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CONCRETE STRENGTH PROPERTIES BY SUBSTITUTING COPPER SLAG FOR SOME OF THE FINE AGGREGATE

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ABSTRACT

There has been a rise in the usage and manufacturing of concrete in recent decades. Concrete's three primary constituents and production method are major contributors to greenhouse gas emissions. In this study, M25 grade concrete was employed, and experiments were performed using varying percentages of copper slag in lieu of sand. Weight-based mix designs are created by substituting varying amounts of copper slag for sand (0%, 20%, 40%, 60%, and 80%) in the concrete batching process. After 24 hours, the cube, beam, and cylinder specimens will be cured and ready to be prepared and demoulded. At 7, 14, and 28 days, we will conduct compression, split tensile strength, and flexural tests on the specimens.
Keywords: Workability, Compressive Strength, Fine Aggregates, Flexural Strength, Split Tensile Strength, and Copper Slag

1.0.INTRODUCTION:

In India, by-products and waste materials are being generated by various types of industries. Disposal of waste materials effects the environment in various zones. Therefore, these waste materials can be recycled and it is great potential in construction industry. Many researchers found that concrete made with wastes and by-products like fly ash, silica fume, copper slag etc acquires excellent properties than the conventional concrete in terms of strength, performance and durability. Hence, in this project, copper slag is taken to investigate its suitability as a replacement material for fine aggregate while making concrete. Copper slag is an industrial by-product material produced during the smelting and refining process of copper, which can be used for a surprising number of applications in the construction field. It is also having similar physical properties of sand, considered as an alternative material to the river sand. It is the waste product material of copper. Disposal of this waste causes environmental pollution. The construction field is the only area where the safe use of waste material like copper slag is possible. When it is taken as a replacement material in concrete, it lessens the environmental pollution, space problem and also lessens the cost of concrete.

1.1 BACK GROUND OF 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 as discussed below.

Copper slag is mainly used for surface blast-cleaning. Abrasive blasting is used to clean and shape the surface of metal, stone, concrete and other materials. In this process, a stream of abrasive grains called grit is propelled toward the work piece. Copper slag is just one of many different materials that may be used as abrasive grit. Rate of grit consumption, amount of dust generated, and surface finish quality are some of the variables affected by

copper slag can be utilized in concrete to act as fine aggregate. The copper slag in the granular form is utilized now as a sand blaster in finishing metal surfaces. But only 15 to 20% of the copper slag produced alone is being used. Some of it used for land filling leaving the rest unused causing environmental pollution. These fine granules of copper slag are similar to sand grains and hence can be used in concrete as a replacement of fine aggregate. The use of copper slag in concrete provides potential environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of copper slag is produced. This innovative material (copper slag) which is an industrial waste product, if effectively utilized, will reduce not only sand mining but also environmental pollution

2.0 LITERATURE REVIEW

R R Chavan & D B Kulkarni (2013) conducted experimental investigations to study the effect of using copper slag as a replacement of fine aggregate on the strength properties and concluded that Maximum Compressive strength of concrete increased by 55% at 40% replacement of fine aggregate by copper slag and flexural strength increased by 14 % for 40 % replacement. Many researchers have investigated worldwide on the possible use of copper slag as a concrete aggregate. Some of the important and published works are reviewed and presented briefly below. investigated the mechanical properties of high strength concrete replacing fine aggregate with copper slag. Micro silica was used to supplement the cementitious content in the mix for high strength requirement. They observed that when copper slag was used to replace fine aggregate, upto 40% copper slag replacement, the strength of concrete was increases while the surface water absorption decreases. They also observed that when more than 40% of copper slag is used, the microstructure of concrete contains more voids, micro cracks, and capillary channels which accelerate the damage of concrete during loading.

Al-Jabri et al (2009, 2011) investigated the performance of high strength concrete made with copper slag as a replacement for fine aggregate at constant workability and studied the effect of super plasticizer addition on the properties of High Strength Concrete made with copper slag. They observed that the water demand reduced by about 22% for 100% copper slag replacement. The strength and durability of High Strength Concrete improved with the increase in the content of copper slag of up to 50%. However, further additions of copper slag caused reduction in the strength due to increase in the free water content in the mix. Also, the strength and durability characteristics of High Strength Concrete were adversely affected by the absence of the super plasticizer from the concrete paste despite the improvement in the concrete strength with the increase of copper content. The test results also show that there is a slight increase in the density of nearly 5% with the increase of copper slag content, whereas the workability increased rapidly with increase in copper slag percentage.

