Effect Of Copper Slag As A Fine Aggregate On Properties Of Concrete

Mr. Zine Kiran Sambhaji[1], Prof. Pankaj B. Autade[2]

[1]PG Scholar, Department of Civil Engineering, P.D.V.V.P. College of Engineering, Ahmednagar, Maharashtra,India.

[2]PG Guide, Department of Civil Engineering, P.D.V.V.P. College of Engineering, Ahmednagar, Maharashtra,India.

ABSTRACT

In this work, an extensive study using copper slag has been carried out to investigate strength, workability and durability. Copper slag is an industrial by-product material produced from the process of manufacturing copper. For, 2.2 tonnes of copper slag is generated at every ton of copper production In the world of copper industry, it has approximately 26.6 million tons of copper slag are generated. Copper slag as a substitute for conventional fine aggregate with partial or full replacement using M25 grade concrete The main objective is to encourage the use of these seemingly waste products as a construction material. In this paper , the effect of using copper slag as a fine aggregate on properties of cement mortars and concrete various mortars & concrete mixtures were prepared with different proportions of copper slag ranging from (0CS+100S)%, (10CS+90S)%, (20CS+80S)%,(30CS+70S)%, (40CS+60S)%, (50CS+50S)%, (60CS+40S)%, (70CS+30S)%, (80CS+20S)%, (90CS+10S)%, (100+0S)%. Form the above test result we concluded that the 50% CS+50% S gives optimum proportional of CS that can be used as a replacement substitute material for fine aggregate in concrete. The design M25 grade concrete for 50% replacement of CS show the HPC characteristics. The design M25 grade concrete for 30% replacement of CS show the HPC characteristics. We can fully replace (100%CS) by fine aggregate in concrete, because of above all test result more than control mix. We can used any proportion of CS replacement as pre our requirement for creating concrete, because we concluded that the all result of replacement of CS is more than control mix.

Keyword:- *copper slag, strength, workability, durability, NDT, modulus of elasticity, etc.*

1. INTRODUCTION

Copper slag is a industrial-product obtained during the matte smelting and refining of copper. In the work Copper slag used in this research work was brought from Sterlite Industries Ltd (SIL), Tuticorin, Tamil Nadu, India. SIL. Hence it is an industrial by-product abundantly available near copper producing industries having similar physical &chemical properties of Sand, considered as an alternative to the river sand. Copper slag possesses physical mechanical and chemical characteristics that qualify the material to be used in concrete as a partial replacement for Portland cement or as a substitute for fine aggregates. For example, copper slag has a number of favorable mechanical properties for aggregate use such as excellent soundness characteristics, good abrasion resistance and good stability reported by (Gorai et al 2003). Copper slag also show pozzolanic properties since it ingredient low CaO Under activation with NaOH, it can show cementitious property , used as partial or full replacement for Portland cement. The usage of copper slag for applications such as Portland cement replacement in concrete, or as raw material has the benefit of lowering the cost of the concrete and help in protecting the environment. In this work, an extensive study using copper slag has been carried out to investigate strength, workability and durability. The attempt is made to prove in all respect the serviceability, durability and economy in experimental study is structurally satisfactory. The method adopted is relevant to real social needs that is accessible , affordable and empowering .It results to save natural resources.

Fig-1: Copper slags from industry

2.LITERATURE REVIEW

Copper slag is a by-product obtained during matte smelting and refining of copper. One of the greatest potential applications for reusing copper slag is in concrete production. Many researchers have studied the effect of replacement of fine aggregate by copper slag on the mechanical and durability properties of ordinary portland cement concrete. The literature being reviewed as below

Khalifa s. al-jabri,abdullah H. Al-saidy ,ramzi taha has investigated the, for cement mortars, all mixtures with different copper slag proportions yielded comparable or higher compressive strength than the strength of the control mixture. There was more than 70% improvement in the compressive strength of mortars with 50% copper slag substitution in comparison with the control mixture.The compressive, tensile and flexural strength of concrete were comparable to the control mix using up to 50% copper slag substitution for sand, but they decreased with a further increase in copper slag contents.

