Effect Of Copper Slag As A Sand Replacement On The Propertes Of Concrete

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Abstract : This study has been undertaken to determine the effects of the copper slag on concrete by replacing sand. A Cu slag is byproduct in various industries.The Copper Slag contains heavy metal traces, which can contribute to air and water pollution. It's commonly classified as hazardous waste due to this risk. Another issue to consider is the sheer volume of slag produced during copper refining. Typically, refineries end up with two units of slag for every one unit of copper produced during smelting.

The use of copper slag as a replacement for fine aggregate in construction will reduce damage to the environment due to the waste resulting from the copper manufacturing process and help in saving natural resources. Work contains the different types of testing of concrete for different proportions of Cu slag. Compressive strength, Split tensile strength, and flexural tests are conducted for different proportion of Cu slag

***IndexTerms* - Replacement,Compressive, Tensile,Proportions.**

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I. Introduction

Copper slagis a by-product obtained during the smelting and refining of copper. Production of one ton of copper generates, approximately 2.2–3 ton copper slag. World at present produces around approximately 46.54 Million Ton of Copper Slag when India at present produces around 96.72 thousand Ton of Copper Slag per annum. Even though the beneficial use of Copper slag in Industries and production has been known for many decades, it is still not yet fully utilized. The major obstacles to further use of Copper slag are the large variation in physical and chemical properties. Current options for management of copper slag include recycling, recovering of metal, production of value added products and disposal in slag dumps or stockpiles. Currently, copper slag has been widely used for abrasive tools, roofing granules, cutting tools, abrasive, tiles, glass, road-base construction, railroad ballast, asphalt pavements, cement and concrete industries.

Another option of reusing copper slag is by using it as a partial replacement of concrete, it will be possible to reuse a waste by-product material beneficially. Large amounts of copper slag can be utilized by using it as fine and coarse aggregates in concrete because more than 75% volume of concrete is occupied by aggregates. The use of copper slag in cement and concrete provides potential environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of copper slag is produced. However, due to the process in smelting and refining of copper, there are variation in the mineral contents and elements in the copper slag from different sources or countries. Virgin copper slag is the copper slag formed after refining and blasted copper slag is copper slag created after using virgin copper slag for blasting and abrasive purpose.

Blasted copper slag has a different chemical composition and physical properties compared to virgin copper slag as sizes of blasted copper slag would be smaller and impurities from target of blasting changes the composition of the copper slag. Therefore, the purpose of this project is to discover how the various properties of washed copper slag change the usual properties of the concrete and the designed loads. Therefore, making the end product render safe to use. Possible ways on improving the quality of the washed copper slag containing concrete would be suggested at the end of this project.

1.1 Copper Slag as a Sand Replacement :-

Copper Slag as a Sand Replacement can be used due to the following reasons:

- It has a high Compressive strength which is equal to that of Fine Aggregate with similar diameter.
- Copper Slag is a non-degradable matter; it is creating an environmental problem so when used as a Replacement for Sand and can minimize Environmental problems.
- It is also available in abundance and at a very low cost at places where copper is processed.
- It increases the dead weight of concrete which can be utilized for pavements and concrete gravity dams.

1.3 Need of Present Study:-

The Copper Slag contains heavy metal traces, which can contribute to air and water pollution. It's commonly classified as hazardous waste due to this risk. Another issue to consider is the sheer volume of slag produced during copper refining. Typically, refineries end up with two units of slag for every one unit of copper produced during smelting

The use of copper slag as a replacement for fine aggregate in construction will reduce damage to the environment due to the waste resulting from the copper manufacturing process and help in saving natural resources..

1.4 Objectives of the study:-

In this Project we have proposed to study the potential of CS as replacement material for sand in cement concrete. Many researchers have investigated the use of CS in the production of cement, mortar and concrete as raw materials for clinker, cement replacement, coarse and fine aggregates. These of CS in cement and concrete provides potential environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of CS is produced and also several researchers have investigated the possible use of CS as fine and coarse aggregates in concrete and its effects on the different mechanical and long-term properties of mortar and concrete. While most of the reports point to benefits of using CS as fine aggregates, in some stray cases some negative effects such as delaying of the setting time have also been reported.

