

Experimental Comparison on Partial Replacement of Fine Aggregate with Copper Slag in Concrete

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ABSTRACT: In this experiment a step is taken to reduce the use of fine aggregate in the concrete with copper slag. The fine aggregate is partially replaced with copper slag for 10%, 20%, 30%, 40% and 50%. The conventional concrete is compared with the copper slag replaced concrete on the basis of compressive strength, flexural strength and split-tensile of the concrete. The test has been conducted for the curing periods of 7 days, 14 days and 28 days.

KEYWORDS: Copper slag; Compressive strength; Flexural strength; Split-tensile

I. INTRODUCTION

The government of Tamil Nadu has banned the taking of sand from the river beds. So, the demand of fine aggregate get increased. It is a current trend to use the waste material as a replacement for the constituents of concrete. Copper slag is a waste or byproduct of copper get hold of during the smelting process of copper. it can be used as a replacement material.

II. MATERIALS

A. CEMENT

Cement is a binding material that glues the fine aggregate and coarse aggregate in concrete. Ordinary Portland cement of grade 53 is used for this experiment.

The test results on cement is tabulated below:

TABLE 1: PROPERTIES OF CEMENT

Sl.No	Properties	Results
1.	Normal Consistency (%)	32
2.	Setting Time (minutes)	
	i) Initial setting time	55
	ii) Final setting time	230
3	Specific gravity	3.10

B. FINE AGGREGATE

The River sand is used as fine aggregate which is locally available. According to IS 383-1970 (reaffirmed 1997), the sieve analysis result shows that sand confirmed to Zone II.

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The test results of fine aggregate are tabulated below

TABLE 2: SIEVE ANALYSIS OF RIVER SAND

IS sieve (mm)	Percentage passing	Grading for zone II as per IS:383-1970
4.75	100.00	90-100
2.36	97.10	75-100
1.18	79.30	55-90
0.60	56.70	35-59
0.30	9.90	8-30
0.15	2.00	0-10
0.075	0.20	-
Pan	0.00	-

C. COARSE AGGREGATE

The materials which was retained in the sieve of 4.75mm sieve is called coarse aggregate. Locally available 20mm size aggregate is used in the experiment. The results were conducted according to is 2386-1963.

The test results of coarse aggregate are tabulated below:

TABLE 3: PROPERTIES OF COARSE AGGREGATES

Sl.No	Properties	Results
1.	Impact value %	21
2.	Crushing value %	25.0
3.	Abrasion value %	24.91
4.	Combined elongation and flakiness indices %	28.0
5.	Specific gravity	2.63
6.	Water absorption %	0.45

D. COPPER SLAG

Copper slag is a by-product of copper get hold of from the smelting process of copper. For the production of 1 ton of copper 2-3 tons of copper slag were produced. Copper slag used in the present studies was got from Sterlite Industries India Limited (SIIL), Tuticorin, Tamil Nadu, India.

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Chemical properties of copper slag are tabulated below:

TABLE 4: CHEMICAL COMPOSITION OF COPPER SLAG

Sl.No	Chemical Components	% Of Chemical Component
1.	Fe ₂ O ₃	68.29
2.	SiO ₂	25.84
3.	LoI	6.59
4.	Al ₂ O ₃	0.22
5.	CaO	0.15
6.	Na ₂ O	0.58
7.	K ₂ O	0.23
8.	Mn ₂ O ₃	0.22
9.	TiO ₂	0.41
10.	So ₃	0.11
11.	CuO	1.20
12.	Sulphide sulphur	0.25
13.	Insoluble residue	14.88
14.	Chloride	0.018

The test results on copper slag is tabulated below:

TABLE 5: SIEVE ANALYSIS OF COPPER SLAG

IS sieve (mm)	Percentage passing	Grading for zone II as per IS:383-1970
4.75	100.00	90-100
2.36	97.80	75-100
1.18	79.40	55-90
0.60	44.10	35-59
0.30	8.40	8-30
0.15	2.40	0-10
0.075	0.90	-
Pan	0.00	-

