

Use Copper Slag in Concrete of Concrete Grade M-20

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Abstract- We need to adopt various construction materials as an alternative has become essential nowadays. Utilization of by-products from industries could provide an alternative to the problems of using precious natural resources for concrete. It is fine aggregates are considered to be very costly in concrete. Alternate material to replace fine aggregate becomes necessary so as to make economical the cost of construction while improving both fresh and hardened properties of concrete. This chapter includes the background needs for the development of the alternative materials to increase the strength of the concrete and the use of copper slag in concrete the available published literature on replacement of fine aggregate by copper slag in concrete technology is also briefly reviewed.

Keywords- Concrete Flash, pulverized fuel ash, blast furnace slag, silica fume.

I- INTRODUCTION

Concrete is used in gargantuan amount almost all around the world over human race has a requirement for organization. For the preparation of concrete, we need cement, fine aggregate and coarse aggregate. For the preparation of matrix, we need fine aggregate in bulk amount. The fine aggregates come from river sand which is a natural resource. As our country is a developing country, we need to preserve our natural resources for our future generation. To prepare concrete we need to look for alternatives of fine aggregates. The industrial wastes are best suitable for the replacement of fine aggregates. Due to huge population on earth, the demand of materials is also very high and the production of waste materials

increases day by day and creates contamination in the environment. Researchers have studied to reuse the useful waste into the concrete like steel slag, copper slag and polymer wastes by using this process we can make concrete cost-effective by replacing waste materials through fine aggregates. River sand is a natural resources and depletion of sand is a big setback for environment. So, it is necessary to protect environment and reduction of waste by recycling and reusing of waste materials. Copper slag is recycled and re used many times but after many recycling it is dumped in the land fill or stock pile which contaminates the land and water bodies. This review study based on the concrete performances by replacing copper slag and to find out the ideal solution of waste replacement in concrete by studying various authors researches and reviews. The primary objective is to study the application of copper slag as an alternative replacement material of sand. Also studies the result of substitution of Fine aggregate with copper slag on mechanical performances of concrete.

COPPER SLAG

Copper slag is an abrasive blasting grit made of granulated slag from metal smelting processes. It is also called iron silicate. Copper slag is a by-product created during the copper smelting and refining process. Copper slag is a by-product obtained during the production of copper metal, which has got pozzolanic property and can be used in the production of cementing materials. The physical and geotechnical properties of the copper slag were first assessed by laboratory tests, including hydraulic conductivity and shear strength tests. Copper slag blasting media/grit - is manufactured of

the granulated slag of copper refineries, and used for cleaning of metal surface due to its abrasive nature. Copper slag has also gained acceptance in the construction industry for use as a filler material. It can also use copper slag in place of sand during concrete construction. Copper slag can also be used as a building material, formed into constructional blocks. Copper slag is widely used in the sand blasting industry and it has been used in the manufacture of abrasive tools. The consumed copper slag is suitable to be used as a filler material for land reclamation. One of the principal advantages to copper slag is the low risk it stances to health and the environment. It also has a high strength-to-weight ratio, making it an effective option in concrete, or as a filler material under the road construction. Some studies were carried out using grained copper slag as partial or complete replacement fine aggregate and fine powder copper slag for partial replacement of cement. It is one of the materials that is considered as a leftover material which could have a capable future in construction industry as partial substitute of either cement or aggregates. Singapore, imports copper slag from various countries to reuse as abrasive material for removing rust and marine deposit from ships. The raw copper slag has particle sizes ranging from micrometers to larger than 1 cm in diameter.

Industrial sludge is generated at a rate of 100 metric tons/day, from a copper slag recycling plant. Copper slag is widely used as an abrasive media to remove rust, old coating and other impurities in dry abrasive blasting due to its high hardness, high density and low free silica content. Sterlite Industries in India has huge potential for the use of copper slag in concrete applications. For every ton of copper produced about 2.2 ton of slag is generated. At present, across the world around 33 tonne's of slag is generated while in India three copper producers Sterile, Birla Copper and Hindustan Copper produce around 6-6.5 tonnes of slag at different sites. Used copper slag is the largest source of waste from shipyards and refineries. Each year 300,000 tonnes are used for abrasive blasting at shipyards.

Copper slag consists mechanical and chemical properties that is eligible as the material to be used in production of concrete as a partial replacement

as a substitute for aggregates. Mechanical property of copper slag has good sound characteristics, good abrasion resistance and good stability for aggregate use. Here an effort has been completed to accumulate the various studies done on the replacement of copper slag in fine aggregate to judge the strength of concrete.

