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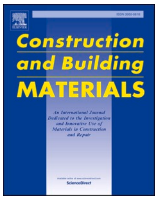

# Exemplification of efficacy of homebrewed sodium silicate solution processed from eco-processed pozzolan and palm oil clinker powder in geopolymer mortar

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ABSTRACT

This study investigated the extraction of alternative sodium silicates using a hydrothermal method, utilizing waste and industrial by-product materials, namely, eco-processed pozzolan (EPP) and palm oil clinker powder (POCP) with moderate silica content. Sodium hydroxide (NaOH) was used at three different molar concentrations of 3, 6, and 9 M. Extraction was conducted by mixing the contents in a solution form for 5 h at 80°C. Moreover, their effects on the development of a geopolymer mortar with 80 % fly ash (FA) and 20 % ground-granulated blast-furnace slag (GGBS) were investigated in terms of flowability, hardened density, ultrasonic pulse velocity (UPV), compressive strength for up to 56 d, field emission scanning electron microscopy (FESEM), and X-ray diffraction (XRD). The results demonstrated an enhancement in the compressive strength across all mixes, with values comparable to those observed in the mixes prepared using conventional sodium silicate. The compressive strengths of the mixes P1-COM (control), P1-POCP-9M, and P1-EPP-9M at 56 days were 62.9, 58.9, and 60.1 MPa, respectively. The specimens activated with extracted sodium silicate (ESS) using 9M-NaOH had a greater compressive strength than those with 3 M and 6M-NaOH. Additionally, an inverse relationship was observed between the NaOH concentration used in the ESS and the flow properties of the geopolymer mortar. The flowability was reduced by 11.53 % and 11.43 % in the case of mixes P1-POCP and P1-EPP, respectively, when 9M-NaOH was used for producing ESS. Microstructural analysis revealed the formation of the C-A-S-H and N-A-S-H phases in the specimens activated with COM-SS and P1-EPP-9M. In contrast, P1-POCP-9M led to the development of both K-A-S-H and N-A-S-H phases.

## 1. Introduction

Alkali activators are essential in geopolymer technology because they initiate the dissolution of aluminosilicate precursors and drive the polymerization process, forming a binding matrix. The most commonly used alkali activators are sodium hydroxide (NaOH), and potassium hydroxide(KOH), sodium silicate ($Na_2SiO_3$), potassium silicate ($K_2SiO_3$), and barium carbonate ($BaCO_3$) [1,2]. Hydroxides serve as strong bases to dissolve aluminosilicates, while silicates supply soluble silica, which enhances the geopolymer gel structure and improves the mechanical properties [3,4]. However, it has been reported that sodium silicate is one of the notable activators that has been extensively used by researchers [2,5].

The manufacturing of conventional sodium silicate is an extremely energy-demanding procedure that results in substantial $CO_2$ emissions. This is attributed to the reaction between silica sodium carbonate and sand at 1400°C [6–9]. Furthermore, it is estimated that every kilogram of commercially produced sodium silicate results in the emission of 1.514 kg of carbon dioxide into the environment [10]. In contrast, the hydrothermal method is recommended for extracting sodium silicate, minimizing high temperatures, and reducing $CO_2$ emissions. Tong et al. [11] reported that a high yield of silica was recorded at temperatures

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