International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Email:editorijoer@gmail.com http://www.ijoer.in

Vol.4., Issue.2., 2016
(Mar-Apr)

RESEARCH ARTICLE

ISSN: 2321-7758

EXPERIMENTAL INVESTIGATION ON COPPER SLAG CONCRETE

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ABSTRACT

In this present study the experimental investigation are carried out to evaluate the strength characteristics of concrete by replacing the copper slag with river sand. Copper slag is one of the industrial waste material. They are used in secondary material in construction industry. For this research work, M35 grade concrete was used. The test were conducted for various proportions of copper slag replacement with river sand of 10%,20%,30%,40% in concrete. The result for control concrete compared with copper slag concrete, the strength is increased upto 40% replacement of copper slag.

Keywords: Copper Slag, Ordinary Portland Cement, Compressive Strength, Split Tensile Strength, Flexural Strength.

I. INTRODUCTION

Now a day, to face great demand of fine aggregates from civil engineering industry. For many years by-products such as fly ash, silica fume, rice husk and slag were considered as waste materials. Copper slag is used to partially replacement in fine aggregate. They have been successfully used in construction industry and road construction. So researchers developed waste material to apply for fine aggregate partially or fully replacement in concrete.

Copper slag is widely used in the sand blasting industry and it has been used in the manufacture of abrasive tools. It is by-product created during the copper smelting and refining process. As refineries draw metal out of copper ore, they produce a large volume of non-metallic dust, soot and rock. Collectively, these materials make up slag, which can be used for a surprising number applications in the building and industrial fields.2600 tons of copper slag is produced per day and a total accumulation 1.5 million tons. To produce every ton of copper, approximately 2.2-3.0 tons copper slag is generated as a by-product material. Several researches have investigated the possible to use of copper slag as fine aggregate.

One of the primary advantages to copper slag is the low risk it poses to health and the environment. Silica sand, which represents the most popular blasting medium and concrete fine currently in use, poses serious health risks when inhaled. It may also contribute to pollution and other environmental concerns. Copper slag also has a high strength-to-weight ratio, making it an effective option in concrete, or as a fill material under the roadway. When added to concrete, it makes the paved surface less porous, which minimizes problems with moisture and freezing. It also makes concrete more fire resistant, and helps to slow the spread of heat and flames.

II. LITERATURE REVIEW

Brindha et al (2011) studied the utilization of copper slag for the production of cement and concrete. Many researchers have already found it possible to use copper slag as a concrete aggregate. They studied the effect of copper slag on durability properties of the concrete. M20 grade concrete was used and tests were conducted for various proportions of copper slag replacement with sand of 0 to 60%, cement of 0 to 20% in concrete. The results shows that the compressive, split tensile strength increases with respect to the percentage of copper slag added by weight of fine aggregate upto 40% of additions and 15% of cement. R RChavan& D B Kulkarni (2013) This paper reports on an experimental program to investigate the effect of using copper slag as a replacement of fine aggregate on the strength properties. Copper slag is the waste material of matte smelting and refining of copper such that each ton of copper generates approximately 2.5 tons of copper slag. Copper slag is one of the materials that is considered asa waste which could have a promising future in construction Industry as partial or full substitute of aggregates. For this research work, M25 grade concrete was used and tests were conducted for various proportions of copper slag replacement with sand of 0 to 100% in concrete. The obtained results were compared with those of control concrete made with ordinary Portland cement and sand. Binaya Patnaik **(2015)** An experiment was conducted to investigate the strength and durability properties of concrete having copper slag as a partial replacement of sand (fine aggregate) and results have been presented in this paper. Two different types of Concrete Grade (M20 & M30) were used with different proportions of copper slag replacement (0 to 50%) in the concrete. Strength & Durability properties such as Compressive Strength, Split Tensile Strength, Flexural Strength, Acid Resistivity and Sulphate Resistivity were evaluated for both mixes of concrete. Test results shows that the strength properties of concrete has improved having copper slag as a partial replacement of Sand (upto 40%) in concrete however in terms of durability the concrete found to be low resistant to acid attack and higher resistance against Sulphate attack.

