A Review on Geopolymer Concrete

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ABSTRACT

The production of the cement concrete industry has grown in this modern world and is considered as one of the major contributions of global pollution. The increase of different infrastructures has directly affected the increase of production of concrete. The production of cement used as a binder contribute to the increase of the amount of CO2 in the atmosphere and also consumes an important number of natural resources; thus, aggravating the modern issue of global warming.

Also, many types of cement concrete structures mostly those built-in corrosive environments designed for a life service of more than 50 years, deteriorate after 20 to 40years.As a result, it's vital to replace cement in concrete with specified alumina-rich materials such as silica fume, blast furnace slag, rice husk ash, fly ash, etc to address the pollution problem.

Based on this, numerous studies have been conducted to develop an innovative and environmentally beneficial material known as green concrete or geopolymer concrete. To improve the qualities of concrete and reduce natural resource use, geopolymer concrete incorporates materials like silica fume, fly ash, blast furnace slag, rice husk ash, and others.

This paper gives an overview and explains how the various factors affect the strength of geopolymer concrete.

Keywords: geopolymer concrete, fly ash, compressive strength, alkali activators, curing time and temperature, aggregates.

INTRODUCTION

Concrete is the most long-lasting, adaptable, and dependable building material on the planet. Concrete’s use in infrastructure, housing, and transportation has aided civilization’s advancement, economic progress, stability, and quality of life.

For the ordinary concrete, the binder used for bounding of material is ordinary Portland cement whose demand for manufacture increases by 25% within 10 years as per the world statistics. Ordinary Portland types of cement whose production requires a large amount of energy is being the second generator of dioxide of carbon, which polluted the environment. The process of manufacturing cement has impacted the environment in such a way that the level of pollution is unsustainable. Hence it is inevitable to look for an alternative material rich in silicon and alumina such as GGBS, red mud, fly ash whose huge quantity is generated around the globe from thermal plants.

In 1994, French Professor Davidovits coined the term “Geopolymer cement” to describe materials defined by networks of inorganic molecules. Fly ash replaces cement in geopolymer concrete, which is then activated using alkali solutions including sodium silicate and sodium hydroxide. Geopolymer cement, fine aggregates, coarse aggregates, and alkaline solutions are used to make geopolymer concrete. Water, which is essential for the hydration of cement concrete is not involved in the chemical reaction of geopolymer concrete and instead, is expelled during the polymerization process.

LITERATURE REVIEW

Iftekar Gull and **Yasir Sofi** examined the properties of fly ash-based Geopolymer concrete. By changing the alkaline to alumina material ratio from 0.3 to 0.45, M20 grade GPC can be created using a notional mix of 1:1.5:3. Compressive, tensile, acid attack, flexural strength, permeability, and other variables that affect the geopolymer were assessed and shown in the laboratory. The testing revealed that geopolymer concrete had good compressive strength and durability.

Suresh Thockchom noticed that after 126 days of exposure to 10% sulfuric acid solution, the GPC mortar made from fly ash with alkaline activators was structurally unchanged and did not show any recognizable change in colour. He concluded that geopolymer concrete had a high sulphuric acid resistance.

S. Jaydeep and **B. J. Chakravarthy** used admixtures to create an ideal mix for Geopolymer concrete. At7 and 28 days, the compressive strength of concrete is evaluated. According to findings, mixing caustic soda and silicate of sodium as alkaline activators improved the interaction of the constituents of GPC.

When compared to direct sunshine curing, oven cured specimens had a higher strength. Geopolymer concrete is more beneficial, ecologically friendly, and costs less than cement concrete.

MATERIALS

Geopolymer concrete is prepared using:

1. **Fly ash**

Fly ash is a by-product of pulverized fuel ash or coal combustion that consists of fine particles blown out of the boiler with the flue gases.

The fly ash's quantity and fineness employed in the activation process of geopolymer concrete affect concrete's strength. Similarly, the higher the fineness, the better the workability and strength within a short heating time.

2. **Fine and Coarse aggregates**

They are inert mineral components that frame approximately 70-80% of the quantity of concrete. Coarse and Fine aggregates mixed should become void-free and homogeneous. The grading of fine particles affects the workability of geopolymer concrete.

Coarse aggregates consisting of gravel of size 10-20 mm are obtained by pulverizing hard rock stones. The locally available fine aggregates consisted of 2 mm size.

