

A Study on the Strength Properties of M35 Grade Concrete with Partial Replacement of Fine Aggregate by Copper Slag and Cement by Metakaolin

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ABSTRACT: Utilization of industrial waste or secondary materials has encouraged in construction industry for the production of concrete because it contribute to reducing the consumption of natural resources. Copper slag is one of the materials that are considered as an industrial waste which can be used in construction Industry. This project work represents the results of an experimental investigation on the mechanical properties of M35 grade concrete using copper slag as partial replacement of fine aggregate and metakaolin as replacement of cement. The fine aggregate is replaced with copper slag at 10%, 20%, 30%, 40% and 50%, and cement is replace with metakaolin by 10% as mineral admixture which kept constant for all trial mixes. Concrete specimens like cube, cylinder and beams of standard size for various trial mixes were casted and cured under water for 7days, 28 days and 56 days. After the respective days of curing the specimens are taken out from curing tank and tested to ascertain the compressive, tensile and flexural strength of concrete in CTM and UTM respectively.

KEYWORDS: Partial Replacement, Mechanical Strength, Copper Slag, Metakaolin, M35 grade concrete.

I. INTRODUCTION

The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Substantial energy and cost savings can result when industrial by products are used as a partial replacement of cement. Fly ash, Ground Granulated Blast furnace Slag, Rice husk ash, High Reactive Metakaolin, silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement.

METAKAOLIN: Metakaoline is a dehydroxylated form of the clay mineral kaolinite Metakaolin is a valuable admixture for concrete/cement applications. Rocks that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume. Metakaolin is a pozzolanic material which is manufactured from selected kaolin, after refinement and calcinations under specific conditions. It is a highly efficient pozzolana and reacts rapidly with the excess calcium hydroxide resulting from OPC hydration, via a pozzolanic reaction, to produce calcium silicate hydrates and calcium alumina silicate hydrates. It differs from other supplementary cementations materials like fly ash, slag or metakaolin, in that it is not a by-product of an industrial process.

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ADVANTAGES OF METAKAOLINE: 1) Increased compressive and flexural strengths, 2) Reduced potential for efflorescence, 3) Increased resistance to chemical attack, 4) Increased durability, 5) Reduced effects of alkali-silica reactivity (ASR), 6) Enhanced workability and finishing of concrete, 7) Reduced shrinkage.

APPLICATIONS: Dams, Bridges, Water retaining structures, High rise buildings, Off shore structure, Mass concreting, Nuclear power stations, etc.

COPPER SLAG: 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. Slags from ores that are mechanically concentrated before smelting contain mostly iron oxides and silicon oxides. Copper slag is one of the materials that can be considered as a waste material which could have a promising future in construction industry as partial or full substitute of any two either cement or aggregates. It is an industrial by-product material produced during the copper smelting and refining process of manufacturing of copper which can be used for a surprising number of applications in the building and industrial fields. Utilization of copper slag as fine aggregates has advantages of eliminating the costs of dumping, reducing the cost of concrete, and minimizing air pollution problems.

II. LITERATURE REVIEW

1) **T.Naidu, B.Govinda Rajulu, S.Ramlal in 2017**, their review shows the effectiveness of copper by replacing cement in the range of 0% (without Copper slag), 5%, 10%, 15%, and 20% is one phase and sand has been replaced by Copper slag accordingly in the range of 0% (without Copper slag), 10%, 20%, 30%, 40% and 50% is second phase by weight of cement for M25 and M30 mix. Comparative study is carried out by compressive test, split tensile test. From the experimental investigation it is observed that replacement of 40% of fine aggregate by copper slag strength increased by 21% and replacement of 15% of fine aggregate by copper slag strength increased by 18%.

2) **V.Ganapathy Selvam, N.Sakthieswaran, G.Shiny Brintha & O.Ganesh Babu in 2017**, in their research, Portland cement was partially replaced by 5%, 10% of metakaolin and GGBS. This combination of mix ratio were taken for each 20%, 40%, 60% replacement of fine aggregate with copper slag. The water to cementations materials ratio was maintained at 0.38 for all mixes. The strength characteristics of the concrete were evaluated by conducting Compressive strength test for 28days, 56days and 90days of curing and flexural & split tensile strength test were conducted for 28&56days of curing on a M30 grade concrete.

