Influence of copper slag and M-sand in compressive strength of concrete

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Abstract - As we all know that natural resources of construction materials like sand are going on decrease day by day due to increase in construction works. So, we have to select an alternative for this problem. We select copper slag as one of alternative. It is a glassy substance which a byproduct obtained from smelting and refining of copper. By using this we can eliminate cost of disposal and we can reduce the cost of construction also. In this investigation strength of M25 concrete taken. The concrete mixture included cement (OPC), fine aggregate, coarse aggregate and copper slag. The percentage of cement, water and coarse aggregate kept constant within the mixture, while the percentage of copper slag as a replacement for sand varied from 0% to 60%. Compressive strength test was conducted for specimens at 7, 14 and 28 days of curing of concrete. From those comparative studies the optimumpercentage of dosage of copper slag was noticed.

Keywords: Copper slag, M25 grade concrete, Compressive strength

I.INTRODUCTION

1.1 General -

Concrete is the man made material widely used for construction purposes. The typical ingredients in concrete are cement, fine aggregate, coarse aggregate, and water. It was observed long ago that the convenient mineral admixtures are mixed in optimum proportions with cement improves the many qualities in concrete. With increasing scarcity of river sand and natural aggregate across the country, researchers began to use cheaply available material as an alternative for natural sand. Usage of industrial waste has increased in construction field for the concrete production because it contributes to reducing the consumption of natural resources. Natural resources are depleting worldwide while at the same time the generated wastes from the industry are increasing substantially. The sustainable development for construction involves the use of nonconventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and find alternative ways conserving the environment. Copper slag is the one of the industrial wastes and it could be useful as a partial replacement of fine aggregate in concrete.

1.2 Literature Review -

Priyatamkumar and H.L.Yadav(2019) investigated about the strength of concrete structure partial replacement of sand by copper slag. The effect of replacing fine aggregate by copper slag on the compressive strength test and split tensile test are attempted in this work. Subsequent test samples are produced with fine and coarse aggregate, progressively replaced by copper slag at 10%, 20%, 30%, 40 and 50%. The experimental results showed that replacement of sand by copper slag shall be up to 40%.

PranshuSaxena and AshishSimalti(2015) investigated that in the present scenario, the use of copper slag is increasing day by day both in research as well as in the construction companies. Since, the physical and mechanical properties of copper slag have maximum advantages, replacement or reuse of it can be done in several manners. Keeping in mind about the rapid urbanization in the country the safe disposal and judicial resource management is the important issue which can be balanced by the reuse of slag. The well-defined scope in the future studies of copper slag is that it can also replaced by cement and fine aggregate very easily and has an application in concrete as a admixture. Maximum strength is obtained when copper slag is replaced with fine aggregate up to 40%. With such considerable properties of copper slag, additional research is done to analyze the scope of replacement extensively.

Brindha D and Nagan S (2010) investigated the potential use of granulated copper slag from Sterlite industries as a replacement for sand in concrete mixes. Replacement of fine aggregate by copper slag on the compressive strength and split tensile strength are attempted in this work. Leaching studies demonstrate that granulated copper slag does

not pave way for leaching harmful elements like copper slag where 0%, 5%, 15%, 20%, 30%, 40%, and 50%. The compressive strength was examined to rise by about 35-40% and split tensile strength by 30-35%. The experimental results showed that replacement of sand by copper slag shall be up to 40%.

Abhisheka H Honnakkalavar(2014) states that the replacement of various percentage of copper slag proved that at 40% replacement of fine aggregate, the concrete gains the maximum compressive strength at 7 and 28 days. The maximum split tensile strength and flexural strength were also obtained at 40% replacement level at 28 days.

M.V. Patil (2016) elucidated that the copper slag in cement and concrete provides probable environment and economic benefits for all industries and particularly in area where considerable amount of copper slag is produced. Moreover the results on the test conducted by replacement of copper slag from 0% to 100% indicate that the compressive strength and flexural strength increased due to high toughness of copper slag. These strength values are higher up to 40%.