PRODUCTION OF COPPER SLAG-

During the process of smelting the larger sized particles gets settled at the bottom and the finer particles stay at the top layer and within the shorter period of time the finer particles travels to the water bowl which is at the lower temperature and gets hardened and further processed to the crusher for next process.



Fig 3.1 Image of copper slag used in the concrete

PROPERTIES OF COPPER SLAG:

Physical and Chemical properties of copper slag-

The copper slag is black in color and have glassy particle and are granular in nature. Slag has same particle size distribution like fine aggregate. The specific gravity of the copper slag is 3.90. The bulk density of the grained copper slag varies from 1.9 to 2.15 kg/m³ which almost similar to the river sand which is used in concrete. The hardness of the copper slag lies between 6 and 7 in MoH scale which is similar to the hardness of the gypsum used in the cement. The pH of aqueous solution of aqueous extract as per IS 11127 varies from 6.6 to 7.2. The water content in the copper slag was less than 0.5%.

In copper slag the silica content is about 26% which is very much needed because one of the main constituents of the natural aggregate is silica which is used in making the concrete matrix. The fitness of copper slag was calculated as 125m²/Kg.

Table 3.1: Physical Properties of copper slag

Physical Properties	Copper slag
Particle shape	Irregular
Appearance	Black & glassy
Type	Air cooled
Specific gravity	3.91
Percentage of voids	43.20%
Bulk density	2.08 g/cc
Fineness modulus of copper slag	3.47
Angle of internal friction	51° 20'
Hardness	6-7 mohs
Water absorption	0.3 to 0.4%
Moisture content	0.1%
Fineness of copper slag	126m ² /kg

Chemical composition of copper slag

Copper slag samples were analyzed for constituent oxides including minor oxides and heavy elements besides mineral phases. The results of chemical analysis are shown in

Table 3.2: Chemical properties of copper slag **4.2.4**

S.No	Chemical Component	% Of Chemical Component
1.	SiO ₂	25.84
2.	Fe ₂ O ₃	68.29
3.	Al ₂ O ₃	0.22
4.	CaO	0.15
5.	Na ₂ O	0.58
7.	K ₂ O	0.23
8.	LoI	6.59
9.	Mn ₂ O ₃	0.22
10.	TiO ₂	0.41
11.	SO ₃	0.11
12.	CuO	1.20
13.	Sulphide sulphur	0.25
14.	Insoluble residue	14.88
15.	Chloride	0.018

Fine Aggregate and Coarse Aggregate

Zone-II sand was considered for work and the properties of zone-2, fine aggregate was shown in table and machine crushed stone used as coarse aggregate. The size of aggregate varies from 20mm to 4.75mm. The physical properties of coarse aggregate are shown in table.

Table 0.1 Sieve Analysis of Fine Aggregate and Coarse Aggregate

Sieve size(mm)	Percentage passing	Sieve size(mm)	Adopted Grading
40	100	10	100
20	100	4.75	100
16	70	2.36	85
12.5	45	1.18	70
10	30	600	45
4.75	0	300	10
		150	0

Fineness modulus of fine aggregate: 3.10

Fineness modulus for Coarse aggregate: 7.15

Specific gravity for fine aggregate:2.62

Specific gravity for Coarse aggregate:2.8

Water

Drinking water supplied by the college was used for the preparation and curing of the concrete.

Table 0.2 Number of specimens' casted for OPC M20.

Specimens	Dimensions(mm)	Number of specimens casted for OPC M20	Purpose
Cubes	150X150X150	3+3	Compressive Strength
Cylinders	150 Ø and 300 height	3+3	Split Tensile Strength
Prisms	100X100X500	3+3	Flexural Strength

Specimens	Dimensions (m)	Number of specimens casted for copper slag as a partial replacement of F.A.					Purpose
		20 %	40 %	60 %	80 %	100 %	
Cubes	150X150X150	3+3	3+3	3+3	3+3	3+3	Compressive Strength
Cylinders	150 Ø and 300 height	3+3	3+3	3+3	3+3	3+3	Split Tensile Strength
Prisms	100X100X500	3+3	3+3	3+3	3+3	3+3	Flexural Strength

Table 0.2 Slump Value of M20 of different mixes.

