International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 02 Issue: 08 | Nov-2015 www.irjet.net p-ISSN: 2395-0072

Assessment of Mechanical and Durability Characteristics of Concrete Containing Copper Slag as a Replacement to Fine Aggregate"

Chidanand Soudi[1], Maneeth P D , Brijbhushan S[3]

[1] M.Tech. Student, Department of Construction technology, VTU regional office, PG center, Kalaburagi, Karnataka, India.

[23] Assistant Professor, Department of Construction technology, VTU regional office, PG center, Kalaburagi, Karnataka, India.

Abstract: Concrete is a material that is widely used for construction building and other civil engineering structures. The costs of construction as well as maintenance are very low. Now a days fine aggregate cost is high, it is essential to find the alternative material for fine aggregate. During the production of copper waste material produced is treated as waste material, thus the waste material produced can be used as partial replacement of fine aggregates in concrete. In this study, M20 grade of concrete was designed and tests were carried out with different percentage of copper slag as a fine aggregate in concrete. The sand is replaced with the copper slag from 0%,20%,40%,60%,80% and100%. For strength parameters the compressive, tensile and flexural strength specimens are casted and cured for 28 days and tested for hardened concrete and for fresh concrete slump and compaction factor test is carried to know the workability of concrete. For durability study Sorptivity test is carried out to know the absorption of water by capillary. From experimental work and results it can be accomplished that the 40% is ideal percentage replacement of sand by copper slag.

Key words: Copper slag, Compressive strength, Tensile strength, Flexural strength, Sorptivity

1. INTRODUCTION:

As we know for the construction of various structures the widely used construction material is concrete and it is so because of its durability. Many years it has been considered as very durable material which requires low construction and also maintenance costs, but in recent years use of concrete for construction purpose became unavoidable as aggregates scarcity has been increased The use of river sand makes the depletion of natural source and also creates problems like erosion and also tending in cause of floods.. Alternative material use has been increased to reduce the consumption of natural resources. Modern squanders or optional materials are normally utilized as fine aggregate substitutions. The silica fume, slag and fly ash debris are referred as waste materials for a long time and are utilized as substitution materials. Some of these are also used as a substitute material for cement also Recent studies have shown that the use of industrial bi products can be used in the production of controlled concrete as well as high performance concrete as partial or full replacement material for both cement as well as fine aggregate. It also reveals that the use of these materials in mix improves the properties of concrete to a larger extent when compared with normal concrete as far as quality, execution and toughness.

In concrete creation aggregates makes 70 % of volume of concrete Aggregate, which makes up to 70 % of

the concrete volume, aggregate is one of the principle constituent materials in Concrete generation. On the other hand, because of the high cost of normal sand utilized as a fine aggregates, thus there is a requirement for the development business to look for option materials as fine aggregates in concrete creation. Copper slag, which is the waste material delivered in the extraction procedure of copper metal in industry, has ease and its application as a fine aggregates in concrete generation have numerous ecological benefits, for example, waste reusing and takes care of transfer.

Copper Slag (CS): Copper slag is a by product produced during the processing of copper industry. It is a glassy granular material with the high specific gravity. About 2600 tons of copper slag is produced per day and 1.5 million tons per year. The copper slag utilization is only 15% to 20% and the remaining is dumped as waste material in turn it causes environment pollution. The particle size of the copper slag is same as that of the fine aggregate. The copper slag is used as both cement and sand replacement. Copper slag is used to study the effects and long term properties of mortar and concrete. High performance concrete is designed to have higher workability, strength and durability than normal concrete. The use of copper slag leads to reduction in cost, energy savings promoting ecological balance and conservation of natural resources.

The main objective of this project is to study the different strength parameters like compressive, tensile, flexural strength and durability study of concrete containing copper slag as a fine aggregate with different percentage replacement for M20 grade concrete and comparing with the conventional concrete and to know the optimum percentage of replacement of copper slag with fine aggregate and also to study the workability properties of concrete containing copper slag as replacement to fine aggregate.

2. MATERIALS AND METHODS

Cement: The cement used in this study was 53 grade (Ultra tech) ordinary Portland cement (OPC). It is brought from aishwarya enterprises near ram mandir, Kalaburagi. The properties of cement used are given in Table 1.

Table 1: Physical properties of cement

Properties	Results
Specific gravity	3.10
Soundness of cement	5mm
Normal consistency	33 %
Initial setting time	45 minutes
Final setting time	210 minutes

Coarse aggregate: Locally available Coarse aggregate of passing through 20mm sieve and retained on 4.75mm sieve were used for this study. Coarse aggregate of 20 mm down size were procured from Lahoti Crushers in Shahabad road from Kalaburagi, Karnataka. Results of preliminary tests on coarse aggregate are presented in Table 2.

