INFLUENCE OF PALM OIL FUEL ASH PARTICULATE INCORPORATION ON THE PHYSICO-MECHANICAL PERFORMANCE OF METAKAOLIN-BASED GEOPOLYMER PASTE

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ABSTRACT

Palm oil fuel ash (POFA) has attracted considerable attention as a sustainable supplementary material for geopolymer binders. However, variations in its chemical composition and physical characteristics arising from differences in source and processing conditions can significantly influence geopolymer performance. This study investigated the influence of POFA particulate incorporation on the physical and mechanical performance of metakaolin-based geopolymer paste. Metakaolin was partially replaced with POFA at levels of 0–30 wt.% and activated using sodium hydroxide and silicate solution. The raw materials and geopolymer binders were characterised using X-ray fluorescence (XRF), X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), density, water absorption, compressive strength and flexural strength measurements. The results confirmed the successful transformation of kaolin into reactive metakaolin, while POFA exhibited a silica-rich composition and predominantly spherical particles. Increasing POFA incorporation reduced the bulk density from 2.05 to 1.80 g/cm³ and increased water absorption from 9.0 to 11.5%. Moderate POFA incorporation improved mechanical performance, with compressive strength increasing from 19.23 MPa to 23.83 MPa at 20 wt.% POFA, while the highest flexural strength of 5.71 MPa was obtained at 15 wt.% POFA. Beyond these optimum levels, mechanical performance decline. Overall, the study demonstrates that controlled particulate incorporation of POFA provides an effective strategy for improving the physico-mechanical performance of metakaolin-based geopolymer paste, with an optimum incorporation level of 15–20 wt.%. The findings further demonstrate the potential of combining locally available kaolin with agricultural biomass ash to develop sustainable geopolymer binders with enhanced engineering performance.

Keywords: Palm oil fuel ash, Geopolymer, Metakaolin, Sustainable binder, Mechanical properties.