Experimental Investigation of Partial Replacement of Fine Aggregate With Copper Slag In Concrete

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Abstract- *Conservation of natural resources and preservation of environment is more important of any modern developments. Last few decades, construction activities increase rapidly. The use of copper slag provides potential environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of copper slag is produced. It reduces the consumption of natural resources. Copper slag is a by-product obtained during refining and smelting of copper. One of the greatest potential applications for reusing copper slag is in concrete production. Approximately 24.6 million tons of copper slag generated at every year of copper production in worldwide. Concrete is prepared by replacing fine aggregate (M Sand) with copper slag of 20%, 40%, 60% of its weight. The maximum compressive strength of concrete attained at 40% replacement of fine aggregate at 7 and 28 days. The split tensile strength and the flexural strength were also obtained higher strength at 40% replacement level at 28 days.*

Keywords- Copper slag, Fine aggregate, Replacement, Strength.

I. INTRODUCTION

The utilization of industrial waste or secondary materials has encouraged the production of cement and concrete in construction field. New by products and waste materials are being generated by various industries. Dumping or disposal of waste materials causes environmental and health problems. Therefore, recycling of waste materials is a great potential in concrete industry. For many years, by-products such as fly ash, silica fume and slag were considered as waste materials. Concrete prepared with such materials showed improvement in workability and durability compared to normal concrete and has been used in the construction of power, chemical plants and under-water structures. Copper slag is an industrial by-product material produced from the process of manufacturing copper. For every ton of copper production, about 2.2 ton of copper slag is generated. It has been estimated that approximately 24.6 million ton of slag are generated from the world copper industry. The use of copper slag in the concrete industry as a replacement for cement can have the benefit of reducing the costs of disposal and help in protecting the environment. Despite the fact that several studies have been reported on the effect of copper slag replacement on the properties of concrete, further investigations are necessary in order to obtain a comprehensive understanding that would provide an engineering base to allow the use of copper slag in the concrete.

II. LITERATURE REVIEW

"STUDY OF PROPERTIES AND EFFECT OF COPPER SLAG IN CONCRETE" by M.V.Patil.

In this paper, the results have shown that as the percentage of Copper slag increases workability increases. Maximum compressive strength of the concrete is increased as 47.29 MPa at 28 days curing with 20% replacement of Copper slag. It is observed that 20% replacement of Copper slag increases the flexural strength by 14%. As the percentage of Copper slag increases the density of concrete increases. The density is increased by 7% due to replacement of fine aggregate at 100%.

"A PARTIAL REPLACEMENT OF FINE AGGREGATE BY COPPER SLAG IN CONCRETE" by Naveed A Shaikh, Pradeep P Tapkire.

In this paper, the results have shown that in M20 grade of concrete 43.90% increase in strength of concrete is observed. Similarly 31.80% highest in the range for M30 grade of concrete is noted for 40% replacement of copper slag. For 7 days strength the highest percentage increase is 41.10% and 34.4% for M20 grade and M30 grade of concrete respectively. For final strength the increase in percentage are observed as 44.20% and 35.50% for M20 and M30 grade of concrete respectively. From the observations and results

obtained 40% replacement of copper slag gives highest strength in M20 grade and M30 grade of concrete.

"STUDY OF THE PROPERTIES OF CONCRETE CONTAINING COPPER SLAG AS A FINE AGGREGATE" by C.H.Srinivas,S.M.Muranal.

This paper states that, the workability increases up to 31.57 % for 100 % replacement of copper slag as a fine aggregate fine aggregate. The maximum compressive strength of concrete increases up to 8.63 % for 20 % percentage replacement of fine aggregate, but up to 40 % percentage of copper slag can be replaced which is greater than the target strength.

"EFFECT OF COPPER SLAG AS A FINE AGGREGATE ON PROPERTIES OF CONCRETE" by Zine Kiran Sambhaj,Prof.Pankaj B Autade.

In this paper, the design M25 grade concrete for 50% replacement of Copper slag show the HPC characteristics. It is observed that when increasing percentage replacement of fine aggregate by Copper slag the unit weight of concrete is gradually increases. The Compressive Strength of Concrete with partial replacement of Fine aggregate with Copper Slag up to 50% can be comparable with control mix. With increased copper slag content beyond the 50% replacement increases free water content due to that compressive strength has decreased but the minimum strength of percentage replacement of Copper slag concrete is 27.41 MPa which is 1.62% more than control mix.

