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A Study on the Strength and Durability of Concrete with Partial Replacement of Cement by Fly Ash and Fine Aggregates by Copper Slag

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***Abstract*— *The environment problems are very common in India due to generation of industrial by products. Concrete is a composite construction material composed mainly of cement, fine aggregate, coarse aggregate and water. Fly ash is used as a supplementary cementitious material (SCM) in the production of portland cement concrete. A supplementary cementitious material, when used in conjunction with portland cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity. Copper slag is a by-product material produced from the process of manufacturing copper. To produce every ton of copper, approximately 2.2–3.0 tons copper slag is generated as a by-product material. In this project control mix is casted for M25 grade and the Fly Ash as cement replacement in range of 10%, 20% and 30% by weight of cement and the Copper Slag as fine aggregate replacement in 20%, 30%, 40% and 50% by weight of fine aggregate and the cubes are tested for compressive strength. The obtained results are compared with M25 grade conventional concrete. Durability properties like alkali resistance, salt resistance and sulphate resistance are determined.*

***Keywords*— *Fly ash, copper slag, compressive strength, alkali resistance, salt resistance, sulphate resistance and durability.*

I. Introduction

Concrete is a widely used construction material around the world, and its properties have been undergoing changes through technological advances. Many materials are used to manufacture good quality concrete. It is a construction material composed of cement as well as other cementations materials such as fly ash, cement, aggregate, water, and chemical admixtures. Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete, since it binds the aggregates and resists the atmospheric action. Most of the properties of concrete depend on cement. Cement is manufactured by calcining argillaceous and calcareous materials at a high temperature. During this process, large amount of CO_2 is released in to the atmosphere. It is estimated that the production of one ton of cement results in the emission of 0.8 ton of CO_2. The reduction in the consumption of cement will not only reduce the cost of concrete but also the emission of CO_2.

Fly ash is used as a supplementary cementitious material (SCM) in the production of portland cement concrete. A supplementary cementitious material, when used in conjunction with portland cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity. A pozzolan is defined as a siliceous or siliceous and aluminous material that in itself possesses little or no cementitious value, but that will in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds having cementitious properties.

Copper slag is a by-product material produced from the process of manufacturing copper. To produce every ton of copper, approximately 2.2–3.0 tons copper slag is generated as a by-product material. As the copper settles down in the smelter, it has a higher density, impurities stay in the top layer and then are transported to a water basin with a low temperature for solidification. The end product is a solid, hard material that goes to the crusher for further processing. This paper examines the possibility of using replacement of cement with fly ash and fine aggregate with copper slag.

II. Scope

- To improve strength and durability properties of concrete by replacement of fly ash and copper slag.
- Fly ash as waste product and it can contribute to environmental pollution control.
- Copper slag as a cheap waste material, to reduce the cost of construction.
- Copper slag can be used in place of sand during construction.

III. Objective

- To determine the mix design of M25 grade concrete.
- To determine the fresh, hardened and durability properties of M25 concrete.
- To determine the fresh, hardened and durability properties of M25 concrete with cement replace by fly ash in various percentage and to find optimum.
- To determine the fresh, hardened and durability properties of M25 concrete with fine aggregate replace by copper slag in various percentage and to find optimum.

IV. Mix Materials

The materials used in the project should confirm certain properties which are given below.

A. Cement

Cement is the well-known building material with adhesive and cohesive properties, which is capable of binding mineral fragment into compact mass. Ordinary Portland cement 53

Jinson Markose and Sreeja S, "Study on the strength and durability of concrete with partial replacement of cement by fly ash and fine aggregates by copper slag," *International Research Journal of Advanced Engineering and Science*, Volume 2, Issue 2, pp. 183-187, 2017.

Grade with properties as give in table has been used in this experimental study.

TABLE I. Properties of cement.

Physical Properties	Result
Specific gravity	3.15
Standard consistency	34 %
Initial Setting Time (min)	120

B. *Fly Ash*

Fly ash is used as a supplementary cementitious material (SCM) in the production of portland cement concrete. A supplementary cementitious material, when used in conjunction with portland cement, contributes to the properties of the hardened concrete through hydraulic or pozzolanic activity.

TABLE II. properties of fly ash.

Physical Properties	Result
Specific gravity	2.1

C. *Fine Aggregates*

Aggregates mainly passing through 4.75 mm IS sieve and and retained on 75 microns IS sieve is permitted for fine aggregates. Aggregates conforming to grading Zone II are used in this experimental work.

