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Study on Strength Performance of Concrete With Partial Replacement Of Fine Aggregate With Copper Slag Using Polypropylene Fiber

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ABSTRACT
This paper's main goal is to examine how concrete performs when fine aggregate is replaced with copper slag from the sterilised manufacturing industry. With various amounts of 10%, 20%, 30%, 40%, and 50% of the weight of fine aggregate, copper slag substitutes some of the fine aggregate. The preliminary test findings were visible in copper slag, cement, fine aggregate, and coarse aggregate. IS 10262 - 2009 was followed in the mix design's completion. M40 grade concrete and water cement are combined at a 0.45 ratio. Over the course of 28 days, a number of strength tests, including the split tensile strength test and the compressive strength test, must be completed.

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I. INTRODUCTION

Concrete is a material that is widely used in the development of many types of designs. The construction industry has promoted the use of secondary materials or industrial solid waste for the manufacturing of cement and concrete since it helps reduce the usage of natural resources. For a very long period, adverse consequences including fly debris, silica haze, and slag were thought of as trash. Some of the byproducts can be utilised as a partial or full replacement for Portland cement and fine and coarse aggregates in the building sector. Metalworking procedures result in copper slag as a byproduct in Reverberator furnaces. Two to two and a half tonnes of copper slag are created for every tonne of copper that is produced. Copper slag is disposed of as trash in the companies that manufacture copper. River sand, which is a limited-supply fine aggregate, is preferable to copper slag because it is glassy and granular in form. Aggregates are crucial components of concrete. Aggregates occupy between 60 and 75 percent of the concrete's volume. In concrete, the fine aggregate is frequently river sand. A river or lake's bed is often mined for natural sand by dredging or mining. The ecology becomes unbalanced as a result. River sand substitutes are being looked into as alternatives to manufactured aggregates, which are expensive. Using industrial waste as aggregates decreases environmental pollution in addition to costs. One substance that can be used in place of sand in concrete is copper slag. As an additional material, polypropylene filaments are used to work on the cement display.

II. MATERIALS AND ITS PROPERTIES

The experiment's materials comprise regular Portland cement of grade 53, fine aggregate smaller than 4.75 mm, and coarse aggregate smaller than 20 mm.

I. Cement

53 grade ordinary Portland cement that complies with IS 1489 (part 1). All of the specimens were cast using regular Portland cement, grade 53. The compatibility of the chemical and mineral additive with cement must also be guaranteed. Cement underwent the required laboratory tests to ascertain its standard consistency, starting and final setting times, and compressive strength in accordance with IS: 4031

II. Coarse aggregate

The 20mm crushed granite course that is readily accessible in the area and meets Indian Standard Specifications (BIS: 383 - 1970). Table 1.2 lists the characteristics of coarse aggregate as determined by laboratory studies.

III. Fine aggregate

The 20mm crushed granite course that is readily accessible in the area and meets Indian Standard Specifications (BIS: 383 - 1970). Table 1.2 lists the characteristics of coarse aggregate as determined by laboratory studies.

IV. Copper slag

Copper slag is a completely inert substance with physical characteristics akin to those of sand found in nature. It is also employed in the manufacture of cement clinker. It serves as a supplemental replacement for mixed cement. Fine and coarse material can be partially replaced with copper slag. Table 1.4 lists the Copper slag's properties.

Table1.1: Properties of cement.

Sl. No	Physical properties	Values
1.	Specific gravity	3.03
2.	Normal consistency	33%
3.	Initial setting time	40 minutes
4.	Final setting time	445 minutes

Table 1.2: Properties of Coarse Aggregate.

Sl.no	Physical properties	Values
1.	Specific gravity	2.70
2.	Fineness modulus	7.37
3.	Maximum size	20 mm
4.	Water absorption	0.5%
5.	Impact factor	20.39
6.	Bulking density	2.78

Table 1.3: Properties of Fine Aggregate.

