Experimental study on contact behaviour of rigid particles suspended in visco-elastic matrix and distinct element modelling of fresh fibre reinforced cement composites

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ABSTRACT

Modelling flow behaviour of fresh fibre reinforced cement composites (FRCC) can be a great help in studying various aspects of concrete technology, e.g., the influence of fresh state rheology on hardened state properties, the flow induced orientation and spatial distribution of fibres in the structure and the optimization of the construction processes and equipment. However, numerical modelling of fresh FRCC is not trivial as they exhibit non-Newtonian, thixotropic and time-dependent fluid behaviour. Furthermore, the heterogeneity of concrete, which arises from constituents of different shapes, sizes and physical properties and which affects the material behaviour greatly, cannot be adequately considered by modelling concrete as a continuum using single-fluid approaches. From this perspective, modelling fresh concrete in a discrete manner using Distinct Element Method (DEM) has proven to be an appropriate approach [1–4]. In the work at hand a DEM model for fresh FRCC is presented. Developed model is based on the experimental study on contact behaviour of rigid spherical particles suspended in visco-elastic polymer-water solution cement pastes and mortars, respectively. The force-displacement relationships obtained from these experiments provide information on particle-particle and particle-wall contact formation, maximum contact forces, and distance at contact breakage. Accordingly, constitutive relations are formulated to describe contact behaviour of particles and eventually implemented into discrete element code as contact model. The steel fibres in concrete are modelled as groups of many spherical particles clumped together serially. The developed distinct element model simulates the rheological behaviour of fresh concrete as a multi-phase material with granular aggregate phase, solid fibre phase and visco-elastic paste/mortar phase. The numerical model is used to study the flow induced fibre orientation and spatial distribution and successfully validated using experimental results.

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