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Study on Mechanical Properties and Durability Studies on Concrete by Partial Replacement of Fine Aggregate with Copper Slag

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Abstract - *Many countries are facing the problem with the lack of natural resources for the upcoming construction industry. The dependency on the natural aggregates is increasing day by day hence, artificially manufactured aggregates and artificial aggregates generated from industrial waste provide an alternative. Copper slag is a byproduct produced during the copper smelting and refining process. For this research work, Copper slag used as partial replacement to fine aggregate in concrete. In which compressive strength, split tensile strength and Flexural tests were carried out. Copper slag of proportions 0, 15, 30, 45, 60% was replaced with fine aggregate. In addition to that Acidic (H_2SO_4) and Sulphate (Na_2SO_4) behaviour of cubes was studied on weight-loss parameters. The behaviour of concrete in this was observed at 3, 7 and 28 days.*

1. INTRODUCTION

Solid waste management is one of the most important environmental concerns in the world. Waste utilization has become an alternative to disposal because of the lack of space for land filling. 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.

Copper slag is an industrial by product material produced from the process of manufacturing copper. It is a glassy granular material with high specific gravity and its Particle sizes are of the order of sand and can be used as fine aggregate in concrete. It has similar physical &chemical properties of Sand. Copper slag has pozzolanic properties so it shows cementitious property and can be used as a partial or full replacement of cement. It is considered as a waste material which could be used in the construction industry as full or 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.

1.1 Materials Used

CEMENT (IS: 12269-1987)

Ordinary Portland cement is by far the most important type of cement. The OPC was classified into three Grades viz., 33 Grade, 43 Grade and 53 Grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988. If the 28 days strength is not less than 33 N/mm2, it is called 33 Grade cement, if the strength is not less than 43 N/mm2, it is called 43 Grade cement, and if the strength is not less than 53 N/mm2, it is called 53 Grade cement.

AGGREGATE

Aggregate properties greatly influence the behavior of concrete, since they occupy about 80% of the total volume of concrete. The aggregate are classified as

(1) Fine aggregate

The sand should be free from clay and inorganic material. For this study locally available river sand used as a fine aggregate which belongs to zone-II. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a round shape. The purpose of fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

(2) Coarse aggregate

The coarse aggregate are granular materials obtained from rocks and crushed stones. Coarse aggregate form the main matrix of the concrete, in case of coarse aggregate maximum 20 mm coarse aggregate is suitable for concrete work. But where there is no restriction 40 mm or large size may be permitted. Crushed granite aggregate conforming to IS: 383-1970 was used for the preparation of concrete. Coarse aggregate of size 20mm, having the specific gravity of 2.74.

Copper slag

Copper slag is a byproduct produced during the copper smelting and refining process. Slag that is quenched in water produces angular granules which are disposed of as waste material and fly ash is produced by burning of powdered coal.

Copper slag

Table 1.1 Physical properties of copper slag

Properties	Copper slag
Hardness	6-7
Specific gravity	3.51
Bulk density	1.87
Particle shape	Irregular
Appearance	Black and glassy
Fineness modulus	3.47
Angle of internal friction	51 20

Chemical properties	Percentage
Fe	42 – 48
Sio2	26 – 30
Al2o3	1.0 - 3.0
Cu	0.6 - 0.7
S	0.2 - 0.3
Cao	1.0 - 2.0
Mgo	0.8 - 1.50
Fe3O4	1.0 - 2.0
As	0.02 - 0.05
Pb	0.06 - 0.08
Co	0.01 - 0.03
Cr	0.02 - 0.04
Zn	0.2 - 0.4
Ni	0.005 - 0.008
Chloride	0.001 - 0.002
PH	7.0 - 7.5

Table 1.2 Chemical properties of copper slag

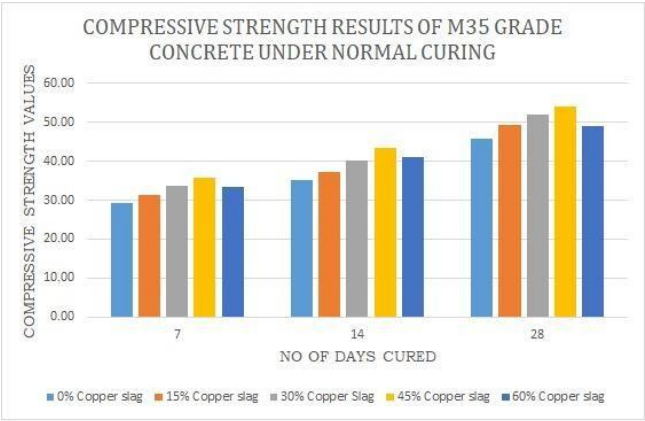
1.2 Preparation and testing of specimen

M35 grade concrete was used to find out the test results. For that concrete specimens were prepared to find out the compressive strength, split tensile and flexural strengths. Concrete cubes of size 150 X 150 X 150mm were casted for all grades of concrete, 150 X 300mm cylinders were used for split tensile strength values and 150 X 150 X 600mm beams were used to find out flexural strength values. The above specimens were cured and tested at 7, 14, 28 days after that the specimens were cured under Acids H2SO4 and Na2SO4 at 28 days after water cured and the results were tabulated below.

