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An Experimental Investigation on Concrete with Copper Slag using Corrosion Resistance Techniques

P. Nithya[1], K. Soundhirarajan[2]

[1]P.G Student, [2]Head of Department in Civil Engineering,
[1,2]Gnanamani College of Engineering, Namakkal, Tamil Nadu, India

ABSTRACT

Now a days, the application of waste material usage in building materials has increased effectively. Copper slag is a by-product created during the copper smelting and refining process. This material represents a popular alternative to sand. Natural sand is used from river bed for all construction stage. Decreasing natural resources create the environmental issues and hence restriction on sand resulted in scarcity and increased in its cost. After long investigation industries and investigator all over the world to explore the possible utilization of copper slag. This paper mainly shows the corrosion in concrete by using copper slag and preventive measures from corrosion. In this project M30 grade of concrete is used. Two different types of corrosion inhibitors were used (calcium nitrate and concare). The influence of copper slag on concrete was investigated with respect to the properties of concrete in the fresh state (workability) and hardened state (mechanical properties and durability). Strength properties of concrete increased 40% replacement of fine aggregate by using copper slag. However further addition of copper slag caused reduction in strength. From chemical composition of copper slag Fe2O3 present in more than 55%. So that here concrete itself getting corrode. Here corrosion inhibitors at the amount of 1%, 2% and 3% by the weight of cement in concrete having copper slag as a fine aggregate is used. Effect of this inhibitor was derived from gravimetric method.

KEYWORDS: *copper slag, calcium nitrate and concare, corrosion inhibitors*

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1. INTRODUCTION

The utilization of industrial waste or secondary materials has encouraged the production of cement and concrete in construction field. New by-products and waste materials are being generated by various industries. Dumping or disposal of waste materials causes environmental health problems, so that the recycling of waste materials is a great potential in concrete industry. Recent year's fly ash and slag etc., were considered as waste materials. Concrete prepared with slag material that shows improvement in workability and durability compared to normal concrete and has been used in the construction of power, chemical plants and under-water structures. In Recent decades, intensive research studies have been carried out to explore all possible reuse methods. Construction waste, blast furnace, coal fly ash and bottom ash it have been accepted in many places for alternative aggregates in embankment, roads, pavements and building construction. Copper slag is an industrial by-product material gets from the manufacturing copper. For each ton of copper production, about 2.1 tonnes of copper slag is generated. Slag has been estimated that approximately 25 million tons of slag is generated from the world copper industry (Gorai et al 2003).

2. MATERIALS INVESTIGATIONS

2.1. STANDARD CONSISTENCY TEST

Trial No.	Wt of cement (g)	% of Water	Amount of water (ml)	Reading of pointer from bottom
1	400	26	104	37
2	400	28	112	34
3	400	30	120	15
4	400	31	124	11
5	400	31.25	125	6

TABLE 2.1- CONSISTENCY TEST OF CEMENT

2.2. SIEVE ANALYSIS

The sample is brought to an air-dry condition before weighing and sieving.

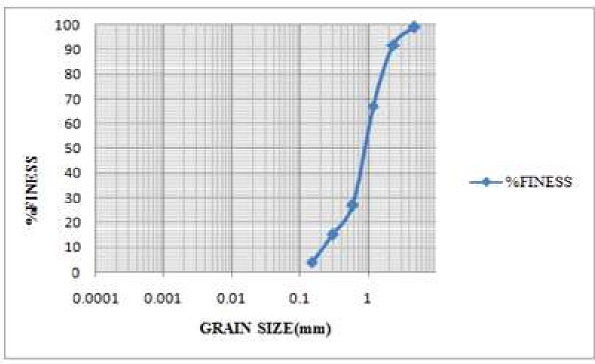

FIGURE 2.1 GRAIN SIZE DISTRIBUTION FOR SAND

2.3. FINENESS MODULUS OF COPPER SLAG

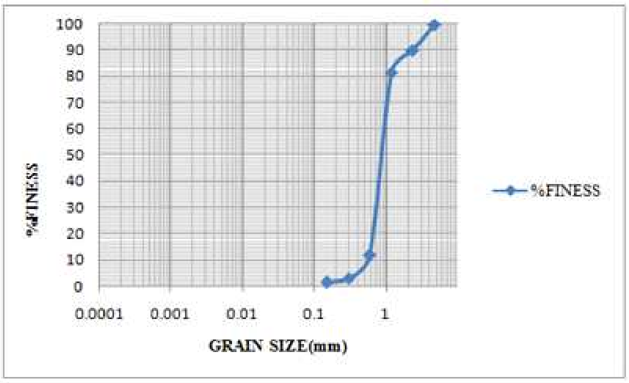

FIGURE 2.2 GRAIN SIZE DISTRIBUTION FOR COPPER SLAG

3. EXPERIMENTAL INVESTIGATION

3.1. COMPRESSIVE STRENGTH

Compressive strength is one of the important properties of concrete. Concrete cubes of size 150x150x150mm were cast with and without inhibitor. After 24 hours the specimen were demoulded and subjected to water curing. After 3, 7 and 28 days of curing, the curing three cubes were taken and allowed to dry and tested in compression strength testing machine.

