Initiation and propagation of strain localization in cohesive soil using a novel miniature triaxial cell and X-ray Computed Tomography

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Particle scale coupled hydro-mechanical interactions play a major role in clay macroscopic behavior and clay, like other geomaterials, deform in a localized manner (failure and strain localization), but conventional laboratory test measurements are made at the sample scale rather than at the local particle scale. Thus, understanding the micro-mechanisms underlying the initiation and propagation of strain localization in cohesive soil will form the foundation for quantitative prediction of strain localization in practical fine cohesive soil.

In the last decade, soil microstructure has been intensively investigated thanks to in-situ microscopy technologies such as X-ray computed tomography (X-CT), which allows a 3D imaging of the sample microstructure without the need of dehydration. Nevertheless, this step forward in the general understanding of soil microstructure regarded exclusively sandy soils, as the limitation given by the X-CT maximum resolution (in the order of few microns) hinder the investigation of the micro-mechanisms in clayey soils, which generally, present a particle size lower than 2 microns and a pore space in the sub-micron range.

In this study, a small amount (2%) of fine sand to silt-sized mica (average particle size of 90 micron, used here as strain markers) have been mixed with kaolinite clay (average particle size of 0.4 micron). Mica is mineralogically a clay and as clays it is platy in shape and electrically charged, notwithstanding particles are big enough to be clearly imaged with an X-CT at high resolution.

A novel miniature triaxial compression cell (5 mm in diameter) has been manufactured in order to use the X-CT to image the in-situ soil microstructure upon undrained triaxial compression at different strain level. The cell was additionally instrumented with a high capacity tensiometer sensor to measure negative pore water pressure developed upon shear, therefore allowing mechanical comparison with macroscopic behaviour. A particle matching code was finally used to match mica particles in consecutive scans at the different strain levels and their kinematics computed. A conceptual model on particle configuration based on the strain localization evolution that has been observed will be presented.

Keywords: clay, micro-mechanisms, cohesive soil, microstructure