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Study on Fly Ash Based Geo Polymer Concrete

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ABSTRACT

Geo polymers 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 Geo polymers. An experimental study was conducted to assess the acid resistance of fly ash based Geo polymer mortar specimens having percentage Na_2O ranging from 5% to 8% of fly ash. The program consisted immersion of specimens in solutions of 10% Sulfuric acid up to a period of 7 days and 28 days and evaluation of its resistance in terms of surface corrosion, changes in weight and compressive strength at regular intervals. Geo polymer mortar samples did not show any noticeable change in colour and remained structurally intact though the exposed surface turned slightly softer. Through Optical microscope, corroded surface could be seen which increased with duration of exposure. Samples almost lost its alkalinity after exposure in the acid solution and showed very low weight loss in the range from 0.81% to 1.64% in Sulfuric acid. Results obtained in the present study indicate that Geo polymers are highly resistant to Sulfuric acid.

Keywords: Fly ash, geo polymer, binder.

1. INTRODUCTION

Concrete is one of the most widely used construction materials; it is usually associated with Portland cement as the main component for making concrete. The global warming is caused by the emission of CO_2 greenhouse gases, such as CO_2, to the atmosphere by human activities. Among the greenhouse gases, CO_2 contributes about 65% of global warming (Mc Caffrey, 2002).

Inspired by the geo polymer technology and the fact that fly ash is a waste material abundantly available, in 2001, the geo polymer Concrete Research Group at Curtin University of Technology commenced a comprehensive research programme on 'Study on Fly Ash-Based Geo polymer Concrete'.

The first part of this research studied the development of mixture proportions, the manufacture of fly ash-based geo polymer conrete, the effect of main parameters on the short-term engineering properties of fresh and hardened concrete. For using fly ash as the main raw material is driven by various factors:

(a) It is cheap and available in bulk quantities
(b) It is currently under-utilized except for its use as an additive in OPC
(c) It has high workability and
(d) It requires less water (or solution) for activation.

Need for the present study: It is evident from the present scenario that ordinary Portland cement is causing much of the environmental hazards such as, Increasing greenhouse gases, Enormous consumption of power for the manufacture of cement, Economic point of view.

So considering all above points there is a need to find some alternative material. Any material which contains silicon and aluminum in amorphous state can be a source of binding material, and Fly ash which contains this is considered to be a waste product which can be utilized effectively to overcome the effects caused by Ordinary Portland Cement.

Objective of the study: The objective of the present investigation is, to study the performance characteristics of the source materials, To study the flexural and compressive strength of geo polymer concrete, To study the durability properties of geo polymer concrete, To study the chemical composition of fly ash obtained from Thermal power station, Neyveli Lignite Corporation Limited.

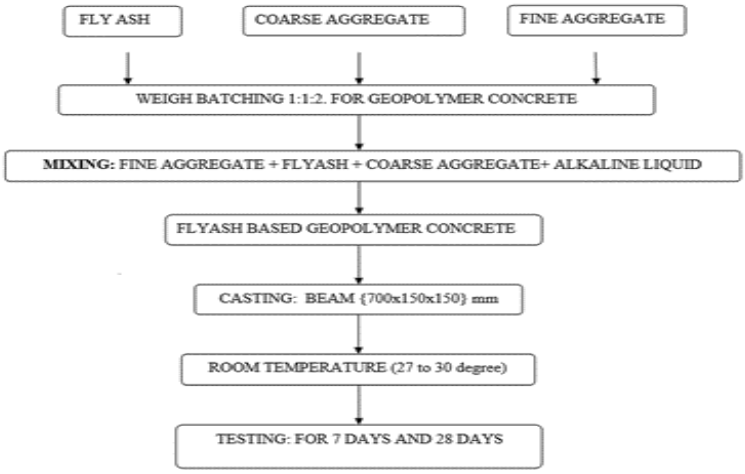
2. MATERIALS AND METHODS

Materials: Geo polymer concrete, Fly ash (Low calcium class F type fly ash), Alkaline liquid [Sodium hydroxide (97% purity in pure form)], Sodium silicate solutions, Coarse aggregate (20mm & 12.5mm), Fine aggregate (fineness modulus 2.6 - 2.8), Distilled Water.

Necessity of using Geo polymer: The application of Geo polymer technology in the mining, energy, construction and waste containment industries offers the opportunity to address a variety of sustainability issues currently experienced by these industries. These issues include, a) Converting by-products currently treated as wastes to useful and valuable, b) Products – from a cost to a new input in their own right, c) Enhancing product

features across the building materials market, d) Providing new long-term management options for a number of waste, e) Containment problems, particularly low level toxic wastes.

Methodology:



Experimental investigation:

Fly Ash: In the present experimental work, low calcium, Class F (American Society for Testing and Materials) dry fly ash obtained from the silos of Thermal Power Station, Neyveli Lignite Corporation Limited, Tamil Nadu, was used as the base material.