S.No	Copper Slag %	Slump Value (mm)
Mix1	0	77
Mix2	20	79
Mix3	40	82
Mix4	60	83
Mix5	80	78
Mix 6	100	75

RESULTS AND DISCUSSIONS

5.1 INTRODUCTION

In this chapter, the experimental results are presented and discussed. The effects of various important parameters on the slump test, compressive strength, split tensile strength and flexural strength of copper slag concrete and Ordinary Portland cement concrete. The parameters considered are as follows:

- i. Ratio of copper slag, by weight of fine aggregates,
- ii. Curing Temperature and Time,
- iii. Water/cement ratio by mass,

The mass of aggregate was approximately 75-80% of the entire mixture. The Section 5.2 shows the slump value of concrete for different grades of concrete. The Section 5.3 shows the variation of compressive strength with replacement of fine aggregates by copper slag. Section 5.4 attribute the comparison of split tensile strength of copper slag concrete and Ordinary Concrete. While section 5.5 details the flexural Strength of copper slag concrete and Ordinary Concrete.

5.2 WORKABILITY OF CONCRETE

Effect of Copper slag on workability of concrete

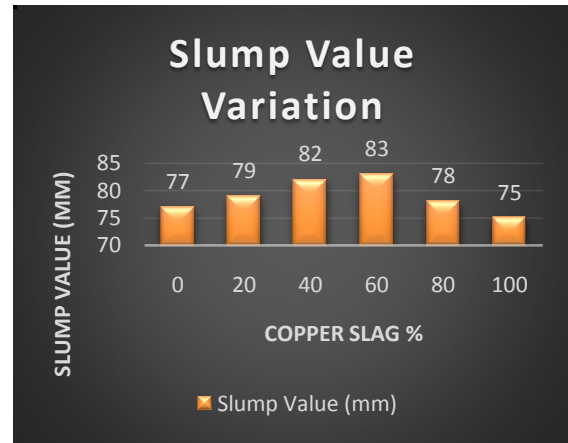


Figure 0.1 Variation of M20 in slump value with variation of copper slag

COMPRESSIVE STRENGTH OF CUBES

Effect of Copper slag on Compressive Strength of Cubes

Table 0.4 Strengths of Copper slag concrete M20 of different mixes.

S.No	Copper Slag %	Compressive Strength (MPa)	
		7 days	28days
Mix1	0	16.45	24.40
Mix2	20	19.92	30.80
Mix3	40	21.65	33.55
Mix4	60	18.78	29.44
Mix5	80	16.19	24.57
Mix6	100	15.17	22.19

For concrete cubes cured for 28 days, the strength reached around 33.55 MPa.

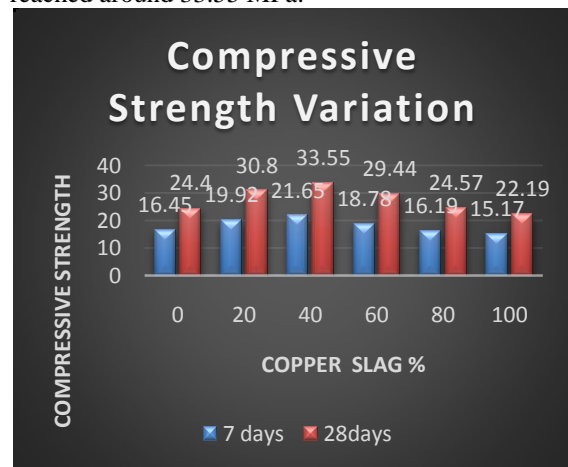


Figure 0.4 Variation of M20 Compressive Strength with variation of copper slag

SPL TENSILE STRENGTH OF CYLINDERS

5.4.1 Effect of Copper Slag Concrete on Tensile Strength of Cylinders

Table 0.6 Tensile strength of copper slag concrete M20 of different mixes.

S.No	Copper Slag %	Split Tensile Strength (MPa)	
		7days	28days
Mix1	0	1.57	2.43
Mix2	20	1.59	2.47
Mix3	40	1.78	2.49
Mix4	60	1.69	2.45
Mix5	80	1.58	2.39
Mix6	100	1.49	2.34

For concrete cylinders cured for 28 days, the strength reached around 2.49 MPa

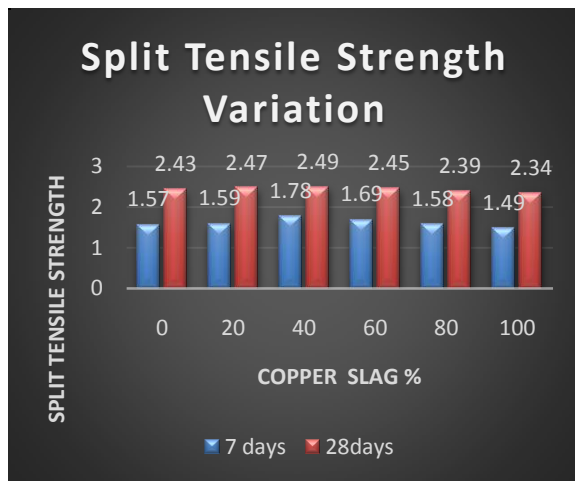


Figure 0.6 Variation of M20 Split Tensile Strength

FLEXURAL STRENGTH OF PRISMS

Effect of Copper Slag Concrete on Flexural Strength of Prisms

Table 0.8 Strengths of copper slag concrete M20 of different mixes.

