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Research Paper

Properties of Concrete Using Copper Slag as Partial Replacement for Fine Aggregate

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ABSTRACT: *In this research work Copper slag is partially used as fine aggregate to produce concrete. Sustainability and resource efficiency are becoming increasing important issues. Here the potential use of granulated copper slag, which is the waste material produced in the extraction process of copper metal, as a replacement to sand in concrete mixes is explored. Here the copper slag is replaced for fine aggregate in different proportions as 40%, 60% and 80%. The effect of replacing fine aggregate by copper slag on the compressive strength of concrete and Slump of concrete were studied in this work. The properties of cement, fine aggregate, coarse aggregate and copper slag used in concrete were tested. The main objective of the work is to encourage the use of these waste products which get from copper manufacturing industry as a construction material.*

KEYWORDS: *Concrete, Copper slag, Replacement of fine aggregate.*

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I. INTRODUCTION

River sand is being used as fine aggregate in concrete for centuries. However, river sand is not a renewable natural resource. In some regions, river sand has been excessively exploited, which has endangered the stability of river banks and the safety of bridges, and creates environmental problems. On the other hand, river sand is expensive due to excessive cost of transportation from natural sources. Seeking for river sand alternatives has become urgent. Manufactured sand is produced by crushing rock depositions which is generally more angular and has rougher surface texture than river sand particles.

The shape and texture of crushed sand particles could lead to improvements in the strength of concrete due to better interlocking between particles. Water reducers and mineral admixtures can be used to improve workability. Few investigations have studied the durability properties and performance characteristics of concrete with copper slag as fine aggregate. They have concluded that the copper slag performs similar or better compared to natural sand concrete. Previous researches have shown that good quality concrete can be made using manufactured sand with high amount of micro fines.

Generally the compressive strength, flexural strength, bond strength, water permeability, impact resistance, sulphate resistance and abrasion resistance tend to increase to a certain limit within creasing proportions of micro fines. After the limit is reached, the strength decreases because there is not enough paste to coat the aggregate. Since the beginning of the industrial era, slags, the glassy materials left over when metals are pyrometallurgically extracted from ores, have been considered waste. One such material is copper slag which is produced during matte smelting and converting steps of pyrometallurgical production of copper.

During matte smelting two separate liquid phases, copper-rich matte (sulphides) and slag (oxides) are formed. It has been estimated that for every ton of copper production about 2.2 tons of slag is generated. Dumping or disposal of this slag causes wastage of metal values and leads to environmental problems. Rather than disposing, these slags can be used taking full advantage of its physico-mechanical properties. In this paper, an extensive study using copper slag has been carried out to investigate strength, workability and durability

II. LITERATURE REVIEW

Al-Jabriet al (2009) has investigated the performance of high strength concrete (HSC) made with copper slag as a fine aggregate at constant workability and studied the effect of super plasticizer addition on the properties of HSC made with copper slag. Two series of concrete mixtures were prepared with different proportions of copper slag. The first series consisted of six concrete mixtures prepared with different proportions of copper slag at constant workability. The water content was adjusted in each mixture in order to achieve the same workability as that of the control mixture. Twelve concrete mixtures were prepared in the second series. Only the first mixture was prepared using super plasticizer whereas the other eleven mixtures were prepared without using super plasticizer and with different proportions of copper slag used as sand replacement. The results indicated that the water demand reduced by almost 22% at 100% copper slag replacement compared to the control mixture. The strength and durability of HSC were generally improved with the increase of copper slag content in the concrete mixture. However, the strength and durability characteristics of HSC were adversely affected by the absence of the super plasticizer from the concrete paste despite the improvement in the concrete strength with the increase of copper content. The following conclusions were drawn from this study .Compared to the control mix, there was a slight increase in the HPC density of nearly 5% with increase of copper slag content, whereas the workability increased rapidly with increase in copper slag percentage. Addition of up to 50% of copper slag as sand replacement yielded comparable strength with that of the control mix. However, further additions of copper slag caused reduction in the strength due to an increase of the free water content in the mix. There was a decrease in the surface water absorption as copper slag quantity increased up to 40% replacement. Beyond that level of replacement, the absorption rate increases rapidly. It was recommended that 40 wt% of copper slag can be used as replacement of sand in order to obtain HPC with good Properties.

Wei wu et al (2010) investigated the mechanical properties of high strength concrete incorporating copper slag as fine aggregate. The workability and strength characteristics were assessed through a series of tests on six different mixing proportions at 20% incremental copper slag by weight replacement of sand from 0% to 100%. A high range water reducing admixture was incorporated to achieve adequate workability.

Micro silica with a specific gravity of 2.0 was used to supplement the cementitious content in the mix for high strength requirement. The following conclusions were drawn from this study:

• The results indicated that the strength of concrete with less than 40% copper slag replacement was higher than or equal to the control specimen.

Figure 1 Copper slag

• The microscopic view also suggest that the microstructure of concrete with more than 40% copper slag contains more voids, micro cracks, and capillary channels that accelerate the damage of concrete during loading.

• The surface water absorption decreases constantly until 40% of copper slag substitution

Najimi et al (2011) investigated the performance of copper slag contained concrete in sulphate solution. In this regard, an experimental study including expansion measurements, compressive strength degradation and micro structural analysis were conducted in sulphate solution on concretes. This was made by replacing 0%, 5%, 10% and 15% of cement with copper slag waste. The results of this study emphasized the effectiveness of copper slag replacement in improving the concrete resistance against sulphate attack.

III.MATERIAL & METHODS

Materials were collected for making concrete. Materials needed for cement concrete are cement, fine aggregate, coarse aggregate, copper slag and water.

3.1 Cement

Cement is a binder, a substance that sets and hardens and can bind other materials together. The cement used in this experimental work is "Birla Super Cement."(OPC53).

