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Influence of Microparticles in the Contact Region of Quartz Sand Grains: A Micro-Mechanical Experimental Study

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Abstract : The mechanical behavior of geological materials is very complex, and this complexity is related to the discrete nature of soils and rocks. Characteristics of a material at the grain scale such as particle size and shape, surface roughness and morphology, and particle contact interface are critical to evaluate and better understand the behavior of discrete materials. This study investigates experimentally the micro-mechanical behavior of quartz sand grains with emphasis on the influence of the presence of microparticles in their contact region. The outputs of the study provide some fundamental insights on the contact mechanics behavior of artificially coated grains and can provide useful input parameters in the discrete element modeling (DEM) of soils. In nature, the contact interfaces between real soil grains are commonly observed with microparticles. This is usually the case of sand-silt and sand-clay mixtures, where the finer particles may create a coating on the surface of the coarser grains, altering in this way the micro-, and thus the macro-scale response of geological materials. In this study, the micro-mechanical behavior of Leighton Buzzard Sand (LBS) quartz grains, with interference of different microparticles at their contact interfaces is studied in the laboratory using an advanced custom-built inter-particle loading apparatus. Special techniques were adopted to develop the coating on the surfaces of the quartz sand grains so that to establish repeatability of the coating technique. The characterization of the microstructure of coated particles on their surfaces was based on element composition analyses, microscopic images, surface roughness measurements, and single particle crushing strength tests. The mechanical responses such as normal and tangential load – displacement behavior, tangential stiffness behavior, and normal contact behavior under cyclic loading were studied. The behavior of coated LBS particles is compared among different classes of them and with pure LBS (i.e. surface cleaned to remove any microparticles). The damage on the surface of the particles was analyzed using microscopic images. Extended displacements in both normal and tangential directions were observed for coated LBS particles due to the plastic nature of the coating material and this varied with the variation of the amount of coating. The tangential displacement required to reach steady state was delayed due to the presence of microparticles in the contact region of grains under shearing. Increased tangential loads and coefficient of friction were observed for the coated grains in comparison to the uncoated quartz grains.

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