

Durability Studies on Self Compaction of Concrete by Using Copper Slag

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ABSTRACT: The main objective of this study was to investigate the Durability studies of self-compacting concrete (SCC) incorporating fly ash as partial cement replacement and copper slag as a replacement of fine aggregate along with the addition of super plasticizer. In the present study, durability test on cube measuring was performed in the laboratory & specimen changes to the SCC concrete cube. A small cube with different mixes of fly ash and copper slag (0%, 10% up to 50%) as partial replacement of cement and fine aggregate respectively with a water-binder ratio of 0.4% is adopted. To improve the workability of concrete, super plasticizer (glenium sky 8233) of 1% is added to the weight of cement. This replacement would prove to have some environment benefits and would be an economical (or) a cost effective technique in concreting for the future.

KEYWORDS: Copper Slag, Cement, Silica fume and Super plasticizers

I. INTRODUCTION

The concrete technology has made tremendous strides in past decade. Concrete is now no longer material consisting of cement, aggregates, water and admixtures but it is an engineered material with several new constituents. The concrete can take care of any specific requirements under most of different exposure conditions. If the development of specifying the concretes as per its performance requirements rather than the constituents and ingredients in concrete has opened innumerable opportunities for producer and user of concrete to design concrete as per specific requirements. Self Compacting Concretes (SCC) were designed initially in Japan around 1988 and since then several research papers have been published and compositions are tried out in different developed countries especially in Western Europe, Canada, Sweden and Netherlands. The Self-compacting concrete is cast so that no additional inner or outer vibration is necessary for the compaction. When it flows like "honey" and has a very smooth surface level after placing. In that regard to its composition, self-compacting concrete consists of the same components as conventionally vibrated concrete, which are cement, aggregates, and water, with the addition of chemical and mineral admixtures in different proportions. In the chemical admixtures used are high-range water reducers (super plasticizers) and viscosity-modifying agents, which change the rheological properties of concrete. The Mineral admixtures are used an extra fine material, besides cement, and in some cases, they replace cement. In this study, the cement content was partially replaced with mineral admixtures of silica fume, slag cement, fly ash admixtures that improve the flowing and strengthening characteristics of the concrete.

II. LITERATURE REVIEW

S.Sujitha et al, (2016) studies done on durability strength on High strength concrete used in industrial wastes such as Metakaoline and GGBS are varied from 5%, 10%, 15% by the weight of cement and copper slag varied from 10%, 20%, 30%, 40%, 50%, and 60% by the weight of aggregate. Mix design is done for the M30 grade concrete with 0.38 w/c. The combination of mix ratio were taken as 5%, 10%, 15% for each 10%, 20%, 30%, 40%, 50%, 60%. Totally 19 number of mix ratios were taken. Concrete cubes 150 x 150 x 150 mm sizes of 3 no's were tested and there average values were used. In the Slag replacement by weight decreases the strength of concretes in short term when compared to control Portland cement concrete. However, in long term, concrete containing slag exhibits a greater

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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final strength than that of control normal Portland cement concrete. When compared to control normal Portland cement concrete, the increase in the water-cementations material ratio decreases more the strength of concrete having particularly high percentages of slag.

Leemarose A et al, (2015) have studied to find out the performance of copper slag on strength and durability properties as partial replacement of fine aggregate in concrete. The fine aggregate is partially replaced with copper slag as a percentage varies from 10%, 20%, 30%, and 40%. It is concluded that addition of copper slag in concrete increases the density of the concrete. The increase in density results in increase of self weight of the concrete. The results of compressive strength test shows that the strength of concrete increases with respect to the percentage of copper slag added by weight of fine aggregate up to 30% of replacement. Concrete with copper slag gains more strength than the conventional concrete.

