Experimental Study Onstrength Characteritics on M20 Concrete with Partial Replacement of Cement With Fly ASH and Replacementof Fine Aggregate with Copper Slag

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Abstract

Consumption of industrial solid waste to concrete production is an environmentally friendly because it contribute to reducing the consumption of natural resources, pollution concrete production, generates and the power its consumes. This study is concerned with utilizing the Copper slag obtained from the Sterlite industries, as a replacement for fine aggregate and partial replacement of cement by fly ash. Since the disposal of slag is a major problem. By doing so, it reduces environmental pollution and in addition can make way for avoiding the ill-effects of uncontrolled exploitation of natural resources.

Copper slag is having similar particle size characteristics likely to that of sand. Hence, it is a better approach in using the slag as the replacement for sand. This research work mainly concentrates on the assessment of improves the strength of concrete for using waste solid slag. For this study M20 grade concrete were used and the tests were conducted for various proportions of copper slag replacement with sand (0%, 10%,20%, 30%, 40% & 50%) and partial replacement of fly ash with cement 30% in concrete. Cubes and Cylinders, Prism specimens were cast and tested for compression, split tensile strength and Flexural strength test.

Key Words

Concrete, Fly ash, Copper Slag, Compressive strength, Split tensile strength, Flexural strength.

I. Introduction

Concrete is one of the widely accepted construction material in the development of infrastructure. It perfectly matches with several requirements like strength, durability, impermeability, and fire-resistance and abrasion resistance. Cement and fine aggregate is the main ingredient used to make concrete, which are obtained from natural resources. Cement is an artificial material manufactured with the naturally available limestone, silica and gypsum. Aggregates are considered one of the main constituents of concrete since they occupy more than 70% of the concrete matrix. As a result of increase in construction requirement, the usage of these natural resources increased a lot which will lead to scarcity of these materials in future. In order to reduce dependence on natural aggregates as the main source of aggregate in concrete, artificially manufactured aggregates and artificial aggregates generated from industrial wastes provide an alternative for the construction industry. Therefore, utilization of aggregates from industrial wastes can be alternative to the natural and artificial aggregates. The other main advantage of using such materials is to reduce the cost of construction. The new material should be environment–friendly and preferably utilize industrial wastes generated as a result of rapid industrialization.

II. Materials

COPPER SLAG: Copper slag is one of the materials that are considered as a waste material which could have a promising future in construction industry as partial or full substitute of either cement or aggregates. It is a by-product obtained during the matte smelting and refining of copper. Since it has a higher composition of Iron oxide (Fe_2O_3) the density of copper slag is relatively higher when compared to other materials. . The copper slag is obtained as a waste product after undergoing several industrial processes in Hindustan Copper Limited, Rajasthan generates 12 to 13 million tons of copper slag every year. Sterlite Industries, Tamil Nadu produces 0.4 million tons of copper every year. When one ton of copper is produced, 2.2 to 3 tons of copper slag is generated. Therefore, in Sterlite industries, 0.8 million tons of copper slag is generated every year. It is assumed that about 25 million tons of copper slag is generated in India every year.

Copper slag is widely used in the sand blasting industry and it has been used in abrasive blast treatment and in the manufacture of abrasive tools. Recent research papers reviewed the use of copper slag in the production of value added products such as abrasive tools, abrasive materials, cutting tools, tiles, glass, and roofing granules, the remainder is disposed of without any further reuse or reclamation. They also reported the potential use of copper slag as a partial substitute of cement and aggregates in concrete and asphalt mixtures.In order to reduce the accumulation of copper slag and also to provide an alternate material for sand, the proposed to study the potential of copper slag as replacement for fine aggregate in cement concrete.