3. **Alkali activators**

For the activation of GGBS, silica fume, fly ash, etc a solution of Na2SiO3 and NaOH are commonly utilized. As per the observations made in numerous studies, the rise of sodium silicate and sodium hydroxide is proportional to the rise of fresh mix viscosity and compressive strength. It's composed of caustic soda and silicate solution. The goal of this alkaline solution is to activate fly ash and GGBS. To guarantee the user's safety, the very alkaline solution should be handled with caution.

PARAMETERS AFFECTING THE STRENGTH OF GEOPOLYMER CONCRETE

1. Curing time and temperature

For a complete polymerization process, the temperature of curing is reported between 40-90 degrees Celsius. Different studies on the curing of alkali activators have shown that the rise of geopolymer concrete' strength was much lesser for a curing time extended after 24hours.

Steam, ambient, and oven curing regimes are all used to cure geopolymer concrete at high temperatures.

- Ambient curing

It is carried out after the specimens have been cast and let to rest for a day at 17-23°C. The compressive strength of Geopolymer concrete increases from 7 to 28 days after ambient curing. Geopolymer concrete can be cured without the use of high heat and can be used in places other than precast members. Fly ash is incorporated with other elements such as meta-kaolin (Zhang et al., 2020), and others to improve compressive strength, set time, and slump of new concrete during ambient curing.

- Steam curing

It's curing in water vapor at temperatures ranging from 160 to 190 degrees Celsius and pressures ranging from 0.55 to 1.70 MPa. Steam curing is carried out after removing concrete from steel mould and placed in a vacuum for a determined time.

After curing, the condition alters the hydration interaction, resulting in concrete with improved sulphate resistance, reduced creep and cracks, no efflorescence and lower humidity.

- Oven curing

Thermal processing experts utilize industrial curing ovens to improve the strength and durability of a material by applying heat to speed up the desired chemical reaction. For 24 hours, the concrete is in the oven at a temperature between 40 and 120 degrees Celsius. Following that, the oven is switched off to let the concrete cool to a normal room temperature before being removed and evaluated for compressive strength. By using the least quantity of water in the mix, creep, cracks and dry shrinkage in geopolymer concrete can be reduced.

2. The solution to fly ash ratio

It is observed through many investigations that the geopolymer's strength increases with the rise of the alkaline solution to fly ash ratio. But a very low rise the speed of strength is observed beyond the solution to fly ash ratio of 0.35.

3. The ratio of water to geopolymer binder

Water was noticed coming out of the mix during the polymerization process due to a chemical reaction. The job of water is to generate usable concrete in a plastic state; it does not affect the hardened concrete's strength. Similarly, as the fineness of the source material grows, the demand for water increases for the identical degree of workability.

According to the findings, compressive strength declines as the water-to-geopolymer binder ratio grows, and the mixture is stiff at 0.25 and separated at 0.40. Water escapes during the polymerization process as well, although it does not affect the strength.

In the past, geopolymer binders required heat curing, had a high pH, and were difficult to work with in the field. As a result, due to its growing popularity in the field, efforts must be made to create a favourable room-temperature that uses solid activators rather than alkaline solutions.

4. Superplasticizers

As per observation, the naphthalene-based superplasticizer is the most successful, resulting in a high percent increase in a relative slump without a drop in concrete strength. However, in a fly ash/slag blended system, a retarding impact of polycarboxylate-based superplasticizer is also noted, though the workability improvement is significant when compared to naphthalene-based superplasticizer.

ADVANTAGES

Very Low Creep and Shrinkage

As a result of the concrete drying and heating, or even the evaporation of water, shrinkage can result in major and even dangerous fractures in the concrete. Traditional concrete hydrates are porous and shrink more than geopolymer concrete.

The creep rate of geopolymer concrete is negligible. Creep, in concrete terms, is the tendency of concrete to become permanently warped as a result of the forces operating on it.

Heat and Cold Resistant

It can withstand temperatures of over 2200 degrees Fahrenheit while remaining stable. Excessive heat can cause concrete to spill or have layers break apart, reducing its stability. Spilling does not occur in geopolymer concrete until temperatures exceed 2200 degrees Fahrenheit.

It is resistant to freezing in cold conditions. Although the pores are so small, water can nevertheless permeate hardened concrete. When temperatures drop below freezing, water freezes and expand, causing fissures to form. Geopolymer concrete is not susceptible to freezing.

High Compressive Strength

It has a compressive strength that is higher than that of conventional concrete. It also has a short strength development and curing time, making it a great choice for speedy builds.