TABLE III. Properties of fine aggregate.

Properties	Result
Specific gravity	2.74
Water absorption %	1.5

D. *Coarse Aggregates*

Aggregate which passes through 75 mm IS sieve and retained on 4.75 mm IS sieve is used as coarse aggregate. Coarse aggregates containing flat, elongated or flaky pieces should be rejected. Aggregates conforming to grading Zone II are used in this experimental work.

TABLE IV. Properties of coarse aggregate.

Properties	Result
Specific gravity	2.74
Water absorption %	0.8

E. *Copper Slag*

Copper slag is a by-product material produced from the process of manufacturing copper. To produce every ton of copper, approximately 2.2–3.0 tons copper slag is generated as a by-product material.

TABLE V. Properties of copper slag.

Physical Properties	Result
Specific gravity	3.5
Water Absorption	0.38
Fineness Modulus	3.11

F. *Water*

Water used for the study was free of acids, organic matter, suspended solids, alkalis and impurities when present may have adverse effect on the strength of concrete. Potable water with Ph value 7 conforming to IS: 456-2000 is used for casting as well as curing.

V. MIX PROPORTION

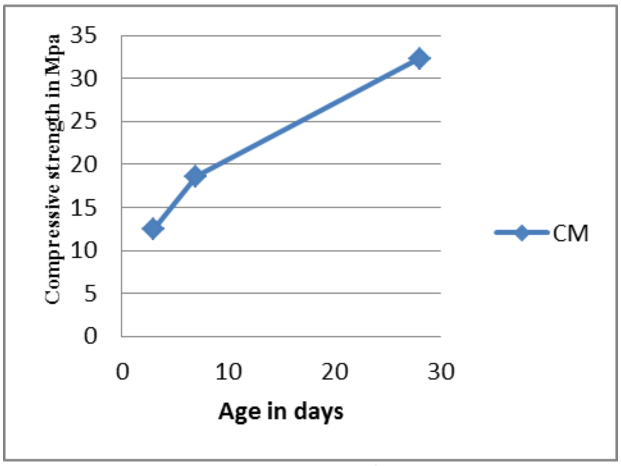
For concrete of compressive strength greater than M55, design parameters given in the Indian standard may not applicable and the values may be obtained from specialized literatures and experimental results. The Nomenclature for mixes used in the study is given in table VI.

TABLE. VI. Nomenclature

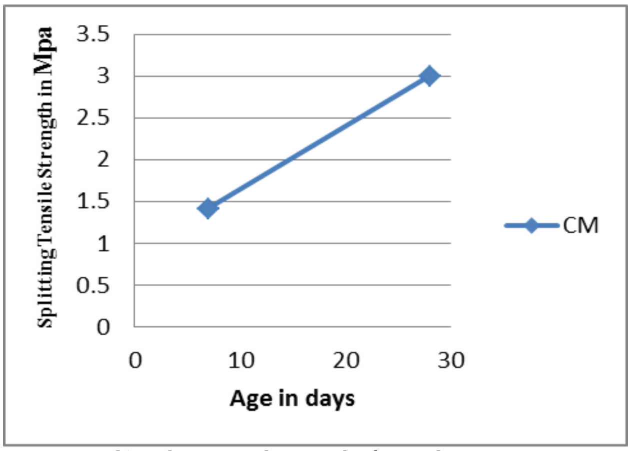
Mix Designation	Description
CM	Conventional Mix
Fly Ash	Concrete mix with 10% replacement of cement with Fly ash
Fly Ash	Concrete mix with 20% replacement of cement with Fly ash
Fly Ash	Concrete mix with 30% replacement of cement with Fly ash
Copper Slag	Concrete mix with 20% replacement of fine aggregate with Copper slag
Copper Slag	Concrete mix with 30% replacement of fine aggregate with Copper slag
Copper Slag	Concrete mix with 40% replacement of fine aggregate with Copper slag
Copper Slag	Concrete mix with 50% replacement of fine aggregate with Copper slag

