International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN: 0974-4290
Vol.8, No.12 pp 442-449, 2015

Effect of Copper Slag on the Mechanical Strengthsof Concrete

T.Ch.Madhavi*, P.V.R.Pavan Kumar, Jothilingam.M

[1]Department of Civil Engg., SRM University, Ramapuram, Chennai, India

Abstract: This paper presents the effect of copper slag when included in concrete as a replacement material for sand. It focuses on the effect of copper slag on behaviour of concrete. This paper outlines the properties, preparation and testing and finally the results obtained from experimental investigations using copper slag which is a waste by product produced during the smelting process of manufacture of concrete from its ore. Experimental investigations are carried out by replacing sand with copper slag in content of 10%, 20%, 30%, 40%, 50%, 60% and 100% keeping all other ingredients constant. It is observed that the optimum content of copper slag that can be used as replacement material is 40% beyond which the strength starts decreasing.
Key words: Copper Slag, Flexure, Split tensile strength, Compression, waste product.

Introduction

Using waste copper slag (CS) as a replacement material for sand in concrete is becoming popular in Singapore and around the world. Copper slag is waste by product produced during the smelting of copper[1]. It has been reported by researchers that copper slag does not cause leaching [2].Application of copper slag in concrete as a replacement material explores the possibility of reducing the environmental impact. Copper slag is granular and has properties similar to that of sand [3]. The grain size of copper slag particles match with sand. But the specific gravity of copper slag is slightly higher than that of sand thus increasing its self weight [4]. The content of silica in copper slag is about 30 % which is desirable and is similar to the natural river sand [5].

Experimental Investigations

Testing is carried out on copper slag concrete cubes, cylinders and beams to study the compression, split tension and flexural strength of copper slag concrete. The sand is replaced with copper slag in the volume fractions of 10%, 20%, 30%, 40%, 50%, 60% and 100%.

Materials

Ultra tech Cement of 53 grade, Coarse aggregate of 12mm, river sand and portable water are used for making concrete. Copper slag is the by-product of Sterlite Industries, Tuticorin. Super plasticizer CONPLAST SP430 is used for improving the workability. The mix ratio adopted is 1:1.05:2.38 while the water cement ratio is 0.4.

The sieve analysis report is presented in Fig 1 and can be observed that the particle gradation is well distributed and acceptable.

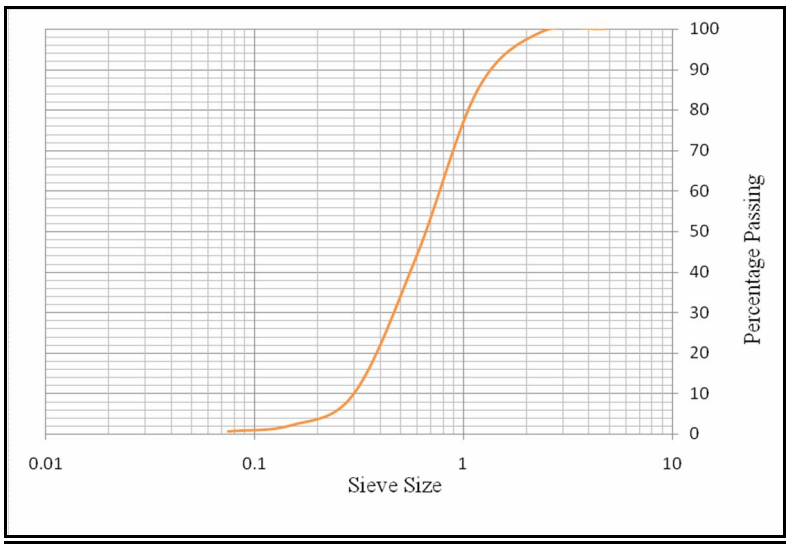

Fig 1.Seive analysis of Copper slag

Results and Discussions

The results obtained by testing various specimens are presented below.

Compressive Strength

A total of 48 cubes of size 150 x 150 x 150 mm are cast and tested in compression testing machine of 200 tons capacity. The concrete cubes are demoulded after 24 hours and cured under water for 28 days. The test results obtained after 7 days and 28 days of curing are shown in table 1 below.