In the study, the following objectives are investigated:

Study the mix design aspects for Copper Slag Replacement.

Understand the various applications and limits for Replacement of copper Slag as Fine aggregate.

3. THE METHODOLOGY AND INVESTIGATIONS

3.1 Introduction

In this chapter the materials used for manufacturing of concrete with their Properties are given. Also the test conducted on cement, sand and aggregate are stated for the preparation of Mix design of M40 grade.

3.2 Materials Used With Their Properties

3.2.1 Cement

Ultra Tech 53 grades Ordinary Portland cement is used for this study. This cement is the most widely used one in the construction industry in India.

3.2.2 Course and fine aggregates

Coarse aggregates of 10 mm and 20 mm size is used for this study which taken from khadakjamb,Chandwad -Nasik, Maharashtra, and Artificial sand is used confirming to grading Zone –I of table 4 of IS 383 were procured from Deccan trap basalt ,Nasik Maharashtra.

3.2.3 Copper Slag

Copper Slag is obtained from Birla Copper private limited Dahej/Lakhigam - 392 130 Dist: Bharuch (GUJARAT)
Ph No: 91-2641-256004/5/6/9 Ext: 2723-2724

3.2.4 Plasticizer

Auronix 400 fox rock plasticizer is used as directed by the manufacture to improve the workability of fresh concrete mix.

3.2.5 Water

Portable water is used for casting and currying of the concrete blocks.

3.3 Test on Material

Test on Cement

Type of cement: Portland Pozzolana Cement (PPC)

Table No. 3.3 Fineness of cement

Sr. no.	Description	Weight
01	Weight of cement	100gm
02	Weight of residue on 90 IS sieve	5gm
03	% Fineness	5%

Requirement:

As per IS 269-197, the fineness of cement by dry sieving should not exceed 10% by weight

Table No. 3.3.2 Consistency of Cement

Sr.no.	Weight of cement	Weight of water	$P_n=(w_2/w_1)*100$	Penetration of plunger from top in mm	Remark
1	500	120	24	07	
2	500	135	27	12	
3	500	145	29	20	P_n=33.5
4	500	155	31	28	
5	500	168	33	35	

Weight of water required to produce a paste of standard consistency=168ml.
Standard consistency (p_n) of cement paste P_n= 33.5%

As per IS: 4031-1968 the standard consistency is obtained the Vicat plunger penetrate to a point 5 to 7 mm from bottom of Vicatmould

Setting Time of cement

Standard consistency (P_n) = 33.5%
Weight of cement sample (W_1) = 400gm
Weight of water added (W_2) = 0.85 P_n*W_1
= 0.85*0.335*400
= 197ml

Initial setting time (t_1) = 45 minute
Final setting time (t_2) = 420 minute

Requirement:-

As per IS 269-1976, the initial setting time shall be not less than 30 minute and final setting time shall be not greater than 600 minutes.

IV. RESULTS AND DISCUSSION

4.1 Effect of Copper Slag on compressive strength

Compressive strength of concrete mixed made with and without Copper Slag of cubes size 150 mm × 150 mm × 150 mm was determined at 7 and 28days. The test results are given in Graph 4.1. The maximum load at failure reading was taken and the average compressive strength is calculated using the following relation.

$$\text{Compressive strength } (\text{N/mm}^2) = \frac{\text{Ultimate load in N}}{\text{Area of cross section } (mm^2)}$$