III. MATERIAL PROPERTIES

a) CEMENT

Cement is a binder, a substance that sets, hardens and binds other materials together. Though all cement conforming to various IS code are suitable, selection of cement should be based on their compressive strength, fineness and compatibility with other ingredients. Ordinary Portland Cement 53 grade was used. This cement is mostly used in construction industry. Ordinary Portland Cement (OPC) 53 grade cement confirming to IS 269: 2013 was used. The property was given below in Table 1.

Table 1-Properties of Cement

Sl.No	Descriptions	OPC
1.	Fineness	3%
2.	Specific Gravity	3.15
3.	Normal Consistency	26%

b) FINE AGGREGATE

The aggregate size is lesser than 4.75mm is considered. It conforms to IS 383:1970 comes under zone II.Sand is an extremely needful material for the construction but this important material must be purchased with all care and vigilance.The Property was given below in Table 2.

Table 2-Properties of Fine Aggregate

Sl.No	Descriptions	OPC
1.	Fineness Modulus	2.56
2.	Specific Gravity	2.62
3.	Bulking of Sand	11.9%

c) COARSE AGGREGATE

The Coarse aggregate size is bigger than 4.75mm is considered.The granular materials chemically inert such as natural sand, gravels, crushed stones or air-cooled iron blast furnace slag are called aggregate. It avoids cracking and gives more strength to concrete. The Property was given below in Table 3.

Table 3-Properties of Coarse Aggregate

Sl.No	Descriptions	OPC
1.	Fineness Modulus	2.29
2.	Specific Gravity	2.67
3.	Water Absorption	0.5%

d) COPPER SLAG

Copper slag from Sterlite Industries India Limited (SIIL), Tuticorin, Tamil Nadu, India. The property was given below in Table 4.

Table 4-Propeties of Copper Slag

Sl.No	Descriptions	OPC
1.	Fineness Modulus	3.03
2.	Specific Gravity	3.58
3.	Particle Shape	Irregular
4.	Appearance	Black & Glassy

IV. MIX DESIGN AND SAMPLE PREPARATION

Concrete mixtures with different proportions of Copper Slag used as a partial replacement for fine aggregate. Investigate the Copper Slag is substitution on the strength normal concrete. Concrete mixtures were prepared with different proportions of Copper Slag. The proportion of copper slag added to concrete mixtures was as follow: 0%, 10%,20%,30%,and 40%. The control concrete was designedto have target 28 days compressive strength of 37.62N/mm^2. The water to binder ratio of 0.43. The mix design was given below in Table5.

Table 5-Mix Proportion (kg/m^3) and mix ratio

Cement	Fine Aggregate	Coarse Aggregate	Water
400	662	1120	172
1	1.6	2.8	0.43

a) Test Specimen & Curing days

Compressive strength test were conducted to evaluate the strength development of concrete mix containing copper slag at the age of 7, 28, 60 days respectively. The cylindrical specimens were also cast for finding the split tensile strength at 7, 28, 60 days and prism specimens also finding the flexural strength at 7, 28, 60 days for each mix specification following the standard test procedure.

V. EXPERIMENTAL PROCEDURE

a) Compressive Strength

3000KN capacity compressive testing machine was used to measure the compressive strength of concrete. The specimens size 150mmX150mmX150mm was used. Totally 45 concrete cubes were casted and it is allowed for 7,28, and 60days curing. The specimen were submerged in clean fresh water in a curing tank and kept there until they have been tested.

b) Split Tensile Strength

1000KN capacity Universal Testing Machine was used to measure the Split Tensile Strength of Concrete. Specimen size 100mmX200mm was used. The cylindrical specimens were tested for the split tensile strength at an age of 7, 28 and 60 days. The specimens were submerged in clean fresh water in a curing tank and kept there until taken out just prior to test. The dimensions of the specimen and their weight were recorded before testing. Three specimens were tested for each percentage and average of three was taken.

c) Flexural Strength

25Kg capacity Flexural Testing Machine was used. Specimen size 100mmX100mmX500mm. Totally 45 concrete prism was casted and it's allowed for 7,28, and 60days curing. The specimens were submerged in clean fresh water in curing tank and kept there until taken out just prior to test. The dimensions of the specimens and their weight were recorded before testing. Three specimens were tested for each percentage and average of three was taken.

