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An Experimental Investigation of Concrete Properties M35 with Metakoaline Due to Addition of Copper Slag

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***Abstract*: The main purpose of this experimental study is to analyse the properties of the reinforced concrete made by adding copper slag and metakaolin. In this study a control mix of M35 grade concrete having metakaolin (5% by weight of cement) and copper slag (10%, 20%, 30%, 40%, 50% and 60% by weight of sand) will be tested for different engineering properties.**

The investigatory results will be beneficial in deciding the suitable composition of the concrete depending on the structure design a specification.

***Keywords*: Concrete Properties M35, Metakoaline, Copper Slag**

1. Introduction

Variety of by-products and waste materials are being generated by numerous industries. Dumping or disposal of such waste materials can cause damage to environment as well as to our health. Hence, recycling of waste materials would help solve the problem of their disposal and can also be of great use in concrete industry. Concrete prepared from such materials or by-products showed enhancement in workability and durability in contrast to typical concrete and has been employed in the establishment of power, chemical plants and under-water builds. Copper industries while manufacturing copper produces by-product called copper slag in large quantities. For every ton of copper that is produced about 2.2 tonnes of copper slag is also formed. Copper slag has both mechanical and chemical properties which qualify the material to be employed in concrete as a fragmentary replacement for Portland cement or as an alternate for aggregates. Copper slag has a numerous advanageous mechanical properties for aggregate use such as excellent soundness, good abrasion resistance and good stability. Copper slag also shows pozzolanic properties as it has low CaO. It also show cementations property when activated by NaOH and further can be used as partial or full replacement for Portland cement. The usage of copper slag as Portland cement replacement in concrete, or as raw material has many benefits among which first is elimination of the cost of disposal, second is to lower the cost of the concrete and other is safegurding the environment.

A. *Objective*

The main purpose of this experimental study is to analyse the properties of the reinforced concrete made by adding copper slag and metakaolin.

In this study a control mix of M35 grade concrete having metakaolin (5% by weight of cement) and copper slag (10%, 20%, 30%, 40%, 50% and 60% by weight of sand) will be tested for different engineering properties.

The investigatory results will be beneficial in deciding the suitable composition of the concrete depending on the structure design and specifications.

B. *Necessity and aim of study*

For a newly developing material like Copper slag metakaolin reinforced concrete, studies regarding its various properties like long term strength, durability, thermal effects, temperature effects and flexural behaviour of beams are of great importance for building confidence among the engineers and builders. Despite of the availability of some literature on copper slag and metakaolin reinforced concrete, there is huge gap between the studies and such reinforced concrete being actually used by engineers. To fill the lacking confidence of engineers an attempt to produce comprehensive study material on copper slag and matakaolin reinforced cement (M35 grade) is made through this experimental yest investigaorty study report.

C. *Production of copper slag*

Copper slag is a by-product of copper formed during the matte smelting process and refining process as reported by Biswas and Davenport (2002). The major components of a smelting charge are sulphides and oxides of iron and copper. Oxides such as SiO_2, Al_2O_3 CaO and MgO, which are either present in original concentrate or added as flux are also the constituents of charge. Iron, Copper, Sulphur, Oxygen and their oxides mainly control the chemistry and physical make-up of smelting system. Another prime influencer is the oxidation/reduction potential of the gases which areemployed to heat and melt the charge stated by Gorai et al (2002). As an outcome of this process copper- rich matte (sulphides) and copper slag (oxides) are formed as two separate liquid phases. Addition of silica while smelting forms strong silicate anions bonds by combining with the oxides.

