EXPERIMENTAL INVESTIGATION ON CONCRETE CONTAINING COPPER SLAG AS A REPLACEMENT TO FINE AGGREGATE

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Abstract: This present study investigates the effect of concrete containing copper slag as a replacement. In this experimental work, M30 grade of concrete was chosen for the design mix. The physical characteristics of binding material, copper slag, fine and coarse aggregate were evaluated. The fresh and hardened state properties of concrete were evaluated in which copper slag is replaced by natural sand at various percentages such as 0%, 20%, 40%, 60%, 80%, and 100% respectively, and compared with the conventional concrete.

***Index Terms* – Copper Slag, Binding Material, Mechanical properties.**

I. INTRODUCTION

Concrete is a versatile material that is most commonly used in all construction works. It comprises binding materials, natural fine, and coarse aggregates along with water which is mixed uniformly to obtain homogeneity. Most of the materials used in concrete are naturally available which is known as conventional concrete. Due to the increase in demand to cater to the population's needs, concrete is being used in building many structures for developing infrastructural facilities. Due to this, the available natural materials are depleting at a faster rate than expected. Many kinds of research are going on focusing on the possibility of utilizing artificial materials in concrete as a substitution to the natural materials. And few of those artificial materials can be of industrial wastes or by-products such as Fly Ash, GGBS, Copper Slag, M sand, Waste Foundry Sand, and many more.
Sand is being used as a conventional material in construction activities, due to the large scale of extraction, it creates a negative impact on marine and biodiversity. FA occupies a volume of 25-40% in concrete[1]. In this present experimental study, natural river sand is replaced with copper slag and its Engineering properties were evaluated and compared with the traditional concrete.

Materials Used:

Binding Material: The binding material used for the experimental work is of OPC 43grade and the physical properties of OPC are evaluated.

Table 1 Physical Characteristics of Binding Material

Property	Value
Specific Gravity	3.06
IST	42 mins
FST	420 mins
Consistency	36%

Fine Aggregate: Natural river sand available nearby premises is chosen and its properties were evaluated as per IS:383-1987[2].

Table 2 Physical Characteristics of Fine Aggregate

Property	Value
Specific Gravity	2.51
Water Absorption	1.09%
Fineness Modulus	2.79
Grading Zone	Zone - II

Coarse Aggregate: The crushed aggregate of 20mm nominal size is used and tests are performed as per IS:383-1987[2].

Table 3 Physical Properties of Coarse Aggregate

Property	Value
Specific Gravity	2.74
Fineness Modulus	7.60
Water Absorption	0.45%

Copper Slag:

In many nations, various kinds of waste materials and by-products are being generated from various industries and the disposal of the waste materials affects the environment[3]. The incorporation of industrial by-products in making concrete will provide a better solution to the inefficient management of wastes[4]. During the manufacturing process of copper, a by-product named copper slag is obtained during the process of matte smelting and refining of copper[5]. Nearly 24.6 million tons of slags are generated from the world copper industries[6]. For each ton of production of copper, approximately 2.2 tons of copper slag is generated as a waste[7]. Copper slag contains a high amount of high iron, silica, and aluminum oxide[4]. Copper slag is widely used in the sandblasting industry and the manufacturing of abrasive and cutting tools, railroad ballast, etc.,[8]. The addition of copper slag in concrete will enhance its fresh and hardened properties.

Table 4 Physical Properties of Copper Slag

Property	Value
Specific Gravity	3.52
Water Absorption	0.13
Fineness Modulus	3.53
Bulk Density	1750 kg/m^3

Water: Water available in the vicinity of college premises is used for curing and concreting as per IS:456-2000.

