Experimental Investigation on Fresh and Hardened Properties of Concrete with GGBS and Pond Ash

P. Dhanabal[1] R. Ajith Kumar[2]
[1]Assistant Professor [2]BE Student
[1,2]Department of Civil Engineering
[1,2]Mailam Engineering College, Mailam, India

Abstract— The purpose of this study is to find the extent of GGBS as a replacement material for cement and pond ash as a replacement material for fine aggregate in concrete without compromising the strength and durability of conventional concrete. The physical and chemical properties of GGBS and pond ash have been studied and it has been found that both the industrial wastes can replace the cement upto 50% and 30% respectively in concrete from literatures. Concrete mix design for M35 grade has been carried out with conventional ingredients. The specimens were tested for mechanical properties such as compressive strength, split tensile strength and flexural strength on 7, 28 days. After determining the properties of the concrete mixes, the optimum percentage replacement levels for GGBS and pond ash has been found and reinforced concrete beams were cast to study the flexural behaviour and cubes to study the durability properties of the optimized concrete mix. It has been found that the mechanical properties of the concrete are affected in short run but the same mechanical properties and durability found to be better than the conventional OPC based concrete.

Key words: Concrete, GGBS and Pond Ash

I. INTRODUCTION

Concrete is considered to be very durable material that requires little or no maintenance. Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure viz., buildings, industrial structures, bridges and highways etc., leading to utilization of large quantity of cement and fine aggregate. Portland cement, already being a very expensive material constitutes a substantial part of the total construction cost of any project and the situation has further been aggravated by the energy crisis, which has further increased the cost of production of Portland cement. Therefore, it is of current important for a country to explore and develop alternate cementing materials cheaper than the Portland cement.

Cement is the most important constituent of the concrete and occupies about 20% of the volume of concrete. The demand for concrete is an ever increasing scale, leading to higher cement production. But the production of cement releases equal amount of CO_2 in to the atmosphere leading to global warming.

The $Ca(0H)_2$ which appears due to the chemical reactions affect the quality of concrete adversely by forming cavities, as it is partly soluble in water and also lacks enough strength. The Ground Granulated Blast-Furnace Slag when used along with cement has positive effect on the $Ca(0H)_2$ compound. At the end of the secondary reaction between GGBS and $Ca(0H)_2$, hydration product such as C-S-H gel is formed.

A. Objective of the Study

- To study the properties of industrial wastes such as GGBS, pond ash and their suitability to partially replace cement and fine aggregate in concrete
- To study the behaviour as well as properties of concrete in fresh and hardened state.
- To study the effect of GGBS and Pond Ash on the workability of concrete.
- To study the structural behaviour of concrete made with industrial wastes.

B. Scope of the Study

Long term durability of concrete made with GGBS and pond ash will enhance the usage and boost the confidence of engineers in using this concrete. The permeability characteristics and soundness of concrete against sulphate and acid attack are essential to establish the durability of the concrete made with GGBS and pond ash

II. MATERIALS USED

A. Cement

Selection of type of cement mainly depends on the specific requirements of concrete. It determines the strength and properties of fresh and hardened concrete. The Cement used for all the specimens were ordinary Portland cement (53 grades) with a specific gravity of 3.12 and conforming to IS: 8112-2013.

B. Fine Aggregate

In the present investigation, normal river sand quarried from Cauvery river near Musiri town was used as a fine aggregate. The fine aggregate was screened to remove deleterious materials and tested as per procedure given in IS 2386 - 1963. The fineness modulus of sand is 2.69 and confirms to Zone II grading.

C. Coarse Aggregate

In the experimental work the coarse aggregates of nominal size 20mm and 12.5mm are blended in the ratio of 60% and 40% respectively and used so that the aggregates are well graded to give required workability, minimum paste content and maximum strength.

