MULTISCALE MODELING AND SIMULATION OF FLUID FLOWS IN INELASTIC POROUS MEDIA

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In this work the problem of upscaling fluid flow in deformable porous media is studied. At the microscale, the physics of flow in deformable porous media is described by the fluid-structure interaction (FSI) problem. Currently, the well-established macroscopic models for poroelasticity such as Biot's law can only be applied to linear elastic solids. Furthermore, macroscopic parameters such as average fluid pressure and solid displacements are typically limited to infinitely small deformations at the pore level. In this work numerical upscaling methods based on the stationary FSI problem for deformable nonlinear solid and Stokes flow are developed. The strains in the solid are assumed small but no restrictions are applied on the magnitude of the displacements. The FSI problem is solved numerically at the fine scale. A nonlinear Darcy-type equation for the averaged pressure is then postulated at the macroscale. A Hybrid Multiscale Finite Element Model (HMFEM) which bypasses the explicit homogenization step by building fine-scale information directly into a coarse-scale computational grid is then developed. Numerical results are presented for both linear and nonlinear solids.

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