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EFFECTIVE USED OF COPPER SLAG IN CONCRETE

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Abstract — *Copper slag is by product material produced during the smelting and refining process of manufacturing of copper. It is estimated that about two tons of copper slag is generated for extracting one tons of copper. Thus this material is produced in large quantity as a waste. Currently it is being used as a replacement of sand in shot blasting and land filling. Construction is one of the largest activity in the country and there is scope of using this copper slag as construction material. This can reduce the hazardous effect due to the disposal of copper slag in land filling. In this study we are going to investigate the constructive use of copper slag as a building material. Copper slag is mixed with fine aggregate in different proportions and tested for various properties of concrete. And also add polypropylene fiber as admixture for more strength. The results of concrete with copper slag with fibers and without copper slag are analyzed for improvements in properties for concrete such as compressive strength as well as tensile strength. Which are used for replacement of sand in concrete as well as in building material and economy in construction.*

Keywords- *copper slag, polypropylene fiber, compressive strength, tensile strength, sand replacement,*

Introduction

1.1 Problem Summary

Developing countries require urbanization and industrialization to increase the economy of the nation and increase the standard of living of the people. Also due to this increasing industrialization severe environmental pollution problems are also arising due to the disposal of industrial waste. The non – renewable sources of raw materials are also declining day by day. Copper slag is also one of the industrial wastes produced during the production of copper. It is formed as a by-product after smelting & refining process of copper ore. It is produced in large quantity. Approximately 2 tons of copper slag is produced for the production of 1 ton of copper metal.

All over India only 3 industries produce copper slag. They are Birla Copper Dahej, Hindustan Copper Ltd., Kolkata & Sterlite Industries Tuticorin. Birla copper Dahej produces about 8 – 9 lac tonnes of copper slag per annum, which is approximately 2500 tonnes of copper slag daily. It is very difficult for the disposal of this much of waste due to its effect to the environment. This copper slag is dumped in piles in the industry and used mostly for filling. So the problem where to use this much of copper slag rises. Construction industry being one of the largest industry in India there is scope of using this copper slag. So we are trying to find out different alternatives of using this copper slag.

1.2 Aim and objectives of the project

main aim of our project is to find a proper use of copper slag in the Construction. This project focuses on using copper slag in building materials. Copper slag will be mixed in cement aggregate and tests will be conducted. In this semester feasibility of using copper slag in building material will be checked.

1.3 Problem Specifications

Large quantity of waste is generated from industries. And most of it is not utilized but disposed of at sites instead. And these sites will be exhausted in the future. Copper slag is also a waste being generated in huge quantity and not being used. Waste Utilization in construction and geotechnical applications is a positive way towards its reduction.

Now a days the Fine aggregate become more expansive. Increase the rate of fine aggregate, increase the cost of construction. Sand are used in concrete only for surfacing and finishing, not for strength characteristic.

for improving these engineering properties various methods are implemented which may be costly. The use of recycled waste material gives a good alternative for increasing the soil properties from economic and environmental point of view. The use of this waste also reduces the problems arising due to landfill. By using the copper slag in we can reduce the high used of sand and also find an economic and stable material for improving the concrete properties.

1.4 Plan of work

Feasibility analysis of using copper slag in concrete is studied. So we had done various tests to check properties on concrete after 7,14,28 days and comparing them before and after addition of copper slag.

For this different mixes of soil and copper slag were made consisting of 3 proportions.

1) Sand + Copper Slag (80% + 20%)

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2) Sand + Copper Slag (70% + 30%)
3) Sand + Copper Slag (60% + 40%)

The tests to be conducted for checking its feasibility are:

- Compressive Strength Test
- Tensile Strength test

The results of the tests before and after addition of copper slag will be compared to check the feasibility of copper slag in improving concrete properties. After checking the feasibility of copper slag in soil stabilization we will be checking the feasibility of using copper slag in concrete as partial replacement of sand. For this we had done literature survey regarding the research previously done in this project. Various research papers were analyzed to decide the mix proportion of copper slag in concrete.

