Durability Study of Concrete Containing Copper Slag as a Replacement Partial Replacement for Fine Aggregate

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Abstract— Among various industrial waste copper slag is one of the industrial waste which is polluting the environmental in different ways. The current work is carried out to compare the mechanical properties of copper slag concrete with conventional concrete at various replacement levels. Concrete mixes were evaluated for acid attack test and water absorption test. Concrete cube 15cmX15cmX15cm was tested for acid attack test and water absorption test. Copper slag as a replacement of sand that concrete exhibits enhanced mechanical properties with reference to conventional concrete.

Key words: Copper Slag, Durability, Sand Replacement, Acid Attack Test and Water Absorption Test

I. INTRODUCTION

Concrete is one of the major construction materials being used worldwide. Concrete is the composite material composed of cement, natural sand and natural aggregates. The materials which are used in the concrete are naturally available except cement, the use of the concrete in the construction is increased now a day's, this will leads to the scarcity of the natural sand and the coarse aggregates occurred. The aggregate which are used in the concrete are obtained either from natural resources or by crushing large size rocks.

However, due to non-availability and the high cost of natural sand used as fine aggregate and rising emphasis on sustainable construction, there is a need for construction industry to search for alternative material as fine aggregate in concrete production. Hence use of the waste material as a replacement of natural resources is necessary in the concrete.

Copper Slag (CS) Is currently being used for many purposes from land filling to grit blasting. Currently, about 2600 tons of CS is produced per day and a total accumulation is around 1.5 million tons. These applications utilize only about 15 % to 20%, and the remaining dumped as a waste material and this causes environmental pollution.

A. Objectives of the Present Study

1) To study the use of copper slag as substitute material for natural sand in concrete.
2) To find the optimum percentage replacement of sand by copper slag as fine aggregate in terms of strength and durability.
3) To investigate the mechanical properties such as acid attack, porosity and Water absorption Test.

II. PROPERTIES OF MATERIAL AND MIX DESIGN

A. Cement

The cement used in this study was ordinary Portland cement (OPC) 43grade from Bharathi company.

Sl no	Properties	OPC 43 grade
1	Specific gravity	3.12
2	Fineness	2.0%
3	Normal consistency	33.0%
4	Initial setting time	40 min
5	Final setting time	210 min

Table 1: Properties of Cement

B. Coarse Aggregate

Coarse aggregate of 20mm down size were procured from locally available quarries. Results of preliminary tests on coarse aggregate are presented in Table 2.2

Sl. No.	Properties	Results
1	Shape of coarse aggregate	Angular
2	Water absorption	0.66 %
3	Specific gravity	2.8

Table 2: Properties of Coarse aggregate

C. Fine Aggregate

Fine aggregate used for normal concrete was river sand obtained from nearby river bed. Copper slag, which was the other fine aggregate used in the study was procured from Saraswati Traders India Company Mumbai, India. The physical properties of fine aggregate are shown in Table 2.3.

Physical Properties	Sand	Copper slag
Particle shape	Irregular	Irregular
Appearance	Brownish yellow	Black & glassy
Type	River sand	Air cooled
Specific gravity	2.74	3.5
Bulk density	1.71gm/cc	1.90gm/cc
Fineness modulus	2.62	3.42
Water absorption	1%	0.19%
Moisture content	1.5%	0.033%

Table 3: Physical Properties of Fine aggregate

D. Water

Portable water was used in the present investigation for both casting and curing.

E. Super Plasticizer

BASF Reo Built SP16, Chemical Admixture

F. Material Calculation

% Replacement of copper slag	Cement in kg	Fine aggregate In kg	Copper slag In kg	Coarse aggregate in kg

0	11.97	24.93	0	43.2
10	11.97	22.43	2.49	43.2
20	11.97	19.94	4.99	43.2
30	11.97	17.45	7.48	43.2
40	11.97	14.799	9.86	43.2

Table 4: Material calculation

III. METHODOLOGY

A. *Acid Attack Test*

The acid test is done and is accompanied by an increase in the volume which occurs due to the chemical reaction between the products of cement hydration and also the solution containing sulphates in it. When the concrete is exposed to ground water and containing sulphate compounds in its hardened state, the hydrated C3S cement paste in its hardened state forms a new chemical called as Ettringite. Which causes expansion and disruption in the concrete Hence it is necessary to limit the permeability of the concrete and block penetration of sulphates in concrete.