Table 2: Physical Properties of Coarse aggregate

Properties	Results
Shape of coarse aggregate	Angular
Water absorption	0.5 %
Specific gravity	2.8

Fine aggregate: Fine aggregates used for normal concrete were natural waterway sand with Zone II determination

going through 4.75mm sieve according to IS 383-1978 and India. The river sand is brought from Bheema river bed near Shahapur. The physical properties of fine aggregate are shown in Table 3

Table 3: Physical properties of Fine aggregate

Properties	Results
Type and Zone	River sand and Zone II
Specific gravity	2.60
Fineness modulus	2.73
Water absorption %	1.0

Copper Slag: Copper slag is procured from Saraswat Trading Company Mumbai, Maharastra, India. Copper slag tests were broke down for constituent oxides including minor oxides and substantial components other than mineral stages.

The material used for the present study is shown below,

Fig 1: Sample of Copper Slag

The physical and chemical Properties are indicated in table 4 and table 5.

Table 4: Physical properties of Copper Slag

Table 5: Chemical properties of Copper Slag

Properties	Copper Slag
Nature	Air cooled
Specific gravity	3.90
Bulk density g/cc	1.90
Fineness modulus	3.47
Water absorption %	0.19

Water: Potable water which is available in laboratory is used for casting of specimen and as well as curing of specimen as per IS 456-2000.

Chemical Component	% of Chemical Component
SiO_2	37.26
Fe_2O_3	47.45
Al_2O_3	3.95
CaO	2.38
Na_2O	0.65
K_2O	2.62
CuO	1.12

Percentage replacement of Copper slag:

The copper slag is used in concrete mix at percentage of 0%, 20%, 40%, 60%, 80% and 100% and is shown in table 6

Table 6: Percentage replacement of Copper slag

Sl.no	Fine aggregate (%)	Copper Slag replacement (%)
1	100	0
2	80	20
3	60	40
4	40	60
5	20	80
6	0	100

3. CONCRETE MIX DESIGN

In this study, M20grade of concrete was used. The Concrete mix design was done using IS 10262:2009.The water-cement ratio adopted is 0.55. cubes, beams, cylinders are casted with different percentage of copper slag and cured for 7 and 28 days strengths. The Mix proportions are shown in table 7

Table 7: M20 Concrete Mix Proportion

Materials	Quantity	Ratio
cement	348.2 kg/m^3	1
Fine Aggregate	689.63 kg/m^3	1.98
Coarse Aggregate	1211.73 kg/m^3	3.48
Copper slag	1034.43 kg/m^3	2.97
Water	191.5 litres	0.55

4.RESULTS AND DISCUSSIONS

Cubes and cylindrical specimens were tested for compressive strength in the Compression testing machine of capacity 2000KN.The cylindrical specimens also were tested to determine split tensile strength. The prism specimens were tested in Universal testing machine of capacity 2000KN.An average of three specimens was tested for each strength tests.

1. COMPRESSIVE STRENGTH TEST

Tests Results of Cube compressive strength are listed in table 8

Table 8: Compressive Strength of M20 for 7days and 28 days

Sl.no	Fine aggregate - Copper slag replacement (%)	Compressive Strength of concrete for 7 days in (N/mm^2)	Compressive Strength of concrete for 28 days in (N/mm^2)
1	100 - 0	18.15	27.23
2	80 – 20	20.00	30.23
3	60- 40	21.84	32.61
4	40 - 60	19.30	29.95
5	20 - 80	17.72	26.55
6	0 - 100	16.46	24.70

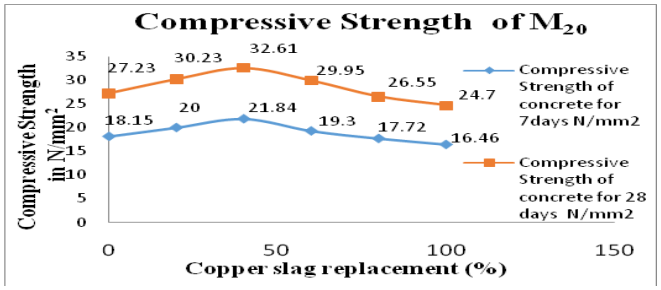

Fig 2: Compressive strength for various replacement of copper slag

It is observed from the above graphs, that strength of the copper slag replaced concrete gives optimum strength at 40% replacement. The strength of the concrete increments up to 40% substitution and goes on decreases as percentage of replacement increases. Thus we reason that 40% is the ideal substitution of copper slag in cement. As the copper slag rate expands workability and density increases.

