STRENGTH & ACID RESISTANCE STUDY ON GEOPOLYMER CONCRETE BY REPLACEMENT OF FLY ASH WITH GGBS & PHOSPHOGYPSUM

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Abstract**—** Geopolymers are a new promising binder manufactured by activation of a solid alumino silicate source material with a highly alkaline activating solution and aided by heat. Fly ash, considered to be a waste material is rich in silica and alumina and hence can be used as a source material for manufacture of Geopolymers. These binders have been reported to achieve high early strength and better durability as compared to Ordinary Portland cement based counterparts**.**

This paper presents the progress of the research on making GeoPolymer Concrete with Flyash and mineral admixtures such as GGBS and Phosphogypsum. The paper reports results of experimental study on development of compressive strength and Acid resistance of Geopolymer concrete. In this study an attempt has been made to produce Flyash based GeoPolymer concrete with partial replacement of Flyash with GGBS and Phosphogypsum and study the strength and durability properties of produced Geopolymer concrete.

An experimental study was conducted to assess the compressive strength and acid resistance of Flyash based Geopolymer concrete specimens of size 150 X 150 X 150 mm having GGBS and Phosphogypsum as replacement from 0, 2.5, 5, 7.5, 10 % of Flyash . Acid Resistance is assessed by immersion of the above specimens in the solution of 5 % concentrated Sulphuric acid for a period of 30,60 and 90 days and evaluated the changes in weight and compressive strength at these intervals.

The visual appearance of specimens after exposure to Sulphuric acid solution showed that acid attack slightly damaged the surface of the specimen. The produced Geopolymer concrete sample showed less weight loss in Sulphuric acid and having more residual compressive strength at the end of test. Geopolymers blended with GGBS and Phosphogypsum are having higher compressive strength and resistance to Sulphuric acid.

***Keywords*-** Geopolymer, Flyash, Alkaline Liquids, GGBS and Phosphogypsum, Compressive Strength, Hydrochloric Acid, Weight loss, Residual Strength.

Introduction

Concrete, the predominantly used construction material in the world has gained its popularity because of its multiple benefits like relatively low cost of production, ease of handling, capacity to be moulded into desired shape, achievement of desired strength ranging from low to very high, serviceability and durability. The principal ingredient of concrete is cement, generally Ordinary Portland Cement (OPC) which acts as the binder and holds the aggregates intact. But unfortunately, OPC is found to be associated with some adverse effects on environment. The production of OPC is highly energy intensive and emits high amount of CO2 into the atmosphere which contributes significantly to the 'Green House' effect. Bhanumathidas & Mehta (2001) stated that the production of one tonne of cement consumes nearly about 1.5 tonnes of earth minerals and also one tonne of CO_2 is released into the atmosphere. The raw materials required for cement production are nonrenewable and are depleting at a rapid rate. But at the same time, a number of industrial and agro wastes with inherent cementitious properties are produced abundantly. But they are mostly disposed into landfills. Employing such byproducts as alternates for cement has various benefits including conservation of environment, sustainability of resources and solving the disposal problem of by-products. Particularly in India, with the ever growing demand for cement to after the rapidly developing constructions and infrastructure projects, the impact created by OPC on the environment is massive. Hence, there is an immediate necessity to control the usage of OPC by developing potential alternates for it. In that context, extensive researches are being carried out around the world in analysing the possibilities of using substitute materials for OPC concrete. One such alternative is 'geopolymer concrete' (GPC) which completely eliminates OPC in its production.

In 1978, Joseph Davidovits (1999) proposed that it is possible to produce binders resulting from the polymerization reaction between alkaline liquids and source materials that are rich in silica and aluminium. He coined the term 'geo-polymer' to describe this family of mineral binders that possess a chemical composition similar to zeolites but exhibiting an amorphous microstructure. Paloma et al (1999) suggested that pozzolanic materials like blast furnace slag can be activated with the help of alkaline liquids to produce binders which could completely replace OPC in concrete production. Contrasting to OPC concrete (OPCC), the principal binders in GPC are not calcium-silicate-hydrates (C-S-H). Instead, an alumino-silicate polymeric gel formed by tetrahedrally-bonded silicon and aluminium with oxygen atoms shared in between acts the binder. The two important constituents of GPC are source materials and alkaline liquids. The source materials must be rich in silicon (Si) and aluminium (Al). These could be of geological origin like metakaolin or by-product materials like fly ash, Silicafume(SILICAFUME), GGBS, rice-husk ash, etc. The alkaline liquids are based from soluble alkali metals usually being sodium or potassium. The most common alkaline liquid used is a combination of sodium or potassium hydroxide along with sodium or potassium silicate correspondingly.

