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Use of Copper Tailings as the Partial Replacement of Sand in Concrete

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Abstract— In India, 4 million tons of copper tailings produce every year, out of which 25,000 tons produce in Khetri Copper Mines, Khetri, and Rajasthan. This research was undertaken to study the effects of copper mine tailings as a replacement of sand on the properties of concrete and also to bring the alternative aggregates for the future. Structural materials depend on natural aggregates; it has been depleted for the last few decades due to the excessive demand from the construction industries and increasing population. The effects of replacing sand by copper tailings on the compressive strength of concrete, workability, water permeability and initial surface absorption values are evaluated. Concrete mixtures containing different levels of copper tailings were prepared water to cementations materials ratio of 0.55, 0.50 and 0.45. The compressive strength increased as replacement levels increases for 0.55w/c and 0.50w/c from the control mix, but the strength at 0.45w/c decreased marginally from the control mix. The water penetration and initial surface absorption decreased as the replacement of copper tailings increases. It can be concluded that copper tailings as fine aggregates in concrete is technically possible and useful.
Keywords— Super plasticizer, Copper tailings, Aggregates, Cement, concrete

I. INTRODUCTION

Concrete is one of the most important construction materials which have been used worldwide. Aggregate occupies nearly 75% of concrete volume and acts as the main constituent materials of concrete besides cement and water. The aggregates type utilizes are coarse aggregates and fine aggregates. During the hydration process, coarse aggregates are bound with cement paste to form cement concrete whereas fine aggregates fill the gaps between the coarse aggregates particles. Copper tailing is one of the materials that is considered as a mining waste material which could have a promising future in construction industry as partial replacement of either cement or fine aggregates. Copper tailings has been included Group III materials along with zinc and gold tailings which have been studied for use as a fine aggregate or concrete filler material. Most of the wastes listed under Group III are yet to be evaluated, as they are in the form of sludge **-** water has to be removed before they can be used as a fine aggregate or as filler in concrete or in bitumen mastic**.** Tailing consists of ground rock and process effluents that are generated in a mine processing plant. . Mechanical and chemical processes are used to extract the desired product from the run of the mine and produced a waste stream known as tailings.

II. LITERATURE REVIEW

Development of value added building materials from mining wastes is one of the important activities of the council. R&D efforts have indicated high potential for utilization of copper mine tailings for production of building bricks. For this purpose, the council has already initiated the process for setting up a pilot plant for producing bricks and identified an entrepreneur who has agreed to adopt the process for production of bricks using copper tailings. The initial field trials were done and the bricks produced by hand moulding were tested as per IS standards and found to be of very good quality.
(Saxena et al., 2002) Studies on potential use of different mining tailings in bricks have revealed that this waste along with clay can be effectively utilized for making better quality fired bricks and use of copper tailings (60%) has resulted in achieving strength of 190 kg/cm" under firing temperature of 950° reported the use of copper tailings up to 50% in replacement of clay in the manufacture of bricks and properties on par with standard bricks meeting the relevant BIS.

III. EXPERIMENTAL PROGRAM

A. Cement

The cement used in this study was ordinary Portland cement (OPC) purchased from local cement dealer manufactured by Birla

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Cement Company.

B. Aggregates

Coarse aggregates (i.e. 20 mm), fine aggregates (i.e. 10 mm) were purchased from a nearby local crusher and fine sand was locally available river sand.

C. Copper Tailings

Copper tailings are a mining waste material produced when copper is extracted from copper slag by the process of froth floatation after cooling, crushing and grinding. Slag floatation tailings are mostly occluded in the slag phase and are unable to interact with the collector. If grinding is not fine enough for efficient floatation, copper is lost in tailings.

D. Super Plasticizer

In order to improve the quality of concrete, Choksey Super plasticizer (SPL-8) manufactured by Choksey Chemicals Pvt. Ltd. was used. It specifies IS 9103-1999, BS 5075 Part-3, ASTM C-494 Type A and Type D.