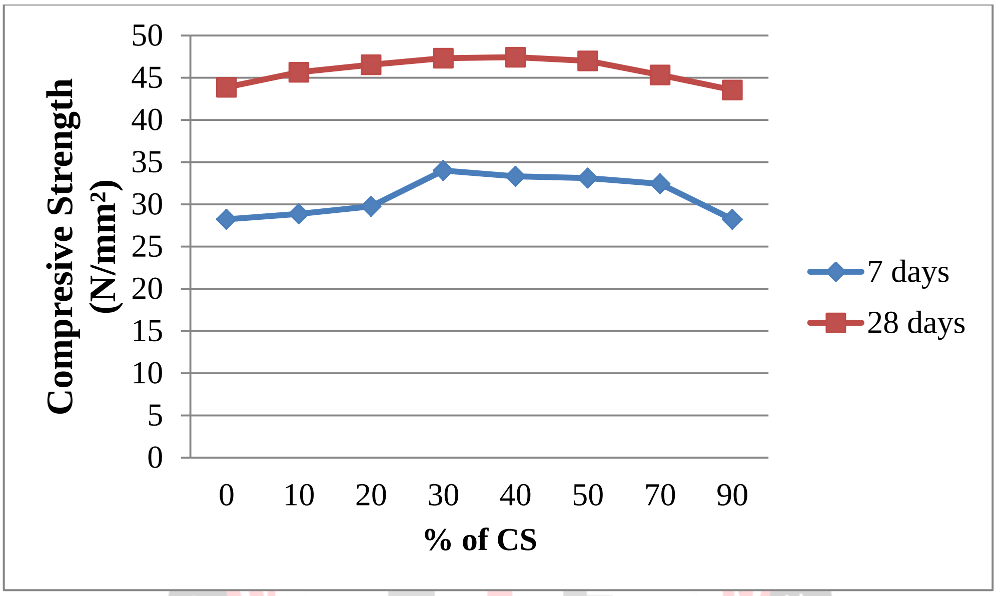
Here 0 to 100 % of Copper Slag was replaced with sand and optimum percentage of replacement was obtained at 40 % replacement of Copper Slag with sand. It was observed that Maximum compressive strength and tensile strength of copper slag concrete increased by 8.11% and 7.58% for 40% replacement more than controlled concrete strength.

Figure 4.1.1 Compression Testing machine

MIX	7 days In	At 7 days in %	28 days In N/mm^2	At 28 days in %

	N/mm^2			
CC	28.22	100.00	43.88	100.00
10CS+90 S	28.88	102.34	45.66	104.06
20CS+80 S	29.77	105.49	46.55	106.08
30CS+70 S	34.00	120.48	47.33	107.86
40CS+60 S	33.33	118.10	47.44	108.11
50CS+50 S	33.11	117.33	47.00	107.11
70CS+30 S	32.44	114.95	45.33	103.30
90CS+10 S	28.22	100.00	43.55	099.25

Table 4.1 Compressive strength gained of sieved Copper Slag concrete with age.



Graph 4.1 Compressive strength of sieved Copper Slag concrete with age.

4 .2 Effect of Copper Slag on Flexural strength:-

Standard beam of size 150 x 150 x 500 mm were supported symmetrically over a span of 350 mm and subjected two points loading. In flexure test, the beam specimen was placed in the machine in such a manner that the load was applied to the upper most surface as cast in the mould. All beams were tested under two point loading in Universal Testing Machine of 50 ton capacity. The load was increased until the specimen failed and the failure load was recorded.

Center point load was applied through loading system as shown in fig. The load was applied up to failure. The flexural strength was determined by the formula,

