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Experimental Study on Concrete Using Admixture Metakaolin, Copper Slag on M30 Grade Concrete

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ABSTRACT

The last few decades are well thought-out to be the era of the self-compacting concrete and thousands of research has been carried out. In India, the development of concrete possessing self-compacting properties is still very much in its initial stages. Over the past couple of years, few attempts were made still the cost of production of such concrete is a challenging issue for the present concrete engineers. Hence, in the present study an attempt is done to understand the effect of copper slag as a mineral admixture on the properties of self compacting concrete. Hence, our attempt is to produce more economical, durable and sustainable SCC using mineral admixture. In the present study copper slag is that by product which is used in replacement with sand without disturbing properties of concrete with respect to strength, workability, and other mechanical properties.

Keywords: Self Compacting Concrete, Admixture, Copper Slag, Durability, Strength

I. INTRODUCTION

Now a day major problems faced by civil engineers is construct durable concrete structure. For making durable concrete structures, proper and sufficient compaction is necessary. For normal or conventional concrete compaction is done by vibrators. In case of highly congested reinforcement, it is very difficult to compact the concrete and if over vibration is done then it causes segregation in concrete. For such structure, concrete which can easily flow is required. Self Compacting Concrete (SCC) is the concrete which settles and get compacted by its own weight. SCC was proposed by Okamura in 1986 for Japan. Later on lots of researchers are working on flowability, strength and durability performance of the concrete.

SCC is the concrete which meets the special performance and uniformity requirements which cannot be always obtained by conventional concrete, normal mixing and curing practices. SCC consists of different engineered materials like cement, sand, aggregate, admixtures. Chemical admixtures were used for care of specific requirements such as strength, high workability, less permeability, high flow ability, durability, resistance to stresses, and resistance to segregation.

Copper slag is a by-product obtained during the production of copper metal, which can be used as pozzolana in the production of cementing materials. The raw copper slag had particle sizes ranging from micrometers to larger than 1 cm in diameter. Industrial sludge is generated at a rate of 100 metric tons/day, from a copper slag recycling plant. An attempt is made to produce more economical and durable concrete using industrial byproducts i.e. copper slag. Technically copper slag is used to improve the strength and the durability of concrete. Hence, aim of our project is to check the behavior of conventional concrete under the influence of copper slag which is normally available in market now days. The effect of copper slag on conventional concrete and SCC were studied.

Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on the molten metal. Slag that is quenched in water produces angular granules which are disposed of as waste or utilized in different applications.

Fig 1 Copper Slag

II. Review of Literature Summary

Purva Parekh and Kishan Vekariya (2022) research paper evaluated the Durability of High Strength Concrete (HSC) containing Metakaolin (MK) as a partially replacement of cement, Copper Slag (CS) as a partially replacement of fine aggregate and Silica Fume (SF) as a mineral admixture.

Results stated that compression strength of the concrete increases when the percentage of replacement up to 15%, then after compressive strength decreases. The acid attack test result show that it is good to resist for acid and corrosion relative to normal concrete. The incorporation of metakaolin, copper slag and silica fume is excellent improvement in compressive strength and durability. The presence of silica fume as a mineral admixture shows excellent results to enhance mechanical and durability properties of concrete. Use of copper slag as a partially replacement of fine aggregate gives good result on durability.

E Lalith Prakash et.al (2021) in the research paper, the mineral admixtures such as fly ash and Ground Granulated Blast furnace Slag (GGBS) were added to the concrete containing fine aggregates which was partially substituted with copper slag. Test experiments were designed using Response Surface Method (RSM) to obtain the various trial proportions. Three factors such as Copper Slag, GGBS, and Fly Ash were considered. The levels were 20%, 30%, and 40% for copper slag; 20%, 35%, and 50% for GGBS; and 15%, 25%, and 35% for Fly ash. Test were performed on each trial proportion to study the compressive strength , split tensile strength, chloride penetration and sorptivity properties.

Results stated that there was considerable improvement in the performance of the copper slag concrete at the optimum dosage of GGBS and fly ash. It was found that the concrete mix in which the river sand is replaced with 20% of copper slag and cement replaced with GGBS and Fly Ash by 50% and 15% respectively, perform better in the strength, permeability, and porosity characteristics.

R. Jeyamahima et.al (2020) objective of the research was to investigate the strength and durability properties of M70 grade of concrete to analyze the properties of concrete containing copper slag as partial replacement of fine aggregate and mineral admixture as partial replacement of cement in the concrete mix design. Copper slag content has been 40% as a replacement of fine aggregate and silica fume 5%,10%,15% & 20% and GGBS 5%,10%,15% & 20% as a replacement of cement respectively.

