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APPLICATIONS OF GEOPOLYMER CONCRETE- REVIEW

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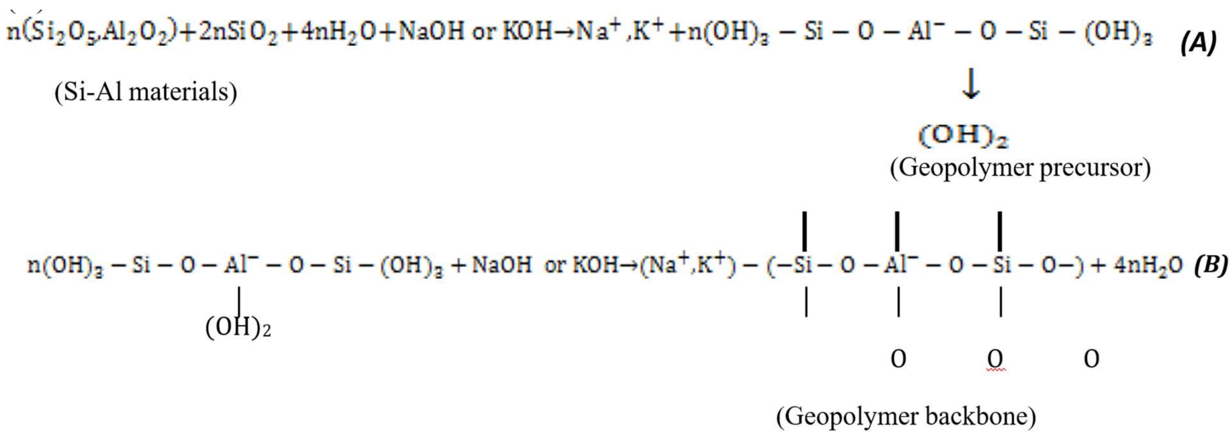
ABSTRACT: The most adaptable, dependable, and long-lasting construction material in the world is concrete. The most commonly used substance, after water, is concrete, which calls for a lot of Portland cement. The manufacturing of ordinary Portland cement is the second largest source of atmospheric pollution caused by carbon dioxide emissions, after automobiles. In addition, the manufacturing of cement required a significant quantity of energy. Finding a substitute for the current Portland Cement, which is the priciest and uses the most resources, is therefore inevitable. An novel building material called geopolymer concrete is created by the chemical reaction of inorganic molecules. There is an abundance of fly ash, a by-product of coal from thermal power plants, around the world. Fly ash has a lot of silica, and when it combined with an alkaline solution, it created an aluminosilicate gel, which served as the concrete's binding agent. It's a great substitute for the current standard cement concrete in construction. Ordinary Portland cement must not be used in the production of geopolymer concrete. This paper provides a quick overview of the components, durability, and possible uses of geopolymer concrete.
KEYWORDS: Geopolymer Concrete, Fly Ash, Strength, Curing, Applications.

I. INTRODUCTION

In 1978, a French professor named Davidovits coined the term "geopolymer" to refer to a wide class of materials that are typified by networks of inorganic molecules (Geopolymer Institute 2010). For a supply of silicon (Si) and aluminium (Al), the geopolymers rely on thermally activated natural resources like Meta kaolinite or industrial byproducts like fly ash or slag. After dissolving in an alkaline activating solution, the silicon and aluminium polymerize into molecular chains, which serve as the binder.Professor B. Vijaya Rangan (2008), Curtin University, Australia, stated that, “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….”The ultimate structure of the geopolymer depends largely on the ratio of Si to Al (Si:Al), with the materials most often considered for use in transportation infrastructure typically having an Si:Al between 2 and 3.5 .

The reaction of Fly Ash with an aqueous solution containing Sodium Hydroxide and Sodium Silicate in their mass ratio, results in a material with three dimensional polymeric chain and ring structure consisting of Si-O-Al-O bonds

The schematic formation of geopolymer material can be shown as described by Equations (A) and (B).