VI. EXPERIMENTAL RESULTS

A. *Control Mix*

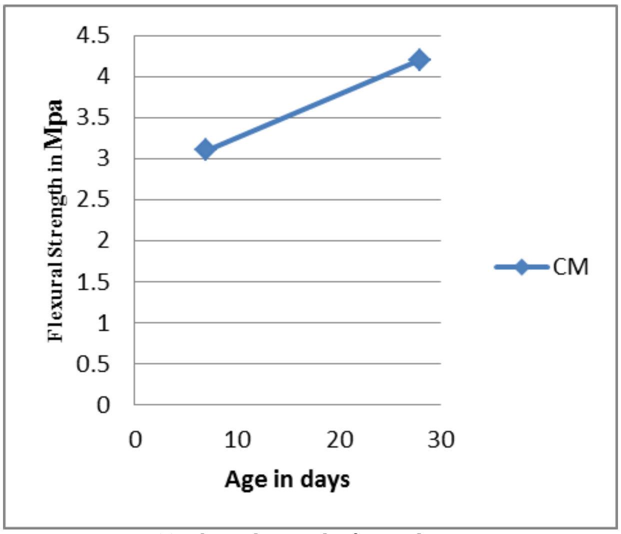


(a). Compressive strength of control mix.



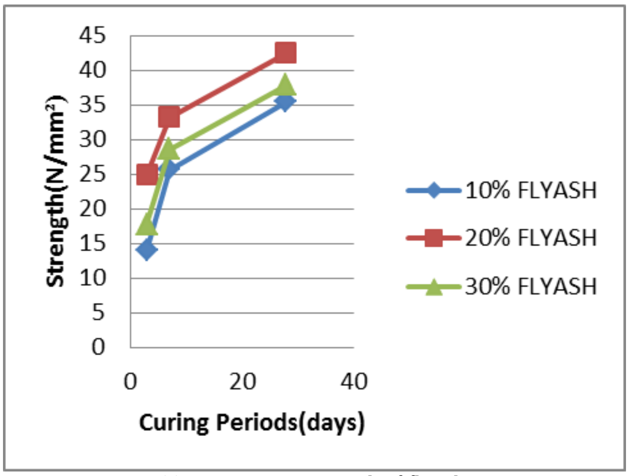
(b). Splitting tensile strength of control mix.

Jinson Markose and Sreeja S, "Study on the strength and durability of concrete with partial replacement of cement by fly ash and fine aggregates by copper slag," *International Research Journal of Advanced Engineering and Science*, Volume 2, Issue 2, pp. 183-187, 2017.

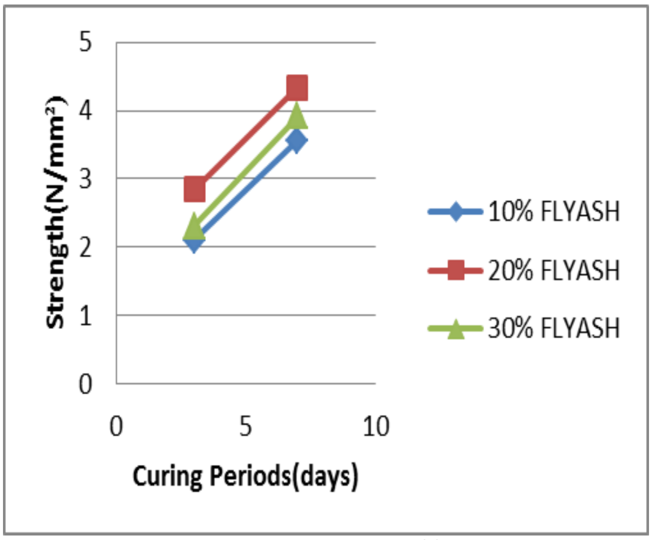


(c). Flexural strength of control mix.

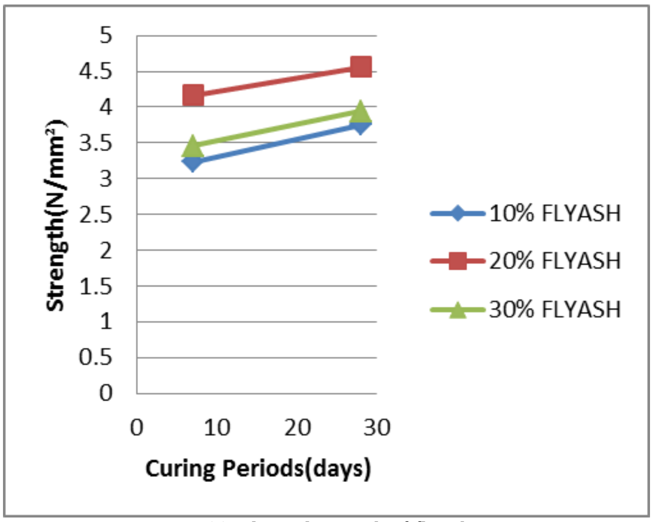
B. Mix with Partial Replacement of Cement with Fly Ash



(a). Compressive strength of fly ash.

