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EXPERIMENTAL INVESTIGATIONS ON FLEXURAL BEHAVIOR OF COPPER SLAG CONCRETE BEAM AT EARLY AGE

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ABSTRACT

The increasing demand for natural aggregates has lead to the attempt of partial replacement of fine aggregates with copper slag in concrete. The primary test on flexural behaviour of beams is conducted on the partially replaced concrete, to determine the possibility of using copper slag as a replacement of sand in concrete. The test results of concrete are obtained by replacing copper slag to sand in various percentages ranging from 0 to 60 percentages. All specimens are cured for 7 days before flexural behaviour of the concrete beams are tested.

Keywords: copper slag, fine aggregate replacement, flexural strength.

INTRODUCTION

To ensure sustainable development one would have to reconcile human needs with the capacity of the planet and to cope with the consequences of human activities as in other words to take from earth as little as possible natural resources and to return to earth as possible non-natural waste.

The growth of construction industry in India is increasing rapidly. The increase in the demand for housing and commercial space had driven the sector to a growth rate of 9.2 per cent every year, against the global average of 5.5 per cent. In recent times, concerns have been raised over the way residential buildings and commercial buildings are designed and constructed. Most of these concerns pertain to technology, environment, energy and sustainable construction methods.

The most common raw material used in construction is steel, cement, glass, aluminium, plastics, bricks. All these are energy-intensive material and should be transported across vast distances resulting in more energy consumption. It is not possible to meet the ever-growing demand for housing by using traditional energy-efficient material like mud, thatch, timber, etc.

Thus there is a need for optimum utilization of the available energy resources and raw material to produce simple, environment-friendly, energy-efficient and sustainable building alternatives. It is in this context that the eco-friendly construction material gain importance. Large quantities of industrial waste and by-products accumulate every year in the developing countries. Resource efficiency and sustainability are increasing and is the most important issues in today's construction industry. Therefore, utilization of secondary materials in construction field are being encouraged. For the production of cement and concrete, high amount of energy is required. Harmful effects of concrete shall be reduced by producing good and durable concrete using industrial by-products. Copper slag is a material which is considered as a waste material which could have a promising and beneficiary future in construction field as partial or full substitute of either cement or aggregates.

Copper slag

As a result of continuous growth in population, the accompanying technologies involving waste disposal, rapid industrialization and the rate of discharge of pollutants into the atmosphere is high. Copper slag is an industrial waste which comes out from blast furnace during metal extraction process. Copper slag is produced as a by-product of metallurgical operations in reverberatory furnaces.

Originally imported from Japan, copper slag was generally used as an abrasive material for removing marine deposits from ships through sandblasting and rust. Because of repetitive recycling and usage, the copper slag loses its original abrasive property and will be of no good use thereafter disposed in landfills.

The factors affecting the durability characteristics of concrete clearly points out to one major dependency, which is the permeability of concrete. Most of the factors influencing the durability of concrete suggest a control measure of lowering the permeability of concrete. It must be noted that the permeability of concrete is dependent on the water cement ratio, porosity and microstructure of concrete. Reducing the water cement ratio and by utilization of denser material will reduce the void ratio and improve the microstructure of concrete. With lower permeability the durability of concrete can be improved.
The slag is a black glassy and is granular in nature and has a particle size range similar to that of sand. The specific gravity of slag ranges between 3.3 and 3.98. The bulk density of granulated copper slag is varying between 1.8 to 2.15 g /cc that is almost similar to that of the bulk density of conventional fine aggregate. The free moisture content present in slag is less than 0.5%. Both sand and copper slags have comparable particle size distribution. However, sand has higher fines content than copper slag.

Flexural strength of beams

Flexural strength can also be called as modulus of rupture, fracture strength, bends strength. It is a material property generally expressed as the stress in a material before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen of

rectangular cross-section is bent until fracture or yielding using a two point loading technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture.

The concrete with three partial replacement levels [20, 40, and 60%] have been tested for their flexural strength after 7 days of curing. The size of the specimen casted was 750mm x 150mm x 150mm.The test was carried out in the Universal testing machine of capacity of 40 Tons. Two point loading system was adopted for the test.