BinayaPatnaik et al, studied the strength and durability properties of copper slag admixed concrete. The sand is partially replaced by copper slag with 0% to 50%. Two different types of Concrete Grade (M20 & M30) were used with different proportions of copper slag replacement (0 to 50%) in the concrete. It is concluded that the High toughness of Copper Slag attributes to Increased Compressive strength. Due to low water absorption, coarser (in nature than sand) and glassy surface of Copper slag the workability of Concrete increased substantially with increase of Copper Slag content in the concrete mixture. Acid resistance test showed that the concrete containing copper slag has a low resistance to H₂SO₄ and HCl solution than the control concrete. It is also concluded that the Concrete with Copper slag as Partial replacement of Sand shows good resistance to sulphate attack.

ShreepadDaesai et al, (2015), in the consequences of an exploratory study on different sturdiness tests on concrete containing mineral admixtures and copper slag as fractional substitution of cement and sand individually. He recommended that up to 20% replacement of the fine aggregate by Copper Slag and 10% replacement of mineral admixture is recommended. Due to low water absorption, coarser (in nature than sand) and glassy surface of Copper slag the workability of Concrete increased substantially with increase of Copper Slag content in the concrete mixture.

Maya T M et al, (2015) studied the sustainable development in construction involves use of waste materials and by-products to replace Portland cement and aggregates. The object of the present study is to evaluate the effect of replacing cement with silica fume and fine aggregate with copper slag. In this research work M30 grade concrete is prepared and is evaluated for fresh concrete properties and hardened Concrete properties like compressive strength and flexural strength. Portland cement is replaced with silica fume at 0, 4, 8 and 12 % and fine aggregate is replaced with copper slag at 0, 10, 20, 30, 40 and 50 %. In that results show that the use of silica fume and copper slag as replacement material improves mechanical properties of the concrete. Concrete including 40 % copper slag and 8 % silica fume as replacement material shows better performance among all the mixes. If Workability of the concrete increases with increase in copper slag percentage and decreases with increase in silica fume percentage. In Workability is reduced when silica fume is added to concrete containing copper slag as fine aggregate. After replacement level of silica fume increases all the mechanical properties are increased up to 8% and up to 40% replacement level of copper slag all the mechanical properties are increased.

Srinivas et al, (2015) the researchers concluded that the workability was increase up to 31.57 for 100% replacement of copper slag as a fine aggregate. When the maximum compressive strength of concrete increases up to 8.63% for 20% replacement of fine aggregate. They also exposed that 40% of the copper slag can be replaced which is greater than the target strength.

III. MATERIALS USED

Cement: Portland Pozzolana cement 53 grade ordinary Portland cement confirming IS: 12269: 1987. Cement is a binding material in concrete. Cement is obtained by burning at a very high temperature mixture of calcareous and argillaceous materials. Cement is a well known building material and has occupied an indispensable place in construction work

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Table 3.2 Properties of Cement

S.No	Test Particulars	Values
1	Specific Gravity	3.15
2	Consistency	32
3	Initial setting(mins)	40
4	Final setting (mins)	590

Fine Aggregate: The fine aggregate used was obtained from our college campus. The fine aggregate conforming to zone III according to IS: 383-1970 was used for this study.

Table 3.3 Properties of Fine Aggregate

S.No	Particulars	Values
1	Specific Gravity	2.67
2	Grading Zone	III
3	Fineness Modulus	2.72
4	Type	River Sand
5	Total water absorption	1 %
6	Net water absorption	0.86 %

Coarse AggregateThe coarse aggregate is according to IS: 383-1970 was used. Locally available aggregate from quarries in Tirunelveli were used in this study. Single size aggregate of 20 mm size was used for the entire study.

Table 3.4 Properties of Coarse aggregate

S.No	Particulars	Values
1	Specific Gravity	2.76
2	Fineness Modulus	6.81
3	Type	Crushed
4	Water absorption	0.5 %
5	Moisture Content	Nil

Water: Water is most an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quality and quantity of water is required to be looked in to very carefully. In the suitability of water for mixing concrete is that, if water is fit for drinking it is fit for making concrete. They does not appear to be a true statement for all conditions. If some waters containing a small amount of sugar would be suitable for drinking but not for mixing concrete and conversely water suitable for making concrete may not necessarily be fit for drinking. If some specification also accept water for making concrete if the pH value of water lies between 6 and 8 and the water is free from organic matter.

