

Enhancing geopolymer mortars: The impact of Algerian metakaolin substitution on mechanical performance and sustainability

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Abstract

Geopolymer binder has been received as sustainable substitute for the Portland cement that ensures lower carbon footprint and higher durability properties. This study focuses on the influence of metakaolin (MK) replacement in Benisaf natural pozzolan (BNP)-based mortars on the rheological and mechanical properties of these latter. The objective is to optimize the metakaolin content for improved mechanical performance while keeping suitable workability. Sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH) were used as activating solutions to synthesize geopolymer mortars, where MK replaced BNP with five different ratios of 10%, 20%, 30%, 40% and 50%. X-ray diffraction (XRD), X-ray fluorescence (XRF), Scanning electron microscopy-energy dispersive X-ray (SEM-EDX) and particle size analysis were used for characterizing the raw materials. The tests focused on flowability in fresh state, and compressive strength (CS) at 14 and 28 days. The outcomes show that increasing MK quantity results in a reduction in workability, since its particle size is finer and its reactivity is higher, consequently the viscosity is higher and the fluidity is lower. As a result, compressive strength was increased considerably, with a maximum value of 24 MPa at 40% metakaolin substitution (150% higher than control geopolymer mortar). This improvement is due to increased availability of aluminosilicate, which allows a denser gel formation as well as a more favorable polycondensation. Over 40% of MK content resulted in incomplete dissolution and decreased strength. A quantitative evaluation of MK-BNP geopolymer interactions is presented, high-lighting that 40% MK replacement can provide an optimal workability- strength equilibrium. This work aids the formulation of sustainable geopolymer mortars suitable for construction. Complementary investigations should emphasize practicability through large-scale applications, and durability and thermal stability as well.

Keywords: Binder Characterization; Geopolymeric Mortar; Mechanical Strength; Metakaolin Substitution; Natural Pozzolan; Rheological Behavior