NUMERICAL MODELLING OF REINFORCED CONCRETE IN THE CRACKED STAGE UNDER TENSILE LOADING

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Cracking of concrete under tensile loading is a complex phenomenon which leads to progressive reduction of the stiffness of the reinforced concrete (RC) structural elements. The stiffness reduction is generally a combination of cracking of concrete under tension and the local loss of the bond between steel bar and concrete. It is, therefore, of primary importance to accurately model and predict the stiffness reduction under tension for a proper design of structural engineering applications.

These approaches are generally satisfactory and convenient when dealing with relatively smaller individual structural elements (beams, columns). However, in the case of large-scale concrete structures (multi-story portal frames, shear walls, etc.) the computational effort would be huge due to the explicit detailed modelling of the steel reinforcements as well as the local degradation phenomena (progressive cracking of concrete, relative slip between concrete and steel). It can be concluded, therefore, that the computational effort is a key point for engineers and modellers in the choice of the modelling approach to be adopted.

The main purpose of this paper is to develop a fast and simplified predictive model to simulate the global behaviour of RC structures dedicated to large scale applications with no need to represent explicitly the reinforcement bars in the model neither the damage of concrete in tension. To this end, a fictitious tension behaviour model of the RC element, where the physics involved in the reinforced concrete, namely relative slip between concrete and reinforcement as well as cracking of concrete, are explicitly accounted for in the developed fictitious constitutive tension stress-strain relationship. The requirements due to both the simplicity and the predictivity (accuracy) of the finite element model are considered of primary importance.

Based on the review of the existing analytical calculation models, the authors developed a fictitious relationship (stress-strain curve), for RC under tension, based on the computing of the mean strain of RC element depending on the both material characteristics (concrete and steel), on the shape of the bond-slip relationship suggested by the C.E.B (European Committee for Concrete) [9], on the number of developed cracks and their opening widths.

The effectiveness of the developed fictitious stress-strain curve has been successfully demonstrated using the ABAQUS software by comparison to experimental results, from reinforced concrete prisms subjected to uniaxial tension, published by Espion and co-workers [6] as well RC beams under bending carried-out by the authors. The full-length paper of this work is recently published in Composite Structures [Composite Structures, 194(2018), pp. 468-477].