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"Study of Strength Properties of Concrete by Partial Replacement with Fly Ash and Copper Slag in Cement And Fine Aggregate"

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***Abstract*- Copper slag is a byproduct of copper extraction by smelting. During smelting impurities become slag which float on the molten metal . slag that is quenched in water produces angular granules which are disposed as a waste material . And fly ash is produced by burning of powdered coal. In this experiment we are replacing cement with fly ash and sand with copper slag to study about the strength and workability of M30 grade concrete . Previously so many research were conducted by replacing cement with fly ash and sand with copper slag to find out the maximum strength of concrete. Now we are doing this investigation by dividing the fineness ratio's percentages as 15% of fly ash as replacement of cement and 10%, 20%, 30%, 40% of copper slag as replacement of sand. Where the replacement of cement by fly ash is same at all percentage replacements of fine aggregate. In this experimental investigation parameters like workability, And the compression strength after 7days and 28 days curing period and split tensile strength after 28 curing period is determined. The investigation is done to find out strength properties of M30 grade of concrete by partial replacement of cement with fly ash and fine aggregate with copper slag , to reduce the cost of the cement and in point of scarcity in sand. Both of the fly ash and copper slag are waste materials, so they can be used for construction.**

INTRODUCTION

A very massive change has been at the end of the 20 th century. When it compared from the beginning of the century. The unique technological changes for the innovations in communication, medicine, transportation, science and engineering from the half of the last century. The construction industry has been no exclusion for these changes, the stimulating achievements in the design and construction of bridges, offshore structures, dams and buildings.

1.1 ROLE OF CEMENT IN PRESENT WORLD

Ordinary Portland cement (OPC) comprises of 95% residue and 5% gypsum. The residue is produced from crushing limestone together with other minerals and then heating the materials for high temperatures (900-1450^{0}C). During finishing the gypsum is added to the residue as it is ground to a small particle size (typically 10-15 microns). The residue is large amount energy and emissions concentrated aspect of cement production. Therefore it is known as"The Residue factor ". By reducing the residue factor the global warming potential of the cement is also reduced. It can be achieved in blended cements. we can find these blended cements in popular places like Europe than in North America , UK and most of Asia .

For every ton of residue produce 0.9 tons of CO2 emitted. Only between 0.3 and 0.4 tons of CO2 energy used is responsible for reduction of the emissions. We cannot reduce the 0.53 tons of CO2 emitted for every ton of residue. The CO2 released from the calcinations of limestone is known as the "process emissions". This when heated breaks down into CO2 and quicklime

In the last 25 years there have been 30% reductions in CO2 emissions as per the report published on 2006 by some reputed companies. This kind of independent evaluation is intended for adoption of more fuel efficient kiln processes.

By increasing the utilization of alternative renewable fuels and by the production of blended cements with mineral additions substituting residue there can be a potential improvement. For every ton of cement Europe's low residue factor translates to a lower energy which is 74% of the global average. For every ton of CO2 emitted Europe emits only 64% of the global average. So it is our responsibility to reduce the cement usage by replacing with mineral admixtures.

II. PROJECT OBJECTIVE:

The objective of the present study is to investigate about workability and mechanical Characteristics of ordinary concrete of M30 using copper slag and fly ash. The specific objectives of the present work are listed below

a) To study the workability in terms of slump.
b) To study the strength characteristic in terms of compressive and split tensile strength of concrete. Standards cubes of 150 X 150 X 150 mm have been cast and tested for obtaining compressive strength 7 days and 28 days. Standard cylinders of 150 mm diameter and 300 mm height were cast and tested for split tensile strength for 7 days and 28 days.

