STRENGTH ASPECTS OF FLY ASH BASED GEO POLYMER CONCRETE

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Abstract : Concrete being one of the most versatile, reliable and durable construction materials is the second most consumed entity in this world. Cement is the major constituent used in the manufacture of concrete whose production results in huge emission of carbon dioxide. The use of industrial wastes like fly ash, silica fume, GGBS etc cause disposal related problems and their reuse is emphasized. In this project the materials used for GPC are fly ash, fine aggregate, coarse aggregate and catalytic liquid system and an attempt has been made to determine the compressive strength of M20 grade geo polymer concrete with different molarities like 10M,12M,14M. The compressive strength of concrete at the age of 7,14 and 28 days is determined after 24 hours of oven curing at 60ºC on cubes of size 150mmX150mmX150mm. The solution (Mixture of NaOH&Na2SO3) to fly ash ratio is 0.35.The solution mix ratio i.e. NaOH to Na2SiO3 is taken as 2.5.

Key Words: Geo polymer concrete, Alkaline solution, Compressive strength, workability.

I. 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. In the context of increased awareness regarding the ill effects of the over exploitation of natural resources, eco friendly technologies are to be developed for effective management of these resources. Concrete usage around the world is second only to water. Cement is conventionally used as the primary binder to produce concrete. The environmental problems associated with the production of cement are well known. The amount of the carbon dioxide released during the manufacture of cement due to the calcinations of limestone and combustion of fossil fuel is in the order of one ton for every ton of cement produced. Hence, it is imminent to find an alternative material to the existing most expensive most resource consuming Portland cement. OPC is extensively used in India due to its low cost and easy availability. Concrete can be cast in almost any desired shape, and once hardened, can become a structural (load bearing) element. On the other hand it also affects environment, also there are many negative influence of OPC. As such, geo polymer concrete has been introduced to reduce this problem. Fly ash is plentifully available to replace totally manufactured cement and make a concrete like material. It is an excellent alternative construction material to the existing plain cement concrete. Geo polymer concrete shall be manufactured without using any amount of ordinary Portland cement. The production of Portland cement releases large amount of CO2 in to the atmosphere. This gas is a major contribution to the greenhouse effect and the global warming of the planet. To reduce greenhouse gas emissions, efforts are needed to develop environmentally friendly construction materials. Unlike with regular concrete the chemical reactions that form geo polymer concrete alternative do not give off carbon dioxide or require high temperatures, which also lead to CO2 emissions. In geo polymer concrete, the geo polymer paste serves to bind the coarse and fine aggregates, and any un-reacted material. Geo polymer concrete can be utilized to manufacture pre-cast concrete, structural and non-structural elements, to make concrete pavements, immobilize toxic waste, and produce concrete products that are resistant to heat and aggressive environments. This paper presents the technology of making geo polymer concrete using natural pozzolan as its source material and presents the results of laboratory tests conducted on this material.

Geo polymer concrete:

The advancement of geo polymer concrete is an important step towards the production of environmentally friendly concrete. The name geo polymer was formed by a French Professor Davidovits in 1978 to represent a broad range of materials characterized by networks of inorganic molecules. The geo polymers depend on thermally activated natural materials like Meta kaolinite or industrial byproducts like fly ash or slag to provide a source of silicon (Si) and aluminum (Al).These Silicon and Aluminum is dissolved in an alkaline activating solution and subsequently polymerizes into molecular chains and become the binder. The polymerization process involves a substantially fast chemical reaction under alkaline conditions on silicon-aluminum minerals that results in a three-dimensional polymeric chain and ring structure. It is used as replacement of cement concrete. In geo polymer concrete cement is not used as binding material.

OBJECTIVE:

1. To understand the properties of geo polymer concrete in order to use it as an alternative for ordinary Portland cement.
2. The main objective of the project is to determine the optimum molarity of NaOH to be used in GPC, for the designed mix (1:1.5:2.5).
3. The objective of the project also involves study of effect of compressive strength of GPC based on different Molarities of NaOH.
4. The main target of this study is to analyze the carbon dioxide free cementitious material, various properties and their effects on Geo polymer concrete.