Khalifa S. Al-Jabri „ Makoto Hisada, Salem K. Al-Oraimi , Abdullah H. Al-Saidy has investigated the performance of high strength concrete (HSC) made with copper slag as a fine aggregate at constant workability and studied the effect. Copper slag can be used as an alternative material for coarse and fine aggregate, since it gives better performance in all the corrosion tests conducted and permeability is less when compared with control concrete. Hence Copper slag can be utilized as sand replacement material without affecting the durability properties of concrete. Copper slag can be used as a potential alternative to coarse aggregate/fine aggregate used in concrete and mortars

R R Chavan & D B Kulkarni has investigated the performance of high strength concrete (HSC) made with copper slag as a fine aggregate at constant workability and studied the effect conducted experimental investigations to study the effect of using copper slag as a replacement of fine aggregate on the strength properties and concluded that Maximum Compressive strength of concrete increased by 55% at 40% replacement of fine aggregate by copper slag and flexural strength increased by 14 % for 40 % replacement. Many researchers have investigated worldwide on the possible use of copper slag as a concrete aggregate

Al-Jabri et al (2009, 2011) investigated the performance of high strength concrete made with copper slag as a replacement for fine aggregate at constant workability and studied the effect of super plasticizer addition on the properties of High Strength Concrete made with copper slag. They observed that the water demand reduced by about 22% for 100% copper slag replacement. The strength and durability of High Strength Concrete improved with the increase in the content of copper slag of upto 50%. However, further additions of copper slag caused reduction in the strength due to increase in the free water content in the mix. Also, the strength and durability characteristics of High Strength Concrete were adversely affected by the absence of the super plasticizer from the concrete paste despite the improvement in the concrete strength with the increase of copper content. The test results also show that there is a slight increase in the density of nearly 5% with the increase of copper slag content, whereas the workability increased rapidly with increase in copper slag percentage

3.OBJECTIVES OF RESEARCH WORK

In this work, an extensive study using copper slag has been carried out to investigate the following,

1. To find the optimum proportion of Copper Slag that can be used as a replacement substitute material for fine aggregate in concrete

2.To evaluate mechanical properties by use of copper slag in concrete specimens.

3To determined Strength, Workability, Durability by using copper slag as fully replacement of fine aggregate using different proportion.

4.MATERIALS AND METHODOLOGY

4.1 Cement:

The cement used in this experimental work is **"**Bhavya Gold Cement."(OPC53).

4.2 Coarse and fine aggregates:

Coarse aggregates (i.e. 20 mm and 10 mm) and fine sand were taken from a nearby crusher in mula @ rahuri Area. The gradation test conducted on the fine sand and copper slag showed that they met specifications requirements for concrete sand.

4.3 Copper Slag

Copper slag is an industrial by-product material produced from the process of manufacturing copper having similar physical, mechanical &chemical properties of Sand can be considered as an alternative to the river sand

5. RESULT AND DISCUSSION

5.1 Strength

5.1.1 Compressive Strength Test

A cube compression test is performed on standard cubes of conventional concrete and Copper Slag concrete with partial replacement of 0%to100% of size 150mm x 150mm after 7 days immersion in water for curing. and 28 day cubes are in possess of curing.

Table-1: Compressive Strength Result

SR. NO.	Compressive Strength N/mm^2
	28D
1	26.96
2	28.89
3	30.74
4	41.70
5	38.74
6	42.22
7	34.81
8	31.63
9	30.74
10	28.74
11	27.41

The mix with M25 grade ,the replacement30% and 50% gives high performance concrete. That there is an increase in the strength of almost 56.56% compared to the control mix at 28D Mixtures with 100% replacement of CS gave the lowest compressive strength 27.41 Mpa which is almost 1.62% greater than the strength of the control mix.