III. PROPERTIES OF COPPERSLAG AND FLYASH

3.1 COPPERSLAG:

The utilization of industrial waste or secondary materials has encouraged the production of cement and concrete in construction field. New by-products and waste materials are being generated by various industries. Dumping or disposal of waste materials causes environmental and health problems. Therefore, recycling of waste materials is a great potential in concrete industry. For many years, by-products such as fly ash, silica fume and slag were considered as waste materials. Concrete prepared with such materials showed improvement in workability and durability compared to normal concrete and has been used in the construction. Copper slag possesses mechanical and chemical characteristics that qualify the material to be used in concrete as a partial replacement for Portland cement or as a substitute for aggregates. For example, copper slag has a number of favorable mechanical properties for aggregate use such as excellent soundness characteristics, good abrasion resistance and good stability reported by (Gorai et al 2003.). Copper slag also exhibits pozzolanic properties since it contains low CaO. Under activation with NaOH, it can exhibit cementitious property and can be used as partial or full replacement for Portland cement. The utilization of copper slag for applications such as Portland cement replacement in concrete, or as raw material has the dual benefit of eliminating the cost of disposal and lowering the cost of the concrete.

Figure.1. COPPER SLAG

3.2 FLYASH:

Fly ash, also known as “pulverized fuel ash” it is one of the fuel combustion product , composed of fine particles that are driven out of the boilers with the flue gases. Ash that falls in the bottom of the boilers is called bottom ash. In modern coal-fired power plant , fly ash is generally captured by electrostatic precipitators or other particles filtration equipment before the fuel gases reach the chimney.

Together with bottom ash removed from the bottom of the boilers, it is known as coal ash . Depending upon the source and makeup of the coal being burned, components of the fly ash vary considerably , but all the fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and the crystalline) , aluminum oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal- bearing rock strata.

Fly ash is produced by coal fried electric and stream generating plants. Typically, coal is pulverized and blown with air into the boiler’s combustion chamber where it immediately ignites , generating heat and producing a molten material residue to harden and form ash. Coarse ash particles, referred to as bottom ash or slag, fall to the bottom of the combustion chamber, while the lighter fine ash particles, termed fly ash remain suspended in the fuel gas.

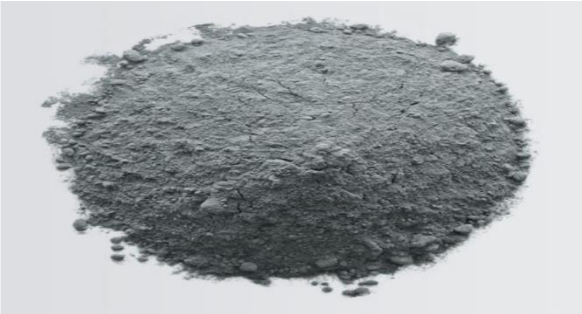

Figure.2. FLYASH

IV.REVIEW OF LITERATURE

Khalifa S. Al-Jabri, Abdullah H. Al-Saidy, Ramzi Taha et. al. [2016](Quaboos university oman) “EFFECT OF COPPER SLAG AS A FINE AGGREGATE ON THE PROPERTIES OF CEMENT MORTARS AND CONCRETE” In this study the author had clearly discussed about the effects of the copper slag in the concrete. The author had worked on M20 mix design and has incorporated the copper slag in percentages from (20 % to 60%).

Sukhoon Pyo et. al. [2016] they studied the straight tensile action of UHP-FRC at strain variation varies as of 90 to 146/s. The tests are conducted using a recently developed impact testing system that uses suddenly released strain energy to create an impact pulse.

Dr. A. Leema rose et. Al. [2015] they find out solution and addition of copper scum use in concrete raises the density in concrete mixture scum by load of fine aggregate exchange 30% of replacement. It is also accomplished that the concrete through copper slag gains more strength than the manage concrete.

Vishwa B Tipashetti et. al. [2014] they investigate on dissimilar strength tests on concrete having sandstone admixtures and copper slag as partial substitution of cement and sand individually. In this description, M30 assessment of concrete was designed and examinations were intended for with varied rates of sandstone admixtures with copper slag. The compressive strength is enlarged up to 10-20% merge of stone admixture and copper slag contains concrete when contrasted with normal concrete.

