

International Journal of Innovative Research in Science, Engineering and Technology

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

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Vol. 8, Issue 5, May 2019

Experimental Study of Concrete by Using Copper Slag

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ABSTRACT: This paper reports the effect of concrete using copper slag as fine aggregate replacement. In this project work, the concrete grade M20 was selected and IS method was used for mix design. The properties of material for cement, fine aggregate, coarse aggregate and copper slag were studied for mix design. The various strength of concrete like compressive, flexural and split tensile were studied and non-destructive test such as rebound hammer test and ultrasonic pulse velocity measurement were studied for various replacements of fine aggregate using copper slag that are 0%, 10%, 20%, 30%, and 40%. The maximum compressive strength of concrete attained at 30% replacement of fine aggregate at 28 days. The Compressive strength and flexural strength were also obtained higher strength at 40% replacement level at 28 days. The rebound hammer test showed higher compressive strength at 40% fine aggregate replacement; this is due to uniformity of concrete. The pulse wave velocity is higher for the 40% fine aggregate replacement, it is understood that the density of the mix is high and free from pores.

KEYWORDS: Concrete, Cement, Sand Replacement, Copper Slag, Compression strength, Density

I. INTRODUCTION

Concrete is a composite material composed of water, coarse granular material (the fine and coarse aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space among the aggregate particles and glues them together. Concrete is widely used for making architectural structures, foundations, brick or block walls, pavements, bridges or overpasses, highways, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats. Concrete is used in large quantities almost everywhere mankind has a need for infrastructure.

The amount of concrete used worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminium combined. Concrete's use in the modern world is exceeded only by that of naturally occurring water. Concrete is also the basis of a large commercial industry. Globally, the ready-mix concrete industry, the largest segment of the concrete market, is projected to exceed \$100 billion in revenue by 2015. In the United States alone, concrete production is a \$30-billion-per-year industry, considering only the value of the ready-mixed concrete sold each year.

Copper slag is used in the concrete as one of the alternative materials. It is the waste product of copper from Sterlite Industries India Ltd, Tuticorin. The safe disposal of this waste is a lack, costly and causes environmental pollution. The construction industry is the only area where the safe use of waste material (copper slag) is possible. When it is introduced in concrete as a replacement material, it reduces the environmental pollution, space problem and also reduces the cost of concrete.

However, further additions of copper slag caused reduction in the strength due to an increase of the free water content in the mix. Mixes with 80% and 100% copper slag replacement gave the lowest compressive strength value of

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approximately 80 MPa, which is almost 16% lower than the strength of the control mix. The results also demonstrated that the surface water absorption decreased as copper slag quantity increases up to 40% replacement; beyond that level of replacement, the absorption rate increases rapidly. Therefore, it is recommended that 40 wt. % of copper slag can be used as replacement of sand in order to obtain HPC with good strength and durability properties.

II. INTRODUCTION OF COPPER SLAG



Fig 1. Copper Slag

Copper slag can be used in concrete production as a partial replacement for sand. Copper slag is used as a building material, formed into blocks. Such use was common in areas where smelting was done, including St Helens and Cornwall in England. In Sweden fumed and settled granulated copper slag from the Boliden copper smelter is used as road-construction material. The granulated slag (<3 mm size fraction) has both insulating and drainage properties which are usable to avoid ground frost in winter which in turn prevents pavement cracks. The usage of this slag reduces the usage of primary materials as well as reduces the construction depth which in turn reduces energy demand in building. Due to the same reasons the granulated slag is usable as a filler and insulating material in house foundations in a cold climate. Numerous houses in the same region are built with a slag insulated foundation.

III. METHODOLOGY

Methodology In fresh state; the workability parameters such as slump value and compacting factor were studied. In hardened state; the strength tests such as compressive strength, split tensile strength and flexural strength were studied and the Non-destructive tests such as rebound hammer test and ultrasonic pulse velocity test were conducted for each mix. The obtained results are tabulated. The conclusions were made from the results and discussions.

Preparation of sample:

The moulds were prepared as per IS 10086 and the samples were prepared and cured as per IS 516. For compression test 6 cubes of size 150×150×150 mm were cast and carried out test at 28 days for each mix. For Split tensile test and Flexure test 3 cylinders of size 150×300 mm and 18 beams of size 500×100×100 mm were cast and carried out test at 28 days for each mix. The Rebound hammer test and the Ultrasonic Pulse Velocity test are carried out for concrete cubes before carrying out strength tests.

