Utilization of Copper Slag in M-Sand as Partial Replacement of Fine Aggregate

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Abstract: **In India, there is a great demand of aggregates, mainly from civil engineering also for concrete construction. Instead of using aggregate in concrete construction some of the waste industrial by-products can be used. This paper reports the investigation carried out on concrete with partial replacement of fine aggregate by copper slag, Concretemixes, viz. Conventional concrete mixes with varying percentages of copper slag (10, 20, 30 and 40%) as fine aggregate replacement material were investigated. The compressive strength test was carried out on 4 concrete mixes at the ages of 7, 14 and 28 days.The effect of copper slag as fine aggregate replacement material on mechanical properties were analysedand compared with conventional cement concrete. This paper briefly presents thecompressive strength, tensile of cubes strength ofall the concrete mixes investigated at the age of 7,14 and 28days.**

***Key words*— copper slag, compressive strength.**

I. INTRODUCTION

Waste utilization has become an alternative to disposal because of the lack of space for land filling. In India, there is great demand of aggregates mainly from civil engineering industry for road and concrete constructions. India itself consume 450 million cubic meter of concrete annually which approximate translates to 1 to 1.5 ton per Indian. But nowadays it is very difficult problem for available of fine aggregates. So researchers developed waste management strategies to apply for replacement of fine aggregates for specific need. For every tone of copper metal production, about 2 to 2.5 ton of waste slag is generated. As the copper settles down in the smelter, it has higher density, impurities stay in the top layer and then are transported to a water basin with a low temperature for Solidification.

Concrete is mixture of cement, fine aggregate, coarse aggregate and water. River Sand is common form of fine aggregate used in the production of concrete but has become very expensive due to rapid depletion of river bed, high transportation cost etc. The sustainable development for construction involves the use of non-conventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment. Using alternative materials in place of natural aggregate in concrete production makes concrete as sustainable and environmentally friendly construction material. M-Sand has similar physical & chemical properties of Sand. Copper slag is considered as a waste material which could be used in the construction industry as partial substitute of either cement or aggregates. The use of copper slag in concrete provides potential environmental as well as economic benefits to the construction industry. Copper slag if not disposed of properly are the main cause for the evaporation of CO2 and other harmful gases which cause global warming, which results in the destruction of the ozone layer which protects the planet earth from harmful cosmic rays.

II. MATERIALS USED

Cement:

Ordinary Portland cement of 43 grade available in local market is used in the investigation. The cement used has been tested for various proportions as per IS 4031 – 1988 and found to be confirming to various specifications of IS 12269-1987. The specific gravity was 3.15 and fineness was 2800 cm2/gm.

Table-1: Chemical Composition of 53grade OPC

OXIDES	OPC
SiO_2	20.98%
Al_2O_3	5.42%
Fe_2o_3	3.92%
CaO	62.85%
MgO	1.76%
Na_2	0.28%
K_2O	0.53%
SO_3	2.36%
Loss on ignition	1.90%

Fine Aggregate:

Manufactured sand. As per IS: 2386 (Part II)-1963, the bulk specific gravity in oven dry condition and water absorption of the sand are 1.6 and 1% respectively.

Table -2 Physical properties of Fine Aggregate

Characteristics	Fine aggregates
Grading	Confirming IS 2386(PART 1):1963 zone 2
Specific gravity	2.52
Water absorption	1.62%
Free Surface Moisture	nil

Coarse Aggregate:

Crushed granite stones of size 12.5mm are used as coarse aggregate. As per IS: 2386 (Part III)-1963, the bulk specific gravity in oven dry condition and water absorption of the coarse aggregate are 2.66 and 0.3% respectively. The dry-rodded unit weight of the coarse aggregate with the coarse aggregate blending (12.5mm) as per IS: 2386 (Part III)1963] is1608 kg/m 3.

Table--3Physical properties of Coarse Aggregate

SL. no	Characteristics	Coarse aggregates
1	Grading	20mm& down
2	Specific gravity	2.71
3	Water absorption	0.55%
4	Free Surface Moisture	nil

Copper slag:

Copper slag is a by- product of copper extraction by smelting. During smelting, impurities becomes slag which floats on the molten metal, slag that is quenched in water produces angular granules which are disposed of as waste. Slag from ores that are mechanically concentrated before smelting contain mostly iron oxide and silicon oxide. As per IS:383-1970, the Fineness modulus of a given sample of fine aggregate is 2.265belong to Grading Zones II.

