

Constitutive Modelling of Plain and Fibre Reinforced Concrete Based on Micromechanical Solutions

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ABSTRACT

A constitutive model for plain concrete based on continuum micromechanics solutions is presented, which was subsequently extended to describe the behaviour of fibre reinforced concrete.

The model for plain concrete assumes a two-phase elastic composite, derived from an Eshelby solution and the Mori-Tanaka scheme [1], which comprises a matrix phase representing the mortar and spherical inclusions representing the coarse aggregate particles. Additionally, circular microcracks with various orientations are distributed within the matrix phase. This approach allows the model to predict the development of tensile stresses within the matrix phase under uniaxial compressive stresses and thus the model is able to simulate compressive splitting cracks in a natural way. Microcrack initiation is assumed to occur in the interfacial transition zone between aggregate particles and cement matrix and is governed by an exterior-point Eshelby solution. In each direction a local rough crack contact model is employed to simulate normal and shear behaviour of rough microcrack surfaces. The implementation of the microcrack initiation criterion into the constitutive model enables the use of realistic material properties in order to obtain a correct cross-cracking response. It is shown, based on numerical predictions of uniaxial, biaxial and triaxial behaviour that the model captures key characteristics of concrete behaviour.

The model has been extended to address the behaviour of fibre reinforced concrete [2]. The addition of randomly distributed short fibres in a concrete matrix can enhance the tensile strength and significantly increase the fracture toughness of the material. Fibre pull-out governs the failure mechanism; as a crack is formed and starts to open, the fibres crossing it undergo debonding and start to pull out from the concrete matrix and in this process they apply closure tractions on the crack faces thus stabilising the crack. The influence of fibres is taken into account at a crack-plane level, in a local constitutive relationship, via a fibre effective damage parameter that characterises the crack bridging state of fibres. The evolution of the fibre effective damage parameter is based on the micromechanics based crack bridging model of Lin and Li [3]. The performance of the extended model is shown through a series of numerical predictions of uniaxial tensile and compressive behaviour for different fibre types and volume fractions.

REFERENCES

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