Caijun Shi et al (2008) reviewed the effect of copper slag on the Engineering properties of cement mortars and concrete. They reported that the utilization of copper slag in cement mortar and concrete is very effective and beneficial for all related industries, particularly in areas where a considerable amount of copper slag is produced. It proved both environmental as well as technical benefits. They observed that there was more than 70% improvement in the compressive strength of mortars with 50% copper slag substitution.

3.0 METHODOLOGY

Table 1: Physical properties of cement

S. No	Property	Test results
1	Normal consistency	30%
2	Specific gravity	3.1
3	Initial setting time	34 minutes
4	Final setting time	465 minutes

Table 2: Physical properties of fine aggregate

S. No	Property	Value
1	Specific gravity	2.46
2	Fineness modulus	4.91
3	Bulk density: Loose Compacted	 14kN/m^3 15kN/m^3
4	Grading	Zone-I

Table 3: Physical properties of coarse aggregate

S. No	Property	Value
1	Specific gravity	2.65
2	Fineness modulus	4.911
3	Bulk density Loose Compacted	 14 kN/m^3 16 kN/m^3
4	Nominal maximum size	20 mm

Table 4: Physical properties of water

S. No	Property	Value
1	$_p$H	7.1
2	Taste	Agreeable
3	Appearance	Clear
4	Turbidity(NT units)	1.75

4.0 MIX DESIGN

M25 grade of concrete is designed in accordance with the guidelines of code book IS 10262:2009 with replacement of fine aggregate by copper slag. The mix proportion obtained is 1:1.65:2.67 (C: FA:CA) with water cement ratio of 0.50. Copper slag is added at varying percentages of 0%, 20%, 40%, 60% and 80% by replacing fine aggregate. The compressive strength specimens are casted and cured in water for 7days and 28 days. The split tensile strength and flexural strength specimens are casted and cured in water for 28 days. After curing, they are tested for their respective strengths.

5.0 SPECIMEN SIZES:

- 150 mm x 150 mm x 150 mm cubes were cast for compression test with replacement 0%, 20%, 40%, 60%, 80% and 100% replacement of copper slag. The specimens were demoulded after 24 hours and tested for 7 days, 14 days and 28 days of curing.

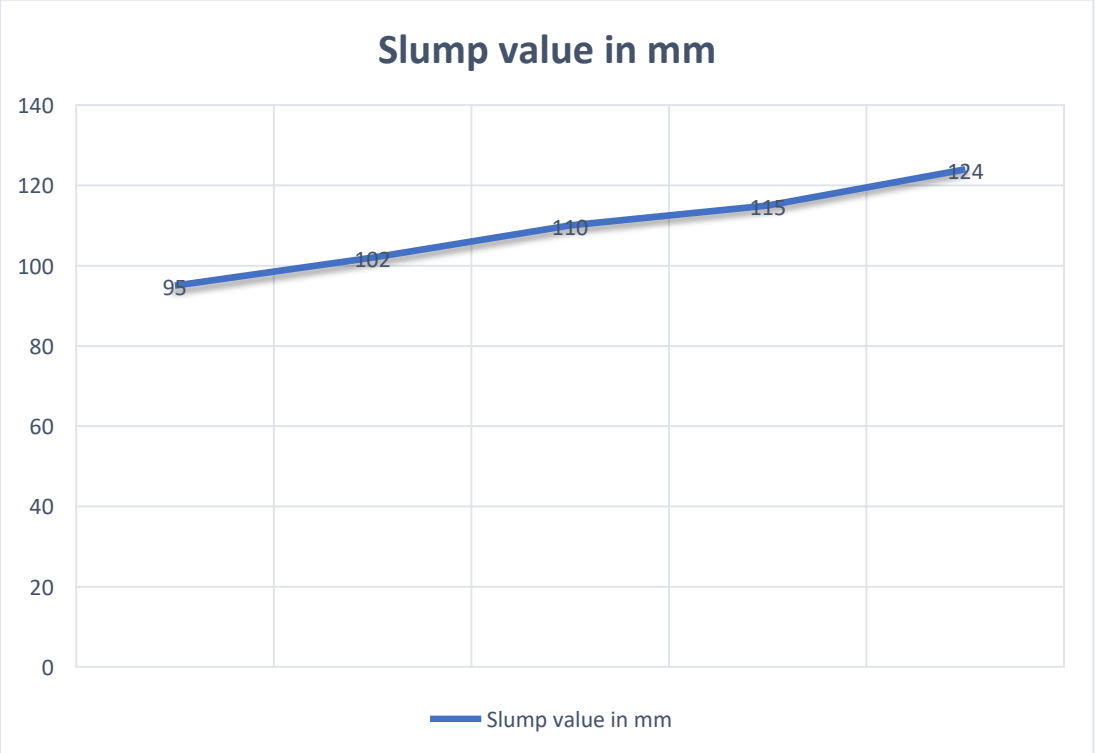
Water: Cement: F.A.: C.A. = 0.5: 1: 1.65: 2.67

