

# Effect of Copper Slag and Basalt Fibers on Various Properties of Concrete

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**ABSTRACT:** The purpose of this research is to find the suitability of copper slag as an alternative material for the river sand. This experimental study was divided into four phases, where in the first phase physical properties of cement, aggregates and copper slag were examined. In the second phase, M30 grade of concrete is chosen to perform the effective replacement of copper slag with fine aggregate by replacement levels of 0%, 20%, 40% and 60% and the behavior of fresh and hardened properties of concrete was carried out. Fibers of the 21st century non-metal inorganic fiber, extracted from Basalt rock called Chopped Basalt Strands which is a relative newcomer to fiber reinforced polymers (FRPs) and structural composites were used in the concrete taken in 0%, 1% and 2% by weight of cement. At 20% replacement of copper slag with 1% basalt fibers showed the maximum strength for cube compressive strength, cylinder compressive strength, split tensile strength. For flexural strength, at 20% replacement of copper slag with 1% basalt fibers showed the maximum strength. By acid attack test, the maximum percentage loss of weight and percentage loss in compressive strength was found for 60% replacement of copper slag.

**KEYWORDS:** Copper Slag, Basalt Fibre, Acid Test, Combination and Strength of Concrete.

## I. INTRODUCTION

Concrete, a material of construction industry which is widely using all over the world. It is versatile, has desirable engineering properties, produced with cost effective materials which can be moulded into any shape. It has synonymous with strength and longevity. It is also brittle in nature. More than ten billion tonnes of concrete are consumed annually. Based on global usage, it was placed in second position next to water.

Aggregate content is a factor, which is having direct and far-reaching effects on the nature and quality of concrete. Unlike the water and cement, which cannot be altered in any particular characteristic, apart from the quantity in which they are used, the aggregate component is infinitely variable in terms of shape and grading.

## II. OBJECTIVE

The main objective of the present experimental investigation is to obtain the influence of the combined application of Copper Slag and Basalt Fibre on various strength properties of M40 grades of concrete. 20%, 40% & 60% of Copper Slag and 1% and 2% of Basalt Fibre. Compressive strength, split tensile strength, Flexural strength & Acid Resistance Test of the concrete prepared using different proportions of 20%, 40% & 60% of Copper Slag and 1% and 2% of Basalt Fibre are to be obtained and the results are to be compared with that of controlled concrete.

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## III. EXPERIMENTAL INVESTIGATION

### A. PROPERTIES OF MATERIALS

#### i. CEMENT

In the present investigation Ordinary Portland Cement (OPC) of 53 Grade confirming to IS specifications was used. The properties of cement are shown in Table.1.

Table 1. Properties of Cement

S. No	Characteristics	Test results	Requirements as per IS 12269 – 1987
1	Fineness (retained on 90- $\mu$ m sieve)	6%	<10%
2	Normal Consistency	32%	--
3	Initial setting time of cement	60 min's	30 minutes (minimum)
4	Final setting time of cement	300 min's	600 minutes (maximum)
5	Expansion in Le-chatelier's method	4 mm	10 mm (maximum)
6	Specific gravity	3.15	3.10 – 3.25

#### ii. FINE AGGREGATE

Locally available river sand confirming to IS specifications was used as the fine aggregate in the concrete preparation. The properties of fine aggregate are shown in Table.2.

Table 2. Properties of Fine Aggregate

S.No	Property	Value
1	Specific Gravity	2.76
2	Fineness Modulus	2.77
3	Bulk Density (Loose)	14.50 kN/m <sup>3</sup>
4	Grading of Sand	Zone – II

#### iii. COARSE AGGREGATE

Crushed granite metal of nominal size 20 mm and 10 mm obtained from the local quarry and confirming to IS specifications were used. The properties of coarse aggregate are shown in Table.3. The coarse aggregate used for the preparation of concrete is a combination of 20 mm and 10 mm size aggregates in ratio 1.5: 1.0.

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Table3. Properties of Coarse Aggregate

S.No	Property	Result
1	Specific Gravity	2.83
2	Bulk Density (Loose )	14.80 kN/m <sup>3</sup>
3	Water Absorption	1.2%
4	Fineness Modulus	7.1

#### iv. COPPER SLAG

Copper Slag, is a black glassy and granular in nature and has a similar particle size range like sand. It is an industrial by-product obtained during the smelting of copper. Copper slag used in this work was from Sterlite Industries (India) Ltd, Tuticorin, Tamil Nadu, which was collected from the supplier Copag Abrasives and Minerals, Tuticorin, Tamil Nadu, India. The properties of Copper Slag are shown in Table 4.