I. Design of Class-F Fly Ash-Based Geopolymer Concrete Mixtures

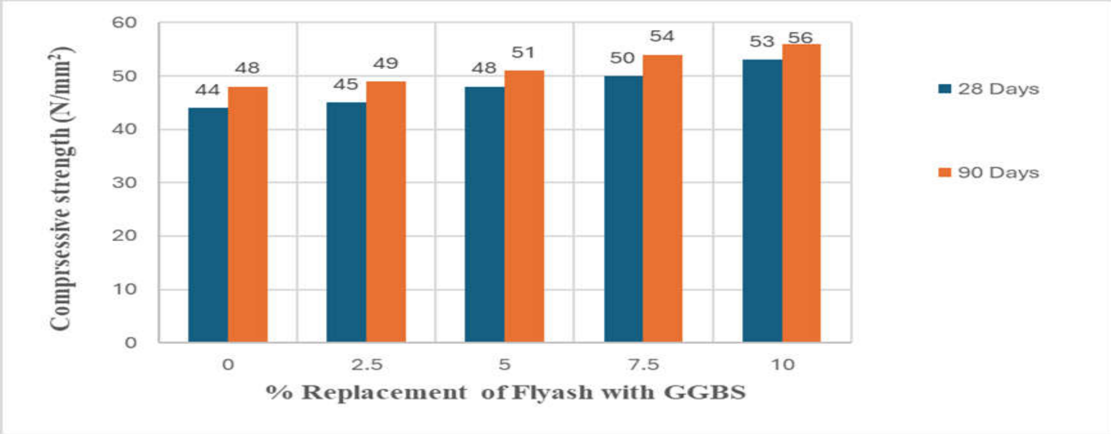
Water – to – geopolymer solids ratio, by mass	Workability	Design Compressive strength (wet-mixing time of 4 minutes, steam curing at 60^{0}C for 24 hours after casting), MPa
0.16	Very Stiff	60
0.18	Stiff	50
0.20	Moderate	40
0.22	High	35
0.24	High	30

TABLE-1- **Design of Class-F Fly Ash-Based Geopolymer Concrete Mixtures**

II. Compressive Strength of Geopolymer Concrete made by Replacement of Flyash with GGBS

Sl No	% Replacement	Compressive Strength (N/mm^2)	
		28 Days	90 Days
1	0	44	48
2	2.5	45	49
3	5	48	51
4	7.5	50	54
5	10	53	56

