HOMOGENIZATION OF A BIOT-STOKES SYSTEM MODELING DEFORMABLE VUGGY POROUS MEDIA

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Vugs are small to medium-sized cavities commonly present in rocks. The presence of vugs may have non-trivial impacts on the hydro-mechanical behaviors of the rock. How to effectively quantify and analyze such effects is still an challenging problem. To address the problem, we derive a macroscopic coupled hydro-mechanical model for single-phase viscous fluid flow through a deformable vuggy porous medium. We first model the hydro-mechanical coupling process on a fine scale using Biots equations within porous matrix, Stokes equations within the vugs, and an extended Beavers-Joseph-Saffman boundary condition on the porous-fluid interface. Based on the homogenization theory, we then obtain macroscopic Biots equations that govern the hydro-mechanical coupling behaviors of vuggy porous media on a large scale. Subsequently, the macroscopic poroelastic coefficients, such as the effective permeability, effective Youngs modulus and effective Biot coefficient, are derived from three cell problems. Finally, several numerical examples are designed to validate the proposed model and to demonstrate the computational procedure for evaluation of the hydro-mechanical behaviors of vuggy porous media.