Holistic mesoscale modelling of concrete – recent developments

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ABSTRACT

Modelling of concrete at the mesoscale is needed in many applications, for example for investigation into the micro-meso mechanics underlying the macroscopic behaviour of the concrete material, and for realistic simulation of damage evolution in critical regions of concrete structures where complex stress conditions take place. Research has been undertaken in recent years by the authors' research group in developing a holistic mesoscale modelling framework for general analysis of concrete material under a variety of loading conditions. This paper presents an overview of the key developments and discusses the applicability and limitation of different levels of the mesoscale model. A 2D mesoscale model incorporating random aggregates and equivalent interfacial transition zones enables examination into the effects of random aggregate structure and the sub-scale non-homogeneity within the mortar matrix on the macroscopic behaviour of concrete. In applications where multi-axial stresses and confinement effects are significant, including high-strain rate loading where the inertial confinement plays an important role, a realistic representation of the multi-axial stress condition becomes necessary, and this requires 3D mesoscale model. Two types of 3D mesoscale concrete model will be discussed, namely a pseudo-3D mesoscale model and a full 3D mesoscale model. Representative applications of the mesoscale models in the analysis of classical problems in the mechanics of concrete, including the effect of confining stress, the size effect, and the mechanisms underlying the strain rate effect in the compressive properties of concrete, will be examined and discussed.