Verification and validation of stabilized mixed material point method for simulations of coupled free-surface and porous-media flow

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Abstract

The Material Point Method (MPM) has seen a significant increase in popularity over the past decades for simulating large deformation solids and geomaterials due to its resemblance to the Finite Element Method (FEM). However, the method still faces many challenges related to the modeling of incompressible fluid-like materials. Volumetric locking, severe quadrature errors, and spurious numerical instabilities are some of the major issues often encountered. In an attempt to address these challenges, our recent research [1, 2] developed a novel stabilized mixed MPM for both free-surface and porous-media flow. Unlike traditional Eulerian CFD FEM solvers, the proposed mixed formulation considers displacement and pressure fields as the unknown variables to be solved concurrently. By doing so, the developed solver eliminates the need for free-surface pressure detection and imposition and allows for a significantly larger time step increment. In the current study, we aim to assess the numerical accuracy of the proposed formulation by conducting several verification and validation tests in (quasi-)1D, 2D, and 3D scenarios. These V&V studies demonstrate and verify the enhanced accuracy, convergence, and stability of our method compared to the state-of-the-art MPM solver and other numerical methods.

Keywords

Material Point Method, Stabilized methods, Mixed formulation, Blurred interface, Flow in porous media

References

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