E. Chemical Composition Of Copper Tailings

This chemical test was conducted in GMS Garg Metallurgical Services, Jawaharlal Nagar, Jaipur, and Rajasthan. Chemical composition of copper tailings is presented in Table 1. From the above table we can see that free and combined limes contribute to only 0.16 % of the chemical composition of copper tailings. This shows that copper tailings is not chemically a reactive material to be used as a cementations material since lime should be available in sufficient quantity in order to achieve the required the rate of hydration and early age strength. On the other hand, copper tailing is considered as siliceous material since it has high concentrations of Si02 (71.52 %) and AI2O3 (13.96 %).

F. Sieve Analysis

Sieve size(mm)	Cumulative % passing
0.30	87.1
0.15	39.85
0.075	10.15
0.045	0.65
< 0.045	-

G. Concrete

The compaction factor of the fresh concrete at different replacement level was determined to ensure that it would be within the design value and to study the effect of copper tailings replacement on the workability of concrete. After 24 hrs, all the specimens were remolded, cured in water and then tested at the required age of 7 and 24 days. To determine the compressive strength of concrete as per IS: 516-1959, nine cubes (100mm x 100mm x 100 mm) and three cubes (150 mm x 150 mm x 150 mm) were cast for each mix and water-to-binder ratio.

Sr.no.	Test	IS Specifications.
1	Compaction Factor Test	IS 1199- 1959
2	Compressive strength Test	IS 516-1959
3	Water Permeability Test	DIN-1048
4	Initial Surface Absorption Test (ISAT)	BS-1881-part -5

IV. RESULTS AND DISCUSSION

Several tests had been performed to study the effects of copper tailings with three different water-cement (w/c) ratios at varying copper tailings contents from 0% to 30%. The results are discussed below.

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A. Sieve Analysis Test Result

