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Innovative in-house sodium silicate derived from coal bottom ash and its impact on geopolymer mortar

Hadria Abd Alati Eisay Ghanim^a, U. Johnson Alengaram^{a,*},
Norazura Muhamad Bunnori^a, Muhammad Shazril Idris Ibrahim^{a,b}

^a Centre for Innovative Construction Technology (CICT), Department of Civil Engineering, Faculty of Engineering, Universiti Malaya, 50603, Kuala Lumpur, Malaysia

^b Institute of Ocean and Earth Sciences (IOES), Universiti Malaya, 50603, Kuala Lumpur, Malaysia

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ABSTRACT

Aluminosilicate precursors and alkaline solutions are combined to produce geopolymers. However, the high cost and energy demand of conventional alkaline activators limit the widespread use of alkali-activated materials (AAMs). Alkaline activators extracted from industrial wastes and by-products can address these challenges by reducing environmental impacts to a certain extent. Researchers have investigated the process for extracting alkali activators from waste materials that are high in silica, such as Waste Glass (WG) and Rice Husk Ash (RHA). However, there were limited studies on the extraction of sodium silicate from materials containing a moderate amount of silica. This study presents detailed findings on the production of alternate sodium silicates from Coal Bottom Ash (CBA) containing 43.7 % SiO₂ using a hydrothermal process, demonstrating the potential of CBA as an affordable and eco-environmental source of alkaline activators for geopolymers. The derived sodium silicate (DSS) was prepared using various sodium hydroxide (SH) molarities (3, 6, and 9M) and stirred for 5h at 80°C. The solubility of silica from CBA was also examined and compared with that of COM-SS and RHA, which served as the control. CBA-SS performance in AAM mortar, flowability, hardened density, compressive strength, and ultrasonic pulse velocity (UPV) tests were performed. The results revealed that the silica dissolution increased with increasing SH concentration. In addition, the specimens activated by commercial sodium silicate (COM-SS), RHA-9M, and CBA-9M exhibited an increase in their compressive strengths at 56 days, which were 62.9, 93.52, and 59.08MPa, respectively. The specimens activated with Coal Bottom Ash Sodium Silicate (CBA-SS) performed similarly to COM-SS. Therefore, geopolymer mortars can utilize CBA as a source of silica to derive sodium silicate. XRD and FESEM-EDX results confirmed the production of aluminosilicate hydrate (C-A-S-H) and calcium sodium aluminosilicate hydrate (N-A-S-H) as the primary components of the geopolymer gel.

List of abbreviations

Abbreviations	Definitions
AAMs	Alkali-Activated Materials
WG	Waste Glass

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* Corresponding author.

E-mail address: johnson@um.edu.my (U.J. Alengaram).

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