Pursuit of Copper Slag and Fly Ash in High Performance Concrete

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Abstract- **The conventional concrete has lost its usage in modern days as it does not serve the present needs. Hence in order to improve the properties of the concrete in the fresh and the hardened state, high performance concrete (HPC) is used. High performance concrete is a concrete that is produced by partially replacing concrete with improvised minerals. High performance concrete has been defined as the concrete that possess high workability, high strength, high dimensional stability, high durability, low permeability and resistance to chemical attack. This project deals with the effects of supplementary cementitious materials in concrete by incorporating fly ash and copper slag with a water binder ratio of 0.45. Here the conventional concrete is obtained by replacing fine aggregate with 60%, 70%, 80%, 90% copper slag and ordinary Portland cement is replaced with 20% of fly ash. From the experimental results, it is observed that high performance concrete exhibits improved compressive strength, split tensile strength and flexural strength when compared with the conventional mix.**

Index Terms- **High Performance Concrete, Copper slag, Fly ash, Durability, Compressive Strength.**

INTRODUCTION

A. General

Concrete is a composite material composed of coarse aggregate bonded together with a fluid cement that hardens overtime. Most concrete used are lime based concretes such as Portland cement concrete or concretes made with other hydraulic cements, such as calcium aluminate cements. However, asphalt concrete is frequently for road surface, is also a type of concrete, where the cement material is bitumen and polymer concrete are sometimes used where the cementing material is a polymer. When aggregate is mixed together with dry Portland cement and water the mixture forms a fluid mass that is easily moulded into shape. The cement reacts chemically with water and other ingredients to form a hard matrix that binds the material together into a durable stone like material that has many uses. Often, additives (superplasticizers) are included in the mixture to improve the physical properties of the finished mix.

B. High Performance Concrete

High performance concrete is a concrete mixture, which possess High strength when compared to conventional concrete. The term high performance is somewhat pretentious because the essential future of this concrete is that its ingredients and proportions are specifically chosen so as to have particularly appropriate properties for the expected use of the structure such as high strength and low permeability. Hence high performance concrete is not a special type of concrete. It comprises of the same material as that of the conventional cement concrete. The use of some mineral and chemical admixtures like copper slag and super plasticizer enhance the strength, durability and workability qualities to a very high extent. It is the concrete that has been designed to be more durable and if necessary, stronger than conventional concrete. High performance concrete mixtures are composed of essentially the same materials as conventional concrete mixtures but the proportions are designed, engineered, to provide the strength and durability needed for the structure and environmental requirements of projects.

MATERIAL USED

Fly ash

Fly ash is obtained as a by-product of the combustion of pulverized coal in thermal power plants. Fly ash exhibits pozzolanic activity.

Table 1 Physical Properties of fly ash

Sl. No.	Particulars	Values
1	Specific gravity	2.04
2	Fineness modulus	2.16
3	Consistency	29%
4	Initial setting time	110 minutes
5	Final setting time	235 minutes

Table 2 Chemical Composition of fly ash

Sl. No.	Chemical component	% of chemical component
1.	SiO_2	42
2.	Fe_2O_3	28
3.	Al_2O_3	22
4.	CaO	2
5.	MgO	1
6.	K_2O	1.30
7.	Na_2O	0.30
8.	SO_3	1

Copper slag

Copper slag is an abrasive blasting grit made of granulated slag from metal smelting processes (also called iron silicate).It is a by-product obtained during the manufacture of copper in copper industries. Copper slag used in this project is the waste generated from Sterlite industries (India) Ltd, Tuticorin which produces annual average of 8 Lakh tons of copper. The presence of silica is about 26% which is desirable since it is one of the constituents of the natural fine aggregate used to normal concreting. Al2O3, SiO2, Fe2O3, about 95% have good potential to produce high pozzolanic quality.