3) **Ambrish E, Dhavamani Doss S, ShanmugaNathan N, Ganapathi Raj S in 2017**, presented the usage of copper slag for the partial replacement for fine aggregate. The experimental procedure is conducted for the replacing percentage of 10%, 15%, 20%, for this above replacement percentage M25 grade concrete is used. The main objective of this project is to know the strength and durability of partial replaced concrete. To evaluate the strength and durability the various test were conducted and concluded that the concrete strength is increased with addition of copper slag with concrete.

4) **N.Sreenivasulu, A.Roopa, M.venkateswarlu, P.Pavani in 2016**, The main objective of their project is to study the strength properties of copper slag as a partial replacement of sand at different levels (0%, 20% and 40%). They studied engineering properties of Copper slag viz. Slump test, compressive strength, split tensile strength after 7, 14 and 28 days at ambient room temperature curing. From the results, it is concluded that the increased replacement level of Copper slag increased the compressive strength, splitting tensile strength values of mixes.

III. MATERIAL PROPERTIES

The raw materials required for manufacture of Portland cement are calcareous materials, such as limestone or chalk and argillaceous materials such as shale or clay. Aggregates are the important constituents in concrete. They

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give body to the concrete, reduce shrinkage and effect economy. Aggregates occupy 70 to 80 percent of volume of concrete. Aggregate are obtained either naturally or artificially. Aggregates can be classified on the basis of size as fine aggregate and coarse aggregate. Metakaolin is a pozzolanic material which is manufactured from selected kaolins, after refinement and calcination under specific condition. It is a highly efficient pozzolana and reacts rapidly with the excess calcium hydroxide resulting from OPC hydration by a pozzolanic reaction, to produce calcium silicate hydrate and calcium aluminosilicate hydrates. Copper slag is a glassy granular material with high specific gravity. Particle sizes are of the order of sand and have a potential for use as fine aggregate in concrete.

Table 3.1: Physical Properties of Portland Cement (53 Grades)

S. NO.	Properties/ Characteristics	Test Results	Requirements As Per Is 12269-1987
1	Normal Consistency	33%	---
2	Setting time a) Initial Setting Time b) Final Setting Time	39 minutes 453 minutes	Not less than 30 minutes Not more than 600 minutes
3	Specific Gravity	3.09	---
4	Fineness of cement by sieving through sieve No.9 (90 microns) for a period of 15 min.	2.90%	<10%
5	Compressive strength of cement (28 days)	53 MPa	53 MPa

Table 3.2: Physical properties of fine and coarse aggregate

S. NO.	Properties	Test Results	
		Fine Aggregate	Coarse Aggregate
1.	Specific gravity	2.41	2.75
2.	Bulk Density (Kg/m ³)	1590 kg/m ³	1520 kg/m ³
3.	Fineness Modulus	-----	7.17

Table 3.3: Physical properties of Metakaolin

Property	Value
Appearance	Off-White
Density (gm/cm ³)	2.17
Bulk density (gm/cm ³)	1.26
Particle shape	Spherical
Specific gravity	2.6

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Table 3.4: Physical properties of Copper slag

S.No	Property	Experimental values
1	Colour	Black, glassy
2	Grain shape	Angular, multi faceted
3	Moisture content	2 %
4	Specific gravity	3.51
5	Fineness modulus	2.26



Fig. 3.1: Metakaolin



Fig. 3.2: Copper slag

IV. EXPERIMENTAL PROGRAMMES

Table 4.1: Number of specimens casted for all trial mixes

Types of specimen	No. of specimen cured in water					
	Mix-1 0%	Mix-2 10%	Mix-3 20%	Mix-4 30%	Mix-5 40%	Mix-6 50%
Cubes	9	9	9	9	9	9
Cylinders	9	9	9	9	9	0
Beams	9	9	9	9	9	0



