International Journal of Advanced Research in Engineering and Applied Sciences
ISSN: 2278-6252

USE OF COPPER ORE TAILINGS - AS AN EXCELLENT POZZOLANA IN THE PREPARATION OF CONCRETE

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Abstract: *Industrialization extremely demands to the uplift of nation's economy. However, it causes severe environmental pollution due to the generated waste materials. Copper ore tailings, is a waste material obtained in the copper mines, after the extraction of copper concentrate from the ore. Some trace percentage of copper will be left in the ore after the extraction process is completed. This copper ore tailing is produced in large quantity in the copper mines. Disposing of this copper ore tailing from the mines premises is a big head ache for the concerned authorities. In this experimental work an attempt has been made to study the suitability of copper ore tailings as an admixture in the preparation of concrete by replacing the cement in different percentages viz., 0%, 10%, 20%, 30%, 40% and 50%. Compressive strength and Water absorption test were conducted on the prepared specimens. The results show that the replacements of ordinary Portland cement by copper ore tailings safe up to 20% considering average minimum field strength. If characteristic strength is considered replacement copper ore tailings upto 30% may be considered as safe and the water absorption decreases at 20% copper ore tailings content and increases for all other copper ore tailings content.*

Key words: *Copper tailings, Compressive strength, Water absorption*

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1.0 INTRODUCTION

Due to the development and increment in the construction industry, the scarcity of the natural resources and building materials has been on a very large scale and the demand for the natural resources and materials is increasing day by day. At the same time, disposal of industrial waste or by-products has become more difficult and expensive as a result of the increasing stringent environmental regulations and shortages of suitable, nearby disposal sites. Industrial by-products also creates environmental hazard as they may be toxic for environment. So the usage of industrial by-products and solid waste materials as aggregates in concrete and in the soil stabilization for road and other type of the construction work is the need of the hour. Some of the mines wastes at the various places throughout the country are copper ore tailings, iron ore tailings, manganese ore tailings, gold ore tailings, zinc ore tailings, lead ore tailings, metal extracts etc[1, 2, 5].

Copper ore tailing is the fine gray type sandy material and it has some acidic smell. It can damage the root of the plants by mixing heavy metal contaminants in the soil. Copper ore tailing wastes, even if treated, contain heavy metals with hazardous properties posing environmental risks for disposal. The heavy metals present in copper tailing may leach into ground water resulting in contamination. Copper ore tailing utilization, especially in concrete, has significant environmental benefits including, increasing the life of pavements and structures by improving stability of soil, reduction in the adverse air emissions when used in copper tailing bricks and stabilized blocks, etc. According to the chemical classification report, copper ore tailing is a good quality class-N natural pozzolana. So we can use copper tailing as a pozzolanic material in the construction industry and in suitable places. Copper ore tailing is available free of cost and only transportation expenses are there [1, 2, 5].

Copper ore tailing is one of the waste by-products, produced by the Ingaldal Copper Mines, a unit of the Hutti Gold Mines Company Ltd., situated at a distance of 10 Kms from Chitradurga, Karnataka. More than 1, 50, 00cu-m of copper ore tailings had been dumped in Ingaldhal. It has become a problem for concerned authorities (H G M limited, Ingaldhal), to dispose off the waste which is more alkaline in nature (pH is above 13), which is unfit for farming.

The main aim of this experimental work was to use of copper ore tailings as an admixture by replacing the cement in different percentages viz., 0%, 10%, 20%, 30%, 40% and 50%, in preparation of concrete.

2.0 EXPERIMENTAL WORK

2.1 MATERIALS USED

Cement: The cement used in the experimentation was ordinary Portland cement-43 grade, which satisfies the requirements of IS: 8112-1989 specifications. The physical properties of tested cement are given in Table No. 2.1.1

Coarse aggregates: The crushed stone aggregate were collected from the local quarry. The coarse aggregates used in the experimentation were 10mm and down size aggregate and tested as per IS: 383-1970 and 2386-1963 (I, II and III) specifications. The aggregates used were having fineness modulus 1.9. Sieve analyses of coarse aggregate are given in Table No. 2.1.2 and physical and mechanical properties of tested coarse aggregates are given in Table No.2.1.3

Fine aggregates: Locally available sand collected from the bed of river Bhadra was used as fine aggregate. The sand used was having fineness modulus 2.96 and confirmed to grading zone-III as per IS: 383-1970 specification. Sieve analyses of fine aggregate are given in Table No. 2.1.4 and physical properties of tested fine aggregate are given in Table No. 2.1.5

Copper ore tailings: Copper ore tailing used in the experimental program was procured from Ingaldal Copper Mines, a unit of the Hutti Gold Mines Company Ltd., under dry mode of condition. The chemical and physical properties of tested copper ore tailing are given in Table No. 2.1.6 and Table No. 2.1.7

Water: Ordinary potable water free from organic content, turbidity and salts was used for mixing and for curing throughout the experimental work.

