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Geopolymer Concrete A Ecofriendly Concrete

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Abstract: *Concrete became most popular material due to its low cost, versatility, availability of ingredients and excellent resistance to water and played significant role in development of the world for last one and half century but cement is the main ingredient for the concrete production. There are different sources of carbon di oxide emission during cement production. The largest source is combustion of fossil fuels to operate rotary kiln and other on is de-carbonation of limestone in the kiln during manufacturing of cement. The raw materials such as lime stone, clay and other minerals are required for the manufacture of cement, but quarrying of these raw materials is also causes environmental degradation. The climate change and environmental pollution is major problem of the world is facing today also responsible to the global warming. Therefore, to preserve the global environment from the impact of cement production then reduced the amount of Portland cement and replacing it with material which has lower manufacturing temperature. Also, to produce environmental friendly concrete, we have to replace the cement with the industrial by products such as fly ash and other geo-based materials. Thus the Geopolymer concrete is a good solution for producing an environmental friendly type of concrete. The geo-polymer concrete is one of the revolutionary developments related to novel materials resulting in low-cost and environmentally friendly material as best alternative to cement concrete. In this work cement is replaced with fly ash by 50%, 75% and 100% and alkaline solution which is the combination of sodium hydroxide and sodium silicate with different proportion i.e. 9M and 12M were used to determine compresive strength for M25 and M30 grade of concrete and compare with the conventional concrete. From the analysis it is observed that the Geopolymer concrete can be used under conditions similar to those suitable for ordinary portland cement concrete also, shows the good alternative to ordinary portland cement concrete.*

Keywords: Geo-polymer. sodium hydroxide, sodium silicate, Alkaline solution,Fly Ash, Compressive Strength

I. INTRODUCTION

Cement is the important material for the constructions. After water, cement is the most used material by the community. Concrete is durable construction material conventionally produced by using the ordinary Portland cement (OPC) as the binder, water, aggregates and additives with special proportion and become most popular material due to its availability of the raw materials over the world, also easy for preparing and fabricating in all sorts of conceivable shapes. More the consumption of concrete more is the requirements of cement production. Portland cement is produced by mixing selected raw materials (clay and lime) with a given proportion, grinding and heating it at 1500^0C.

But, ordinary portland cement concrete structures emits large amounts of carbon dioxide and contributing to 7% of world CO_2 emissions, which results the global warming. Global warming is a big challenge for earth. Portland cement industry is the major producers of carbon dioxide. A need of present status is to find alternative binder system to make concrete.

Around the globe from thermal power plants huge quantity of fly ash generated and generally used as a filler material in low level areas. Fly ash is the main by product created from the combustion of coal in coal-fired power plants. Alternative binder system with fly ash to produce concrete eliminating cement is termed as “Geo-polymer Concrete”. There are two main constituents of geo-polymers, which are the source materials and the alkaline solution. The alkaline solutions like Potassium hydroxide or sodium hydroxide solutions are use as alkali activators in different mix proportions.

The materials required for making geo-polymers depends on factors such as availability, cost, type of application, and specific demand. Fly ash contains silica and alumina which reacted with alkaline solution produced alumina-silicate gel that acted as the binding material for the concrete. Geo-polymer binders are used together with aggregates to produce geo-

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polymer concrete which are ideal for building and repairing infrastructures and for pre-casting units, because they have very high early strength, their setting time can be controlled and they remain intact for very long time without any need for repair. In this work 50%, 75% and 100% fly ash with alkaline solutions like sodium hydroxide and sodium silicate with different molarities i.e. 9M and 12M are use to find out compressive strength for M25 and M30 grade.

II. Aim of The Work

The aim of this work is to understand a potential mix design process for alkaline-activated fly ash geo-polymer concrete and to develop high strength geopolymer concrete. Within this research there is the acquisition of a large amount of experimental data, to be developed into a number of graphs, which will form the core of the process.

- The main aim of this work is to determine strength of concrete.
- To understand basic mix design of geo-polymer concrete with fly ash.
- To familiarize with making of geo-polymer concrete.
- To find the effect of varied concentration of alkaline solution on the strength of concrete.

III. Experimental Program

The work completed during the study of Geopolymer concrete was almost entirely practical experiment based. For the study 50%, 75% and 100% fly ash as a source material with alkaline solution which is combination of sodium hydroxide and sodium silicate with two different molarities i.e. 9 Molar and 12 Molar concentration of sodium hydroxide were used. The Sodium based solution were choose as comparative to potassium based solution, because potassium based solution is costlier than sodium based solution.