Fig. 1: Hand mixing of concrete



Fig. 2: Placing & compacting of concrete

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Fig. 3: Compression testing setup in CTM



Fig. 4: Cracks pattern observed in cube specimen



Fig. 5: Cylinder testing setup in CTM



Fig. 6: Cracks pattern observed in cylinders



Fig. 7: Casted cylinders & beams



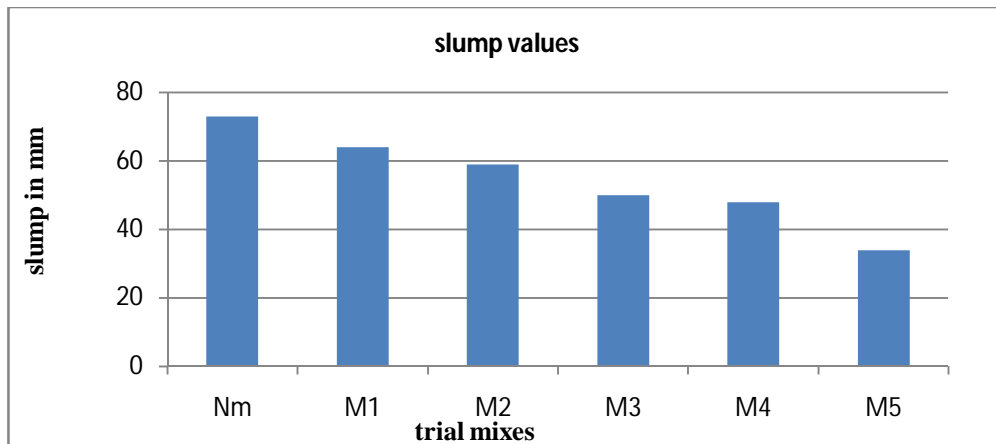
Fig. 8: Flexure strength setup in UTM

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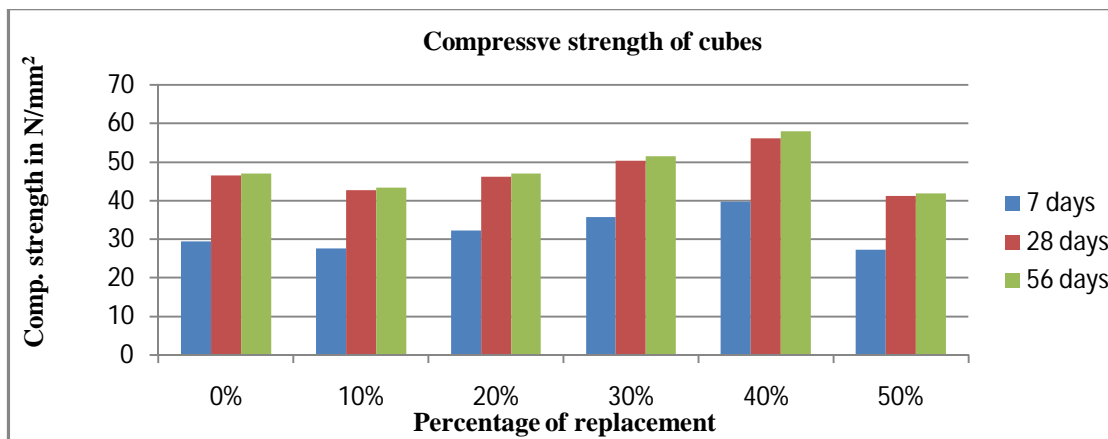
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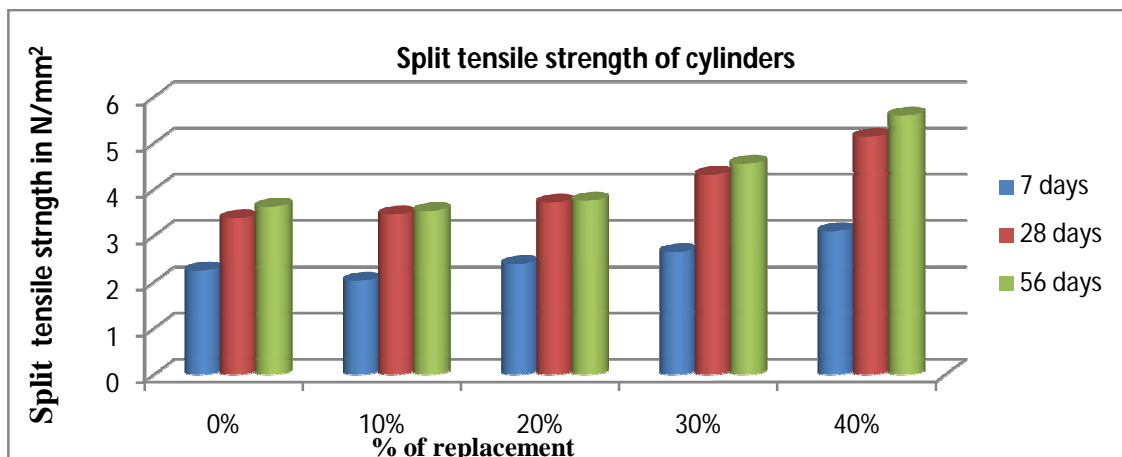
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Graph 1: Slump values of trial mix concrete & normal concrete



