*International Journal of Research in Advent Technology (IJRAT) Special Issue "*ICADMMES 2018*"*
E-ISSN: 2321-9637
Available online at www.ijrat.org

Mechanical Properties of Concrete By Partial Replacement of Fine Aggregate With Angular Granuled Copper Slag

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Abstract – Concrete is the most popular of all construction materials. It is used in everything from bridges to pavement. New technologies are making concrete stronger than ever and the future looks bright for the engineers of tomorrow. Concrete is made up of two main materials, aggregate and a paste that acts like glue to hold the aggregate together. The aggregate are divided into two classifications: Fine Aggregate and Coarse Aggregate. Copper Slag is an industrial waste which comes out from blast furnace during metal extraction process by and large, a waste product, if consumed by construction industry in large quantities superplasticizers, when added to stone dust concrete, can lower water cement ratios, and improve the strength, volumetric stability and handling characteristics of the wet mix. The behaviour of copper slag seems to be similar to river sand, for its use as fine aggregate (partially or in blending) in concrete mixes.Addition of copper slag (having higher density) in concrete increases the density, thereby the self-weight of concrete, (by about 4.5% for 50% replacement).The results showed that the workability of concrete increased substantially with increase of copper slag content in the concrete mixture due to the low water absorption, coarser (in nature than sand) and glassy surface of copper slag, thereby the strength properties also improved.

Index Terms – Ordinary Portland Cement, Copper Slag, Conventional concrete, Compressive strength, Split tensile strength.

1. INTRODUCTION

In many countries, there is a scarcity of natural aggregate that is suitable for construction, whereas in other countries the consumption of aggregate has increased in recent years, due to increases in the construction Industry. In order to reduce depletion of natural aggregate due to construction, artificially manufactured aggregate and some industrial waste materials can be used as alternatives. Thus our project is to utilize the copper slag is the replacement for fine aggregate for maintaining economy and increasing the strength of concrete. By this project we can also solve the problem of disposal of this type of industrial waste. Different types of slag according to the property can be utilized in different purposes.

2. NECESSITY OF PRESENT STUDY

The demand for natural sand is quite high in developing countries since the available sand is not able to meet the demands of construction sector, because natural sand takes millions of years to form and it is not replenish able. Due to continuous dragging of the sand from river beds reduces the water head, leads to less percolation of rain water in to the ground. This leads to lower ground water level, which results in scarcity of drinking water. Hence there is an urgent need to identify a suitable substitute for natural sand, which should be eco-friendly and inexpensive. On the other hand, large quantities of slag produced as a by-product of metallurgical operations, resulting in environmental concerns with its disposal. Hence there is an increased need to explore the possibility of utilization of Industrial waste materials in making concrete. This will lead to sustainable concrete design and greener environment. The effect of the partial replacement of sand by slag on mortar and concrete properties is investigated. Two different sands and four different volume contents of copper slag 20%, 40%, 60% and 80% were used in mortar mixtures. Firstly the plain concrete cubes will be casted without any replacement of copper slag of ratio 1:1:2 [cement: fine aggregate: coarse aggregate (10mm and 20mm)] of size (15x15x15) cm. After that cubes with different percentage of copper slag replacement will be casted. Concrete mixes incorporating copper slag instead of fine aggregate, with different cement contents, are also produced and characterized.

The comparison to control mixtures indicates that cooper slag might be suitable for mortar and concrete. Copper slag residues are also used for the production of concrete blocks. After 7 days, 14 days and 28 days the compressive strength will be determined. The comparison between the compressive strength of both the normal and of replaced percentage of copper slag cubes will be done.

3. OBJECTIVES AND SCOPE OF THE STUDY

- To study the suitability of copper slag as replacement to conventional river sand in concrete
- To find the optimum proportion of copper slag that can be used as a replacement/ substitute material for fine aggregate.
- To evaluate compressive and tensile strength of copper slag admixed concrete specimens.

