

# A REIVEW PAPER ON EFFECT OF TEMPERATURE ON STRENGTH OF GEOPOLYMER CONCRETE

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## **Abstract:**

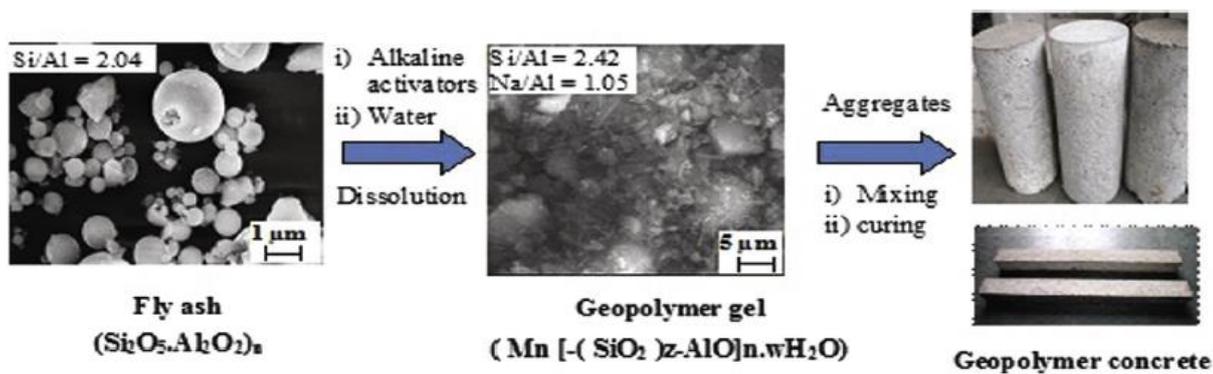
*An Overview of geopolymers formed by the alkaline activation of aluminosilicates is presented along with opportunities for their use in building construction technique. Properties of mortars/concrete made from geopolymeric binders are discussed with respect to fresh and hardened states, interfacial transition zone between aggregate and geopolymer. The Bond with steel reinforcing bars and resistance to elevated temperature. The durability of geopolymer pastes and concrete is highlighted in terms of their deterioration in various aggressive environments, R&D works carried out on heat and ambient cured geopolymers at CSIR-CBRI are briefly outlined alongwith the product developments. Research findings revealed that geopolymer concrete exhibited comparative properties to that of PPC concrete which has potential to be used in civil engineering applications. The effects of the additives and binder content in the mixtures were determined from experimental results. The results show that inclusion of additives with fly ash significantly enhanced the early age properties. Setting time reduced to reasonable values and compressive strength increased to enable early de-moulding of specimens. The compressive strength increased with the increase of binder content. However workability results showed an optimum binder content for the fly ash geopolymer blended with the additives. The results suggest that suitable geopolymer mixtures can be designed for ambient curing with low calcium fly ash and the additives as partial replacement.*

**Key Words:** flyash, alkaline solution, curing etc

## **Introduction:**

Increasing emphasis on energy conservation and environmental protection has led to investigation of alternatives to customary building materials. Among the goals of these investigations are to reduce greenhouse gas emissions and minimize the energy required for material production. Currently, Portland cement is the leading material for industrial concrete demand worldwide, fulfilling a demand of over 1.5 billion tons annually. The production of Portland cement is energy-intensive and releases a significant volume of carbon dioxide (CO<sub>2</sub>) to the atmosphere. For each ton of Portland cement manufactured, it is estimated that one ton of CO<sub>2</sub> is released into the environment. The process involves very high temperatures (1400– 1500 °C), the destruction of quarries to extract raw materials, and the emission of greenhouse gases such as CO<sub>2</sub> and NO<sub>x</sub>. The costs associated with these energy requirements are significant. Consequently, the need arose for further investigation into cementitious products with decreased environmental impacts and enhanced economic benefits.

The term “geopolymer” is generically used to describe the amorphous to crystalline reaction products from the synthesis of alkali aluminosilicates with alkali hydroxide/alkali silicate solution. Geopolymeric gels and composites are also commonly referred to as low-temperature aluminosilicate glass, alkali activated cement, geocement, alkali-bonded ceramic, inorganic polymer concrete, and hydroceramic.



## LITERATURE REVIEW

Term „geopolymers“ was first introduced to the world by Davidovits (1994) of France, thus, inventing area in the field of concrete technology. He explained that geosynthesis is the science of manufacturing artificial rock at a temperature below 100°C in order to obtain natural characteristics (hardness, longevity and heat stability) of rock. Geopolymers can, thus, be viewed as the mineral polymers resulting from geo-chemistry or geo-synthesis.

