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ON THE MECHANICAL PERFORMANCE OF ALKALI-ACTIVATED MORTARS REINFORCED WITH SHORT PVA FIBERS

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Abstract: Alkali-activated materials (AAM), also known as geopolymers, have superior performance in several aspects when compared to traditional Portland cement (PC) based products and therefore have been the subject of increasing interest and research. However, as well as PC-based mortars and concretes, AAM are fragile materials that may have their mechanical behavior improved with fiber reinforcement. Several types of fibers have already been employed in AAM reinforcement. Among them, poly vinyl alcohol (PVA) fibers stand out for their high stability in alkaline environments and excellent interaction with the alkali-activated matrix. In the study of high performance composites, there is a special interest that the matrices meet the micromechanical sizing criteria that ensure the production of Strain-Hardening Cementitious Composites (SHCC) with high deformation capability. This paper investigates the influence of the matrix composition on properties related to the deformation capability of alkali-activated mortars reinforced with short PVA fibers, aiming to obtain the strain-hardening behavior. Metakaolin (MK) was used as the main solid precursor in the production of the AAM. This precursor material was partially replaced by silica fume (SF) with the aim of reducing the amount of sodium silicate in the activating solution – composed of sodium silicate and sodium hydroxide (NaOH) – and, at the same time, to keep the matrix SiO2/Al2O3 molar ratio constant: either 3.0 or 3.8. The composites were reinforced with 2% vol. of PVA fibers. The mechanical properties investigated were compressive and flexural strengths, as well as the modulus of elasticity. Apparent dry density, porosity and water absorption of the mortars were also assessed and used to give an estimation of the durability of the AAM. Single fiber pullout, fracture toughness and direct tensile tests were also performed in order to understand the parameters necessary to the determination of the performance indexes (Pseudo Strain-Hardening Index – PSH) related to tension (PSHtension) and energy (PSHenergy), used in the design of strain-hardening composites. The results indicate that SF may effectively replace sodium silicate as a source of soluble silica in the alkaline solution in order to produce sustainable AAM with deflection-hardening behavior, without compromising the physical and mechanical characteristics of the composites. The addition of 2% vol. of PVA fibers, in general, promotes the deflection-hardening behavior in the studied composites, with substantial toughness increase, although still not capable to generate the strain-hardening behavior. The paper finally discusses the strategies that may be employed to optimize the mechanical performance of the studied materials and to obtain the strain-hardening behavior, either by changing the fiber, matrices or fiber-matrix interface properties.

Keywords: geopolymers, alkali-activated materials, PVA fibers, metakaolin, silica fume, strain-hardening behavior