Modelling of Clay Thermal Creep and Sand flow: A combined soil mechanics and granular physics prospective

by Xiaohui Cheng

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Abstract:

The thermo-mechanical response of clays has been studied in the context of applications including nuclear waste disposal, energy foundations and seasonal ground heat storage. There is extensive data to show that heating and cooling produces irrecoverable deformations in clays under fully drained conditions. The effects are most pronounced for normally and lightly overconsolidated clays that undergo significant compression. Most constitutive models have key limitations for predicting the thermo-mechanical response of clays through long-term (seasonal) cycles of heating and cooling. The Tsinghua ThermoSoil model (TTS) presents a novel theoretical framework for simulating the coupled thermo-mechanical response of clays. The model uses a double entropy approach to capture effects of energy dissipation at the microscopic particulate contact level on continuum behavior.

Liquefied sand and landslides caused by earthquakes or other dynamic impacts have caused tremendous damage. Such granular flows threaten vital infrastructure such as pipelines, cables, foundations for various structures and submerged tunnels. It has required increasingly more sophisticated research of sand rheology at low effective stress conditions to accurately describe and predict post-liquefaction behavior. In space exploration, it is important to understand the dynamic and rheological behavior of granular materials in microgravity conditions µg. With accurate rheological models in µg, impact forces on landing gear can be accurately predicted and the design of such landing gear can be optimized. Liquefaction has also been observed on the Moon, which has made research of dynamic properties of Lunar regolith or simulants in µg subject to the low effective isotropic stress important. In order to characterize the complex rate-dependent behavior of sand flow, a modified version of Hardin & Richard's formula is used to approximate the shear modulus and mobilized shear friction coefficient at critical state and isotropic consolidated state; and an extension of the MiDi model to include rate-dependent steady and transient flows of granular materials is formulated. The predictions of this newly formulated sand flow model are compared to experimental data of Toyoura sands.

Bio:

Dr Cheng is Associate Professor at the Department of Civil Engineering of the Tsinghua University. He obtained his PhD at TU Delft in 2004. His key publications can be found at: http://www.civil.tsinghua.edu.cn/en/ce/essay/534/2343.html