"Study on Properties of Concrete For Partial Replacement of Fine Aggregate (Sand) Bycopper Slag"

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Abstract- *Copper slag is a by-product obtained during matte smelting and refining of copper. The common management options for copper slag are recycling, recovering of metal, production of value added products such as abrasive tools, abrasive, tiles, roofing granules, cutting tools, glass, road-base construction, asphalt pavements, railroad ballast,. Despite increasing rate of reusing copper slag, the large amount obits annual production is disposed in dumps or stockpiles to date. One of the greatest potential applications for reusing copper slag is in cement and concrete production. Many researchers have investigated the use of copper slag in the production of cement, mortar and concrete as raw materials for clinker, cement replacement, coarse and fine aggregates. In this work, the concrete grade M-40 is selected and I.S.10262-2009 has been used for concrete mix design purpose. The various strength of concrete like compressive, flexural and split tensile test for various replacements of fine aggregate using copper slag that are 0%,15%, 30%, 45%, and 60%. All specimens cured for 7 days and 28 days. the analysis of experimental data showed that the 45% replacement is possible. By using the copper slag in construction field, the chance of getting pollution due to copper slag will be reduced and it will be the cost effective method for any construction industry. in the present study with certain degree of variability has been incorporated by referring previous researchers and investigators.*

Keywords- Copper slag, compression strength, flexural Strength, split tensile

I. INTRODUCTION

BACKGROUND OF COPPER SLAG :-Sterlite Industries India Limited (SIIL), Tuticorin, Tamil Nadu is the principal subsidiary of Vedantha Resources public limited company (PLC), a diversified and integrated FTSE 100 metals and mining company, with principal operations located in India and Australia.The annual turnover of SIIL, Tutucorin, India is Rs.13, 452 cores. SIIL, a leading producer of copper in India, pioneered the manufacturing of continuous cast copper roads and established India's largest copper smelting and refining plant for production of world class refined copper. SIIL is the producer of copper slag (Figure 1.1) during the manufacture of copper metal. Presently, about 2500 tons of copper slag is produced per day and a total accumulation of around 1.5 million tons.

ADVANTAGES OF COPPER SLAG:-

i. Reduces the construction cost due to saving in material cost.
ii. Reduces the heat of hydration.
iii. Refinement of pore pressure.
iv. Reduces permeability.
v. Reduces the demand for primary natural resources.
vi. Reduces the environmental impact due to quarrying and aggregate mining.
vii. Copper Slag has similar properties as river sand as it contains silica (SiO2) similar to sand.

OBJECTIVE OF WORK :-

a. To study the property of fresh concrete.
b. To study The Compressive strength, flexural strength, tensile strength of concrete by replacing fine aggregate with copper slag
c. Cost analysis of concrete with copper slag will be studied.

II. LITERATURE REVIEW

Al-Jabri (2009) investigated the "effect of using copper slag as a replacement of sand on the properties of high performance concrete (HPC)". Eight concrete mixtures were prepared with different proportions of copper slag ranging from 0% (for the control mix) to 100%. Concrete mixes were evaluated for workability, density, compressive strength, tensile strength, flexural strength and durability The results also demonstrated that the surface water absorption decreased as copper slag quantity increases up to 40% replacement; beyond that level of replacement, the absorption rate increases rapidly.

Al-Jabri et al (2011) investigated the "effect of using copper slag as a fine aggregate" on the properties of cement mortars and concrete. Various mortar and concrete mixtures were prepared with different proportions of copper slag ranging from 0% (for the control mixture) to 100% as fine aggregates replacement. Cement mortar mixtures were evaluated for compressive strength, whereas concrete mixtures were evaluated for workability, density, compressive strength, tensile strength, flexural strength and durability. The results obtained for cement mortars revealed that all mixtures with different copper slag proportions yielded comparable or higher compressive strength than that of the control mixture. The resultsdemonstrated that surface water absorption decreased as copper slag content increases up to 50% replacement. Beyond that, the absorption rate increased rapidly and the percentage volume of the permeable voids was comparable to the control mixture. Therefore, it was recommended that upto 40–50% (by weight of sand) of copper slag can be used as a replacement for fine aggregates in order to obtain a concrete with good strength and durability requirements.