D. Advantages of copper slag reinforced concrete

- Lighter weight: Copper Slag reinforced concrete can be cast into thinner sections which are75% lighter than pieces cast with traditional concrete of same size.
- Reinforcement: As we know Copper Slag is reinforced internally so there is no need for other kind of reinforcements which sometimes can be difficult to place into complex shapes.
- Toughness: Copper Slag does not crack easily, it can be cut without chipping.
- Surface finish: Because it is sprayed on the surface therefore it leaves no bug holes or voids.
- Sustainable: Because it uses less cement than equivalent concreteand also often uses significant quantities of recycled materials (as a pozzolana), Copper Slag qualifies as sustainable.
- Reduces the construction cost due to saving in material cost. Reduces the heat of hydration.
- Refinement of pore pressure.
- Reduces permeability.
- Reduces the demand for primary natural resources.
- Reduces the environmental impact due to quarrying and aggregate mining.

2. Experimental investigation

A. Introduction

The experimental investigation is carried out with an objective to study the properties of the reinforced concrete made by adding copper slag and metakaolin. The main parameter investigated were compressive strength and flexural strength

B. Material used

Cement: Ordinary Portland cement of 43 grade has been used in this experimental work. OPC 53 grade of ULTRATECH cement has been used after 14 investigate the strength of cement at 28 days as per IS 4031-1988.

Fine aggregates: Locally available river sand passed through 4.75mm IS sieve has been used in the preparation of Copper Slag. It confirms to IS 383-1970 which comes under Zone I. The physical Properties of sand like Fineness Modulus, Specific Gravity and water absorption are 3.25, 2.67 and 2.31% respectively.

Coarse Aggregates: The Coarse aggregateare obtained from a local quarry has been used. The coarse aggregate with a maximum size 20mm having a specific gravity 2.89. In this experimental work coarse aggregates of 20mm are taken. The physical Properties of coarse aggregates like Fineness Modulus, Specific Gravity are3.49, 2.89 respectively.

Copper Slag and Metakaolin: Copper slag is a by-product material produced from the process of manufacturing copper. As the copper settles down in the smelter, it has a higher density, impurities stay in the top layer and then are transported to a water basin with a low temperature for solidification. Theend product is a solid, hard material that goes to the crusher for further processing.

Metakaolin: It is gotten by the calcinations of unadulterated or refined Kaoliniteearth at a temperature between 6500 C and 8500 C, trailed by pounding to accomplish an artfulness of 700-900 m2/kg. It is a brilliant pozzolonic material, which is mixed with cement so as to improve the toughness of cement. At the point when utilized in solid it will fill the void space between bond particles bringing about an increasingly impermeable cement. Meta kaolin, is a generally new material in the solid business, is compelling in expanding quality, lessening sulfateassault and improving air-void system. Pozzolanic responses change the microstructure of cement and science of hydration items by devouring the discharged calcium hydroxide (CH) and generation of extra calcium silicatehydrate (C-S-H), bringing about an expanded quality and decreased porosity and accordingly improved sturdiness.

Water: Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000 Potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly, potable tap water was used for the preparation of all concrete specimens.

C. Test on materials

The cement use for the experimental studies was Ultratech cement 43 grade OPC as per the specifications of Indian Standard Code IS: 8112-1989. It was fresh and without any lumps. The various test performed and their value is given in table 1.

Table 1
Characteristics Properties of Cement

S. No.	Characteristics	Experimental value	Specified valueas per IS:8112-1989
1	Consistency of cement (%)	29%	---
2	Specific gravity	3.14	3.15
3	Initial setting time (minutes)	140	>30 As Per IS 4031-1968
4	Final setting time (minutes)	200	<600 As per IS4031-1968
5	Compressive strength (N/mm^2) (i) 3 days (ii) 7 days (iii) 28days	 37.29 51.21 59.52	 >23 >33 >43
6	Soundness (mm)	1.00	10
7	Fineness of Cement	5%	10% As Per IS 269-1976.