Dr. T.Ch. Madhavi et. al. [2013] investigated the performances of substitution of Fine aggregate with copper slag on behavior of mechanical functions of concrete and the application of copper slag as a substitution replacement material of sand. Copper slag which is an industrial waste product can be used as replacement for cement with sand and contributes to the increase in various mechanical properties of concrete. Copper slag can be used up to 30% but when used ahead of 50% results in decrease in strengths.

V.EXPERIMENTAL WORK

5.1 MATERIALS AND THEIR PROPERTIES:

The properties of various materials used in making the concrete are discussed in the following sections.

Cement:

The Ordinary Portland Cement of 53 grades is used specifying all the properties from IS12269-1987.

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Coarse Aggregate:
20mm and 10mm coarse aggregate are selected by passing the aggregate through 20mm and 10mm sieves respectively. Particle shape of both the aggregate is angular. Different test are to be conducted like specific gravity, fineness modulus and water absorption. Coarse aggregate is dust free and free from surface moisture.

Fine Aggregate:
Natural Sand is selected as fine aggregate. Sand is sieved from 4.75 mm sieve and also washed to reduce the silt content. Here, water demand is slightly less for natural sand, which is therefore more preferable. The specific gravity, fineness modulus and water absorption test are conducted on Natural sand.

VI. LABORATORY TESTS AND RESULTS:

Various tests were carried out in the laboratory for finding the strength and durability and other important properties of the concrete used during the study. Slump cone test, Compaction test, compressive strength and split tensile strength were conducted and the details of these tests are given in the following sections.

6.1 EXPERIMENTAL PROCEDURE:

SLUMP CONE TEST: In all over the world the test on fresh concrete are widely used .though the slump test won't consider the workability of concrete but helpful in detecting the deviations in the uniformity of a mix of given nominal proportions.

Figure.3.Slump test

6.2 WORKABILITY OF FRESH CONCRETE:

Workability depends on water content, aggregate (shape and size distribution), cementicious content and age (level of hydration) and can be modified by adding chemical admixtures, like super plasticizer. Raising the water content or adding chemical admixtures increases concrete workability.

STUDIES ON MIX PROPORTION AND WORKABILITY

S.No	Mixed details	% of copper slag	W/C ratio	Workability in (cm)
1	1:1.87:3.16	0	0.4	30
2	1:1.87:3.16	10	0.4	29
3	1:1.87:3.16	20	0.4	29
4	1:1.87:3.16	30	0.4	27
5	1:1.87:3.16	40	0.4	26

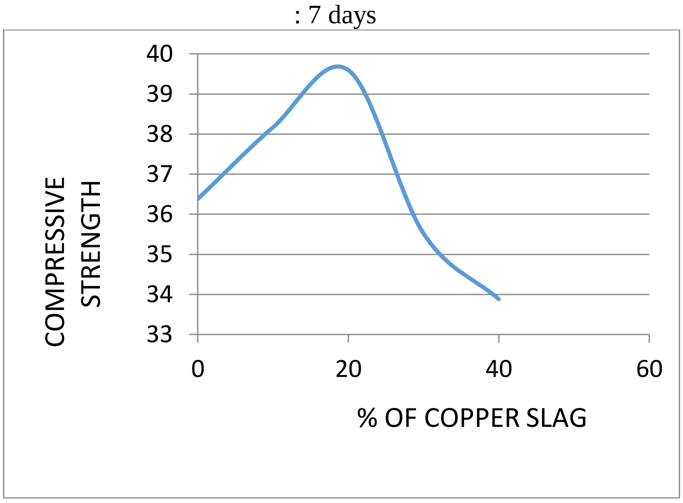
Table 6.1 Mix Proportion and workability

VII. COMPRESSIVE STRENGTH

Compression test is the most pervasive test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the sought-after trait properties of concrete are qualitatively related to its compressive strength. The cube specimen is of the size 15 x 15 x 15 cm. The largest nominal size of the aggregate does not exceed 20mm, 10cm size cubes may also be used as an alternative.