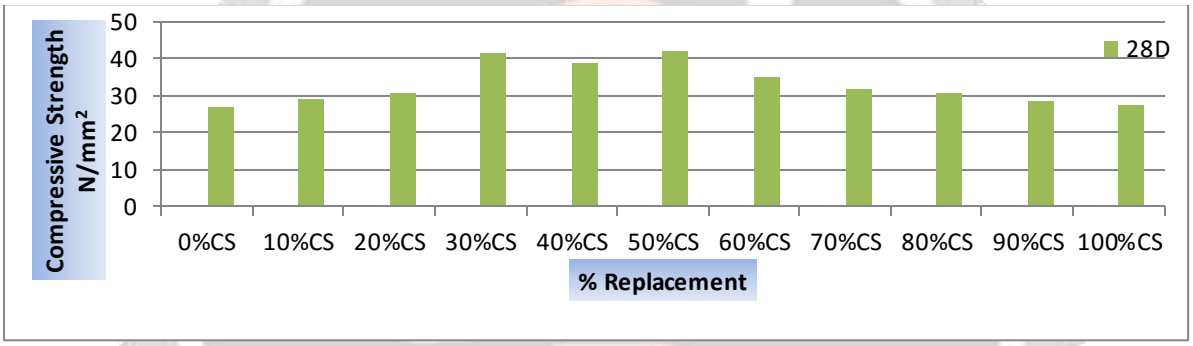

Chart-1: Compressive Strength (N/mm^2) Vs. % Replacement

5.2Workability

5.2.1SLUMP TEST

To measure the uniformity and consistency of fresh concrete

W/C =0.45

Table-2: Slump Cone Result

Sr. No.	% Replacement	Slump (mm)
1	0	29
2	10	34
3	20	43
4	30	46
5	40	51
6	50	55
7	60	57
8	70	62
9	80	66
10	90	69
11	100	78

It was noted that the slump value increased with the percentage of copper slag increases in concrete. The measured slump was 29 mm for the control mixture whereas 78 mm with 100% replacement of fine aggregate using copper slag. It is observed that, 10%, 20%, 30% low , 40%, 50%, 60%, 70%, 80%, 90% Medium, 100% High workability of concrete, where it is use as per placing condition of concrete.

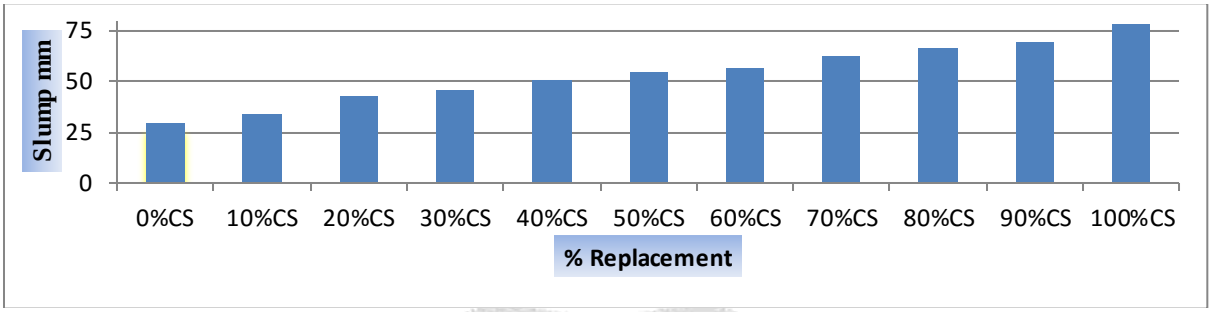

Chart-2: Slump Vs. % Replacement

5.3 Durability

Sulphate resistance of concrete is determined by immersing test specimens of size 150mm X150mm X 150mm cubes in 10% sodium sulphate. The deterioration of specimens was presented in the form of percentage reduction in weight and percentage reduction in compressive strength of concrete specimens at 28days. and were immersed in 10%H2SO4 solutions for next 28 days.

5.3.1 strength loss

The deterioration of concrete cube specimens was investigated by measuring the strength deterioration factor expressed in percentage and it was calculated by using the equation -

$$SDF = \left[\frac{(f_{cw} - f_{ca})}{f_{cw}}\right] x\ 100$$

Where, fcw is the average compressive strength of concrete cubes cured in water and fca is the average compressive strength of cubes immersed in acid solutions. The compressive strength test was carried out for each specimen in both the solutions after 4 weeks of immersion period. In each test period, the average value of three specimens were tested and reported.

