INVESTIGATION OF BEHAVIOR OF SAND-FINES MIXTURES USING DIRECT SHEAR (DS) TESTING AND DEM SIMULATIONS

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Introduction. The Critical State Framework describes a relationship between the shear strength and the void ratio of a soil and it is mostly applicable to describe the behavior of pure clay and pure sand samples of relatively uniform particle sizes. However, mixtures of different particle size materials do not always follow this theory; the presence of some small particles can destabilize and affect the behavior of those mixtures under the applied shear stress. This Project's main objective is to investigate the effect of the fines content in mixtures of sand and fine particles using Discrete Element Method (DEM) computer simulations and Direct Shear (DS) laboratory testing. Investigation of the effect of the fines content on the force distribution between particles and hence on the shear strength of the materials can be helpful in the prediction of the shear strength and deformation characteristics of granular mixtures in civil engineering and powder industries.

Materials and methods. The experimental part of the Project includes DS testing of different sand-fines mixtures under two confining pressure values (54,5kPa and 109kPa) to study the relation between the fines content and shear strength. The modeling part of the Project is focused on the two-dimensional DEM simulations of same mixtures under DS loading in order to confirm the experimental results and to investigate further the micromechanical characteristics which include the patterns of strong force chains that are attributable to the shear strength of the sample and the size distribution of the particles that carry those strong forces.

Results and discussions.

- The peak shear stress values of dense samples decrease with increasing values of the fines content.
- The initial void ratios of dense and loose samples depend on the fines content values, which forms a bilinear relationship where the initial void ratio value decreases from 0% fine content to a minimum void ratio at approximately 30% and 50% of fines content for dense and loose samples respectively.
- Dense and loose samples do not approach the same void ratio value at the critical state, which is due to the localization of shear movements into a narrow shear band at the middle of the sample's height. DEM investigation however showed that a unique critical state void ratio value was achieved inside the shear band zone for both dense and loose samples.
- The DEM results of the force transmissions between particles are separated into two contact groups: one transmits (strong) contact forces larger than the average force and the other one transmits (weak) forces smaller than the average force. Particles that transmit strong forces form strong force chains resisting the applied shear stress and these force chains evolved as different frictional resistance levels were utilized during the shearing deformation process. The size of the particles that were involved in the strong force transmission was monitored and a size distribution was calculated that can be related to the evolvement of the strong force chains.