"AN EXPERIMENTAL INVESTIGATION ON COPPER SLAG AS REPLACEMENT OF FINE AGGREGATE IN CONCRETE" by J.Anne Mary

This paper states that, Copper slag is a very good alternative material for fine aggregate it can be replaced upto 40% with fine aggregate so that it gives highest strength at 28 days compare to normal concrete with M20 mix. By replacing fine aggregate with 40% of copper slag gives the strength 37.55% , 10% and 40.72% more than the reference with conventional concrete at 28 days for compression strength, split tensile strength and flexural strength respectively.

III. MATERIAL PROPERTIES:

A. CEMENT:

Cement is one of the important constituents of mortar. It is the binding material in mortar which is used for all building elements. Ordinary Portland cement 53 grade is used for casting the specimens. The Portland cement comprises of four principal compounds such as tri-calcium silicate (3Cao SiO_2), di-calcium silicate (2Cao SiO_2), Tri-calcium Aluminate (3CaO) and tetra calcium alumina ferrite (4CaO Al_2O_3). These different types of Portland cements are suitable under different conditions and requirement of a structure.

Table 1-Cement Property Tests

Tests	Results
Fineness test	4.61%
Consistency test	32%
Specific gravity test	3.15

B. FINE AGGREGATE (M-SAND):

Sand is either round or angular grain and is often found mixed in various grading of fineness at different zones. According to size the fine aggregate may be described as coarse sand, medium sand and fine sand. IS specification classify the fine aggregate into four types according to its grading as fine aggregate of grading zone-1 to grading zone-4. Depending upon the nature of rock from which it was found and an erosive action to which it has been subjected, many other minerals may be found as constituents mica feldspars, shale are a few of them. Specification for sand to be suitable for concrete is that it should be free from all these injuries materials. Further percentage of clay and silt content are restricted to a maximum of 0.5% and it should be free from organic impurities such as tannin acid derived from surface vegetation. Sands are classified according to the sources such as M-Sand, River sand, Pit sand, Sea sand etc.,

Table 2-M Sand property test

Tests	Results
Fineness modulus	2.69
Specific gravity	2.75

C. COARSE AGGREGATE:

Coarse aggregate of size more than 4.75mm, is classified as coarse aggregate and is the one of the most important ingredient of concrete. It gives strength to the concrete and constituents about 70 to 75 percent volume of concrete. Crushed stone used as coarse aggregate which is black in colour, angular and in local name known as black metal. Coarse aggregate are generally derived by crushing natural rocks. These rocks are classified as igneous and metamorphic. Igneous rocks are fine grained, strong and dense, formed by the cooling of parts of the molten material which is in general is called as basalt. Aggregate developed by

crushing these rocks are black in colour in common, by used in concrete work. Sedimentary rocks also called derivatives rocks were deposited by some geological age mechanically through the agency of water, wind or ice action chemically or organically. These rocks cover about three quarters or the earth's land surface, sand stone is one of its types used in concrete production for being hard and durable. Sand stone in the forms of strips also used in slab construction. Metamorphic rocks formed igneous or sedimentary rocks. The igneous and sedimentary rocks finally subjected to earth movements and carried down to depths in crust where they are acted upon by great heat & pressure because of these agencies rock are also partly or wholly changed to form a new type of rock.

Table 3-Coarse aggregate property test

Tests	Results
Specific gravity test	2.7
Impact test	22.8%
Water Absorption test	0.25%

D. COPPER SLAG:

1) CHEMICAL COMPOSITION OF COPPER SLAG:

During smelting and refining of copper, silica is added directly for the complete isolation of copper. Adding silica during smelting process forms strongly bonded silicate anions by combining with the oxides. Copper slag contains highly toxic elements like arsenic, barium, cadmium, copper, lead and zinc. Copper slag can release these elements into the environment causing pollution of soils, atmospheric air, surface waters and groundwater. Copper smelter releases copper selenium. They are highly toxic if present overabundant. They contaminate the soil in the vicinity of smelters, destroying the vegetation.

2) APPLICATIONS OF COPPER SLAG:

Copper slag possesses physical and chemical characteristics that qualify the material, to be used in concrete as an excellent substitute for Portland cement or as a partial replacement for aggregates. For example, copper slag has a number of favourable engineering properties for using as aggregate like excellent soundness characteristics, good abrasion resistance and good stability by Gorai et al. (2002). Copper slag also has pozzolanic 24 properties since it contains low CaO. Under activation with NaOH, it exhibits cementitious property and can be used as partial or full replacement for Portland cement. Using copper slag for the manufacture of Portland cement or concrete has multiple benefits of eliminating the cost of disposal and reducing the cost of producing cement /concrete.