III. MIX PROPORTION

The M40 grade concrete is prepared with the following mix proportion

TABLE 6: MIX PROPORTIONS (Kg/m³) AND MIX RATIO

Cement	Fine Aggregate	Coarse Aggregate	Water
350	896	1140	140
1	2.56	3.25	0.4

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IV. RESULT AND DISCUSSIONS

TABLE 7: CONCRETE MIXTURES WITH DIFFERENT MIX PROPORTIONS

Mix Materials	Cement Kg/m ³	CA Kg/m ³	FA Kg/m ³	CS Kg/m ³
M0	350	1140	896	0
M1	350	1140	806.4	89.6
M2	350	1140	716.8	179.2
M3	350	1140	627.2	268.8
M4	350	1140	537.6	358.4
M5	350	1140	448	448

A. SLUMP TEST

TABLE 8: SLUMP VALUE

Sl.No	Mix proportions	Slump value
1	M0	23.5
2	M1	24.0
3	M2	24.5
4	M3	25
5	M4	25.5
6	M5	26

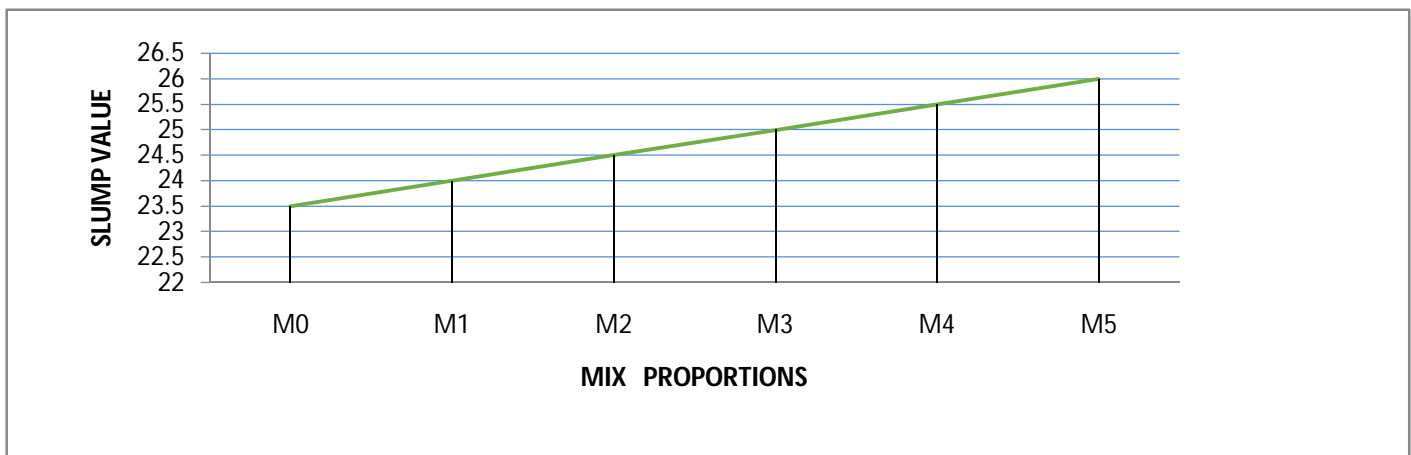


Fig.1 Results of Slump Test

B. COMPRESSIVE STRENGTH

60 concrete cubes of size 150 mm X 150 mm X 150 mm were prepared as per IS 10086-1982. Once the specimen is cured, it is tested for compressive strength. The maximum load at failure reading was taken and their average compressive strength is given in Table 9.

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TABLE 9: COMPRESSIVE STRENGTH OF VARIOUS SAMPLES (N/MM2)

Mix	7th day	14th day	28th day
M0	47.62	51.73	55.83
M1	49.02	53.9	58.92
M2	51.95	56.15	60.95
M3	53.94	56.99	62.54
M4	55.61	60.84	66.27
M5	48.26	51.52	55.37