Table 1 Compressive strength after 7 days curing

S.No	Copper Slag Content in %	Compressive strength after 7 days N/mm^2	% Increase in Compressive strength
1	0	27.2	-
2	10	27.7	1.8
3	20	29.3	7.8
4	30	29.9	9.8
5	40	31.7	16.7
6	50	27.2	0.0
7	60	21.3	-21.6
8	100	17.3	-36.3

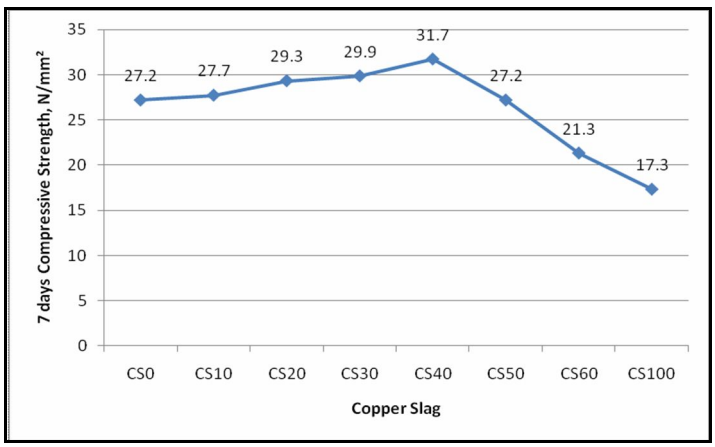

Figure 1 Compressive strength after 7 days curing

Table 2 Compressive strength after 28 days curing

S.No	Copper Slag Content in %	Compressive strength after 28 daysN/mm^2	% Increase in Compressive strength
1	0	32.0	-
2	10	34.4	7.5
3	20	34.9	9.2
4	30	35.4	10.7
5	40	56.9	77.8
6	50	53.3	66.7
7	60	36.4	13.9
8	100	35.6	11.1

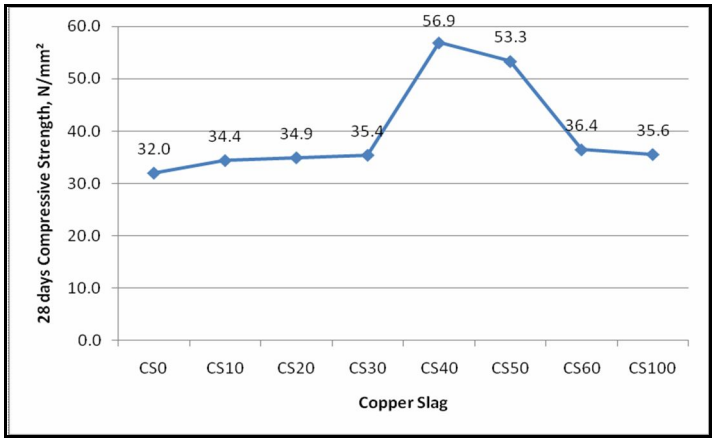

Figure 2 Compressive strength after 28 days curing

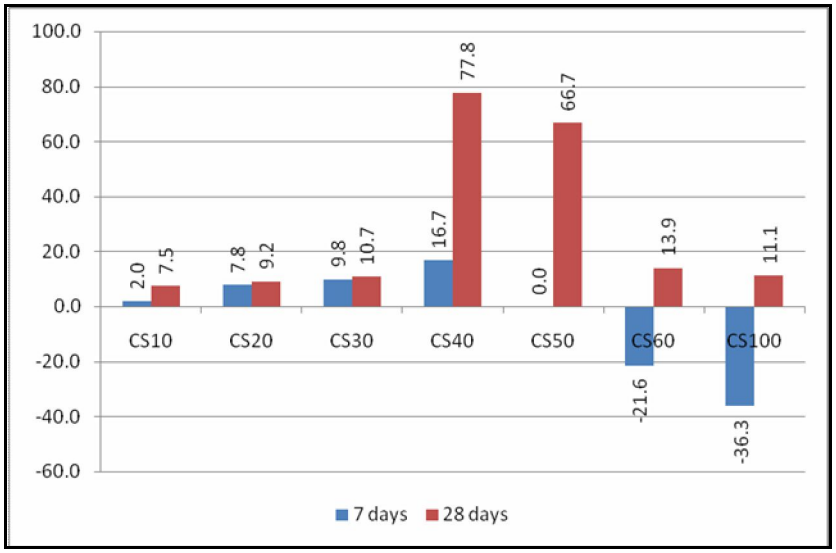

Figure 3 Comparison of increase in strength after 7 days and 28 days

Thoughafter 7 days the compressive strength increased initially with copper slag content of upto 40 %, beyond this volume, the concrete started losing its strength. But After 28 days, the compressive strength was higher than the conventional concrete even when 100% of sand is replaced with copper slag. The increase in compressive strength is shown clearly in Fig 3.

