INFLUENCE OF NANO-SILICA, MAGNESIUM OXIDE AND ALUMINA ON EFFLORESCENCE BEHAVIOUR OF LOW CALCIUM ALKALI ACTIVATED MATERIALS

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Keywords

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Introduction

As urbanization accelerates and construction projects multiply, there has been a significant surge in the global consumption of concrete and its primary binding agent, known as ordinary Portland cement (OPC). A significant increase in cement production results in the emission of considerable quantities of greenhouse gases, which contribute to global warming and enlarge the carbon footprint. The cement industry is responsible for approximately 5% to 8% of global CO_2 emissions; therefore, for every ton of cement produced, approximately 900 kg of CO_2 will be emitted. Therefore, it is imperative to explore alternative binding materials for concrete production. Previous studies have demonstrated that geopolymers derived from industrial by-products, which are abundant and beneficial in this context, can effectively mitigate the CO_2 emissions of OPC by a range of 45-80%. Alkali activated materials (AAMs), also known as geopolymers, are produced through the reaction of aluminosilicate-rich raw materials (e.g., fly ash (FA), metakaolin (MK), slag (GGBS), silica vapors (SF), and others) with an alkaline solution (e.g., sodium/potassium hydroxide). This results in the formation of an NASH(high FA) or CASH(high Slag). Geopolymers possess an extensive array of advantages in comparison to OPC, which extend beyond their superior durability properties. The aforementioned characteristics include notable volume stability, high early strength, low permeability, resistance to chemical attacks, effective freezing and thawing capabilities, and an adhesive quality.

Efflorescence is a phenomenon that occurs when free alkalis migrate through a material's pore network to the surface and react with carbon dioxide from the environment under specific humidity conditions it is one of the major problem in geopolymers which must be studied in order to fully understand how a structural material's structural qualities are affected.

Therefore, it is yet unknown how efflorescence may impact a geopolymer's microstructure and characteristics. This is due to the complexity of efflorescence mechanisms and the elements that impact them. Thus far, very little direct research has been done on this subject.In this study, the investigation aims to elucidate the impact of Nano silica, Magnesium oxide and aluminium oxide on intensity of efflorescence and mechanical properties of low calcium alkali activated materials.

Objectives

1. To find the effect of SiO_2 on intensity of efflorescence and mechanical properties of low calcium alkali activated materials
2. To find the effect of MgO on intensity of efflorescence and mechanical properties of low calcium alkali activated materials
3. To find the effect of Al_2O_3 on intensity of efflorescence and mechanical properties of low calcium alkali activated materials

Methodology

Phase 1: Experimental Design and Preparation

- Formulation of Alkali Activated Materials (AAMs)
    - Utilization of fly ash and GGBS as precursors
    - Use of 1.1MS and 12% Na_2O as alkaline activator.
- Variations in Mix Compositions
    - Testing various mix compositions to assess the impact of different additives.
    - Formulations include:
        - Mix 1: 100% FlyAsh + 12% Na_2O + 1.1 MS
        - Mix 2: 70% FlyAsh + 30% GGBS+ 12% Na_2O + 1.1 MS
        - Mix 3: 70% FlyAsh + 30% GGBS+ 1% SiO_2+12% Na_2O + 1.1 MS
        - Mix 4: 70% FlyAsh + 30% GGBS+ 2% SiO_2+12% Na_2O + 1.1 MS
        - Mix 5: 70% FlyAsh + 30% GGBS+ 1% MgO+12% Na_2O + 1.1 MS
        - Mix 6: 70% FlyAsh + 30% GGBS+ 3% MgO+12% Na_2O + 1.1 MS
        - Mix 7: 70% FlyAsh + 30% GGBS+ 5% MgO+12% Na_2O + 1.1 MS
        - Mix 8: 70% FlyAsh + 30% GGBS+ 1% Al_2O_3+12% Na_2O + 1.1 MS
        - Mix 9: 70% FlyAsh + 30% GGBS+ 3% Al_2O_3+12% Na_2O + 1.1 MS
        - Mix 70% FlyAsh + 30% GGBS+ 5% Al_2O_3+12% Na_2O + 1.1 MS
- Specimen Preparation:
    - Casting the designed paste and Mortar mixtures into molds with dimensions of 30X30X30 mm and 40X40X40 mm respectively
    - Natural curing under ambient conditions at a temperature of 30 degrees Celsius.
- Efflorescence Testing Conditions
    - Exposure to air.
    - Partial immersion in water.