The proportion decided is partial replacement of sand with 30% of copper slag.

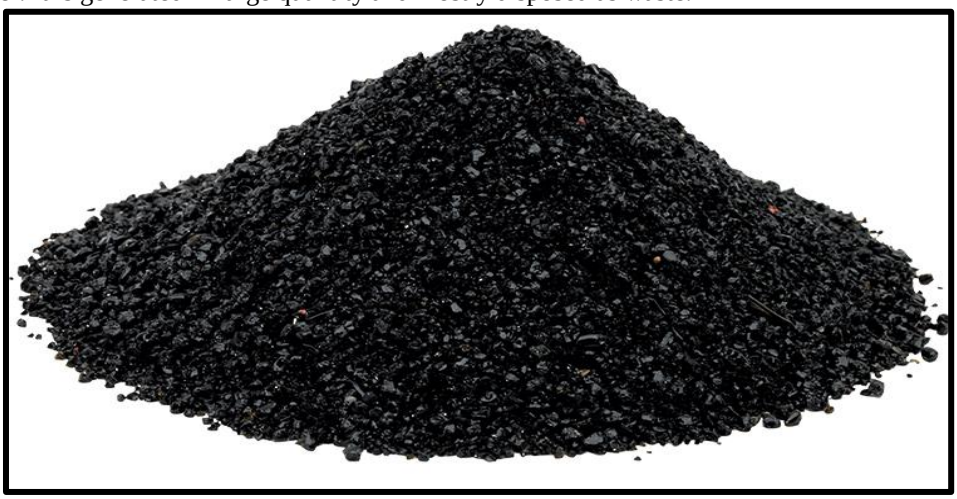
Addition to this mixture we had added polypropylene fibers which helps to increase the flexural strength of concrete.

Materials / Tools Required

1) Copper Slag

Copper slag was collected from Birla Copper Industries, Dahej, Bharuch.

Copper slag is granular material similar to coarse sand in blackish colour. It is by-product generated during smelting process of extracting copper. It is generated in large quantity and mostly disposed as waste.



Copper Slag

Table 1 : Chemical Analysis of Copper Slag

Element /Compound	Analysis Range (%)
Cu	0.60 - 0.70
Fe	42 – 48
SiO^2	26 – 30
Al^2O^3	1.0 - 3.0
S	0.2 - 0.3
CaO	1.0 - 2.0
MgO	0.8 - 1.5
Fe^3O^4	1.0 - 2.0
Co	0.01 - 0.03
Cr	0.02 - 0.04
Zn	0.2 - 0.4
Ni	0.005 - 0.008
W/s. Chloride	0.001 - 0.002
PH	7.0 - 7.5
Moisture	Max 2.0

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2) Polypropylene Fibers

Polypropylene fibers used in this study are Recon 3s of Reliance product and purchased from Trend Engineers, Near ABC, GIDC, Narmadanagar-392015 Bharuch.

Properties of Polypropylene Fibers

Specification Values	Specification Values
Aspect ratio 1800	Aspect ratio 1800
Tensile strength $2.5x10^3$ Mpa	Tensile strength $2.5x10^3$ Mpa
Elasticity modulus $8x10^3$ Mpa	Elasticity modulus $8x10^3$ Mpa
Specific gravity 8 gm/cm^3	Specific gravity 8 gm/cm^3

Polypropylene Fibers

CONCRETE MIX DESIGN

a) Grade Designation = M 20
b) Type of Cement = PPC 53 grade conforming to IS 8112
c) Maximum nominal size of aggregate = 20 mm
d) Minimum cement content = 320 kg/m3
e) Maximum water cement ratio = 0.50
f) Workability = 750 mm
g) Exposure condition = Moderate
h) Method of concrete placing = Hand Mixing
i) Degree of supervision = Good
j) Type of aggregate = Crushed Angular Aggregate
k) Specific gravity of cement = 3.15
l) Specific gravity of course aggregate = 2.85
m) Specific gravity of fine aggregate = 2.63

