The Maurice A. Biot Lecture

Department of Civil Engineering & Engineering Mechanics, Columbia University
Engineering Mechanics Committee, ASCE Metropolitan Section
Engineering Mechanics Institute, ASCE

PERSISTENT SHEAR BAND IN UNSATURATED POROUS MATERIALS

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November 7, 2013 (6:30-7:30 pm)
Davis Auditorium, 412 CEPSR

Abstract: A persistent shear band is a dominant pattern of localized deformation in a heterogeneous material. It may or may not be the first one to emerge, but it is the prevailing pattern that persists in the end. In unsaturated porous materials, the persistent shear band depends crucially on degree of saturation, since fluid in the pores of a solid imposes a volume constraint on the deformation of the solid. When fluid flow is involved, the persistent shear band also depends on the heterogeneity of a material, which is quantified in terms of the spatial variation of density, degree of saturation, and matric suction. In this lecture, I will present a mathematical framework for coupled solid-deformation/fluid-diffusion in unsaturated porous media considering material and geometric nonlinearities. The framework relies on the continuum principle of thermodynamics to identify an effective or constitutive stress for the solid matrix, and a water retention law that highlights the interdependence of degree of saturation, suction, and porosity of the material. I will discuss the role of heterogeneity, quantified either deterministically or stochastically, on the development of a persistent shear band. This work is inspired by current testing capabilities that allow nondestructive and non-invasive measurement of density and degree of saturation through high resolution imaging.

Biosketch: Ronaldo Borja works in theoretical and computational solid mechanics, geomechanics, and geosciences. At Stanford University, he teaches an undergraduate course in geotechnical engineering, a graduate course in mechanics and the finite element method, and two doctoral level courses in computational plasticity and computational poromechanics. His research includes the development of multi-scale discontinuity framework for crack and fracture propagation utilizing the strong discontinuity and extended finite element methods; solution techniques for multi-physical processes such as coupled solid deformation-fluid diffusion in saturated and unsaturated porous media; stabilized finite element methods for solid/fluid interaction and nonlinear contact mechanics; and nanometer-scale characterization of the inelastic deformation and fracture properties of shales. Ronaldo Borja is the author of a textbook entitled *Plasticity Modeling and Computation* published by Springer. He serves as co-editor of two leading journals in his field, the *International Journal for Numerical and Analytical Methods in Geomechanics* and *Acta Geotechnica*, and as co-editor of a book series, the Springer Series in Geomechanics and Geoengineering.

The Maurice A. Biot Lecture was established at Columbia University in 2004 in remembrance of the late Prof. Maurice Anthony Biot and his renowned achievements as an engineer, physicist, and applied mathematician. Biot was a professor of mechanics at Columbia University in the period 1937-1945.

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