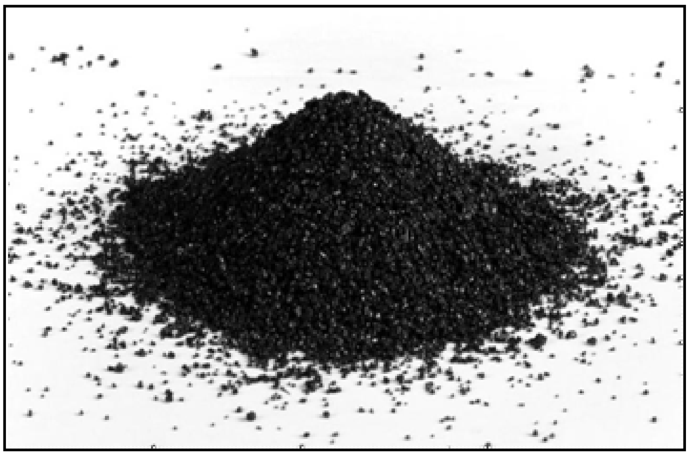

Fig. 1: Appearance of copper slag

FLY ASH

Fly ash is a byproduct of coal burning at utility plants. As coal is burned, noncombustible mineral impurities in coal evaporate and condense into tiny particles of glass, almost totally spherical in shape. "The individual particles are very small, like talcum powder, and are carried up and out of the boiler in the flow of exhaust gases leaving the boiler after the coal is consumed" (Western Region Ash Group). The fly ash particles are removed from the exhaust stream in bag houses or electrostatic precipitators and then stored for later shipment. The different chemical compositions of coal results in fly ash of different types – Class C or Class F.

Fig.2 :Appearance of fly ash

III. Properties Of Materials

Physical Properties Of Copper SLAG:

Table:1 Physical properties of copper slag

S.No	Appearance	Black Glassy
1	Color	Black
2	Moisture	< 0.1%
4	Bulk gravity	2.08 g/cc
5	Fines modulus of copper slag	3.47
6	Type	Air cooled

Chemical Properties Of Copper SLAG:

Copper slag has a high percentage of iron (Fe) followed by aluminum (Al), calcium (CA), copper (Cu), Zinc (Zn) and magnesium (Mg). The predominant chemical compositions are mainly iron compounds (e.g. Ferro silicate $Fe2Si2O6$). This can help to improve the quality of concrete made with it.

Table:2 Chemical properties of copper slag

S.No	Chemical compounds	% of compounds
1	Fe_2O	68.36%
2	Sio_2	25.14%
3	$Al2O_3$	1.78%
4	Cao	1.09%
5	MgO	0.29%
6	Na_2 O	0.2%
7	K_2O	0.19%
8	LOI	6.65%

Utilization Of Copper SLAG:

Table:3 Utilization of copper slag

S.NO	Approximate anchor pattern (microns)	Recommended Applications
1	25-30	Light Treatment Of Steel, Aluminium Remove Mill Scale And Metal Constructions
2	80-100	Pipelines, Tanks Repair, Ship Building & Oil Industry

Physical Properties Of Flyash

The specific gravity, loss on ignition (LOI) and specific surface area are the prominent physical properties of fly ashes. The specific gravity of fly ash may vary from 1.3 to 4.8. The iron oxide content plays a decisive role in the specific gravity of the material The specific gravity is more for fly ashes containing more iron oxide and vice versa. The presence of opaque spherical magnetite and hematite particles in sufficient quantity will increase the value of specific gravity to about 3.6 to 4.8. On the other hand, as the amount of quartz and mullet increases, the specific gravity decreases. However, coal particles with some minerallic impurities will have lower specific gravity in the range 1.3 to 1.6. The range of specific gravity of Canadian fly ashes is reported to be in the range of 1.91 to 2.94 and that of American fly ashes in the range of 2.14 to 2.69. Deal and Sinha (1999) have reported the specific gravity of Indian coal ashes to range between 1.94 and 2.34 with a mean value of 2.16 and standard deviation of 0.21. The specific gravity of fly ash decreases as the particle size increases. The specific gravity increases when the fly ash particles were crushed. Typical values of the specific surface of Indian fly ashes (3267 to 6842 cm2/g) were comparable with that of the foreign ashes (2007 to 6073 cm2/g).

Chemical Properties Of Fly Ash

The main chemical compounds of class F fly ash are silica, alumina and iron oxide. Other minor constituents include oxides of calcium, magnesium, titanium, sculpture, sodium and potassium. Class C fly ash contains relatively higher proportion of calcium oxide and lesser proportion of silica, alumina and iron oxide than class F fly-ash.

USES: Several factors have impeded fly ash utilization in India, while it is being extensively used globally. Coal-based thermal power stations have been operational for more than 50 years but the concept of developing environment-friendly solutions for fly ash utilization is only about 15 years old.

IV. Methodology

Production of quality concrete requires meticulous care exercised at every stage of manufacture of concrete.