Mix Notations:

Table 5 Mix Notations for concrete with varying percentages of replacement

	Mix Notations					
Materials	CS0	CS20	CS40	CS60	CS80	CS100
Cement	100 %					
River Sand	100 %	80 %	60 %	40 %	20 %	0 %
Copper Slag	0 %	20 %	40 %	60 %	80 %	100 %
Coarse Aggregate	100 %					

Experimental Data:

Sieve Analysis:

Table 6 Sieve Analysis of CS

IS Sieve size in mm	Cumulative Percentage passing					
	100% NS	80% NS& 20% CS	60% NS & 40% CS	40% NS & 60% CS	20% NS & 80% CS	100% CS
4.75	99.9	99.92	99.76	99.66	99.29	99.85
2.36	97.4	96.21	97.60	94.96	94.94	88.55
1.18	82.8	70.41	73.98	61.99	51.95	31.05
0.6	35.6	39.70	37.15	25.42	21.60	9.7
0.3	10.1	10.05	9.38	6.22	6.47	2.2
0.15	0.03	0.06	0.05	0.03	0.03	0.11

Workability Tests:

Slump Cone & Compaction Factor:

Table 7 Workability on fresh concrete

Mix	Value of Slump (mm)	Compaction Factor
CS0	45	0.84
CS20	50	0.85
CS40	55	0.87
CS60	60	0.88
CS80	70	0.88
CS100	80	0.89

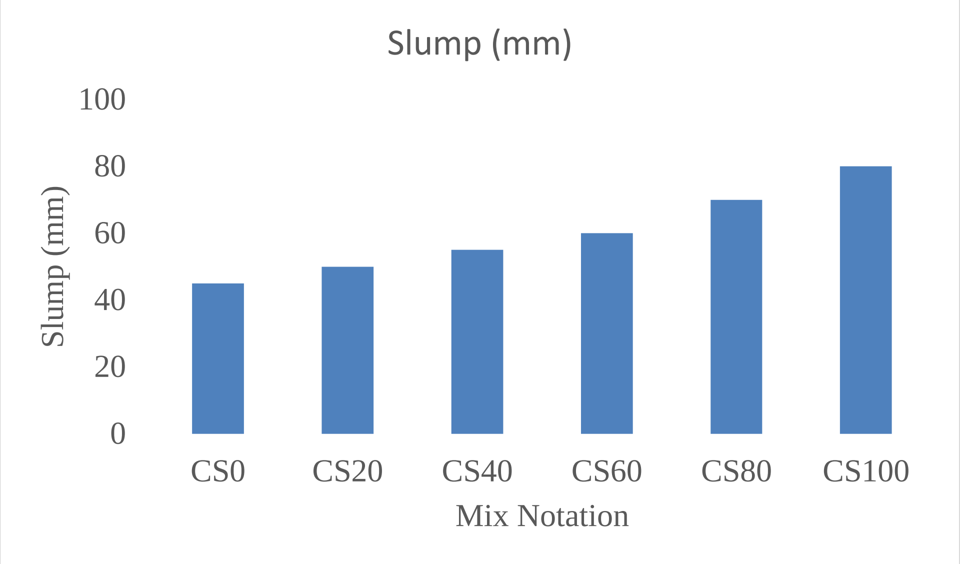

Figure 1 Slump

Density Test:

Table 8 Density test on Concrete

Mix	Fresh Density (KN/m^3)	Density after demolding of cubes (KN/m^3)
CS0	2420	2400
CS20	2730	2660
CS40	2820	2690
CS60	2890	2730
CS80	2920	2830
CS100	3160	3040