Table-3: Effect On Compressive Strength Result

SR. NO.	Proportion	Compressive strength by Water	Compressive strength by H2SO4	% Loss and gained
	% Rep.	KN/m^2	KN/m^2	%
1	0	26.96	26.52	1.65
2	10	28.89	28.81	0.26
3	20	30.74	30.52	0.72
4	30	41.70	41.48	0.53
5	40	38.74	39.26	-1.34
6	50	42.22	42.07	0.35
7	60	34.81	34.96	-0.43
8	70	31.63	31.56	0.23
9	80	30.74	30.96	-0.72
10	90	28.74	28.81	-0.26
11	100	27.41	27.85	-1.62

The reduction ion strength loss 40%,60%.80%,90% ,100%was not done,10%, 20%,30%,50% 60% was reduce in strength but not more than control mix. The conventional concrete specimens are severely affected the acid attack than the CSC

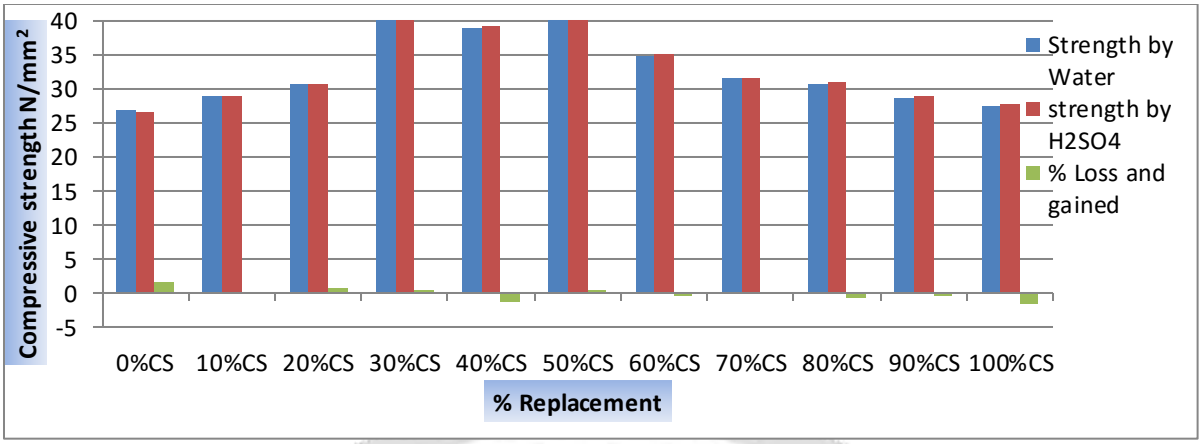

Chart-3: Compressive Strength(H2SO4) Vs. % Replacement

5.4 Non-destructive Testing of Concrete

5.4.1 Pulse Velocity Method

The ultrasonic pulse velocity measurement is the measure of quality of concrete.

Table-4: Pulse Velocity Result

SR. NO.	Proportion	Velocity	Concrete Quality Grading
	% Rep.	KM/sec	
1	0	5.32	Excellent
2	10	5.35	Excellent
3	20	7.45	Excellent
4	30	5.13	Excellent
5	40	10.22	Excellent
6	50	12.72	Excellent
7	60	4.77	Excellent
8	70	4.51	Excellent
9	80	4.03	Good
10	90	4.1	Good
11	100	4.65	Excellent

3)At 28th day measurement, the concrete showed excellent quality for 0% to 70% and 100% replacement of fine aggregate and showed good quality for 80% and 90% replacement of fine aggregate.

5) It is mainly related to its density and modulus of elasticity which in turn, depends upon the materials and mix proportions it is greater for 50% replacement i.e. it was observed that the pulse wave velocity is 12.78 km/sec for that concrete

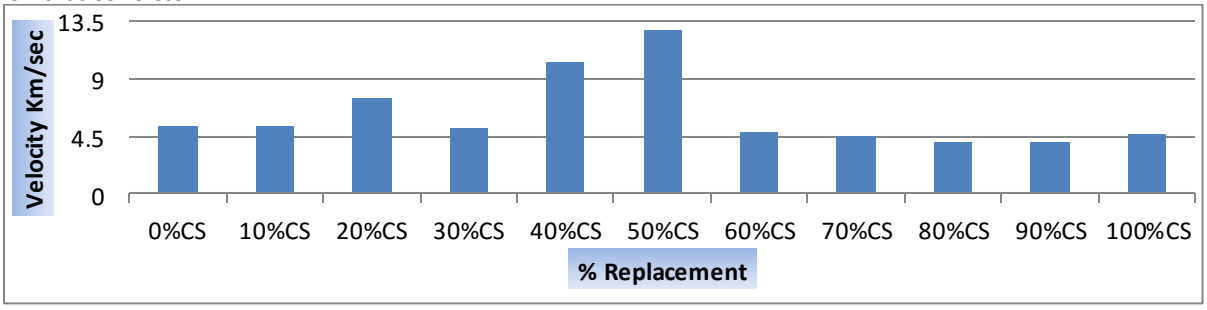

Chart-4: Pulse Velocity Vs. % Replacement

5.5 Modulus Of Elasticity

modulus of elasticity decreased in accordance with an increase of replacement of natural sand by copper slag.(according to IS: 456-2000 by the formula $E = 5000\sqrt{Fck}$ ((page-16) =5000√25=25GPa)