Table2.1.1: Physical properties ordinary Portland cement 43-grade (IS: 8112-1989)

Properties	Results	Permissible limit as per IS: 8112-1989
Fineness	28.1 m^2/N	Should not be more than 22.5 m^2/N
Normal consistency	29.7	-
Specific gravity	3.15	-
Setting time a. Initial b. Final	 170 Min 273 Min	 Should not be less than 30 Minutes Should not be more than 600 Minutes

Soundness test a. Le-chat expansion b. Auto clave%	 1 0.09	 10mm maximum 0.8% maximum
Compressive strength of mortar cubes for a.3days b.7days c.28 days	 24.5N/mm^2 36 N/mm^2 46.5N/mm^2	 Should not be less than 23 N/mm^2 Should not be less than 33 N/mm^2 Should not be less than 43 N/mm^2

Table 2.1.2: Sieve analysis of coarse aggregate (IS: 383-1970)

IS sieve size	Weight retained (grams)	Cumulative weight retained (grams)	Cumulative percentage weight retained	Cumulative percentage passing	ISI permissible limit
12.5mm	0	0	0	100	100
10mm	0	0	0	100	85-100
4.75mm	1860	1860	93	7	0-20
2.36mm	93	1953	97.65	2.35	0-5
pan	47	2000	-	-	-
Total	2000	-	190.65	-	-

Fineness modulus = 190.65/100 = 1.9

Table 2.1.3: Physical and Mechanical properties of coarse aggregate (IS: 2386-1963)

Properties	Results	Permissible limit as per IS: 2386-1963
Impact value	15.50 %	Should not be more than 30% used for concrete
Crushing value	25%	Should not be more than 30% for surface course and 45% other than wearing course
Specific gravity	2.65	In between range 2.6-2.8
Moisture content	0.16%	-

Table 2.1.4: Sieve analysis of fine aggregate (IS: 383-1970)

IS sieve size	Weight retained (grams)	Cumulative weight retained (grams)	Cumulative percentage weight retained	Cumulative percentage passing	Grading zone III
10	0	0	0	100	100
4.75	5	1	99	-	90-100
2.36	44	45	09	91	85-100
1.18	30	75	15	85	75-100
600µm	50	125	25	75	60-79
300µm	185	310	62	38	12-40
150µm	120	430	86	14	0-10
Pan	70	500	-	-	-
Total	500 gm	-	296	-	-

Fineness Modulus: 296/ 100 = 2.96

Table 2.1.5: Physical properties of fine aggregate (IS: 2386-1963)

Properties	Results	Permissible limit as per IS: 2386-1963
Organic impurities	Colourless	Colour less /Straw Colour/Dark Colour
Silt content	0.7%	Should not be more than 6-10%
Specific gravity	2.63	Should be between the limit 2.6-2.7
Bulking of sand	16%	Should not be more than 40%
Moisture content	0.65%	-

Table 2.1.6: Chemical properties of copper ore tailings

Properties	Test results
Loss on ignition(L.O.I.)	2.19
Silica(SiO2)	71.52
Magnesium oxide(MgO)	0.49
Calcium oxide(CaO)	0.16
Aluminium oxide(Al2O3))	13.96
Iron oxide (Fe2O3)	3.64
Potassium oxide(K2O)	1.82
Sodium oxide(Na2O)	4.12
Titanium oxide(TiO2)	0.013
Copper oxide(CuO)	0.32
Manganese oxide (Mn2O2)	0.072
SiO2+AL2O3+Fe2O3	92.12

Table 2.1.7: Physical properties of copper ore tailings

Properties	Test results
Specific gravity	3.10
Fineness	6.70 to10.20 %
Standard Consistency	27.5%
Compressive Strength	zero
pH	13.60

2.2 EXPERIMENTAL PROCEDURE

The concrete ingredients namely cement, fine aggregate (sand) and coarse aggregate (jelly) were weighed according to their proportion and they were dry mixed on non-absorbent plat form and mixed thoroughly in dry state and required quantity of tailings was added in dry condition and mixed again thoroughly. To this, the calculated quantity of water was added mixed rigorously and homogeneously. Before any fresh concrete was poured into the concrete moulds, all concrete moulds were cleaned from the existing concrete stain and oil was applied inside the moulds.

The fresh concrete was placed into the mould with the help of scoop. The moulds were filled with concrete in workability condition in three layers each layer being compacted by using standard tamping rod thoroughly and vibrated using table vibrator to achieve an adequate compaction. After adequate compaction, the specimens were finished smooth and left. After 24 hours, the specimens were demoulded and transferred to curing tank where in they were allowed to cure for 28 days.

Concrete specimens for compressive strength test were of dimensions 150mm x 150mm x 150mm. The specimens were placed in between the platens of a compression-testing machine. Load was applied gradually until the specimen fails.

