

Study of Properties of Concrete containing Copper Slag as Fine Aggregate

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Abstract— Concrete is a widely used construction material for various types of structures due to its durability. Durability is a major concern for concrete structures exposed to aggressive environments. Due to the high cost of natural sand used as a fine aggregate and the rising emphasis on sustainable construction, there is a need for the construction industry to search for alternative materials as fine aggregates in concrete production. Copper slag is one of the materials which is considered as waste materials in the production of copper, which can be used as partial replacement of fine aggregates in concrete. This report presents the results of an experimental study on various durability tests on concrete containing copper slag as partial replacement of sand. In this report, M30 grade of concrete was designed and tests were conducted with different percentage of copper slag as fine aggregate in concrete. The results indicate that workability increases with increases in the copper slag percentages. The Compressive Strength is increased up to 8.63 % as compared to normal concrete.

Index Terms—Copper Slag, Fine Aggregate, Compressive Strength, Tensile Strength & Durability.

I. INTRODUCTION

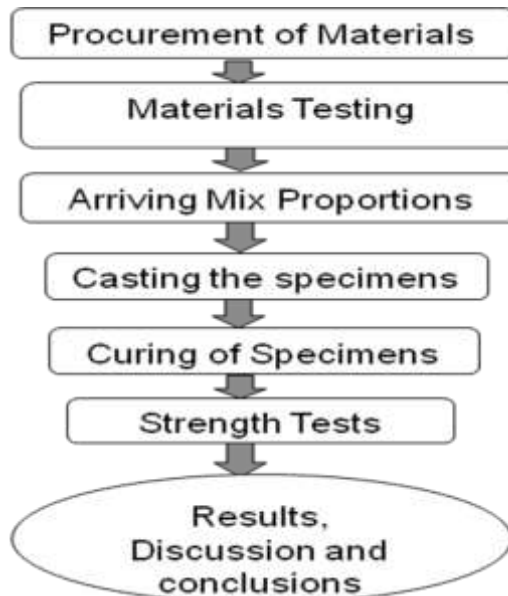
Concrete is a widely used construction material for various types of structures due to its durability. For a long time it was considered to be very durable material requiring a little or no maintenance. In the recent revision of IS:4562000, one of the major points discussed is the durability aspects of concrete. The use of concrete is unavoidable, at the same time the scarcity of aggregates are also increasing nowadays. Utilization of industrial soil waste or secondary materials has been encouraged in construction field for the production of cement and concrete because it contributes to reducing the consumption of natural resources. For many years, by products such as fly ash, silica fume and slag were considered as waste materials. They have been successfully used in the construction industry for partial or full replacement for fine and coarse aggregates. Some of the by products are also used as a Portland cement substitute.

Copper Slag (CS) is currently being used for many purposes from land filling to grit blasting. Currently, about 2600 tons of CS is produced per day and a total accumulation is around 1.5 million tons. These applications utilize only about 15 % to 20 %, and the remaining dumped as a waste material and this causes environmental pollution. CS is a glassy granular material with high specific gravity. Particle sizes are of the order of sand and have a potential for use as fine aggregate in concrete. In order to reduce the accumulation of CS and also to provide an alternate material for sand, CS was used as a replacement material for sand in cement concrete. In order to reduce the accumulation of CS and Also several researchers have investigated the possible use of CS as fine and coarse aggregates in concrete and its effects on the different mechanical and long-term properties of mortar and concrete. High performance concretes (HPC) can be designed to have the desired higher workability, higher mechanical properties and greater durability than those of conventional concretes. The effect of copper slag as fine aggregates on the performance of normal strength concrete was increase in the strength and workability. This would also lead additional benefits in terms of reduction in cost, energy savings, promoting ecological balance and conservation of natural resources.

II. OBJECTIVES OF THE STUDY

- To study the use of copper slag as substitute material for natural sand in concrete.
- To find the optimum percentage replacement of sand by copper slag as fine aggregate.
- To find the properties of concrete like compressive strength, split tensile strength and workability of the concrete partially containing copper slag as Fine aggregate.
- To estimate the improvement in the properties of concrete partially containing copper slag as Fine aggregate.

III. METHODOLOGY



IV. PHYSICAL PROPERTIES OF CONCRETE INGREDIENTS

A. Cement:

Table 1: Properties of Cement

Sl.No	Properties	OPC 43(G)
1	Specific gravity	3.15
2	Fineness	2.0 %
3	Normal consistency	33.0 %
4	Initial setting time	100 min
5	Final setting time	210 min

B. Coarse Aggregate:

Table 2: Properties of Coarse aggregate

Sl.No.	Properties	Results
1	Shape of coarse aggregate	Angular
2	Water absorption	0.5 %
3	Specific gravity	2.8

C. Fine Aggregate and copper slag:

Table 3: Physical Properties of Fine aggregate

Sl.No	Properties	FA	C S
1	Particle shape	Irregular	Irregular
2	Type	River sand	Air cooled
3	Specific gravity	2.60	3.90
4	Bulk density g/cc	1.71	1.90
5	Fineness modulus	2.73	3.47
6	Water absorption %	1.0	0.19
7	Moisture content %	0.50	0.033

D. Chemical Composition of Copper Slag:

Table 4: Chemical Properties of Copper Slag

Sl.No.	Chemical Component	% of Chemical Component
1	SiO ₂	37.26
2	Fe ₂ O ₃	47.45

3	Al ₂ O ₃	3.95
4	CaO	2.38
5	Na ₂ O	0.65
6	K ₂ O	2.62
7	Mn ₂ O ₃	0.086
8	TiO ₂	0.33
9	SO ₃	2.75
10	CuO	1.12

V. Results & Discussion:

A. Slump Results:

The Slump test was conducted on fresh concrete for various percentage of replacement of fine aggregate with Copper slag and their results are tabulated below.