Ordinary Portland cement (OPC), grade 43 is used for the experimental work and the coarse aggregate used have a maximum size of 20 mm with grading confirming to IS-383-1970. The natural river sand passing through 4.75mm sieves is used. The design of concrete mix is done for M-25 and M-30 grades of concrete as per guidelines of IS 10262: 2009. The simple hand mixing method was employed for mixing of concrete.

The conventional method used in making of normal concrete is adopted for the making of Geopolymer concrete with fly ash. First coarse aggregate, fine aggregate and fly ash are mixed in dry condition for 3 to 4 minutes and then alkaline solution which is combination sodium hydroxide and sodium silicate solution is added to the dry mix. The mixing is done about 4 to 8 minutes for proper bonding of all materials. After the mixing, the cubes are casted by giving proper compaction. The sizes of the cubes are used are of size 150 mm x 150mm x 150mm. Then cubes are place in laboratory at room temp between 35^0-45^0c for 24 hours. As the only tests that were to be conducted within the scope of this research were standard compressive tests for 7day, 14day and 28days of curing.

IV. Material and It's Properties

4.1 Cement

In this work 43 grade cement is used with fly ash in different percentage i.e. 25%, 50% and 100%. The following table shows chemical properties of cement.

Oxides	Percentage
CaO	60-67
SiO_2	17-25
Al_2O_3	3.0-8.0
Mgo	0.1-0.4
Alkalies (K2O, Na2O)	0.4-1.3
SO_3	1.3-3.0

A. Fineness of Cement

Sr. No.	Wt. of sample (gm)	Wt. of residue (gm)	Fineness (%)	Avg. fineness
1	100 gm	8	8	6.5 %

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2	100 gm	6	6	
3	100 gm	8	8	
4	100 gm	4	4	

$$\text{Fineness of cement} = \frac{\text{Wt.of residue}}{\text{Wt.of sample}} \times 100$$

Fineness of cement=[8+6+8+4/4] = [26/4]
= 6.5 %

B. Consistency of Cement

Sr. No.	% of water	Quantity of water (ml)	Penetration (mm)
1	26	104	10
2	27	108	11
3	28	112	22
4	29	116	24
5	30	120	26
6	31	124	30
7	32	128	33

The consistency of the cement is found to be 32%.

C. Initial and Final Setting Time

The initial and final setting time is found to be 90 minutes and 270 minutes respectively.

4.2 Chemical Properties of Fly Ash

Sr. No	Test Conducted	Test Results
1	Silicon di oxide(SiO2) in percent by mass	57.40
2	Silicon di oxide(SiO2) + Aluminium oxide(Al2O3) + Iron oxide(Fe2O3) in percent by mass	87.06
3	Magnesium oxide (Mgo) content - %	0.56
4	Ferric Oxide (Fe2o3) content - %	4.55
5	Total alkalies as Sodium (Na2O) - %	0.19
6	Calcium Oxide (CaO) content - %	0.77
7	Alkalies aspotassium (K2O) - %	0.22

4.3 Physical Properties of Fly ash

Sr. No	Test Conducted	Test Results
1	CONSISTENCY	35.5
2	SPECIFIC GRAVITY(gm/cc)	2.34
3	FINENESS(Sq.m/kg)	596

A. Alkaline Solution

In this study, as the alkaline liquid, a combination of sodium hydroxide and sodium silicate was choosen. Sodium based solutions were choosen because they are economical than Potassium based solutions and easily available. Generally sodium hydroxide and sodium silicate are readily available in market in the form of gel and pellets. The sodium silicate solution is available in different grades and sodium hydroxide with 97-98% purity, in pellet form is commercially available. To make solution with required concentration the sodium hydroxide and sodium silicate have to dissolve in water. The concentration of sodium hydroxide solution can vary in range between 8 molar and 16 molar. Molecular weight of NaOH is 40 and NaOH solution with concentration of 9 molar consist of 360 gram of NaOH solids per liter of solution. In this work 9 and 12 molarity of sodium hydroxide solution is used.

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B. Tests on Coarse Aggregate

Tests Conducted	Test Result
Specific Gravity	2.858
Water Absorpion	0.92%
Impact Test	6.5%
Creshing Value Test	25.6%
Fineness Modulus	7.38%

C. Tests on Fine Aggregate

Tests Conducted	Test Result
Specific Gravity	2.672
Water Absorpion	1%
Fineness Modulus	3.07%
Bulk Density	1.4 Kg/Lit

V. METHODOLOGY

In the laboratory, the fly ash and the dry aggregates were first mixed for about three minutes. After the mixing of dry material i.e. aggregates and fly ash the liquid component of the mixture is added and the mixing continued usually for another four minutes. After addition of sodium silicate solution the geopolymerization process is starts. In this study concentration of NaOH solution is taken as 9M and 12M with ratio of Na2SiO3 / NaOH as 2 for M-25 and M-30 grades of concrete. The dimension of concrete specimen is 150 mm x 150 mm x 150 mm. The moulded concrete was demoulded after casting for 24 hours. The demoulded concrete specimens were cured. After curing process, the concrete specimens were tested for the compressive strength of the geopolymer concrete at the age of 7, 14 and 28 days.

