Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 4, April : 2023

AN EXPERIMENTAL STUDY OF GEO-POLYMER CONCRETE WITH Na_2SiO_3/KOH AT DIFFERENT CURING TEMPERATURES USING DIFFERENT MOLARITIES

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Abstract:

Increase in demand of Portland cement with industrialization and manufacture process of cement which emits pollutants and contributes to environmental damage, is a novel strategy for creating green concrete. Using industrial byproducts like Fly Ash and GGBS can reduce the environmental impact of pollution.

One such alternative is Geo-Polymer Concrete, in which Fly Ash, GGBS, and Alkaline Activator are utilized for material binding in place of Portland cement. The solutions of potassium hydroxide and sodium silicate are the alkaline liquids utilized in the polymerization process.Six different molarities i.e. 10M, 11M, 12M, 13M, 14M and 16M were taken to prepare the mix. The cube specimens are taken of size 15cm*15cm*15cm are casted to test the compressive strength. Three different curing temperatures (ambient curing, oven curing at 85°C &100°C) were adopted in this study. Testing of the Geo-polymer concrete specimens and comparison of the test findings with the traditional M20 concrete mix were done as part of the experimental effort.

The results of testing several molarities of KOH solutions with various AAS binder ratios reveal that Geo polymer concrete had the maximum compressive strength in relation to the matching molarity and ratio.

Keywords:

Geo-polymer concrete, Fly ash, GGBS, Sodium silicate, Potassium hydroxide, ambient curing, oven curing (85°C &100°C).

I. Introduction:

Concrete is the second most commonly used material in the world, after water. Ordinary Portland cement has traditionally been used as the primary binder in the production of concrete due to its global availability of raw materials and ease of preparation and fabrication in all conceivable shapes.OPC manufacture results in carbon dioxide (CO2) emissions, which add to the atmosphere's concentration of greenhouse gases.OPC may be replaced by geo-polymer concrete, which also presents a chance to create useful byproducts from a number of waste streams.Also, the development of geo-polymers aims to lower greenhouse gas emissions associated with the manufacture of concrete goods. It lessens the demand for OPC, which lowers CO2 emissions.It makes use of industrial wastes like fly ash and GGBS.It defends water sources from contamination caused by the discharge of fly ash.It saves acres of land that were previously used for the disposal of garbage. It results in a more resilient infrastructure. The qualities of geo-polymer concrete are as follows: 1) Increased resistance to corrosion. 2) Much improved fire resistance. 3) Quickly increasing strength and reduced shrinking. 4) A 90% decrease in greenhouse gas emissions. 5) Consolidates garbage into items that are valuable. 6) Polymerization is a factor in the setting mechanism. 7) The curing temperature ranges from 60° to 90°.

This study examines the impact of varying molarities of alkaline activators on the compressive strength and water absorption of geo-polymer concrete based on fly ash (made by thermal power

plants) and ground granulated blast furnace slag (GGBS- obtained from steel plants).

Materials:

1. **Fly ash (Class F):**

A byproduct of burning pulverized coal in electricity producing plants is fly ash. Fly ash, which are spherical glassy particles, are formed as the fused material cools and solidifies as it rises. Fly ash has a 1.84 specific gravity.

2. **GGBS (Ground Granulated Blast Furnace Slag):**

A glassy, granular by-product of manufacturing iron and steel called molten iron slag from a blast furnace is quenched in water or steam to generate GGBS or GGBFS, which is then dried and crushed into a fine powder. It is kept in secure bags. In this project work, GGBS with a specific gravity of 2.6 is utilized.

3. **Fine Aggregate:**

Natural river sand is used as the fine aggregate in this experiment. Sand came from nearby sources. During the experimental programme, fine material that passes through an IS 4.75mm sieve but is kept on an IS 150 micron sieve is taken into account. The fineness modulus is 3.02, while the specific gravity is 2.6.

4. **Coarse Aggregate:**

The aggregate is made up of sand, gravel, and naturally existing crushed and uncrushed stones. It should be as strong, clear, hard, robust, and dense as possible, free of adhesive coating, disintegrated bits, alkali, and other harmful chemicals. Avoiding flaky and elongated chunks is advised. The 20mm sieve passing and 12.5mm sieve held locally accessible aggregates are employed in this experiment. It ought to have an angular shape..The specific gravity is 2.7.