The tensile strength of geopolymer concrete is very high. It is less brittle and can withstand greater movement than Portland concrete. It is not earthquake-proof, but it does outperform standard concrete in terms of withstanding the earth's movement.

Chemical Resistance

It is chemically resistant to a high degree. Geopolymer concrete is unaffected by acids, toxic waste, or saltwater. Corrosion is less likely with this concrete than with ordinary Portland concrete.

DISADVANTAGES

While geopolymer concrete appears to be the super concrete that would eventually replace ordinary Portland concrete, it has certain drawbacks, including:

Difficult to Make and handle.

Due to the risks connected with its manufacture, geopolymer concrete is simply available as a precast or premix material.

In the geopolymerization process, there is no consistency.

Like cement concrete, there are many unresolved issues that could cause major problems throughout the mixing

CONCLUSIONS

1. Geopolymer concrete has significant potential for usage as a construction material in a variety of applications. The design provisions code for OPC concrete described in ACI guidelines and other National Codes are said to apply to geopolymer concrete as well.

2. In comparison to OPC concrete, geopolymer concrete has better strength and durability. Geopolymer concrete has the potentiality of becoming a future material because it is not only environmentally benign but also has good strength and durability.

3. Although geopolymer concrete is an ultimate replacement material and reduces CO2 emissions, its use in structural components has yet to acquire widespread adoption due to a lack of structural design standards and norms.

REFERENCES

1. "Geopolymer Concrete with Fly Ash," by I. N. A. Lloyd and B. V. Rangan. The Curtin University of Technology, Curtin University of Technology, Curtin University of Technology, Curt
2. Use of geopolymer concrete for a cleaner and sustainable environment-A review of mechanical properties and microstructure, Journal of Cleaner Production, 223 (2019) 704-728. II. Amer Hassan, Mohammed Arif, M. Shariq, Use of geopolymer concrete for a cleaner and sustainable environment-A review of mechanical properties and microstructure, Journal of Cleaner Production, 223 (2019) 704-728.
3. K.K. Aligizaki, K.K. Aligizaki, K.K. Aligizaki, K.K. Alig Cement-based materials have a porous structure. New York's Taylor &Francis.
4. T. Bakharev, J.G. Sanjayan, and Y.-B. Cheng, Alkali activation of Australian slag. cement, 1999a. Cement Concrete Research, vol. 29, no. 1, pp. 113-120.
5. F. Collins, The effect of pore size distribution on alkali-activated slag concrete drying shrinkage. Res. 30, 1401-1406. Cement Concrete.
6. Geopolymer technology: the present state of the art, Journal of Material Science, 42, 2917 - 2933. VI. Duxson, P., et al., 2007b.
7. M. Nasir, M. Fareed, Fadhil Fareed, Fadhil Fareed, Fadhil Fareed, Fadhil Fareed, Fadhil Compressive strength and workability of self-compacting geopolymer concrete based on low-calcium fly ash. Environ. Struct. Constr. Archit. Eng. 5, 64-70. International Journal of Civil, Environ. Struct. Constr. Archit. Eng. 5, 64-70.
8. P.K. Mehta and P.J.M. Monteiro, 2006. Microstructure, Properties, and Materials of Concrete New York: McGraw-Hill.
9. S.E. Wallah, D.S.D.M.J., R.B.V, 2005. IX. Wallah, S.E., Hardjito, D.S.D.M.J., R.B.V., 2005. Under sulphate and acid exposure, the performance of fly ash-based geopolymer concrete' 153-156 in Geopolymer Proc.
10. "Fracture Properties of Fibre Reinforced Geopolymer Concrete," by X. Deepa Raj S., Ruby Abraham, N. Ganesan, and Divya Sasi. Volume 4, Issue 5, May 2013 ISSN 2229-5518 International Journal of Scientific and Engineering Research IJSER, vol. 75, no. 8, pp. 75-80, 2013.
11. "Effect of Steel Fibres and Low Calcium Fly Ash on Mechanical and Elastic Properties of Geopolymer Concrete Composites," XI. Atteshamuddin S. Sayyad and Subhash V. Patankar. Volume 2013, Article ID357563, pages 1-8 in Indian Journal of Materials Science
12. N. Ganesan*, P.V. Indiraa, and Anjana Santha Kumar, "Engineering properties of steel fiber reinforced geopolymer concrete," Department of Civil Engineering, National Institute of Technology Calicut, NIT Campus P.O, Pin.673601, Kerala, India, 2013, pp 305-318.