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STRENGTH PROPERTIES OF FLY ASH BASED GEOPOLYMER CONCRETE WITH & WITHOUT GLASS FIBERS

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ABSTRACT

This present work aims at studying the compressive strength behavior of geopolymer concrete with and without addition of glass fibers at different curing regimes, and also at different Molarities of Alkaline liquids .It consists of fly ash, alkaline liquids and glass fibres. Alkaline liquid to the flyash ratio as 0.45 and also replacing cement by100% fly ash. Compressive strength is determined at 24hrs, 48hrs and 96hrs by oven curing at temperature 60ºc and comparing these results by adding glass fibres as 0.04% by volume of GPC concrete

Keywords: Geopolymer- compressive strength-alkaline liquids-glass fibers

I. INTRODUCTION

It is a well know fact that cement production depletes significant amount of natural resources and releases large volume of CO_2.Cement production is also highly energy intensive after steel and aluminum. On the other hand coal burning power generation plants produce huge quantities of fly ash. Most of the fly ash is considered as waste and dumped in landfills.

In order to address the issues mentioned above it essential that order forms binders must be developed to make concrete. The Geopolymer technology offers an attractive solution to address the problem. The present work embraces the concept of geopolymers to make fly ash based geopolymer concrete.

In Geopolymers the polymerization process involves a chemical reaction under highly alkaline conditions on Al-Si minerals yielding Si-O-Al-O bonds.The chemical composition of geopolymers similar to Zeolite, but shows an amorphous Micro-Structure. The structural model of geopolymer material is still under investigation; hence the exact mechanism by which geopolymer setting and hardening occur may consists of dissolution, transportation or orientation and polycondensation and takes place through and exothermic process.

The strength of geopolymer depends on the nature of source materials. Geopolymers made from calcinated sour materials, such as metakaoline (calcinated kaoline, Fly ash, slag etc, yield higher from non-calcinated materials, such as Kaoline clay. The source are combination of sodium ore, potassium silicate and sodium ore, Potassium Hydroxide has been widely used as alkaline activator.

There are two main constituents of geopolymers, namely the **source materials and the alkaline liquids**. The source materials for geopolymers based on alumina-silicate should be rich in silicon (Si) and aluminum (Al), These should be natural minerals such as kaolite,clays etc.Alternatively ,by-product materials such as flyash, silica fume, slag, rice-husk, red mud etc, could be used as source materials. The choice of materials for making geopolymers depends on factors such as availability, cost, type of application, and specific demand of the end users.

The alkaline liquids are from soluble alkali metals that are usually Sodium or potassium based. The most common alkaline liquid used in geopolymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate.

Several efforts are in progress to supplement the use of Portland cement in concrete in order to address the global warming issues. These include the supplementary cementing materials such as flyash, silica fume, granulated blast furnace slag, rice husk and metakaoline and development of alternate binders to Portland cement

Past studies reveal that several researchers have investigated the effect of inclusion of fibres in concrete consisting of either 100% cement or partial replacement of cement by fly ash. The present investigation is designed to evaluate the compressive strength properties of glass fibre reinforced Geopolymer Concrete Composites consisting of 100% Fly ash and with different molarities of alkaline liquids at different curing durations .

II. EXPERIMENTAL INVESTIGATION

The compressive strength of geopolymer concrete is determined by replacing 100% of cement by flyash and compare the obtained results by adding glass fibres of 0.04%(by volume of concrete) by varying the curing durations to obtain optimized grade of concrete.

III. MATERIALS:

Fly Ash

Fly ash used in the investigation was procured from KTPP Power plant (Kakatiya Thermal power plant) from Chelpur. This is collected from electrostatic precipitator. The silica content of flyash was estimated to be 96%.The fly ash passing from 90μ sieve was used throughout the experiment. The colour of fly ash is sandal wood colour. The Specific gravity of fly ash is 2.10

Table1: Chemical composition of fly ash (Mass %)

Oxides	**Percentage**
SiO_2	60.54
Al_2O_3	26.20
Fe_2O_3	5.87
CaO	1.91
MgO	0.38
K_2O+Na_2O	1.02
SO_3	0.23
Loss On ignition	2.0

Glass Fibres

The glass fiber used in the investigation is Anti crack HD with modulus of elasticity is 72Gpa, filament diameter 21μ, length of fiber is 12mm, and specific gravity of glass fiber is 2.4.

Alkaline Liquid

Alkaline liquid used in making geopolymer concrete is NaOH and sodium silicate (Na_2SiO_3) to act as a binders between fine aggregate, coarse aggregate and fly ash the Alkaline solutions are to be prepared at least 24hrs prior to their use.