Maguneaswaran.P and Eswaramoorthi.P, (2013) in their investigation, the mechanical parameter of concrete was tested by inoculation of silica fume at the progressive interval of 2.5% with fully replacement of river sand by M-sand. The rise in percentage of silica fume increased the strength and durability in high performance concrete.

KhalifS.Aljabri and Makoto hisada(2009) inferred that the concrete mixes with copper slagwere evaluated for workability,density,compressive strength, tensile strength, flexural strengthand durability. The results show that the workability increased rapidly with the increase in copper slag content. Addition upto 50% of copper slag as sand replacement yield comparable strength with the control mix(0% replacement), however further replacement causes reduction in the strength due to increase in water content which is almost 16% lower than the strength of control mix.

Binayapatnaik and SeshadriSekhar.T(2015)explained that upto 40% replacement the strength properties is increased however in terms of durability the concrete is found to be low resistant to acid attack and higher resistance against sulphate attack. Many other alternatives for river sand were studied but the percentage of replacement with high strength was obtained in copper slag.

Burrriyakshareddy and Gurujawahar.J(2013)investigation shows that copper slag and vermiculite were used as a replacement of fine aggregate in different percentages in geo polymer concrete mixes. The results proved that the increase in percentage of copper slag increases the properties of geo polymer concrete whereas the increase in percentage of vermiculite decreases the properties of geo polymer concrete.

II. MATERIALS AND MIX DESIGN

2.1 Copper slag–

Copper slag (shown in Figure 1) is by product obtained during the manufacture of copper. Huge amount of copper slag are extracted as waste worldwide during the copper smelting, converting and refining process. For every ton production of copper, nearly 2.2-3.0 tons copper slag is obtained as a by-product material. Utilization of copper slag in application such as Portland cement substitution and aggregates has threefold advantages of eliminating the cost of dumping, reducing the cost of concrete, and minimizing air pollution problems. Many researchers have investigated the use of copper slag in the production of cement, mortar and concrete as raw materials for clinker, cement replacement, fine and coarse aggregate. The usage of copper slag in cement and concrete provides certain environmental and economic growth for all related industries

Figure1. Copper slag

2.2 Cement–

The cement used in this project is 43 grade ordinary Portland cement (OPC). The specific gravity was identified to be 3.15 using Le Chatelier's flask.

2.3 Fine aggregate–
M-Sand was used as a partial replacement of fine aggregate. The specific gravity of manufactured sand is 2.45, a Fineness module is 2.8 and the bulkdensity is 1612 kg/m^3.

2.4 Course aggregate–
The specific gravity of an aggregate is studied to be the amount of strength or quality of the material. Stones having low specific gravity are mostly weaker than those with higher specific gravity. 20mm size angular crushed granite metal having specific gravity of 2.91 and the bulk density of 1608kg/m^3.

2.5 Mix design-
The grade of concrete is used as M25 and the water cement ratio is 0.5. The mix ratio is obtained as 1: 1.75: 3.13 and the mix design are tabulated in Table 1.

Table -1 Mix proportion and mix details (in Kg/m^3)

Mixof Materials	CS 0%	CS 15%	CS 30%	CS 45%	CS 60%
Cement	383	383	383	383	383
Copper slag	0	100.99	201.98	302.97	403.96
Water	191.58	191.58	191.58	191.58	191.58
Fine aggregate	673.26	572.27	471.28	370.29	269.3
Coarse aggregate	1199.51	1199.51	1199.51	1191.51	1191.51

III.EXPERIMENT AND RESULTS

3.1Hard Concrete test- Compressive strength of concrete–
Once after the completion of workability test for fresh concrete, the cubes of size 15 cm x 15cm x 15 cm were prepared for cube tests. The concrete is cascaded in the mould and tempered properly so as not to have any voids and is shown in the Figure 2.

