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Tensile and Direct Shear Responses of Basalt-Fibre Reinforced Composite Using Alkali Activate Binder

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Abstract : Basalt fabric reinforced cementitious composites (FRCM) have attracted great attention because they result in being effective in structural strengthening and eco-efficient. In this study, authors investigate their mechanical behavior when an alkali-activated binder, with tuned properties and containing high amounts of industrial by-products, such as ground granulated blast furnace slag, is used. Reinforcement is made up of a balanced, coated bidirectional fabric made out of basalt fibres and stainless steel micro-wire, with a mesh size of 8x8 mm and an equivalent design thickness equal to 0.064 mm. Mortars mixes have been prepared by maintaining constant the water/(reactive powders) and sand/(reactive powders) ratios at 0.53 and 2.7 respectively. Tensile tests were carried out on composite specimens of nominal dimensions equal to 500 mm x 50 mm x 10 mm, with 6 embedded rovings in the loading direction. Direct shear tests (DST), aimed to the stress-transfer mechanism and failure modes of basalt-FRCM composites, were carried out on brickwork substrate using an externally bonded basalt-FRCM composite strip 10 mm thick, 50 mm wide and a bonded length of 300 mm. Mortars exhibit, after 28 days of curing, a compressive strength of 32 MPa and a flexural strength of 5.5 MPa. Main hydration product is a poorly crystalline CASH gel. The constitutive behavior of the composite has been identified by means of direct tensile tests, with response curves showing a tri-linear behavior. The first linear phase represents the uncracked (I) stage, the second (II) is identified by crack development and the third (III) corresponds to cracked stage, completely developed up to failure. All specimens exhibit a crack pattern throughout the gauge length and failure occurred as a result of sequential tensile failure of the fibre bundles, after reaching the ultimate tensile strength. The behavior is mainly governed by cracks development (II) and widening (III) up to failure. The main average values related to the stages are σ_I= 173 MPa and ε_I= 0.026% that are the stress and strain of the transition point between stages I and II, corresponding to the first mortar cracking; σ_u = 456 MPa and ε_u= 2.20% that are the ultimate tensile strength and strain, respectively. The tensile modulus of elasticity in stage III is E_{III}= 41 GPa. All single-lap shear test specimens failed due to composite debonding. It occurred at the internal fabric-to-matrix interface, and it was the result of fracture of the matrix between the fibre bundles. For all specimens, transversal cracks were visible on the external surface of the composite and involved only the external matrix layer. This cracking appears when the interfacial shear stresses increase and slippage of the fabric at the internal matrix layer interface occurs. Since the external matrix layer is bonded to the reinforcement fabric, it translates with the slipped fabric. Average peak load around 945 N, peak stress around 308 MPa, and global slip around 6 mm were measured. The preliminary test results allow affirming that Alkali Activated Binders can be considered a potentially valid alternative to traditional mortars in designing FRCM composites.

Keywords : alkali activated binders, basalt-FRCM composites, direct shear tests, structural strengthening
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