VI. TEST AND RESULTS

6.1 Compressive Strength Test

The compressive strength of concrete is important and useful properties of concrete. In this experimental work the concrete cubes are casted for testing compressive strength for 50%, 75%, 100% fly ash with alkaline solution i.e. combination of sodium hydroxide and sodium silicate solution with different molarity i.e. 9M and 12M.

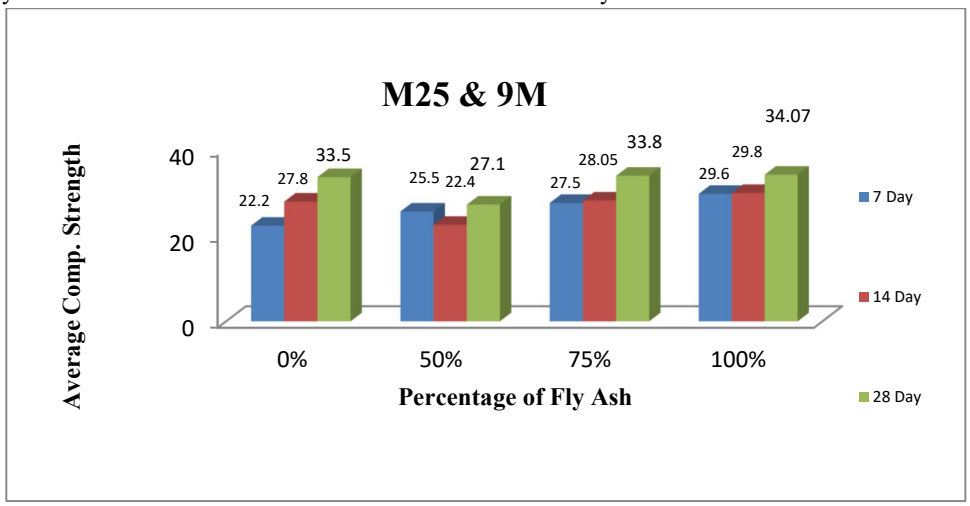

Fig. shows combine graph of 7, 14 and 28 day average compressive strength for M-25 grade of concrete with 09 molarity.

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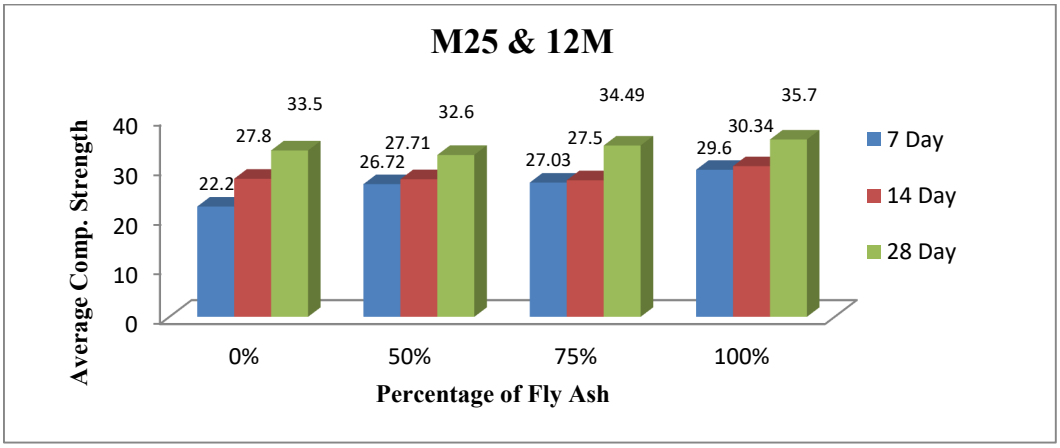

Fig shows combine graph of 7, 14 and 28 day average compressive strength for M-25 grade of concrete with 12 molarity.
From the results it is observed that the 7, 14 and 28 days compressive strength for M-25 grade and 9 molar solution is more than control mix by 33%, 7.19% and 1.7% respectively.
The compressive strength at 7,14 and 28 days for M-25 and 12 molar is more than control mix by 33%, 9.13% and 6.56% respectively.