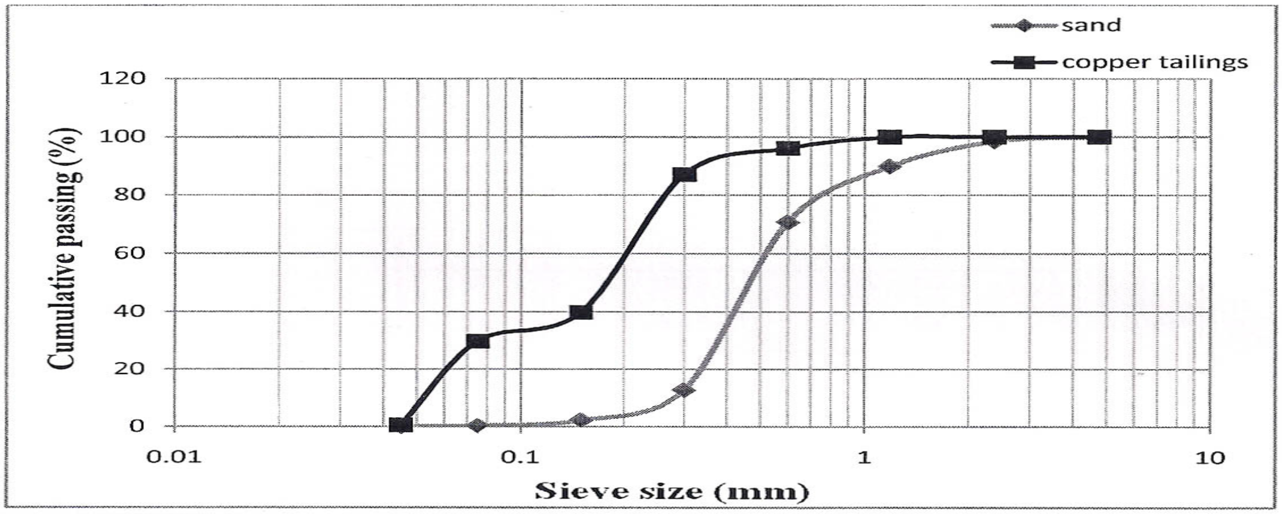

Fig1: Sieve analysis of copper tailings and sand

B. Compaction Factor Test

S.NO.	CUBE TITLE	CT %	W/C	Super plasticize %	CF
1	C11	0	0.55	0	0.90
2	C12	10	0.55	0	0.83
3	C13	20	0.55	0.4	0.88
4	C14	30	0.55	0.5	0.84
5	C21	0	0.50	0.4	0.87
6	C22	10	0.50	0.6	0.86
7	C23	20	0.50	0.8	0.89
8	C24	30	0.50	0.9	0.83
9	C31	0	045	1.0	0.83
10	C32	10	0.45	1.2	0.87
12	C33	20	0.45	1.4	0.89
13	C34	30	0.45	1.5	0.82

Table1: Workability of concrete mixes with three different water-cement (w/c) ratios at 0.55, 0.50 and 0.45 with varying copper tailings contents from 0% of 30% of sand.

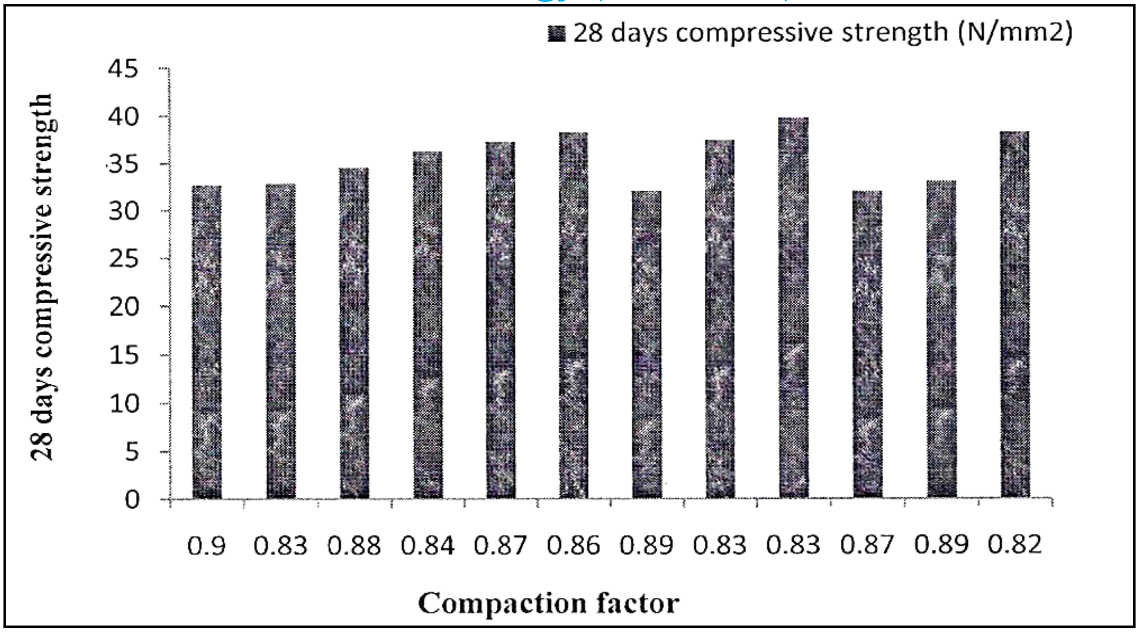

Fig2: Compaction factor v/s Compressive strength

C. Compressive Strength of Concrete

S. No	Cube Title	w/c	CT (%)	Comp, strength in N/mm^2 (7 days)	Comp, strength in N/mm^2 (28 days)
1	C11	0.55	0	20.2	32.7
2	C12	0.55	10	21.0	32.9
3	C13	0.55	20	21.4	34.6
4	C14	0.55	30	24.7	36.3
5	C21	0.50	0	22.6	37.3
6	C22	0.50	10	24.9	38.3
7	C23	0.50	20	21.3	32.1
8	C24	0.50	30	24.8	37.5
9	C31	0.45	0	28.8	39.8
10	C32	0.45	10	23.5	32.1
11	C33	0.45	20	25.3	33.1
12	C34	0.45	30	25.4	38.3

Table 2: Compressive strength of concrete at three different water-cement (w/c) ratios with varying copper tailings contents.

