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Development of Fly Ash Based Geopolymer Concrete

Kashimalla Ramesh, K Balraju, B Sai, B Uday Kiran, R Shrujana

Assistant Professor, Dept. of Civil Engineering, Guru Nanak Institute of Technology, Hyderabad
Student, Dept. of Civil Engineering, Guru Nanak Institute of Technology, Hyderabad
Student, Dept. of Civil Engineering, Guru Nanak Institute of Technology, Hyderabad
Student, Dept. of Civil Engineering, Guru Nanak Institute of Technology, Hyderabad
Student, Dept. of Civil Engineering, Guru Nanak Institute of Technology, Hyderabad

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Abstract *-Concrete is the most widely used construction material, but its environmental impact mainly due to Ordinary Portland Cement (OPC), which contributes about 7–8% of global CO_2 emissions has raised serious sustainability concerns. Geopolymer concrete offers an eco-friendly alternative by completely replacing cement with pozzolanic materials like fly ash and alkali-activated solutions as binders. This study focuses on selecting suitable materials and developing a mix design to achieve the required strength and workability, considering factors such as fly ash content (25%, 30%, and 35%), fineness, and proportions of aggregates and alkaline solutions. The ratio of alkali-activated solution to fly ash is maintained at 0.45, and sodium hydroxide to sodium silicate ratio at 2.5, with sodium hydroxide solution prepared 24 hours before casting. Both conventional concrete cubes and fly ash-based geopolymer concrete cubes are casted conventional cubes are water-cured, while geopolymer cubes are oven-cured at 60°C for 24 hours. Finally, their compressive strengths are compared to evaluate performance.*

Key Words: Fly ash, Alkali activated solution, Geopolymer, Sodium hydroxide solution, Sodium silicate solution, Oven Curing, Moles

1.INTRODUCTION

Geo-polymer was the name given by Davidovits in 1978 to materials which are characterized by chains or networks of inorganic molecules. Geo-polymer cement concrete is made from the utilization of waste materials such as fly ash is commonly used. Fly ash is a waste product generated from thermal power plants, The main constituent of geopolymers source of silicon and aluminum which are provided by thermally activated natural materials (e.g. kaolinite) or industrial byproducts (e.g. fly ash or slag) and an alkaline activating solution which polymerizes these materials into molecular chains and networks to create hardened binder.

1.1 Objectives

1. To study the compressive strength of M20 grade concrete and fly ash-based geopolymer concrete.
2. To determine the functionality of geopolymer concrete by replacing cement with fly ash at 25%, 30%, and 35%.
3. The main objective is to study the behavior of geopolymer binder with alkali-activated solution.
4. To optimize the most efficient percentage replacement for achieving strength using 8M, 10M, and 12M sodium hydroxide solutions.

1.2 Materials

Class F Fly ash, Fine Aggregate, Coarse Aggregate, Alkali activated solution (Sodium Hydroxide and Sodium Silicate), Water

Fig – 1: Geopolymer materials

1. Fly Ash = 25%, 30% and 35%
2. Alkali activated solution / Fly ash = 0.45
3. Na_2SiO_3 / NaOH = 2.5

1.3 Properties of Sodium Hydroxide

Generally, sodium hydroxides are available in solid state by means of pellets and flakes. The cost of the sodium hydroxide is mainly varied according to the purity of the substance. For an economical geo-polymer concrete, it is recommended to use the lowest cost possible i.e. up to 94%

to 96% purity. In this investigation the sodium hydroxide pellets of 8 molar concentrations were used.

Fig – 2: Sodium Hydroxide flakes

1.4 Properties of Sodium Silicate

Sodium silicate arrangement which was gotten so from nearby providers was utilized in this undertaking. The concoction arrangement of the sodium silicate arrangement was Na2O=8%, SiO2=28%, and water 64% by mass. The blend of sodium silicate arrangement and sodium hydroxide arrangement will frames the basic fluid.

Fig – 3: Sodium Silicate Solution

1.5 Properties of Class F Flyash

Fly debris, the most plenteous material on this Earth. It assumes an essential job as a fixing in the production of Geo-polymer solid procedure. A pozzolan is a sort of material that can shows different cementitious properties when joined with the calcium hydroxide. The fundamental result of influenza debris made from the ignition of coal in coal-terminated power plants. There are two sorts classes of fly debris, Class F and Class C. Each class of fly debris has its own special properties.