Water is released during the curing and subsequent drying processes rather than being a part of the chemical reaction of geopolymer concrete. On the other hand, when Portland cement and water are combined, the hydration reactions take place and result in the production of calcium hydroxide and calcium silicate hydrate. This distinction not only makes the resulting geopolymer concrete more resistant to heat, water infiltration, alkali-aggregate reactivity, and other forms of chemical attack, but it also has a substantial effect on its mechanical and chemical qualities. The role of calcium in these systems is critical for fly ash-based geopolymers since its presence can produce flash setting, which means it needs to be carefully managed. The source material is combined with an activating solution—potassium hydroxide or sodium hydroxide are frequently used—that supplies the alkalinity required to release the Si and Al, and it may also contain an extra source of silica, though sodium silicate is most frequently utilised.While certain systems have been created that are intended to be cured at ambient temperature, temperature during curing is crucial. Depending on the source materials and activating solution, heat frequently needs to be supplied to assist polymerization. This study goes into great length about the benefits of geopolymer concrete, including its properties, applications, and limitations.

II. REQUIREMENT OF GEOPOLYMER CONCRETE

Construction is one of the fast growing fields worldwide. As per the present world statistics, every year around 260,00,00,000 Tons of Cement is required. This quantity will be increased by 25% within a span of another 10 years. Since the Lime stone is the main source material for the ordinary Portland cement an acute shortage of limestone may come after 25 to 50 years. More over while producing one ton of cement, approximately one ton of carbon di oxide will be emitted to the atmosphere, which is a major threat for the environment. In addition to the above huge quantity of energy is also required for the production of cement. Hence it is most essential to find an alternative binder.

The Cement production generated carbon di oxide, which pollutes the atmosphere. The Thermal Industry produces a waste called flyash which is simply dumped on the earth, occupies larges areas. The waste water from the Chemical Industries is discharged into the ground which contaminates ground water. By producing Geopolymer Concrete all the above mentioned issues shall be solved by rearranging them.

Waste Fly Ash from Thermal Industry + Waste water from Chemical Refineries = Geo polymer concrete. Since Geopolymer concrete doesn't use any cement, the production of cement shall be reduced and hence the pollution of atmosphere by the emission of carbon di oxide shall also be minimized.

III. INGREDIENTS OF GEOPOLYMER CONCRETE

The following are the constituents of Geopolymer concrete

- Fly Ash- rich in Silica and Aluminium
- Sodium Hydroxide or Potassium Hydroxide
- Sodium Silicate or Potassium Silicate

IV. PROPERTIES OF GEOPOLYMER CONCRETE

The superior properties of Geopolymer concrete, based on Prof. B. Vijaya Rangan and Hardijito, are

- sets at room temperature
- non toxic, bleed free
- long working life before stiffening
- impermeable
- higher resistance to heat and resist all inorganic solvents
- higher compressive strength

Compressive strength of Geopolymer concrete is very high compared to the ordinary Portland cement concrete. Geopolymer concrete also showed very high early strength. The compressive strength of Geopolymer concrete is about 1.5 times more than that of the compressive strength with the ordinary Portland cement concrete, for the same mix.Similarly the Geopolymer Concrete showed good workability as of the ordinary Portland Cement Concrete.

V. APPLICATIONS

Geopolymer concrete has a lot of promise for use in bridge applications in the near future, including precast structural components and decks as well as structural retrofits with geopolymer-fiber composites. Because many modern geopolymers require a regulated, high-temperature curing environment, and handling delicate components (such as high-alkali activating solutions) can be done relatively easily, precast applications are where geopolymer technology is most advanced. Precast pipes, bricks, paving slabs, and pavers are further possible near-term uses.