Table 4. Properties of Copper Slag

S.No.	Property	Value
1	Particle shape	Irregular
2	Appearance	Black and Glassy
3	Type	Air Cooled
4	Specific gravity	3.91
5	Percentage of voids %	35
6	Bulk density g/cc	2.08
7	Fineness modulus	3.47
8	Angle of internal friction	51° 20'
9	Ultimate shear stress kg/cm	0.4106
10	Water absorption %	0.16
11	Moisture content %	0.1

#### v. BASALT FIBRE:

In the present experimental investigation, Chopped Basalt Strands of 18 mm length procured from NICKUNJ EXIMP ENTERPRISE PVT LTD, Mumbai, India were used. The properties of Chopped Basalt Fibers compared with other majorly used fibers. The properties of Basalt Fibre are shown in Table 5.

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Table 5. Properties of Basalt Fibre

Item	Chopped Basalt Fiber
Density(g/cm <sup>3</sup> )	2.63
Tensile Strength(MPa)	3200-3850
Elastic Modulus (GPa)	75-90
Elongation at break (%)	3.1
Softening Point (°C)	1050
Working Temperature (°C)	260-650
Temporary Temperature (°C)	1100

### vi. WATER

Water used for casting and curing of concrete test specimens is free from impurities which when present can adversely influence the various properties of concrete.

### vii. CONCRETE MIX PROPORTION

In the present experimental investigation the influence of combined application of Copper Slag and Basalt Fibre as partial replacement of sand & cement on M30 grade concrete is studied.

M30 grade of concrete were designed as per the Indian Standard code of practice. The various ingredients for one cubic meter of M30 grade concrete are shown in Table 6.

Table. 6 Quantities of Ingredients per cum of M30 Grade Concrete

S. No	Mix Identification	Cement (kg's)	Fine Aggregate		Coarse Aggregate (kg's)	Water (lit)	Basalt Fibres (kg's)
			Sand (kg's)	Copper Slag (kg's)			
1	C.C	360	739	0	1290	162	0
2	20% C.S	360	591.2	147.8	1290	162	0
3	40% C.S	360	443.4	295.6	1290	162	0
4	60% C.S	360	295.6	443.4	1290	162	0
5	20% C.S + 1% B.F	360	591.2	147.8	1290	162	3.6
6	40% C.S + 1% B.F	360	443.4	295.6	1290	162	3.6
7	60% C.S + 1% B.F	360	295.6	443.4	1290	162	3.6

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8	20% C.S + 2% B.F	360	591.2	147.8	1290	162	7.2
9	40% C.S + 2% B.F	360	443.4	295.6	1290	162	7.2
10	60% C.S + 2% B.F	360	295.6	443.4	1290	162	7.2

## B. TEST SPECIMENS

Concrete test specimens consist of 150 mm × 150 mm × 150 mm cubes, cylinders of 150 mm diameter and 300 mm height and 100 mm × 100 mm × 500 mm prisms. Concrete cube specimens were tested at 3, 7, 28, 56 & 90 days of curing to obtain the compressive strength of concrete. Cylindrical specimens were tested at the age of 28 days to obtain the compressive strength and split tensile strength of concrete. The prisms were tested at the age of 28 days to obtain the flexural strength of concrete. The rate of loading is as per the Indian Standard specifications. Acid Attack test is also performed for durability.

## IV. RESULTS AND DISCUSSIONS

### A. COMPRESSIVE STRENGTH

The variation of the cube compressive strength with the age of M30 grade concrete prepared using the various proportions of Copper Slag and Basalt Fibre is shown in Fig.1. Each value of the cube compressive strength indicates the average of three test results. It can be observed that the compressive strength of Copper Slag and Basalt Fibre concrete exhibits more than the control concrete up to 20% Copper Slag and 1% Basalt Fibre and with further increase in Copper Slag the strength decreases for the given Basalt Fibre content.