The test results indicated that the strength properties of concrete were improved having copper slag as a partial replacement of fine aggregate (40%) and Silica fume & GGBS as partial replacement of cement (up to 15%). It was further observed that the use of copper slag and mineral admixture in concrete has shown considerable increase in strength and reduction of cost when compared with normal concrete.

Objectives:

- To locate the ideal extent of copper slag and mineral admixtures that can be utilized as a substitution/substitute material for fine total and concrete.
- To assess the impact of copper slag and mineral Admixtures substitution on the usefulness and thickness of cement.
- To locate the compressive quality, split elasticity, flexural quality and Durability investigations of copper slag and mineral admixtures supplanted solid examples.
- To propose an observational connection between mechanical properties of cement.

Concrete Mixtures

Concrete mixtures with different proportions of Copper slag used as a partial or full substitute for fine aggregates were prepared in order to investigate the effect of Copper slag substitution on the strength of normal concrete. Concrete mixtures were prepared with different proportions of Copper slag. The proportions (by weight) of Copper slag are added to concrete mixtures as follows, 0% (for the control mix), 10%, 20%, 30%, 40%, 50%, 60%, 80%, and 100%, the control mixture (with 0% Copper slag and 100% sand) was designed to have a target 28 day compressive strength of 30 N/mm2 (M30), using a water-to-cement ratio of 0.48.

Table 1. Sieve Analysis of fine, Coarse Aggregate, and Copper Slag

IS Sieve (mm)	Coarse Aggregates	Fine Aggregates	Copper Slag
	Cumulative % Retained	Cumulative % Retained	Cumulative % Retained
20	0.7	0	0
16	4.15	0	0
12.5	15.48	0	0
10	48.75	0	0
4.75	97.25	1.17	0.2
2.36	100	5.68	4.75
1.18	100	28.14	50.65
0.6	100	57.07	88.25
0.3	100	95.39	96.15

0.15	100	98.65	98
FM	6.67	2.8	3.38

Note – FM – Fineness Modulus

Table 2 M 30 Mix proportions (Kg/m 3) and Mix ratio

Cement	Fine Aggregate	Coarse Aggregate	Water
435	575	1216	208.8
1	1.32	2.79	0.48

Preparation of Sample

The samples were prepared in accordance with the IS standard relevant to each test. Table 4.3 samples for the tests. Cubes samples were used for compression testing and Rectangular moulds were used to prepare samples for flexural testing The specimens were prepared by two methods. First one is a tamping method and second one is a vibratory method. The tamping method consisted of filling the moulds in three layers, tamping each layer 25 times following by tamping the side of the mould 10 times. The vibratory method used, consists of use of a vibratory table and filling the moulds in two equal layers with each layer being vibrated for approximately 5 seconds as per IS standard. After this each sample was allowed to harden for a period of 24 ± 1 hour, the samples were removed from the moulds and placed into large curing tanks for curing.

Table 3 Sizes and Types of Moulds Used testing in experimental work in laboratory

Type of Test	Sample Type	Sample Size (mm)
Compression Test	Cube	150 × 150 × 150
Flexural Test	Rectangular	500 × 100 × 100

Fig 2 Steel cubes and moulds used in current experimental work

III. Curing Method

The strength of concrete is directly related to the curing age. Curing time is the time required under certain conditions to gain strength. Concrete continues to gain strength, with time, depending on curing conditions. The samples prepared were allowed to harden in the moulds for 24 ± 1 hour, and then removed from their moulds. The samples were then placed into large curing tanks, containing tap water kept at a constant temperature of 23 ± 3°C (73 ± 3°F) as per IS 456-2000 clause no.13.5 Curing. At predetermined curing ages, different samples were removed from the tanks and tested for various properties. Compression testing was performed at curing ages of, 7, 28and 56-days and Flexural strength was tested at 28-days of curing.

Fig. 3 displays some of the cubes and rectangular beams are put in water tank for curing purpose.

