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SPLIT TENSILE STRENGTH OF COPPER SLAG CONCRETE

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ABSTRACT

This research is based on the study of splitting tensile strength in concrete with replacement of copper slag which is a by-product of copper extraction by smelting. Slag that is quenched in water produces angular granules which are disposed as waste or utilized as replacement product. The objective of this study is to find the splitting tensile strength of concrete with copper slag for the replacement of fine aggregate which helps in reduction of pollutants in the environment caused by copper slag. This research work is done by replacing copper slag with sand from 0% to 60% in concrete and the splitting tensile strength of replaced copper slag concrete was compared with control concrete.

Keywords: copper slag, fine aggregate, splitting tensile strength, replacement.

INTRODUCTION

The main constituent of concrete is aggregate. It occupies more than 70% of the concrete matrix. In most of the countries, there is a scarcity of natural aggregate used for construction, whereas in some countries the consumption of aggregate has increased in recent years, due to increases in the construction industry. In order to reduce scarcity of natural aggregate due to construction, some industrial waste materials can be used as alternatives. Copper slag (CS) produced during matte smelting and copper conversion was considered as waste and disposed as landfill. It has been measured that for every ton of copper production about 2.2-3 tons of slag are generated (Gorai *et al*., 2003).Slag containing < 0.8% copper are either discarded as waste or sold cheaply. Processed granulated CS has a number of favorable mechanical properties for aggregate use. The tests indicate that the heavy metals present in the slag are stable and are not likely to dissolve significantly even through repetitive leaching under acid rain.

This slag is a black glassy and granular material and has a similar particle size like sand which indicates that it could be tried as replacement for the sand in cement mixture. The specific gravity of the slag is 3.58. The bulk density of granulated copper slag varies from 1.70 to 1.90 g/cc which is similar to the bulk density of conventional fine aggregate. The hardness of the slag lies between 6 and 7 in MoH scale. This is equal to the hardness of gypsum. The free moisture content available in slag is less than 1%. The sieve analysis for copper slag infers that the gradation properties of fine aggregates at all the replacement percentage are similar to the specification for sand zone II as per IS: 383. The available of silica in slag is near to 26% which is desirable since it is one of the constituents of the natural fine aggregate used in normal concreting operations. Al-Jabri *et al* (2009, 2011) said that the addition of copper slag up to 50% CS for sand yielded comparable strength to that of a control mixture with no CS. Further addition of CS caused a reduction in strength. Khalifa al Jabri (2009) said that Utilization of CS for applications such as replacement for fine aggregate (FA) in concrete has the dual benefit of avoiding the costs of disposal and reducing the cost of the concrete.

Materials

Cement

53 grade Ordinary Portland Cement is used for all concrete sample mixes. The cement used was fresh and without any lumps.

Table-1. Properties of Cement.

S. No.	Characteristics	Values	Standard value
1	Initial setting time	36 min	Not less than 30min
2	Final setting time	210 min.	Not greater than 600min
3	Fineness (%)	3.5	<10
4	Specific gravity	3.15	-

Fine aggregate

The size of the aggregates less than 4.75 mm is considered as fine aggregate. The main source of fine aggregate is that from river or seashore bed sand, pit sand. The shape of river or bed sand is round and that of pit sand is irregular or partially round.

Table-2. Properties of fine aggregate.

1	Water absorption	1.122%
2	Specific gravity	2.61
3	Sieve analysis	4.70

Coarse aggregate

Size of aggregate higher than 4.75 mm is considered as coarse aggregate and the main source of coarse aggregate is rock quarrying, bounder on river bed. For our project we are considering 20 mm size of coarse aggregate. Since lesser the size of the aggregate, it increases the surface area which promotes workability and hence water is less which gives higher strength than traditional concrete.

Table-3. Properties of coarse aggregate.

1	Water absorption	0.663%
2	Specific gravity	2.84
3	Sieve analysis	4.754

Water

Water is the important ingredient of concrete as it actively participates in chemical reaction with cement. Quantity and quality of water should be good. Optimization quantity of water is always required to get the best result. Whereas when quality is concerned the potable water should have pH value from 6 to 8 and the water should be free from organic matter.