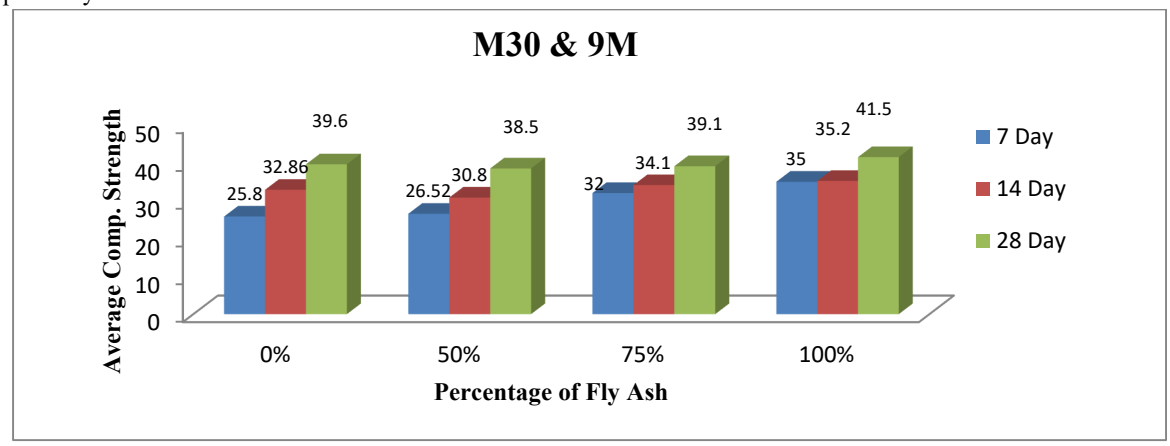

Fig shows combine graph of 7, 14 and 28 day average compressive strength for M-30 grade of concrete with 9 molarity.

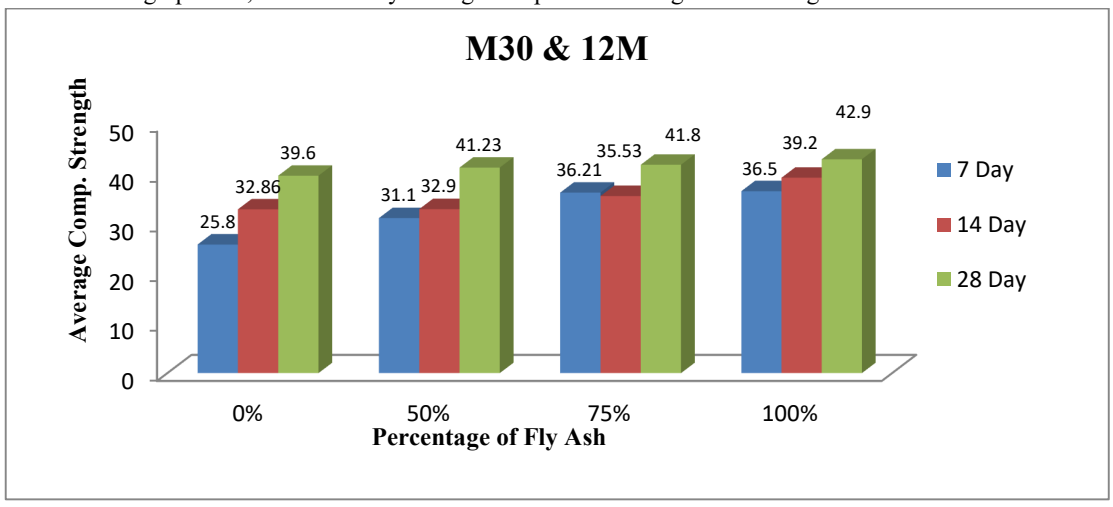

Fig shows combine graph of 7, 14 and 28 day average compressive strength for M-30 grade of concrete with 12 molarity.

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The compressive strength at 7, 14 and 28 days for M-30 grade concrete and 9 molar solution is more than control mix by 35.6%, 7.12% and 4.7% respectively.

The compressive strength at 7, 14 and 28 days for M-30 grade concrete and 12 molar solution is more than control mix by 41%, 19.2% and 8.3% respectively.

VII. CONCLUSION

1. Compressive strength for 12M gives better results than 9M.
2. As the percentage of fly ash increases with alkaline solution gives more compressive strength.
3. Geo-polymer concrete can be manufactured with the same cost of OPC concrete and comparable properties.
4. Geopolymer concrete achieves maximum strength at 7 day.
5. In M25 grade of concrete, the maximum compressive strength is obtained at 28 days for the mix proportion of 100% FA with 12 molarity of solution the strength is increased by 6.56% as compare to the control mix.
6. In M30 grade of concrete, the maximum compressive strength is obtained at 28 days for the mix proportion of 100% FA with 12 molarity of solution the strength is increased by 8.3% as compare to the control mix.

Also it is concluded that Geopolymer concrete is economical than normal cement concrete, alkaline solution in some amount is costlier but overall cost of Geopolymer concrete is very less.

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