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A layered-wise, composite modelling approach for fibre textile reinforced cementitious composites

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Abstract

Textile Reinforced Cements (TRCs) offer an adequate alternative to more conventional building systems in construction due to their tunable and lightweight geometries. TRCs are currently either modelled by means of a discrete approach, where the textiles and the matrix are modelled separately, or by means of a smeared approach that averages the material's mechanical response over the cross-section.

The research presented in this paper proposes a new, layered-wise approach of modelling where the through-thickness response of the composite is subdivided in different layers with individual mechanical properties. A tensile experimental campaign on different combinations of TRC layups, combining both glass and carbon fibre textiles, is performed and used as an input for the layered-wise numerical model. The model is then validated by comparison with flexural experiments performed on four different TRC layup combinations. The good agreement witnessed between the numerical predictions and the experimental results validates the layered-wise modelling approach proposed in this paper.

Keywords: TRC, composite lay-up, smeared model, tension, bending, experimental characterization, numerical model

1. Introduction

The main goal of a composite material is to combine two or more, inherently less performing materials into one material that takes advantage of the mechanical strengths of its components and at the same time bypasses their lacunas. In the case of TRC, the composite material combines a cementitious matrix with a fibre textile reinforcement. The cementitious matrix provides the structural stability and compressive resistance of the composite and serves as a backbone for the fibre textiles. These textiles offer a good tensile resistance and bridge the tensile cracks inside the cementitious matrix, which leads to a more controlled tensile response that is also more ductile than the tensile behaviour of the cementitious matrix on its own [1]–[3]. Another advantage offered by TRCs is the ease at which they can be tuned geometrically towards the application's needs [1], [4]–[7].

In literature, several ways of modelling TRCs are described. When the fibre textiles are present in a discrete manner throughout the TRC section, they lend themselves for discrete modelling approaches [8]–[12]**,** where the fibre textiles are modelled as a separate entity inside the cementitious matrix. However, when the fibre textiles are more uniformly distributed, micromechanical composite models can be applied to describe their mechanical behaviour [13] and smeared modelling approaches are to be preferred [7], [14]–[16]. The main advantage of discrete modelling approaches is their theoretical ability to perfectly match