Table 1. Chemical composition of Lignite Fly ash

Characteristics	Fly ash (% wt)
Silica	35-59%
Iron oxide	0.5-2%
Aluminium oxide	20-33%
Calcium oxide	5-16%
Magnesium oxide	1-5.5%
Sulphates	0.5-1.5%
Loss on ignition	1-2%

Table 2. Physical Properties of low calcium class F Fly Ash

Physical properties	Properties of fly ash used	Properties of fly ash according to IS 1320-1981
Specific gravity	2.51	-
initial setting time	120 minutes	-
final setting time	280 minutes	-
Fineness specific surface in m^2/kg min	320	340
Lime reactivity avg compressive strength	4.00	6.200

Table 3. Physical Characteristics of Aggregates

Physical properties	Fine aggregate (sand)	Coarse aggregate (12.5 mm down)
Specific gravity	2.60	2.61
Fineness modulus	2.78	-
Loose bulk density (kg/m^3)	1536	1290
Dry rodded bulk density (kg/m^3)	1640	1500

Preparation of sodium hydroxide solution with a concentration of 10 M: Total 20 litres of distilled water, NaOH solids 8 kg

Sodium Silicate Geopolymer concrete: Sodium hydroxide solution + Sodium Silicate Solution = 1:2.5 by weight (Total 35 kg)

Preparation of sodium hydroxide solution with a concentration of 8 M: Total 20 litres of distilled water, NaOH solids 6.4 kg

Table 4. Details of Geo polymer Concrete Mixtures

MIX No.	Aggregate		Fly ash (F) kg/m³	NaOH kg/m³	Na_2SiO_3 kg/m³	Water/Fly ash (W/F)
	Coarse	fine				
1	1016	767	315	86.56	216.41	0.44
2	980	739	377	86.56	216.41	0.37
3	944	712	441	86.56	216.41	0.32
4	872.6	658	566	86.56	216.41	0.25

3. RESULTS AND DISCUSSION

From the above experimental investigation we got results of flexural strength of Geo polymer concrete beams 8 molarity and 10 molarity of sodium Hydroxide solution of alkaline solution were casted and tested after the 7 days of casting and 28 days of casting. The flexural strength of Geo polymer concrete beam for 7 days testing is mentioned in the table 5.1 for 8 molarity and10 molarity. The flexural strength of Geo polymer concrete beam for 28 days testing is mentioned in the table 5.2 for 8 molarity and 10 molarity.

Table 5. Flexural strength test results at 28 days for Beam 700X150X150mm

	Specimen	Flexural strength N/mm²	Avg. flexural strength N/mm²
8M	Sample 1	2.24	2.41
	Sample 2	2.37	
	Sample 3	2.64	
10M	Sample 1	3.82	3.79
	Sample 2	3.73	
	Sample 3	3.82	

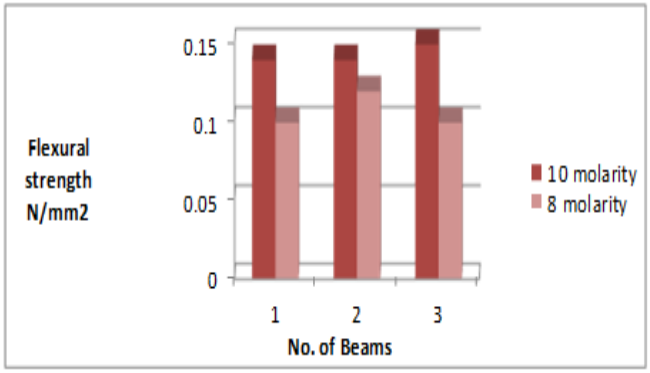


Figure 1. Chart of Flexural Strength of Geo polymer Concrete Beam for 28 Days

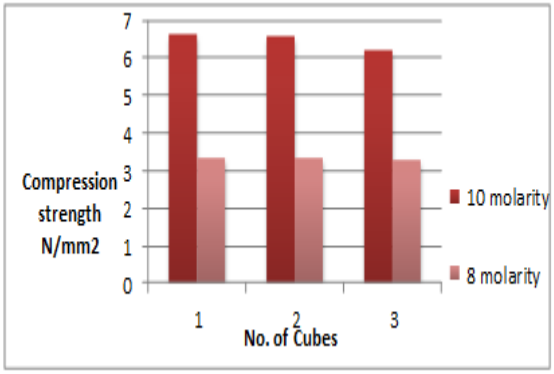


Figure 2. Chart of Compressive Strength for Acid Resistant Test of Geo polymer Conrete Cubes for 28 Days

From the above experimental investigation we got results of compressive strength for acid resistant test of Geo polymer concrete cubes 8 molarity and 10 molarity of sodium Hydroxide solution of alkaline solution were casted and tested after the 7 days of casting and 28 days of casting. The compressive strength for acid resistant test of Geo polymer concrete cubes for 7 days testing is mentioned in the table 5.3 for 8 molarity and10 molarity. The compressive strength for acid resistant test of Geo polymer concrete cubes for 28 days testing is mentioned in the table 5.4 for 8 molarity and 10 molarity.