Figure 4 Failure of cube Specimen

Figure 5 Failure of Cylindrical specimen

Split tensile Strength

The split tensile strength was obtained by resting cylinders of 150 mm diameter and 300 mm depth. The test was carried out by placing the cylinder horizontally and applying the load diagonally. The results obtained for different concrete mixes are presented in table 3.

Table 3 Split tensile strength after 7 days

S.No	Copper Slag Content in %	Split tensile strength after 7 days	% Increase in split tensile strength
1	0	2.41	-
2	10	2.55	5.8
3	20	2.55	5.8
4	30	2.62	8.7
5	40	2.69	11.6
6	50	2.55	5.8
7	60	2.41	0.0
8	100	2.26	-6.2

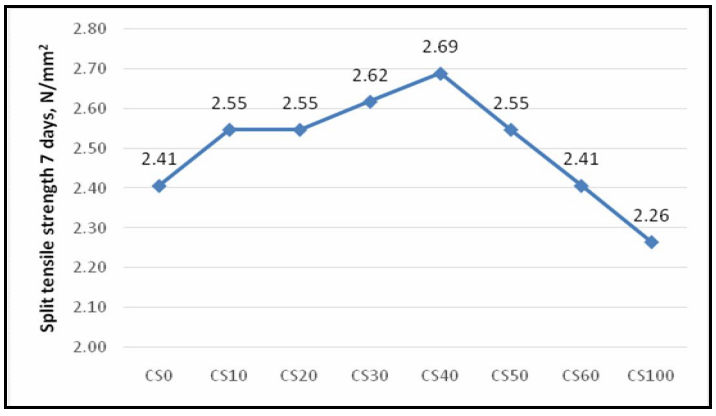

Figure 6 Split tensile strength

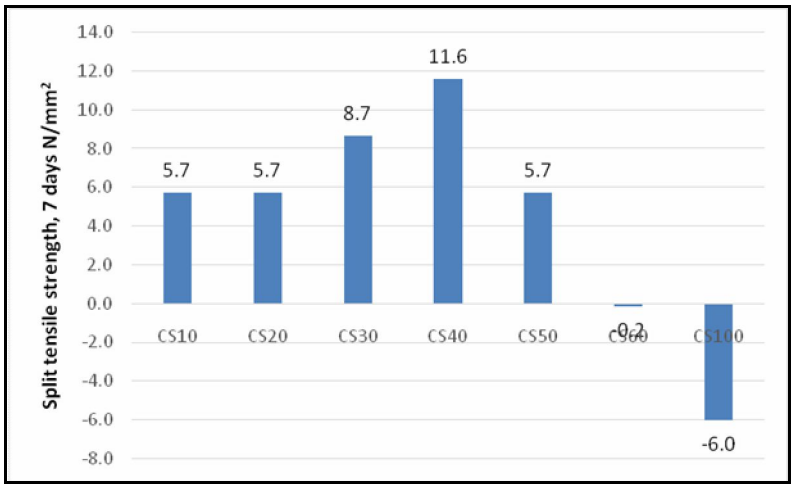

Figure 7 Variation of split tensile strength in %

Table 4 Split tensile strength after 28 days

S.No	Copper Slag Content in %	Split tensile strength after 28 days	% Increase/decrease in split tensile strength
1	0	3.44	-
2	10	3.54	2.9
3	20	3.68	7.0
4	30	3.40	-1.2
5	40	3.26	-5.2
6	50	3.11	-9.6
7	60	2.97	-13.7
8	100	2.83	-17.7