VI. DISCUSSION OF RESULTS

a) Compressive Strength of Cubes

The maximum load applied to the specimen was recorded and any usual appearance in the type of failure was noted. The compressive strength of the specimen was calculated by using the formula. According to IS 9013: 1978, methods of test for strength of concrete, the compressive strength were determined.

$$F = P/A$$

Where, F = Compressive strength in Mega-Pascal
P = Load at which the specimen fails in Newton
A = Area over which the load is applied in mm^2.

From the fig 1.0 it can be observed that by partially replacing sand with copper slag up to 40%, the compressive strength of concrete increased. For M35 Grade mix concrete was used. The Compressive strength were compared with control concrete. Compare the strength in 40% replacement of copper slag at 7, 28, and 60 days. 34.22N/mm^2, 45.63N/mm^2 and 48.22N/mm^2, compared with 25.48N/mm^2, 37.62N/mm^2 and 42.44N/mm^2.

Copper slag has a lower water absorption capacity when compared with sand.

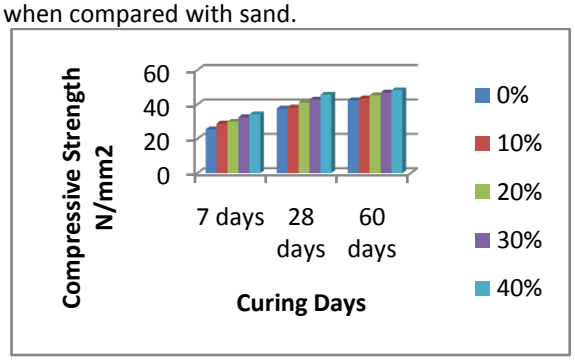

Fig 1.0 Compressive strengths for 7, 28, and 60 days

b) Split Tensile Strength Testing

The size of the specimen is 100mm diameter and 200mm height. The load was applied without shock and increased continuously until the resistance of the specimen to the increasing load broke down and no greater load can be sustained. The maximum load applied was then recorded. Any unusual type of failure was noted. According to IS 516:1959; method of splitting tensile strength of concrete specimen was determined.

Tensile strength = $2P/\pi DL$

Where, P = Load on the cylinder in Kilo-Newton

D = Diameter of the cylinder in mm

L = Length of the cylinder in mm.

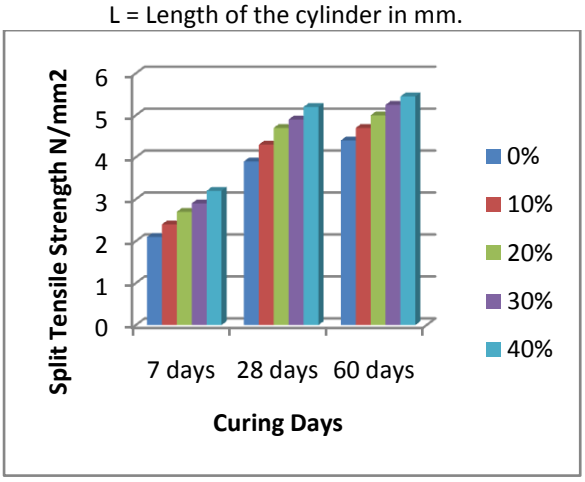

Fig 2.0 Split Tensile Strengths for 7, 28, and 60 days

From the fig 2.0 show in Split Tensile Strength for 7, 28, and 60 days.For M35 Grade concrete the 7, 28, and 60 days split tensile strength were 3.2N/mm^2, 5.2N/mm^2, and 5.45N/mm^2 compared with 2.1N/mm^2, 3.9N/mm^2, and 4.4N/mm^2 for the concrete mixture. There is 33% increase in the strength of replacement copper slag at 28 days. However, mixture with partial replacement of copper slag gave the highest strength.

