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An Experimental Investigation of Geological Materials' Microslip Displacement

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Abstract

We look at the inter-particle tangential force-displacement behaviour of various granular materials. The major experiments are carried out using a custom-built micromechanical loading apparatus, and the work focuses on microslip displacement. We show that the microslip displacement increases with the increase in normal force for all materials tested, and that extended threshold displacements are observed for rougher and softer grains [1-15].An analytical expression proposed in the literature is modified by incorporating material micro-hardness in a normalised form to create an expression that can be used in micromechanical-based analysis of geological materials problems.

Researchers have used micromechanical-based analyses to improve their understanding of the complex behaviour of granular materials such as soils and fractured rocks, as well as the analysis of large-scale and multi-scale problemsThe discrete element method (DEM) (after is one of the most widely used micromechanical-based computational tools in geomechanics research and it has grown in popularity in recent decades.

Introduction

Based on DEM or coupled FEM/DEM, studies into problems such as penetration mechanisms railway ballast behaviour and sand-silt mixture mechanics have been conducted, providing important new insights into the complex behaviour of granular materials. Complex mechanisms of granular flows and the behaviour of rocks and sandstone reservoirs weathering and erosion processes and the evolution of the microstructure in particulate media have all been studied using DEM. DEM has also aided researchers in their investigations of geo-energy issues, such as the behaviour of methane-hydrate bearing soils.

The inter-particle coefficient of friction, as well as the normal and tangential force-displacement relationships at soil grain contacts, are important input parameters in DEM studies. Despite significant progress in the development of contact models for unbonded and bonded grains DEM researchers must sometimes make assumptions for the input properties to be used in the numerical analysis, owing to the scarcity of experimental data investigating the grain contact behaviour of real soils According to Iversonsignificant differences in the output of different numerical models can be obtained due to the lack of robust equations or parameter values in Their numerical investigation into the behaviour of sandstone reservoirs emphasised the importance of obtaining grain contact parameters in the laboratory, which can advance the state-of-the-art in the micromechanical-based study of complex granular materials. It is therefore emphasised that additional laboratory insights into the grain contact behaviour of real soils are required to advance the state-of-the-art in geomechanics and provide a platform for more realistic models to be produced for use as input in DEM studies.

Subjective Heading

The inter-particle coefficient of friction, as well as the normal and tangential force-displacement relationships at soil grain contacts, are important input parameters in DEM studies. Despite significant progress in the development of contact models for unbonded and bonded grains DEM researchers must sometimes make assumptions for the input properties to be used in the numerical analysis, owing to the scarcity of experimental data investigating the grain contact behaviour of real soils Because of the lack of robust equations or parameter values, stated that it is possible to obtain significant differences in the resultant output from different numerical models. In their numerical study of the behaviour of sandstone reservoirs, the authors emphasised the importance of obtaining grain contact parameters in the laboratory, which can advance the state-of-the-art in the micromechanical-based study of complex granular materials. It is therefore emphasised that additional laboratory insights into the grain contact behaviour of real soils are required to advance the state-of-the-art in geomechanics and provide a platform for more realistic models to be produced for use as input in DEM studies. DEM analyses commonly use the Hertz and Mindlin and Deresiewicz models to simulate the force-displacement relationship in the contacted grains' normal and tangential directions, respectively Researchers demonstrated that the Hertz model can be used satisfactorily to fit the experimental normal force - displacement data, yielding useful information on the Young's modulus of the contacted surfaces, using experiments on real soil grains and reference materials (e.g., chrome steel balls and glass beads). It has been reported, however, that this model has a limitation in that it cannot capture the initial regime of soft behaviour obtained for most materials.

Discussion

Different elastic-plastic models exist in the tangential direction that focus primarily on the stick condition and are typically derived on the basis of a limited spectrum of material types. Olsson and Larsson recently accounted for slip behaviour in elastic-plastic materials by taking into account different plastic responses and varying hardness. Many previous studies or developed models have typically been limited to engineered materials, possibly due to a lack of sophisticated

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experimental data for real geological materials. This is especially true for real soil grain contacts that have a sphere-sphere (or grain-grain) configuration Nardelli et al. [48] and Sandeep et al. [54] found that for real geological materials, The Mindlin and Deresiewicz models fit the experimental tangential force-displacement data on Eglin sand and completely decomposed volcanic granules poorly. Previous works have highlighted the need for theoretical model adjustments to be considered in order to apply better fitting to the force-displacement relationship of soil grain contacts.In this study, the inter-particle tangential force displacement relationship of different geological and reference grains was examined The laboratory tests were conducted experimentally, with a focus on the slip (or microslip) displacement. The determination of the slip displacement of contacted surfaces is critical in modelling and characterising energy dissipation, fretting, and damping.This slip behaviour is related to various properties of the tested materials, such as friction, surface morphological and elastic properties, and material hardness.

The current study looked at the micromechanical behaviour of chrome steel balls (CSB) and three naturally occurring geological materials: Leighton Buzzard sand grains (LBS), crushed limestone (LS), and completely decomposed granite (CDG). Sandeep and Senetakis [56] investigated these materials, focusing on the inter-particle coefficient of friction at steady-state sliding and its relationship with surface roughness and the Young's modulus of the contacted surfaces. The current study focuses on the experimental investigation of the force-displacement relationship of various materials, with an emphasis on the role of material type on the observed Table 1 summarises the properties of the materials tested in this study by providing their basic characteristics. The LBS grains are made of quartz and have a fairly rounded and spherical shape with a low roughness. The LS grains are irregular in shape and made of crushed non-clastic rock. CDG is a weathered rock from Hong Kong that is widely used in geotechnical and infrastructure engineering, as well as the study of landslides in tropical and subtropical regions. It is composed of irregularly shaped grains with extremely high roughness, and a portion of the original minerals (primarily feldspars and mica) has been chemically altered to form a clay coating on the grains' surfaces. Mechanically, the three geological materials.

Conclusion

According to the literature, surface roughness has a significant impact on the behaviour of interfaces of engineered and geological materials The roughness of the materials was measured with the Veeco NT9300 optical surface profiler at the City University of Hong Kong in order to incorporate this parameter qualitatively in the analysis of the micromechanical test results. Because of its ability to scan large areas of heterogeneous materials, the vertical scanning interferometry (VSI) mode was chosen to obtain surface roughness The current optical surface profiler's VSI mode allows for non-destructive evaluation of surface roughness with a high resolution of 0.1 nm. According to Sandeep and Senetakis for the measurement of roughness for the various

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Conflict of Interest

The authors declare that they are no conflict of interest

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