II. EXPERIMENTAL STUDY

2.1 Material Used:

1) Fly ash:

It was a waste product which was formed by industries and from other sources The specific gravity of fly ash is 1.9. Fineness is 70%

2) Fine Aggregate :

This material which passes through BIS test sieve number 4 (4.75mm) is called as fine aggregate usually natural sand is used as a fine aggregate at places where natural sand is not available crushed stone is used as fine aggregates.

1. Specific gravity of fine aggregate is 2.4
2. Sieve Analysis was conducted to the fine aggregate which shows the sand belong to zone III as per IS: 383-1917.
3. Water absorption for fine aggregate is 1%

3) coarse aggregate:

The material which is retained on BIS test sieve number greater than 4.75mm size of aggregate is termed as coarse aggregate. The broken stone is generally used as a stone aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 20mm was used. Specific gravity is 2.8 and water absorption is 0.8.

4) Alkaline Liquid:

The alkaline liquid used was a combination of sodium silicate solution and sodium hydroxide solution. The sodium silicate solution (Na2O= 13.7%, SiO2=29.4%, and water=55.9% by mass) was purchased from a local supplier in bulk. The sodium hydroxide (NaOH) in flakes or pellets from with 97%-98% purity was also purchased from a local supplier in bulk. The NaOH solids were dissolved in water to make the solution.

III. MIX DESIGN

Before having any concrete mixing, the selection of mix materials and their required materials proportion must be done through a process called mix design. In the present study IS method has been adopted and altogether five batches of mixtures were determined. The grade of concrete is M20.The mix design in the case of geo-polymer concrete is based on conventional concrete with some modification. In the case of conventional concrete the material proportion can be found out for the required strength using the code. The mix proportions give is taken as a reference one, several trial mixes are prepared with fly ash and constant molarity of NaOH as 10M, 12M, and 14M. The mix which gives high workability is taken as final one and the project continues with the final one. the compressive strength of M20 grade geo polymer concrete with different molarities like 10M,12M,14M. The compressive strength of concrete at the age of 7, 14 and 28 days.

Table 1: Mixing proportions of the geo-polymer concrete:

Age of curing 7, 14, 28 Days with proportion (1:1.5:2.5)

Sl.no	NaOH Molarity	Samples	NaOH Solution (ml)	NaSiO3 Gel (ml)	Fine Aggregate (kgs)	Coarse Aggregate (kgs)	Fly ash (kgs)
1	10M	1	100.89	249.70	2.27	3.79	1.516
		2	100.89	249.70	2.27	3.79	1.516
		3	100.89	249.70	2.27	3.79	1.516
2	12M	1	100.89	249.70	2.27	3.79	1.516
		2	100.89	249.70	2.27	3.79	1.516
		3	100.89	249.70	2.27	3.79	1.516
3	14M	1	100.89	249.70	2.27	3.79	1.516
		2	100.89	249.70	2.27	3.79	1.516
		3	100.89	249.70	2.27	3.79	1.516

3.1 Manufacturing Process of Geo Polymer Concrete:

Following steps were followed during manufacturing of Geo polymer Concrete:

1. Mixing of sodium silicate solution, sodium hydroxide pellets and water according to predefined proportion to make alkaline activator, at least one day prior to its use.
2. Hobart mixer with rotating blades, was used for preparing geo polymer mix
3. Mixing of fly ash and alkaline activator in the Hobart mixer for about five to six minutes to get a homogeneous paste.
4. Apparent Porosity tests were conducted.

