

The Effect of Sodium Hydroxide Concentration in Alkaline Activator on the Formation, Compression Strength and Morphology of Heat-Treated Fly Ash Geopolymers

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Structured Abstract

Background: The construction industry's reliance on Ordinary Portland Cement (OPC) significantly contributes to global carbon dioxide (CO₂) emissions and exacerbating climate change. This study addresses the urgent need for sustainable alternatives, focusing on Geopolymer Concrete (GPC) made from industrial by-products like fly ash (FA). However, existing research lacks insights into raw FA containing high levels of unburned carbon content and impurities, which can adversely affect GPC's properties. Furthermore, the optimum concentration of NaOH solution that gives highest compressive strength in GPC remains unclear. The objectives of this study are to investigate the effects of unburned carbon content in FA on the morphology, compressive strength, and functional groups in GPC and to determine the optimum concentration of NaOH solution that enhance the compressive strength of the GPC.

Methods: The FAs were heated for 1-4 hours at 600°C. The untreated and heat-treated FAs were further analyzed using CHNS Elemental Analysis, FTIR, and SEM Analysis. Then, while maintaining constant ratios, the geopolymers were prepared with various concentration of NaOH solutions: 6M (GP6), 8M (GP8), and 10M (GP10). Characterization of the geopolymer samples were done after 28 days of aging using FTIR, SEM Analysis, and compressive strength test.

Results: For the characterization of FA, according to CHNS analysis, the carbon content significantly reduced within the first two hours of heat treatment. While FTIR analysis showed that the O-H peak at 3435 cm⁻¹ became narrower and shifted to lower wavenumbers, SEM micrographs showed significant structural degradation and presence of fused silica particles. For the characterization of geopolymer, after 28 days of aging, FTIR spectra confirmed that the main Si-O-Si peak shifted from 1078 cm⁻¹ and 999 cm⁻¹. SEM showed a denser, more homogenous matrix in GP8 and GP8 recorded the highest compressive strength of 2.17 MPa.

Conclusion: In conclusion, unburned carbon content in FA was effectively reduced by 2 hours of heat treatment at 600°C, and the optimum concentration of NaOH in alkaline activator solution was 8M.

Keywords: geopolymer, fly ash, heat treatment, alkaline activator, NaOH

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