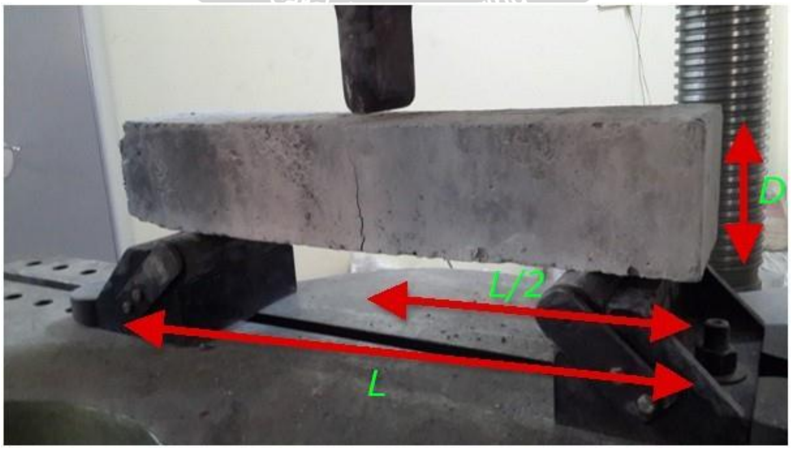


Figure.4.2: Centre Point Loading Setup In Flexural Test

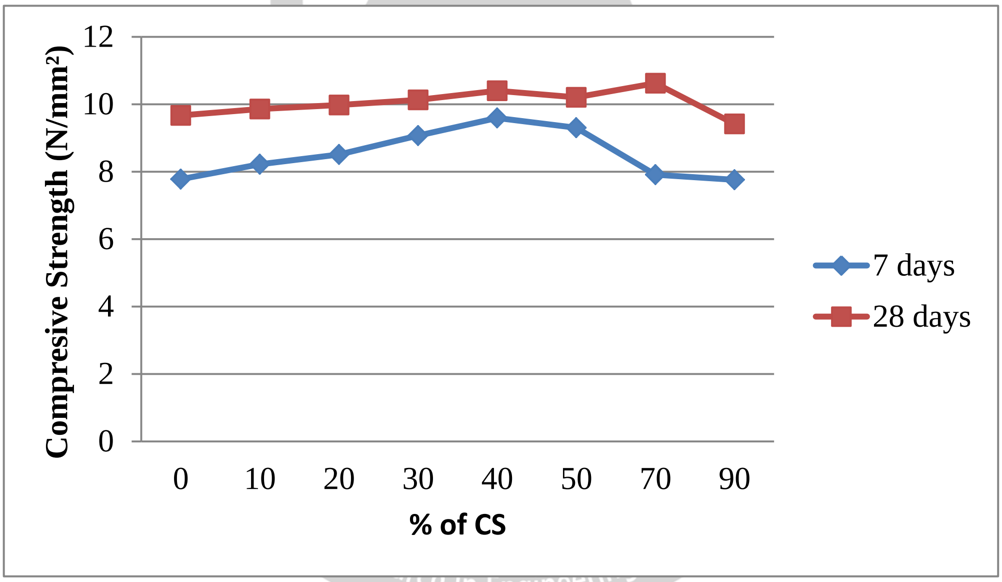
$$f_t = \frac{3PL}{2Bd^2}$$

Where,

f_t = Flexural strength(Mpa)
P = central point through two point Loading System (KN)
L = Span of beam (mm)
b = Width of beam (mm)
d= =L/3=Depth of beam (mm)

MIX	7 days In N/mm^2	At 7 days in %	28 days In N/mm^2	At 28 days in %
CC	7.777	100.00	9.669	100.00
10CS+90 S	8.221	105.709	9.862	101.99
20CS+80 S	8.511	119.68	9.978	103.19
30CS+70 S	9.071	116.72	10.132	104.78
40CS+60 S	9.592	122.52	10.402	107.82
50CS+50 S	9.302	119.60	10.209	105.58
70CS+30 S	7.913	101.82	9.627	99.56
90CS+10 S	7.758	99.75	9.418	97.40

Table 4.2 Flexural strength gained of sieved Copper Slag concrete with age.



Graph 4.2 Flexural Strength of Copper Slag concrete with age.