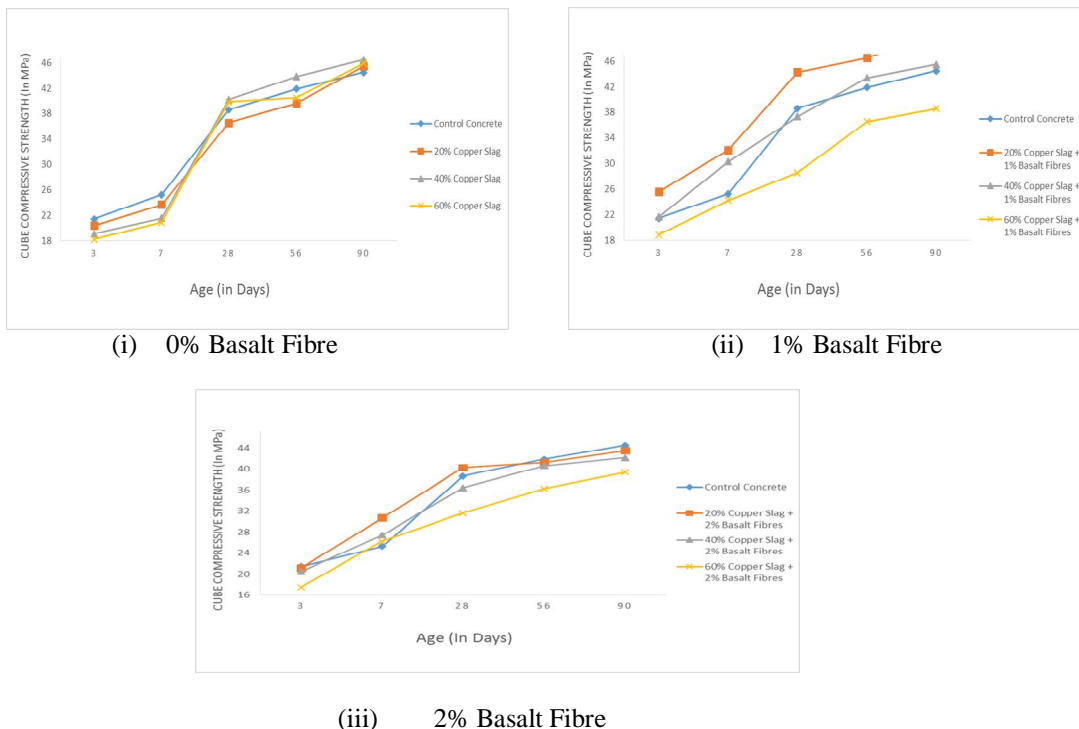


Fig. 1. Variation of Cube Compressive Strength of M30 Grade Concrete with age for different percentages of Copper Slag and Basalt Fibre.

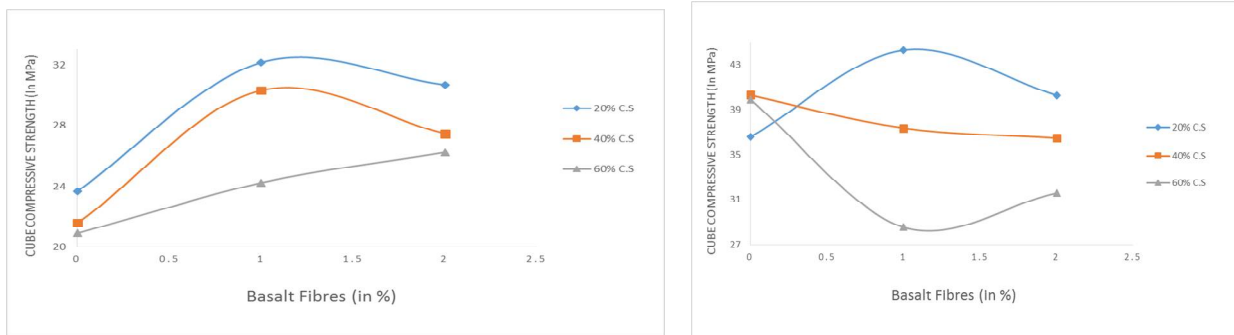
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The variation of 7 days and 28 days cube compressive strength of M30 grades of concrete prepared with Copper Slag containing different percentages of Basalt Fibre is also shown in Fig.2. The compressive strength of concrete initially increases up to 20% Copper Slag and 1% Basalt Fibre and then the strength decreased with increase in Copper Slag and Basalt Fibre.



(a) 7 days Cube Compressive Strength

(b) 28 days Cube Compressive Strength

Fig. 2 Variation of 7 days and 28 days Cube Compressive Strength of M30 Grade of Concrete with different percentages of Copper Slag and Basalt Fibre

Comparison is also made between the 28 days cube compressive strength and cylindrical compressive strength of concrete containing various percentages of Copper Slag and Basalt Fibre. The test results are shown in Table 7. The ratio of cube strength to the cylinder strength is found to be around 0.98 for concrete containing Copper Slag and Basalt Fibre.