Sl. No	Physical properties	Values
1.	Specific gravity	3.92
2.	Fineness modulus	3.47
3.	Maximum size	4.75mm
4.	Water absorption	0.13%

Table 1.4: Properties of Copper slag

SI.no	Physical Properties	Values
1.	Specific gravity	2.60
2.	Fineness modulus	2.89
3.	Maximum size	4.75mm
4.	Zone confirmed	II
5.	Bulking density	23.39
6.	Water absorption	0.5%

MIXTURE PROPORTION AND TEST PREPARATION

a. Mix design proportion

The specifics of the mixing ratios and designations for grade 40 MPa concrete (M 40), include information for both conventional and copper slag concrete. The physical characteristics of the components, such as specific gravity, water absorption, and moisture content, were taken into account throughout the design mix process to give a consistent mixing procedure for the selected ratio. The mix design of concrete utilising Portland cement was carried out manually.

b. Workability test

The mould for the slump test is a 300mm-high frustum of a cone. The hole at the top is narrower, measuring 100mm, while the base is 200mm in diameter. The container is filled with three layers of concrete that have been tested for workability after the foundation has been set up on a flat surface. The concrete slump test gauges how fluid new concrete is before it hardens. It is done to examine whether freshly poured concrete is workable and, consequently, if concrete flows easily. Due to the straightforward gear and straightforward process, the test is well-liked. Under real-world circumstances, the slump test is utilised to guarantee homogeneity for various concrete loads.

c. Compressive Strength

Concrete cubes 150mm in size were used for the cube compression testing. In accordance with IS 516-1965, a test was conducted to determine the compressive strength of concrete at 7, 14, and 28 days. The compression testing machine (CTM) 2000 kN was used to test the cubes. Based on the test findings, it was determined that copper slag concrete had more strength than regular concrete The strength of concrete increases with an increase in copper slag and 0.4% of polypropylene fibre up to a level of 40% replacement, after which the strength decreases at 50% replacement of copper slag in concrete during various curing times. The correlations between the number of days and its mean compressive strength values are depicted in the tables and graphs below. After removing the surface moisture from the specimen, all of the cubes were examined in a saturated state. After the specimen was centred in the testing apparatus, the tests were conducted under a constant load.

e. Split Tensile Strength

The exam followed the IS 5816-1999 code requirement. One of the fundamental and significant characteristics of self-compacting concrete is split tensile strength. In accordance with IS 516-1959, a test was conducted to determine the split tensile strength of concrete at 28 days of age. Utilising a compression testing machine (CTM) with a 2000KN capacity, the cylinders were put to the test. The strength of concrete increases with the addition of copper slag and 0.4% polypropylene fibre up to a replacement level of 40%; after that, the strength decreases at 50% replacement of copper slag in concrete during various curing times. River sand is replaced in concrete with foundry sand of an equivalent weight The correlations between the number of days and its mean split tensile strength values are depicted in the tables and graphs below. Due to its low tensile strength and brittleness, concrete is often not anticipated to sustain the direct tension. The alternative methods for determining the tensile strength of concrete, aside from flexure, may be roughly divided into direct and indirect approaches. owing to the challenges with direct stress testing. A cylinder with a 150mm diameter and 300mm height was utilised to measure split tensile strength. The cylinder test specimen was created according to protocol. The cast forces were in contact with the testing machine's plates while this specimen was spread down horizontally in the compression testing apparatus. Up until the sample failed, the load was applied steadily. At a failure, the load was noticed.

TEST RESULTS

a. Slump workability test:

The test results are tabulated below 1.5

S.No	Concrete grade	copper slag replaced	Slump value in (mm)
1.	M40	0%	75
2.		10%	75
3.		20%	73
4.		30%	72
5.		40%	72
6.		50%	70

b. Compressive Strength of Concrete:
The test results are tabulated below in 1.6

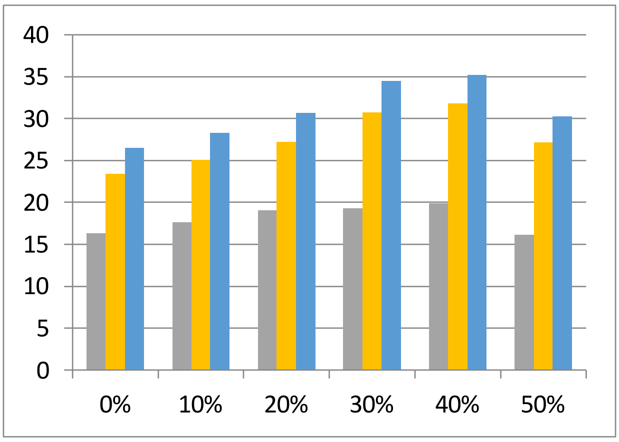
S.No	Percent of copper slag added	Compressive strength (N/mm^2) 28 Days		
		Test – 1	Test – 2	Test – 3
1.	10%	27.9	28.1	28.26
2.	20%	31.28	30.92	30.61
3.	30%	34.23	33.76	34.44
4.	40%	34.88	35.56	35.20
5.	50%	29.84	31.89	30.24

c. Split Tensile Strength of Concrete: The test results are tabulated below in 1.7