Phase 2: Comprehensive Testing and Analysis

- Compressive Strength Assessment:

  Evaluation of structural integrity and load-bearing capacity of paste and mortar samples at the age of 28 days and under different exposure conditions.

- Microstructural Analysis using Scanning Electron Microscopy (SEM):

  Detailed examination of internal composition and surface morphology to identify irregularities, voids, or phases influencing material properties.

- Thermogravimetric Analysis (TGA):

  Investigation of thermal behavior by measuring weight loss as a function of temperature to understand composition and stability under different environmental conditions.

- Efflorescence Simulation:

  Exposure to air simulates atmospheric conditions. Partial immersion and complete submersion simulate controlled moisture levels and challenges related to water absorption and potential degradation.

Results and Conclusions

Visual observation

Wet 0 day Efflorescence	**Wet 20 day Efflorescence**

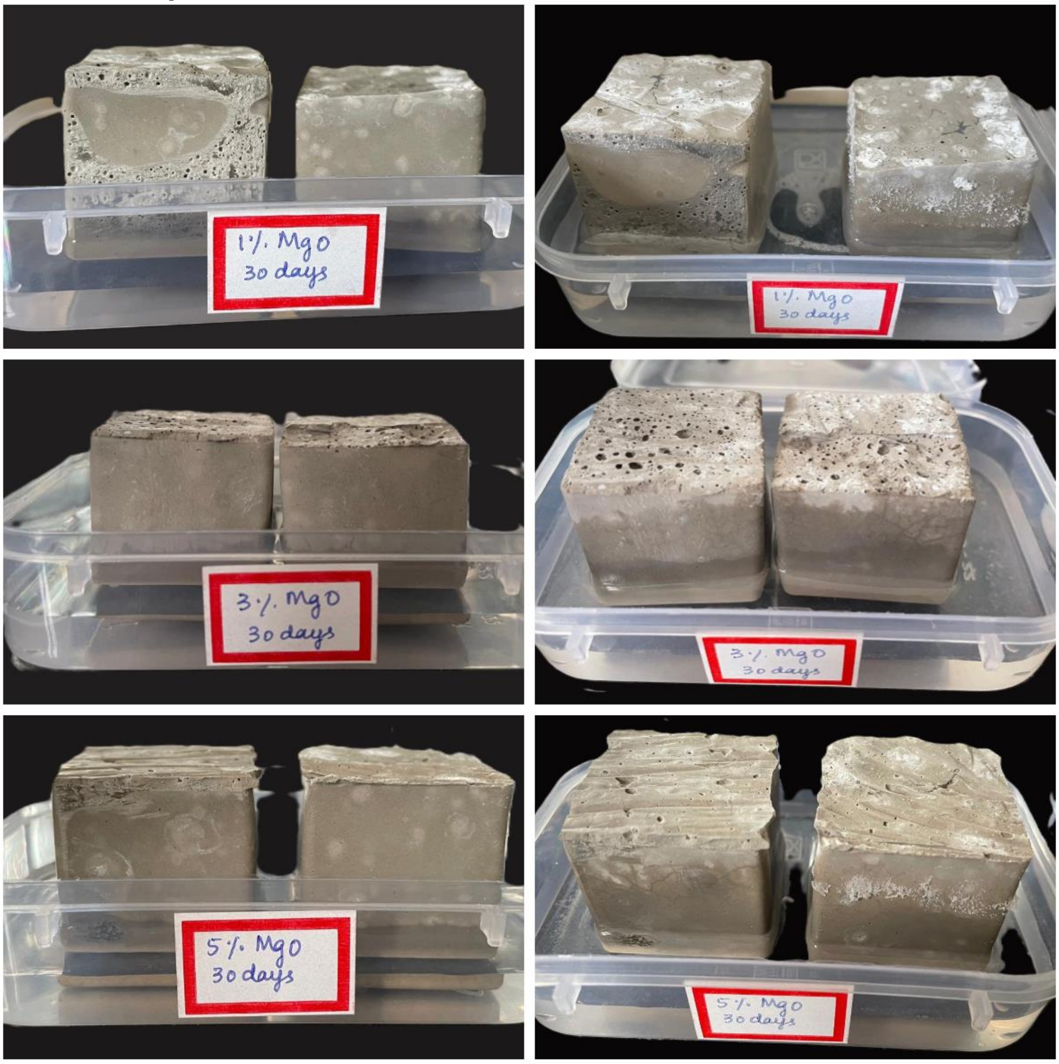

Figure 1. Efflorescence of 0 day and 20 day aged geopolymer specimens when stored with the bottom in contact with water