5. **Potassium Hydroxide :**

The 85% pure potassium hydroxide is offered in pellet form. To create a solution, potassium hydroxide is diluted in water to the desired concentration.

6. **Sodium Silicate:**

The sodium silicate was bought from the supplier as a gel (Na2O = 10%, SiO2 = 27%, water = 63%). In this experiment, sodium silicate with a specific gravity of 1.61 was used.

II. Literature Review:

Geo-polymer concrete is a man-made material in which fine and coarse aggregates are bonded together by Fly Ash and GGBS when mixed with alkaline activators.Here is an overview of literature which discusses various experiments conducted by many authors on the replacement of cement with Fly Ash and GGBS under this heading.

Partha Sarathi Deb, Pradip Nath, Prabir Kumar Sarker(2013) When cured at room temperature, the incorporation of ground granulated blast-furnace slag (GGBFS) with class F fly-ash has been shown to significantly affect the setting and strength development of geo-polymer binders.GGBFS was added to the total binder in this investigation at levels of 0%, 10%, and 20%, with varying activator contents (40% and 35%). Geo-polymer concretes with greater GGBFS and lower sodium silicate to sodium hydroxide ratios in the mixtures showed a significant increase in strength and some reduction in workability.The ACI 318 and AS 3600 codes' estimations of the tensile strength of ambient-cured geo-polymer concrete tend to be similar to those for OPC concrete.

Materials: FA, GGBS, AL, aggregates,water**ALratio:** 1.5 to2.5

Proportion **:** 1: 1.6:3**Curing type:** Ambient

Andi Arham Adam (2014) He noticed that for the geo-polymerization reaction to produce increased strength, the ideal temperature and curing time are crucial. By using sodium silicate and

sodium hydroxide solution, the fly ash was activated.Alkaline activator was used in a 1:2 ratio with sodium silicate, and the activator dosage was set at 55%. The results demonstrate that the temperature and cure time of 120°C for 20 hours produced the best compressive strength.
Materials: FA, AL, aggregates,water **Molarities**:10M
ALratio: 2 **Water: FA:** 0.35 **Curingtype:**oven**Curing temp :** 80°c, 100°c, 120°c.
Davidovits(1988c; 1988d)He combined kaolinite source material with alkalis (NaOH, KOH) to create geo-polymers. Various patents issued on the applications of the so-called "SILIFACE Process" have disclosed the technology for making geopolymers.
Davidovits(1994) Geo-polymer cement is also acid-resistant because, unlike Portland cement, it does not rely on lime and cannot be dissolved by acidic solutions. According to the results of tests exposing the specimens to 5% sulphuric acid and chloric acid, geopolymer cement was relatively stable with weight loss ranging from 5-8%, whereas Portland-based cement was destroyed and calcium-alumina cement lost weight ranging from 30-60%.
Nguyen Van Chanh (2008)An example of an amorphous aluminium silicate cementitious material is geo-polymer. Alkali polysilicates and the precursor for geopolymer can be combined to create geo-polymer.As comparison to Portland cement, geo-polymer manufacturing offers a higher relative strength, exceptional volume stability, and superior durability. A novel substance called geo-polymer concrete based onpozzolana doesn't require Portland cement to act as a binder.In this paper, the findings from research on materials, composite mixtures, geopolymer microstructure, and factors influencing the characteristics of geopolymer concrete are presented.
Materials : Fly Ash (FA), fine aggregate, alkaline liquid (AL), water, super plasticiser
Molarities : 14M, 18M.

III. Methodology:

- In this project, 50% Fly ash, 50% GGBS, and activated solution were employed to bind the materials in place of cement. Also, the mix percentage taken is 1:1.3:3.0 in ratio.
- The following step involves mixing fly ash, GGBS, fine aggregate, and coarse aggregate for roughly three minutes. Next, according to the mixture, the sodium silicate solution is added.
- Then, 24 hours before mixing the GPC, potassium hydroxide solution by combining it with water in various concentrations.
- The mixture is mixed for 3-4 minutes more. They are then cast into 15cm*15cm*15cm cubes.
- They are then stored for one day at the appropriate curing temperatures in the oven, followed by 28 days of regular curing.
- Different molarities of 10M, 11M, 12M, 13M, 14M, and 16M cubes were prepared for the AAS ratios 1.5 and 2.0.
- The curing temperatures used are ambient curing and oven curing at temperatures 85°C, and 100°C.
- The cube specimens are subjected to a compression test following a 28-day curing period.