- 150 mm x 300 mm cylinders were cast for split tensile test with replacement of 0%, 20%, 40%, 60%, 80% and 100%replacement of copper slag. The specimens were demoulded after 24 hours and tested for 7 days, 14 days and 28 days of curing.
- Beam mould of size 15 x 15x 70 cm (when size of aggregate is less than 38 mm) or of size 10 x 10 x 50 cm (when size of aggregate is less than 19 mm)

6.0 RESULTS AND DISCUSSIONS

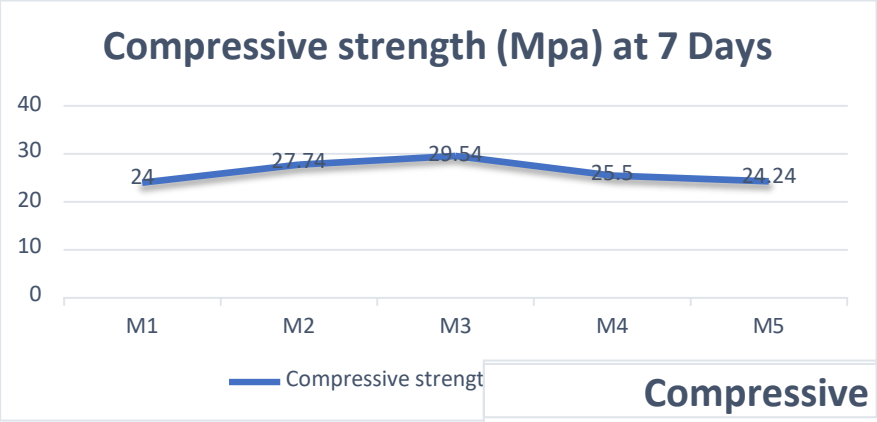
Slump Cone Test Results

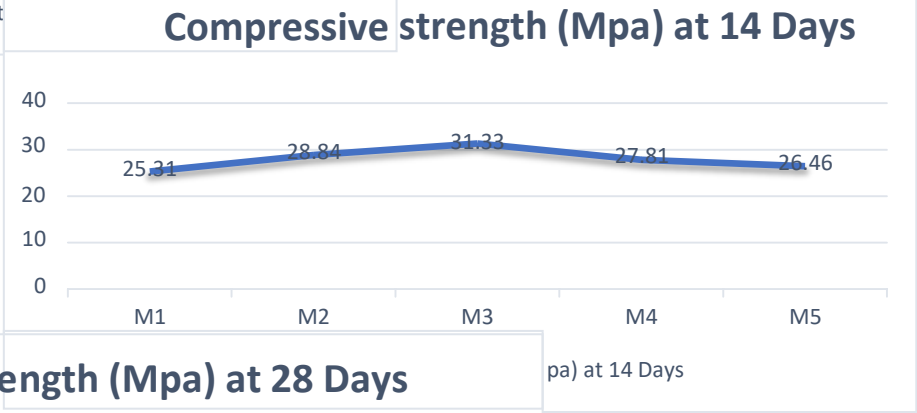
S.No	% Copper Slag +% Fine Aggregate	MIX Name	Slump Value (mm)
1	0% CS + 100% FA	M1	95
2	20% CS + 80% FA	M2	102
3	40% CS + 60% FA	M3	110
4	60% CS + 40% FA	M4	115
5	80% CS + 20% FA	M5	124