Table 4-Copper Slag property test

Tests	Results
Specific Gravity	3.62
Fineness Modulus	2.23

IV MIX PROPORTIONS (M20 GRADE CONCRETE)

Table 5-Mix Ratio

W/C ratio	Cement	Fine Aggregate	Coarse Aggregate
0.54	1	1.48	2.95

V. TESTS AND RESULTS

Table 6-Compressive strength test results

% of Copper Slag Replaced	Compressive strength (MPa)	
	7 days	28 days
0	13.05	22.25
20	15.34	24.45
40	18.51	27.86
60	14.67	22.94

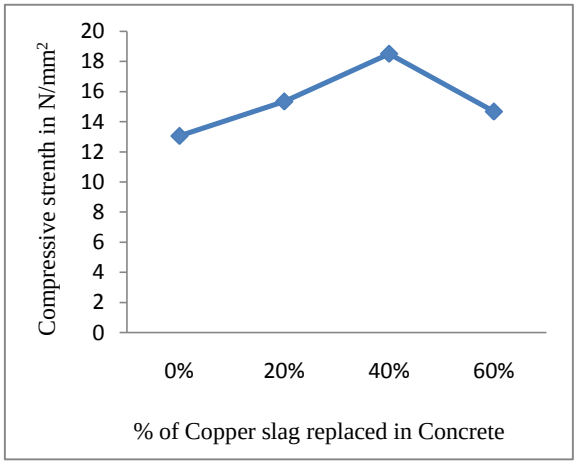

Fig1 Compressive strength results of Concrete (7 days)

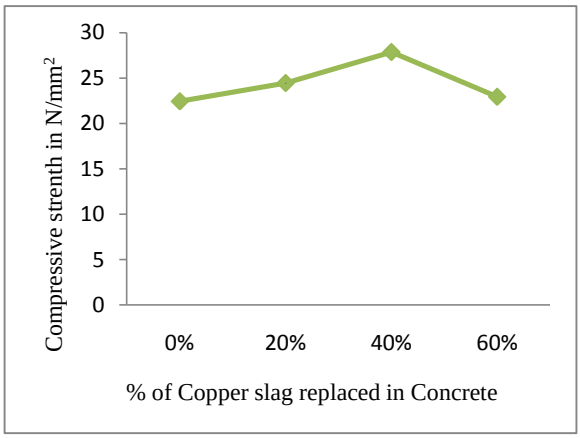

Fig2 Compressive strength results of Concrete (28 days)

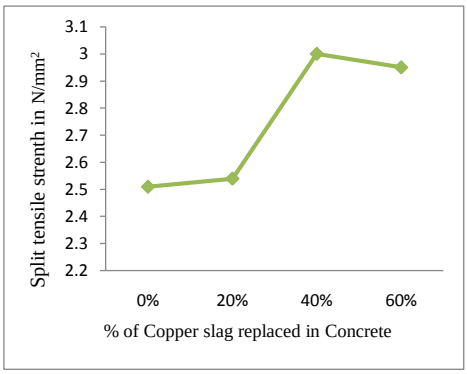

Fig 4 Split tensile strength of Concrete (28 days)

Fig 3 Compression testing of cubes

Fig 5 Split Tensile testing of cylinders

Table 7 Split tensile strength test results

% of Copper slag replaced	Split Tensile strength (MPa)
0	2.51
20	2.54
40	3.00
60	2.95

Table 8 Flexural strength test results

% of Copper slag replaced	Flexural strength (MPa)
0	3.41
20	4.27
40	4.84
60	4.97

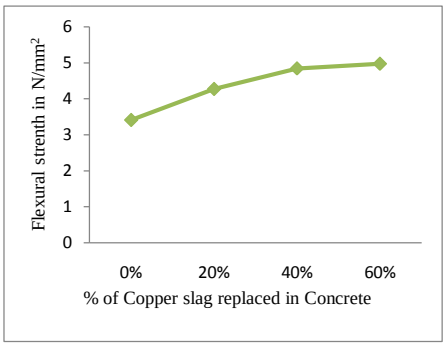

Fig 3 Flexural strength of Concrete (28 days)

Fig 4 Flexural strength testing of beams

VI. CONCLUSION

1. From the experimental results, it is clearly shown that the strength of concrete increases when 40% of copper slag is replaced as fine aggregate.
2. Compressive strength is increasing gradually by increasing the replacement of copper slag upto 40%, in 60% replacement the strength gets reduced.
3. Split tensile strength has increased when 40% of copper slag was replaced for M Sand in concrete. It shows strength of 3.00 N/mm^2 by comparing with nominal concrete as 2.51 N/mm^2.
4. Better flexural strength was obtained when the copper slag is 60% replaced to the concrete as 4.97 N/mm^2 while the M Sand concrete as 3.41 N/mm^2.
5. The maximum Compressive strength is obtained at 40% of copper slag replacement to the concrete as 27.86 N/mm^2.

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