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AN APPROACH FOR THE MODELLING OF THE UNIAXIAL TENSILE BEHAVIOUR OF TEXTILE REINFORCED CONCRETE

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ABSTRACT

In this contribution, a model for the simulation of Textile Reinforced Concrete (TRC) under uniaxial tensile loading is presented. Textile Reinforced Concrete [1] is a composite consisting of a matrix of fine-grained concrete (maximum aggregate size $\leq$ 1 mm) and a reinforcement of multi-filament yarns of high-performance fibres (glass, carbon, aramid), which are processed to textiles.

In the model, the matrix and the reinforcement are discretized with chains of bar elements, which have material (Young's modulus E and tensile strength f_t) and geometrical (cross sectional area A) properties of the respective constituent of the composite. The matrix is modelled as a single chain of bar elements while the reinforcement is discretized more detailed, because of its heterogeneous structure and of different bond conditions inside a yarn. In the case of ordinary steel reinforced concrete, the reinforcement can also be modelled with one chain of bar elements. For the discretization of the yarn reinforcement the segmentation approach is used, which is shown in principle in Figure 1. While every segment is assumed homogeneous itself, the modelling of the heterogeneity of the reinforcement is also possible, because any number of segments with different properties can be chosen. In order to cover the

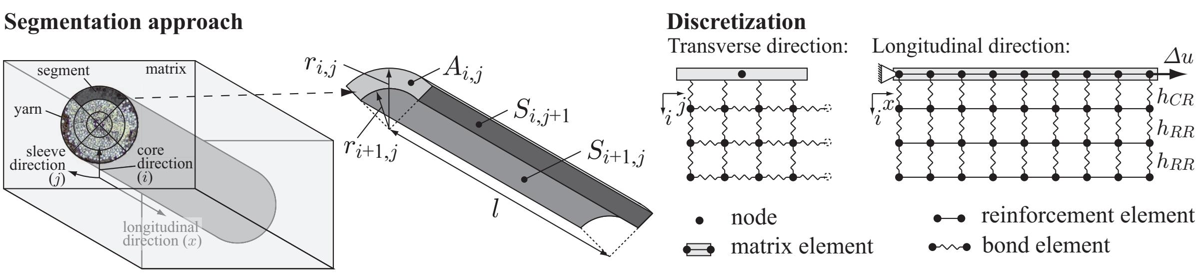

Figure 1: Geometrical model (top) and lattice discretisation in the cross section (bottom left) and the longitudinal section (bottom right)

cracking behaviour of the matrix and the failure behaviour of the reinforcement the bar elements get assigned a limited tensile strength. The fracture energy of the matrix is relatively small because of the small aggregate sizes and it is therefore neglected in a first approach. The bar elements are connected by zero-thickness bond elements at the nodes of the elements. The bond elements act according to non-linear bond laws h, which are formulated as bond stress-slip relations. The bond laws are defined by a number of characteristic points, for instance a maximum point and a residual point, between which is interpolated with the "Piecewise Cubic Hermite Interpolating Polynomial" (PCHIP) algorithm [3]. The bond law, which is described in more detail in [2] contains also a degradation algorithm. This algorithm ensures that the degraded bond cannot heal after the maximum value is reached. Depending on the position in the segmentation scheme, which also determines the bond area S, different parameter configurations can be chosen for the bond laws. The nonlinear problem, which arises with this modelling approach, is solved with the Finite Element Method.

This model is applicable for a broad range of continuous reinforced concrete structures as for example textile reinforced concrete or steel bar reinforced concrete exposed to uniaxial tension. It determines non-homogeneous stress and strain distributions in the longitudinal and the transverse direction, for instance the load-dependent variations of the stress and strain profiles in the cross section of single yarns of the textile reinforcement. The local, microscopic load carrying and failure mechanisms induce the global, macroscopic behaviour, which reveals itself for instance for tension bars in load-displacement curves and discrete cracking with crack spacing and crack widths. Thus, effects like suppression of cracks and tension stiffening, i. e. the participation of the reinforcement on the load carrying before matrix cracking and the participation of the matrix on the load carrying between cracks respectively, are covered by the model. The results of the calculations are validated by a comparison to experiments performed on tension bars [4] and pullout specimens [5]. The model also allows to cover particular effects like internal constraints as they may arise with varying temperatures because of different thermal expansions of the constituents of the composite, the shrinkage of the concrete matrix, the fracture energy of the concrete matrix or cyclic loading. Furthermore, stochastic variations of the material and geometric properties may be regarded with a Monte-Carlo approach. Uncertainties remain with the micromechanical bond behaviour where the parameters cannot be experimentally determined, but have to be evaluated with concepts of inverse analysis.

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