TABLE-2- **COMPRESSIVE STRENGTH OF GEOPOLYMER CONCRETE MADE BY REPLACEMENT OF FLYASH WITH GGBS**

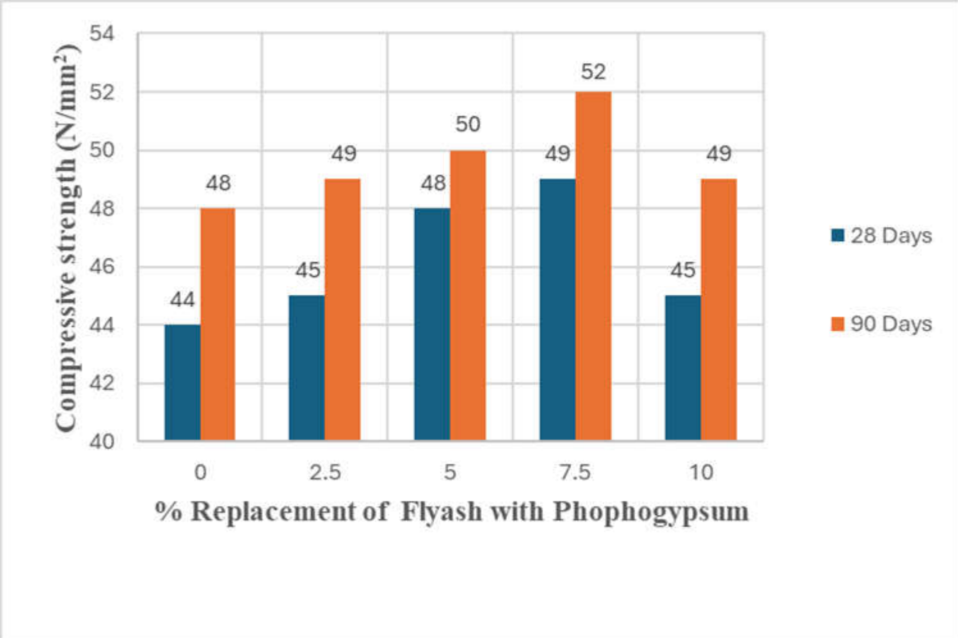


GRAPH-1- **COMPRESSIVE STRENGTH OF GEOPOLYMER CONCRETE MADE BY REPLACEMENT OF FLYASH WITH GGBS**

III.COMPRESSIVE STRENGTH OF GEOPOLYMER CONCRETE MADE BY REPLACEMENT OF FLYASH WITH PHOSPHOGYPSUM

Sl No	% Replacement	Compressive Strength (N/mm^2)	
		28 Days	90 Days
1	0	44	48
2	2.5	45	49
3	5	48	50
4	7.5	49	52
5	10	45	49

TABLE-3- **COMPRESSIVE STRENGTH OF GEOPOLYMER CONCRETE MADE BY REPLACEMENT OF FLYASH WITH PHOSPHOGYPSUM**

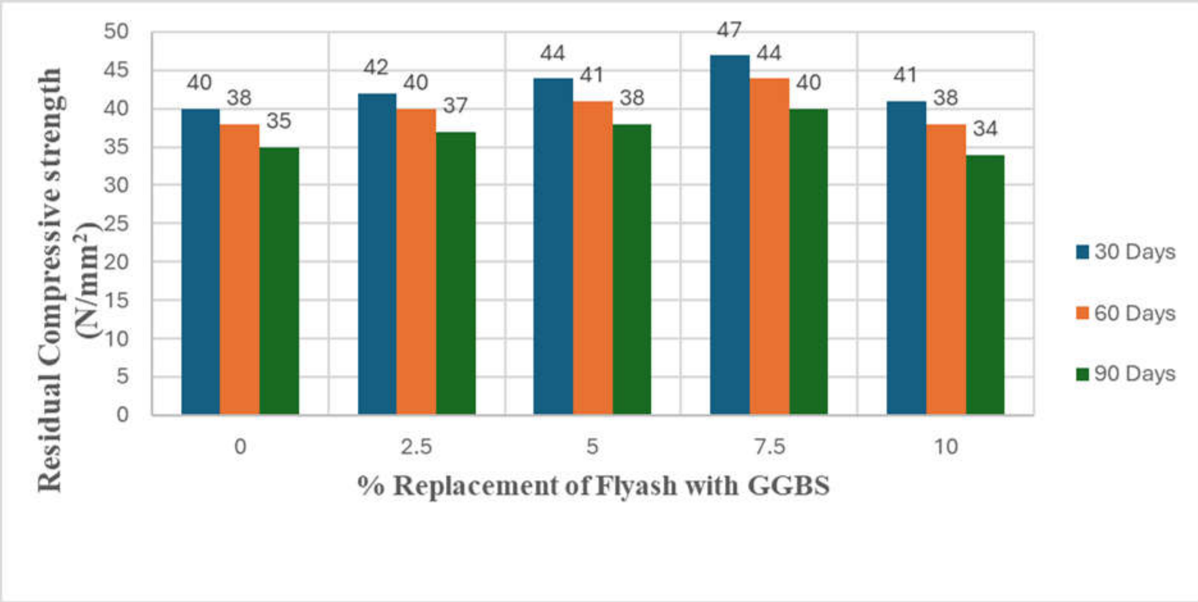


GRAPH-2- **COMPRESSIVE STRENGTH OF GEOPOLYMER CONCRETE MADE BY REPLACEMENT OF FLYASH WITH PHOSPHOGYPSUM**

IV. COMPRESSIVE STRENGTH OF GEOPOLYMER CONCRETE MADE BY REPLACEMENT OF FLYASH WITH GGBS

Sl No	% Replacement	Compressive Strength (N/mm^2)		
		30 Days	60 Days	90 Days
1	0	40	38	35
2	2.5	42	40	37
3	5	44	41	38
4	7.5	47	44	40
5	10	41	38	34