Graph 2: Compressive strength of cubes



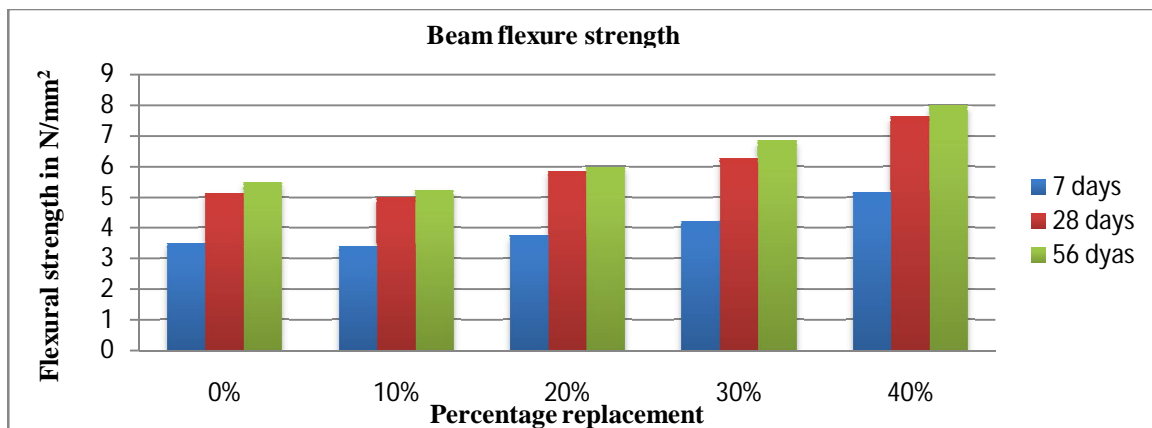
Graph 3: Split tensile strength of cylinders

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Graph 4: Flexure strength of beams.

