A double-scale FEMxDEM model applied to cohesive-frictional granular materials in polyaxial loading conditions

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From a multi-scale perspective to solving boundary value problems, the development of homogenization techniques provide a mean to upscale the effect of micro-scale complexities in the material fabric to a larger continuum scale. Considering these micro-structural aspects, inherent to the nature of porous media, is of particular interest when modeling large scale problems for which analytical solutions to the constitutive relation are difficult to obtain.

In this context, we present specific advances in the development of a FEMx-DEM double-scale numerical model with the purpose of simulating the behavior of cohesive-frictional geomaterials under polyaxial loading conditions. In this fully integrated computational homogenization approach, the macro-scale problem is resolved using the Finite Element Method (FEM); while at the micro-scale, a simulation using the Discrete Element Method (DEM) is performed on a periodic elementary volume, composed of a 3D spheres packing with a predetermined initial state. As the two models are used simultaneously, the later acts as a constitutive relation for the macro-scale simulation where each elementary volume, associated with an integration point, is continuously evolving with the imposed deformation. In turn, the FEM simulation is directly dependant on the state and properties of these granular arrangements representative of the behavior of the micro-structure.

In this communication, we present a series of numerical simulations performed in plane strain and stress invariant control loading conditions (constant mean stress and Lode angle). Resulting mechanical behavior and modes of localization are than compared with experiments performed in a laboratory setting on a porous sandstone.