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Improving flexural strength and toughness of geopolymer mortars through additively manufactured metallic rebars

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Abstract

This paper presents the results of an experimental study on the flexural reinforcement of a geopolymer mortar through additively manufactured metallic rebars. A mortar employing a geopolymer binder with low calcium content fly ash is reinforced with Ti6Al4V rebars additively manufactured though electron beam melting. The effectiveness of reinforcements realized with rebars featuring either smooth or rough surface profiles is studied through three-point bending tests and post-test microscopy analysis. The given experimental results highlight micro and macroscale pullout failure mechanisms in specimens reinforced with rebars showing cylindrical embossments on the lateral surface, which remarkably improve the flexural strength and the interfacial bond strength of the analyzed mortar. The role played by the surface roughness of the reinforced elements on the bond-slip response of the matrix-rebar interface is highlighted, while drawing comparisons with available literature results on cement mortars.

Keywords: Geopolymers, mortars, toughness, flexural strength, surface roughness, pullout, additive manufacturing

1. Introduction

Recent research has investigated the use of additively manufactured materials for the fabrication of novel composite materials at different scales (refer, e.g., to [1]-[18] and references therein). The employed materials in this area include metals [1]-[2],[9]-[15] , polymers [1],[7],[16]-[17], and carbon fiber-polymer composites [5][6][8], among others, while available additive manufacturing technologies encompass polyjet 3D printing, laser and electron beam melting (EBM), fused deposition modeling, and projection micro-stereolithography, just to mention a few relevant examples [18]-[21]. The use of recycled materials in additive manufacturing is gaining attention [22]-[24], due to the urgent need to increase the sustainability of the material manufacturing process in many engineering fields [25]-[34].

A special class of environmentally friendly materials is that of construction materials employing geopolymers as binders, in substitution of cementitious binders [35]-[37]. The production of such binders requires reduced industrial processing of raw materials and reduced CO_2 consumption, giving rise to sustainable building and offshore materials, which combine good mechanical