Wet

0 day Efflorescence

Wet

20 day Efflorescence

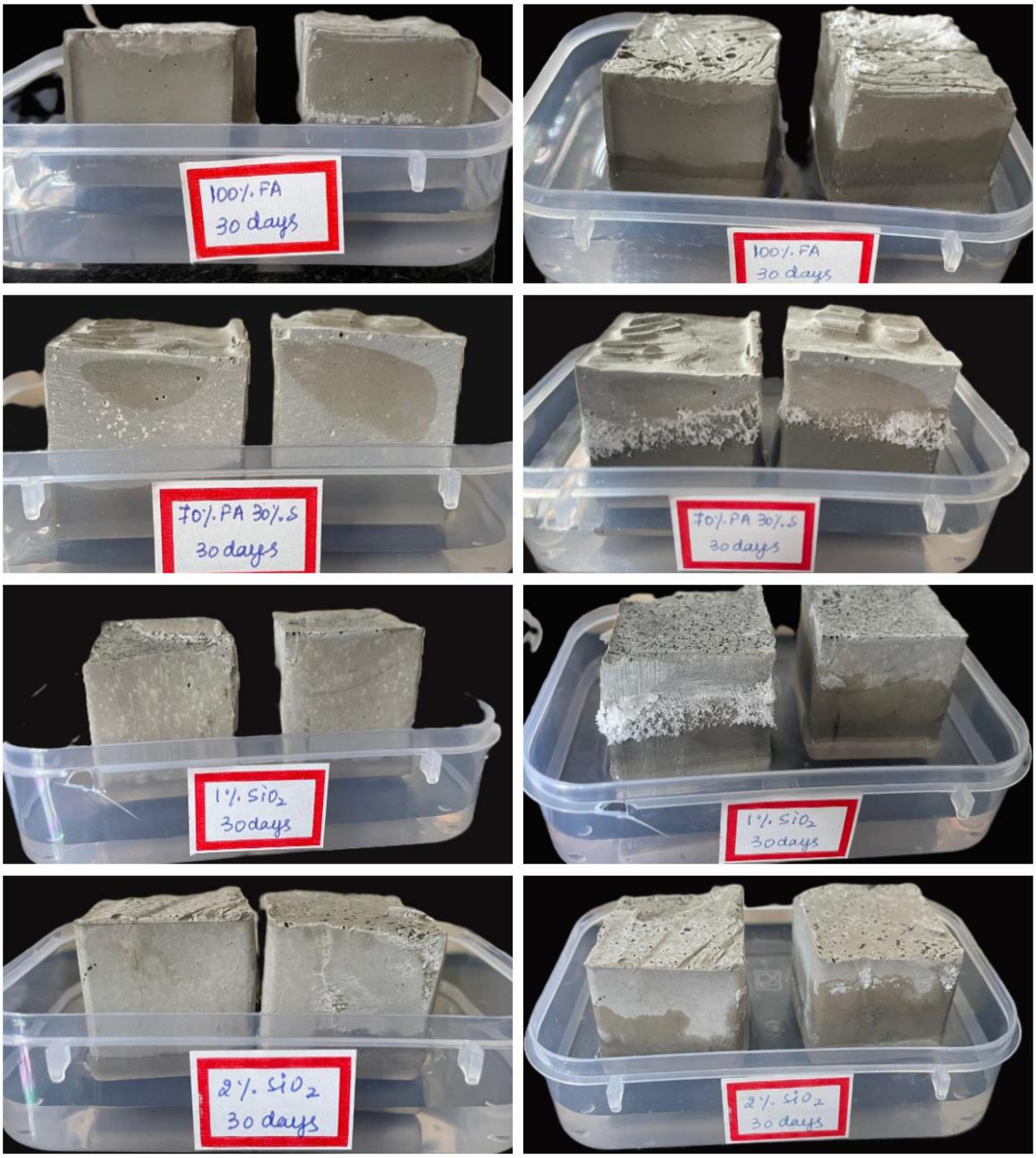

Figure 2. Efflorescence of 0 day and 20 day aged geopolymer specimens when stored with the bottom in contact with water