Table 6. Compressive Strength for Acid Resistant Test results at 28 days for Cube 150X150X150mm

	Specimen	Compressive strength N/mm²	Avg. compressive strength N/mm²
8M	Sample 1	3.37	3.34
	Sample 2	3.35	
	Sample 3	3.30	
10M	Sample 1	5.24	5.41
	Sample 2	5.37	
	Sample 3	5.64	

From the above experimental investigation we got results of compressive strength of Geopolymer concrete cubes 8 molarity and 10 molarity of sodium Hydroxide solution of alkaline solution were casted and tested after the 7 days of casting and 28 days of casting. The compressive strength of Geopolymer concrete cubes for 7 days testing is mentioned in the table 5.5 for 8 molarity and10 molarity. The compressive strength of Geopolymer concrete cubes for 28 days testing is mentioned in the table 5.6 for 8 molarity and 10 molarity.

Table 7. Compressive Strength for Curing test results at 28 days for Cube 150X150X150mm

	Specimen	Compressive strength N/mm^2	Avg.compressive strength N/mm^2
8M	Sample 1	10.12	10.65
	Sample 2	11.23	
	Sample 3	10.61	
10M	Sample 1	13.54	14.05
	Sample 2	14.00	
	Sample 3	14.61	

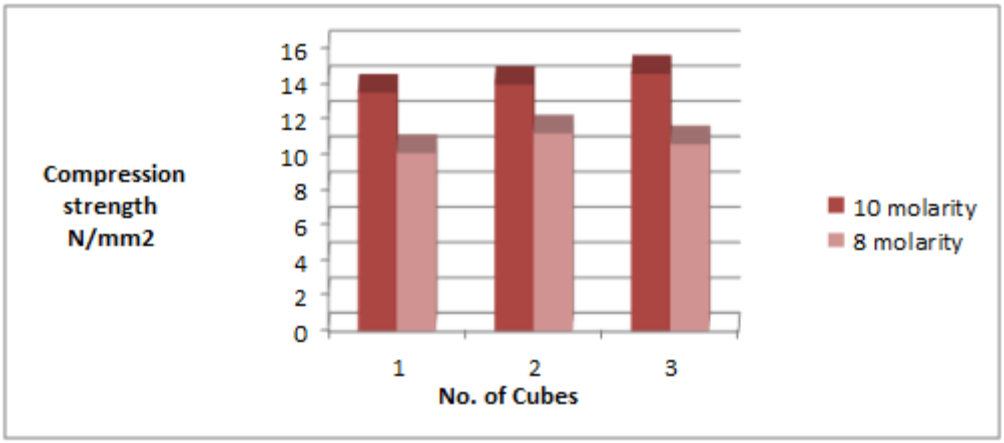


Figure 3. Chart of Compressive Strength for Curing of Geopolymer Concrete Cubes for 28 Days

4. SUMMARY AND CONCLUSIONS

This chapter presents a detailed summary and important conclusion that were drawn from the project. After arriving the conclusions of the project, some economic benefits of using Geopolymer concrete for masonry works involving cubes, blocks are being furnished. With the information available about the Geopolymer concrete from the literature surveying and from the past researches done on this topic. The mixture proportion was selected so as to have a balanced workability and strength. The mixing was done manually. The compaction was done by mechanically and testing was done for compressive strength.

Conclusion: The construction industry is in demand of ecofriendly & greener materials which are durable. As compared to the existing concrete materials, fly ash is advantageous but its uses as tested against strength & durability needs to be confirmed. The present project work emphasis on the research & development activity in construction materials using fly ash with geopolymers.The project work revels with preparation of test samples of fly ash with geopolymers of different molarities such as 8,10.

Tests for flexural strength, compressive strength, acid resistant test and curing of test specimen are carried out on samples as above for ambient temperature (A.T) for 7 & 28 days, as per prevailing standards for respective properties. The details of the results are summarized as under.

- As higher concentration in terms of molar of solutions, results in higher flexural strength of fly ash based geopolymer concrete.
- It is identified that, there is considerable increase in loss of strength only with Flyash replacement.
- It is observed that, when quantity of sodium silicate & sodium hydroxide is reversed by mass, it is observed that compressive strength increases as increase in molarity.
- It is observed that, compressive strength is more for oven drying as compare to specimen left in ambient temperature.

Economical benefits: The cost of one ton of fly ash is only a small fraction otherwise negligible also in some place. When compared with bricks and OPC concrete beam with the Geopolymer beam, the Geopolymer concrete uses only waste materials from the chemical industry and power plants, which materials unless otherwise utilized may become harmful. More over the usage of waste is highly reduced which makes it more cheaper than conventional OPC concrete products.

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