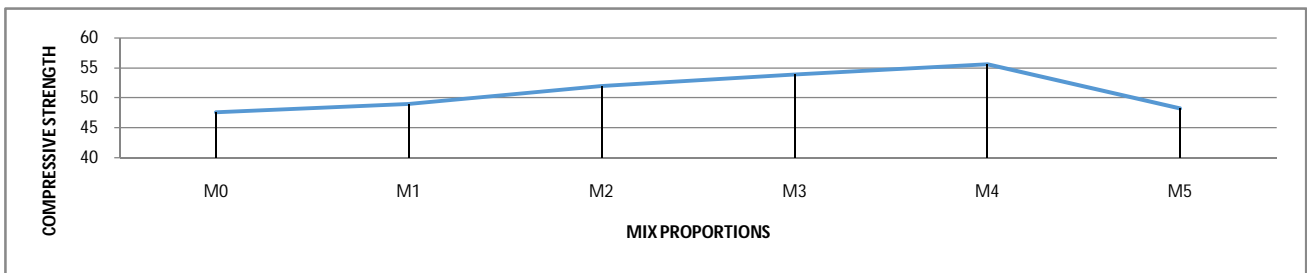


Fig. 2 Compressive Strength in 7th day

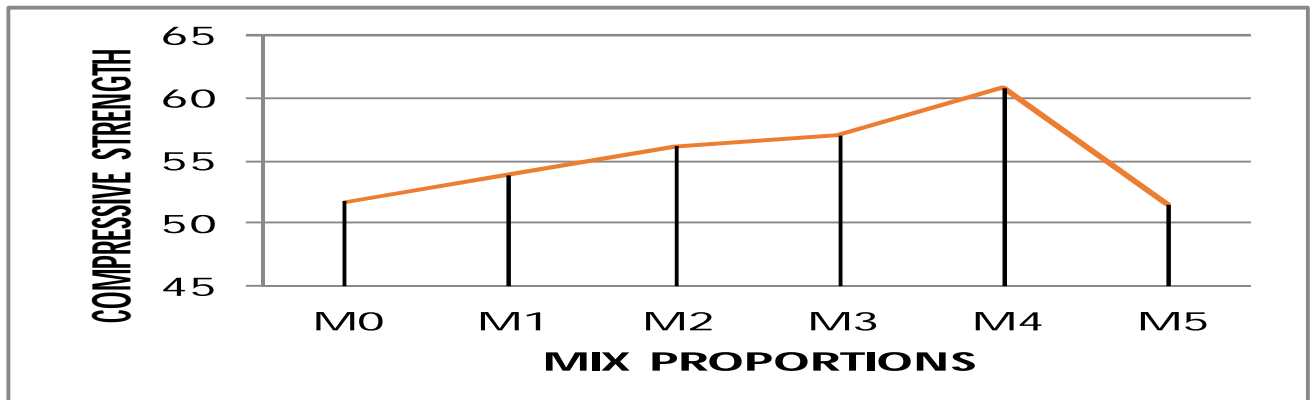


Fig. 3 Compressive Strength in 14th day

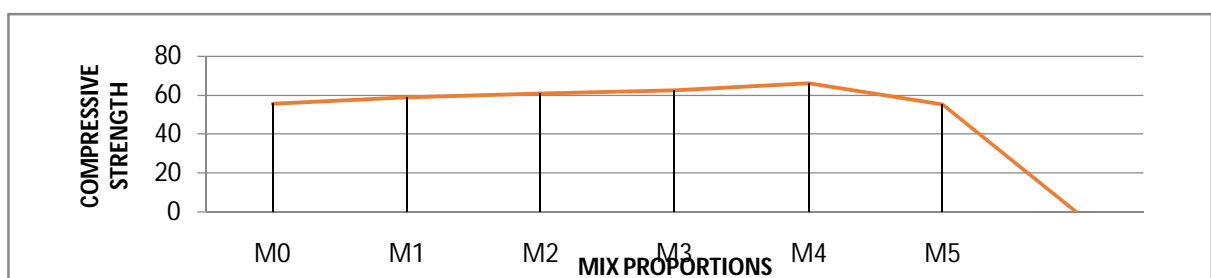


Fig. 4 Compressive Strength in 28th day

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C. FLEXURAL STRENGTH

It is the ability of a beam or slab to resist failure in bending. The flexural strength of concrete is 12 to 20 percent of compressive strength.

TABLE 9: FLEXURAL STRENGTH OF VARIOUS SAMPLES (N/MM²)

Mix	7th day	14th day	28th day
M0	38	41.35	44.66
M1	39.216	43.12	47.136
M2	41.56	44.92	48.76
M3	43.152	45.592	50.032
M4	44.488	48.672	53.016
M5	38.608	41.16	44.296