D. Fineness modulus of fine aggregate

Total weight of sand taken= 1 kg
Time of sieving = 15 minutes

Table 2
Sieve Analysis of Fine Aggregate (as per IS: 383- 1970)

S. No.	IS Sieve Designation	Mass Retained On Sieve (Gm)	%Age Retained	Cumulative %Age Retained (C)
1	4.75mm	65.0	6.6	6.6
2	2.36mm	101	10.3	16.9
3	1.18mm	119	12.1	29.0
4	600µ	163	16.6	45.6
5	300µ	291	29.6	75.2
6	150µ	230	23.4	98.6
7	Pan	14	1.4	100
∑ C				271.9

Calculations:

Fineness modulus of sand = ∑ C/100

Fineness modulus of sand= 271.9/100=2.72

E. *Fineness modulus of coarse aggregrates*

Total weight of coarseaggregate = 5 kg

Time of sieving = 15 minutes

Table 3
Sieve Analysis for Coarse Aggregate

S. No.	IS Sieve Designation	Mass Retained On Sieve (Gm)	Cumulative %Age Retained		
1	80mm	0	0		
2	40mm	0	0		
3	10mm	602	12		
4	4.75mm	4366	99.4		
5	2.36mm	19.00	99.7		
6	Pan	0.00	0		
	∑ C		211.1		

Calculations:

Fineness Modulus of Coarse Aggregate = ∑C / 100

Fineness Modulus of Coarse Aggregate = 211.1 /100 = 2.11

3. Experimental setup

In this section the specimens will be tested for compressive strength, split tensile strength, Flexture strength.

A. *Compression strength*

The test was conducted on cubes according to IS code 516-1959. Specimens were taken out from curing tank at the age of 7 and 28 days of moist curing and were then tested.

Table 4
Compressive Strength (N/mm^2)

Mix Identity	Compression strength at 7th day	Compression strength at 28th day
CC	27.02	37.02
S0	25.06	35.5
S10	22.96	36.04
S20	24.88	36.04
S30	23.6	37.24
S40	25.02	37.55
S50	27.78	37.11
S60	21.64	34.66

B. *Split tensile strength*

The test was conducted on cylinders according to IS code 516-1999. Specimens were taken out water. Specimens weretested on split tensile testing machine 100 tonnes capacity bearing the requirement given in IS 516.

Table 5
Split tensile strength (N/mm^2)

Mix Identity	Split stensile strength at 7th day	Split tensile strength at 28th day
CC	2.52	3.23
S0	2.09	3.32
S10	2.004	3.39
S20	2.28	3.48
S30	2.29	3.56
S40	2.45	3.72
S50	2.33	3.60
S60	2.47	3.42

C. *Flexural strength*

Flexural strength estimates the load at which the concrete members may crack.

Table 6
Flextural strength (N/mm^2)

Mix identity	Flexural stength at 28th day
CC	3.72
S0	3.72
S10	3.81
S20	3.95
S30	4.42
S40	4.35
S50	4.61
S60	4.12

Fig. 1. Compression strength testing machine

Fig. 2. Split tensile strength test machine

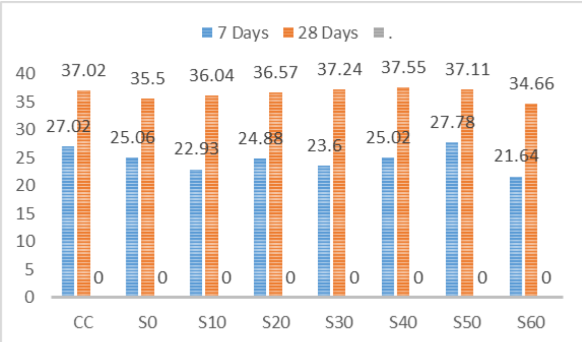

Fig. 3. Compressive strength of concrete cubes at 7 & 28 days

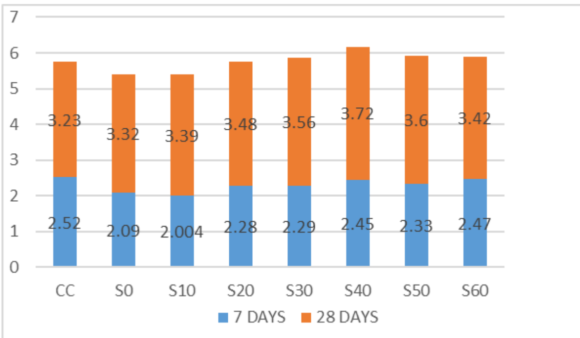

Fig. 4. Split Tensile strength of concrete cubes at 7 & 28 days

4. Conclusion

Based on the investigations, the following conclusions were drawn.