c) FLEXURAL STRENGTH

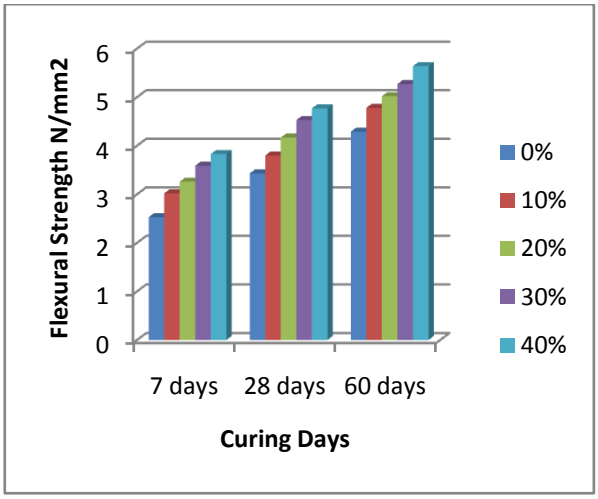

Fig 3.0 Flexural Strengths for 7, 28, and 60 days

From the fig 3.0 show in Flexural Strength for 7, 28, and 60 days. For M35 Grade concrete the 7, 28, and 60 days flexural strength were 3.83N/mm^2, 4.77N/mm^2, and 5.64N/mm^2 compared with 2.53N/mm^2, 3.43N/mm^2, and 4.29N/mm^2 for the concrete mixture. There is 39% increase in the strength of replacement copper slag at 28 days. However, mixture with 40% replacement of copper slag gave the highest strength.

VII. CONCLUSION

The utilisation of copper slag in concrete provides additional environmental as well as technical benefits for all related industries. Partial replacement of copper slag in fine aggregate and cement reduces the cost of making concrete. The workability of concrete increases significantly with the increase of copper slag content in concrete mixes. This was attributed to the low water absorption and glassy surface of copper slag.The initial and final setting time of copper slag admixed concrete is higher than control concrete. The results of compressive, split tensile, Flexural strength test have indicated that the strength of concrete increases with respect to the percentage of copper slag added by the weight of fine aggregate up to 40% (CS40). Further additions of copper slag caused reduction in strength due to an increase of free water content in the mix.

REFERANCE

[1]. Brindha, D,Baskaran.Tand Nagan, S. "Assessment of Corrosion and Durability copper slag admixed concrete", Internationl Journal of Civil and Structural Engineering, Vol. 1, No.2, ISSN 0976-4399, 2010.

[2]. R RChavan& D B Kulkarni." Performance of Copper Slag on Strength Properties as Partial Replacement of Fine Aggregate in Concrete Mix Design" E-ISSN2249-8974, july-sep., 2013/95-98.

[3]. BinayaPatnaik, SeshadriSekhar. T, SrinivasaRao. " Strength and Durability Properties of Copper Slag Admixed Concrete" Vol:04 Issue:01, eISSN:2319-1163| pISSN:2321-7308, 2015.

[4]. Wei wu, Zhang.w, and Ma.G, "optimum content of copper slag as fine aggregate in high strength concrete", Material Design, vol.31, No.6, pp.2878-2883, 2010.

[5]. Sioulas, Z.B. and Sanjayan, J.G. "Hydration temperatures in large high-strength concrete columns incorporating slag", journal of cement and concrete research, Vol.30, No.11, pp.1791-1799, 2000.

[6]. Lima, "copper slag waste as a supplementary cementing material to concrete", J.Mater. Sci., vol.42, pp.2226-2230, 2007.

[7]. Indian Standard code of practice for recommended guidelines for concretemix design, IS: 10262-1982 (Reaffirmed 2004). Bureau of IS, New Delhi.

[8]. IS 12269: 2013, Ordinary Portland cement 53 Grade — Specification.

[9]. IS: 2386 (Part I) – 1963, Methods of Test for Aggregates for Concrete, Part I Particle Size and Shape.

[10]. IS: 2386 (Part II)-1963, Methods of Test for Aggregates for Concrete, Part II Estimation of Deleterious Materials and Organic Impurities.

[11]. IS:2386 (Part IV)-1963, Methods Of Test For Aggregates For Concrete, Part IV Mechanical Properties

[12]. IS: 2386 (Part III) – 1963, Methods of Test for Aggregates for Concrete, Part III Specific Gravity, Density, Voids, Absorption and Bulking.

[13]. IS. 456: 2000, Plain and Reinforced Concrete Code of Practice.