Table-4 Physical Properties of Copper Slag:

Physical Composition	
Specific gravity	3.30
Hardness	7Moh scale
Conductivity mS/M	4.8
Chloride Content	<0.0002
Carbonates	Not detected
Sulphates	0.65%
Water Absorption	Not detected
Arsenic	Not detected
Cadmium	Not detected

Table-5 Chemical properties of Copper Slag:

Chemical Composition	
Al_2O_3	3.01%
Tio_2	0.60%
Fe_2o_3	55.00%
SiO_2	35.00%
CaO	0.20%
MgO	0.90%
K_2O	1.02%
Na_2O	0.95%
CU	0.42%

III. MIX DESIGN METHOD

Concrete mixture with different proportions of Copper Slag used as a partial or full substitute for fine aggregate were prepared in order to investigate the effect of copper slag substitution on the strength normal concrete. concrete mixtures were prepared with different proportions of copper slag added to concrete mixtures were as follows 0%, 10%, 20%,30%and 40%. the control mixtures were designed to have a target 28 days' compressive strength of 40N/mm^2 (M-40) using a water cement ratio of 0.55.

IV. RESULTS AND DISCUSSIONS

The different tests conducted in laboratories are shown following It consist mixing of concrete in thelaboratory by replacing Copper Slag as fine aggregate with proportions (by weight) of Copper Slag added to concrete mixtures were as follows: 0% (for the control mix), 20%, ,30%, and 40%. Concrete samples were prepared and cured in the laboratory, and are tested, to slump, Density and compressive Strength.

Strength Test

One of the most important properties of concrete is the measurement of its ability to withstand compressive loads. This is referred to as a compressive strength and is expressed as load per unit area. One method for determining the compressive strength of concrete is toapply a load at a constant rate on a cube(150×150×150 mm), until the sample fails. The compression tests performed in this project were completed in accordance with IS standard 516"Methods of Tests for Strength of Concrete". Theapparatus used to determine the compressive strength of concrete in this project was a testing machine. For this study samples were tested for compression testingat 7, 14 & 28days of curing.

Table-6: Comparison of Convention Concrete with Copper Slag Replaced Concrete

Days	0%	10%CS	20%CS	30%CS	40%CS
7	26.84	30.59	34.22	35.55	34.73
14	36.11	36.87	40.20	41.52	40.29
28	46.72	47.78	49.04	50.53	47.16

