EXPERIMENTAL INVESTIGATION ON STRENGTH AND CHARACTERISTICS OF CONCRETE WITH PARTIAL REPLACEMENT ON FINE AND COARSE AGGREGATE BY USING COPPER SLAG AND RECYCLED COARSE AGGREGATE

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Abstract: *Copper slag, a slag from metal smelting process, is efficiently used as a replacement for sand in conventional concrete which is highly efficient in increasing the strength without affecting it's properties in fresh and hardened state. Also recycled coarse aggregate was used as 30% of total coarse aggregate for all mixes.M40 grade of concrete is taken and 1 : 2.56 : 3.26 mix is adopted for partial and full replacement of sand with copper slag and recycled coarse aggregate..*
Cubes, cylinders & Prisms are cast and cured to conduct compressive strength, split tensile and flexural test on 7 days,14 days and 28 days test. Slump of concrete mix with different proportions are measured and recorded. Obtained results on different parameters like strength, workability were compared with those of control concrete made with ordinary Portland cement, sand and coarse aggregate.

Keywords: *Concrete,coppersag,recycled coarse aggregate,workability and strength.*

I. INTRODUCTION

Concrete is a widely used construction material for various types of structures due to its durability. For a long time it was considered to be very durable material requiring a little or no maintenance. Many environmental phenomena are known significantly the durability of reinforced concrete structures. We build concrete structures in highly polluted urban and industrial areas, aggressive marine environments and many other hostile conditions where other materials of construction are found to be nondurable.

In the recent revision of IS:456:2000, one of the major points discussed is the durability aspects of concrete. So the use of concrete is unavoidable. At the same time the scarcity of aggregates are also greatly increased nowadays. Utilization of industrial soil waste or secondary materials has been encouraged in construction field for the production of cement and concrete because it contributes to reducing the consumption of natural resources.

For many years, byproducts such as fly ash, silica fume and slag were considered as waste materials. They have been successfully used in the construction industry for partial or full replacement for fine and coarse aggregates (Akihiko Y, Takashi Y 1 & Ayano Toshiki, Kuramoto Osamu, Sakata 2). Some of the byproducts are also used as a Portland cement substitute (AlJabri K, Taha R et al 3 .). Copper slag is widely used in the sand blasting industry and it has been used in the manufacture of abrasive tools.Nature has a way of clearing off some of mess by process of biodegradation but now certain products have come up which are non-biodegradable. One way of reducing such waste is the process recycling and this is a solution in many areas of life.

The best solution would be to reuse the demolished concrete. Presently, demolished concrete is being used as a base material in highway construction. As a further scope towards the use of waste concrete the concrete rubble is also being used as a substitute for natural aggregate in making new concrete.

II. COPPER SLAG

Copper slag is a byproduct of operation of reverberatory furnaces. A large amount of concentrate, up to about 300 tons, may be placed in the furnace at one time. Impurities form a less dense liquid that floats on top of the copper melt. These impurities include iron, lime, and silica, and form the slag. The slag is skimmed off the top, while the melted material, which has up to 50 percent copper, is called matte. The copper matte goes through a converter to blow forced air into it. The air forces the silica back into the copper matte to collect the impurities and make more slag. The slag is skimmed off and air cooled. The slag is subjected to a process of staged crushing using jaw and impact crushers and screened to achieve a uniform and angular particle shape.

BENEFITS

- It provides good cohesive pumpable mix at low W/C ratio & moderate cement contents.
- Imparts extreme fluidity to the concrete, which facilitates rapid placement of concrete.
- Helps in controlled & predictable retardation of setting with improved slump retention.
- The copper slag used is 3 to 4 times economical when compared to river sand.
- Some mosaic companies, used copper slag to replace sand.
- Useful in production of self-compacting concrete.
- Applied in complicated formwork or with congested reinforcement.
- Achieves good compaction without any excessive vibration.
- Reduced permeability, segregation and bleeding.
- Helps in increasing compressive and flexural strength.
- It is chloride – free.

