AN EXPERIMENTAL INVESTIGATION ON USE OF COPPER SLAG AS PARTIAL REPLACEMENT OF FINE AGGREGATE IN CONCRETE

Priyatam kumar [*1], M.C. Paliwal [2], Vikash Kumar Singh [3]
*1 M.Tech.Scholar, 2 Associate Professor, 3 Assistant Professor, Department of Civil Engineering.
[1,2] National Institute of Technical Teachers Training & Research, Bhopal.
[3] Lakshmi Narain College of Technology, Bhopal, India

***Abstract:** This paper manages the trial Investigation on concrete by partial replacement of fine aggregate with copper slag to improve the quality strength parameters, for example compressive strength, split tensile strength, and flexural strength of the M-25 and M-30 grade of concrete. Here the fine aggregate partially replaced with copper slag in concrete with 5%, 10%, 15% & 20% by weight of fine aggregates and cement Mix design was prepared for M-25 and M-30 grade of concrete by replacement of copper slag as fine aggregate and cement. We can reduce the digging of river sand which effects the hydraulic structure stability and as well as we can reduce the open land fill and environmental pollution with copper slag usage it in concrete. Test outcomes shows that the strength performances of concrete has enhanced having copper slag as a partial substitution of Sand and cement (0-20%) in concrete however in conditions of stability the concrete establish to be low resistant to acid attack and high resistance against sulphate attack. At that point investigate variation between values of results with conventional concrete. Graphs are drawn strength vs. replacement with fine aggregate results are compared with normal concrete.*

***Key words:** Fine aggregate, copper slag, compressive strength, tensile strength, FlexureStrength*

I. Introduction

Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape it also replaces old construction materials such as brick and stone masonry etc. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementations material, aggregate and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of applications. Concrete is normally used in the frame structure. But there is limitation like self compaction, surface finishes maintains strength at congested area. Construction of high performance structures such as high rice reinforced and pre stressed concrete buildings, long span concrete bridges, etc. aggregates and cement are considered one of the main constituents of concrete. The utilization of copper slag for applications such as Portland cement replacement in concrete, or as raw material has the dual benefit of eliminating the cost of disposal and lowering the cost of the concrete. 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.

Copper slag is an industrial by-product material produced from the process of manufacturing copper. For every ton of copper production, about 2.2 tons of copper slag is generated in world. It has been estimated that approximately 24.6 million tons of slag are generated from the world copper industry. Although copper slag is widely used in the sand blasting industry and in the manufacturing of abrasive tools, the remainder is disposed of without any further reuse or reclamation. Copper slag possesses mechanical and chemical characteristics that qualify the material to be used in concrete as a partial replacement for Portland cement or as a substitute for aggregates. The utilization of copper slag for applications such as Portland cement replacement in concrete, or as raw material has the dual benefit of eliminating the cost of disposal and lowering the cost of the concrete. 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 concrete.

II. Literature Review

Al-Jabri et al (2009) has investigated the performance of high strength concrete (HSC) made with copper slag as a fine aggregate at constant workability and studied the effect of super plasticizer addition on the properties of HSC made with copper slag. Two series of concrete mixtures were prepared with different proportions of copper slag. 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. Ben narendran S et al (2014) investigated that Growing demand for construction materials necessitated the usage of alternate materials in the production of conventional concrete. The present study discusses the influence of copper slag in the behavior of composite concrete. Ordinary Portland cement of 43 grade and M-25 and M-30 grade of concrete is used. The test specimens are cured for a period of 7, 14, 28 and 50 days and tested for compressive strength and split tensile strength. The results are compared with conventional concrete.

III. Methodology

Materials -The materials used in the projects for making concrete mixture are cement, Fine aggregate, coarse aggregate, copper slag, are detailed describe below:

Cement: Cement is by far the primary constituent of concrete, in that it performs the binding substance for the discrete ingredients. Prepared out of naturally generating raw materials and sometimes

blended or interground with industrial wastes. The cement used in this study was OPC 53 grades Ordinary Portland cement (OPC) conforming to IS12269-1987.

Fine Aggregate: Aggregates which engage nearly 70 to 75 percent quantity of concrete are sometimes observed as inert ingredients in more than one sense. However, it is now well recognized that physical, chemical and thermal properties of aggregates substantially influence the properties and performance of concrete. The fine aggregate (sand) used was clean dry sand was sieved in 4.75 mm sieve to take out all pebbles.