Table 5: Replacement of sand by copper slag.

Sl.No.	% of fine aggregate	% of copper slag replacement	Slump value (mm)
1	100	0	73
2	80	20	77
3	60	40	83
4	40	60	87
5	20	80	92
6	0	100	96

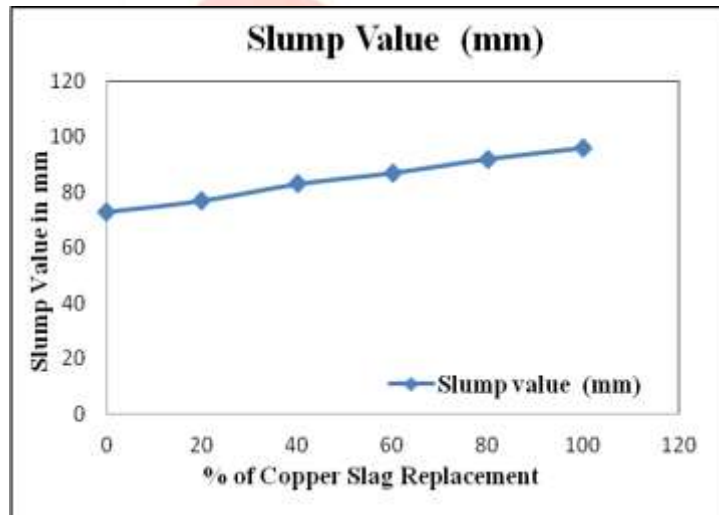


Fig.1: Effect of copper slag replacement on workability

B. Compressive Strength of Concrete:

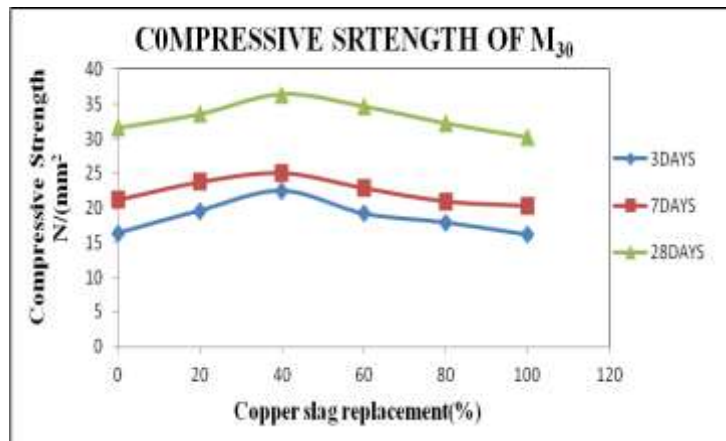


Fig.2: Compressive strength for various replacement of copper slag.

C. Tensile Strength of Concrete:

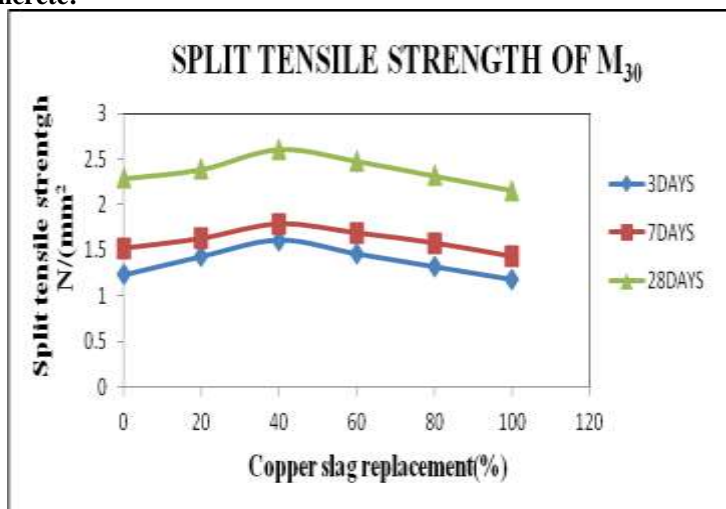


Fig.2: Tensile strength for various replacement of copper slag.

It is observed from the above graphs, that strength of the copper slag replaced concrete gives optimum strength at 40% replacement. The strength of the concrete increases up to 40% replacement and goes on decreases as percentage of replacement increases. Hence we conclude that 40% is the optimum replacement of copper slag in concrete. as the copper slag percentage increases workability and density increases.

VI. Conclusion:

- Increase in the copper slag content in the concrete increases the workability of the concrete.
- The workability increases up to 28% for 100 % replacement of copper slag as a fine aggregate.
- Increase in copper slag content in concrete increases the Density of concrete
- The compressive strength of concrete increases up to 13.11% 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.
- The split tensile strength of concrete increases up to 6.88% 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.
- The maximum strength obtained at 40% replacement of copper slag; hence it is the optimum percentage of replacement.
- Strength of the concrete increases up to 40% replacement and above replacement goes on decreasing.

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