Mostafa Khanzadi and Ali Behnood (2009) presented the results of a study undertaken to investigate the feasibility of using copper slag as coarse aggregates in high-strength concrete. The percentages of the cement replacements by silica fume were 0%, 6% and 10%. The use of copper slag aggregate compared to limestone aggregate resulted in a 28-day compressive strength increase of about 10–15% and a splitting tensile strength increase of 10–18%. It can be concluded from the results of this study that using copper slag as coarse aggregate in high-strength concrete is technically possible and useful.

Zerdi conduct an "Experimental Investigation on Properties of Concrete by Replacement Copper Slag for Fine Aggregate". The fine aggregates were replaced with percentages 0% (for the control mix), 20%, 40%, and 60% of Copper Slag by weight. Tests were performed for properties of fresh concrete and Hardened Concrete. Compressive strength was determined at 3, 7,14 and 28 days. Improvement in the strength properties of plain concrete by the inclusion of up to 40% Copper slag as replacement of fine aggregate was observed as 25.58 N/mm2at 28 days for M20 concrete.

Madhavi, Pavan Kumar & Jothilingam studied on "Effect of Copper Slag on the Mechanical Strengths of Concrete". Experimental investigations are carried out replacing the sand with copper slag in proportions of 10%, 20%, 30%, 40%, 50%, 60% and 100% keeping all other ingredients constant. It was seen that the optimum content of copper slag is 40% beyond which the strength starts.

III. METHODOLOGY

COLLECTION OF MATERIAL:-

Cement :-Cement- Ordinary Portland cement of 53 grade conforming to Indian Standard IS 12269-1987 9 was used throughout the experimental program.

Fine Aggregate :-(NATURAL RIVER FINE AGGREGATE): Locally available river sand having density of 1600 kg/m^3 and fineness Modulus (FM) of 2.45 is used. The specific gravity was found to be 2.70 as per IS 383:1970

Copper Slag :- Copper slag is an irregular, black, glassy and granularin nature and its properties are similar to the river sand. In this project,Copper slag used is brought from Sterile Industries India Ltd, Tuticorin.Every ton of copper will generate approximately 2.2-3 tons of copperslag . Sterlite Industries India Ltd produces 400,000t/year of copperand during the process, around 800,000t of copper slag is generated in ayear. The chemical traces such as copper, sulphate and alumina presentin the slag are not harmful

Coarse Aggregate:-Crushed hard basalt chips of maximum size 20 mm were used in the concrete mixes. The bulk density of aggregate was 1545 kg/m3 and specific gravity was found to be 2.74

Water:-Potable water conforming to IS 456-2011 was used for casting and curing.

LABORATORY TEST ON COURSE AGGREGATE:-

In a concrete, aggregates constitute of about 70 to 75% of the total mass of the concrete. The strength of concrete depends on the strength of three things; Strength of the cement paste, Strength of the bulk of aggregates and Strength of the bond between cement paste and aggregate. Therefore it is required to evaluate the mechanical, physical and chemical properties of the aggregate, before using them in concrete. The BIS has recommended the IS: 2386-1963 to refer for the determination of various properties of aggregates. Following are the test on aggregates which are required to be conducted to determine properties of aggregate.

i. Aggregate Crushing Value Test IS: 2386 (Part IV)-1963
ii. Aggregate Impact Value Test IS: 2386 (Part IV)-1963
iii. Specific Gravity Determination IS: 2386 (Part III)-1963
iv. Test for bulk Density IS: 2386 (Part III)-1963