D. Pond Ash

The physical properties of pond ash were tested in the laboratory as per standard procedure. It has a specific gravity of 1.972 with fineness modulas of 2.39 . The chemical composition of the pond ash has been taken from the literatures

E. Ground Granulated Blast Furnace Slag

The GGBS used in this study was brought from Nandhi cements, Bangalore. The physical properties of GGBS used were found as per standard procedure and the findings the specific gravity in 2.98 with fineness modulas is 2.39

F. SUPERPLASTICIZER

A sulphonated naphthalene formaldehyde based super plasticizer commercially available under the brand name conplast SP430 has been used to get the required workability in fresh concrete in this experimental investigation.

G. Water

The water used for concrete making and curing was tap water available in the laboratory and free from all types of harmful chemicals, organic material, oil, chloride, silt and suspended materials confirming IS 456-2000. No test on the quality of water has been carried out as the water available in the laboratory is of drinking water quality

III. MIX DESIGN

A. Mix Design for M20 Concrete

The concrete mix is designed as per IS 10262 – 1982, IS 456- 2000 and SP 23 for the control concrete. The water cement ratio adopted is 0.38. The basic data employed for concrete mix design is given below

CEMENT	FA	CA	Water	W/C
420	641.46	1157.8	157.6	0.38
1	1.53	2.76	0.38	

Table 1: Mix Proportion of SCC

B. Fresh Properties

Workability of all the trail mixes were found using slump test and the values obtained are detailed in the Figure 1

C. Hardened Properties

1) Test Specimen:

The 150 mm size concrete cubes, 150mmX300mm cylinders and concrete beams of size 100 mm x 100 mm x 500 mm has been cast to determine the compressive strength, split tensile strength and flexural strength respectively (Fig.2 to Fig.6).