3.2. NUMBER OF CUBES WITHOUT INHIBITORS

Specimen Identification	No. of cubes casted			Total cubes
	3 days	7 days	28 days	
CS 0	3	3	3	9
CS10	3	3	3	9
CS20	3	3	3	9
CS30	3	3	3	9
CS40	3	3	3	9
CS50	3	3	3	9

TABLE 3.1 NUMBER OF CUBES WITHOUT INHIBITORS

3.3. NUMBER OF CUBES WITH INHIBITORS

Specimen Identification	No. of cubes casted			Total cubes
	3 days	7 days	28 days	
CS40+1% OF $Ca(NO_3)_2$	3	3	3	9
CS40+1% OF $Ca(NO_3)_2$	3	3	3	9
CS40+1% OF $Ca(NO_3)_2$	3	3	3	9
CS40+Concare	3	3	3	9

TABLE 3.2 NUMBER OF CUBES WITH INHIBITORS

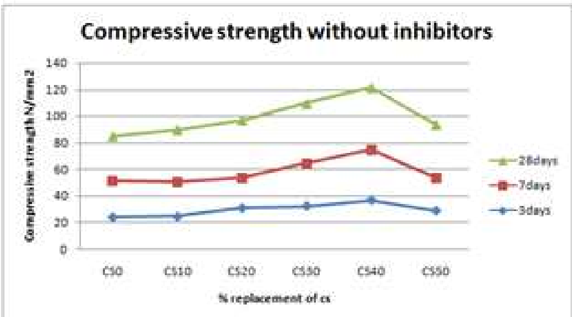

FIGURE 3.1 LINE CHART OF COMPRESSIVE STRENGTH WITHOUT INHIBITORS (N/mm²)

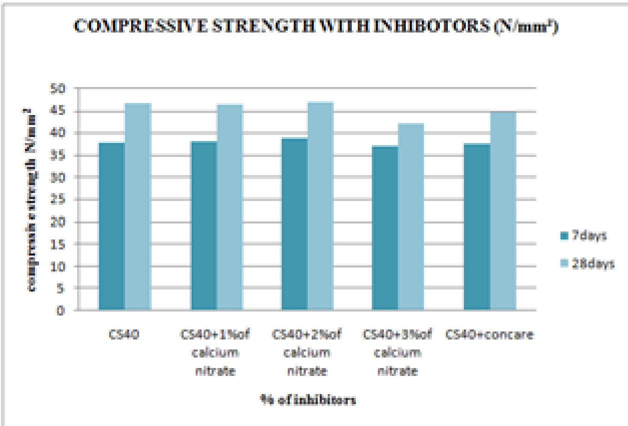

FIGURE 3.2 COLUMN CHART OF COMPRESSIVE STRENGTH WITH INHIBITORS (N/mm²)

4. RESULTS DISCUSSIONS

4.1. SPLIT TENSILE STRENGTH

% of CS	3 days		7 days		28 days	
	Mean load (kN)	Strength (N/mm²)	Mean load (kN)	Strength (N/mm²)	Mean load (kN)	Strength (N/mm²)
CS 0	133	1.8	154	2.17	172	2.43
CS 10	128	1.81	175	2.47	194	2.74
CS 20	159	2.25	176.3	249.5	187.1	2.64
CS 30	172.5	2.44	185.5	2.62	203.1	2.87
CS 40	190.3	2.69	212.2	3.00	239.2	3.38
CS 50	176	2.49	164.5	2.32	155.5	2.20

TABLE 4.1 SPLIT TENSILE STRENGTH (N/mm²)

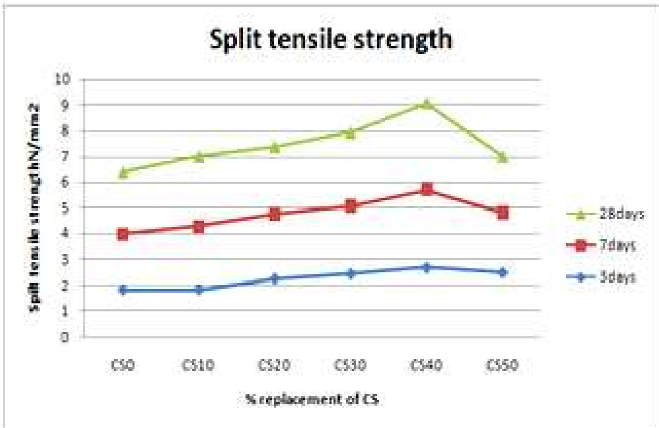

FIGURE 4.1 LINE CHART OF COMPRESSIVE STRENGTH (N/mm²)

4.2. FLEXURAL STRENGTH

% of CS	3 days		7 days		28 days	
	Mean load (kN)	Strength (N/mm²)	Mean load (kN)	Strength (N/mm²)	Mean load (kN)	Strength (N/mm²)
CS 0	9.15	4.57	15.1	7.55	16.2	8.1
CS 10	13	6.5	17.15	8.57	20.95	10.7
CS 20	15.8	7.9	17.9	8.95	21.8	10.8
CS 30	17.1	8.55	21	10.5	24.65	12.3
CS 40	17.5	8.75	22.8	11.3	27.15	13.5
CS 50	15.8	7.87	20.4	10.2	24	12