v. Grading of Aggregate IS: 2386 (Part I)-1963

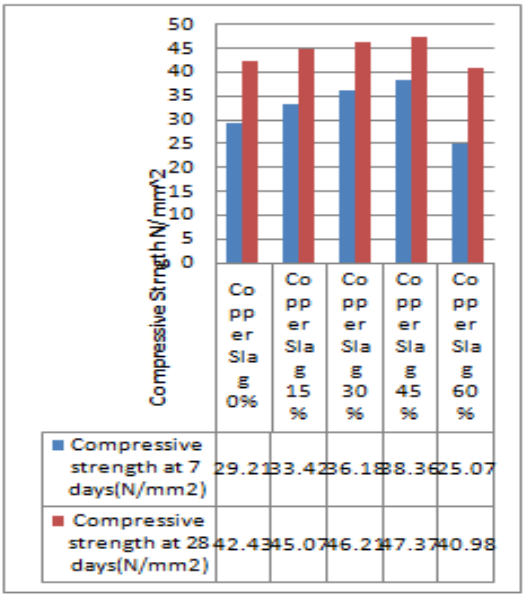
IV. EXPERIMENTAL RESULT AND ANALYSIS

CASTING OF SPECIMEN :-

Mixdesign of concrete for grade M-40 was done the concrete is prepared for the use of different percentage of copper slag in concrete all the material required for preparing the concrete weight as per required proportions. First of all the ingredients were mixed in dry state, then water is added to in accordance to the design proportion.Concrete is done in the standard mould in three layers each layers is compacted at list 25 times while they were vibrate over the table vibrate for two minutes thereafter, moulds were kept over a level surface in damp environment for 24 hours. After 24 hrs, the specimen were removed from the mould and immersed in clean water for period of 7 and 28 days.

Table : Details of specimen used in the study

Sr. no	Mix	No. of Cube to be tested after 7 days	No. of Cube to be tested after 28days	No. of Cylinder to be tested after 7 days	No. of Cylinder to be tested after 28 days	No. of Beam to be tested after 7 days	No. of Beam tobe tested after 28 days
i.	CS 0%	3	3	3	3	3	3
ii.	CS 15%	3	3	3	3	3	3
iii.	CS 30%	3	3	3	3	3	3
iv.	CS 45%	3	3	3	3	3	3
v.	CS 60%	3	3	3	3	3	3
Total	15	15	15	15	15	15	15



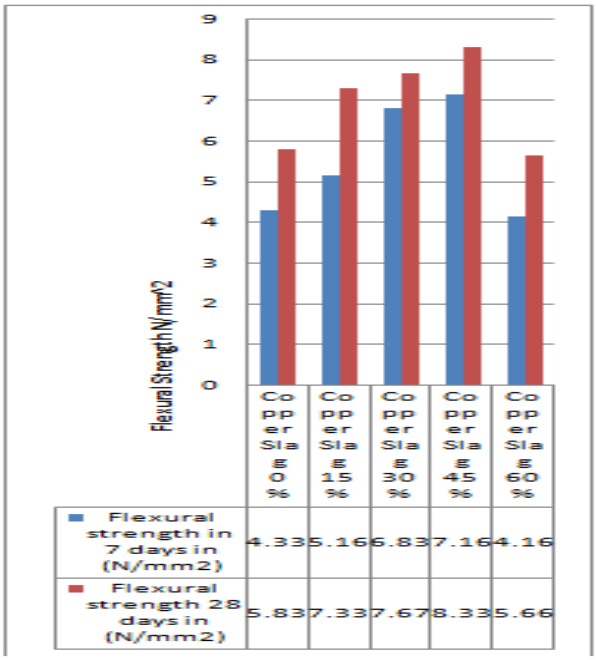


Fig 1- Comparison of flexural strength at 7 days and 28 days for 0% to 60% in N/mm^2

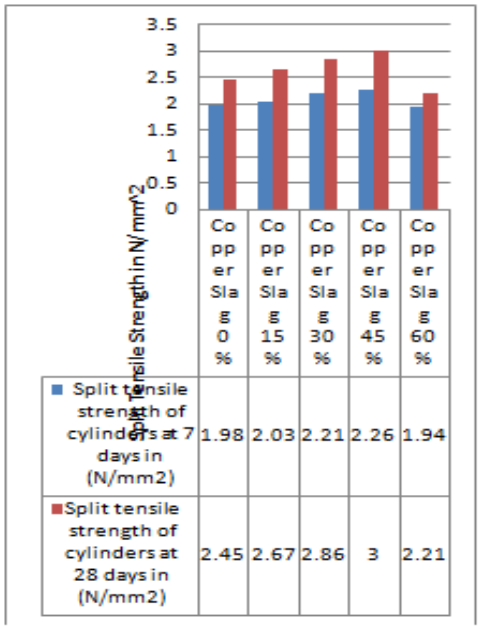


Fig.2 -Comparison of spilt tensile strength at 7 days and 28 days for 0% to 60% in N/mm^2

COST COMPARISON :-

Table. Cost comparison for $1m^3$Quantity of Concrete with Copper slag

Sr. No	Material	Rate	Unit	C S 0 %		C S 45 %	
				Quantity in Kg	Amount	Quantity in Kg	Amount
1	Cement	6	Kg	394	2364	394	2364
2	Fine aggregate	2	Kg	736	1472	405	810
3	Course aggregate	0.76	Kg	1218	926	1218	926
4	Copper Slag	0.55	Kg	0	0	331	182
Total Cost				4762		4282	
Percentage Difference				11%			

It has been seen that there is a saving of 11% of money if sand is replace by copper slag. The saving would be more if the sand availability is at greater distance. This also reduces the burden of dumping copper slag on earth which is eco friendly.