III.STUDY AND COMPOSITION OF MATERIALS

GENERAL

Cement, Fine aggregate, copper slag & Coarse aggregate are the various Materials used in this project. Before casting the specimen various tests of materials has been conducted.

STUDY OF MATERIALS

CEMENT:

In the most general sense of the world, cement is a binder, a substance which sets and hardens independently, and can bind other materials together. The volcanic ash and pulverized brick additives which were added to the burnt lime to obtain a hydraulic binder were later referred to as cementum, cimentum, and cement. Cements used in the construction are characterised as hydraulic or non-hydraulic. The most important use of cement is the production of mortar and concrete the bounding of natural or artificial aggregates to form a strong building material which is durable in the face of normal environmental effects. The most commonly used type of cement is Ordinary Portland Cement. Portland Cement is the basic ingredient of concrete, mortar and most non speciality grout. The use of Portland Cement is the production of concrete.

Composition of Ordinary Cement:

INGREDIENT	PERCENTAGE (%)	RANGE
Lime (CaO)	62	62-67
Silica (SiO_2)	22	17-25
Alumina (Al_2O_3)	5	3-8
Cal1cium Sulphate ($CaSO_4$)	4	3-4
Iron Oxide (Fe_2O_3)	3	3-4
Magnesium (MgO)	2	0.1-3

FINE AGGREGATE:

Fine aggregate is the natural material that fills voids in between the coarse aggregate.

COPPER SLAG:

Copper slag is a byproduct of operation of reverberatory furnaces.

COARSE AGGREGATE:

It gives body to the concrete, reduce shrinkage and effect economy the aggregate occupy 70-80% of volume of the concrete. Here the fresh coarse aggregate was replaced upto 30% by recycled coarse aggregate.

IV.TESTING OF MATERIALS

Tests for cement:

The fineness test of cement has an important on the rate of hydration and hence on the rate of gain of strength. To find the fineness of the given cement, the equipment required is IS Sieve: 90 micron

Procedure:

100g of the given cement is weighed accurately and is placed on IS 90 micron sieve and is sieved continuously for 15 minutes by circular and vertical motion. The underside of the sieve is lightly brushed with the given brush after every 5 minutes of sieving. The weight of the residue is found accurately and thus the fineness of the cement is found out by the ratio of weight of residue and weight of sample taken which is expressed in percentage. The experiment is repeated with fresh samples and results are tabulated.

Fineness test for cement

Sl.no	Wt of sample taken (w1)g	Wt of residue (w2)g	Percentage weight of residue (w2/w1)x100
1	100	6	6
2	100	5	5

Analysis of results

Thus from the results we infer that the fineness of the cement is 5.5% and the fineness requirement of cement as a residue should not exceed 10% for ordinary Portland cement.

Physical Properties of copper slag

Particle shape	Irregular
Appearance	Black & glassy
Type	Air cooled
Specific gravity	3.91
Percentage of voids	43.20%
Bulk density	2.08 g/cc
Fineness modulus of copper slag	3.47
Angle of internal friction	51° 20’
Hardness	67
Mohs Water absorption	0.3 to 0.4%
Moisture content	0.1%
Fineness of copper slag	125 m^2/kg

Chemical composition of copper slag

Copper slag samples were analysed for constituent oxides including minor oxides and heavy elements besides mineral phases.

Chemical properties of copper slag

S.No	Chemical Component	% of Chemical Component
1	SiO2	25.84
2	Fe2O3	68.29
3	Al2O3	0.22
4	CaO	0.15
5	Na2O	0.58
6	K2O	0.23
7	LoI	6.59
8	Mn2O3	0.22
9	TiO2	0.41
10	SO3	0.11
11	CuO	1.20
12	Sulphide sulphur	0.25
13	Insoluble residue	14.88
14	Chloride	0.018

Recycled Concrete Aggregate:

Recycled concrete aggregate is comprised of crushed concrete or stone that can be graded to meet the specifications for both aggregate base as well as sub base. Specifying recycled materials creates a market for material that would otherwise be land filled and in most instances, is a more economicalalternative to using virgin material.