4. SCOPE OF THE STUDY

The government of India has targeted the year 2020 for providing housing for all. Such large scale housing construction activities require huge amount of money. Out of the total cost of house construction, building materials contribute to about 70 percent costs in developing countries like India. Therefore the need of hour is replacement of costly and scarce conventional building materials by innovative, cost effective and environment friend by alternate building materials. Since copper slag concrete showed an enhanced mechanical performance and also has non-substance deemed as toxic was leached, it can be used as a building raw materials. Therefore in this investigation, possibilities of using copper slag for various purposes were examined and reported

5. RESULTS AND DISCUSSIONS

Several researchers have investigated the possible use of copper slag as fine and coarse aggregates in concrete. Although there are many studies that have been reported by investigators from other countries on the use of copper slag in cement concrete, not much research has been carried out in India concerning the incorporation of copper slag in concrete. Even though there are various research studies have been reported by investigators about copper slag, its physical properties and chemical composition varies country wide and hence its mechanical performance also varies according to that. Therefore, this research was performed to generate specific experimental data on potential use of copper slag replacement in concrete.

M20, M25 and M30 concrete was used to perform this investigation. The following tests were conducted to examine the mechanical behaviours of concrete incorporating copper slag as partial replacement of sand.

- Compressive strength test on concrete specimens
- Split tensile test on concrete cylinders of size 150mm diameter and 300mm height.
- Flexural strength test on concrete beam specimens of size 750 x 150 x 150mm.

5.1 Compressive Strength Test on Concrete Cubes

Compressive Strength test results of M20, M25 and M30 grade concrete using varying proportions (0 to 80%) of Copper Slag at 7-Days, 14-Days and 28-Days of curing. Strength studies of M20, M25 and M30 Grade concrete with varying proportions of copper slag. Concrete cubes replaced by 0%, 20%, 40%, 60% and 80% of copper slag. The measured compressive strength values are presented in the below.

Table 1 Abstract Statement on Compressive Strength of Concrete Specimens (N/mm^2)

% Replacement of Sand with Copper Slag	M20 Grade Concrete Mix		
	7 Days	14 Days	28 Days
0%	21.49	24.64	26.47
20%	25.19	31.05	35.43
40%	26.29	34.46	37.45
60%	27.92	35.46	39.45
80%	28.26	35.76	40.28

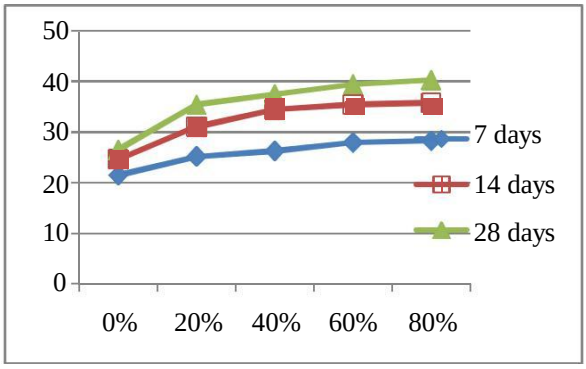

Fig. 1 Compressive Strength of M20 Concrete Specimens

5.2 Split Tensile Strength Test on Concrete Cylinders

Split tensile strength is defined as a method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter. 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.

Table 2 Abstract Statement on Compressive Strength of Concrete Specimens (N/mm^2)

% Replacement of Sand with Copper Slag	M25 Grade Concrete Mix		
	7 Days	14 Days	28 Days
0%	27.44	32.52	34.58

20%	31.49	35.24	38.59
40%	31.86	36.33	40.39
60%	32.62	40.45	43.59
80%	32.92	40.51	43.68

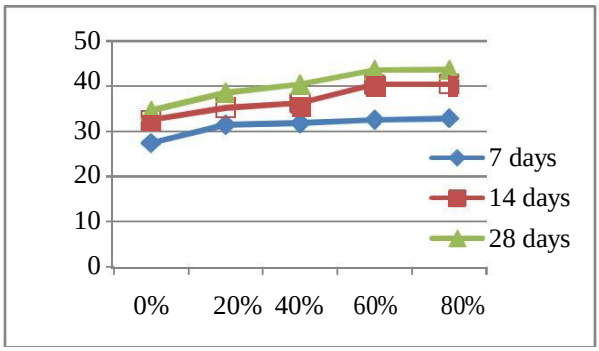

Fig. 2 Compressive Strength of M25 Concrete Specimens

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. The effect of copper slag substitution as a fine aggregate on split tensile strength of concrete is given in the table below.