TABLE-4- **COMPRESSIVE STRENGTH OF GEOPOLYMER CONCRETE MADE BY REPLACEMENT OF FLYASH WITH GGBS**

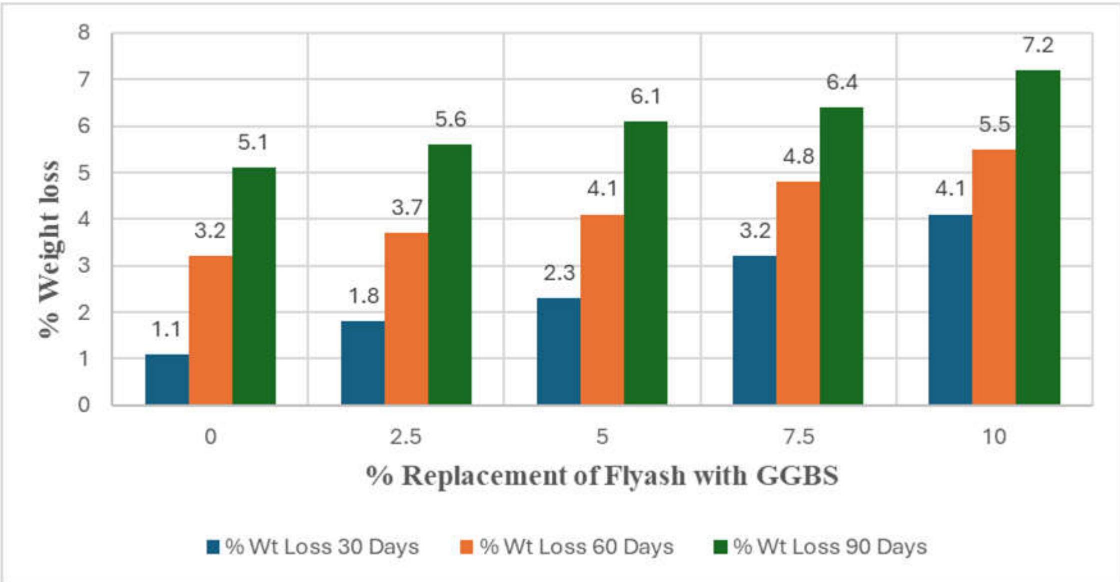


GRAPH-3- COMPRESSIVE STRENGTH OF GEOPOLYMER CONCRETE MADE BY REPLACEMENT OF FLYASH WITH GGBS

V. WEIGHT LOSS OF GEOPOLYMER CONCRETE MADE BY REPLACEMENT OF FLYASH WITH GGBS

Sl No	% Replacement	% Wt Loss		
		30 Days	60 Days	90 Days
1	0	1.1	3.2	5.1
2	2.5	1.8	3.7	5.6
3	5	2.3	4.1	6.1
4	7.5	3.2	4.8	6.4
5	10	4.1	5.5	7.2

TABLE-5- WEIGHT LOSS OF GEOPOLYMER CONCRETE MADE BY REPLACEMENT OF FLYASH WITH GGBS



GRAPH-4- WEIGHT LOSS OF GEOPOLYMER CONCRETE MADE BY REPLACEMENT OF FLYASH WITH GGBS

VI. CONCLUSIONS

The use of by products like Flyash, GBS and Phosphogypsum has gained significant importance because of the requirement of environmental protection and sustainable construction in future. On the basis of this study, the following conclusions can be drawn

1. GGBS and Phosphogypsum helps in increasing the mechanical properties on Geopolymer concrete.
2. The compressive strength of Flyash based Geopolymer concrete blended with GGBS and Phosphogypsum is higher than plain Geopolymer concrete.
3. Geopolymer concrete blended with GGBS showed gradual increase in compressive strength from 0 to 10%.
4. Geopolymer concrete blended with Phosphogypsum showed gradual increase in compressive strength up to 7.5% replacement of Flyash and then decreased.
5. The loss of weight when immersed in H_2SO_4 was observed higher in specimens blended with GGBS and Phosphogypsum compared to the normal Flyash based Geopolymer concrete.
6. The residual compressive strength at the end of 30,60 and 90 days has increased up to 7.5% and later decreased in case of Flyash based Geopolymer concrete blended with GGBS specimens.
7. In case of Phosphogypsum specimens residual compressive strength increased up to 5% replacement of Flyash and then decreased.
8. The specimens blended with GGBS and Phosphogypsum when exposed to acidic environment yeileded very low weight loss during initial stages and at later time intervals weight loss is more in case of both blended specimens.
9. By incorporation of GGBS and Phosphogypsum in Flyash based Geopolymer concrete as partial replacement showed better mechanical properties and better durability to acid attack.

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