Water Absorption for (NCA & RCA):

For Natural Coarse Aggregate = 9.8%

For Recycled Concrete Aggregate = 12.7%

V.RESULTS AND DISCUSSIONS

RESULTS FOR WORKABILITY TEST:

It is the concrete phase from time of mixing to end of placing concrete in the structure. Thus, in practice, it is difficult to measure the workability as defined above, and what we measure is workability which is applicable to particular method adopted.

Slump Cone Test

Copper Slag (%)	Slump in mm
0	60
20	56
40	55
60	56
80	50
100	53

Compaction Factor Test

Copper Slag (%)	Compaction factor
0	0.96
20	0.96
40	0.96
60	0.97
80	0.96
100	0.97

From the workability results, it was confirmed that, the addition of Copper Slag decreases the workability of concrete.

Compression Test results for specimens with 0% Copper Slag with 30% RCA

Mix	7 Days	28 Days
Specimen 1	38.2	48.6
Specimen 2	37.6	49.2
Specimen 3	38.6	49.8
Average	38.13	49.2

Split tensile test results for specimens with 0% Copper Slag with 30% RCA

Mix	28 Days
1	4.6
2	4.9
3	5.36
Average	4.95

Split tensile test results for specimens with 40% Copper Slag with 30% RCA

Mix	28 Days
1	5.8
2	5.96
3	5.84
Average	5.87

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Compressive test results for specimens with 20% Copper Slag with 30% RCA

Mix	7 Days	28 Days
Specimen 1	39.26	50.5
Specimen 2	42.6	51.8
Specimen 3	41.13	51.6
Average	41	51.3

Split tensile test results for specimens with 20% Copper Slag with 30% RCA

Mix	28 Days
1	5.2
2	5.36
3	5.7
Average	5.42

Compression Test results for specimens with 40% Copper Slag with 30% RCA

Mix	7 Days	28 Days
Specimen 1	42.36	52.8
Specimen 2	42.9	53.9
Specimen 3	43.3	53.5
Average	42.85	53.4

Compression Test results for specimens with 60% Copper Slag with 30% RCA

Mix	7 Days	28 Days
Specimen 1	41.36	51.9
Specimen 2	41.9	52.6
Specimen 3	40.31	53.3
Average	41.19	52.6

Split tensile test results for specimens with 60% Copper Slag with 30% RCA

Mix	28 Days
1	5.6
2	5.48
3	5.16
Average	5.41

Compression Test results for specimens with 80% Copper Slag with 30% RCA

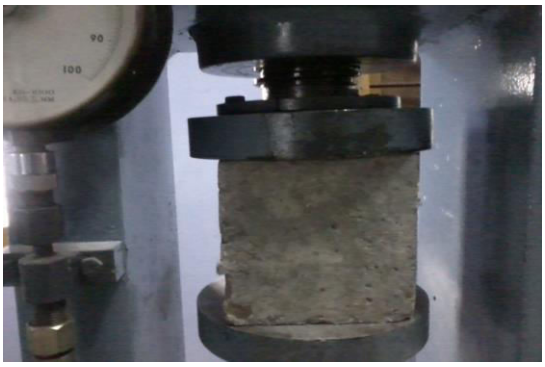
Mix	7 Days	28 Days
Specimen 1	39.31	49.8
Specimen 2	39.6	48.6
Specimen 3	38.7	49.2
Average	39.2	49.2

Split tensile test results for specimens with 80% Copper Slag with 30% RCA

Mix	28 Days
1	4.9
2	4.86
3	5.18
Average	4.98

VI.PHOTOGRAPHS

Testing of specimen



Failure of cylinder

Failure of cube

VII.CONCLUSION

- The concrete with copper slag and RCA shows better workability.
- The compression strength was increased with the addition of copper slag in concrete upto 60% and the n it was found to be decreased.
- For the full replacement of sand with copper slag, the strength was increased to 40.75 N/mm^2
- The split tensile strength was increased with the addition of copper slag in concrete similar to compressive strength.
- For the full replacement of sand with copper slag, the strength was slightly decreased.
- Thus it can be concluded, that the copper slag can be effectively used as fine aggregate in concrete.

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