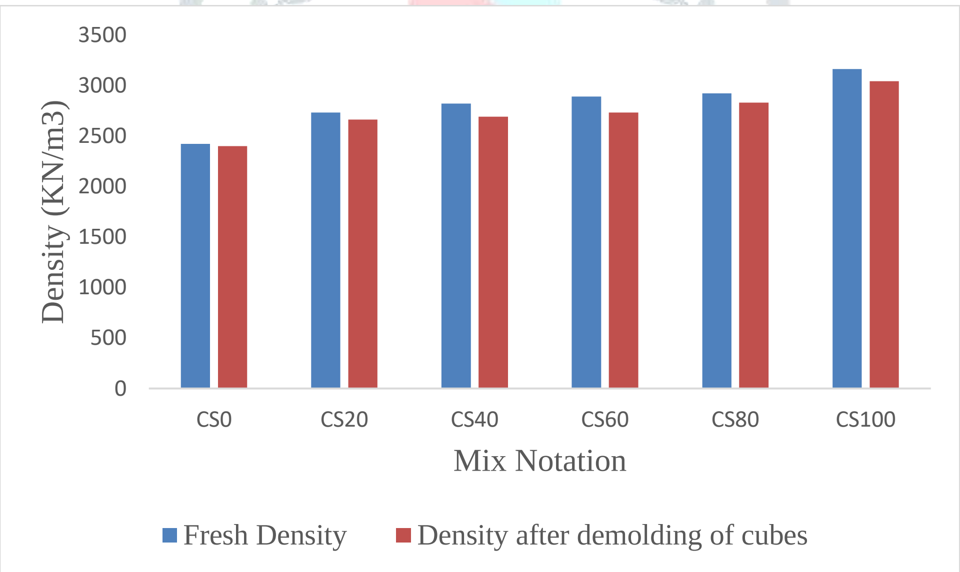

Figure 2 Density

Compressive Strength:

Table 9 Average Compressive Strength after 7,14 & 28 days of curing

Mix	Average Compressive Strength in MPa		
	Strength@7-days	Strength@14-days	Strength@28-days
CS0	38.11	39.66	43.14
CS20	33.30	35.14	38.11
CS40	36.59	39.44	44.63
CS60	27.00	36.33	38.70
CS80	24.44	30.69	36.59
CS100	22.66	26.93	31.66

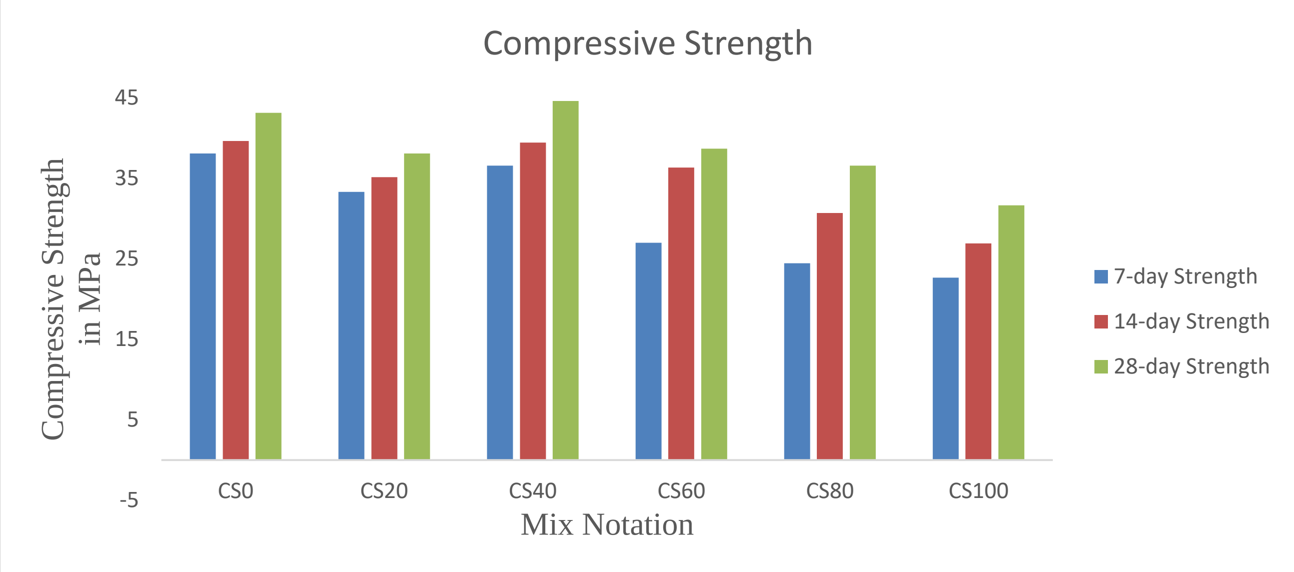

Figure 3 Compressive Strength

Split Tensile Strength:

Table 10 Splitting Tensile Strength after 28 days of curing

Mix	Splitting Tensile Strength (28 Days) in MPa
CS0	3.20
CS20	3.50
CS40	3.81
CS60	3.62
CS80	3.58
CS100	3.51