S.No	Copper Slag %	Flexural Strength (MPa)	
		7 days	28 days
Mix1	0	2.18	3.39
Mix2	20	2.37	4.24
Mix3	40	2.69	4.77
Mix4	60	2.36	4.45
Mix5	80	2.14	4.05
Mix6	100	1.97	3.25

For concrete beam cured for 28 days, the strength reached around 4.77 MPa

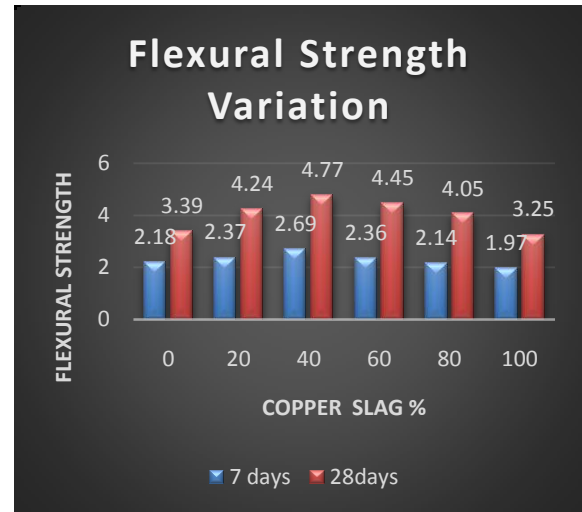


Figure 0.8 Variation of M20 Flexural Strength with variation of copper slag

CONCLUSIONS

From the experiments conducted on the Copper Slag Concrete, developed in the concrete laboratory of RSR RCET, the following conclusions have been made.

1. 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.
2. Copper Slag behave same like river sand both contains river sand.
3. It is observed that when increasing percentage replacement of fine aggregate by Copper slag the unit weight of concrete is gradually increases.
4. Compressive Strength of Concrete with partial replacement of Sand with Copper Slag up to 40% can be comparable with control mix. with increased copper slag content beyond the 40% replacement compressive strength decreased.
5. Split Tensile Strength and Flexural Strength of Concrete with partial replacement of Sand with Copper Slag up to 40% showed better results with increased copper slag content beyond the 40% replacement strength decreased.
6. The suitable addition of copper slag in matrix is 0 to 40%.
7. It will help to counteract the problem of disposal of copper slag for the production industry and in addition to that it will also help

in preparing greener concrete and conserve our natural resource.

8. It can be concluded that replacement of fine aggregates by copper slag till 40%, concrete mix may be conveniently allowed