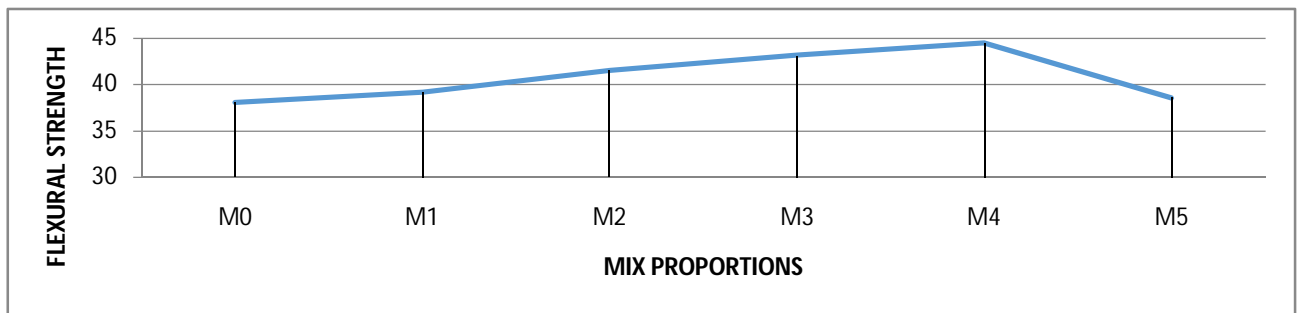


Fig.5 Flexural Strength in 7th day

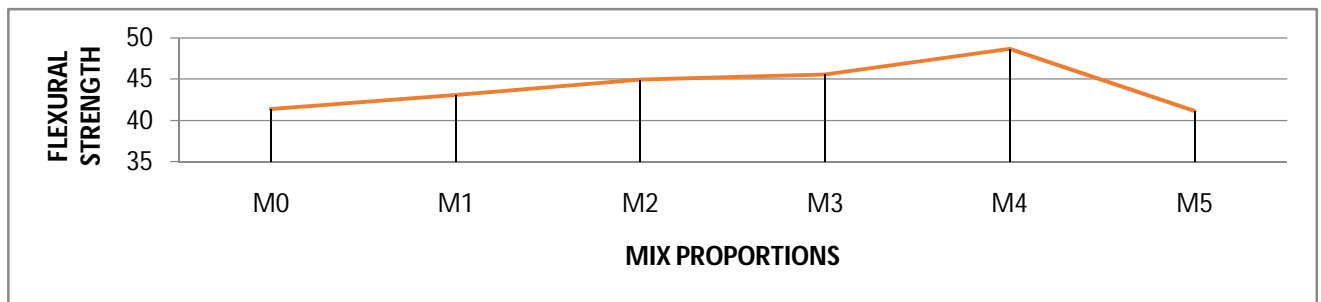


Fig. 6 Flexural Strength in 14th day

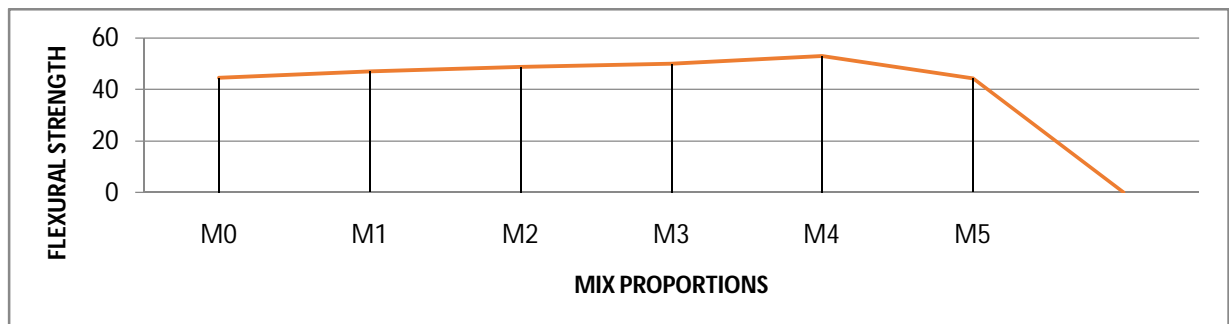


Fig. 7 Flexural Strength in 28th day

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D. SPLIT-TENSILE STRENGTH

TABLE 9: SPLIT-TENSILE STRENGTH OF VARIOUS SAMPLES (N/MM²)

Mix	7th day	14th day	28th day
M0	33.334	36.211	39.081
M1	34.314	37.73	41.244
M2	36.365	39.305	42.665
M3	37.758	39.893	43.778
M4	38.927	42.588	46.389
M5	33.782	36.064	38.759