Fig 3 Curing tank with cubes and beams

IV. Results

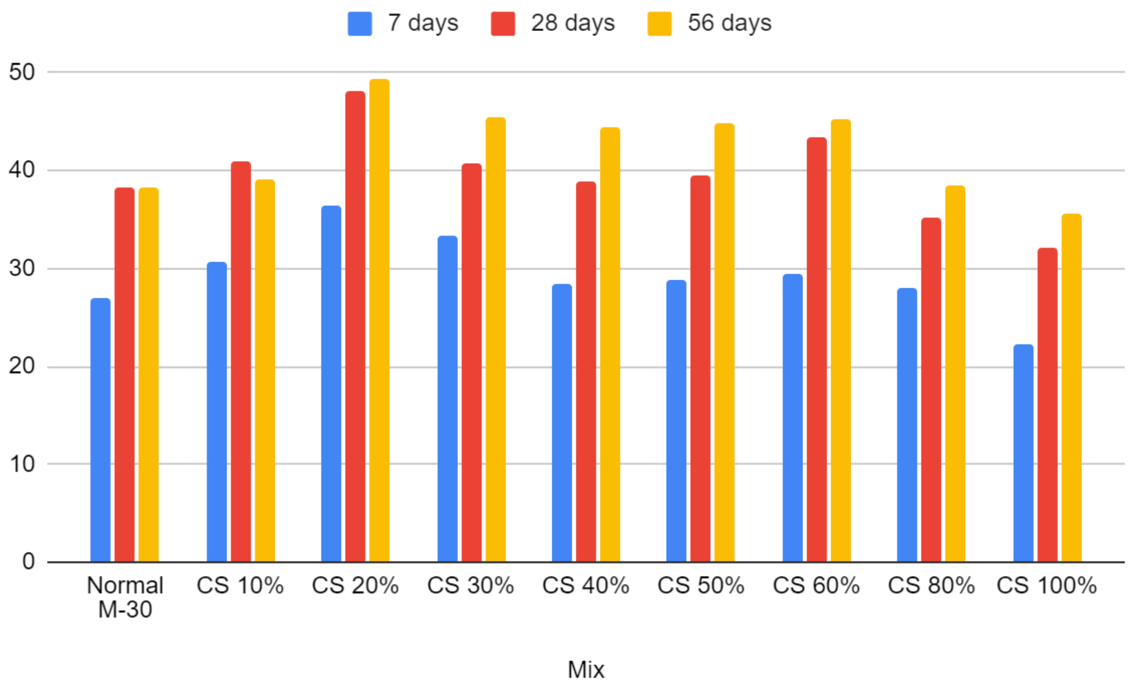

Fig 4 Compressive Strength Test Results

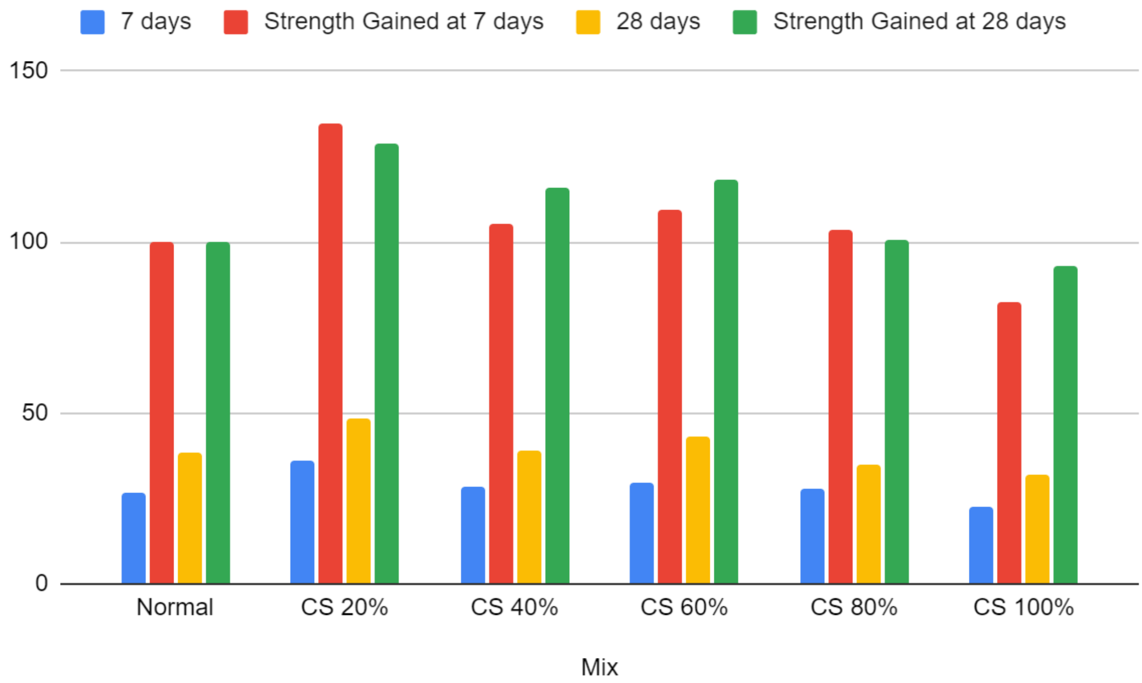

Fig 5 Compressive strengths test result

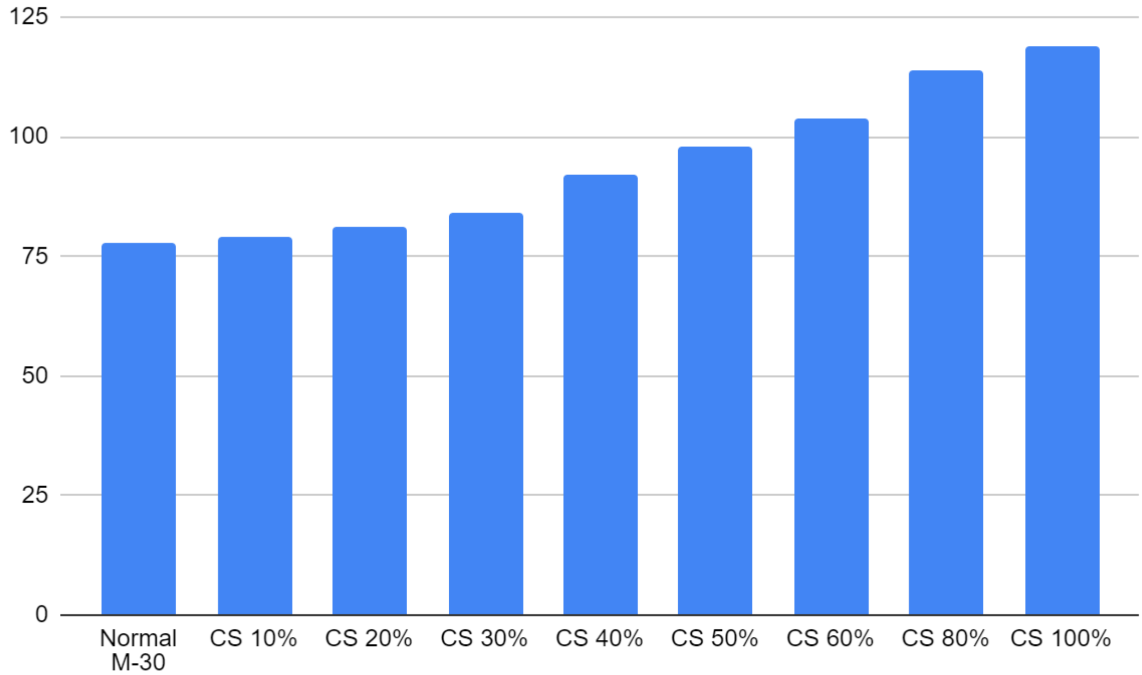

Fig 6 RCPT Result Value

Discussion: RCPT values for mix with CS 100% was on the higer side while te normal mix and CS 40% provided satisfactory results.

V. CONCLUSION

As the percentage of Copper Slag in concrete mix increases, the workability of concrete increases. This is because copper slag is unable to absorb the water in large proportion.

- Maximum Compressive strength of concrete for a replacement of fine aggregate by 20% of copper slag increased by 34% at 7 days and increased by 29% at 28 days. Similar increase is observed at 56 days strength.
- Replacement of copper slag up to 80% will increase the strength of design mix, but beyond 80% replacement the strength started to reduce. The strength at 100 % replacement is reduced by 7% at 28 days.
- It is observed that, the flexural strength of concrete at 28 days is higher than design mix (Without replacement) for 20% replacement of fine aggregate by Copper slag, the flexural strength of concrete is increased by 14%. This also indicates flexural strength is more for all percentage replacements than design mix.
- Compressive strength and Flexural strength was increased due to the high toughness property of Copper slag.
- As the percentage of Copper slag in design mix as replacement increases, the density of harden concrete observed to be increased. The density was increased by 7% when replacement of Fine aggregate by 100% copper slag. This is because weight of concrete increases with copper slag.
- The test was carried out to study the effect of copper slag as a fine aggregate replacement on the resistance against chemical attack. The 10 × 10 × 10 cm concrete cube specimens were cast and cured in water for 28 days. $MgSO_4$ solutions with initial concentrations of 5% by volume were prepared in acid resistant. The initial weight was determined and then the specimens were immersed into sulphate solution for 4 weeks. After 4 weeks the specimen was taken out and weight was measured. Weight loss was least with 10% copper slag.
- CS 80% provided reasonable satisfactory results matching conventional concrete providing a sustainable option in case of water absorption test.
- RCPT values for mix with CS 100% was on the higher side while the normal mix and CS 40% provided satisfactory results.

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