- The utilisation of copper slag in concrete provides additional environmental as well as technical benefits for all related industries. Partial replacement of copper slag in fineaggregateand cement reduces the cost of making concrete.
- The initial and final setting time of copper slag admixed concrete is higher than control concrete.
- Water absorption of copper slag was 0.18% compared with 1.27% for sand. Therefore, the workability of concrete increases significantly with the increase of copper slag content in concrete mixes. This was attributed to the low water absorption and glassy surface of copper slag.
- Compressive strength of S0 i.e. only metakaolin and no copper slag is less than the control mix, but with addition of copper slag cohesion is increased and thus the compressive strength.
- Compressive strength of copper slag and matakaolin blended concrete keeps inecreasing till S40 but shows a decrease for S50 and further decrese for S60. The compressive strength value for S30, S40 and S50 are more than the plain concrete.
- It is observed that the split tensile strength increases upto 15.17% at 40% copper slag concrete blend.
- It is also observed that Split tensile strength till S40 is more than that of plain concrete. Any blend of more than 40% copper slag concrete reduces the Split tensile strength ofin comparison to plain concrete.
- It is observed that the Flexural strength of metakaolin and copper Slag blend concrete gets increased up to 23.92 % as compared to plain concrete.
- It can be concluded that Flexural strength of the GFRC increases continuously till S50 and decreases after S50 but is still more than that of plain concrete.
- Utilisation of copper slag as Portland cement replacement in concreteand as a cement raw material has the dual benefit of eliminating the costs of disposal and lowering thecost of the concrete.
- It was observed that, the copper slag replacement for sand is more effective than cement.

References

[1] Al-Jabri, K.S., Abdullah, H., Al-Saidy and Ramzi Taha. "Effect of copper slag as a fineaggregate on the properties of cement mortars nd concrete", Construction and Building Materials, Vol. 25, pp. 933-938, 2011
[2] Al-Jabri, K. and Makoto Hisada. "Copper slag as sand replacement for high performance concrete", Cement & Concrete Composites, Vol. 31, pp. 483- 488, 2009.
[3] Isa Yuksel and Turhan Bilir, "use of Industrial by-products to produce plain concreteelements", Vol. 21, No. 3, pp. 686-694, 2007.
[4] M. V. Patil, "A Study on Properties and Effects of Copper slag in Concrete", International Journal of Engineering Trends and Technology, vol. 8, pp. 2313-2319, 2014.
[5] Ramazan Demirbog, and Rustem Gul, "Production of high strength concrete by use of industrial by-products", Building and Environment, Vol. 41, No. 8, pp.1124-1127, 2007.
[6] R R Chavan" Performance of Copper Slag On Strength Properties As Partial Replace of FineAggregate in Concrete Mix Design" International Journal of Advanced Engineering Research and Studies, pp.95-98,2017.
[7] T. Ch. Madhavi" Effect of Copper Slag on the Mechanical Strengths of Concrete" International Journal of ChemTech Research, Vol. 8, No.12, pp 442-449, 2015.
[8] Teik Thye Luin, and Chu J. "Use of spent copper slag for land reclamation", waste management and research, Vol. 24, pp. 67-73,2006.
[9] Wu, W., Zhang, W. and Ma, G. "Optimum content of copper slag as a fine aggregate in high strength concrete", Material design, Vol. 31, No. 6, pp. 2878-2883, 2010.