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A CFD-DEM Approach for Modelling Fresh Concrete Flow

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Fresh concrete is a complex mix comprising cement, water, sand, coarse aggregates, addition and admixture, and it exhibits complex flow behaviours influenced by the complex interactions between component phases at different length scales. The traditional way to model fresh concrete flow is by treating it as a non-Newtonian homogeneous fluid, specifically a Bingham fluid. The Bingham approach is useful for capturing the lump flow behaviour, but it is overly simplified, ignoring the multiphase nature of concrete mixes. As such, it cannot capture the relative motions between phases, which dominate the concrete flow and are the main causes for such common defects as segregation, congestion and bleeding etc., as shown in Figure 1. In this work, we propose a multiphase flow approach for modelling fresh concrete, which is treated as a two-phase mix: mortar and coarse aggregates. The mortar is modelled as a continuous phase, using Computational Fluid Dynamics (CFD), while the coarse aggregates are modelled as a dispersed phase, using Discrete Element Method (DEM). This CFD-DEM approach captures the interactions between individual particles of coarse aggregates and the continuous mortar, which is treated as a Bingham fluid. As such, it can correctly capture segregation and congestion behaviours, which are not possible by using the classical single-phase approach. To improve the accuracy and computational efficiency of the proposed CFD-DEM approach, we also present two novel numerical formulations to remove the time-stepping limitation caused by drag forces and to better capture the fluid volume exchanges between particles and the continuous fluid. Some examples are shown in Figure 2.

Figure 1. Construction defects related to fresh concret flow

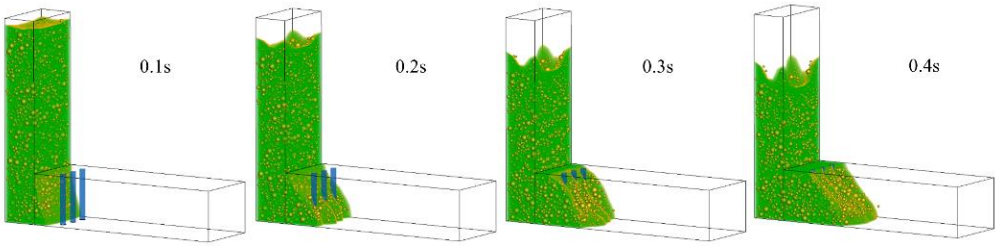

Figure 2. CFD-DEM simulation of L-box test