2. SPLIT TENSILE STRENGTH: Tests Results of Split tensile strength are shown in table 9

Table 9: Split Tensile Strength of M20 for 7days and 28days

Sl.no	Fine aggregate - Copper slag replacement (%)	Split Tensile Strength of concrete for 7 days in (N/mm^2)	Split Tensile Strength of concrete for 28 days in (N/mm^2)
1	100 - 0	1.60	2.32
2	80 – 20	1.68	2.40
3	60- 40	1.88	2.58
4	40 - 60	1.74	2.42
5	20 - 80	1.63	2.35
6	0 - 100	1.51	2.23

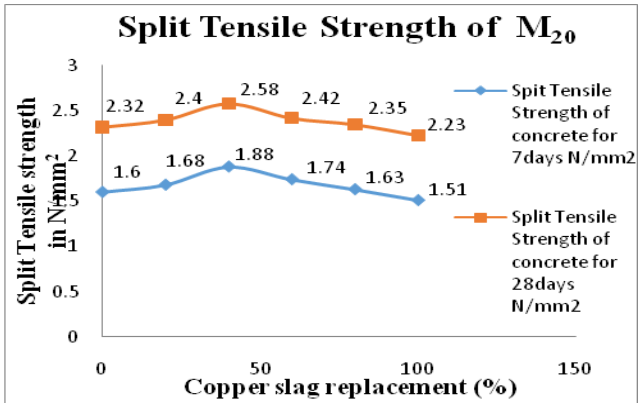

Fig 3: Split tensile strength for various replacement of copper slag

It is observed from the above graphs, that strength of the copper slag replaced concrete gives optimum strength at 40% replacement. The strength of the concrete increases up to 40% replacement and goes on decreases as percentage of replacement increases. Hence we conclude that 40% is the optimum replacement of copper slag in concrete. as the copper slag percentage increases workability and density increases.

3. FLEXURAL STRENGTH TEST

Tests Results of Flexural strength are shown in table 10

Table 10: Flexural Strength of M20 for 7days and 28days

Sl.no	Fine aggregate - Copper slag replacement (%)	Flexural Strength of concrete for 7 days in (N/mm^2)	Flexural Strength of concrete for 28 days in (N/mm^2)
1	100 - 0	2.20	3.43
2	80 – 20	2.35	3.58
3	60- 40	2.68	3.92
4	40 - 60	2.53	3.79
5	20 - 80	2.40	3.53
6	0 - 100	2.12	3.37

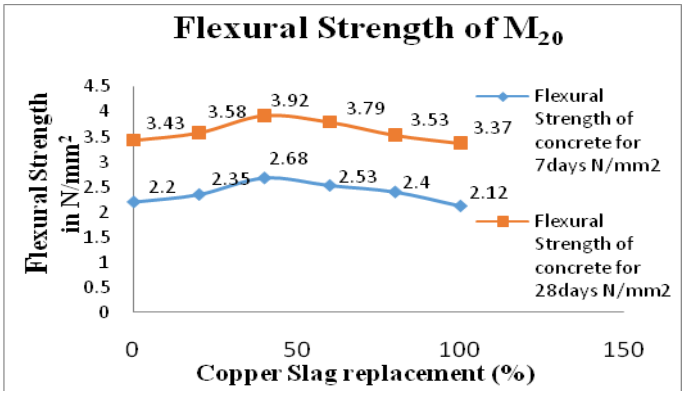

Fig 4: Flexural Strength for various replacement of copper slag

4. SORPTIVITY TEST: The following formula is used for the calculation of sorptivity

$I=S.t^{1/2}$

$S=I/t^{1/2}$ Where; S= measure of sorptivity in mm

t= the elapsed time in minutes

$I=\Delta w/Ad$

Δw= difference in weights = W_2-W_1

W_1 = Oven dry weight of cube specimen in grams

W_2 = Weight of cube specimen in grams after 30 minutes of capillary suction of water

A= surface area of cube specimen were the penetration of water takes place. And d= water density

Table 11: Sorptivity of copper slag replaced concrete

Sl. No	Percentage of fibers (%)	Dry weight in grams	Wet weight in grams	Sorptivity value in 10^-7mm/min^0.5
1	0	8138	8142	6.48
2	20	8472	8478	7.74
3	40	8698	8707	7.82
4	60	8992	8996	6.67
5	80	9325	9328	5.21
6	100	9523	9525	4.85