Table.7. Comparison between 28 days Cube and Cylinder Compressive Strength of Concrete Prepared with Copper Slag and Basalt Fibre

S. No	Mix Designation	Cube Compressive Strength (MPa) $\sigma_{\text{Cube}}$	Cylinder Compressive Strength (MPa) $\sigma_{\text{Cylinder}}$	$\sigma_{\text{Cylinder}} / \sigma_{\text{Cube}}$
1	C.C	38.62	32.46	0.84
2	20% C.S	36.58	35.64	0.97
3	40% C.S	40.25	30.54	0.76
4	60% C.S	39.87	27.56	0.69
5	20% C.S + 1% B.F	44.28	41.25	0.93
6	40% C.S + 1% B.F	37.35	35.58	0.95
7	60% C.S + 1% B.F	28.58	28.12	0.98
8	20% C.S + 2% B.F	40.23	38.43	0.96

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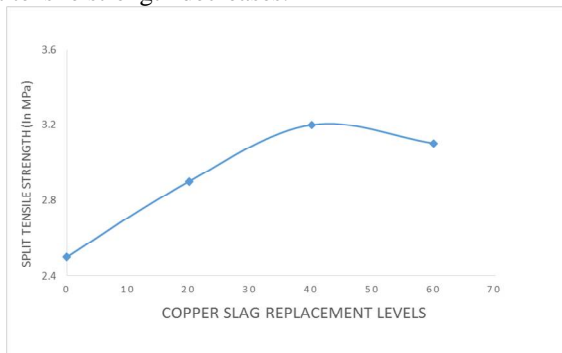
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9	40% C.S + 2% B.F	36.45	33.28	0.91
10	60% C.S + 2% B.F	31.59	25.32	0.80

### B. SPLIT TENSILE STRENGTH

The variation of split tensile strength of M30 grade of concrete with increase in Copper Slag is shown in Fig. 3. The split tensile strength of M30 grade of control concrete is 2.5 N/mm<sup>2</sup>. The split tensile strength of concrete initially increases up to 20% Copper Slag and 1% Basalt Fibre and with further increase in the Copper Slag and Basalt Fibre the split tensile strength decreases.



(i) Copper Slag



(ii) Basalt Fibre

Fig.3 .Variation of Split Tensile Strength of M30 Grades of Concrete with different percentages of Copper Slag and Basalt Fibre.

### C. FLEXURAL STRENGTH

The variation of flexural strength of M30 grade of concrete containing various proportions of Copper Slag and Basalt Fibre is shown in Fig.4. The flexural strength of M30 grade of control concrete is 3.70 N/mm<sup>2</sup> respectively. The flexural strength of concrete initially increases up to 20% Copper Slag and 1% Basalt Fibre and then with further increase in the Copper Slag and Basalt Fibre.

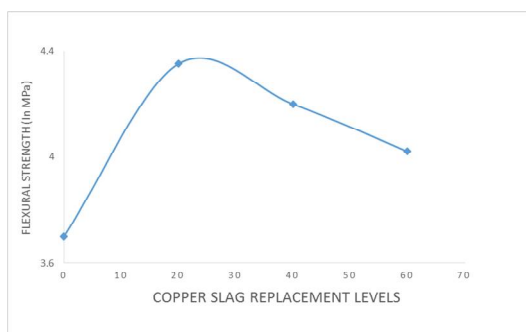


Fig.4 . (i) Copper Slag



(ii) Basalt Fibre

Fig.4 .Variation of Split Tensile Strength of M30 Grade of Concrete with different percentages of Copper Slag and Basalt Fibre.

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### D. ACID ATTACK TEST:

The durability tests of M30 grade of concrete containing various proportions of Copper Slag and Basalt Fibre is shown in Fig.5. it was observed that the percentage loss of weight for controlled concrete is 1.65%. The maximum percentage loss of weight for found at 40% replacement of copper slag with 2% basalt fibers. The minimum percentage loss of weight for found at 60% replacement of copper slag. The percentage loss in compressive strength for controlled concrete is 6.92%. The highest percentage of loss in compressive strength is found at 60% replacement of copper slag with 0% basalt fibers.