B. *Scope*

In our experimental investigation the experiment is designed such that to have to study the loss or gain of weight of concrete specimen and loss or gain of compressive strength of concrete

C. *Test Specimens*

Cubes which have sizes of 150X150X150mm were casted using the mixes. These specimens were tested according to as per the code of IS 516 and IS 1199.

D. *Water Absorption Test*

After 28 days curing the specimens weight taken out from curing tank. Specimens were dried in an oven at 105^0C for 24hrs. The dried specimens were cooled to room temperature (25^0C) weighed accurately and noted as dry weight. Dry specimens were to immersed in a water container. Weight of specimen at predetermined intervals was taken after wiping the surface with dry cloth. This process was continued up to constant weight was obtained in two successive observations.

$$\% \text{ absorption} = \frac{\text{Saturated wt.} - \text{Dry wt.}}{\text{Dry weight}} \times 100 \quad (1)$$

E. *Porosity*

Porosity is the measure of percentage of pores or air voids present in the specimen and for this air dried weight and under water weight was taken and exact dimensions of cubes were measured after 28 days of curing period the specimen are taken out from the curing tank and allowed them to dry for 24hrs in a room, then using a spring balance and the basket the weight of the specimens are taken once in air and once in water. Porosity is determined as follows.

$$\% \text{ of porosity} = \left[1 - \frac{(w2 - w1)}{(pw \times vol.)}\right] \times 100$$

W1 = weight under water in g
W2 = Air dried weight in g
Pw = Density of water in g/cm^3
Vol. = Volume of specimen in cm^3

IV. RESULTS AND DISCUSSION

A. *General*

This chapter deals with the presentation of test results and discussions on water absorption and Acid attack of concrete containing copper slag as partial replacement of fine aggregate in concrete The present study is based on trial mixes and achieving target strength. Mix proportions have been obtained for M30 grade concrete. Then copper slag is replaced by 0%, 10%, 20%, 30%, and 40% by the mass of fine aggregate to study the above tests

B. *Acid Attack Test*

The results and observations of acid resistance of the concrete for all mixes are recorded in table 4.1 it represents the loss in weight at every 5 days interval up to 45 days and percentage of weight loss of cubes From results it can be seen that when compared to conventional concrete the copper slag concrete will be more resistance to acid attack leading less loss in weights for the concrete with copper slag replacements with in different copper slag replacement level 40% copper slag replacement is more resistant to the acid attack as percentage of copper slag decreases the resistant against acid attack has reduced.

Sl no	1	2	3	4	5
Test designation	CS 0%	CS 10%	CS 20%	CS 30%	CS 40%
5days	0.83	0.13	0.55	0.93	0.98
10days	1.05	0.75	0.98	0.84	0.64
15days	1.05	0.82	1.07	0.63	0.58
20days	1.75	1.5	1.96	0.85	0.83
25days	1.92	1.96	0.98	0.94	0.82
30days	2.12	2.06	1.45	0.98	1.39
35days	2.6	2.09	1.04	2.26	1.95
45days	3.2	3.18	2.98	2.05	2.95