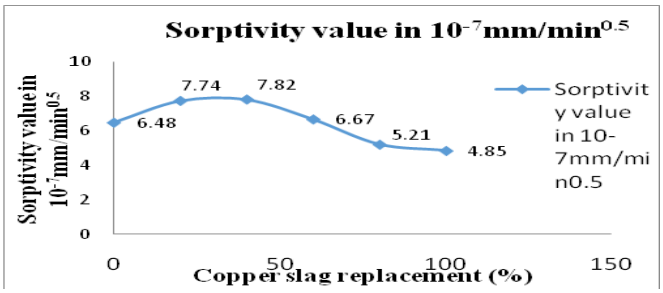

Fig 5: Sorptivity of Copper slag replaced Concrete

The above figure 4 it is clear says that sorptivity values have been increasing. At 40% replacement of copper slag, the value of sorptivity is 7.82×10^{-7}mm/min$^{0.5}$ And as the percentage of replacement is increased value of sorptivity has been decreased gradually, because the water absorption capacity of copper slag is itself 0.19 lower as compared to sand. From the above it can be concluded that due to the replacements the sorptivity values increases in case of 40% and there is decrement is observed as the percentage of replacement is increased.

5. CONCLUSIONS

From the experimental investigation the study concludes the following points.

- Increase in the copper slag content in the concrete increases the workability of the concrete.
- The workability increases up to 12.05 % at 40% replacement of copper slag as a fine aggregate.
- Increase in copper slag content in concrete increases the Density of concrete.
- The Compressive strength of concrete increases up to 16.50% for 40% percentage replacement of fine aggregate, but up to 40 % percentage of copper slag can be replaced which is greater than the target strength.
- The Split tensile strength of concrete increases up to 10.08% for 40 % percentage replacement of fine aggregate, but up to 40 % percentage of copper slag can be replaced which is greater than the target strength.
- The Flexural strength of concrete increases up to 12.05% for 40% percentage replacement of fine aggregate, but up to 40 % percentage of copper slag can be replaced which is greater than the target strength.
- The sorptivity values increases at 40% replacement, sorptivity value is 7.82×10^-7mm/min^0.5, Further replacements decreases the sorptivity values of the mixes.
- Strength of the concrete increases up to 40% replacement and above replacement goes on decreasing.
- The maximum strength obtained at 40% replacement of copper slag, hence it is the optimum percentage of replacement..

6. REFERENCES

1. Abdullah H Al-Saidy, Ramzi Taha, "Effect of copper slag as a fine aggregate on the properties of cement mortars

and concrete", Construction and Building Materials, Vol. 25, 2011, pp. 933 – 938.

2. Caijun Shi, Christian Meyer, Ali Behnood, "Utilization of copper slag in cement and concrete" Resources, Conservation and Recycling, Vol. 52, 2008, pp. 1115 – 1120.

3. Khalifa S Al-Jabri, Makoto Hisada, Salem K Al-Oraimi, Abdullah H Al-Saidy, "Copper slag as sand replacement for high performance concrete", Cement & Concrete Composites, Vol. 31, 2009, pp. 483–488.

4. Meenakshi Sudarvizhi S, Ilangovan R, "Performance of Copper slag and ferrous slag a Partial replacement of sand in Concrete", International journal of civil and structural engineering, Vol. 1, No. 4, 2011, pp. 918 – 927.

5. Pazhani K, Jeyaraj R, "Study on durability of high performance concrete with industrial wastes", Peer-reviewed & Open access journal, ATI- Applied Technologies & Innovations, Vol. 2, Issue 2, August 2010, pp. 19-28.

6. Ramzi Taha, "Effect of copper slag as a fine aggregate on the properties of cement mortars and concrete", Construction and Building Materials, Vol. 25, 2011, pp. 933 – 938.

7. Wei Wu, Weide Zhang, Guowei Ma "Optimum content of copper slag as a fine aggregate in high strength concrete" Materials and Design, Elsevier science Ltd, Vol. 31, 2010, pp. 2878–2883..

AUTHORS BIOGRAFHY:

Mr.CHIDANAND SOUDI was born on 31th July,1991 in Bijapur District, Karnataka. He was awarded his Bachelor of Engineering degree in Civil Engineering from Basaveswar Engineering College Bagalkot, Karnataka under Visvesvaraya Technological University, Belagavi in 2013. Presently he is a final year student, pursuing his M.Tech degree in Construction Technology from VTU Postgraduate studies Kalaburagi under Visvesvaraya Technological University, Belagavi.

Mr.MANEETH P.D received the B.E Civil engineering degree and M.Tech Degree in Construction Technology from N.I.T suratkal, Karnataka, India. He is presently working as Assistant Professor in the department of construction technology in the centre for PG studies, regional office Kalaburagi, karnataka. He has four years professional teaching experience.

Mr. BRIJBHUSHAN S received the B.E Civil Degree and M.Tech Degree in Construction Technology from VTU, Karnataka, India. He is presently working as Assistant Professor in the department of construction technology in the centre for PG studies, regional office Kalaburagi, karnataka. He has two years professional work experience in Construction industry and two years teaching experience.