Properties of Alkaline liquid

NaOH used in preparing GPC are of molarities 8M, 12M, 14M, and 16M.Molecular wt: 40gm/mol,Specificgravity:2.1

Sodium silicate

Sodium silicate used is having Na_2O=13.39% and Sio_2=30.39 (%by wt), Mole Ratio=2.36, Weight Ratio=2.28, specific gravity=1.54.

Fine Aggregates
Fineness modulus = 3.24 ; Bulk density=1.52g/cc
% of void ratio and porosity=38% ; Void ratio =0.62
Specific gravity=2.46

Coarse Aggregates

Coarse aggregate (10mm)
Fineness Modulus =7.27; Bulk density=1.38g/cc
%voids and porosity=51.169% ; Specific gravity=2.84

Coarse Aggregate (20mm)
Bulk density=1.402g/cc ; %voids and porosity=50.1% Specific gravity=2.18

Mix proportion:
Combined aggregates =1848kg/m^3
Low calcium fly ash=380.68kg/m^3
Sodium silicate solution =122.45kg/m^3
Sodium Hydroxide solution=48.85kg/m^3

Geopolymer concrete mix was produced by sodium silicate Solution with Sio_2/Na_2O ratio by mass=2.28, Na_20=13.39% Sio_2=30.39% and water=56.22% by mass is selected. The sodium hydroxide solids NaOH with 97-98%purity is purchased from commercial sources and mixed with water to make solution with concentration of NaOH 8M, 12M, 14M, 16M .This solution comprises of 26.2% NaOH solids and 73.83% water by mass.

The sodium hydroxide flakes were dissolved in distilled water to make a solution with a desired concentration at least one day prior to use. The fly ash and the aggregates mixed together in a pan for about three minutes. The sodium hydroxide solution and sodium silicate solutions were mixed together and then added to the materials and mixed for about four minutes, the slump of fresh geopolymer concrete was determined in accordance with slump test IS: 516-1959.After determination of slump, fresh concrete was cast into mould of 150mmx150mm cubes The specimens were compacted in three layers placing and tamping using a tamping rod. The specimens was wrapped with thin vinyl sheet to avoid loss of water then transferred to an oven set at a temperature of 60ºC and stored for 24hrs, After curing, the specimens were allowed to cool in air, and then de-moulded and kept in open air till the day of testing,. A total of 72cubes specimens of size 150mmx150mmx150mm were cast and compressive strength tests were performed for 28days on 200tons compression testing machine.

IV. RESULTS

Table 2: Compressive strength of GPC without glass fibers @ 60°C oven curing

Duration of curing	Molarity of alkaline liquids			
	8M	12M	14M	16M
24hrs	17.456	32.264	34.595	38.957
48hrs	31.392	34.988	40.984	44.907
96hrs	29.648	32.572	36.624	37.932

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Table3: Compressive Strength of GPC with glass fibers @ 60°C oven curing

Duration of curing	Molarity of alkaline liquids			
	8M	12M	14M	16M
24hrs	20.248	36.945	38.135	42.070
48hrs	29.648	39.886	43.442	45.850
96hrs	30.095	35.827	41.018	42.483

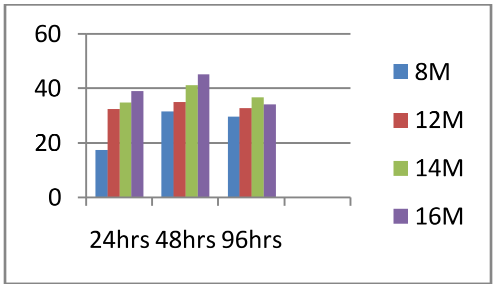

Figure 2: Variation of Compressive strength of GPC without glass fibers @ 60°C oven curing.

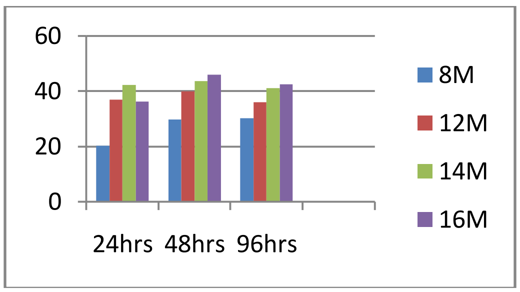

Figure3: Variation of Compressive strength of GPC with glass fibers @ 60°C oven curing

V. CONCLUSION

a. It is observed that as Molarity of the alkaline liquid increases compressive strength increases.
b. As curing time increases compressive strength increases up to 48hrs and then it decreases from 96hrs.
c. By addition of glass fibers it is observed that compressive strength increases by 6-8%.
d. A Reduction in bleeding is observed by addition of glassfibres in the glass fibre concrete mixes.
e. The maximum compressive strength in GPCC without glass fibers is observed to be 44.90MPa @16M of the alkaline liquids.and at 48 hours of curing
f. The maximum compressive strength in GPCC with glass fibers is observed to be 45.85MPa @16M of the alkaline liquids.and at 48 hours of curing

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