COPPER SLAG

Table 3 Physical properties of copper slag

Particle shape	Irregular
Appearance	Black & Glassy
Type	Air cooled
Specific gravity	3.91
Percentage of voids %	43
Bulk density g/cc	2.08
Fineness modulus of copper slag	3.47
Water absorption %	0.15 to 0.20

Table 4 Chemical composition of copper slag

Sl. No	Chemical component	% of chemical component
1.	SiO_2	25.84
2.	Fe_2O_3	68.29
3.	Al_2O_3	0.22
4.	CaO	0.15
5.	Na_2O	0.58
6.	K_2O	0.23
7.	LoI	6.59
8.	Mn_2O_3	0.22
9.	TiO_2	0.41
10.	CuO	1.20
11.	SO_3	0.11
12.	Sulphidesulphur	0.25
13.	Insoluble residue	14.88
14.	Chloride	0.018

Super plasticizers

The new generation super plasticizer- 400 was used.

- Colour - Brown
- Type - Liquid
- Specific gravity - 1.175 at 300
- Storage condition - in cool dry place shelf life - 1 year

CONTROL MIX DESIGN

The mix proportion were designed as per I.S.10262-2009, 1:1.23:2.19:0.38 (cement: fine aggregate: coarse aggregate: water) by weight of cement was used throughout.

Table 5 Partial Replacement Details

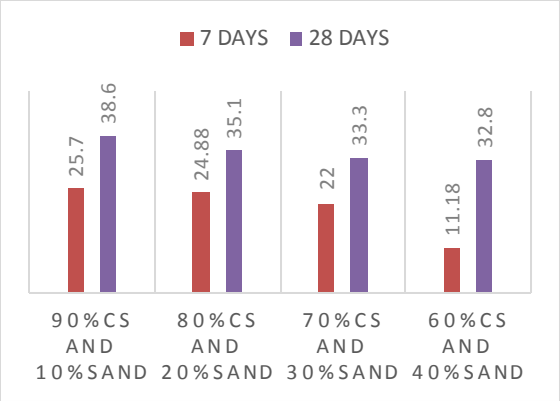
S.no	Mixing details	Mix ratio	Partial replacement of fly ash		Partial replacement of fine aggregate		Super plasticizer %
			Fly Ash %	OPC %	Fine aggregate %	Coppes r slag %	
1	CONTROL	M1	0	100	100	0	0
2	BINARY CEMENT MIXERS	M2	20	80	10	90	0.2
		M3	20	80	20	80	0.2
		M4	20	80	30	70	0.2
		M5	20	80	40	60	0.2

RESULTS

Compressive Strength

Test result of cubes and cylinders after partial replacement of copper slag and fly ash.

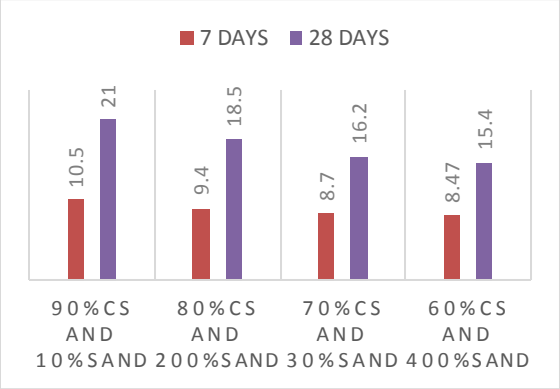
Fig 1 Cube compressive Strength for M30 Grade



Split tensile Strength

Test result of cylinder after partial replacement of copper slag and fly ash.

Fig 2 Split Tensile Strength for M30 Grade



CONCLUSION

Replacement of Copper Slag with fine aggregate has an important effect on the compressive strength of concrete under normal curing. The concrete mix with 90% copper slag (M2) shows an improved compressive strength and the strength goes on decreasing with 80%(M3),70%(M4),60%(M5) replacement of sand by copper slag and Cement (OPC) by fly ash (20%) at 7 days and 28days. The addition of super plasticizer increases the workability of the concrete mix. The increase in curing period increases the strength of concrete specimens at 7 and 28 days.

The use of copper slag is experimentally found that it reduces the amount of water content required for the concrete mix. Since the self-weight of the copper slag is comparatively higher than sand and hence it increases the strength of the concrete. It is found that the compressive strength of concrete decreases as the percentage of fly ash increases. The mix ratio (M2) 90% replacement of copper slag with fine aggregate and 20% replacement of fly ash with cement gives better result.

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