Sulfuric acid resistance of blended ash geopolymer concrete

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HIGHLIGHTS

- Geopolymer concrete prepared with blended ash (PFA + POFA), activated by alkaline solution and 1.5 year 2% H2SO4 exposure.
- The evaluation of acid resistance in terms of visual appearance, mass change and compressive strength was examined.
- The effect of H2SO4 investigated by XRD, FTIR, TGA/DTG, SEM.
- H2SO4 exposed geopolymer concrete was superior to OPC, due to more stable cross-linked aluminosilicate polymer structure.

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ABSTRACT

This study presents an investigation into the durability of geopolymer concrete prepared using blended ash of pulverized fuel ash (PFA) and palm oil fuel ash (POFA) along with alkaline activators when exposed to 2% solution of sulfuric acid for up to 18 months. Ordinary Portland Cement (OPC) concrete was also prepared as control concrete. The main parameters studied were the evaluation of mass, compressive strength, products of degradation and microstructural changes. The deterioration was examined using X-ray diffraction (XRD), Fourier transform infrared (FTIR), thermogravimetry (TGA/DTG), scanning electron microscopy (SEM). The results of geopolymer and OPC concretes were compared and discussed. The performance of geopolymer concrete when exposed to 2% sulfuric acid solution for more than a year was superior to OPC concrete which is attributed to a more stable cross-linked aluminosilicate polymer structure formed in the geopolymer concrete.

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1. Introduction

Ordinary Portland Cement (OPC) is widely used binder in construction practices. For a long time, OPC concrete was considered to be a very durable material requiring a little or no maintenance. Unfortunately, its resistance to chemical attacks such as acids and sulphates is of concern. It is well known that OPC concrete is susceptible to acid attack because of its alkaline nature. The components of the cement paste break down during contact with acids, most pronounced being the dissolution of calcium hydroxide [1]. Acid attack has not traditionally attracted much attention, even when cement composites are severely damaged by acids wherein calcium hydroxide is dissolved and the hydrated silicate and alumina phases are decomposed, and the concrete loses its strength and deteriorates quickly [2,3].

Geopolymers are a class of binders manufactured by activation of solid aluminosilicate source material with a highly alkaline activating solution and aided by thermal curing. In the past few decades, geopolymer binders have emerged as one of the possible alternatives to OPC binders due to their reported high early strength and resistance against acid and sulphate attack apart from its environmental friendliness [2,4,5]. Fly ash based geopolymers are one branch of the geopolymer family and have attracted more attention since the 1990s. As a novel binder, the performance of fly ash based geopolymers is promising, especially in some aggressive situations where OPC concretes are vulnerable [6–9]. Geopolymer binders might be a suitable alternative in the development of acid resistant concrete. It is an inorganic binder material and can be produced by a geopolymeric reaction of alkali activating solution with silica and alumina rich source material from geological origin or pozzolanic materials such as metakaolin, fly ash, and rice husk ash [2]. Geopolymers exhibit many excellent properties such as high early strength, low creep, low shrinkage, and good resistance against acid and sulphate attack in addition to its environmental friendliness [4,9,10]. Since geopolymers are novel binders that rely on aluminosilicate rather than calcium silicate hydrate bonds for structural integrity, they have been reported as being acid...