A Review Paper on a Laboratory Assessment of Different Molarity of Alkaline Activator Geopolymer Concrete by Replacement of Fly Ash by Rice Husk Ash

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Abstract — The evolution of sustainable construction materials has directed attention towards geopolymer concrete (GC), primarily developed from aluminosilicate-rich waste materials such as fly ash (FA). The alkali-activated binders in GC are pivotal for its unique structural and durability properties. While FA-based GC has been extensively researched, the partial replacement of FA with rice husk ash (RHA) presents a new frontier, especially given the high silica content in RHA. This study focuses on understanding the influence of different molarities of alkaline activators on the properties of GC when FA is partially replaced with RHA.

Keywords: Mix Design, Rice Husk Ash (RHA), Slump Value, Molarity, Curing Temperature and Compressive Strength

I. INTRODUCTION

The construction industry, responsible for building the backbone of our urban landscapes, has historically been reliant on conventional materials like ordinary Portland cement (OPC) for concrete production. While effective, the environmental footprint of OPC is concerning. The production of one ton of cement emits approximately one ton of carbon dioxide into the atmosphere, making the cement industry accountable for nearly 8% of the world's CO2 emissions. In this environmentally conscious era, these statistics have spurred significant research into sustainable and eco-friendly alternatives. Enter geopolymers. Pioneered in the late 20th century, geopolymer technology embodies the synthesis of aluminosilicate materials activated by alkaline solutions to produce binders with properties akin to, or in some instances superior than, OPC. One prominent precursor for geopolymers is fly ash (FA), a byproduct of coal combustion in power plants. FA, rich in aluminosilicate content, is typically considered a waste material. However, its utilization in geopolymer concrete not only provides a sustainable alternative to cement but also contributes to waste management solutions. However, FA's availability and variances in its chemical composition across sources have led researchers to explore other potential precursors. An intriguing alternative is rice husk ash (RHA). Produced by burning the husks of rice grains, RHA is predominantly composed of silica (SiO2). Thus, RHA not only offers an eco-friendly alternative to FA but also addresses the waste disposal problem associated with rice production.

II. LITERATURE REVIEW

A. Geopolymer Concrete

Geopolymer concrete (GC) emerges as a revolutionary construction material that challenges the traditional dominance of Ordinary Portland Cement (OPC) based concretes. Pioneered by Davidovits in the 1970s, geopolymers are a range of synthetic aluminosilicate materials synthesized by the alkali-activation of aluminosilicate precursors. The resultant binder possesses properties comparable to OPC, with the added benefits of reduced carbon footprint and potential for waste utilization. In the realm of concrete, the term "geopolymer concrete" denotes the replacement of traditional cement with geopolymer as the binding material.

B. Role of Alkaline Activators

The geopolymerization process is significantly influenced by the alkaline activators used. These activators, primarily sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate, foster dissolution of the aluminosilicate precursor materials, leading to the formation of the geopolymer binder. The concentration, or molarity, of the activator solution directly impacts the setting time, workability, strength, and durability of the geopolymer concrete. Research indicates that higher molarities generally accelerate setting times but may compromise long-term durability.

C. Fly Ash in Geopolymer Concrete

Fly ash (FA), a byproduct from coal combustion in power plants, is an aluminosilicate material that has found significant use in geopolymer concrete. Being rich in silica (SiO_2) and alumina (Al_2O_3), FA serves as an excellent precursor for geopolymer synthesis. FA-based geopolymer concretes demonstrate improved resistance to sulfate attack, reduced permeability, and enhanced fire resistance compared to their OPC counterparts. Its utilization in GC not only elevates waste material to a resource but also aligns with global sustainability aspirations.

D. Rice Husk Ash: Properties and Benefits

Rice husk ash (RHA) is derived from the combustion of rice husks and is predominantly rich in silica. Given its high amorphous silica content, RHA has the potential to contribute to the geopolymerization process. Beyond its chemical advantages, the utilization of RHA, an agricultural waste, addresses disposal challenges in regions with significant rice production. Furthermore, RHA has demonstrated potential benefits such as improved resistance to chemical attacks and a refinement of the pore structure of the geopolymeric matrix.

E. Previous Studies on RHA in Geopolymer Concrete

The integration of RHA in geopolymer concrete is not entirely novel, with several studies exploring its potential. Some researchers have reported an enhancement in compressive strength with partial FA replacement by RHA, attributing this to the reactive silica content of RHA. Others have emphasized the necessity of optimizing the RHA particle size and burning temperature to maximize benefits. However, a common observation across studies is the enhancement in durability properties, especially resistance to chemical attacks, in geopolymer concretes containing RHA. While several studies have focused on RHA as a singular precursor, its combined effects with FA, especially under varying molarities of activators, demand deeper exploration

Joseph Davidovits et al (1978) explained about geo-polymer chemistry and their production along with the correct scientific definition, concept, and chemical structure.