The followings are the limitations

- Bringing the base material fly ash to the required location
- High cost for the alkaline solution
- Safety risk associated with the high alkalinity of the activating solution.
- Practical difficulties in applying Steam curing / high temperature curing process

Considerable research is ongoing to develop geopolymer systems that address these technical hurdles.

Flyash interacted with an alkaline solution to generate a binding substance, as Joseph Davidovits discovered. According to Hardijito & Rangan, geopolymer concrete with a higher sodium hydroxide concentration (molar) has a higher compressive strength as well as a larger ratio of sodium silicate to sodium hydroxide liquid by mass. Additionally, they discovered that a longer curing period and an increase in the curing temperature between 30 and 90 °C both improved the compressive strength of geopolymer concrete. They worked with the geopolymer concrete for up to 120 minutes without seeing any setting or reduction in compressive strength, which led to minimal drying shrinkage and minimal creep.

According to Suresh Thokchom et al., after 18 weeks of exposure to a 10% sulfuric acid solution, the fly ash and alkaline activators used to make the Geopolymer mortar specimens remained structurally intact and did not exhibit any discernible colour changes. Additionally, the Geopolymer Concrete demonstrated a high level of resistance against sulfuric acid.

According to D. Bondar et al., when the mass ratio of water to geopolymer solids increased, the strength of the geopolymer concrete dropped. Anuar et al. found that the strength characteristic of geopolymer concrete was impacted by the concentration (measured in molarity) of NaOH. Elastic modulus and Poission's ratio were found to be within permissible bounds, and S. Vaidya et al. investigated that a consistent temperature was formed throughout the mass. Raijiwala et al. observed that GPC's split tensile strength increased over controlled concrete by 1.5 times, and its compressive strength increased over controlled concrete by 1.5 times (M-25 reaches M-45). Flexural strength of GPC surpassed that of controlled concrete by 1.6 times and by 1.45 times, respectively. It is suggested by Fadhil Nuruddin et al. that cast in-situ application in Geopoymer concrete is a feasible option. Douglas et al. effectively stabilized trash by the use of geopolymer concrete. Chemical poisons were immobilized and leachate level concentrations were lowered by geopolymer concrete. Quarry dust will partially replace the fine aggregate because there is a market for natural sand. Due to its high silica content, quarry dust can be partially replaced with geopolymer concrete to boost the material's compressive strength. Various sodium hydroxide solution concentrations (8M, 10M, 12M, 14M, and 16M) will be employed, and the properties will be examined. In a similar vein, the various curing techniques will also be investigated. The various molar ratios of sodium hydroxide solutions indicated above will be examined for hot air curing, steam curing, sun curing, and ambient curing. Different structural elements, such as plain cement concrete beams, reinforced cement concrete beams, reinforced concrete columns, and reinforced beam column joints, must be cast for the aforementioned concentrations of sodium hydroxide solution and curing conditions and tested in order to study the use of geopolymer concrete as regular concrete. It is recommended to utilise geopolymer concrete instead of regular Portland cement concrete after a study of its properties and testing results are considered.

VI. CONCLUSION

Conditions acceptable for regular portland cement concrete can also be applied to user-friendly geopolymer concrete. These components of geopolymer concrete must be able to be combined with an activating solution that is reasonably low in alkali and must be able to cure in a fair amount of time in ambient conditions. Geopolymer concrete is a versatile and affordable material that may be mixed and dried similarly to portland cement. The material geopolymer concrete must be utilised for restoration and maintenance projects. Because of its high early strength, geopolymer concrete can be utilised efficiently in the precast industries to achieve large production in a short amount of time while minimising breakage during transportation. For the beam-column junction of a reinforced concrete construction, geopolymer concrete will work well. The infrastructure projects will also make use of geopolymer concrete. Furthermore, flyash will be used efficiently, so there is no need to dump it in landfills.The government can take the appropriate actions to recover sodium hydroxide and sodium silicate solution from chemical industry waste materials in order to lower the price of the alkaline solutions needed to create geopolymer concrete.

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