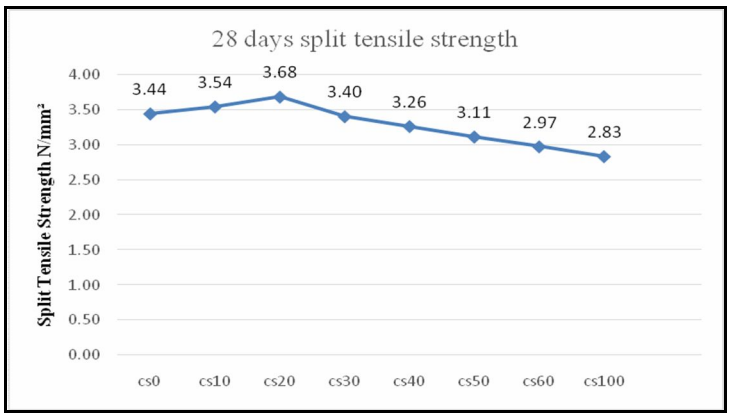

Figure 8 Split tensile strength after 28 days

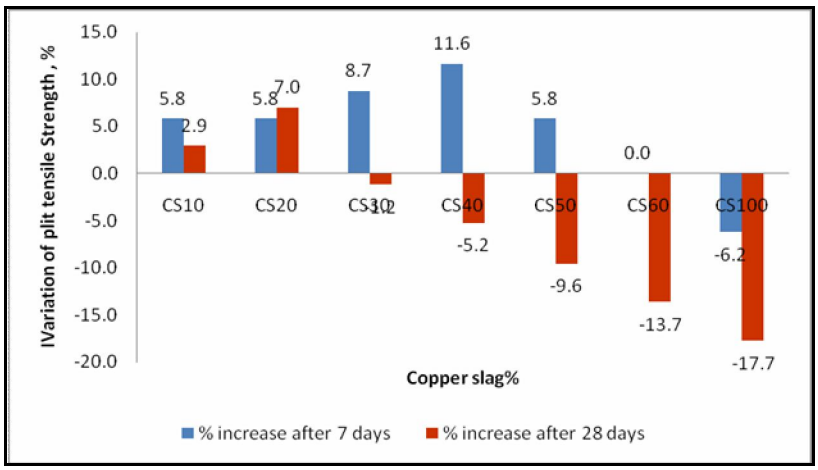

Figure 9 Comparison of increase in split tensile strength after 7 days and 28 days

The split tensile strength at 7 days increased up to 20 % by 11.6% for 40% replacement of sand. The increase in split tensile strength was 5.8%, 5.8%, 8.7% and 11.6% for 10%, 20%, 30%, 40% copper slag content. The strength decreased beyond this.

After 28 days, the split tensile strength decreased from 30% and the maximum increase observed with addition of copper slag is7% at 20 % of copper slag and the strength dropped by 17.7 % when 100 % copper slag is used.

Flexure

Beam specimens of size 100 x 100 x 500 mm are cast and tested in a Universal Testing Machine of 400 kN capacity under two point loading as shown in fig. 10.

Figure 10 Flexure test

Table 5 Flexural Strength

S.No	Copper Slag Content in %	Flexural strength after 28 days	% Increase in Flexural strength
1	0	3.8	-
2	10	4.0	5.3
3	20	4.2	10.5
4	30	4.4	15.8
5	40	4.8	26.3
6	50	4.4	15.8
7	60	4.2	10.5
8	100	4.0	5.3

It can be clearly seen that the flexural strength increased with increase in copper slag content upto 40% but beyond 40% the strength started decreasing. The flexural strength increased from about 5% to 26 %.

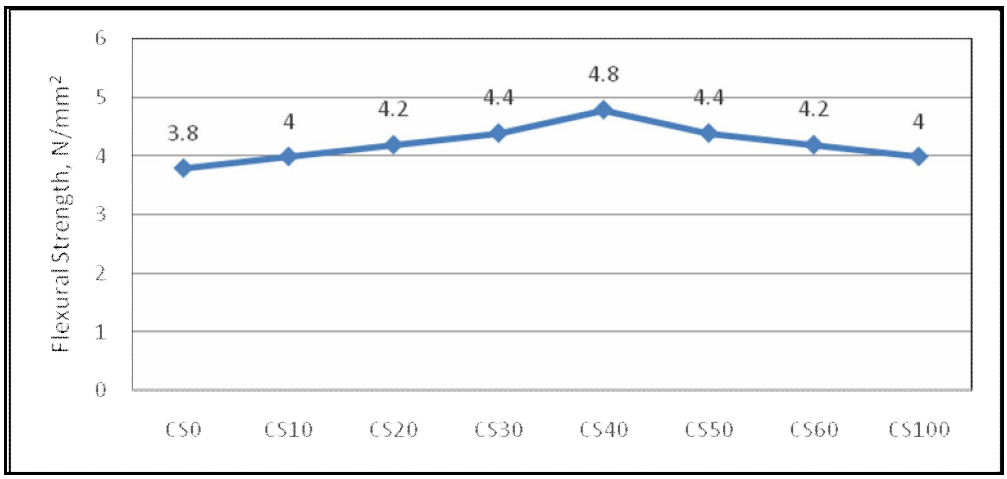

Figure 11 Flexural strength for different percentages of copper slag.