IV. TEST AND RESULTS

4.1 Experimental Test

4.1.1 Compressive strength:

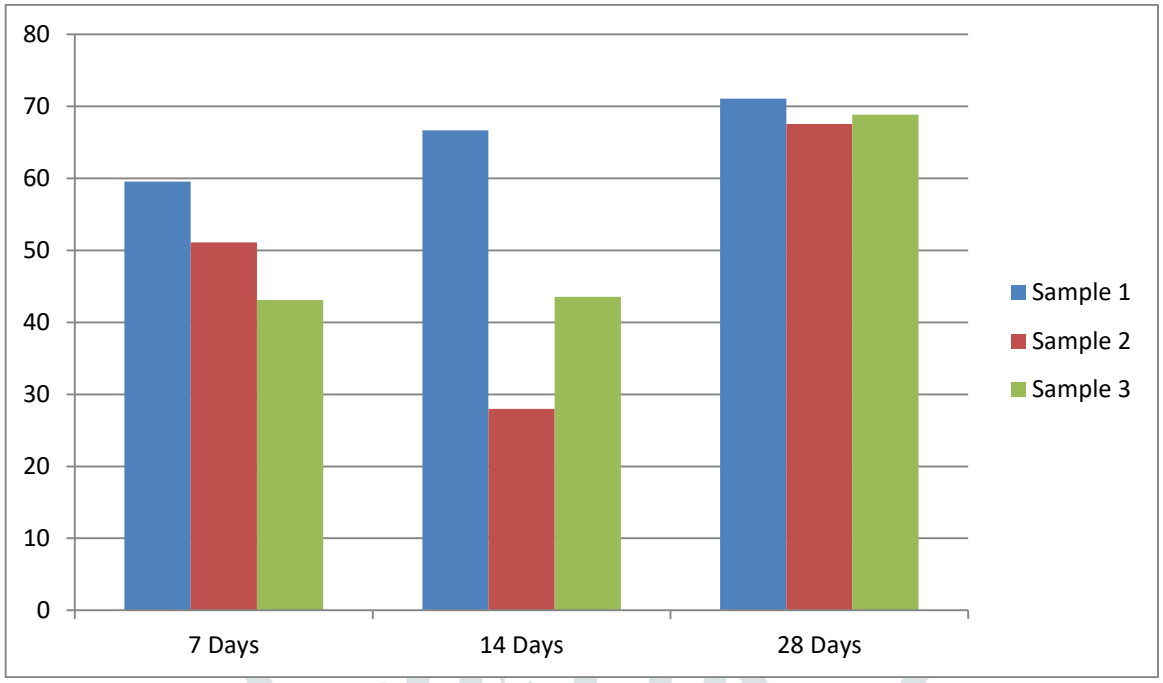
The compressive strength of a material is that value of uni-axial compressive stress reached when the material fails completely. The cubes are then tested between the loading surfaces of the compressive testing machine of capacity 2000KN in such a way that the smooth surface directly receives the load and it is applies until the failure of the load. The compressive strength is determined by the ratio of failure load to the cross sectional area of the specimen.

Figure 1 : Testing of Cube Specimens

1. In order to determine the compressive strength of geopolymeric concrete each of the subsequent mixtures were prepared in 150x150x150 mm cubes and the compressive strength for these samples were tested.
2. Three samples of each condition were tested for 7, 14 and 28 days, and the average compressive strength values reported as the results.
3. For the curing of geo-polymer concrete cubes, the cubes are placed in direct sun light.
4. For the sun light curing, the cubes are demoulded after 1 day of casting and they are placed in the direct sun light for 7 days.
5. The compressive strength of concrete at the age of 7,14 and 28 days is determined after 24 hours of oven curing at 60ºC.

