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Effect of quaternary binder slag-based geopolymer slurries on mechanical durability and microstructural properties of green prepacked composites

Haluk Görkem Alcan [a], Mahmood Hunar Dheyaaldin [b c d], Kenan Toklu [e], Barış Bayrak [a], Gökhan Kaplan [f], Abdulkadir Cüneyt Aydın [f]

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Highlights

- Substitution the slag based geopolymer to powders to enhance sustainability performance.
- Assessment of strengths bot normal-high temperature condition to determine their resilience.
- Microstructural analysis to identify and implement improvement in geopolymer matrix.
- Optimization of metakaolin and powders as replacement for slag.

Abstract

This study conducts a detailed investigation into the effects of slag-based quaternary binder geopolymer slurries on the physico-mechanical properties, high temperature resistance, and microstructural characteristics of prepacked composites. This research employs a strategic combination of aluminosilicate precursors, including metakaolin (MK), pumice powder (Pum), and perlite powder (Per), which are blended with slag in varying mix proportion to identify and optimizing the composite's performance. In the key finding reveal that samples containing 20 % of MK achieved superior performance, displaying the lowest porosity and water absorption rates. The oven-dry density of the mixtures demonstrated a marked improvement with the inclusion of MK, increasing from a range of 2150–2230 kg/m^3 in 0 % MK mixture to 2250–2350 kg/m^3 in those with 20 % MK. Post heat curing, the compressive strength peaked at 31.12 MPa in the mixture comprising 20 % MK, 20 % pumice, and 10 % perlite; however, this strength reduced to 11.92 MPa when subjected to a temperature of 600°C. In high temperature resistance tests, the combination of 20 % MK and 10 % perlite resulted in a minimal mass loss of 4 % at 600°C, indicating a robust resistance to thermal degradation. Furthermore, the 24-hwater capillary absorption displaying lowest water absorption rates. This study provides a critical advancement in the use of natural pozzolans for developing high-performance, slag based geopolymer slurries. The enhanced high-temperature strength and reduced water absorption underscore the potential of these materials to deliver durable and sustainable solution for the construction industry, particularly in application requiring superior thermal resistance and longevity.