D. Water Permeability Test

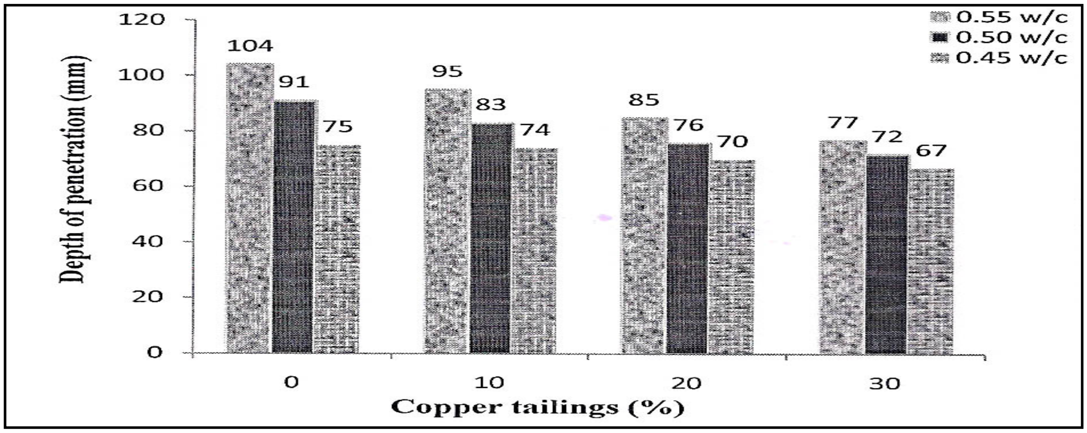

Fig3: Copper tailings (%) v/s 7 Depth of penetration of water permeability test

E. Initial Surface Absorption Test (ISAT)

SI. no	Cube Title	CT (%)	w/c	10 min. (mm)	30min. (mm)	1 hr. (mm)	2 hr. (mm)
1	C11	0	0.55	240	180	120	88
2	C12	10	0.55	207	140	100	85
3	C13	20	0.55	160	135	88	63
4	C14	30	0.55	135	95	55	35
5	C21	0	0.50	210	160	88	73
6	C22	10	0.50	168	115	82	65
7	C23	20	0.50	125	97	68	49
8	C24	30	0.50	100	73	43	21
9	C31	0	0.45	110	77	58	36
10	C32	10	0.45	95	48	39	27
11	C33	20	0.45	65	47	36	25
12	C34	30	0.45	55	39	26	18

Table3: Water absorption level of the concrete surface at different intervals.

V. CONCLUSIONS

Workability decreased as the copper tailings increases. Super plasticizer played an important role in making the concrete mix

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workable.

Compressive strength increased as the replacement levels of copper tailings increases at 0.55 w/c and 0.50 w/c. But the compressive strength at 0.45 w/c decreased marginally from the control mix.

Water penetration is decreased as the replacement levels of copper tailings increases (up to 30%), it is probably due to the fineness of copper tailings which blocks the small pores present in concrete.

The rate of initial surface absorption of water on the surface of the hardened concrete also decreased as the replacement levels of copper tailings increases.

VI. FUTURE SCOPE

It should be noted that further research is required to study the effect of copper tailings in hardened concrete with increasing replacement levels of copper tailings and with different types of cement.

Other durability parameters like corrosion, abrasion, air permeability, sulphate attack, carbonation properties and freeze-thaw test could be conducted to study the performance of concrete containing copper tailings.

