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FAILURE MECHANISMS IN HETEROGENEOUS PORO-PLASTICITY MEDIA IN APPLICATION TO FSI PROBLEMS

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It is well known that the sensitivity to failure of cohesive materials, such as soils or concrete, is strongly influenced by material heterogeneities. Furthermore, these materials are porous, and the presence of the pore fluid strongly influences their response to extreme loads with an increase of the risk for final failure. In this paper, we propose the use of a fine scale model that can fully take into account any failure mode of this kind. In particular, the model is constructed by using the discrete beam lattice constructed from Voronoi cells, and the corresponding discrete approximation of the pore pressure is obtained by discretizing the pressure filed by using Delaunay triangularization. The coupling effect between the solid and fluid phase is accounted for at numerical quadrature points. The representation of different failure mechanisms in saturated soil is based on inelastic Timoshenko beam finite elements with enhanced kinematics in axial and transverse direction. The coupling equations for the soil-pore fluid interaction are derived from Terzaghi's principle of effective stresses, Biot's porous media theory and Darcy's law for fluid flow through porous media. The application of the model to soil mechanics is illustrated through several numerical simulations.

The proposed predictive model is further extended to deal with acoustic fluid-structure interaction problems in quasi-static setting. For such a quasi-static case, and confined fluid limited to a small motion, we can provide discrete approximation of fluid described by Lagrangian finite element formulation with displacement and pressure degrees of freedom. Given that the structure response is based upon poro-plasticity, the cohesive link beam elements also provide an enhanced kinematics with pore pressure as a nodal degree of freedom. Such a choice for discrete approximation is able to enforce the direct exchange of the pressures at the fluid-structure interface, with no need for special procedure, such as added mass approach. Numerical simulations are used to illustrate the model performance. Here, we are able to model the saturation of the material, and all different phases of the nonlinear response towards fracturing in the saturated structures, where fluid acts both as a source of the saturation and the loading.

More details are given in our recent works [1,2,3,4,5]

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