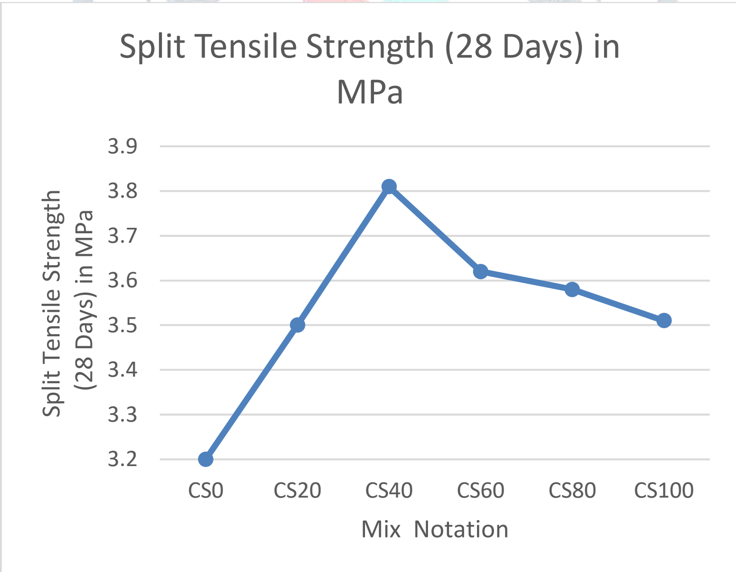

Figure 4 Splitting Tensile Strength

Flexural Strength:

Table 10 Flexural Strength after 28 days of curing

Mix	Flexural Strength (28 Days) in MPa
CS0	6.26
CS20	6.32
CS40	6.66
CS60	6.42
CS80	6.36
CS100	6.31

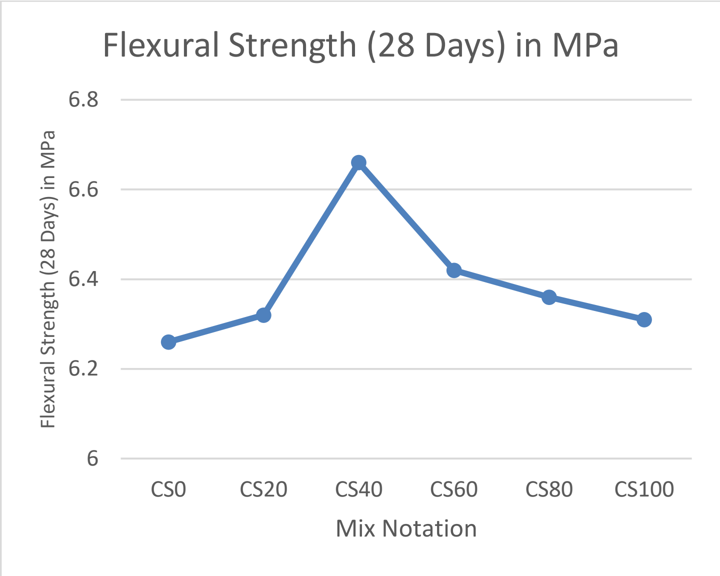

Figure 5 Flexural Strength

NDT Tests:

Table 11 NDT tests after 28 days of curing

Mix	Ultra-Sonic Pulse Velocity Km/s	Quality of concrete as per IS 13311 (Part I) 1992
CS0	4.5	Good
CS20	4.3	Good
CS40	4.5	Good
CS60	4.6	Good
CS80	4.5	Good
CS100	4.3	Good

Conclusions:

1. As Copper Slag possesses higher specific gravity than natural sand, it resulted in the production of high-density concrete.
2. Water absorption of copper slag is found to be lesser than that of natural sand.
3. Copper Slag has a higher fineness modulus and bulk density than the fine aggregate.
4. As the percentage of copper slag replacement increases, the slump value increased.
5. Mechanical properties such as Compressive, Split Tensile and Flexural Strengths were found to be optimum at 40% replacement of fine aggregate with copper slag.
6. By adding Copper Slag in concrete production, lessens the environmental issues related to its disposal, reduces the cost of construction, and reduces the consumption of natural resources.

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