Copper Slag:The copper slag is an abrasive blasting grit made of granulated slag from metal smelting processes.

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Vol. 3, Issue 1, January 2014



Super plasticizers: The super Plasticizers also known as Plasticizers, include Water reducing Admixtures. High Range Water Reducers are the admixtures that allow large water reduction or greater flow ability without substantially slowing set time or increasing air entrainment. The Glenium sky 8233 is an admixture of a new generation based on modified polycarboxylic ether. When the product has been primarily developed for applications in high-performance concrete where the highest durability and performance is required. Glenium sky 8233 consists of a carboxylic ether polymer with long side chains. In that beginning of the mixing process, it initiates the same electrostatic dispersion mechanism as the traditional super plasticisers, but the side chains linked to the polymer backbone generate a steric hindrance which this process, flow able concrete with a large reduction in the water content is obtained.

IV. METHODOLOGY

Flexural strength tests were carried out at the end of 7, 14 and 28 days for the concrete cube specimens of size 150 mm, using a Flexural Testing Machine as per IS: 516-1959. The Flexural strength results presented in the report are an average of two readings. Arriving mix proportions in collection of material and test of preparation of concrete. Workability of fresh concrete is test.

Durability tests were carried out at the end of 14 days for the concrete cube specimens of size 150 mm, using a Flexural Testing Machine.

V. EXPERIMENTAL INVESTIGATION AND RESULT ANALYSIS

Tests on Fresh Concrete

Workability tests

The workability test was conducted as per IS 6461 (Part 7)-1973, from test results were compared with other mixes.

Slump flow test

Slump flow test and T500 time is a test to assess the flow ability and the flow rate of SCC in the absence of obstructions. Its based on the slump test described in EN 1253- 2. The result is an indication of the filling capacity of SCC, and the T500 time is a measure of the speed of flow and hence viscosity. If the fresh concrete is poured into a cone to when the concrete has flowed to a diameter of 500mm is measured; this is the T500 time. Slump instrument largest diameter of the slow spread of the concrete and the diameter of the spread at right angles to it are then measured and the mean is the slump flow.

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Table 5.1 Workability test on values of Cubes

Test method	Slump flow	T500
Recommended values	650-800mm	2.5 sec
Actual value	Average flow diameter	time to flow
C	680mm	5 sec
D	685mm	4 sec
E	680mm	4 sec
F	690mm	3sec
G	695mm	3sec

Mix Design for M40 Concrete

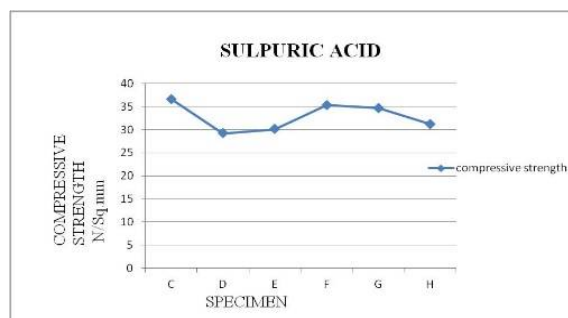
Nan - Su Method: Mixture proportioning procedures for self -compacting concrete using Nan- Su method. Mix proportions - 1: 2.87: 2.21 As per mix design proportions.

Durability Test Methods: Durability studies were conducted at 7 & 28 days for various mixes to find out the resistance to acid attack (H₂so₄), Sulphate attack and water absorption

Acid resistance: Sulphuric Acid (H₂SO₄) resistance was tested on 150 mm size cube specimens at the age of 7 & 28 days of curing. The cube specimens were weighed and immersed in water diluted with one percent by weight of sulphuric acid for 7 & 28 days.