Coarse Aggregate: Coarse aggregate are used for building concrete. They could be in the form of unequal broken stone or naturally occurring gravel. Materials that are large to be maintained on 4.75mm sieve size are named coarse aggregates. Its highest size may be up to 40 mm.

Water: Water is a main component of concrete as it actively contributes in the chemical reaction with cement. Since it helps to perform the strength giving cement gel, the amount and quality of water is essential to be looked into very carefully. Portable water is generally considered satisfactory.

Copper Slag: Copper slag which is an industrial waste generates from smelting and refining process of copper from Industry. Copper slag is mixed in the concrete as replacement material of fine aggregate. It is the waste product of copper produces from iron or steel plants.

IV. Experimental Procedure

The estimation of concrete with copper waste and Fine aggregates used as substitute of aggregate materials is completed during concrete specimen testing. Concrete include cement, water, fine aggregate, coarse aggregate. Concrete is replaced with alternative materials by varying percentage of replacement. The copper slag is used as partial replacement for fine aggregate and Cement in the range of 5%, 10%, 15% and 20% by weight of sand and cement and its optimum level is to be found. For testing the strength of normal and other variation mix totally 180- cubes of size 150x150x150mm were casted for compression strength test. For testing the Split tensile strength 45-cylinders of 150mmx300mm are casted as per mix design proportions. Once 24hours completed from casting the concrete specimens are de-moulded and allowed for continuous curing in a tank with portable water. The specimen are taken and tested at required 7th day, 14th day, 28th day & 50th day from curing for compression test at 7th ,14th, 28th & 50th day and tensile & durability test at 28th day from curing. Then compare the Strengths of M25 and M-30 design mixes.

V. Results and Discussion

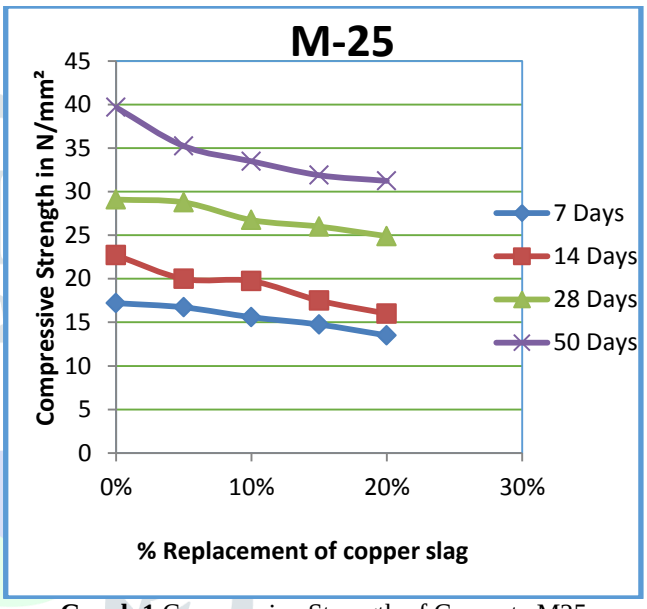
In this study the designed concrete is subjected to various tests to estimate the strength and other properties of the casted concrete. The main aim of the project is to monitor the developed strength attained by the concrete at various testing days from curing. Generally proper casting and curing of concrete will increase the strength of the concrete. For this project each test is carried out with 3 samples for every mix ratio and tested at required curing time. Then the average values are used for the investigations. The series of testing procedures are detailed below:

4.1. Compressive Strength Test

Concrete is weak in tension and strong in compression so the concrete should be strong to attain high compression. In this study for each mix 3-samples were tested and the average strength is compared with nominal mix of M25 and M-30 grade. Compressive strength test finds out the high amount of compressive load a material can bear below facture limit. The results of compressive strength at the age of 7, 14, 28 and 50 days are shown in table 1 and 2.