REFERENCES

- [1] G. Esakki Muthu, N. Sakthieswaran, G. Shiny Brintha, O. Ganesh Babu "Microstructure Study on cement mortar using green sand and copper slag" *International Journal for research in applied science and Engineering and Technology (IJRASET) Volume 4, Issue V, May 2016.*
- [2] Mr. Neel P. Patel, Dr. P.J. Patel, "Sand Replacement with Copper Slag on Mechanical Properties of Concrete" *International Journal of advance engineering and research development, e-ISSN: 2348-4470, p-ISSN: 2348-6406, Volume 3, Issue 5, May-2016.*
- [3] Mankare Ulka S, Prof. Ajay. A. Hamme, "Experimental study replacement of various wastes in concrete" *International Journal of Modern Trends in Engineering and research, e-ISSN: 2349-9745, Vol.03, Issue 05, and May-2016.*
- [4] Dr. A. Leema rose, P. Suganya "Performance of Copper Slag on Strength and Durability Properties as Partial Replacement of Fine Aggregate in Concrete" *International Journal of Emerging Technology and Advanced Engineering, Volume 5, Issue 1, January 2015.*
- [5] Chinmay buddhadev, Jayesh kumar pitroda, Prof. Chetna m. Vyas, "A review of innovative use of copper slag and foundry sand in design mix concrete" *Journal Of International Academic Research For Multidisciplinary, Impact Factor 1.625, ISSN: 2320-5083, Volume 2, Issue 12, January 2015.*
- [6] M.R. Amarnaath, S. Jaya pradeep, R.A. kavin, P. Dinesh, "Study on effective Replacement of fine aggregate using copper slag" *International Journal of Science Technology & Engineering, Volume 1, Issue 10, April 2015.*
- [7] Binaya Patnaik, Seshadri Sekhar.T, Srinivasa Rao, "Strength and Durability Properties Of Copper Slag Admixed Concrete" *International Journal of Research in Engineering and Technology, e-ISSN: 2319- 1163, p-ISSN: 2321-7308, Volume 4, Issue 1, Feb 2015.*
- [8] Pranshu Saxena, Ashish Simalti, "Scope of Replacing Fine Aggregate With Copper Slag In Concrete" *International Journal of Technical Research and Applications, e-ISSN: 2320-8163, Volume 3, Issue 4, August 2015, PP.44-48.*
- [9] Srinivas C. H, S. M Muranal, "Study of the Properties of Concrete Containing Copper Slag as a Fine Aggregate" *International Journal of Engineering Research & Technology, e-ISSN: 2278-0181, Vol.-Issue 02, Feb 2015.*
- [10] V. Sushma, Dr. T. Suresh Babu, K.V. Manikanta, M Anvesh Kumar, M Praveen Kumar, "A Study on the Partial Replacement of Fine Aggregate with Copper Slag by Observing the Compression, Split Tensile and Flexural Properties" *International Journal of Innovative Research in Engineering & Management (IJIREM), ISSN: 2350-0557, Volume-2, Issue-4, July 2015.*
- [11] Vishwa B Tipashetti, Shreepad Desai, "Evaluation on Accelerated Corrosion Properties of the Concrete Produced by Replacing Sand by Copper Slag" *International Journal of Engineering Research & Science (IJOER), Vol-1, Issue-4, July-2015.*
- [12] M. Ramesh, K.S.Karthic, T. Karthikeyan and A. Kumaravel, "Construction Materials from Industrial Wastes-A Review of Current Practices" *International Journal of Environmental Research and Development, ISSN 2249-3131 Volume 4, Number 4 (2014), pp. 317- 324.*
- [13] Dr. T.Ch. Madhavi, "Copper Slag in Concrete as Replacement Material" *International Journal of Civil Engineering and Technology (IJCIET), ISSN 0976 – 6316, Volume 5, Issue 3, March (2014), pp. 327-332.*
- [14] M.C. natraja, G. N. Chandan, T. J. Rajeeth, "Concrete Mix Design Using Copper Slag As Fine Aggregate" *International journal of civil engineering and technology (IJCIET), e-ISSN 0976 – 6316, Volume 5, Issue 9, September (2014), pp.90-99.*
- [15] R R Chavan, D B Kulkarni, "Performance of copper slag on strength Properties as partial replace of fine aggregate in concrete mix design" *International Journal of Advanced Engineering Research and Studies, E-ISSN 2249–8974, Volume 2, Issue 4, Sep (2013), pp.95-98.*
- [16] J. Ramesh Kumar, K. V. Ramana, "Use of Copper Slag and Fly Ash in High Strength Concrete" *International Journal of Science and Research (IJSR), e-ISSN: 2319-7064, Volume 4 Issue 10, October 2015.*
- [17] Junwei Song, "An experimental of strength properties of concrete admixed with copper slag" *Journal of Chemical and Pharmaceutical Research, ISSN: 0975-7384, 2014.*
- [18] M. Chockalingam, D. Jayganesh, J. Vijayaraghavan, Dr. J. Jegan, "Scope for Reuse of Copper Slag in Concrete", *International Journal of Civil Engineering and Technology, e-ISSN: 0976-6316, Volume 4, Issue 6, 2013.*
- [19] Suresh T, Ravikumar C, "Influence of Copper Slag as Partial Replacement of Sand in Cement

Concrete”, International Journal of Innovative Research in Technology, ISSN: 2349-6002, Volume 2 Issue 1, June2015.

- [20] *J. Swathi, Ms. V. Gnanadevi, “An experimental investigation on Concrete by partial replacement of copper slag for fine aggregate and ceramic waste with coarse Aggregate”, IJETCSE, ISSN: 0976-1353, Vol.13, Issue 4,2015.*
- [21] *M. V. Patil, “A Study on Properties and Effects of Copper Slag in Concrete”, IRF international conference,2015.*
- [22] *SukhoonPyo, Sherif El-Tawil, Antoine E. Naaman, “Direct tensile behavior of ultra high performance fiber reinforced concrete (UHP- FRC) at high strain rates”, Elsevier2016.*