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REPLACEMENT OF COPPER SLAG WITH FINE AGGREGATE

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Abstract - *In this work, an extensive study using copper slag has been carried out to investigate strength, workability and durability. Copper slag is an industrial byproduct material produced from the process of manufacturing copper. For, 2.2 tons of copper slag is generated at every ton of copper production In the world of copper industry, it has approximately 26.6 million tons of copper slag are generated. Copper slag has an excellent by-product which retains its original properties. The main objective is to encourage the use of these seemingly waste products as a construction material. In this paper , the effect of using copper slag as a fine aggregate on properties of cement mortars and concrete various mortars & concrete mixtures were prepared with different proportions of copper slag ranging from (20CS+80S)%, (30CS+70S)%, (40CS+60S)%, (50CS+50S)%, (60CS+40S)%,(70CS+30S)%.The cubes were prepared & demoulded after 24 hours and properly cured. Form the above test result we concluded that the 50%CS+50%S gives optimum proportional of CS that can be used as a replacement substitute material for fine aggregate in concrete. We can use any proportion of CS replacement as per our requirement for creating concrete, because we concluded that the all result of replacement of CS is more than control mix.*

Key Words: Copper Slag, Strength, Workability, Fine aggregate, sieve analysis, etc.

1. INTRODUCTION

Now a days there is lack of River sand and also lots of restrictions on river sand mining and its transportation. For that it is necessary to find the alternative for river sand. It is beneficial to find the by-product so that its cost is less and also it can be usable. For that the best option is Copper Slag [2].Copper slag is an industrial product obtained during matte smelting and refining of copper [1, 3]. By using copper slag in concrete we can the environmental pollution as well as we reduce the cost of concrete [2]. Copper slag can possesses the physical, chemical and mechanical properties that can be used in concrete as a partial replacement for fine aggregate [1].Copper slag is one of the materials that can be considered as a waste material which could have a promising future in construction industry as partial or full substitute of any two either cement or aggregates [5]. It is an industrial by-product material produced during the copper smelting and refining process of manufacturing of copper which can be used for a surprising number of applications in the building and industrial fields [4]. This material represents a popular alternative to sand as a blasting medium in industrial cleaning [5]. Using blasting or high-pressure spraying techniques, companies are using copper slag to clean large smelting equipment or furnaces [7].Material like copper slag can be used as one which can reduce the cost of construction [3].

Approximately 24.6 million tons of slag is generated from the world copper industry revealed the various regions of copper slag generation depicted in Table1 [6].

Fig -1: Copper slag

Table -1: Copper slag generation in various regions

Sr.No.	Regions	Copper slag generation/annum in million ton
01.	Asia Europe	7.26
02.	North America	5.90
03.	Europe	5.56
04.	South America	4.18
05.	Africa	1.23
06.	Oceania	0.45

1.1 Production of copper slag

Copper slag is a by-product obtained during the matte smelting and refining of copper. In India, three copper producers Sterlite, Birla Copper and Hindustan Copper produces around 6-6.5 tons of copper slag. To produce

every ton of copper, approximately 2.2–3.0 tons copper slag is generated as a by-product material. Utilization of copper slag in applications such as Portland cement substitution and/or as aggregates has threefold advantages of eliminating the costs of dumping, reducing the cost of concrete, and minimizing air pollution problems. The researchers depicted the physical and chemical properties of copper slag given in Table 2 and Table 3, respectively.

Table -2: Physical properties of Copper slag

Sr.No.	Physical Properties	Value
01.	Particle shape	Irregular
02.	Appearance	Black & Glassy
03.	Type	Air cooled
04.	Specific Gravity	3.91, 3.68
05.	Percentage of Voids	43.20%
06.	Bulk density	1.70 to 1.90 g/cc
07.	Fineness modulus of copper slag	3.47
08.	Angle of internal friction	51° 20’
09.	Particle size	0.075mm to 4.75mm
10.	Hardness	Between 6 & 7

Table -3: Chemical properties of Copper slag

Sr.No.	Chemical Component	Chemical Component (%)
01.	SiO_2	25.85
02.	Fe_2O_3	68.29
03.	Al_2O_3	0.22
04.	CaO	0.15
05.	Na_2O	0.58
06.	K_2O	0.23
07.	LoI	6.59
08.	Mn_2O_3	0.22
09.	TiO_2	0.41

1.2 Applications

a. Coarse grade is used for the removal of heavy corrosion and coating leaving a surface profile about 100 to 120 microns.
b. Medium grade is used for cleaning mill scale and medium rust removal, creating of surface profile of about 60 to 80 microns.
c. Fine grade is used on new steel to remove mill scale and light rust resulting in the surface profile of about 40 microns.

1.3 Industrial users includes

- Blast & Paint Contractor
- Container Manufacturing / Repair
- Marine Shipbuilding Repair
- Die casting
- Oil and Gas/ Pipeline
- Steel Fabrication
- Plant Maintenance

2. MATERIAL & METHODS

Materials were collected for both Steel Reinforced and Bamboo Reinforced concrete. Materials needed for Reinforcement cement concrete are cement, fine aggregate, coarse aggregate, steel rod, bamboo, copper slag and water.

Cement

Cement is a binder, a substance that sets and hardens and can bind other materials together. The cement used in this experimental work is “Birla Super Cement.”(OPC53).

Table -4: Properties of cement

Sr.No.	Property	IS Code 8112
01.	Specific Gravity	3.12
02.	Consistency	53
03.	Initial Setting Time	30 minutes
04.	Final Setting Time	10 hours

Sand

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e. a soil containing more than 85% sand-sized particles (by mass).