Table.1 Compressive Strength on Concrete M25 Cubes

Compressive Strength (N/mm²)				
Grade:M-25				
Percentage replacement	7 Days	14 Days	28 Days	50 Days
0%	17.20	22.70	29.10	39.68
5%	16.72	20	28.77	35.25
10%	15.59	19.75	26.75	33.5
15%	14.75	17.5	26	31.9
20%	13.5	16	24.9	31.24

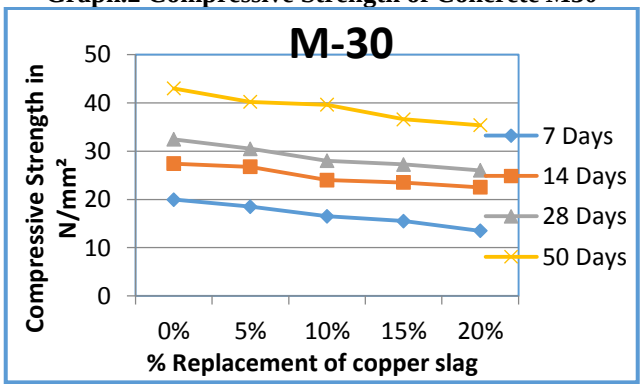


Graph.1 Compressive Strength of Concrete M25

Table.2 Compressive Strength on Concrete M30 Cubes

Compressive Strength (N/mm²)				
Grade:M-30				
Percentage Replacement	7 Days	14 Days	28 Days	50 Days
0%	19.94	27.42	32.43	42.97
5%	18.5	26.75	30.5	40.19
10%	16.5	24.00	28.00	39.59
15%	15.5	23.5	27.25	36.59
20%	13.5	22.5	25.99	35.36

Graph.2 Compressive Strength of Concrete M30

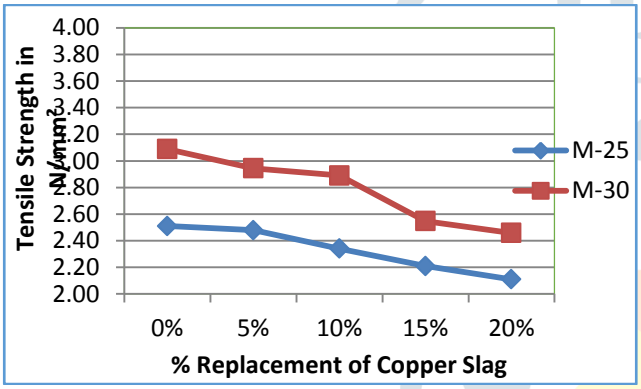


4.2. Split Tensile Strength Test

The split tensile strength of concrete is tested by casting cylinder of size 150mm x 300mm and is continuously cured for 28 days testing. Totally 45 cylinders were casted for normal M25, M30 grade and for 5%, 10%, 15% and 20% by weight partial replacement of copper slag for sand & cement. Three samples are tested and the average values are taken as tensile strength of concrete. The values of split tensile strengths are shown in table.

Table.3 Split Tensile Strength of Concrete at 28 Days

Percentage Replacement of Copper Slag	Split Tensile Strength (N/mm²)	
	M-25	M-30
0%	2.51	3.088
5%	2.479	2.944
10%	2.34	2.89
15%	2.21	2.547
20%	2.11	2.458



Graph.3 Split Tensile Strength at 28 Days

4.4. Waste Management

Copper slag is mixed in the concrete as replacement material of fine aggregate. It is the waste product of copper produces from iron or steel plants. The safe disposal of this waste is lack, Costly and causes environmental Pollution. The construction industry is the only area where the safe use of Copper slag is possible. When it is introduced in concrete as a replacement material, it reduces the environmental pollution, space problem and also reduces the cost of concrete. Many researchers had already establish, copper slag achievable use as a material in concrete. In this Experimental study Copper slag is used in concrete in the form of replacement material of fine aggregate. For this study, M25 and M30 grade of concrete is prepared and the test are conducted for various substitute of fine aggregate and cement using copper slag as 0%, 5%, 10%, 15%, 20% in concrete prepared with fine aggregate.

V. Conclusion

- A Copper slag is a type of waste mixed as a substitute to natural sand in concrete.
- From this investigation, the copper slag particles are waste of low cost material which would help to resolve solid waste disposal problem and protect environment from pollution.
- Cost of Concrete production reduces when Copper Slag is used as a fine aggregate in concrete.
- Copper Slag behaves similar to River Sand as it contains Silica (SiO2) similar to sand.
- Addition of Copper Slag increases the density of concrete thereby increasing the Self-weight.
- The Compressive Strength of Concrete with partial replacement of Sand with Copper Slag up to 20% can be comparable with conventional Concrete.
- Partial substitution of Copper waste in concrete with shows good resistance to sulphate attack.

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