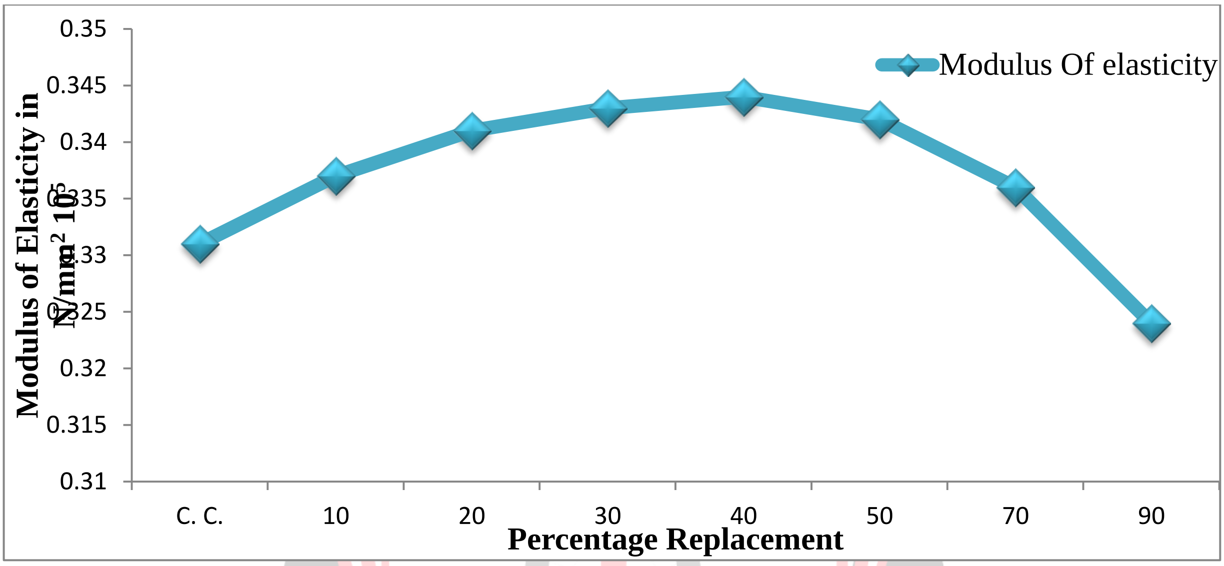
4.3 Effect of Copper Slag on modulus of elasticity at 28 days :-

The modulus of Elasticity of cube specimen is calculated according to IS: 456-2000 by the formula $E = 5000\sqrt{F_{ck}}$ where $f_{ck}$is 28 days cube compressive strength. It was found that the modulus of elasticity increased in accordance with an increase of replacement of natural sand by Copper Slag. The modulus of Elasticity of reference concrete is 0.344× 10^5N/mm^2 for 40% replacement. The Graph 4.2 shows the variation in modulus of Elasticity for 28 days.

Mix	Modulus of Elasticity In N/mm^2	Percentage Variation in Modulus of Elasticity
CC	0.331×10^5	100.00
10CS+90 S	0.337×10^5	101.81

20CS+80 S	0.341×10^5	103.02
30CS+70 S	0.343×10^5	103.62
40CS+60 S	0.344×10^5	103.92
50CS+50 S	0.342×10^5	103.32
70CS+30 S	0.336×10^5	101.51
90CS+10 S	0.324×10^5	97.88

Table 4.3 Modulus of Elasticity of sieved Copper Slag concrete at 28 day.



Graph 4.3 Modulus of Elasticity of sieved Copper Slag concrete at twenty eight days.

4.4 Discussion:-

Maximum compressive strength and flexural strength of copper slag concrete increased by 8.11% and 7.82% for 40% replacement more than controlled concrete strength.We observed the maximum strength is achieved at 40% of replacement.The strength of concrete is found to be more at 10% to 70% of replacement than controlled concrete.It is one of the economical materials, by using this we can save sand and its uses in concrete help to clean environment.As the percentage of Copper Slag increases workability increases. To maintain the workability of concrete for 100 mm slump super plasticizer used.Modulus of Elasticity of Copper Slag concrete increased by 3.92% for 40 percent replacement more than controlled concrete strength..

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