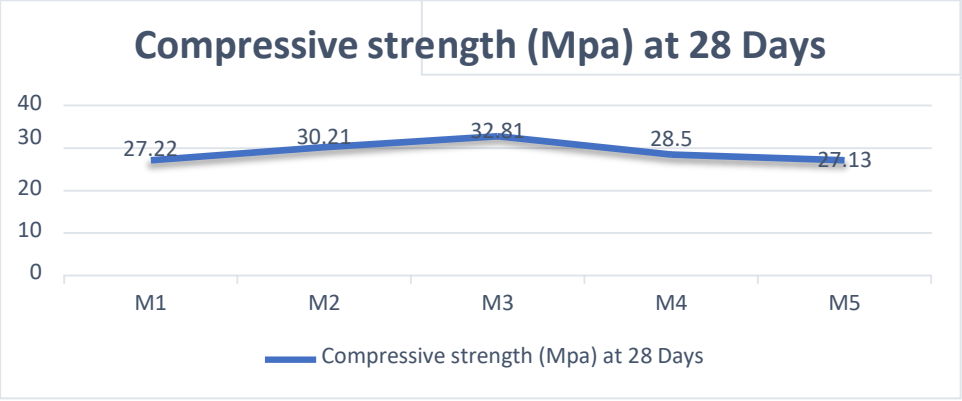


COMPRESSIVE STRENGTH TEST RESULTS

S.No	% Copper Slag +% Fine Aggregate	MIX Name	COMPRESSIVE STRENGTH, MPa		
			7 Days	14 Days	28 Days
1	0% CS + 100% FA	M1	24	25.31	27.22
2	20% CS + 80% FA	M2	27.74	28.84	30.21
3	40% CS + 60% FA	M3	29.54	31.33	32.81
4	60% CS + 40% FA	M4	25.5	27.81	28.5
5	80% CS + 20% FA	M5	24.24	26.46	27.13