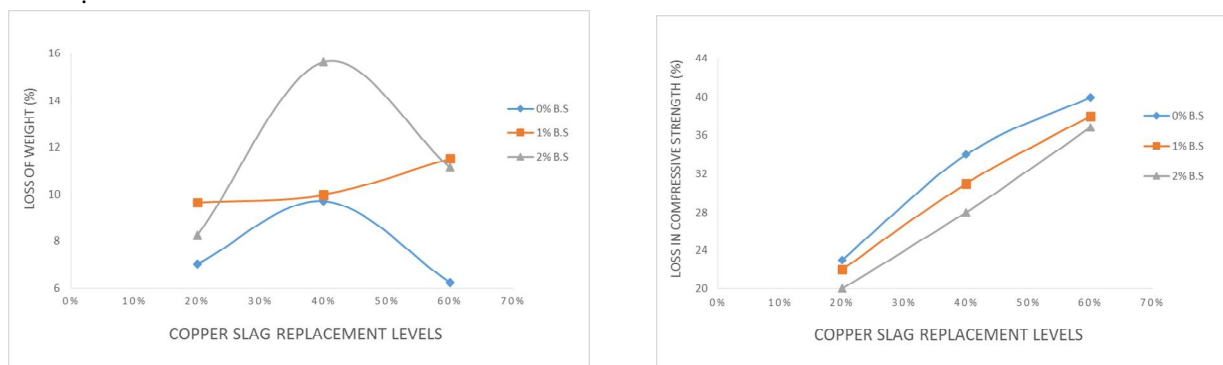


Fig.5 .Variation of Loss of Weight and Loss of Compressive Strength of M30 Grade of Concrete with different percentages of Copper Slag and Basalt Fibre

### V. CONCLUSIONS

From the test results, it was concluded that cube compressive strength, cylinder compressive strength and split tensile strength of concrete had higher strength for 50% replacement of copper slag with 1% basalt fiber. Copper slag replacement at 40% with and without basalt fibers showed a marginal variation in cube compressive strength, cylinder compressive strength and split tensile strength.

There was more than 50% improvement in the flexural strength of concrete at 20% replacement of copper slag with 1% basalt fibres when compared to control mixes. By the addition of basalt fibers, there is a significant effect in the improvement of the compressive strength, split tensile strength and flexural strength of concrete than the controlled mix. This is because basalt fibres can bond chemically with the cement, which decreases the number of pores in concrete, and consequently enhances its permeability.

Full replacement of copper slag cannot be allowed with and without basalt fibers as there was a drastic down fall in the cube compressive strength, cylinder compressive strength, split tensile strength and flexural strength than the controlled concrete. From acid resistance test, it was observed that the concrete containing copper slag was found to be low resistant to the H<sub>2</sub>SO<sub>4</sub> solution than the control concrete. The maximum percentage loss in weight is found for 60% replacement of copper slag with 2% basalt fibers

### REFERENCES

1. K.S. Al-jabri, H. Al-oraimi, A.S. Alnuaimi, "Copper slag as fine aggregate for high performance concrete", TJER 9(2), 90–102 (2012).
2. Md. Tabsheer Ahmed, Md. Abid Alam, "Experimental Study on Mechanical Properties of Basalt Fibre Reinforced Concrete", International Journal of Science and Research, August 2013, No: 2319-7064.



## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 1, January 2017

3. M. V. PATIL, "study on properties and effects of copper slag in concrete", IRF International Conference, 11th January 2015, Pune, India, No:978-93-84209-82-7.
4. Shetty M. S., "Text book of Concrete Technology: Theory and Practice", New Delhi, India, S. Chand & Company, 2009.
5. Neville A. M., "Concrete technology", Pearson Education, India, 2008.
6. Prof. A. Nizad, Premal. V G, "Strength and Durability Characteristics of Steel Fibre Reinforced Concrete Containing Copper Slag as Partial Replacement of Fine Aggregate", International Journal of Engineering Research & Technology, 2015 No: 2278-0181.
7. Savaş Erdem, Marva Angela Blankson, "Chloride-Ion Penetrability and Mechanical Analysis of High Strength Concrete with Copper Slag", International Journal of Engineering Research and Applications, ISSN: 2248-9622, Vol. 4, Issue 5 (Version 4), May 2014, pp.101-113.
8. IS 4031-1988: Part IV (Reaffirmed 2005), Indian Standard Methods of physical tests for hydraulic cement: Determination of consistency of standard cement paste.
9. IS 4031-1988: Part V (Reaffirmed 2005), Indian Standard Methods of physical tests for hydraulic cement: Determination of initial and final setting times.
10. IS 5816-1999 (Reaffirmed 2004), Indian Standard splitting tensile strength of concrete- Method of test.
11. IS 9399-1979 (Reaffirmed 2004), Indian Standard Specification for apparatus for flexural testing of concrete.
12. IS 12269-2013, "Specification for 53 Grade Ordinary Portland Cement" (First Revision), Bureau of Indian Standards, New-Delhi, India.