The average modulus of rupture (flexural strength) was determined using the following expression

$F_{cr} = FL/BD^2$

Where,

Fcr = modulus of rupture,
F = ultimate load in KN,
L = length of beam in mm,
B = Average width of specimen in mm,
D = Average depth of specimen in mm.

The bending moment, induce compressive stress at the top and tensile stress at the bottom of beam. The beam fails in tension. The first cracks formed between the locations of the maximum bending moment. Thereafter, by subsequent load increment more cracks started to form over the shear span on both sides of the beam. Flexural beam replaced with copper slag as partial replacement for fine aggregate gave more flexural strength compared to that of the control specimens.

Figure-1. Experimental set up.

Table-1. Flexural strength of beams after 7 days.

S. No.	**Copper slag** (%)	**Ultimate load** (KN)	**Flexural Strength** (N/mm^2)	**Increase in Flexural Strength** (%)
1	Control mix	79	17.55	-
2	CS 20	88	19.50	11.11
3	CS 40	91	20.22	15.21
4	CS 60	96	21.33	21.54

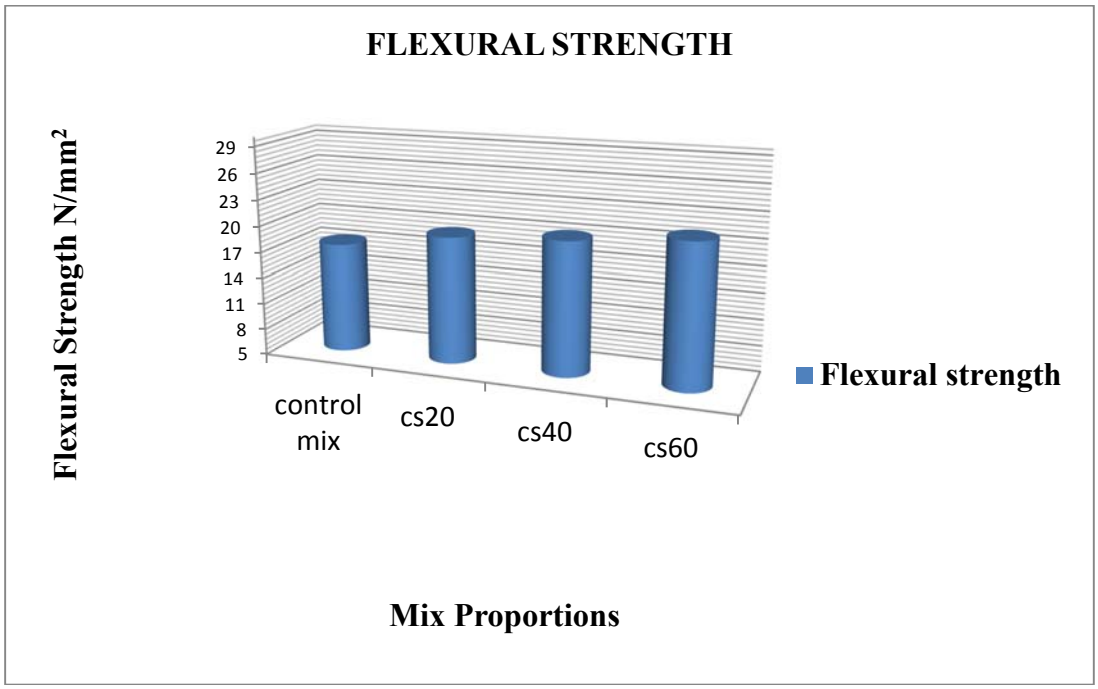

Figure-2. Flexural strength of beam after 7 days.

CONCLUSION

The following conclusions were obtained from this research study with replacement of sand to copper slag on the concrete properties

- The addition of copper slag has improved the flexural strength of concrete.
- While replacement of copper slag in concrete increases, the density of concrete increases.
- It was observed that the partial replacement of copper slag as fine aggregate greatly increased the compressive strength at 20%, 40% and 60%.
- The flexural strength of the beam increased by 11% to 21% with replacement of copper slag.

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