Davidovits J and Sawyer J L (1985), were concluded that What's more, an instant mortar bundle that required just the expansion of blending water to deliver a strong and quick quality increasing material was created and used in reclamation of solid air terminal runways, covers and runways, parkway and scaffold decks, and for a few new developments when high early quality was required. Geopolymer has likewise been utilized to supplant natural polymer as a cement in fortifying auxiliary individuals. Geopolymers were observed to be fireproof and solid under UV light.

Joseph Davidovits (1994), introduced an innovative form of concrete known as geopolymer concrete, distinct from traditional Portland cement-based concrete. Geopolymer is an inorganic alumina-silicate polymer created through the synthesis of predominantly silicon (Si) and aluminum (Al) materials sourced from geological origins or by-products. The chemical composition of geopolymer materials bears resemblance to zeolite, yet they exhibit an amorphous microstructure. The synthesis process involves the combination of silicon and aluminum atoms, forming building blocks that mirror the chemical and structural attributes of those found in natural rocks. Geopolymer cements, characterized by their acid-resistant and zeolitic properties, have been developed for the enduring containment of hazardous and toxic wastes. Furthermore, the incorporation of GGBS (Ground Granulated Blast Furnace Slag) not only expedites the setting time of concrete but also enhances the compressive and flexural strength of geopolymer concrete.

Van Jaarsveld J GS, et al., (1999), carried out experiments on geopolymers victimization 2 varieties of fly ash. They found that the compressive strength when 14 days was within the range of 5 – 51 MPa. The factors moving the compressive strength were the blending method and therefore the chemical composition of the ash. a better CaO content shriveled the microstructure consistency and, in turn, multiplied the compressive strength. Besides, the water-to-fly ash magnitude relation conjointly influenced the strength. it absolutely was found that because the water-to-fly ash magnitude relation shriveled the compressive strength of the binder multiplied.

Palomo A, et al., (1999), studied the influence of curing temperature, solidification time and basic solution-to-fly ash magnitude relation on the compressive strength. They according that the employment of hydroxide (NaOH) combined with water glass (Na_2SiO_3) answer made the very best strength. Compressive strength up to sixty MPa was obtained once cured at 85°C for five hours.

Xu H and Van Deventer J S J (2000), investigated the geo-polymerization of 15 natural Al-Si minerals. it absolutely was found that the minerals with higher extent of dissolution incontestable better compressive strength when chemical change. the proportion of lime (CaO), metal compound (K_2O), the molar magnitude relation of Si-Al within the supply material, the sort of alkali, and therefore the molar magnitude relation of Si/Al within the answer throughout dissolution had a vital impact on the compressive strength.

Shankar H Sanni and B Khadiranaikar et al, (2000) prepared the alkali answer with water glass to hydroxide ratio varied as 2, 2.5, 3, 3.5 for all grades of geo-polymer concrete mixes. hydroxide of eight M concentration was ready and superplasticizer dosage of 1.5% by mass of ash was adopted. The chemical admixture i.e. superplasticizer (HRWRA) tagged as “CONMIX SP- 430”.

Swanepoel J C and Strydom C A (2002), each the curing time and therefore the solidification temperature affected the compressive strength, and therefore the optimum strength occurred once specimens were cured at 60°C for an amount of 48 hours.

F. Gaps Identified from the Literature Review:

Based on the findings from the literature review, following gaps were identified;

- Molar concentration of sodium hydroxide plays key role of durability of concrete. With some modifications in the equation of IS code, geopolymer mix can be designed.
- On developing various mix design by adding various trial contents of sand and other cementitious materials, their optimum quantity as well as its effect on geopolymer concrete can be determined.
- The ultimate aim to develop such a concrete is to reduce global carbon dioxide emissions and move towards a sustainable development.
- Geopolymer binders is not limited to use in geopolymer concrete, but in variety of applications depending upon its Si : Al ratio.
- On developing various mix design by adding various trial contents of sand and other cementitious materials, their optimum quantity as well as its effect on geopolymer concrete can be determined.
- The ultimate aim to develop such a concrete is to reduce global carbon dioxide emissions and move towards a sustainable development.
- Geopolymeric materials are fire and heat resistant, which serves the main aim of developing this inorganic geopolymer.
- The present research work aims to address the above-mentioned gaps identified from the literature.

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