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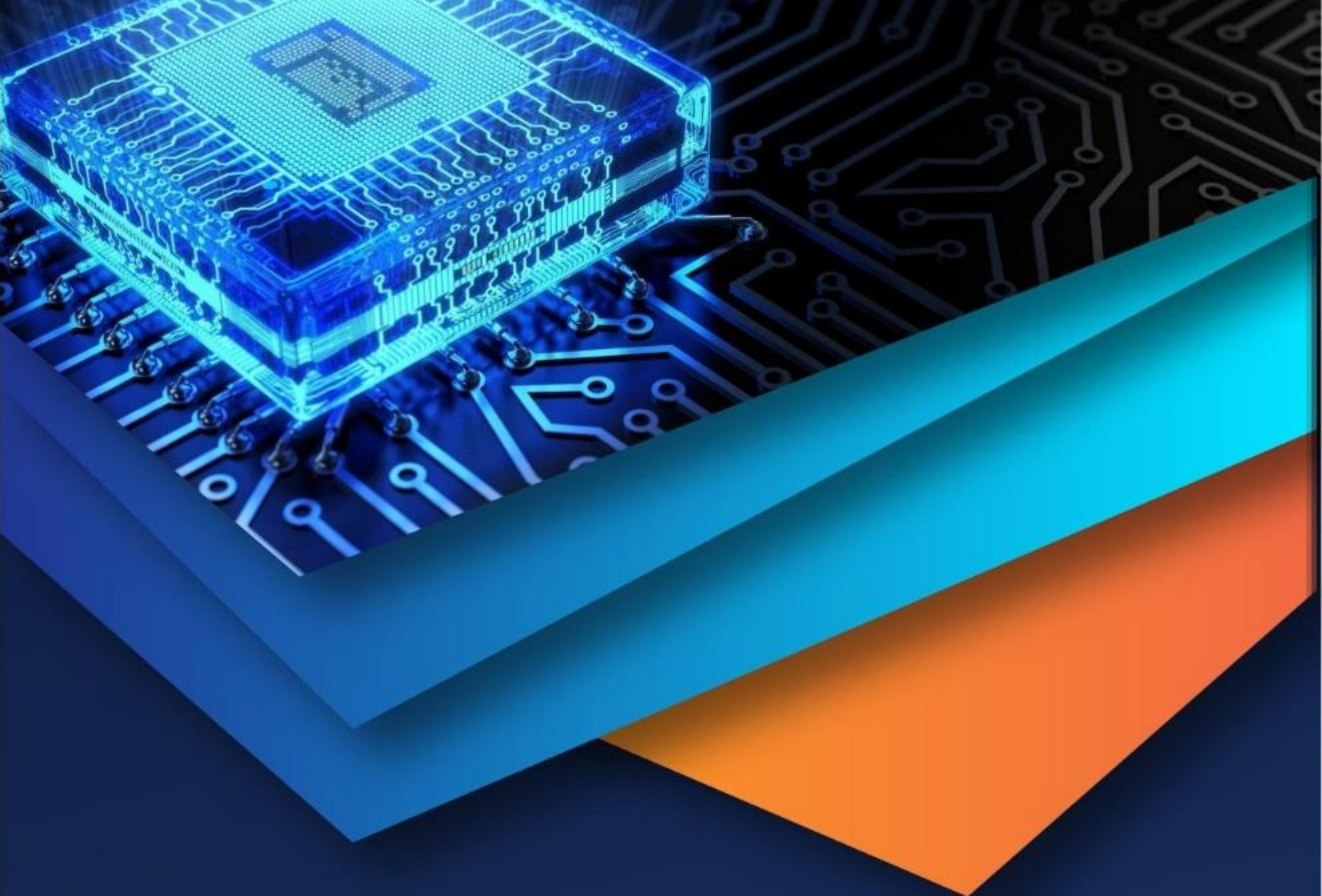

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