3.2 Sand

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type; i.e., a soil containing more than 85 percent sand-sized particles by mass.

3.3 Copper Slag

Copper slag is an industrial by-product material produced from the process of manufacturing copper having similar physical, mechanical &chemical properties of Sand can be considered as an alternative to the river sand.

Figure 2 Casting cubes,

3.4 Coarse Aggregate

Aggregates are the most mined materials in the world. Aggregates are component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material.

3.5 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully

Table 3.1 Specific Gravity

Cement	3.14
Copper slag	3.83
Fine Aggregate	2.51
Coarse Aggregate	2.72

3.5 Specimen Preparation

The cubes were designed having dimensions 150mm X 150mm X 150mm. The M25 grade concrete was prepared with copper slag as a replacement of fine aggregate in various proportions i.e. 40, 60 & 80% by hand mixing then casted cubes are then unmolded and was cured for 7days and 28days.

Figure 3 Curing of concrete cubes,

IV. RESULTS AND DISCUSSION

4.1 Testing Of Specimen

Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A compression test is performed on standard cubes of concrete with copper slag as partial replacement of fine aggregate as 40%, 60% and 80% of size 150mm x 150mm x 150mm after 7 days immersion in water for curing and 28 day cubes are in possess of curing.

Figure 4 Determination of Compressive Strength of concrete

4.2 Split Tensile Test

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. It has been estimated that tensile strength of concrete equals roughly about 10% of compressive strength.

Table -9: Compressive Strength of Concrete

Sl.No.	Percentage Replacement of Copper slag	Compressive Strength N/mm^2
1	0%	29.33
2	20	32.56
3	40	35.11
4	60	42.88
5	80	39.11

Figure 5 Determination of Split tensile Strength of concrete

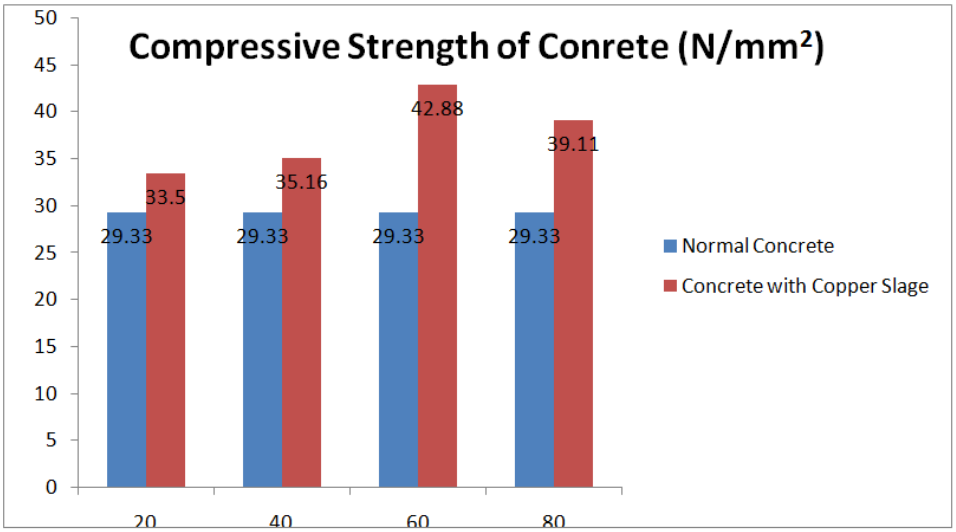

Figure 5 Compressive strength of concrete with different percentage of copper slag with normal concrete.

Table -9: Compressive Strength of Concrete

Sl.No.	Percentage Replacement of Copper slag	Compressive Strength N/mm^2
1	0%	2.96
2	20	3.12
3	40	3.53
4	60	4.1
5	80	3.82

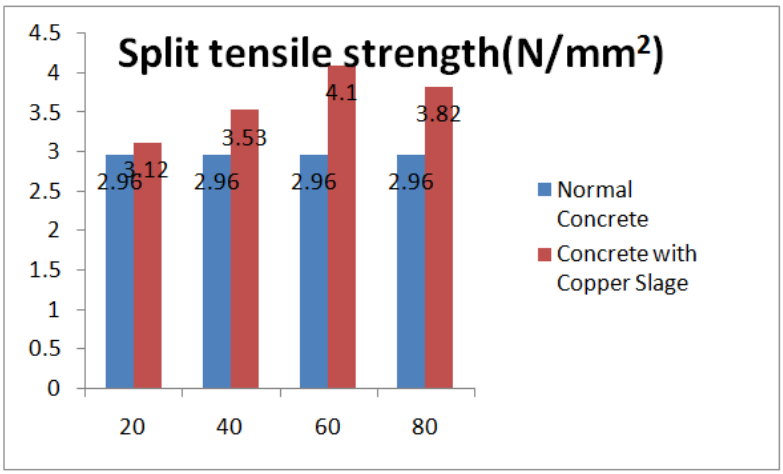

Figure 5 Compressive strength of concrete with different percentage of copper slag with normal concrete.

V. CONCLUSION

Copper slag can be used as an alternative to natural sand in concrete. When Copper slag is replaced with equivalent weight because of the fact more mortar is there to surround the aggregate therefore may workability will increase in terms of slump, however the compaction factor is more or less same comparable to that of the natural sand. Compressive strength of concrete is increased up to 40% due to the replacement of Copper slag.. Because of the significant difference in the specific gravity between fine aggregate and copper slag, higher strength was achieved in Copper slag used concrete. The results indicated that adding up to 60% of copper slag as sand replacement yielded highest compressive strength. However, further additions of copper slag caused reduction in the strength. It is recommended that 60% of copper slag can be used as replacement of sand in order to obtain higher strength.

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