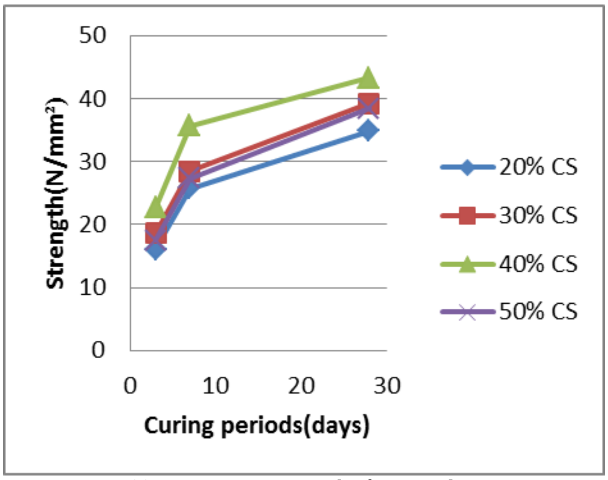


(b). Splitting tensile strength of fly ash.

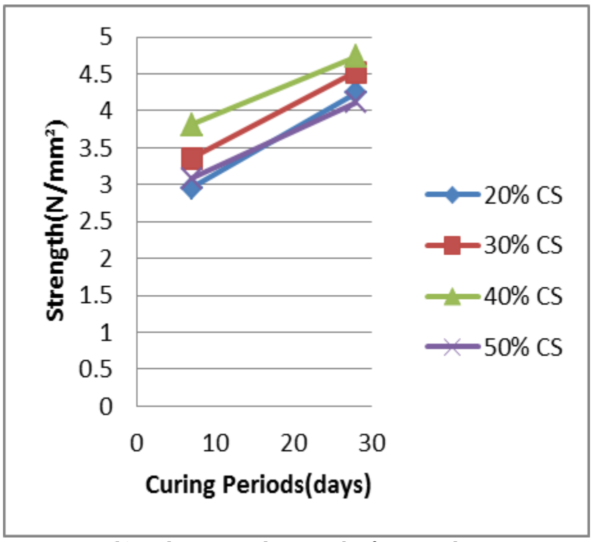


(c). Flexural strength of fly ash.

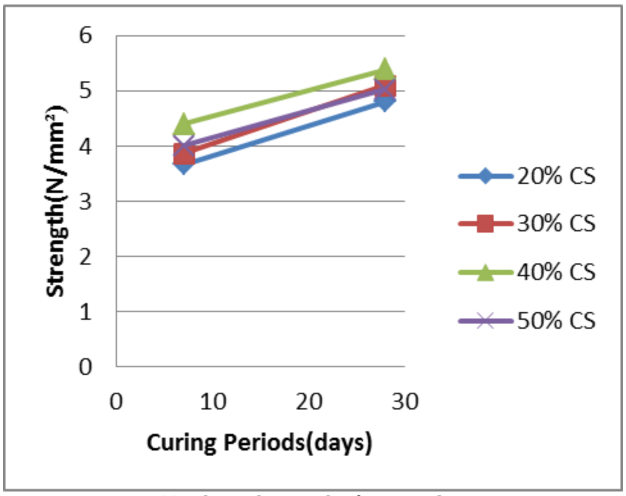
C. Mix With Partial Replacement of Fine Aggregate with Copper Slag



(a). Compressive strength of copper slag.

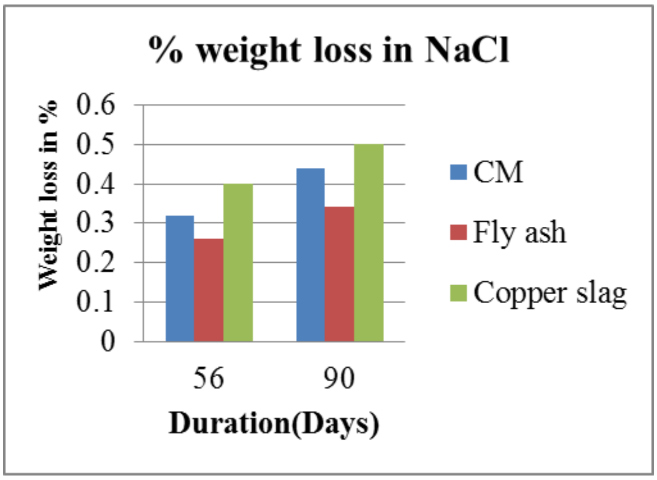


(b). Splitting tensile strength of copper slag.