Table 5: Acid test results

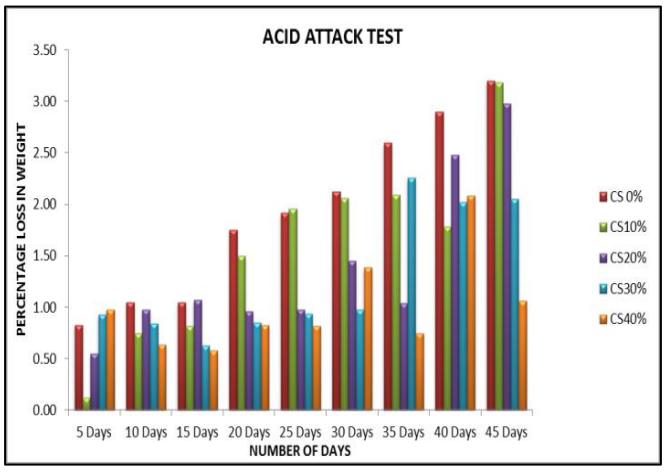

Fig. 1: Acid attack test

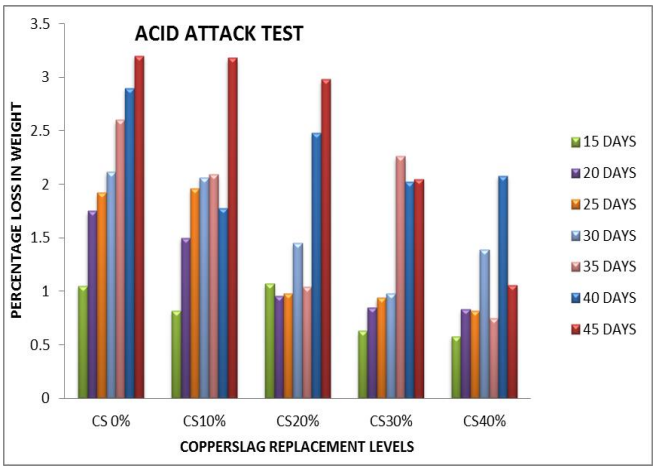

Fig. 2: Acid attack test

C. Water Absorption

The results and observations of water absorption of concrete with all mixes are represented in table 4.2 it has been observed that the water absorption value of conventional concrete is more than copper slag concrete except 10% replacement level of copper slag. As compared to conventional concrete copper slag concrete with 20%, 30% and 40% shown less water absorption i.e.0.225, 0.28 and 0.22 respectively.

Sl No	% Replacement of copper slag	Normal Dry Weight	Moisture Weight	Water Absorption Weight
1	0	8460	8500	0.47
2	10	8620	8670	0.58
3	20	8860	8880	0.225
4	30	8950	8975	0.28
5	40	9053	9073	0.22

Table 6: Water absorption test results

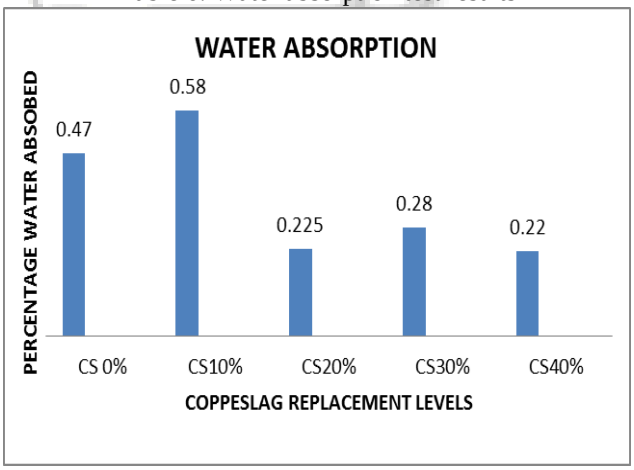

Fig. 3: Water absorption test

1) Porosity

The results and observations of porosity of the concrete for all mixes are recorded in table 5.6 from the results it was observed that there is a porosity valve of conventional concrete is more than copper slag concrete except 10% replacement level of copper slag. As compared to conventional concrete copper slag concrete with 20%, 30% and 40% shown less water absorption i.e. 2.22, 4.21 and 2.01respectively.

Sl No	% Replacement Of Copper Slag	Normal Dry Weight	Voides Ratio Weight	% Voides Ratio
1	0	8684	5460	4.47
2	10	8620	5520	8.14
3	20	8860	5560	2.22
4	30	8950	5720	4.21
5	40	9053	5745	2.01

Table 7: Porosity Test Tabular Column

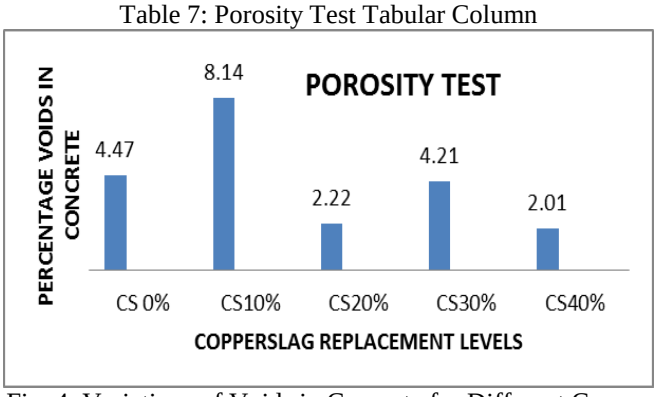

Fig. 4: Variations of Voids in Concrete for Different Copper Slag Replacement Levels

V. CONCLUSION

1) Resistance to acid attack is more for copper slag concrete then that of conventional concrete when % Replacement of copper slag increased decrees in loss of weight is observed
2) Water absorption & porosity capacity of copper slag is less as composed to conventional concrete except 10% replacement level less porosity & less water absorption capacity indicates more suitable concrete foe water construction
3) 20%, 30%, 40% copper slag replacement concrete shows good durability characters as compared to conventional concrete & 10% replacement level.

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