IV.Results and Analysis:
Compressive strength of conventionalconcrete:

Both the matrix's strength and the aggregate's particle tensile strength affect the maximum compressive strength that concrete may achieve. For 28 days, concrete's compressive strength was studied.

The compressive strength measured for concrete of grade M20 is as follows:

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 4, April : 2023

Days	Compressive strength N/mm2
28	36.2

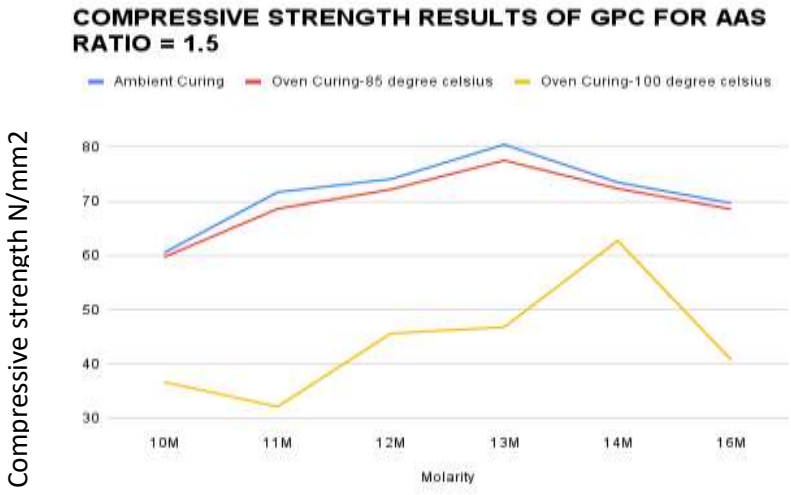
Table-1 Compressive strength of CC

Compressive strength of Geo-PolymerConcrete:

Here are the compressive strengths of GPC at various KOH concentrations and cure times:

COMPRESSIVE STRENGTH OF GPC FOR AAS RATIO 1.5 (28 DAYS)in N/mm2				
S.NO	**MOLARITY**	**AMBIENT CURING**	**OVEN CURING (85°C)**	**OVEN CURING (100°C)**
1	10M	60.52	59.71	36.70
2	11M	71.70	68.63	32.16
3	12M	74.12	72.21	45.64
4	13M	80.50	77.57	46.82
5	14M	73.51	72.37	62.77
6	16M	69.68	68.58	40.79

Table-2 Compressive strength of GPC at different curing temperatures for AAS ratio 1.5

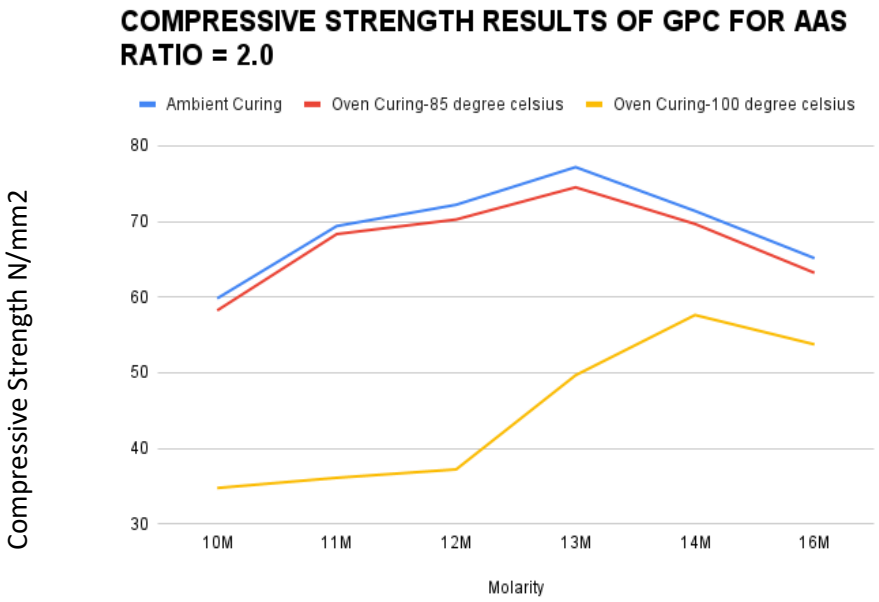


Graph-1 Compressive strength of GPC for AAS ratio 1.5

COMPRESSIVE STRENGTH OF GPC FOR AAS RATIO 2.0 (28 DAYS)in N/mm2				
S.NO	**MOLARITY**	**AMBIENT CURING**	**OVEN CURING (85°C)**	**OVEN CURING (100°C)**
1	10M	59.83	58.24	34.74
2	11M	69.4	68.34	36.09
3	12M	72.22	70.27	37.20