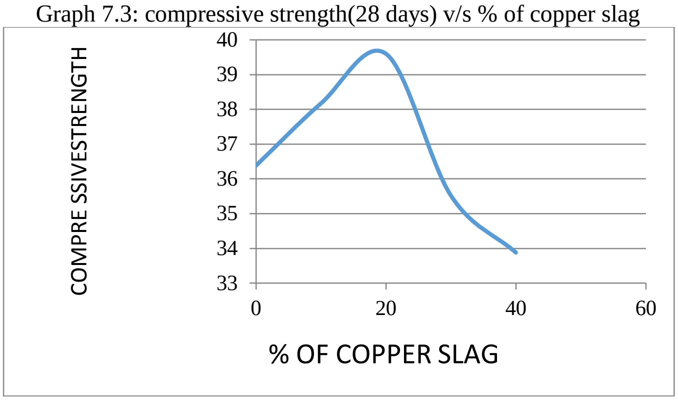
Figure.4.Testing of compressive strength of specimen

7.1 Graphical representation of Compressive Strength Values : 7 days



Graph7. 2: compressive strength(7days) v/s % of copper slag

Graph 7.3: compressive strength(28 days) v/s % of copper slag



Graph 7.4: compressive strength(28days) v/s % of copper slag

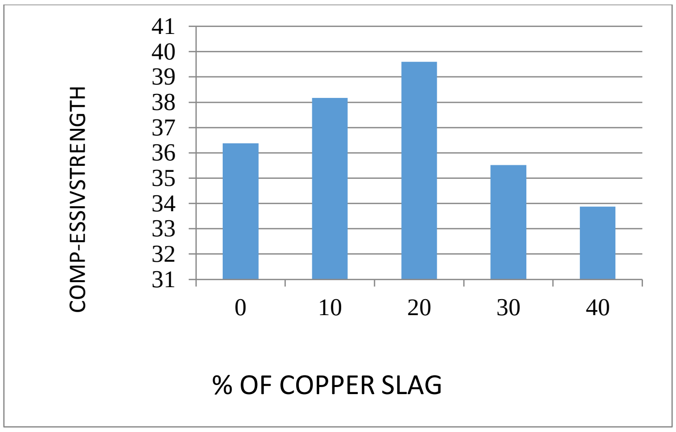


Table 7.3 Compression Strength of M30 Grade Concrete for 28 days

Composition	Specimen 1 N/mm^2	Specimen 2 N/mm^2	Specimen 3 N/mm^2	Average Compressive Strength N/mm^2
0% CS+0% FA	35.13	39.23	34.78	36.38
10% CS +15% FA	35.40	42.14	36.97	38.17
20% CS +15% FA	38.16	37.63	43.01	39.60
30% CS +15% FA	33.99	39.23	33.34	35.52
40% CS +15% FA	37.29	30.86	33.49	33.88

VIII. SPLIT TENSILE STRENGTH:

The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. Cracking is a form of tension failure. From the below formula the split tensile strength of the specimen is determined, the load at which the concrete members may crack. Cracking is a form of tension failure. The usefulness of the split tensile test for assessing the tensile strength of concrete in the laboratory is widely accepted and the usefulness of the above test for control purposes in the field is under investigation.

Split tensile strength= 2P/ (ΠDL)

P = ultimate load, L= span of the specimen, D= width of the specimen.