D. Fresh Properties of Concrete

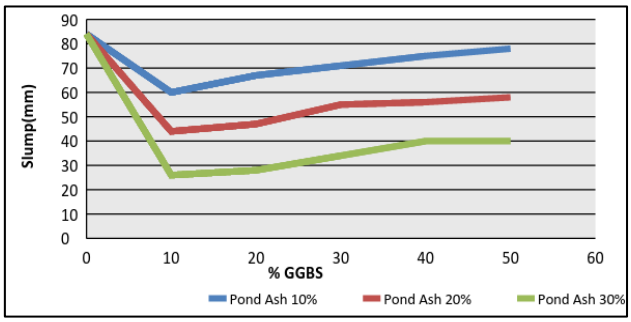

Fig. 1: Slump Value

E. Compressive Strength of Concrete

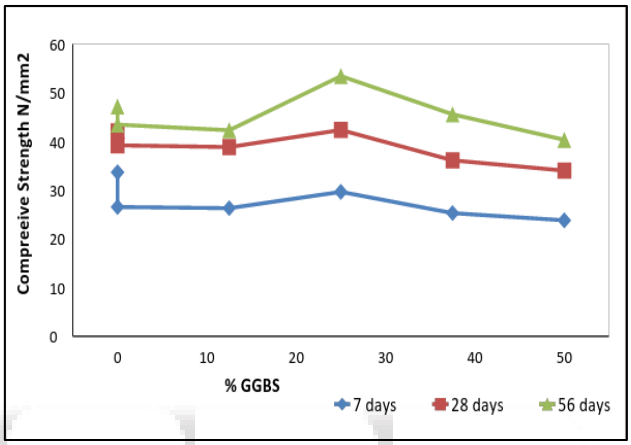

Fig. 2: Compressive Strength of Concrete with 10% Pond Ash

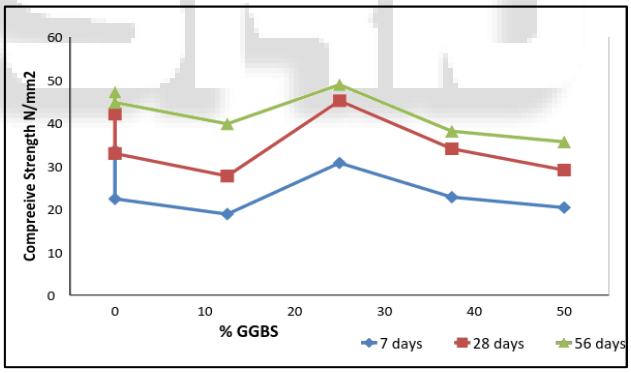

Fig. 3: Compressive Strength of Concrete with 20% Pond Ash

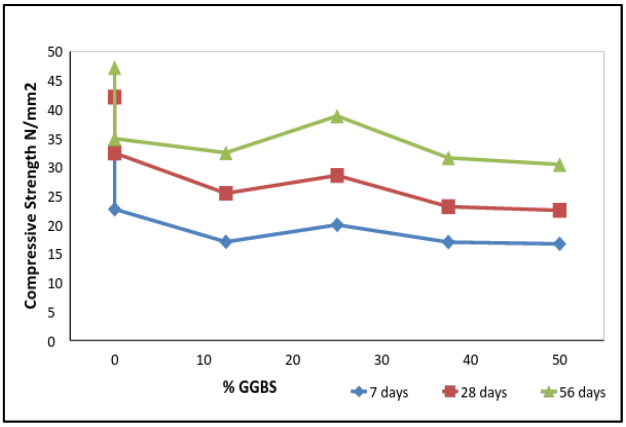

Fig. 4: Compressive Strength of Concrete with 30% Pond Ash

F. Split Tensile Strength of Concrete

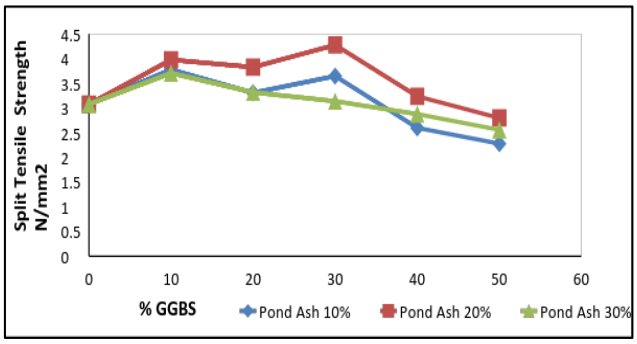

Fig. 5: Split Tensile Strength of Concrete

G. Flexural Strength of Concrete

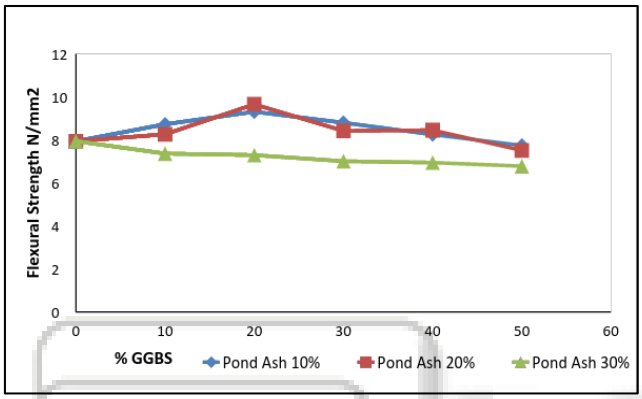

Fig. 6: Flexural Strength of Concrete

IV. CONCLUSION

1) Concrete mix with high proportions of pond ash as fine aggregate show very harsh mixing characteristics, demanding more water for the mix to satisfy workability criteria. Use of super plasticizer is essential to maintain the desired degree of workability
2) Addition of pond ash drastically reduces the workability of concrete mixes due to coarse nature of pond ash and high carbon content, whereas the addition of increased percentage of GGBS improves the workability of pond ash mixed concrete due to fineness of GGBS particles.
3) There is a reduction of compressive strength of concrete mixes at 28 days of curing for all the mixes due to low heat of hydration of GGBS and pond ash. The compressive strength of the mixes with GGBS upto 30% and pond ash upto 10% showed compressive strength more than control concrete. All other mixes failed to recover initial loss in early gain in strength.
4) The split tensile strength of concrete is not affected by pond ash. But when GGBS content goes beyond 30% the same is adversely affected.
5) The flexural strength of the concrete has been affected when GGBS content is more than 50% and pond ash content more than 30%.

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