Step 1: - Target mean strength

Fck: - fck+1.65 S = 26.6 ; S = 4

Step 2: - Selection of W/C Ratio

From Table 5 of IS: 456-2000, maximum water cement ratio = 0.50 (Moderate exposure)

Step 3: - As per table in IS 456:2000

For nominal maximum Aggregate size

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20mm Water Content per cum

Adding 3% for 750 mm slump

Water Content=191.58kg

Step 4: - Calculation of Cement Content

$\frac{w}{c}$ = 0.50

Therefore c = $\frac{191.58}{0.5}$ = 383.16 kg/m^3

383.16 > 250 kg/m3 **OK**

Step 5: - Determination of Coarse Aggregates

As per IS 10262-2009 clause 4.4

For zone 3 Fine Aggregate

Volume of coarse = 0.62 m^3

Volume of Fine Aggregate=0.38 m^3

Step 6: - Mix proportion

Volume of concrete:-1 m^3

Volume of cement:=

$\frac{\text{mass of cement}}{\text{sp gravity}} * \frac{1}{1000}$

$= \frac{383.16}{3.15} * \frac{1}{1000}$

= 0.1216 m^3

Volume of Water

$= \frac{191.58}{1000}$

Water = 0.1916 m^3

Volume of all aggregates

=A-(B+C)

=1 - (0.1216 + 0.1916)

= 0.687 m^3

Mass of Coarse Aggregate:-

= Total Volume of Aggregates *Volume of Coarse Aggregate*Sp. Gravity of Coarse Aggregate*1000

= 0.687*0.62*2.85*1000

= 1213.93 kg

Mass of Fine Aggregates

=0.687*0.38*2.63*1000

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=686.59 kg

Final mix design

Cement	Water	Fine aggregate content	Natural Coarse content	Water cement ratio
383.16 kg	191.58kg	686.59 kg	1213.93	0.50

Cement	Fine aggregate	Coarse aggregate
383.16 Kg	686.59 Kg	1213.93 Kg
1	1.79	3.17

Copper Slag Design Mix

For partial replacement of copper slag the mix design will be same as that of normal concrete. The fine aggregate i.e. sand will be replaced partially in respect to volume.
For 30 % replacement of copper slag

Mass of Fine Aggregates

Sand = 0.687*0.38*2.63*1000*0.7 = 480.61 Kg

Copper Slag = 0.687*0.38*3.51*1000*0.7 = 274.89 Kg

Cement	Water	Fine Aggregate Content	Copper Slag Content	Natural Coarse content	Water Cement ratio
383.16 kg	**191.58kg**	**480.61 kg**	**274.89 kg**	**1213.93**	**0.50**

Mixing of Concrete

There are two methods of mixing concrete:

- Hand mixing
- Machine mixing

Hand Mixing:
We used hand mixing for the casting of the test specimens for our project. We have considered 10% extra quantity of raw materials for wastage & other things.

Procedure:
- Measured quantity of Fine aggregate and Cement spread on the mixing platform.
- Spread quantity was mixed in dry state till the colour of the mixture becomes uniform.
- Then, measured quantity of coarse aggregate is mixed with Raw materials.
- Proper mixing was carried out for the whole mixture.
- Measured quantity of Polypropylene fiber was mixed with water and then it is added to dry mixture of raw materials.
- Then, mixing process continued till uniform mix is obtained.

Test Results

Compressive Strength
Concrete cubes of size 150 mm × 150 mm × 150 mm confirming to IS code: 516-1964 was cast for determining the compressive strength. After 24 hours the cubes were removed from the mould and placed in to water for curing. Water curing periods for the cubes were 7 days, 14 days and 28 days. Before testing, the cubes were air dried for 2 hours. Then, the cubes were tested in compression testing machine & crushing loads were note down for 7 days, 14 days and 28 days age.