Wet **Wet**

0 day Efflorescence **20 day Efflorescence**

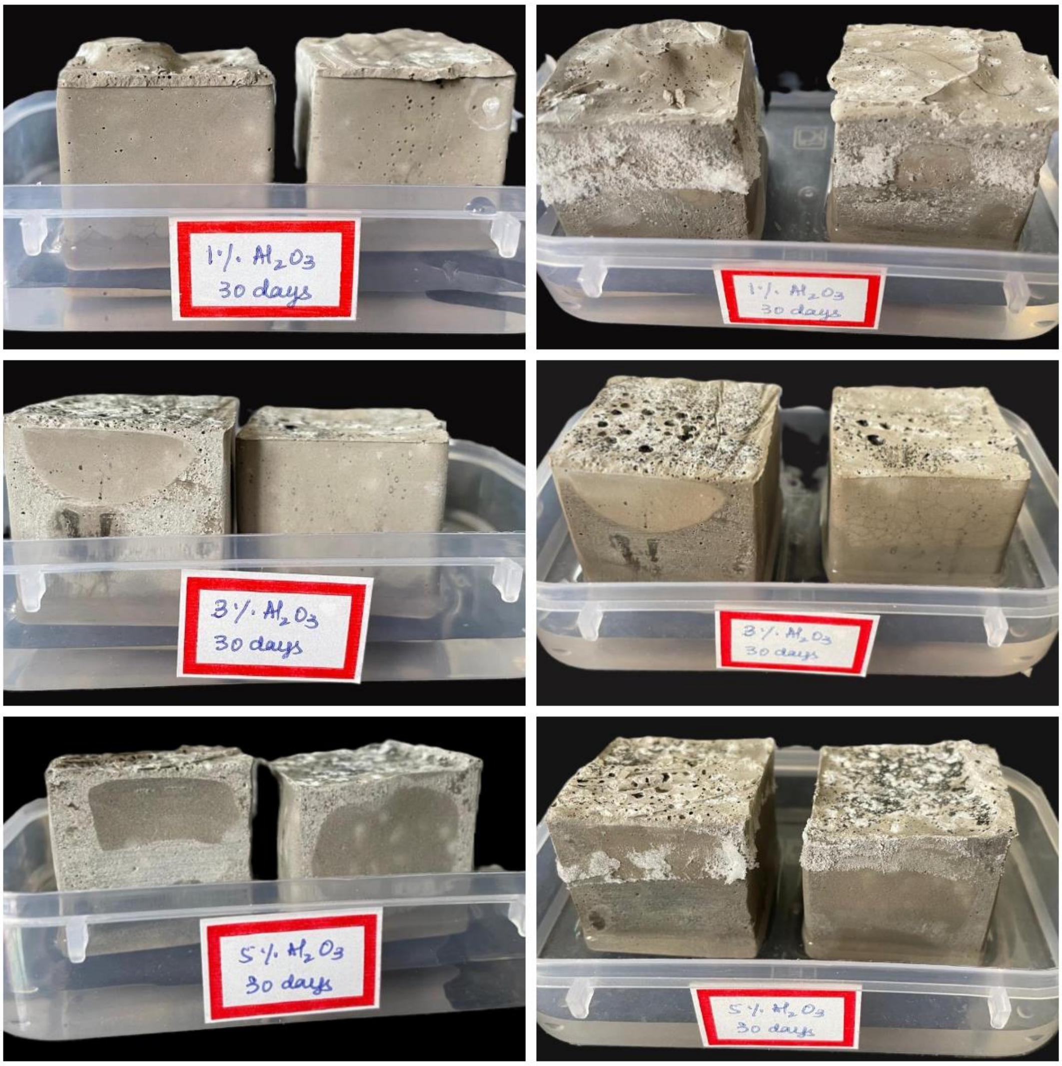

Figure 3. Effloresecence of 0 day and 20 day aged geopolymer specimens when stored with the bottom in contact with water

Fig. 1,2,3 shows the efflorescence of 0 day and 20 day aged geopolymers when stored with the bottom in contact with water.

It can be seen that Mix 2,3,5,7,8,10 showed efflorescence due to the presence of porous structure which provides channels for the movement of water and alkali cations.

Innovation in the Project

Use of magnesium oxide and aluminium oxide to test the influence on efflorescence on low calcium activated geopolymers

Scope for Future Work

1. To determine retrofitting measures for the efflorescence induced geopolymer concrete
2. To achieve a stoichiometric reaction using an aluminosilicate precursor.
3. To determine the precise influence of efflorescence on the microstructure properties of the materials.