4	13M	77.20	74.53	49.66
5	14M	71.40	69.68	57.63
6	16M	65.15	63.21	53.74

Table-3 Compressive strength of GPC at different curing temperatures for AAS ratio2.0



Graph-2 Compressive strength of GPC for AAS ratio 2.0

Analysis:

- According to graphs, it was found that all curing times had a considerable rise in compressive strength as KOH concentration increased.
- It can be said that using fly ash and GGBS in place of cement results in concrete that is much stronger than regular concrete.
- The compressive strength is higher at 85° C temperature in each mix.
- Moreover, the compressive strength in each mix has decreased at 100°C temperature compared to 85°C temperature.
- According to the test results, geo-polymer concrete that has been cured at an 85°C temperature is stronger at 13M, whereas geo-polymer concrete that has been cured at a 100°C temperature is stronger at 14M.

V. Conclusion:

These inferences are made in light of the test findings:

1.GPC's reduced carbon dioxide emissions make it a suitable building material. GPC is an excellent alternative toOPC.

2. It is appropriate for practical applications because it quickly reaches excellent compressive strength.

3.As the molarity increases strength increases and reaches the maximum at certain point and thendecreases.

4.Ambient curing gives higher strength to GPC. While oven curing between 60-90°c gives good strength toGPC, as the strength has decreased at 100°c.

5.When the ratio of sodium silicate to potassium hydroxide is 2.0, an increase in compressive strength is seen.

6.Potassium hydroxide solution with a higher concentration has greater strength.

7. Compared to oven curing at various temperatures, compressive strength from ambient curing is higher.

8. For all the 6 conc. of KOH, the ultimate load increased with the increasein concentration ofKOH.

9. The test results of GPC compared to conventional concrete has higher compressive strength at an earlyage.

10. Highest compressive strength of GPC with the combination of KOH with Na_2SiO_3 occurred at 13M under the AAS ratio of 1.5&2.0 at ambientcuring and also at 14M under the AAS ratio of 1.5&2.0 at 100°c.

11. Geo polymer concrete is well known for its promising mechanical qualities and is a suitable substitute for OPC concrete in building.

VI. References:

[1]Davidovits 2008. "Geo-polymer chemistry and application." Institute geo-polymer, Saint Quentine,France.
[2] Hardjito, D, S.Wallah, D. M. J Sumajouw and B. V. Rangan 2004. "Onthe development of fly ash based GPC." ACI materials journal, vol 101, no6.
[3]Rangan B. V. "Low-calcium, fly ash based GPC." Concrete construction engineering handbook. Taylor and Francis group, Boca Raton, FL,2008.
[4]Lloyd N, and V. Rangan 2009. "Geo-polymer concrete-sustainable cement less concrete.
[5] Recent research Geo-polymer Concrete- Nguyen Van Chanh Bui Dang Trung, Dang Van Taun during the 3rdACF International conference- ACF/VCA2008.
[6]Apoorva. S, Namrata. F. Dabali 2016 Investigations on The Strength Characteristics of Geo-polymer Concrete at ambient and oven curing International Journal of Scientific and ResearchPublications.
[7]Bhaumik Barot, Prof K. A Parmar. "Husk Ash by curing at ambienttemperature."
[8]Rohit Zende, Mamatha. A. "Study on Fly ash and GGBS based Geo-polymer Concrete under ambientcuring."
[9]V Sathish Kumar, n Ganesan and P V Indira. "Effect of molarity Potassium Hydroxide and curing method on the compressive strength of ternary Blend Geo- polymerConcrete."
[10] Prasanna Venkatesan Ramani, PazhaniKandukalpattiChinnaraj. "GPC with GGBS and black rice huskash."