ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization Volume 3, Special Issue 5, July 2014

International Conference On Innovations & Advances In Science, Engineering And Technology [IC - IASET 2014]

Organized by

Toc H Institute of Science & Technology, Arakunnam, Kerala, India during 16th - 18th July -2014

Effect of Copper Slag, Fly Ash and Granite Power as a Partial Replacement in Fine Aggregate

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ABSTRACT: The demand for sand is the major problem for conventional construction recently. We need a best alternate construction material to fulfill the sand demand. In this paper we presents the results of an experimental investigation carried out to evaluate the mechanical properties of concrete mixtures in which fine aggregate (sand) was partially replaced with fly ash, copper slag and granite powder using M_{30} grade concrete. Fine aggregate (sand) was replaced with four different percentages (0%, 25%, 50% and 75%) of fly ash, copper slag and granite powder by weight. Tests were performed for properties of fresh concrete. Compressive strength, split tensile strength were determined at 7, 14 and 28days. Test results indicate significant improvement in the strength properties of plain concrete by the inclusion of above mentioned industrial waste as partial replacement of fine aggregate (sand) and it can be effectively used in structural concrete. Concrete is an artificial conglomerate stone made essentially of Portland cement, water, sand and coarse aggregates. The mixture of the materials results in a chemical reaction called hydration and a change in the mixture from plastic to a solid state. The worldwide consumption of sand as fine aggregate in concrete production is very high, and several developing countries have encountered some strain in the supply of natural sand in order to meet the increasing needs of infrastructural development in recent years. A situation that is responsible for increase in the price of sand, and the cost of concrete.

KEYWORDS: Copper slag, Fly Ash, Granite powder, Compressive strength, Split tensile strength

I. INTRODUCTION

Concrete is the widely used structural material in the world today. The demand to make this material lighter has been the subject of study that has challenged scientists and engineers alike. The challenge in making a lightweight concrete is decreasing the density while maintaining strength and without adversely affecting cost. Introducing new aggregates into the mix design is a common way to lower a concrete's density. Normal concrete contains four components, cement, crushed stone, river sand and water. The crushed stone and sand are the components that are usually replaced with lightweight aggregates.

The use of alternative both fine and coarse aggregate has become necessity for the construction industry because of the economic, environmental and technological benefits derived from their use. In developing countries where abundant agricultural and industrial wastes are discharged, these wastes can be used as potential material or replacement material in the construction industry. This will have the good advantage of reduction in the cost of construction material.

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Fine aggregate (sand) was replaced with four different percentages (0%, 25%, 50% and 75%) of fly ash, copper slag and granite powder by weight. Tests were performed for properties of fresh concrete. Compressive strength, split tensile strength were determined at 7, 14 and 28days. Test results indicate significant improvement in the strength properties of plain concrete by the inclusion of above mentioned industrial waste as partial replacement of fine aggregate (sand) and it can be effectively used in structural concrete.

II MATERIALS USED

Ordinary Pozzolana cement (OPC) 43grade conforming to IS 12269:1987 and ASTM type 1 specifications was used. Natural river sand owing to their rounded shape was used in this work to ensure a better packing characteristic than that of the crushed sand. The grading of sand satisfied the IS: 383:1970. Fly Ash (FA) was taken from Tuticorin Thermal Power Plant and its chemical composition is given in Table 1. Copper Slag (CS) used in this work was brought from Sterlite Industries Ltd (SIL), Tuticorin and its chemical composition is given in Table 2. Granite Powder (GP) is a commercially available material, collected from K.R Traders, Madurai and its chemical composition is given in the Table 3. Crushed 20-mm (maximum) graded quartzite aggregate was used as coarse aggregate. The overall grading requirement of coarse aggregate satisfied ASTM C 33-03 and IS: 383:1970. The specific gravity of materials used in the mix is given in Table 4.

Table 1: Composition of Fly Ash

Constituents	Composition wt%
SiO_2	59.02
Al_2O_3	38.02
MgO	0.28
Na_2O	0.47
KO	0.22
CaO	0.94

Table 2: Composition of Copper Slag

Constituents	Composition wt%
Al_2O_3	3.01
Tio_2	0.60
Fe_2o_3	55.0
SiO_2	35.0
CaO	0.20
MgO	0.90
K_2O	1.02
Na_2O	0.95
CU	0.42

Table 3: Composition of Granite Powder

Constituents	Composition wt%
Al_2O_3	14.42
Tio_2	0.30
Fe_2o_3	1.22

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SiO_2	72.04
CaO	1.82
MgO	0.71
K_2O	4.12
Na_2O	3.69
FeO	1.68
MnO	0.12
P_2O_5	0.05

Table 4: Specific gravity of materials used

Materials	Specific Gravity
Cement	3.15
Fly Ash	2.60
Copper Slag	3.51
Granite Powder	2.10
Fine Aggregate	2.65
Coarse Aggregate	2.90

III.EXPERIMENTAL PROGRAMME

A. Design Mix

Normal strength concrete of grade M30 is used for this study. The water cement ratio of 0.42 is used. The cement with coarse aggregate to fine aggregate ratio used is 1:1.87:3.5. The quantity of materials used is given in Table 5. The mix design was prepared based on the guidelines of IS: 10262(1982).