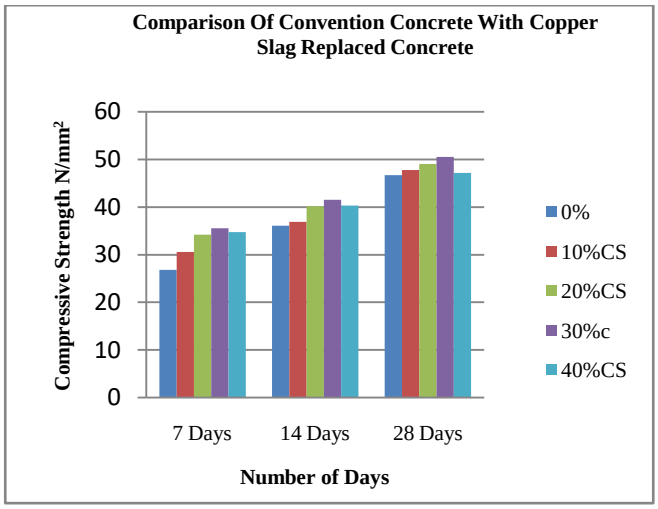

Chart-1: Comparison of convention concrete with copper slag replaced concrete

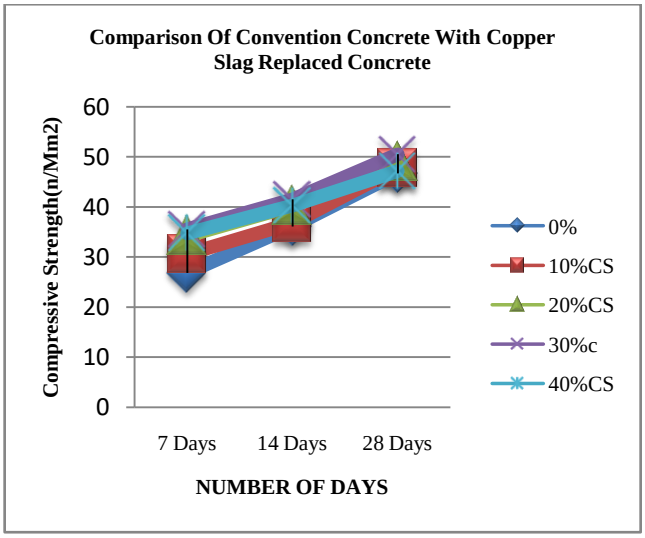

Table-6 Comparison of Percentage Change in Strength of Partial Replaced Copper Slag Concrete W.R.T Conventional Concrete

Percentage replacement	Strength attained at 7 days	Strength attained at 14 days	Strength attained at 28 days	Percentage change in strength w.r.t 7 days	Percentage change in strength w.r.t 14 days	Percentage change in strength w.r.t 28 days
0% replacem	26.84	36.1	46.72	-	-	-
ent						
10% replacement	30.59	36.87	47.78	13.97%	2.10%	2.268%
20% replacement	39.22	40.20	49.046	27.4%	11.32%	4.96%
30% replacement	35.55	41.52	50.53	32.4%	14.4%	8.15%
40% replacement	34.73	40.29	47.16	27.4%	11.5%	0.94%

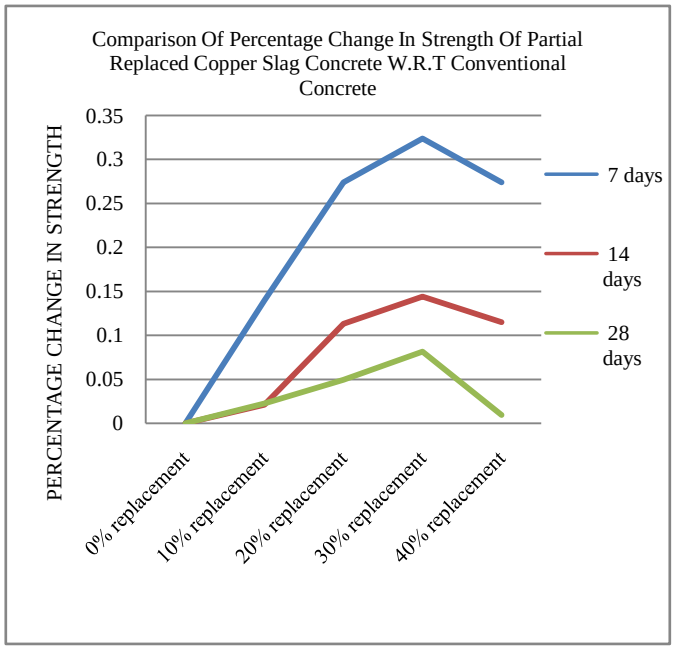

Chart-2 Comparison of percentage change in strength of partial replaced copper slag concrete w.r.t conventional concrete

V. CONCLUSION

By our Project, we conclude that strength of concrete increased by the replacement of M-sand by copper slag, saves concrete material cost. Here we are using OPC of 53 grade, Well graded coarse and fine aggregate.

- 30% copper slag replacement showed Maximum workability. The workability of concrete had been found to decrease after 30% in concrete.
- Among different mixes of concrete 30% showed maximum compressive strength at later ages. At later stages strength of concrete decreases due to segregation and bleeding.
- The cost analysis indicates that percent of fine aggregate reduction decrease the cost of concrete, but at the same time the strength also increases.
- The mix prepared with 30% replacement of fine aggregate(M-sand) by copper slag is most

economical and gives high strength compared to conventional mix.

Other uses are:

- Greater Strength
- Decreased Permeability
- Increased Durability
- Self-compacting Concrete

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