mm <sup>2</sup> )	Flexural Strength (N/mm <sup>2</sup> )
		7 <sup>th</sup> Day	28 <sup>th</sup> Day	28 <sup>th</sup> Day	28 <sup>th</sup> Day
1	SCC	18.83	31.19	2.44	2.52
2	CS10%	20.11	32.40	2.98	2.67
3	CS20%	21.29	34.34	3.17	2.74
4	CS30%	22.31	35.48	3.36	2.76
5	CS40%	22.86	36.33	3.75	2.80
6	CS50%	19.19	31.86	2.68	2.62



**Fig 4 Compressive strength of concrete**



**Fig 5 Flexural strength of concrete**

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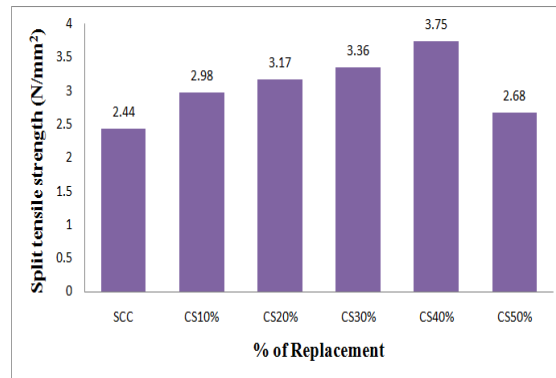


Fig 6 Split Tensile Strength of concrete

## IV. DISCUSSION

1. Workability increases with increase in copper slag content because copper slag has lower water absorption capacity when compared with fine aggregate.
2. The compressive strength, split tensile strength and flexural strength increases up to 16%, 54% and 11% respectively at 40% replacement of copper slag.
3. From the results it was observed that the strength increases up to 40% replacement of copper slag beyond which it decreases. The increase in strength is due to the high toughness of copper slag. Whereas copper slag does not possess sufficient binding property which causes the strength to decrease beyond certain limit.
4. Thus it is recommended that copper slag can be replaced up to 40%.

## V. CONCLUSION

The replacement of copper slag as fine aggregate in SCC is studied and the following conclusions have been achieved in this experimental study.

1. Up to 40% of replacement of copper slag in SCC the compressive strength, split tensile strength and flexural strength of concrete is increased.
2. The strength of concrete is increased due to the high toughness of copper slag.
3. Beyond 40% the strength decreases because there is not enough paste to coat the aggregate.

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