Palomo ,Grutzeck and Blanco [1986]Research in a new field the alkali activation of various by-produce materials.This has become a prime area of research in many research laboratories as there is a possibility to use the materials to synthesize relatively inexpensive and green binder like cement which can be used for construction. In this paper, the activation of puzzolonamaterial; fly ash with alkaline solutions with high alkalinity is studied. The solutions, used for research were made using NaOH(Sodium Hydroxide) ,KOH (Potassium Hydroxide),  $\text{Na}_2\text{SiO}_3$  (Sodium Silicate/water glass).The reaction products were a aluminosilicate gel with compressive strengths of the order of 60 MPa were observed after curing the mix at 85° C for 5 h duration. Temuujin et al. [1996]Study about Australian class F and Mongolian class C fly ashes. They found that class F based geopolymer structure has not been affected by chemical attacks whereas; class C based geopolymer structure changes after the chemical attacks. Furthermore, low calcium based geopolymer binder are not dehydrated when subject to high temperature . Compared to class C fly ash class F has higher aluminium content, therefore class F creates durable geopolymer matrix. Chindaprasirt et al. investigate characteristics of alkali activated class C fly ash mixes.They found that when the mix has high pH level (>13), CaO/SiO<sub>2</sub> ratio in the range of 0.59-0.69 and SiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> is in the range of 2.57- 4.79, the final geopolymer binder has mainly C-S-H or C-A-S-H. Furthermore, they reported that at low pH level with lower Ca<sup>2+</sup> concentration formed N-A-S-H as the major reaction product. D.Hardjito and B.V.Rangand describe the development the mixture proportion amnd the short term properties of low calcium fly ash based geopolymer concrete. Subsequent reported the long term properties and the behaviour and the strength of reinforced geopolymer concrete. Olivia et al (2008) have investigated on the water penetrability of low calcium fly ash geopolymer concrete. The conclusion drawn is that fly ash geopolymer concrete exhibits low water absorption and sorptivity, Low water/binder ratio and a better grading are recommended in order to reduce the capillary porosity and the overall porosity of geopolymer concrete. P. Chindaprasirt et. al. presented the study of synthesis of high strength geopolymer using fine high calcium fly ash. The effect of fineness of flyash on the setting time of geopolymer paste, workability, strength development and drying shrinkage of geopolymer mortars mde from classified fine high calcium fly ash was investigated . Harbert Sinduj et.al. aimed to determine the optimum value of the alkaline activator/ fly ash ratio. The effect of the oxide molar ratios of SiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub>, water content of the water glass content were studied for each Alkaline activator/flyash ratio. Result revealed that the alkaline activator/flyash ratio 0.40 has the optimum amount of alkaline liquid, which shows the highest rate of

geopolymerization compared to other ratios. Alloucher et al. (2011) studied the self-curing properties of geopolymer concrete. The study shows that the temperature generated is dependent upon the amount of concrete mixed. The strength of GPC was found to increase with curing period. The modulus of elasticity and Poisson's ratio corresponding to 28 days' curing were found to be within acceptable range for typical concrete used in a structural application. Rajjiwala et al (2011) they reported the progress of the research on making geopolymer concrete using the thermal power plant fly ash Gujarat, India. The project aims at making and studying the different properties of geopolymer concrete using this fly ash and the other ingredients locally available in Gujarat. Potassium Hydroxide and sodium Hydroxide solution were used as alkali activators in different mix proportions. Effects of various salient parameters on the compressive strength of low calcium fly ash-based geopolymer concrete are discussed by considering the ratio of alkaline solution to fly ash (by mass) 0.35 constant. The specimens were cured at two different temperature 25°C and 60°C for 24 hours in the oven. The main parameters studied were the compressive strength, curing temperature, effect of wet-mixing time, influence of handling time on compressive strength, effect of super plasticizer on compressive strength, effect of super plasticizer on slump of concrete, effect of water-to-geopolymer solids ratio by mass on compressive strength, stress-strain relation of geopolymer concrete in compression. Experimental results indicate that the compressive strength of GPC increased over controlled concrete by 1.5-1.6 times and split tensile strength of GPC increased over controlled concrete by 1.45 times. The flexural strength of GPC increased over controlled concrete by 1.6 times. For pull out test GPC increases over controlled concrete by 1.5 times.

**Conclusion :** Geopolymer materials represent an innovative technology that is generating considerable interest in the construction industry, particularly in light of the ongoing emphasis on sustainability. In contrast to the Portland cement, the most geopolymer systems rely on minimally processed natural materials or industrial byproducts to provide the binding agents. Since Portland cement is responsible for upward of 85 percent of the energy and 90 percent of the carbon dioxide (CO<sub>2</sub>) attributed to a typical ready-mixed concrete, the savings of the potential energy and carbon dioxide through the use of geopolymers can be considerable. Consequently, there is growing interest in geopolymer application in construction industry. On this backdrop, the geopolymer technology introduced by Davidovits (1994a) provides an alternative binder to the OPC. Geopolymer concretes (GPC) are cementless concrete which utilize by product materials like fly ash in the presence of alkaline solution to produce binders.