S.No	Percent of copper slag added	Split tensile strength (N/mm^2) 28 Days		
		Test – 1	Test – 2	Test - 3
1.	10%	3.69	3.45	3.52
2.	20%	3.37	3.51	3.59
3.	30%	3.72	3.68	3.69
4.	40%	3.78	3.90	3.80
5.	50%	3.14	3.11	3.27

COMPARISON OF SPECIMENS

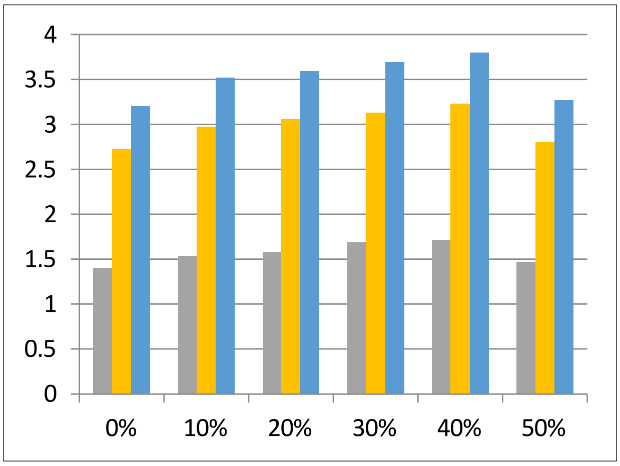
The compressive strength values for ordinary concrete, concrete with various percentages of copper slag replacement, and concrete with 0.4% polypropylene fibre replacement are shown in the accompanying table.
The compressive strength test on 7 days, 14 days and 28 days are depicted below:



Compression strength test on 7days, 14days and 28 days.

The following table 7.5 show the split tensile strength value for both conventional and different percentage copper slag replaced and 0.4% of polypropylene fiber replaced concrete.

The split tensile strength test on 7 days, 14 days and 28 days are depicted below:



Split strength test on 7days, 14days and 28 days.

III. DISCUSSION

It has been shown that copper slag concrete has better strength than regular concrete. The strength of concrete increases with an increase in copper slag and 0.4% of polypropylene fibre up to a level of 40% replacement, after which the strength decreases at 50% replacement of copper slag in concrete during various curing times. The strength of concrete increases with the addition of copper slag and 0.4% polypropylene fibre up to a replacement level of 40%; after that, the strength decreases at 50% replacement of copper slag in concrete during various curing times. River sand is replaced in concrete with foundry sand of an equivalent weight. The correlations between the number of days and its mean split tensile strength values are depicted in the tables and graphs below. Concrete samples were used in the experimental investigations, and the behaviour of sea concrete was examined and its strength characteristics compared. The concrete used in the control experiment was cast and cured after 28 days. Workability tests like the compaction factor test and slump cone test for the 0%, 10%, 20%, 30%, 40%, and 50% were almost identical and likewise had good workability values. When compared to the typical M40 grade of concrete, the aforementioned tests on hardened concrete, such as the compression test and split tensile test, have a good tendency.

IV. CONCLUSION

The experimental research done on concrete built using copper slag led to the following results. The M40 grade of concrete was created with copper slag as the fine aggregate and 0.4% of polypropylene fibre as an admixture. Partial replacements of 0%, 10%, 20%,

30%, 40%, and 50% are also taken into consideration. The workability of the concrete mix was prepared, and each mix's strength properties were identified. At the curing ages of 7, 14, and 28 days, the strength characteristics such as cube compressive strength, cylinder breaking tensile strength, and prism the modulus of rupture are taken into consideration. Following the completion of all tests on the specimen, it was found that a 40% substitution of copper slag for fine aggregate improved the compression strength. The inclusion of up to 40% replacement of copper slag and 0.4% fibre increases the concrete's compressive strength by 5 to 10% compared to normal concrete, while the addition of 50% replacement reduces their strength. When fine aggregate is substituted with 40% copper slag, the tensile strength rises to 3%–5%. Additional copper slag addition results in less strength than regular concrete. There have been minimal adjustments in flexure strength. In the end, this form of concrete is selected to reach the needed strength up to 40% copper slag replacement and 0.4% polypropylene fibre.

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