Copper slag

CS used in this work is the slag produced by Sterlite Industries Ltd (SIL), Tuticorin, Tamil Nadu, India.

Table-4. Properties of copper slag.

1	Water absorption	0.636%
2	Specific gravity	3.36
3	Sieve analysis	4.33

Mix design

The mix tried in this investigation is M30 concrete and W/C ratio is taken as 0.45.

EXPERIMENTAL WORK

Split tensile test on concrete

The tensile strength is one of the important properties of the concrete. The concrete is not normally expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is important to determine the load at which the concrete members may crack. The cracking is a form of tension failure.

The cylinder mold shall is of metal, 3 mm thick. Each mold is capable of being opened longitudinally to the removal of the specimen and is provided with a means of keeping it closed while in use. The mean inner diameter of the mold is 15 cm ± 0.2 mm and the height is 30 +/- 0.1 cm. Each mold contains metal base plate .Mold and base plate should be coated with a thin film of mold oil before use, in order to prevent adhesion of concrete. The samples cured for 7 days were tested using UTM machine.

Figure-1. Specimen used for split tensile test.

Table-5. Split tensile test for 7 days.

Specimen	**Load** (KN)	**Tensile strength** (N/mm^2)
CS 0%	60	0.85
CS 20%	70	0.99
CS 40%	88	1.24
CS 60%	72	1.01

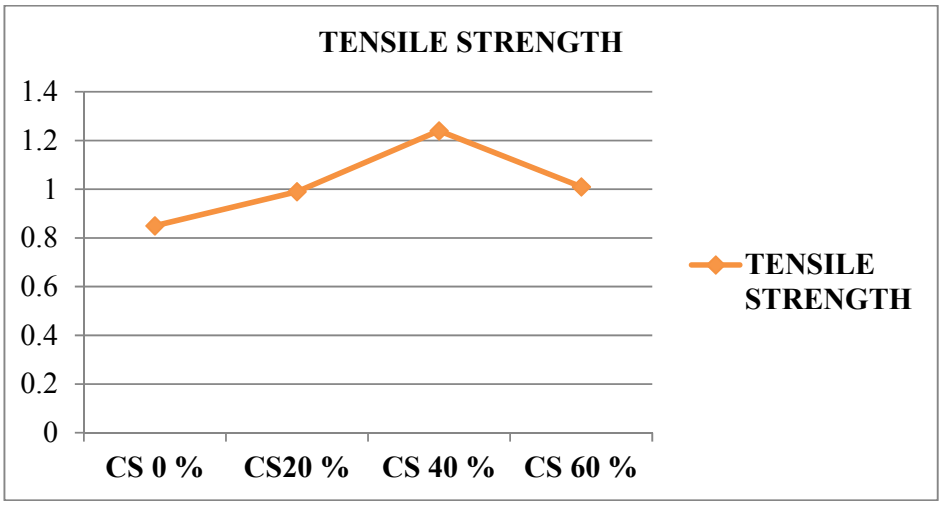

Figure-2. Tensile strength results of cylinder.

DISCUSSIONS

The use of CS as a replacement in fine aggregate on low-strength concrete and reported to get high tensile strength.

It is observed that replacement of copper slag by 20% is evident with increase in tensile strength by 14% more than control mix. Likewise 40% replacement is evident with increase by 31% more than control mix.

The addition of copper slag up to 50% CS for sand yielded comparable strength to that of a control mixture with no CS. Further addition of CS caused a reduction in strength.

CONCLUSION

The following conclusions are drawn from the study:

- It is observed that for all percentage replacement of fine aggregate by Copper slag the tensile strength of concrete is more than control mix.
- It is observed that, the tensile strength of concrete at 7 days is higher than design mix (Without replacement). This also indicates tensile strength is more for all percentage replacements than design mix.
- Splitting tensile Strength is increased due to high toughness of Copper slag.

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