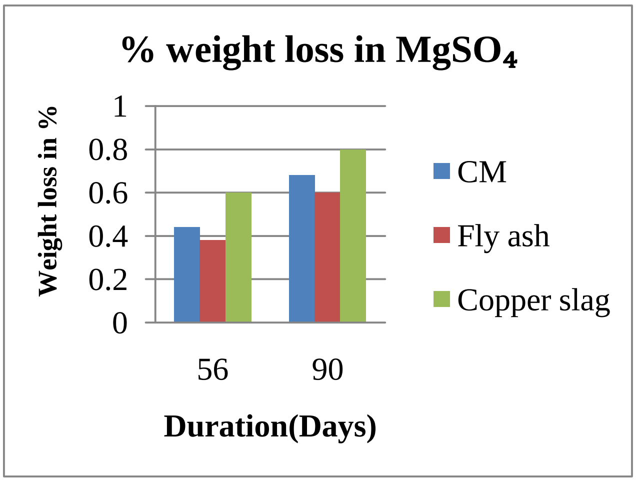


(c). Flexural strength of copper slag.

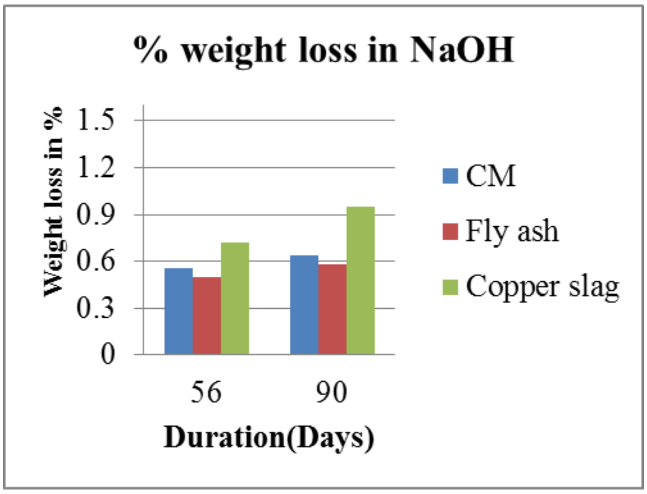
D. *Weight Loss (%) of Cube Dipped in Various Solutions*



(a). Immersed in sodium chloride solution.



(b). Immersed in magnesium sulphate solution.



(c). Immersed in alkali solution.

From the above results, it can be seen that it can be seen that fly ash improves the compressive strength and reached maximum containing 20% cement replacing fly ash. As the percentage replacement of cement with fly ash increases, the compressive strengths increase, reach a maximum value and then decrease. The maximum compressive strength obtained at 20% replacement was found to be 42.47 N/mm^2. It can be seen that it can be seen that copper slag improves the compressive strength and reached maximum containing 40% fine aggregate replacing copper slag. The maximum compressive strength obtained at 40% replacement was found to be 43.24 N/mm^2. So it is clear that in both the cases as the percentage increases more that the optimum the compressive strength decreases. From the figure weight loss % of cube dipped in various solutions such as sodium chloride, magnesium sulphate and alkali solution. This is due to deterioration of concrete. Weight loss is more sodium hydroxide solution than magnesium sulphate solution.

VII. CONCLUSION

Experiments were conducted by partial replacement of cement by fly ash and fine aggregate by copper slag. The study was carried out on M25 grade concrete. The following are the conclusions obtained.

- Compressive strength of M25 grade concrete increased with the replacement of cement with fly ash.
- The optimum percentage of fly ash is 20% due to improve workability and to increase the setting time of cement.
- The optimum replacement of fine aggregate with copper slag is found to be 40%, and to reduce cost of construction.
- Durability study it can be shown that loss of strength of 20% cement replacing fly ash less compared to conventional concrete.
- Durability study it can be shown that loss of strength and loss of weight of 40% fine aggregate replacing copper slag slightly increase Compared with conventional concrete.

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