B. Casting and Curing of specimens

Nine cubes each of size 150mm x150mm x 150mm are prepared and tested at an age of 7,14 and 28 days. The concrete mix was designed as per code IS 10262(1982). The constituents materials are weigh batched. The specimens are cast in steel moulds. The specimens are demoulded on the next day. The specimens are cured by immersing in water. Specimens were tested for age of 7, 14 and 28 days. Nine specimens are tested on each day using compression testing machine and tensile testing machine. The compressive strength and tensile strength is determined and reported in this paper.

Table 5: Mix used in this study

Specimen	Materials					
	Cement	FA	CA	Ash	Slag	Granite
CCGF0	100%	100%	100%	-	-	-
CCGF 25	100%	75%	100%	8.33%	8.33%	33%
CCGF 50	100%	50%	100%	16.67%	16.67%	16.67%
CCGF 75	100%	25%	100%	25%	25%	25%

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C. Design Mix

The test data is given in Table 6, 7. The test results are also given in Fig 1, 2.

Table 6: Compressive strength of specimens

Curing days	Average Compressive strength N/mm^2			
	CCGF0	CCGF25	CCGF50	CCGF75
7 days	20	22.7	28.30	29.5
14 days	26	27.9	28.8	31.65
28 days	33	28.8	30.7	51.8

Table 7: Split Tensile strength of specimens

Curing days	Average Split tensile strength N/mm^2			
	CCGF0	CCGF25	CCGF50	CCGF75
7 days	1.17	2.80	1.50	2.8
14 days	1.50	2.50	1.80	2.42
28 days	1.70	2.6	1.90	3

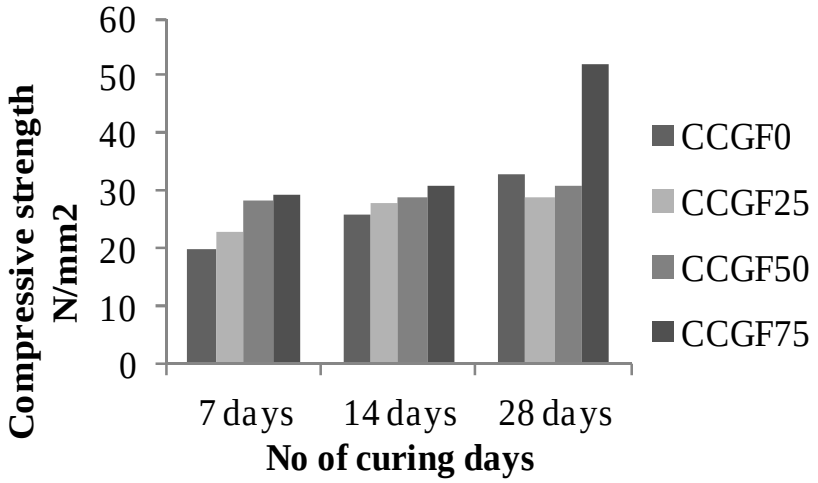

Fig 1: Comparison of Compressive strength with different ages

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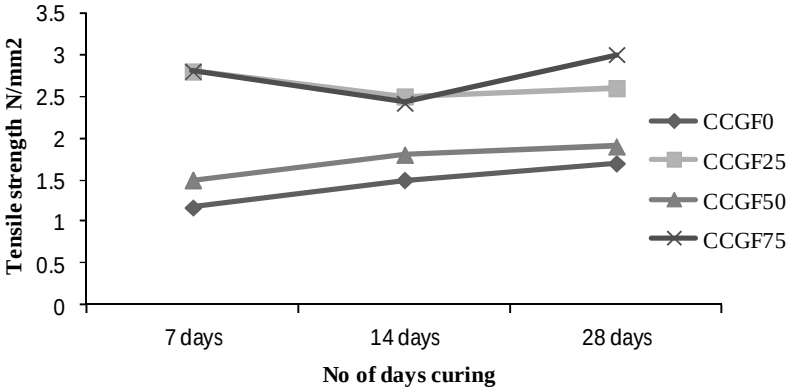

*D. **Results and Discussion***

The test results are given in Table 6 and 7. As a result the compression strength attains with the 75% replacement of cement with Fly Ash, Copper slag, Granite powder is found to be greater strength compared to all other mixes. While considering tensile strength, CCGF25 decreases by days of curing. At the replacement of FA, CCGF0 and CCGF50 increase by days of curing. At the replacement of FA, CCGF75 decrease and then suddenly increases with days of curing.

IV. CONCLUSION

The strength of concrete is determined by the properties of Copper slag, Granite powder, Fly ash and percentage replacement. From the experimental results and discussion, the combination of CCGF has a potential of High strength in concrete. The combination of CCGF can reduce the material cost so that construction cost becomes low and abundant industrial waste. Sustainable in nature prevents the industrial wastes for environment degradation. The compressive strength of various mixes of Copper slag, Granite powder, and Fly ash fiber in concrete at 28days will be 51.8 N/mm ^{2}.

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