

# Effect of Copper Slag as Partial Replacement of Fine Aggregate in Concrete: A Literature Review

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**ABSTRACT:** In present scenario, alternative materials in all forms of constructions is introduced to reduce the pressure on good quality natural materials, which will balance the economical purpose of the project while also taking care of the surrounding environment. A large amount of by-product or wastes such as fly-ash, copper slag, silica fume etc. are generated by industries, which causes environmental as well as health problems due to dumping and disposal. Copper slag is a by-product produced during smelting of copper. Each ton of copper produced, produces around 2.2 tons of copper slag. Copper slag can be utilized as fine aggregate in cement mortars, normal concrete and also as aggregates (coarse) in concrete (high strength). As fine aggregate in cement mortar, copper slag provides good interlocking which leads to better volumetric and mechanical quality of different mixes. It was reported that about 50% substitution of copper slag in cement mortar increased the compressing strength highly, slightly increased the density and significantly increased the workability [1]. This paper presents literature review on replacement of fine aggregate by copper slag which includes current and future trends of research.

**KEYWORDS:** Concrete, Compressive Strength, Copper slag, Flexure Strength, Fine aggregate

## I. 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 [2]. 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 CO<sub>2</sub> 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.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 12, December 2016

## II. ADVANTAGE OF COPPER SLAG IN CONCRETE

- Cost of Concrete production is reduced when Copper Slag is used as a fine aggregate in concrete.
- High toughness of Copper Slag contributes to Increased Compressive strength.
- Due to low water absorption and due to glassy surface of Copper slag the workability of concrete is increased with increase of Copper Slag content in the concrete mixture.
- Use of copper slag has helped in waste management and dumping of industrial wastes.
- Copper Slag has similar properties as river sand as it contains silica ( $\text{SiO}_2$ ) similar to sand.
- Addition of Copper Slag increases the density of concrete thereby increasing the self-weight.

## III. REVIEWS OF ARTICLES ON EFFECT OF COPPER SLAG AS PARTIAL REPLACEMENT OF FINE AGGREGATE IN CONCRETE

- **Nataraja, Chandan&Rajeeth** studied on concrete mix design using copper slag as fine aggregate. This paper presents the experimental results of an on-going project to produce concrete with copper slag as a fine aggregate. The effect of replacing fine aggregate with copper slag on the compressive, flexural and split tensile strength of concrete are studied in this work. It was seen that for design mix (1:1.66:3.76) with w/c = 0.45 and 0 to 60% replacement 7- days compressive strength (MPa) was found to be 36.00(equivalent volume) 37.26(equivalent weight) for 100% replacement of copper slag[3]
- **Leema Rose & Suganya** examines the Performance of Copper Slag on Strength and Durability Properties as Partial Replacement of Fine Aggregate in Concrete. The main aim of this study is to find the strength and durability properties of concrete in which fine aggregate replaced with Copper slag partially by 10%, 20%, 30%, 40%. They concluded that the addition of copper slag in concrete increases the density of the concrete. The results of compressive tests show that the strength of the concrete increases with respect to the percentage of copper slag added by weight of fine aggregate up to 30% of replacement of copper slag strength was found to be 45.42 N/mm<sup>2</sup> for a design mix 1: 1.4: 2.6 keeping w/c ratio as 0.4[4]
- **Singh & Bathin** their paper studied the use of copper slag as fine aggregate - a case study. Dependence on natural aggregates as the main source of aggregate in concrete can be replaced by artificially manufactured aggregates or artificial aggregates generated from industrial wastes and has provided an alternative for the construction industry. The results indicate that the use of copper slag in concrete increases the flexural strength of about 17% with that of control mixture. It is recommended that up to 40% of copper slag can be used as replacement of fine aggregates. Maximum flexural strength (6.67 N/mm<sup>2</sup>) was observed for 40% replacement after that flexural strength trend decrease for further replacement. [5]
- **Srinivasu, Kranti, Nagasai & Saikumar** study on compressive strength properties and effects of copper slag as partial replacement of fine aggregate in concrete. The Two different types of concrete grades M30 & M40 were used with different percentage of copper slag replacement from 0 to 100 percentage. The percentage replacement of sand was 0%, 10%, 20%, 30%, 40%, 50%, 60%, 80% & 100%. The concrete was tested for 7 days & 28 days compressive strength after casting the moulds. Increased compressive strengths for the above grade of concretes were observed. For M30 grade concrete, the highest compressive strength was achieved at 7 days by 50% replacement of copper slag is 39.105 Mpa and the maximum compressive strength was achieved at 28 days by 10% replacement of copper slag and which was found about 44.66 MPa, compared with nominal mix (29.87 N/mm<sup>2</sup> and 41.65 N/mm<sup>2</sup>) and for M40 grade concrete, the maximum compressive strength was achieved at 7 days by 20% replacement of copper slag is 44.44 MPa and the highest compressive strength was achieved at 28 days by 50% replacement of copper slag and which was found about 53.105 MPa, compared with nominal mix (32.33 N/mm<sup>2</sup> and 47.11 N/mm<sup>2</sup>). [6]
- **Shia, Meyer & Behnood** studied on Utilization of copper slag in cement and concrete. The cement, mortar and concrete containing different forms of copper slag have good performance in compressive strength with ordinary Portland cement having normal and even higher strength. [7]
- **Arivalagan** carried an Experimental Study on the Flexural Behavior of Reinforced Concrete Beams as Replacement of Copper Slag as Fine Aggregate. The test results of concrete were obtained by replacing the sand by copper slag in various percentages ranging from 0%, 20%, 40%, 60%, 80% and 100%. Curing of all specimens