Figure2. Casting of concrete cube

24 hours afterwards these moulds are removed and test specimens are put into the water for curing process. The top surface of the test specimens should be made even and smooth. This is done by applying cement paste and then spreading smoothly on total area of specimen. These specimens are tested by compression testing machine as shown in Figure 3 after 7 days, 14 days and28 days curing. Load at the failure divided by area of specimen delivers the compressive strength of concrete.

Figure 3. Compressive strength test of concrete

3. 2 Results and discussion-

The compressive strength tests were conducted using compression testing machine for the cubes prepared without copper slag and with copper slag of 15%, 30%, 45% & 60%. The test results for the 7days, 14 days & 28 days curing are tabulated in Table 2. Pictorial presentation is shown in the Figure 4.

Table-2 Compressive strength test Results (in N/mm^2)

Mix	7^{th} day	14^{th} day	28^{th} day
CS 0%	22	24.4	30.6
CS 15%	24.9	28	32
CS 30%	26.3	31.55	33.67
CS 45%	27.11	34	40
CS 60%	24.56	29.33	32.11

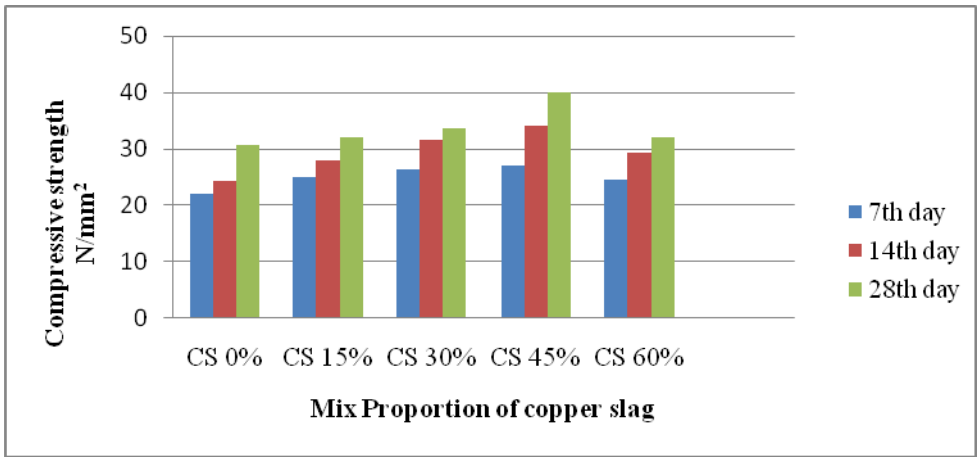

Figure4. Compressive strength of concrete(variation for CS 0% to60%)

- It can be seen that there is increase in strength with the increase in Copper Slag percentages up to 45%. The highest compressive strength for 28 days cube was achieved at 45% replacement of copper slag, which was found about 40 MPa compared with 30.6MPa for the control mixture. It denotes that there is an increase in the strength of almost 30% compared to the control mix.However, mixtures with 60% replacement of copper slag gave the lowest compressive strength of 32.11MPa for 28 days because of segregation and bleeding.
- And hence, it is recommended that up to 45% of copper slag can be used as replacement of fine aggregates.

IV. CONCLUSION

In this project OPC of 43 grade, well graded fine aggregate (M-sand), copper slag as partial replacement of fine aggregate and well graded coarse aggregate were used. In thisproject, it is concluded that the strength of concrete increased by the replacement of sand by 45% of copper slag and one can also save concrete materials costs. Furthermore it is concluded with the following advantages of using copper slag.

- Concrete production cost reduces when copper slag is used as a fine aggregate in concrete.
- High toughness of copper slag refers to increased compressive strength.
- Inclusion of copper slag boosts the density of concrete thereby increasing the self weight.
- With the use of copper slag in concrete, the construction field promotes the better usage of slag and reduce the pollutant.
- The complete replacement of river sand by M-sand and copper slag proves to be better alternative of fine aggregate in the construction.

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