This concrete is produced by activating different alumino-silicate based waste materials with highly alkaline solution. The curing of freshly prepared geopolymer concrete is the most crucial aspect and it plays an important role in the entire geopolymerisation process. The proper curing of concrete has a positive effect on the final properties of the geopolymer concrete. The curing of such concrete is mostly carried out at elevated temperatures; however, curing at ambient temperatures is also carried out at times. It is believed that higher temperatures activate alumino-silicate phases in the fly ash; therefore, they are generally cured at elevated temperatures between 60°C- 90°C.

#### References:

- [1] J. Davidovits, Geopolymer cements to minimize carbon-dioxide green house warming, in: M. Moukwa, S.L. Sarkar, K. Luke, M.W. Grutzeck (Eds), Cement Based Materials: Present, Future and Environmental Aspects, Am. Ceram. Soc., CeraTrans. 37 (1999) 165–182.
- [2] T. Naik, Sustainability of concrete construction, Pract. Period. Struct. Des. Constr. 13 (2) (2008) 98–103.
- [3] L.O. Williams, Fossil Fuels-An End to Global Warming, Elsevier, United Kingdom, 2002.

- [4] K.H. Yang, J.K. Song, K.I. Song, Assessment of CO<sub>2</sub> reduction of alkali-activated concrete, *J. Cleaner Prod.* 39 (2013)265–272.
- [5] P. Duxson, A. Fernandez-Jimenez, J.L. Provis, G.C. Lukey, A. Palomo, J.S.J. Van Deventer, Geopolymer technology: the current state of the art, *Mater. Sci.* 42(9) (2007) 2917–2933.
- [6] T. Tho-in, V. Sata, P. Chindaprasirt, C. Jaturapitakkul, Previous high-calcium fly ash geopolymer concrete, *Constr. Build. Mater.* 30 (325) (2012) 366–371.
- [7] J.L. Provis, P. Duxson, J.S.J.V. Deventer, The role of particle technology in developing sustainable construction
- [8] S. Kumar, R. Kumar, S.P.Mehrotra, Influence of granulated blast furnace slag on the reaction, structure and properties of fly ash based geopolymer, *Mater. Sci.* 45 (3) (2010)607–615.
- [9] C. Shi, R.L. Day, Early strength development and hydration of alkali-activated blast furnace slag/fly ash blends, *Adv. Cem. Res.* 11 (4) (1999) 189–196. *materials*, *Adv. Powder Technol.* 21 (1) (2010) 2–7.
- [10] T. Xie, T. Ozbakkaloglu, Behavior of low-calcium fly and bottom ash-based geopolymer concrete cured at ambient temperature, *Ceram. Int.* 41 (2015) 5945–5958.
- [11] S.A. Bernal, R.M. Gutierrez, J.L. Provis, Engineering and durability properties of concretes based on alkali-activated granulated blast furnace slag/metakaolin blends, *Constr. Build. Mater.* 33 (2012) 99–108.
- [12] Temuujin J, Minjigmaa A, Lee M. Characterisation of class F fly ash geopolymer pastes immersed in acid and alkaline solutions. *CemConcr Comp* 2011;33:1086–91.
- [13] Bakharev T. Resistance of geopolymer materials to acid attack. *CemConcr Res* 2005;35:658–70.
- [14] Ariffin MAM, Bhutta MAR, Hussin MW, Mohd Tahir M, Aziah N. Sulfuric acid resistance of blended ash geopolymer concrete. *Constr Build Mater* 2013;43:80–6.
- [15] Sathia R, Ganesh Babu K, Santhanam M. Durability study of low calcium fly ash geopolymer concrete. In: 3rd ACF international conference, Ho chi minh city, Vietnam; PP2008.
- [16] Bakharev T, Sanjayan JG, Cheng Y-B. Resistance of alkali-activated slag concrete to acid attack. *CemConcr Res* 2003;33:1607–11.
- [17] Fernandez-Jimenez A, Garcia-Lodeiro I, Palomo A. Durability of alkali-activated fly ash cementitious material. *J MaterSci*2009;42:3055–65.
- [18] Bakharev T. Durability of geopolymer materials in sodium and magnesium sulfate solutions. *CemConcr Res* 2005;35:1233–46.
- [19] Ismail I, Bernal SA, Provis JL, Hamdan S, van Deventer JSJ. Microstructural changes in alkali activated fly ash/slag geopolymers with sulphate exposure. *MaterStruct* 2013;46:361–73.