MECHANICAL ENGINEERING

"Concurrent and Hierarchical Multiscale Modeling for Strain Localization in Fluid-infiltrating Porous Solids"

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Abstract: The mechanical behavior of a fluid-infiltrating porous solid is significantly influenced by the presence and diffusion of the pore fluid in the void. This hydro-mechanical coupling effect can be observed in a wide range of materials, including rocks, soils, concretes, bones and soft tissues. Due to the high computational demand, explicitly simulating the pore scale solid-fluid interactions remains impractical for engineering problems commonly encountered in the field and basin scales. The objective of this talk is to present two classes of multiscale technologies that couple across different spatial and temporal scales. The first class of model is a concurrent coupling model in which deformation-diffusion problems are casted as the two-fold saddle point that optimizes the constrained partitioned incremental work of a multi-field energy functional. By enforcing compatibility across length scales, pore-scale simulations in confined domain can be coupled with large-scale field problems while maintaining numerical stability and accuracy. The second class of multiscale model is a nonlocal hierarchical multiscale framework that couples grain-scale discrete element simulations with a macroscopic explicit dynamics finite element model. This hierarchical nonlocal DEM-FEM coupling retains the simplicity and efficiency of the continuum-based finite element model, while possessing the original length scale of the granular system. The pros and cons of these two different coupling strategies will be demonstrated in numerical examples.

Professor Sun obtained his B.S. from UC Davis; M.S. in civil engineering (geomechanics) from Stanford; M.A. degree from Princeton; and Ph.D. in theoretical and applied mechanics from Northwestern. Prior to joining Columbia, he was a senior member of technical staff in the mechanics of materials department at Sandia National Laboratories (Livermore, CA). Professor Sun works in the fields of theoretical and computational solid mechanics, poromechanics and multiscale modeling of fully coupled multi-physical systems, with a special emphasis on geomechanical applications. His research includes the development of solution techniques for coupled deformation-diffusion in non-isothermal saturated and unsaturated porous media, formulations of stabilized mixed-field finite element model for large deformation multiphysics problems, modeling and homogenization of mechanical and hydraulic properties of porous media from CT images, applications of mathematical tools, such as graph theory, Lie algebra, and combined deterministic-stochastic method, for modern engineering problems. He is the recipient of the 2013 Caterpillar BestPaper Prize for his paper on multiscale DEM-LBM coupling in Acta Geotechnica.

Friday, January 23rd, 2015
11:00 am Seminar in 233 Mudd
Lunch served at 12:00pm
in MECE Lobby