2. Results and Discussions

2.1 Compressive strength test

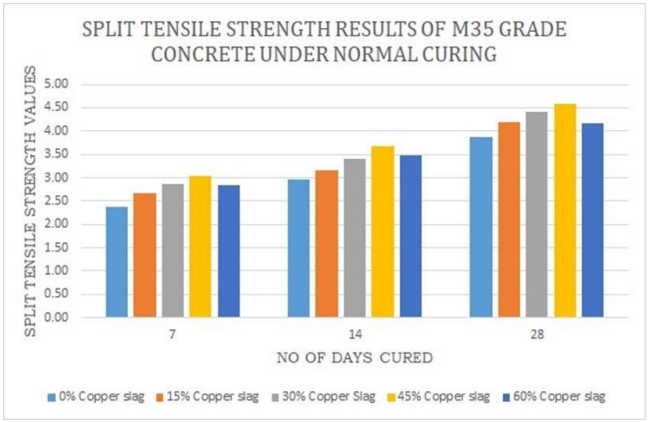
The compressive strength results were carried out at 7, 14 and 28 days under curing under normal water and with acids and the results were as shown below



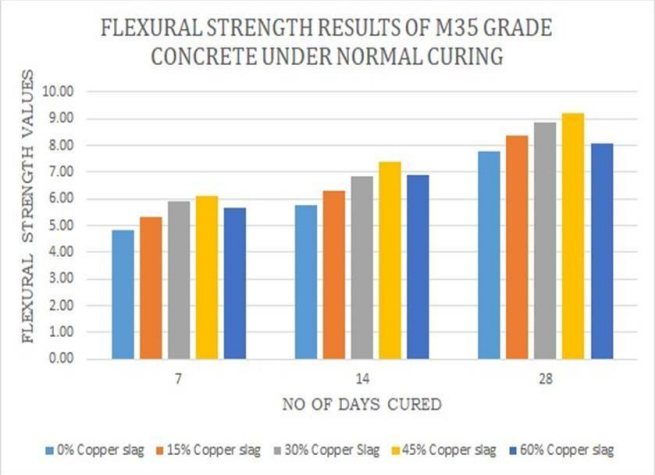
2.2 Split tensile strength test

The split tensile strength results were carried out at 7, 14 and 28 days under curing under normal water and with acids and the results were as shown below

2.3 Flexural strength test



The Flexural strength results were carried out at 7, 14 and 28 days under curing under normal water and with acids and the results were as shown below.



From the above test results it shows that upto 45% replacement of sand with copper slag the compressive strength, Split tensile Strength and Flexural strength the strength increases and from there onwards it decreases. Hence the optimum percentage of replacement is marked at 45%.

Effect of H_2SO_4 on weight loss

Copper slag (%)	% loss of weight		
	7 days	14 days	28 days
0	8.675	11.570	14.054
15	6.950	9.450	13.850
30	5.150	7.977	11.667
45	4.957	5.450	8.125
60	3.750	4.756	7.985

Effect of sodium sulphate on weight loss

As sodium sulphate is a non-toxic material the effect of Na2SO4 gives the same results. No change in the weight is observed.

3. CONCLUSIONS

1. The compressive strength increased with increase in copper slag content up to a replacement level of 45%. The optimum replacement level of copper slag is observed at 45%.

2. Beyond 45% replacement of copper slag there is decrease in strengths were observed.

3. The split tensile strength increased with increase in copper slag content up to a replacement level of 45%. The optimum replacement level of copper slag is observed at 45%.

4. The flexural strength increased with increase in copper slag content up to a replacement level of 45%.The optimum replacement level of copper slag is observed at 45%.

5. With the increase in replacement level of copper slag there is loss in weight of the concrete which is observed at 28 days of curing under H_2SO_4 acidic solution.

6. The behavior of concrete shows same values when cured under NA_2SO_4 solution.

7. Corrosion of reinforcement will be observed because copper slag contains 50% of ferrous content.

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