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Compressive Strength:



Fig 2.Compressive Testing

Compressive strength is often measured on a universal testing machine. By definition, the ultimate compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength (N/mm²) is calculated by using the formula.

$$C_s = \text{Ultimate Load (N)} / \text{Area of c/s}$$

Size of Specimen for Test

Compression Test - 150mm X 150mm X 150mm

Flexural Strength:



Fig 3.Flexural Testing

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The flexural strength represents the highest stress experienced within the material at its moment of rupture. The flexural strength (N/mm²) of rectangular cross-section using a three point flexural test technique is obtained by the formula,

$$\text{Flexural test} = PL / BD^2$$

Where, P=Ultimate load at failure (N), L=Length of specimen (mm), B=Breadth of specimen (mm) and D=Depth of specimen (mm)

Size of Specimen for Test

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Flexural Test - 500mm X 100mm X 100mm

IV. EXPERIMENTAL RESULTS

I. Compressive Strength of Concrete

1. Replacement by 10 % in cube

Table No.1 Compressive Strength Results (N/mm²)

Sr No	Grade of concrete	Force	Average	Compressive Strength Results
1	M20	525	532.66	23.67 N/mm ²
		527		
		546		

2. Replacement by 20 %

Table No.2 Compressive Strength Results (N/mm²)

Sr No	Grade of concrete	Force	Average	Compressive Strength Results
1	M20	559	563.67	25.05 N/mm ²
		562		
		570		

3. Replacement by 30 %

Table No.3 Compressive Strength Results (N/mm²)

Sr No	Grade of concrete	Force	Average	Compressive Strength Results
1	M20	583	592	26.31 N/mm ²
		601		
		592		

4. Replacement by 40 %

Table No.4 Compressive Strength Results (N/mm²)

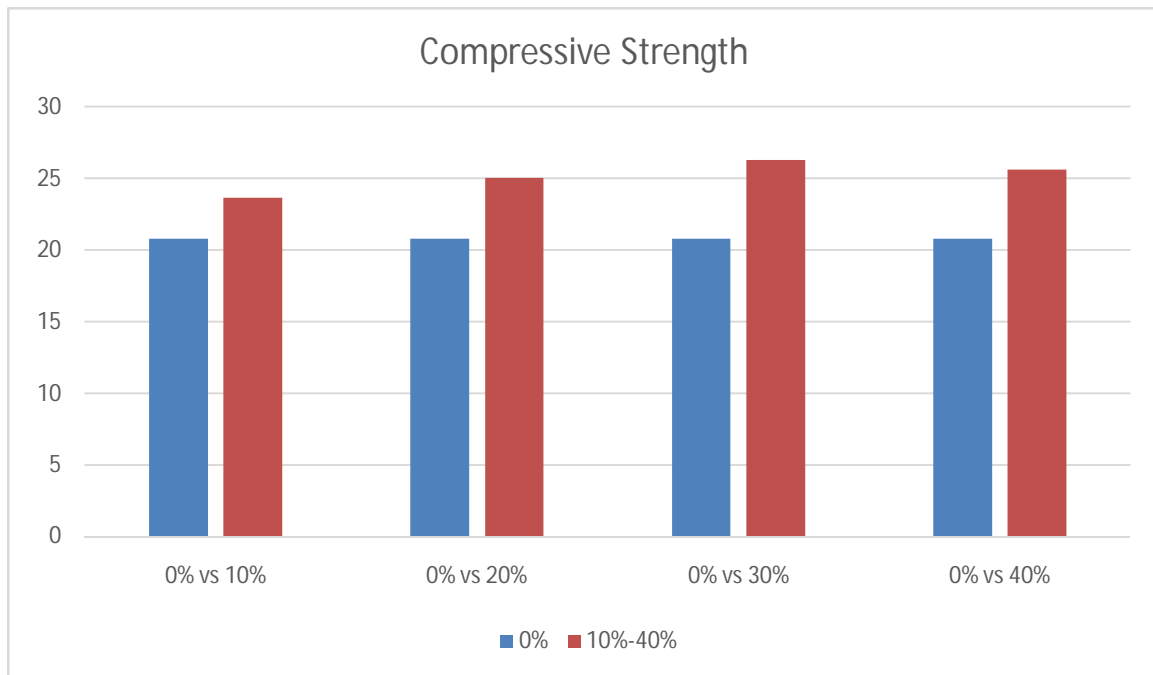
Sr No	Grade of concrete	Force	Average	Compressive Strength Results
1	M20	580	576.67	25.62 N/mm ²
		578		
		572		