Table 5.2 Compressive strength of the specimen

S.no	Name of the specimen	Breaking load (kg)	Stress(N/mm ²)
1	C	84000	36.63
2	D	67000	29.21
3	E	69000	30.10
4	F	81000	35.32
5	G	79000	34.67
6	H	71500	31.18



Graph 5.1 Compressive strength of the specimen

Sulphate Attack: The sulphate attack testing procedure was conducted by immersing concrete specimens of the size 150*150*150 mm over the specified initial curing in a water tank. Then, they were cured in 5% Sodium sulphate solution 7 & 28 days respectively. This type of testing represents an accelerate testing procedure, which indicates the performance of particular concrete mixes to sulphate attack on concrete. The degree of sulphate attack was evaluated by measuring the weight losses of the specimens at 28 days, respectively.

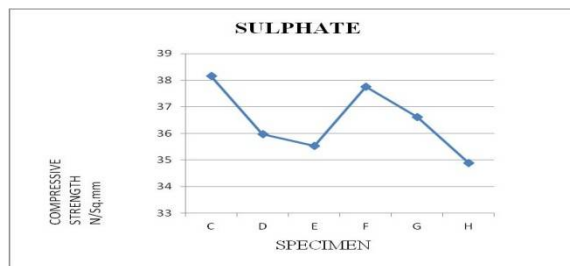
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Table 5.3 Compressive strength of the specimen

S.no	Name of the specimen	Breaking load (kg)	Stress (N/mm ²)
1	C	87500	38.15
2	D	82500	35.97
3	E	81500	35.53
4	F	86600	37.75
5	G	84000	36.62
6	H	80000	34.88

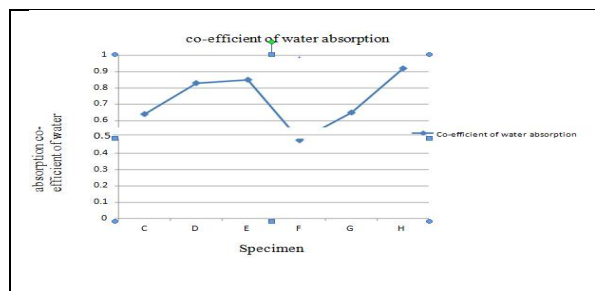


Graph 5.2 Compressive strength of the specimen

Water absorption test: Water absorption test was conducted on 150*150*150 mm cubes at the age of 28 days curing. The specimens were weighed before drying at room temperature (27±2°c). The drying process is continued, until the difference in mass between two successive measurements at a 24 hour interval closely agreed. The dry specimens were cooled at room temperature and then immersed in water. If specimens were taken out at regular intervals of time, surface dried and weighed. If difference between the saturated mass and the oven dried mass expressed as a percentage of the oven dried mass gives the saturated water absorption.

Table 5.4 Co-efficient of water absorption

S.no	Specimen	Co-efficient of water absorption
1	C	0.64
2	D	0.83
3	E	0.85
4	F	0.48
5	G	0.65
6	H	0.92



Graph 5.3 Co-efficient of water absorption

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VI. CONCLUSION

The following are the conclusions drawn from the above experimental investigation:

1. Mix design for M40 grade concrete was done by Nan-Su method for control of specimen.
 2. Various mix proportions were arrived for self compacting concrete and test for fresh concrete such as workability test and casting of specimens was carried out.
 3. Durability properties of alternate wet and dry method, Sulphuric acid test, sulphate attack resistance test, water absorption test are to be conducted.
 4. The result of compressive strength test have indicated that the strength of concrete increases with respect to the percentage of copper slag added by weight of fine aggregate up to 50%.
 5. The compressive strength of 30% copper slag specimen is 1.5 % higher than the controlled concrete and weight loss in 28 days for 1.35% in distilled water curing.
 6. The compressive strength of 30% copper slag specimen is 3.70% higher than the controlled concrete and weight loss in 28 days for 1.37% in sulfuric acid water curing.
 7. The compressive strength of 30% copper slag specimen is equal than the controlled concrete and weight loss in 28 days for 1.36% in sea water curing.
 8. The compressive strength of 30% copper slag specimen is 1.05% higher than the controlled concrete and weight loss in 28 days for 2.17 % in sulphate attack water curing.
 8. It show that the water consumed by the copper slag during mixing is very less when compare with river sand.
- In this study points out the beneficial aspects of using copper slag as a best replacement material of fine aggregate.

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