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Towards A Greener Future: Geopolymers in Sustainable Construction and Building Climate Management

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Extended Abstract

In recent years, there has been greater investment in research to develop sustainable construction materials with suitable properties, such as improved climate control in buildings. The construction sector, in particular the production of Ordinary Portland Cement (OPC), is associated with 7% of harmful gas emissions [1]. In parallel, the mining industry sector contributes to increased pollution due to inadequate tailings management. These pose serious problem for the surrounding ecosystems, including soil and water acidification [2], [3].

One possible solution is to incorporate tailings into types of building materials, commonly referred to as geopolymers. Geopolymer is a term used to describe inorganic polymers formed through the chemical reaction between aluminosilicates and alkaline solutions. The interest in these materials is explained by their excellent mechanical, physical and thermal properties. Their production emits fewer greenhouse gases, consumes less energy and water compared to OPC [4], [5].

This work focuses on the characterization of geopolymers with the inclusion of tailings from a copper and iron sulphate mine. The samples were selected at four strategic points in the Tinoca mine, located in Campo Maior, Portugal: the slag heap (SZ), the leaching area (LZ), the sedimentation dam (YZ) and the iron hat area (IZ). The source of aluminosilicates was metakaolin (MK) from Aveiro, Portugal.

Various formulations were made with percentages from 0 wt. % to 30 wt. % of the tailings and analysed for simple compressive strength, X-ray Diffraction (XRD), X-ray Fluorescence, Scanning Electron Microscopy/Energy Dispersive Spectroscopy, Thermal Conductivity and Thermal Diffusivity and Fourier Transform Infrared (FTIR) spectroscopy.

The tailings have a major content of SiO_2, Al_2O_3, Fe_2O_3 complemented with harmful oxides/elements such as SO_3, Cu, Zn and Pb in significant proportions.

After evaluating the FTIR spectra and the XRD patterns, it was concluded that geopolymerization was successfully achieved and that it was possible to incorporate approximately 20 wt. % of the tailings. Analysis of the results of the simple compression tests after 90 days of curing showed that the formulations with 20 wt. % of tailings had values of around 37 MPa for MKSZ20, 34 MPa for MKYZ20, 33 MPa for MKLZ20 and MKIZ20. With these values, the formulations can be applied for more advanced purposes, such as the anti-corrosion protection of concrete reinforcements [6].

Additionally, thermal properties were measured, with thermal conductivity ranging from 0.581 to 0.395 W/m.K and thermal diffusivity from 0.381×10^{-6} to 0.290×10^{-6} m²/s. These values indicate that geopolymers are effective insulators due to their low thermal conductivity and diffusivity, allowing them to better retain indoor temperatures in buildings during both winter and summer [7].

Finally, to determine the viability of these geopolymers, the ones with the highest compressive strength and the lowest thermal properties were selected to ensure better structural support and energy management within the buildings. The formulations MKYZ20 and MKSZ20 were identified as the most promising, achieving compressive strengths of 36.5 MPa and 33.9 MPa, respectively, after 90 days of curing, with thermal conductivity values of 0.450 and 0.482 W/m.K, and thermal diffusivity values of 0.290×10^{-6} and 0.325×10^{-6} m²/s, respectively.

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