The test was conducted after the concrete specimens were cured for 28 days. The test procedure was carried out accordance with Indian standard: 516-1959 specification.

The compressive strength of concrete can be calculated using the following formula:

$fc = P/A$

Where, fc = Compressive strength of concrete.

P = Maximum load applied to the specimen.

A = Cross sectional area of the specimen.

3.0 EXPERIMENTAL RESULTS-

The following Table No. 3.0.1 and Table No. 3.0.2 give the details of the experimental result.

Table 3.0.1: Compressive strength test results of concrete with different percentage replacement of cement by copper tailings

Mix ratio	Percentage replacement of cement by copper tailings	Compressive strength in N/mm^2 for different curing period in days		
		7	14	28
M10 1:3:6 W/C 0.60	0	9.70	13.90	14.45
	10	9.20	13.10	13.70
	20	8.50	12.20	12.80
	30	6.90	9.90	10.60
	40	6.30	8.00	8.70
	50	5.75	7.11	7.14
M15 1:2:4 W/C 0.55	0	16.11	21.04	22.63
	10	13.62	18.15	20.03
	20	12.45	17.60	18.75
	30	11.65	15.60	16.90
	40	9.40	13.40	14.25
	50	7.58	11.51	12.01

M20 1:1.5:3 W/C 0.50	0	24.12	31.56	33.94
	10	20.43	27.22	30.14
	20	18.67	26.40	28.12
	30	17.47	23.40	25.35
	40	14.10	20.41	21.37
	50	11.38	17.02	18.01
M25 1:1:2 W/C 0.45	0	36.18	47.34	50.91
	10	30.64	40.83	45.21
	20	28.00	39.60	42.18
	30	26.20	35.10	38.02
	40	18.33	26.53	27.78
	50	12.82	20.05	21.30

Table 3.0.2: The water absorption test results of concrete with different percentage replacement of cement by copper tailings

Mix ratio	Percentage replacement of cement by copper tailings	Percentage water absorption for different curing Period in days		
		7	14	28
M10 1:3:6 W/C 0.60	0	2.34	3.07	2.92
	10	2.89	2.47	2.31
	20	2.55	2.38	2.17
	30	2.09	1.97	1.89
	40	2.02	1.79	1.69
	50	1.93	1.62	1.51
M15 1:2:4 W/C 0.55	0	2.65	2.35	2.20
	10	2.55	2.23	2.08
	20	1.99	1.97	1.81
	30	1.96	1.64	1.53
	40	1.72	1.54	1.19
	50	1.69	1.44	1.11
M20 1:1.5:3 W/C 0.50	0	2.75	2.65	2.40
	10	2.65	2.43	2.38
	20	1.59	1.37	1.31
	30	1.46	1.34	1.23
	40	1.32	1.31	1.18
	50	1.22	1.19	1.08
M25 1:1:2 W/C 0.45	0	2.76	2.46	2.40
	10	2.65	2.33	2.37
	20	1.69	1.39	1.41
	30	1.56	1.34	1.39
	40	1.52	1.31	1.29
	50	1.12	1.11	1.07

4.0 OBSERVATIONS AND DISCUSSIONS

Based on the experimental results the following observations were made

1. It has been observed that from the experimentation, strength of concrete blocks decreases with increase in the percentage of tailings. The cement can be replaced by copper tailings upto 30%.
2. It has been observed that the addition of copper tailings as replace to ordinary Portland cement causes reduction in the compressive strength of concrete.
3. It has been observed that the replacement of ordinary Portland cement by copper tailings safe upto 20% considering average minimum field strength. If characteristic strength is considered replacement upto 30% may be considered as safe.
4. It has been observed that the increase in replacement of ordinary Portland cement cause decrease in water absorption and consequently enhancing the durability of the concrete, which can be considered as a favourable phenomenon

5.0 CONCLUSIONS

The following conclusions can be drawn from the results obtained from the experimental work carried out.

1. It can be concluded that the feasibility of utilization of copper tailings improves the properties of concrete has been identified in this experimental work.
2. It can be concluded that the water absorption decreases at 20% copper tailings content and increases for all other copper tailings content.
3. It can be concluded that the replacement of ordinary Portland cement by copper tailings proves to be economical by 17.28%.
4. Utilization of copper tailings for partial replacement of cement on concrete solves the problem of dumping down the waste materials

ACKNOWLEDGEMENTS

The authors would like to thank Vice-Chancellor, Christ University, Fr. Benny Thomas, Director and Dr. Iven Jose, Associate Dean, Christ University Faculty of Engineering, Bangalore for their constant encouragement

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b. IS: 6461 (part-II)-1972 Glossary of terms relating to cement concrete.

c. IS: 6491-1972 Method of sampling fly ash.

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ISSN: 2278-6252

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