8.1 Graphical representation of Split Tensile Strength Values:

split tensile strength (28 days) v/s % of copper slag

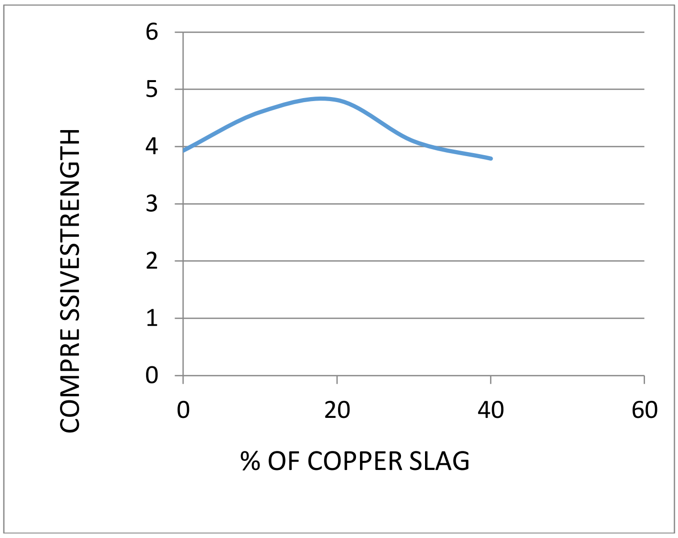


Table 7.4 Split Tensile Strength of M30 Grade Concrete for 28 days

Composition	Specimen 1 N/mm^2	Specimen 2 N/mm^2	Specimen 3 N/mm^2	Average Compressive Strength N/mm^2
0% CS+0% FA	3.92	3.98	3.89	3.93
10% CS +15% FA	4.79	4.29	4.72	4.60
20% CS +15% FA	4.75	4.69	4.99	4.81
30% CS +15% FA	4.21	3.94	4.12	4.09
40% CS +15% FA	3.61	3.85	4.91	3.79

Figure.5.Testing of split tensile strength of specimen

IX. CONCLUSIONS:

1. The workability of concrete decreases from 0% to 40% replacement of copper slag & 15% fly ash.
2. Compressive strength and Split tensile strength increases with increase of copper slag
3. Up to certain limit.
4. Concrete acquires maximum compressive strength at 20% replacement of copper slag

of M30 Grade concrete.

5. The maximum Split tensile strength for 28 days curing was obtained at 20% replacement of copper slag and 15% replacement of fly ash.
6. The compressive strength of and split tensile strength of concrete decreases from 30% & 40% replacement of copper slag.
7. The compressive strength of concrete was also found to be more than the target mean strength 36.6 $N\backslash mm^2$.
8. Hence ,it can be concluded that cement content can be reduced for the preparation of concrete by the use of copper slag is for sand and fly ash as cement replacement and considerable percentage increase in various strength properties of concrete can be obtained.
9. The replacement of fine aggregate using slag in concrete increases the density of concrete thereby increases the self weight of the concrete.
10. The workability of concrete increased with the increase in copper slag content of fine aggregate replacement at same water cement ratio.
11. Optimum strength is obtained 20% replacement of copper slag and 15% of fly ash.
12. There is no impact on environment by using copper slag and fly ash.
13. The copper slag and fly ash is a leftover materials,so using these materials are economical for construction.
14. In replacement 30% and 40% of copper slag and 15% of fly ash, there will be an occurrence of segregation.

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XI .SCOPE FOR FUTURE RESEARCH

The following experimental studies can be conducted in future with respect to ordinary concrete-

1. Further research has to be carried out on the reasons for increase in workability, increased compressive strength and tensile strength up to 20% COPPER SLAG.
2. There is a scope to alter the mix proportions of concrete which may reduce the stripping time of concrete and faster strength gain

3. Different water cement ratios other than applied in this project can be tested
4. Mix designs which can offer much strength properties of concrete elements can be designed to with stand heavy load conditions
5. Further research has to be carried out on the reasons for workability, durability characteristics of ordinary concrete, compressive strength and tensile strength with increase in % of fly ash and copper slag.
6. Further research has to be carried when other puzzolonic materials are used other than the fly ash with copper slag.
7. Further research has to be carried out on the shrinkage and the creep properties of ordinary concrete, when 20% COPPER SLAG and 15% FLY ASH added to Ordinary Concrete.
8. Further research has been carried out reduction of Cost & Quantity of cement, when 20% COPPR SLAG and 15% FLY ASH added to Ordinary Concrete.

Further research has been carried out on the chemical reactions when COPPER SLAG and FLY ASH is added to cement

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