V. CONCLUSION

- ❖ The slump values for conventional concrete with W/C ratio = 0.45 is observed to be 73mm, and for all other trial mixes of partially replaced concrete the maximum slump values is observed to be 64mm, which is 9mm less than the normal concrete.
- ❖ The maximum values of compressive strength at 7 days, 28 days and 56 days are found to be 39.80 N/mm², 56.20 N/mm² and 58.10 N/mm² respectively for 40% copper slag replacement as fine aggregate. Whereas for normal concrete it is observed to be 29.43N/mm², 46.50N/mm² and 47.05 N/mm² at 7, 28 and 56 days of curing respectively.
- ❖ For copper slag replacement above 40%, the compressive strength decreases to the least value (i.e., less than normal concrete) at all respective ages of concrete.
- ❖ The 28 days cylinder split tensile strength is found to be 3.38 N/mm² for conventional concrete whereas these value increased to 5.14N/mm² for concrete with 10% cement replacement by metakaolin and 40% copper slag replacement for fine aggregate.
- ❖ Beyond 40% replacement of copper slag in concrete as fine aggregate, the split tensile strength is found to be decreased at 7, 28 and 56 days of curing.
- ❖ Among the five mixes (i.e., 0%, 10%, 20%, 30%, 40% and 50% replacement), 40% replacement mix has attained highest strength and 50% replacement mix has recorded least strength..
- ❖ After adding copper slag the concrete becomes very rich mix, so the strength of the concrete increased upto certain level (upto 40% replacement) then it start decreases with further adding of copper slag.
- ❖ Flexural strength of beam specimen at 7, 28 and 56 days for normal concrete is observed to be 3.48 N/mm², 5.13 N/mm² and 5.47 N/mm². Whereas with 40% replacement of copper slag the flexure strength at 7, 28 and 56 days are found to be 5.16 N/mm², 7.62 N/mm² and 7.98 N/mm² respectively.

REFERENCES

1. K. Sathishkumar, K.Anitha, experimental investigation on partial replacement of cement by dolomite and fine aggregate by copper slag International Journal of Pure and Applied Mathematics Volume 116 No. 14 2017, 25-30.
2. Kasu Naveena, k.Anantha Lakshmi, partial replacement of cement with ggbs and metakaolin international journal of advances in mechanical and civil engineering, issn: 2394-2827, volume-4, issue-2, april-2017.
3. T.Naidu, B.Govinda Rajulu, S.Ramlal, A study on the properties of concrete on partial replacement of cement and sand with copper slag, international journal of recent trends in engineering & research (ijrter) volume 03, issue 12; december - 2017 [issn: 2455-1457].
4. N.Sreenivasulu1, A.Roopa, M.Venkateswarlu, P.Pavani, international research journal of engineering and technology (irjet), e-issn: 2395 - 0056, volume: 03 issues: 07 July - 2016.

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(A High Impact Factor, Monthly, Peer Reviewed Journal)

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5. V.Ganapathy Selvam, N.Sakthieswaran, G.Shiny Brintha³ & O.Ganesh Babu, Experimental Behavior on Mechanical Properties of Concrete Using Industrial Byproducts, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 4 Issue V, May 2016, ISSN: 2321-9653.
6. Ambrish E, Dhavamani Doss S, ShanmugaNathan N, Ganapathi Raj S, Partial Replacement of Copper Slag as Fine Aggregate, SSRG International Journal of Civil Engineering (SSRG-IJCE) – volume 4 Issue 3 – March 2017.
7. Deepika K P, Dr.Asha.K, utilization of copper slag as a partial replacement of fine aggregate in concrete, international journal of innovative research in advanced engineering (ijirae) issn: 2349-2763 issue 10, volume 3 (october 2016).
8. Bose christy arun and Preethi ramaswamy, properties of concrete partially replaced with copper slag as fine aggregate and ceramic tile waste as coarse aggregate, indian journal of science and technology, vol 9(5), february 2016, issn (online) : 0974-5645.
9. M. V. Patil, Y. D. Patil, G. R. Veshmawala, performance of copper slag as sand replacement in concrete, international journal of applied engineering research issn 0973-4562 volume 11, number 6 (2016) pp 4349-4353.
10. K Nandini, G Murali krishna, investigation on use of copper slag as partial replacement of fine aggregate in concrete, journal of emerging technologies and innovative research (jetir), november 2016, volume 3, issue 11.
11. Suresh T, Ravikumar C, influence of copper slag as partial replacement of sand in cement concrete, june 2015 | ijirt | volume 2 issue 1 | issn: 2349-6002.
12. Kethireddy mamatha, S.Kamalakar rao, stress strain behaviour of concrete by partial replacement of fine aggregate with copper slag, international journal of research in advanced engineering technologies, volume 6, issue 2 Nov 2017.
13. Zine Kiran Sambhaji, Prof. Pankaj B. Autade, Effect of Copper Slag as a Fine Aggregate on Properties of Concrete, International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2763 Issue 08, Volume 3 (August 2016).