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Tensile and Bond Characterization of Basalt-Fabric Reinforced Alkali Activated Matrix

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Abstract : Recently, basalt fabric reinforced cementitious composites (FRCM) have attracted great attention because they result to be effective in structural strengthening and cost/environment efficient. In this study, authors investigate their mechanical behavior when an inorganic matrix, belonging to the family of alkali-activated binders, is used. In particular, the matrix has been designed to contain high amounts of industrial by-products and waste, such as Ground Granulated Blast Furnace Slag (GGBFS) and Fly Ash. Fresh state properties, such as workability, mechanical properties and shrinkage behavior of the matrix have been measured, while microstructures and reaction products were analyzed by Scanning Electron Microscopy and X-Ray Diffractometry. 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. An appropriate experimental campaign based on direct tensile tests on composite specimens and single-lap shear bond test on brickwork substrate has been thus carried out to investigate their mechanical behavior under tension, the stress-transfer mechanism and failure modes. 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) 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, an average compressive strength of 32 MPa and flexural strength of 5.5 MPa. Main hydration product is a poorly crystalline aluminium-modified calcium silicate hydrate (C-A-S-H) gel. The constitutive behavior of the composite has been identified by means of direct tensile tests, with response curves showing a tri-linear behavior. Test results indicate that the behavior is mainly governed by cracks development (II) and widening (III) up to failure. The ultimate tensile strength and strain were respectively σ_u = 456 MPa and ε_u= 2.20%. The tensile modulus of elasticity in stage III was EIII= 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 a 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 Materials 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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