1. Preparation of mould
2. Batching
3. Mixing
4. Placing
5. Compacting
6. Curing
7. De-molding
8. Testing

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V. Results and Discussion

RESULTS ON PROPERTIES OF HARDENED CONCRETE:

Compressive Strength

For cube compression testing of concrete 150 X 150 X 150 mm cubes was used. All the cubes were tested in saturated condition after wiping out the surface moisture. Three cubes for each mix were tested at the age of 28 days curing using universal testing machine

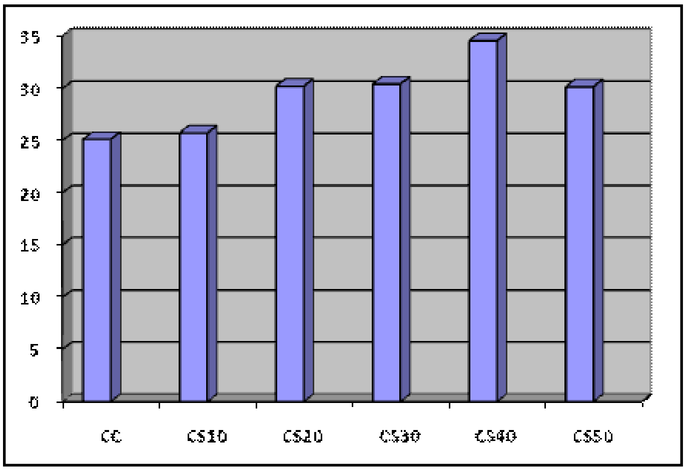

Fig.3: Graph showing compressive strength

Split Tensile Strength

This is an indirect test to determine the tensile strength of cylindrical specimens. Splitting tensile strength tests were carried out on cylinder specimens of size 150 x 300 mm length at the age of 28 days curing, using universal testing machine. The load was applied gradually till the specimens split and readings were noted.

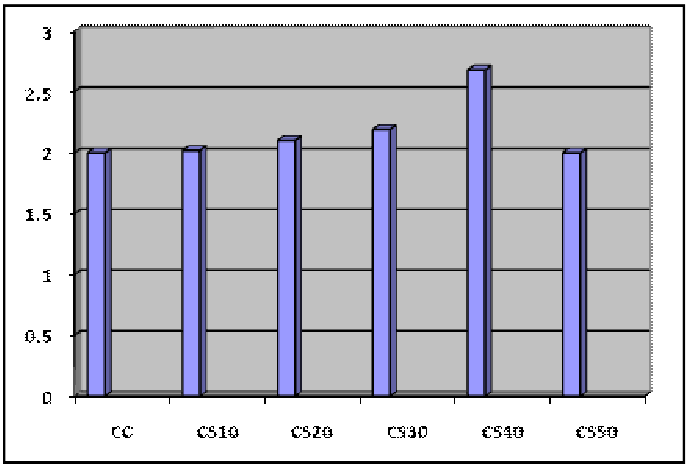

Fig.4: Graph showing Split tensile strength

Flexural Strength

Beam specimens of size 500 X 100 X 100 mm were used casted and tested to determine the modulus of rupture at the age of 28 days. The bearing surfaces of the supporting and loading rollers are wiped and clean and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers. The specimen is then placed in the machine in such a manner that the load is applied to the uppermost surface as cast in the mould, along two lines spaced 13.3 cm apart. The axis of the specimen is carefully aligned with the axis of loading device.

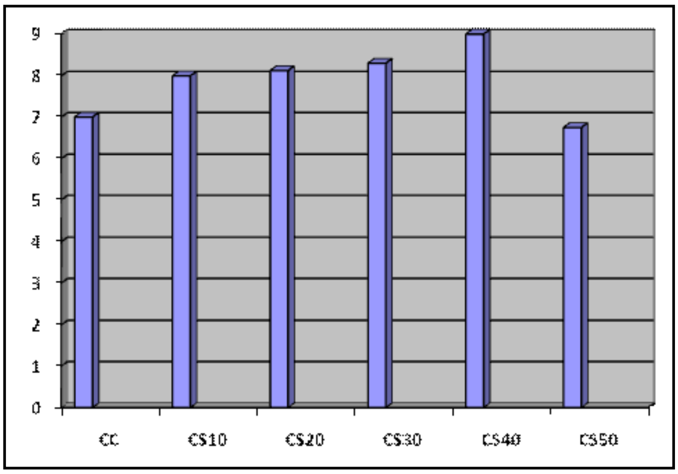

Fig.5: Graph showing flexural strength.

VI. Conclusion

1. The compressive strength of concrete cubes with 40% replacement of fine aggregate with copper slag shows an increase of 15% when compared to the normal concrete cube.
2. In the similar manner, there was increased in the split tensile strength of concrete with 40% replacement of fine aggregate with copper slag shows an increase of 34% when compared to conventional concrete.
3. The flexural strength of prism with 40% replacement of fine aggregate with copper slag shows an increase of 28.57% when compared to the normal concrete prism.
4. With higher levels of replacement (100%) there has bled during cast and recommended that up to 40% of CS can be used as replacement of sand

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