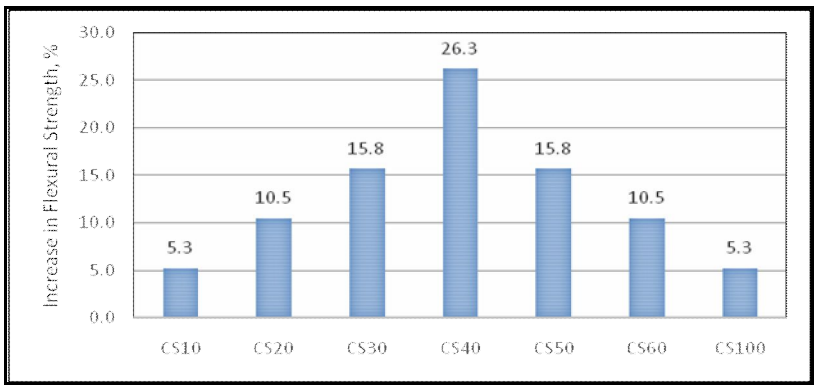

Figure 12 % increase in flexural strength after 28 days

Conclusions

1. Copper slag shows considerable increase in compressive strength when used upto 40%. The increase in compressive strength is16.7 % and 77.8% after 7 days and 28 days respectively.
2. Though the compressive strength decreasedbeyond 40%, after 28 days the strength in no case has gone down less than the conventional concrete.
3. The 28 days flexural strength increased with application of copper slag from 5% to 26%. Upto 40% replacement with sand.
4. The split tensile strength does not improve much with increase in content of copper slag. The maximum increase in strength was observed to be 7%
5. The most suitable content of copper slag which can be used to replace fine aggregate is 40%.

Acknowledgements

The authors would like to thank the management of SRM University for supporting this project and extending financial grant for carrying out these experimental investigations.

References

1. D.Brindhaand S.Nagan, "Utilization of Copper Slag as a Partial Replacement of Fine Aggregate in Concrete" International Journal of Earth Sciences and Engineering,ISSN 0974-5904, Vol. 03, No. 04, August 2010, pp. 579-585.
2. R.R.Chavan & D.B.Kulkarni,"Performance Of Copper Slag on Strength Properties as Partial Replacement of Fine Aggregate in Concrete Mix Design" International Journal of Advanced Engineering Research and Studies.July-Sept 2013, pp 95-98.
3. ThongamPrantic Singh, Dr.Rajashekhara.M.R, Suhas R, "Utilization of Copper Slag as Fine Aggregates in Cement Concrete Pavements", International Journal for Research in Applied Science and Engineering Technology, Vol. 2 Issue VII, July 2014, pp358-365.
4. Deepak Gowda B, H.B.Balakrishna,"Experimental Study on Flexural Behavior of Reinforced Concrete Beams by Replacing Copper Slag as Fine Aggregate"Vol. 2, Issue 1, Month: April 2014 - September, pp.97-103.
5. VamsiPradeep, Kishore Kumar, "The Behaviour of Concrete in Terms of Flexural, Tensile & Compressive Strength Properties by Using Copper Slag as an Admixture*"* International Journal of Engineering and Innovative Technology, Volume 3, Issue 4, October 2013..
6. Alnuaimi, "Effects of Copper Slag as a Replacement for Fine Aggregate on the Behavior and Ultimate Strength of Reinforced Concrete Slender Columns", TJER, Vol. 9, No. 2, 90-102, 2012.
7. Bipragorai, R.K. Jana, Premchand, "Characteristics and utilisation of copper slag - a review". Resources, Conservation and Recycling, 39, pp.299-313, 2013.
8. Antonio M. Arinoand BarzinMobasher, "Effect of Ground Copper Slag on Strength and Toughness of Cementitious Mixes", ACI Materials Journal ,V.96, No.1, pp.68-74, 1999.
9. BinayaPatnaik, Seshadri, Sekhar.T andSrinivasaRao, "An Experimental Investigation on Optimum Usage of Copper Slag as Fine Aggregate in Copper Slag Admixed Concrete" International Journal of Current Engineering and Technology, Vol.4, No.5, Oct 2014.
10. B. Mobasher M, R. Devaguptapu , A.M.Arino, "Effect Of Copper Slag on the Hydration of Blended Cementitious Mixtures" Proceedings, ASCE, Materials Engineering Conference, Materials for the New Millenium, ed. K. Chong, pp. 1677-86, 1996.
11. Caijun Shi, Christian Meyer, Ali Behnood"Utilization of copper slag in cement and concrete" Resources, Conservation and Recycling, 52, pp 1115–1120, 2008.

*****