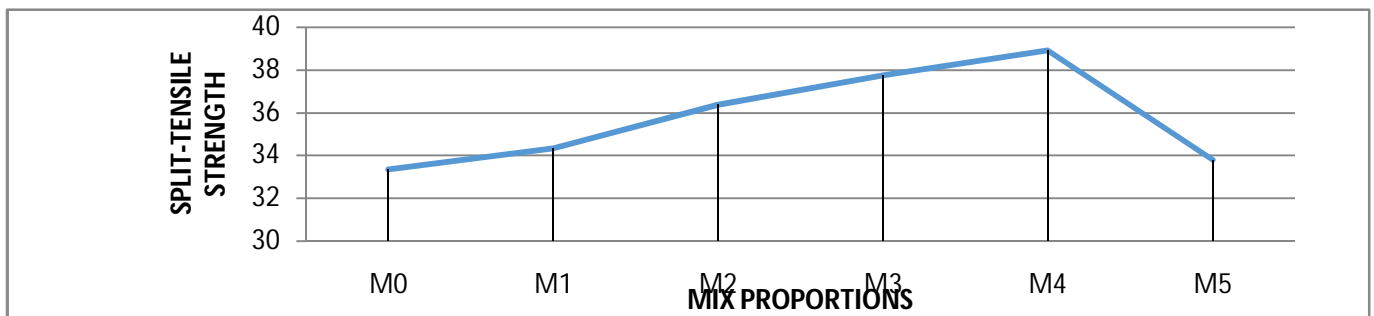


Fig. 8 Split-Tensile Strength in 7th day

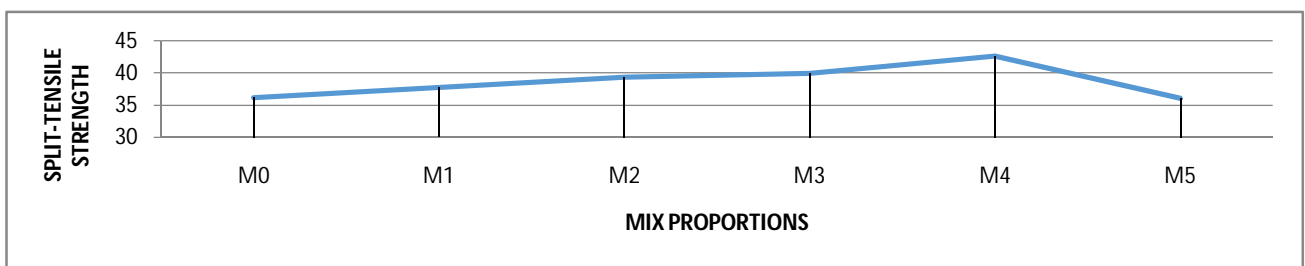


Fig. 9 Split-Tensile Strength in 14th day

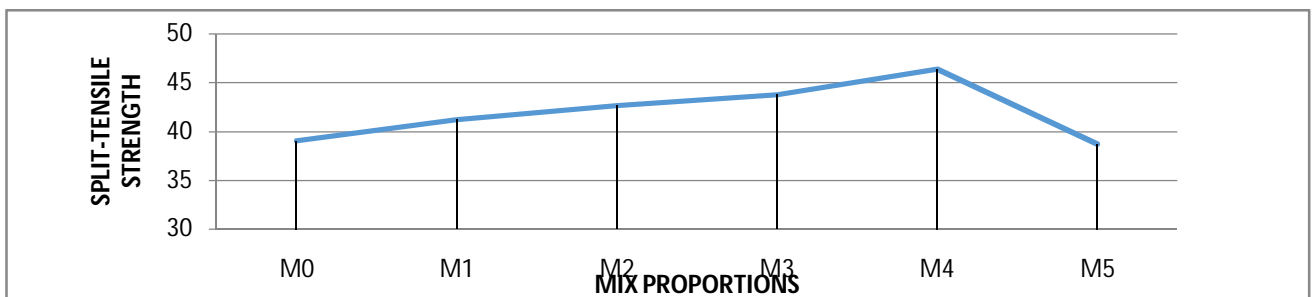


Fig. 10 Split-Tensile Strength in 28th day

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V. CONCLUSION

- The results of tests indicated that the strength of concrete increases with respect to the percentage of slag added by weight of fine aggregate up to 40% of additions.
- Compressive strength is increased due to high toughness of Copper slag.
- The strength of concrete on 40% replacement increases up to 20% when compared with conventional concrete.
- The strength of concrete gradually decreases when the replacement exceeds 40%.
- This copper slag replaced concrete is very cost effective when compared to conventional concrete.

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