Copper Slag

Copper slag is an industrial by-product material produced from the process of manufacturing copper having similar physical, mechanical &chemical properties of Sand can be considered as an alternative to the river sand.

Coarse Aggregate

Aggregates are the most mined materials in the world. Aggregates are component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material.

Table -5: Properties of FA, CA, CS

Sr.No.	Properties	FA	CA	CS
01.	Specific Gravity	2.64	2.70	3.68
02.	Fineness Modulus	3.24	7.40	3.47

Water

Water is 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 quantity and quality of water is required to be looked into very carefully.

Concrete Mix Design Quantity

For M25 grade of Concrete-

Table -6: Quantity of FA, CA, CS (M25)

Sr.No.	% Replacement	FA(%) Kg	CA(%) Kg	CS(%) Kg
01.	20	9.36	23.76	2.34
02.	30	8.19	23.76	3.51
03.	40	7.02	23.76	4.68
04.	50	5.85	23.76	5.85
05.	60	4.68	23.76	7.02
06.	70	3.51	23.76	8.19

3. SPECIMEN PREPARATION

The cubes were designed having dimensions 150mm X 150mm X 150mm. The M25 grade concrete was prepared with copper slag as a replacement of fine aggregate in various proportions i.e. 20,30,40,50,60&70% by hand mixing then casted cubes are then unmolded and was cured for 7days and 28days.

Fig -2: Specimen Preparation

4. TESTING OF MATERIAL

SLUMP CONE TEST-

The Slump Cone apparatus for conducting the slump test essentially consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as : Bottom diameter : 20 cm, Top diameter : 10 cm, Height : 30 cm and the thickness of the metallic sheet for the mould should not be thinner than 1.6 mm.

Fig -3: Slump Cone Test

SIEVE ANALYSIS-

Table -7: Sieve analysis of Copper slag

Sr.No.	Sieve Size	Weight Retained (Kg)
01.	4.75mm	0.000
02.	2.36mm	0.020
03.	1.18mm	0.376
04.	600micron	0.436
05.	425micron	0.152
06.	300micron	0.004
07.	150micron	0.004
08.	90micron	0.004
09.	75micron	0.003
10.	PAN	0.001

5. TESTING OF SPECIMEN

Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection.

A compression test is performed on standard cubes of concrete with copper slag as partial replacement of fine aggregate as 20% to 70% with 10% intervals of size 150mm x 150mm x 150mm after 7 days immersion in water for curing and 28 day cubes are in possess of curing.

6. RESULTS & ANALYSIS

SLUMP CONE TEST

Table -8: Slump Cone test values

Sr.No.	Percentage Replacement	Slump (mm)
01.	20%	43
02.	30%	46
03.	40%	51
04.	50%	55
05.	60%	57
06.	70%	62

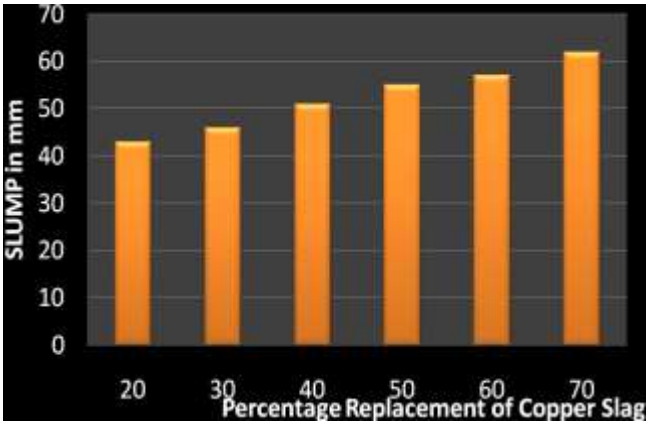

Fig -4: Graphical representation Slump Cone Test

COMPRESSIVE STRENGTH TEST

Table -9: Compressive Strength of Concrete

Sr.No.	Percentage Replacement	Compressive Strength (Mpa)
01.	20%	28.65
02.	30%	33.50
03.	40%	31.40
04.	50%	38.75
05.	60%	28.75
06.	70%	26.85

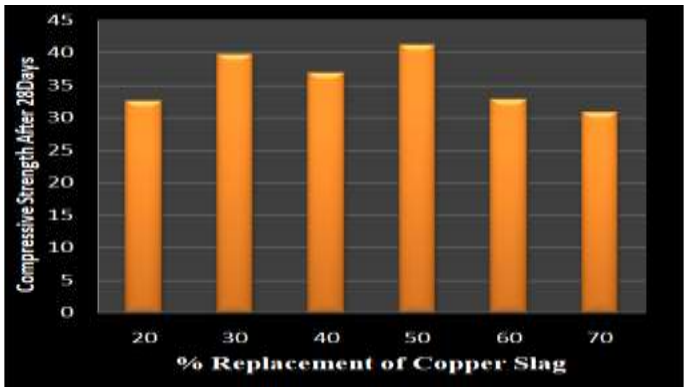

Fig -5: Graphical representation- Compressive Strength Test

CONCLUSION

1. The mix design of M25 grade of concrete gives HPC concrete when replacement of copper slag is 50%.
2. In this case we observed that Copper slag behaves like river sand.
3. It is observed that when increasing percentage replacement of fine aggregate by Copper slag the unit weight of concrete is gradually increases.

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