V. CONCLUSION

In this report experimental results are presented to evaluate the feasibility of partial replacement of fine aggregate by using copper slag in concrete. such as 0%, 15%, 30%, 45%,60% By using M40 grade of concrete. In this study compressive test, split tensile test & flexural strength test were done on concrete with varying percentages replacement of fine aggregate by using copper slag in concrete.

The following conclusions have been drawn.

1. The workability of concrete increased with the increase in copper slag content of replacement of fine aggregate at same w/c ratio.
2. The experiment study shown the result of compressive strength of concrete specimens higher value At 45% replacement of fine aggregate using copper slag.
3. The split tensile strength of hardened concrete increases marginally till 45% replacement of sand by copper slag
4. It is observed that up to 45% replacement of natural sand by copper slag, the flexural strength of concrete is increased. So it is recommended that 45% of fine aggregate can be replaced by copper slag.
5. Use of copper slag as partial replacement of FA can reduces the cost of construction .For 45% replacement of copper slag, saving in cost is 11%
6. The aim of project to promote usability of copper slag to substitute natural fine aggregate in building construction, road construction in cement concrete, concrete beam, column, slab and concrete wall in canal.

REFERENCES

[1] Ali Behnood, " Utilization of Copper Slag as aggregates in High Strength Concrete" Proceedings of the International Conference on Advances in concrete and construction, ICACC-2004, 16-18 Decemnber,2004, Hyderabad, India, pp 583-590.

[2] Antonio M. Arino and Barzin Mobasher, Effect of ground copper slag on strength and toughness of cementitious mixes, ACI Material Journal, 1999, TitleNo.96-M10.

[3] Arivalagan.S, "Experimental Study on the Flexural Behavior of Reinforced Concrete Beams as Replacement of Copper Slag as Fine Aggregate", Journal Of Civil Engineering And Urbanism Volume 3,2013.

[4] Brindha D, Baskaran T, Nagan S, "Assessment of corrosion and Durability Characteristics of Copper Slag Admixed Concrete", International Journal of civil and structural Engineering volume 1, No.2, 2010.

[5] Brindha.D and Nagan.S, Durability studies on copper slag admixed concrete, Asian journal of civil engineering (Building and Housing) VOL. 12, NO. 5, 2011, pp. 563-578

[6] Mobasher.B.M, and Devaguptapu .R , Arino A.M, "Effect of copper slag on the hydration of blended cementitious mixtures", Proceedings, ASCE, Materials

[7] Al-Jabri KS, Hisada M, Al-Saidy AH, Al-Oraimi SK (2009) Performance of High Strength Concrete made with

Copper Slag as a Fine Aggregate. Construction and Building Materials 23: 2132-2140.

[8] Santhakumar AR (2006) Concrete Technology. Oxford University Press, Engineering and Computer Science.

[9] Shetty MS (2006) Concrete Technology Theory and Practice. S Chand & company ltd, India.

[10] Brindha D, Baskaran T, Nagan S (2010) Assessment of Corrosion and Durability Characteristics of Copper Slag Admixed Concrete. International Journal of Civil and Structural Engineering 1: pp. 192-211.

[11] Saha, P. Use of copper slag as sustainable aggregate. ASCE India Section, Oct 17 – 18, 2014, Hitex, Hyderabad, Telangana, India, 2014.

[12] Chavan, R.R.and Kulkarni, D.B. Performance of copper slag on strength properties as partial replace of fine aggregate in concrete mix design. International Journal of Advanced Engineering Research and Studies. 95-98, 2013.

[13] Nataraja, M. C. Concrete mix design using copper slag as fine aggregate. International journal of civil engineering, 5(9), 90-99, 2014.

[14] Rose, D. A. Performance of Copper Slag on Strength and Durability Properties as Partial Replacement of Fine Aggregate in Concrete.

[15] International Journal of Emerging Technology and Advanced Engineering, 5(1), 434-437, 2015.