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Editorial: Understanding geomaterial instability: physics and mechanics of landslides and seismic events

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Editorial on the Research Topic

Understanding geomaterial instability: physics and mechanics of landslides and seismic events

Geomaterial instability, manifesting as catastrophic events like landslides and seismic activities, induces profound socioeconomic disruptions through the destruction of critical infrastructure and loss of human life. Understanding the underlying physics and mechanics of these failure processes is therefore essential for advancing predictive capabilities and developing effective risk mitigation strategies in vulnerable regions.

Previous studies have substantially advanced the understanding of geomaterial instability across multiple fronts. Notably, Hu Wei's team [1] identified a metastable state preceding seismic shear failure, uncovering mechanisms of co-seismic weakening and post-seismic healing that refined the classical Newmark sliding-block model [2, 3]. Research under extreme thermo-hydro-mechanical-chemical (THMC) coupled conditions has improved predictions of deformation and failure in deep geological environments, directly supporting the safety assessment of energy reservoirs and subsurface storage projects [4, 5]. Meanwhile, satellite-based InSAR monitoring has been operationalized for large-scale slope stability assessment, providing millimeter-resolution deformation data essential for regional early warning systems [6, 7]. Further contributions include innovative slope stabilization methods using lightweight geofoam [8] and models quantifying freeze-thaw damage in cold regions [9], forming a multifaceted foundation for hazard mitigation. Nevertheless, further research is essential to advance the fundamental understanding of the mechanisms governing geomaterial instability under multi-physical coupling conditions.

This Research Topic seeks to advance our understanding of the fundamental physics and mechanics underlying geomaterial instability, with the goal of clarifying its implications for geohazard mitigation and its significance within broader physical research. The Research Topic currently features 16 papers spanning the fields of geology, physics, mechanics, and

engineering, reflecting the key emerging themes and interdisciplinary nature of research in geomaterial instability.

The dynamic responses of foundations and slopes were examined. It was found by [Tao and Gao](#) through numerical simulation that the displacements of suction-bucket foundations in saturated sand peak synchronously with peak ground acceleration, and that liquefaction leads to marked settlement and loss of bearing capacity. Likewise, it was shown by [Wang and Wen](#) via shaking-table tests that rocky slopes subjected to seismic loading undergo a three-stage failure sequence characterized by crack opening, sliding, and shear failure. [Chen et al.](#) demonstrated by limit-equilibrium analysis that non-uniform geosynthetic (anchor) pullout strength reduces the seismic stability margin of slopes, suggesting that the common assumption of uniform strength may overestimate seismic performance.

Several papers investigated novel soil-improvement techniques. For instance, [Yan et al.](#) reported that expansive soil stabilized with industrial by-products (CKD+CCS) at a 10% CKD + 9% CCS ratio exhibits substantially increased strength and suppressed swelling. Additionally, an electrochemical stabilization method combining a movable anode with CaCl_2 injection was proposed by [Han et al.](#) [Sang et al.](#) showed that the addition of a low-concentration PVA solution together with plant fibers to sandy soils markedly enhances strength and ductility; and [Tao and Gao](#) found that increasing polymer content in polyurethane-reinforced granular materials reduces porosity and permeability, for which a pore-constriction model was advanced to explain the observed effect.

Advances in reinforced structures and embankment systems were also reported. [Hu et al.](#) introduced a non-foamed polyurethane-bonded gravel pile material that, relative to ordinary gravel, exhibits higher strength and stiffness while retaining high permeability, making it suitable for rapid construction. [Zhao and Zheng](#) found from field data that a well-compacted geogrid-reinforced soil platform beneath pile-supported embankments can significantly reduce lateral displacement of the embankment, with geogrid stiffness and interface friction identified as key controlling factors.

Moreover, seismic-wave propagation and crustal imaging were addressed. [Qiu and Zhang](#) developed a model for the reflection and transmission of obliquely incident P-waves at an elastic-saturated-porous interface, and showed that incidence angle, frequency and related parameters substantially influence wave propagation. [Hu et al.](#) applied double-difference tomography in the Huoshan region and found that mid-strong earthquake epicenters coincide with gradients in seismic velocity and Poisson's ratio. [Huang et al.](#) used Rayleigh-wave tomography to reveal fault-geometry-controlled differential subsidence and noted that the previously active Sankeshu pull-apart basin is approaching dormancy.

Several studies developed predictive models for fracture and failure processes in geomaterials. [Lei et al.](#), using an elastic wellbore model, showed that drilling-induced fractures can evolve into “J”-shaped cracks, providing a basis for their identification; [Deng et al.](#) proposed a nonlinear Mohr–Coulomb criterion to describe unloading-induced failure in frozen weakly cemented sandstone; [Gu et al.](#) observed that pervasive micro-fissures in deep

columnar-jointed basalts lead to rapid post-unloading relaxation and reductions in acoustic velocity; and [Liu et al.](#), employing SPH simulations of high-pressure jet grouting, found that tensile failure predominates in the soil under jet action.

We sincerely thank all contributing authors, the anonymous reviewers for their rigorous evaluations, and the editorial staff for their invaluable efforts. It is hoped that this Research Topic will inform and inspire future research and engineering practice in advancing the analysis of geomaterial instability.

Author contributions

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