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Crushed Cubes

Compressive Strength Results

Type	Day	Cube	Peak Load	Comp. Strength	Avg. Comp. strength
			KN	N/mm^2	
Normal	7	1	385.56	17.136	17.235
		2	375.45	16.69	
		3	402.33	17.88	
	14	1	551	24.49	22.88
		2	524	23.29	
		3	469.5	20.87	
	28	1	554.5	24.64	27.04
		2	632	28.09	
		3	638.5	28.38	
C.S. 30%	7	1	273.5	12.16	15.95
		2	447	19.87	
		3	356	15.82	
	14	1	444.5	19.76	21.62
		2	523	23.24	
		3	492	21.87	
	28	1	579	25.73	24.18
		2	528	23.47	
		3	525	23.33	

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Split Tensile Strength

Split tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. Concrete cylinders of size 150 mm diameter and height 300 mm confirming to IS code: 516-1964 was cast for determining the split tensile strength. After 24 hours the cylinders were removed from the mold and placed in to water for curing. Water curing periods for the cylinders were 14 days and 28 days. Before testing, the cylinder were air dried for 2 hours. Then, the cubes were tested in compression testing machine & crushing loads were note down for 7 days, 14 days and 28 days age.

Testing of cylinders for split tensile strength

Split tensile strength is calculated as: -

T = 2P/ pi DL
Where P = applied load
D = diameter of the specimen
L = length of the specimen

Split Tensile Strength Results

Type	Day	Cylinder	Peak Load	Split tensile strength	Avg.
			KN	N/mm^2	
Normal	14	1	129.5	1.83	
		2	125.45	1.78	1.84
		3	135.67	1.92	
	28	1	142.5	2.02	
		2	132.5	1.88	1.92
		3	133	1.88	
C.S. 30%	14	1	145	2.05	
		2	139.5	1.97	1.98
		3	135.5	1.92	

