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A Multiscale Study of Shear Response of Geomaterial Contacts for Geotechnical Applications

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Extended Abstract

The interaction at the non-dilative interface of geomaterial contacts, namely, particulate and smooth continuum materials, is complex and can profoundly influence the efficiency, stability, and performance of geotechnical structures. Friction plays a vital role in the transfer of loads at these interfaces, and the predominant mechanisms involved are sliding and plowing, without any dilation. Furthermore, they often do not follow Amonton's law [1], and traditional soil mechanics concepts are not sufficient to describe their underlying shearing mechanisms. The non-dilative interfaces are sensitive to the shape and mineralogy of granular material, hardness of the continuum material, and normal stress [2], [3]. Vangla and Gali [2] revealed that the non-dilative interface frictional response depends on shear-induced surface changes by the effective contacts of the particles on the continuum material. Thus, the current research investigates the effect of multiscale surface topographic features of a single particle, interacting with continuum materials of different hardness values. The study explores the multiscale aspects of the effect of particle shape, hardness of continuum material, and normal load on the shear response of non-dilative geomaterial contacts using custom-built mechanical shear testing apparatus. The custom-built apparatus [4] has successfully captured the interface shear response of different types of geomaterial contacts and provided insights for understanding the frictional mechanism. The micro level shear tests revealed that the friction coefficient of the interface systems is dependent on the shearing mechanism (either sliding or plowing), which further depends on the particulate material morphology, continuum material hardness, and normal load. The friction coefficient decreases with an increase in normal load in the case of sliding, which is attributed to the non-linear increase in contact area with an increase in load. However, the friction coefficient in the case of plowing increases with an increase in normal load due to the high shearing resistance offered by deeper penetration of surface asperities of particles into the continuum materials. It is observed that the coefficient of friction increases with increase in angularity and decreases with increase in hardness. However, the effect of angularity is more pronounced in the case of softer continuum material at higher normal load since the angular material can easily plow it and form deeper grooves and thus, offers high interface shear resistance. Further, the correlations between the testing parameters (sphericity, roundness, hardness, normal load and output parameter (frictional force) of the different interface contacts was inspected by the Spearman's correlation test. It is observed that the there is a very strong positive agreement between the normal load and frictional force whereas there is strong negative agreement between the sphericity, roundness and hardness with the frictional force. Further the agreement between the testing parameters is weak. The value of significance for the spearman correlation is noticeably less than 0.05 for the correlation of frictional force with all the testing parameters and thus, signifies an exact correlation. The experimental results and observations aid geotechnical engineers with a better understanding to interpret the laboratory results, develop more accurate data driven force prediction models and consider the material damage in modeling the non-dilative interface behavior.

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