Table – 1: Moles of NaOH

Molarity	NaOH	Water	Final Volume
8M	320g	700-800 ml	1 liter
10M	400g	700-800 ml	1 liter
12M	480g	700-800 ml	1 liter

2. PREPARATION OF GEOPOLYMER CONCRETE

The alkaline activator used in the present experimental work was a combination of sodium hydroxide and sodium silicate solution. Sodium hydroxide was used in the form of pellets with 98% purity. The role of alkaline activators is to dissolve and activate the reactive portions of source materials such as silicon and aluminum present in fly ash and prepare a solution with 8M, 10M and 12M of Molarity(320g, 400g, and 480g) and mix the solution with sodium silicate before 30minutes of casting of concrete and mix the coarse aggregate, fine aggregate, fly ash and mix it then add alkali activated solution which have been prepared and cast the geopolymer concrete cubes then leave it for 24 hours and demold the concrete cubes and keep in the oven for heat curing for polymerization at 60^0 C and it will gain the strength.

3. RESULTS

Table -2: Conventional Concrete cubes compressive strength of M20 grade

Age (in days)	Compressive Strength (MPa)
7	13
14	18
28	20

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Table – 3: Geopolymer concrete 25% fly ash of 8M NaOH

Age (in days)	Compressive Strength (MPa)
7	25
14	29
28	32

Table – 4: Geopolymer concrete 30% fly ash of 10M NaOH

Age (in days)	Compressive Strength (MPa)
7	30
14	35
28	40

Table – 5: Geopolymer concrete 35% fly ash of 12M NaOH

Age (in days)	Compressive Strength (MPa)
7	36
14	42
28	48

Fig – 4: Testing of Geopolymer Cubes

The compressive strength of geopolymer concrete is increases with the increases with the molarity concentration increases and it should compare with the conventional concrete of M20 grade which will be tested for 7 days, 14 days and 28 days and the compressive strength will be more compared to conventional concrete.

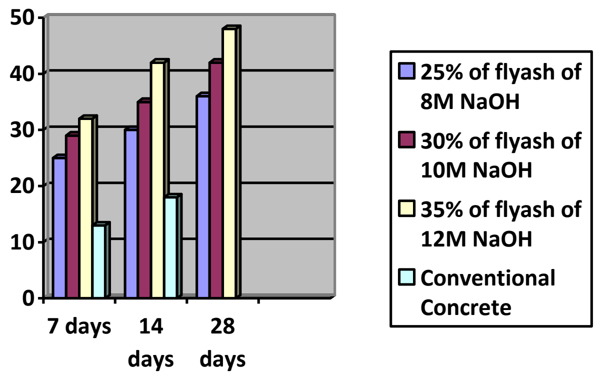

Chart -1: Age of concrete vs Compressive strength

Fig -5: Geopolymer Concrete Cubes

3. CONCLUSIONS

Here we can observe that the compressive strength of geopolymer concrete increases with the increase in fly ash content at 25%, 30%, and 35%, respectively. Similarly, as the molarity of Sodium Hydroxide increases from 8M to 10M and 12M, the compressive strength also increases. With the increase in both these components, the compressive strength of concrete improves.

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From the column chart I can conclude as the following.

1. As the percentage of fly ash and NaOH Molarity increases the compressive strength also increases.
2. Higher concentration (in terms of molarity) of sodium hydroxide solution results in higher compressive strength of fly ash-based geopolymer concrete.
3. Compared to conventional concrete, fly ash-based geopolymer concrete exhibits higher compressive strength.
4. As the age of concrete increases, the compressive strength of geopolymer concrete also increases.
5. As the curing temperature in the range of 60^0 to 90^0 Centigrade increases, the compressive strength of fly ash based geopolymer concrete also increases.

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BIOGRAPHIES

	Kashimalla Ramesh, Assistant Professor, Dept. Civil Engineering, Guru Nanak Institute of Technology, Hyderabad
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	B. Uday Kiran, Student, Dept. of Civil Engineering, Guru Nanak Institute of Technology, Hyderabad

	R. Shrujana, Student, Dept. of Civil Engineering, Guru Nanak Institute of Technology, Hyderabad