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Graph No.1 Compressive Strength Results (N/mm²)

II. Flexural Strength of Concrete

1. Replacement by 10 % in beam

Table No.5 Flexural Strength Results (N/mm²)

Sr No	Grade of concrete	Load	Avg	Flexural strength (MPa)
1	M20	12.2	12.73	6.365
		12.95		
		13.04		

2. Replacement by 20 %

Table No.6 Flexural Strength Results (N/mm²)

Sr No	Grade of concrete	Load	Avg	Flexural strength (MPa)
1	M20	14.05	15.08	7.54
		14.98		
		16.23		

3. Replacement by 30 %

Table No.7 Flexural Strength Results (N/mm²)

Sr No	Grade of concrete	Load	Avg	Flexural strength (MPa)
1	M20	17.15	18.42	9.21
		18.95		
		19.18		

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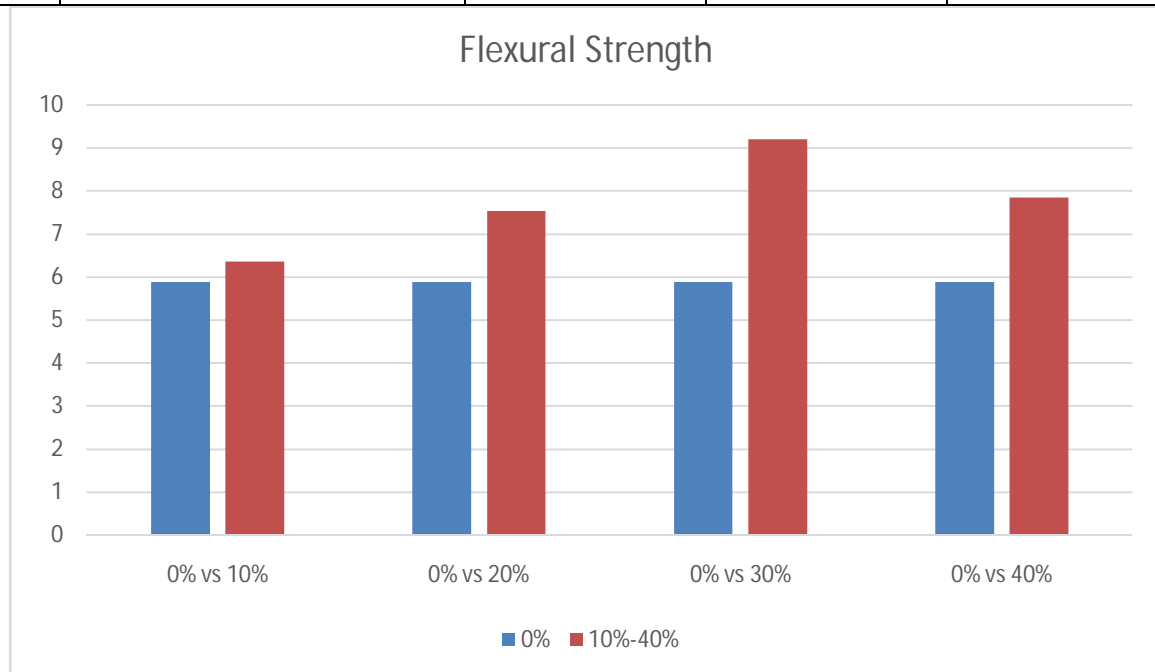
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4. Replacement by 40 %

Table No.8 Flexural Strength Results (N/mm²)

Sr No	Grade of concrete	Load	Avg	Flexural strength (MPa)
1	M20	15.90	15.71	7.85
		15.01		
		16.24		



Graph No.2 Flexural Strength Results (N/mm²)

V. CONCLUSION

1. Copper slag which is an industrial waste product can be used as replacement for cement and sand and contributes to the increase in various mechanical properties of concrete.
2. From the result we found that replacement of sand by copper slag on 30% gives the maximum strength. Whereas the strength starts collapsing from replacing 40% of sand by copper slag.

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ISSN(Online): 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

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Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

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