TABLE 4.2 FLEXURAL STRENGTH (N/mm²)

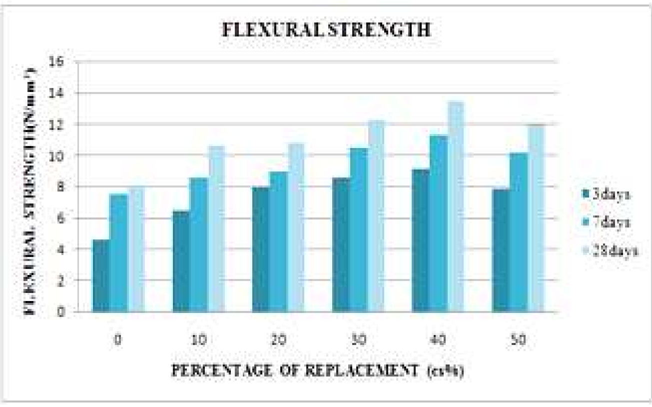

FIGURE 4.2 COLUMN CHART OF FLEXURAL STRENGTH

4.3. GRAVIMETRIC WEIGHT LOSS MEASUREMENT

Mix id	Weight of rod(gm) Before corrosion	Weight of rod(gm) After corrosion	% loss in wt in rod	Corrosion rate mm/yr
CS0	220	218.5	0.68	0.100
CS40	220	212.2	3.50	0.520
CS40+1% OF $Ca(NO_3)_2$	220	214.3	2.59	0.380
CS40+2% OF $Ca(NO_3)_2$	220	218.9	0.5	0.073
CS40+3% OF $Ca(NO_3)_2$	220	213.9	3.00	0.410
CS40+CONCARE	220	218.6	0.63	0.091

TABLE 4.3 RESULTS FOR GRAVIMETRIC WEIGHT LOSS

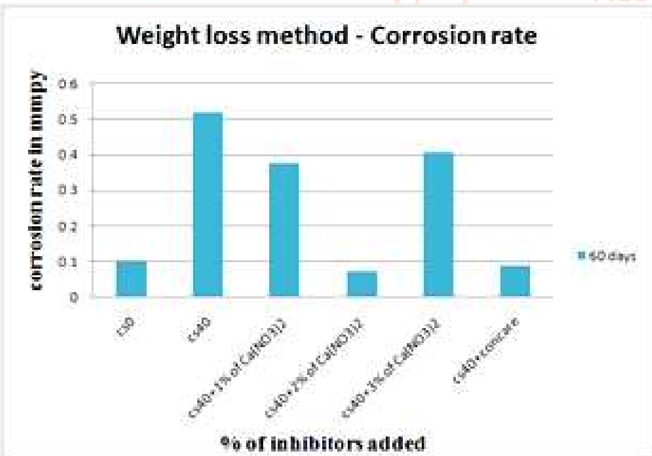

FIGURE 4.3 CORROSION RATE IN mmpy

4.4. ACID RESISTANCE TEST

Specimen Identification	CS40+1 % OF $Ca(NO_3)_2$	CS40+1 % OF $Ca(NO_3)_2$	CS40+1% OF $Ca(NO_3)_2$	CS40+ CONCARE
Cubes casted	3	3	3	3

TABLE4.4 NUMBER OF CUBES 15

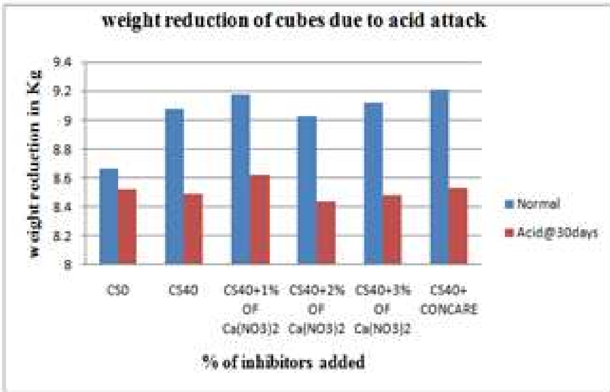

FIGURE 4.4 WEIGHT REDUCTION DUE TO ACID ATTACK

5. CONCLUSION

The CS as it is has higher fineness modulus indicating coarser average particle size. Therefore, it may be preferable to avoid the use of CS as the only fine aggregate in concrete mixes; it may be necessary to add conventional sand also in order to improve the particle size distribution of the concrete mix to get the cohesiveness and satisfactory workability.

Water absorption of copper slag was 0.16% compared with 1.25% for sand. Therefore, the workability of concrete increases significantly with the increase of copper slag content in concrete mixes. This was attributed to the low water absorption and glassy surface of copper slag.

The test results indicate that for mixtures prepared using upto 40% copper slag replacement, the compressive strength of concrete increased. However, for mixtures with CS40 and CS50 copper slag, the compressive strength decreased rapidly.

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