Table: 3 Results for Split Tensile Strength of Concrete using 0% Copper Slag at 7 days, 14 days and 28 days

S.NO	Grade of Con	7 days St /	14 days Str /	28 days Str /
1	M20	2.962	2.171	2.50
2	M20	2.149	2.326	2.54
3	M20	2.123	2.963	2.47
Average Strength		2.258	2.486	2.50

Table: 4 Results for Split Tensile Strength of Concrete using 60% Copper Slag at 7 days, 14 days and 28 days

S.NO	Grade of Concrete	7 days St /	14 days St /	28 days St /
1	M20	2.31	2.42	2.58
2	M20	2.36	2.47	2.54
3	M20	2.39	2.43	2.45
Average Strength		2.258	2.35	2.44

Table: 5 Results for Split Tensile Strength of Concrete using 0% Copper Slag at 7 days, 14 days and 28 days

S.NO	Grade of Con	7 days St /	14 days St /	28 days St /
1	M25	2.409	2.762	3.19
2	M25	2.513	2.967	3.54
3	M25	2.147	3.042	3.29
Average Strength		2.258	2.356	2.923

Table: 6 Results for Split Tensile Strength of Concrete using 60% Copper Slag at 7 days, 14 days and 28 days

S.NO	Grade of Concrete	7 days Strength /	14 days Strength /	28 days Strength /
1	M25	2.547	2.917	3.46
2	M25	2.179	3.202	3.97
3	M25	2.949	2.827	3.76
Average Strength		2.258	2.558	2.982

Table: 7 Results for Split Tensile Strength of Concrete using 0% Copper Slag at 7 days, 14 days and 28 days

S.NO	Grade of Concrete	7 days Strength /	14 days Strength /	28 days Strength /
1	M30	2.546	2.982	3.34
2	M30	2.667	3.182	3.68
3	M30	2.121	2.800	3.17
Average Strength		2.258	2.454	2.988

Table: 8 Results for Split Tensile Strength of Concrete using 60% Copper Slag at 7 days, 14 days and 28 days

S.NO	Grade of Concrete	7 days St /	14 days St /	28 days St /
1	M30	2.574	2.924	3.67
2	M30	2.793	2.986	3.97
3	M30	2.989	3.091	3.94
Average Strength		2.258	2.785	3.000

CONCLUSIONS

From the above result it can be concluded that we are going to use copper slag as an alternative of fine aggregate the cost of concrete production will be reduced and strength of 80% replaced copper slag concrete will be increased to twice of plain concrete strength. Based on the experimental investigations carried out, the following conclusions were drawn:

- The behaviour of copper slag seems to be similar to river sand, for its use as fine aggregate (partially or in blending) in concrete mixes.
- Addition of copper slag (having higher density) in concrete increases the density, thereby the self-weight of concrete, (by about 4.5% for 50% replacement).
- The results showed that the workability of concrete increased substantially with increase of copper slag content in the concrete mixture due to the low water absorption, coarser (in nature than sand) and glassy surface of copper slag, thereby the strength properties also improved.
- The early compressive strength of concrete was not adversely affected by copper slag addition up to the proportion of 60%.
- Compressive Strength and Flexural Strength of copper slag admixture concrete, increased due to high toughness of copper slag.
- Partial replacement of copper slag in fine aggregate reduces the cost of making concrete.
- The results showed that copper slag used in concrete, strength increases 20% to 80% then after it starts decreases.
- The initial and final setting time of copper slag admixed concrete is higher than control concrete.
- It was observed that, the copper slag replacement for sand is more effective than cement.
- For higher replacement of copper slag in sand, (greater than 60%) the compressive and split tensile strength decreases due to an increase of free water content in the mix.

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