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Grainsize effect on the crushing behavior of unsaturated granular solids

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ABSTRACT

Failure and strain-localization in granular soils and porous rocks subjected to high pressures involves considerable alteration of the microstructure. Such processes are affected by the grainsize characteristics (e.g., grain size distribution and mean grain size), as well as by environmental variables such as moisture content and capillary pressure. In this contribution, we use a reformulation of the Breakage Mechanics theory to model comminution in wet granular assemblies. By using an extensive dataset for sands, we quantify the relation between a geometric descriptor of the assembly (i.e., the mean grainsize) and the constants that control the suction air-entry value and the stress threshold at the onset of crushing. Such relations are used to define contrasting scenarios for the coupling between degree of saturation and yielding. In the first scenario, the suction air-entry value scales inversely with the mean grainsize (as suggested by the capillary theory), whereas the energy input for comminution is assumed to be independent of the size of the grains. The outcome of this assumption is that changes in degree of saturation play a more intense role in finer gradings. In contrast, if we assume that the energy input for grain breakage scales inversely with the size of the particles (e.g., in accordance with scaling laws inspired by linear elastic fracture mechanics), the effect of the degree of saturation is predicted to be stronger in coarser assemblies. These results provide a theoretical basis to infer the relation between continuum-scale properties of soils and rocks (e.g., the yielding stress at the onset of crushing) and basic attributes widely used for soil/rock characterization (e.g., the grain size distribution).