Compressive Strength of GPC in Cube Specimens (N/mm2)

For 10M of NaOH :

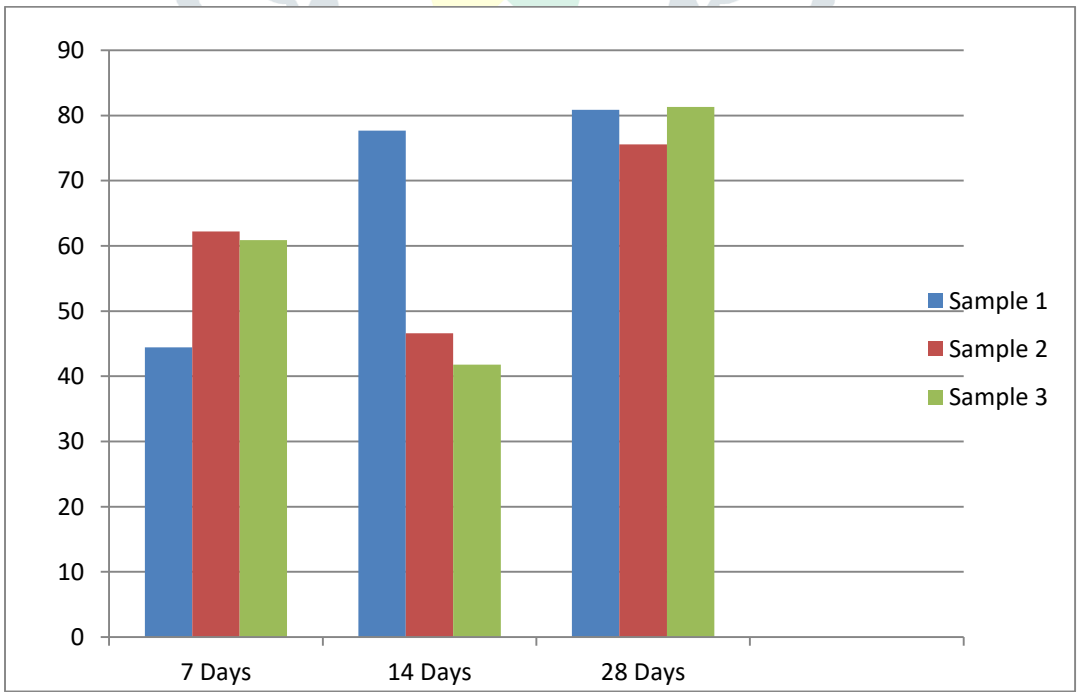


The average compressive strength of 10M of NaOH For

7 Days-57.25
14 Days-46.07
28 Days-69.17

Compressive Strength of GPC in Cube Specimens (N/mm2)

For 12M of NaOH :

