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Bifurcation and Post Localization Behavior of Granular Soils

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Strain localization, particularly shear banding, due to bifurcation in the stress-strain response leading to strain softening is one of the most challenging aspects of granular soil behavior. As a result of localized deformation, the load-carrying capacity of the soil reduces with increasing strain and strain softening ensues. This lecture presents a combined Discrete Element Method (DEM) and elasto-plasticity modeling of the stress-strain, strain localization and strain softening behavior of granular soils. DEM modeling using the Particle Flow Code (PFC) is employed to obtain microscopic understanding of strain localization in granular soils. Homogenization techniques are used to convert discrete micro-mechanical quantities to continuum macro-mechanical parameters. A macroscopic plasticity model is developed based on the micro-mechanical observations obtained from particulate simulations of the response of granular soil. Post-localization modeling is based on a homogenization technique, where it is assumed that elastoplastic deformation comes from the localized deformation in the shear band while the material outside the shear band deforms elastically. The complete continuum plasticity model is shown to be capable of replicating the DEM results on the full spectrum of the stress-strain behavior of granular soils from strain hardening to failure and strain softening. Use of the model in simulating the response of sands shows that the model can credibly reproduce realistic granular soil behavior spanning the pre-peak, peak and post-peak regimes.