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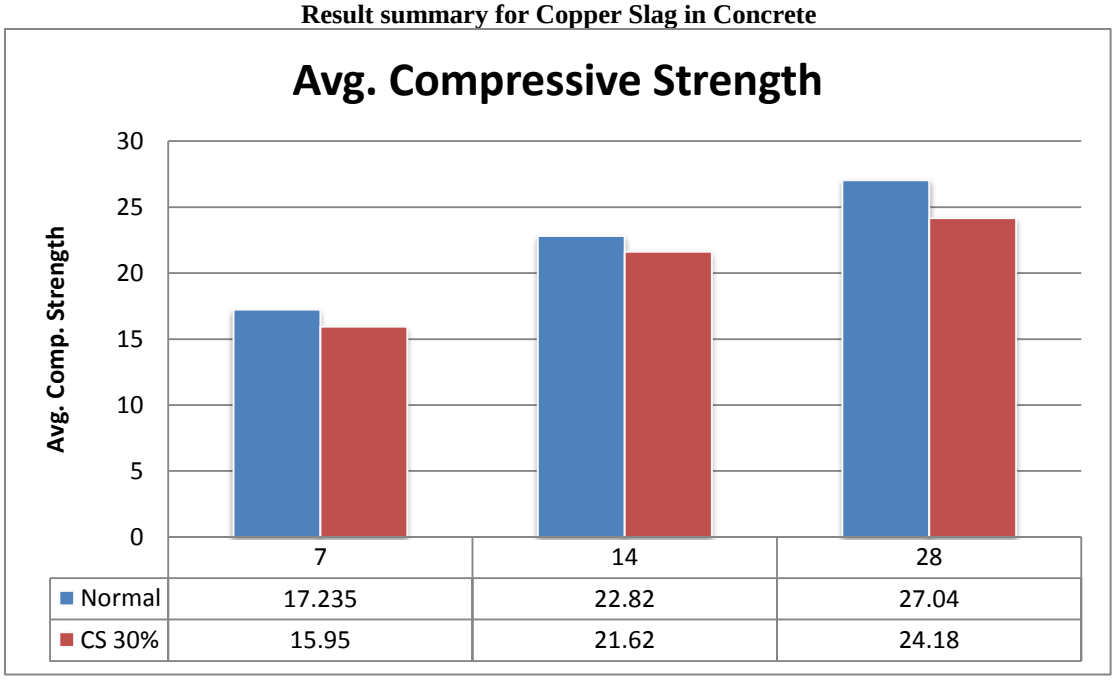
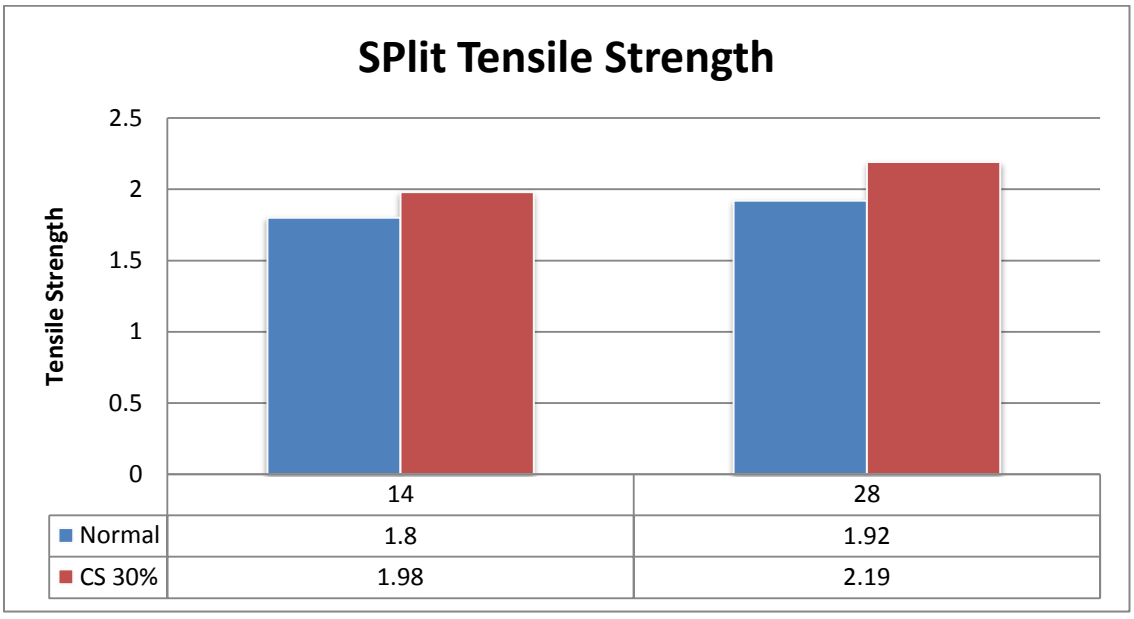
	28	1	156.5	2.22	
		2	159.6	2.26	2.19
		3	148	2.09	

Result summary for Copper Slag in Concrete





- The design strength of concrete was achieved by our mix design in normal as well as partial replacement of copper slag.
- The design compressive strength was achieved in 14 days itself.
- The strength of normal concrete was more compared to copper slag concrete.
- The split tensile strength of concrete was not satisfactory even after 28 days of curing.
- The split tensile strength achieved was less than the minimum required strength.

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Usefulness of Copper Slag.

Also by using copper slag in concrete by partial replacement we can achieve the design strength of concrete. Since the tensile strength of copper slag concrete was less it cannot be used in structures where tension forces act such as retaining wall and underground structures. But we can use copper slag concrete in structures under low loadings such as beams and columns of compound walls. And by using copper slag we can also reduce the various problems of waste industrial waste disposal.

Conclusion

Also when we compare the results of CBR and Unconfined Compressive Strength there is increase. This shows that by addition of copper slag we can improve soil properties. In concrete when we compare the results of normal concrete with copper slag concrete there is not much effect in its design strength. But the tensile strength of concrete achieved was less compared to the required strength which makes the concrete less useful for heavy loading structures. From all the results we can say that use of copper slag in soil stabilization and concrete is feasible and it helps in waste utilization.

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