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Vol. 5, Issue 12, December 2016

was done for 28 days before the compression strength test, splitting tensile test and flexural strength. The high compressive strength obtained was 35.11MPa (40% replacement) and the corresponding strength to control mix was 30MPa. [8]

- **Velumani&Maheswari** studied on Mechanical and Durability Properties of RC Beams Using Copper Slag as Fine Aggregate in Concrete. Copper slag has physical properties similar to the fine aggregate, so it can be used as a replacement of fine aggregate in concrete. Copper slag has lower absorption and higher strength properties than fine aggregate. Replacement of copper slag increases the self-weight of concrete specimens to the maximum of 15% to 20%. [9]
- **Madhavi, Pavan Kumar &Jothilingam** studied on Effect of Copper Slag on the Mechanical Strengths of Concrete. Experimental investigations are carried out by replacing the sand with copper slag in proportions of 10%, 20%, 30%, 40%, 50%, 60% and 100% keeping all other ingredients constant. It was seen that the optimum content of copper slag is 40% beyond which the strength starts decreasing. [10]
- **Patil,Patil&Veshmawala** observe the Performance of Copper Slag as Sand Replacement in Concrete.M30 concrete was used and various tests like compressive, flexural, split tensile strength were conducted for different percentages of copper slag and sand from 0 to 100%. The result showed that workability increases with increase in percentage of copper slag. Maximum Compressive strength of concrete increased by 34 % at 20% replacement of fine aggregate with copper slag, and up to 80% replacement of copper slag, concrete gain more strength than normal concrete strength. The flexural strength of concrete found to be increased by 14% with 30% replacement of copper slag. [11]
- **Zerd** conduct an Experimental Investigation on Properties of Concrete by Replacement Copper Slag for Fine Aggregate. The fine aggregates were replaced with percentages 0% (for the control mix), 20%, 40%, and 60% of Copper Slag by weight. Tests were performed for properties of fresh concrete and Hardened Concrete. Compressive strength was determined at 3, 7,14 and 28 days. Properties like workability and density were increased with the use of copper slag in concrete. Improvement in the strength properties of plain concrete by the inclusion of up to 40% Copper slag as replacement of fine aggregate was observed as 25.58 N/mm<sup>2</sup> at 28 days for M20 concrete. [12]

## IV. CONCLUSION

The review of earlier studies related to partial replacement of fine aggregate with copper slag reveals that there is a significant change in the strength properties of concrete such as compressive strength, flexural strength, split tensile strength. These experiments were carried out in various grade concrete such as M20, M25, M30 and M35 to find out the result. From the above literature reviews improvement in the strength of concrete has been observed in terms of Compressive Strength, Flexural Strength and Tensile Strength on partial replacement of fine aggregate with copper slag. Therefore, the scope of further research work as partial replacement of fine aggregate with copper slag in terms of high strength concrete (i.e. M40) has still to be studied.

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Vol. 5, Issue 12, December 2016

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