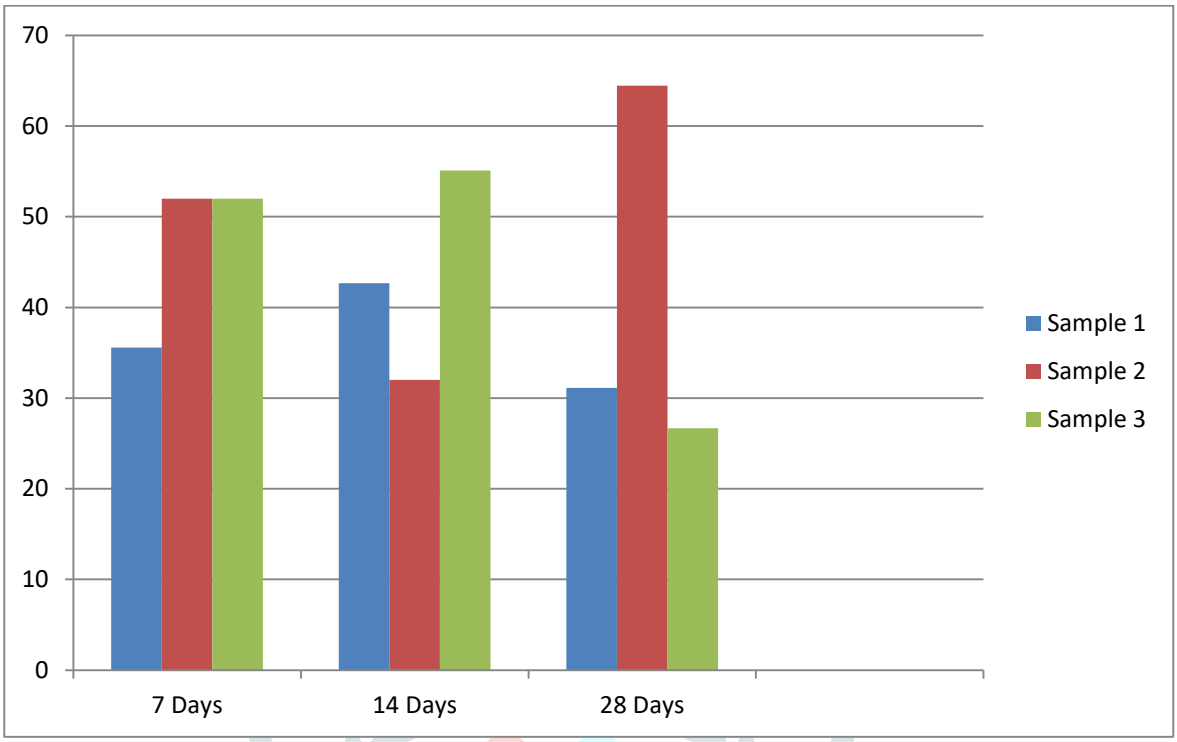


The average compressive strength of 12M of NaOH For

7 Days-55.48
14 Days-55.35
28 Days-79.2

Compressive Strength of GPC in Cube Specimens (N/mm2)

For 14M of NaOH:



The average compressive strength of 14M of NaOH For

7 Days-46.5
14 Days-43.75
28 Days-40.74

Limitations:

1. Geo polymer concrete did not harden immediately at room Temperature as in conventional concrete.
2. Geo polymer concrete specimens took a minimum of 3 days for complete setting without leaving a nail impression on the hardened surface.

These two limitations of geo polymer concrete mix was eliminated by replacing 10% of fly ash by OPC on mass basis with alkaline liquids resulted in Geo polymer Concrete Composite and are considered as drawbacks of this concrete to be used for practical applications

Advantages:

- The price of fly ash is low.
- Better compressive strength.
- Fire proof i.e. higher resistance to heat
- Low permeability.
- Eco-friendly.
- Magnificent properties within both acid and salt environments.

V. CONCLUSION

Based on the experimental work reported in this study, the following conclusions are drawn.

1. Based on the results of 14days and 28days, it was observed that the average compressive strength of geo polymer concrete increased from 10M to 12M of NaOH and then decreased from 12M to 14M of NaOH.
2. The average compressive strength of 14M concentration concrete was less than 10M concentration of NaOH.
3. The average compressive strength of 12M concrete increased by 30% from 14 days to 28 days.
4. Significant progress has been made in developing an understanding of the phenomena underlying geopolymerization of aluminosilicates.
5. Fly ash based geo polymer concrete has shown excellent properties and was recommended for structural applications by the researchers and with increasing the value of NaOH molarity the strength of geo polymer concrete gets increased as shown in the above tables.
6. Geo-polymer concrete shall also be used in the Infrastructure works.
7. In addition to that fly ash shall be effectively used and hence no landfills are required to dump the fly ash.
8. However, lack of standard specifications and regulations related to processing and application in the industry level hinder its wide use in real structures. It is hoped that concentrating over such issues and needs and researching elaborately in this field will help to emerge fly ash based geo polymer concrete as a commercial and environment-friendly material and ensure the sustainability of construction industry.
9. From the past research studies, it can be sequel that: The reduced CO2 emissions of Geo polymer cements build them a good alternative to Ordinary Portland Cement. Geo polymer cement produces a substance that is comparable to or better than traditional cements with respect to most properties.
10. Higher concentration of sodium hydroxide solution results in higher compressive strength of geo polymer concrete.
11. Geo polymer concrete has excellent properties within both acid and salt environments.
12. Low calcium fly ash based geo polymer concrete has excellent compressive strength, exposure to aggressive environment, workability, exposure to high temperature and is suitable for structural applications.

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