Table-5: Modulus Of Elasticity (E) Result

SR. NO.	Proportion	E by Practically		E by IS	Average E	% Increasing compared to IS
	% Rep.	E1	E2	GPa	GPa	
1	0	31.84	31.33	25	31.59	26..36
2	10	33.91	33.45		33.68	34.72
3	20	35.37	33.32		34.35	37.40
4	30	36.31	40.35		38.33	53.32
5	40	38.42	43.64		41.03	64.12
6	50	41.48	49.75		45.62	82.48
7	60	38.80	41.11		39.96	59.84
8	70	36.80	38.46		37.62	50.48
9	80	33.99	34.01		35.50	42.00
10	90	33.23	35.70		34.46	37.84
11	100	33.01	34.69		33.85	35.40

The modulus of elasticity of copper slag added concrete was gradually increased up to 50% replacement and then decreased with further fine aggregate replacement. Mixtures with 100% replacement of CS almost gives the modulus of elasticity 33.85 Mpa which is 35.40% greater than the strength of the IS.

Chart-5: Modulus Of Elasticity (E) Vs. % Replacement

6. CONCLUSION

1. The design M25 grade concrete for 50% replacement of CS show the HPC characteristics

2. Copper Slag behaves like to River Sand both having same contain Silica (SiO2)

3. It is observed that when increasing percentage replacement of fine aggregate by Copper slag the unit weight of concrete is gradually increases.

4. The Compressive Strength of Concrete with partial replacement of Sand with Copper Slag up to 50% can be comparable with control mix. with increased copper slag content beyond the 50% replacement increased free water content due to compressive strength decreased but the minimum strength of percentage replacement of CSC is 27.41 MPa which is 1.62% more than control mix.

5. It is observed that, the workability of concrete increased with the increase in copper slag content of fine aggregate replacements at same water-cement ratio, the replacement of CS 10%, 20%, 30% low , 40%, 50%, 60%, 70%, 80%, 90% Medium, 100% High workability of concrete.

The ultrasonic pulse velocity test indicated the excellent quality of concrete at up to 70% and 100%, good for 80% and 90% replacement of CS

6.Acid durability test showed that the concrete containing copper slag has effected on weight but not on compressive strength at 10% H2So4 solution

7. ACKNOWLEDGEMENT

My Heartfull Thanks To Prof. P. B. Autade, my guide, Prof. U.R. Kawade, H.O.D., Civil Engineering Department for their valuable suggestions and last but not the least I am indebted to my parents, |Brother a, Friends and my Colleagues for their support and supplications.

6. REFERENCES

1. Akihiko, Y. and Takashi, Y. "Study of utilisation of copper slag as fine aggregate for concrete", Ashikaya Kogyo Daigaku Kenkyu Shuroku, Vol. 23, pp. 79-85, 1996.
2. Al-Jabri, K. and Makoto Hisada. "Copper slag as sand replacement for high performance concrete", Cement & Concrete Composites, Vol. 31, 483- 488, 2009.
3. Al-Jabri, K.S., Abdullah, H., Al-Saidy and Ramzi Taha. "Effect of copper slag as a fine aggregate on the properties of cement mortars and concrete", Construction and Building Materials, Vol. 25, pp. 933-938, 2011.
4. Al-Jabri, K.S., Taha, R.A., Al-Hashmi, A. and Al-Harthy, A.S. "Effect of copper slag and cement by-pass dust addition on mechanical properties of concrete", Construction and building materials, Vol. 20, 322-331, 2006.
5. Wu, W., Zhang, W. and Ma, G. "Optimum content of copper slag as a fine aggregate in high strength concrete", Material design, Vol.31, No.6, pp. 2878- 2883,2010.
6. Taeb, A. and Faghihi, S. "Utilization of copper slag in the cement industry", Zement Kalk Gips International, Vol.55, No.4, pp. 98-100, 2002.