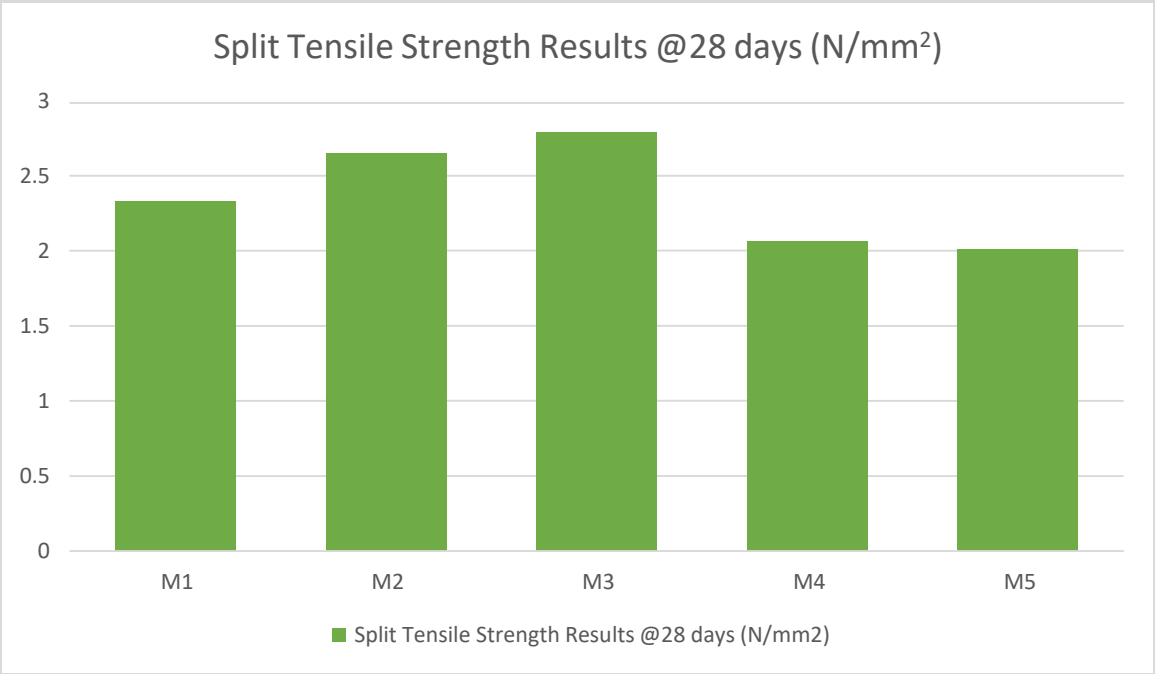






SPLIT TENSILE STRENGTH

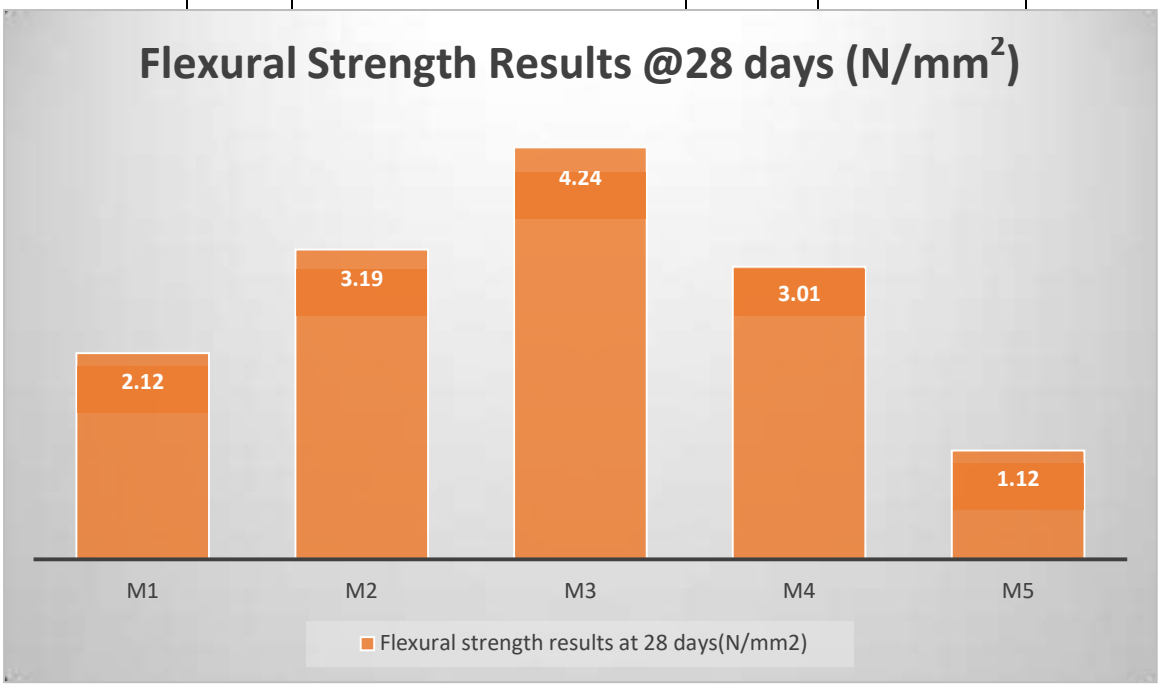
S.No	% Copper Slag +% Fine Aggregate	MIX Name	Split tensile strength (N/mm^2)
1	0% CS + 100% FA	M1	2.33
2	20% CS + 80% FA	M2	2.65
3	40% CS + 60% FA	M3	2.79
4	60% CS + 40% FA	M4	2.06
5	80% CS + 20% FA	M5	2.01



FLEXURAL STRENGTH TEST RESULTS

S.No	% Copper Slag +% Fine Aggregate	MIX Name	Split tensile strength (N/mm^2)
1	0% CS + 100% FA	M1	2.12
2	20% CS + 80% FA	M2	3.19
3	40% CS + 60% FA	M3	4.24

4	60% CS + 40% FA	M4	3.01
5	80% CS + 20% FA	M5	1.12



7.0 CONCLUSIONS

- The compressive strength of 40% replacement of fine aggregate by copper slag for 28 days is 32.81 N/mm^2 and for 7 days is 29.54 N/mm^2 is higher as compared to conventional mix that are 24 N/mm^2 and 27.22 N/mm^2 for 7 days and 28 days respectively.
- It also observed that, after 28 days of curing, the split tensile strength and flexural strength are obtained for the same 40% replacement that are 2.79N/mm^2 and 4.24N/mm^2 is greater than conventional mix results, which are 2.33N/mm^2 and 2.12N/mm^2 respectively.
- Form the results of compressive strength, split tensile strength and flexural strength, the concrete shown higher value at 40% replacement of fine aggregate by using copper slag.
- We conclude that, by using copper slag as replacement for fine aggregate in concrete increases the density of concrete.
- Hence, 40% replacement of copper slag is the optimum proportion for replacing fine aggregate.

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