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EDITED AND REVIEWED BY
Carmen Sanchez-Valle,
University of Münster, Germany

*CORRESPONDENCE
Xianwei Zhang,
xwzhang@whrsm.ac.cn

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Editorial: Multiscale characterizations of special soils and the geotechnical implications

Ran An[1,2], Xinyu Liu[3], Xianwei Zhang[4]* and Shilong Gan[1]

[1]School of Civil and Hydraulic Engineering, Hefei University of Technology, Hefei, China, [2]School of Engineering, University of Bristol, Bristol, United Kingdom, [3]School of Civil and Hydraulic Engineering, Huazhong University of Science and Technology, Wuhan, China, [4]State Key Laboratory of Geomechanics and Geotechnical Engineering, Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Wuhan, China

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Editorial on the Research Topic
Multiscale characterizations of special soils and the geotechnical implications

1 Introduction

In the expansive realm of Earth Science, soil mechanics serves as a crucial bond among geology, civil engineering, and environmental science. The depth and breadth of its research profoundly impact the safety and sustainability of human living environment and infrastructure construction. In practical engineering applications, a wide variety of special soils are frequently encountered in construction, including residual soil, expansive soil, glacial sediment, diatomaceous earth, coral sand, loess, frozen soil, contaminated soil and so forth. The distinctive chemical, physical, and mechanical properties of these soils present numerous obstacles to the conventional theory of soil mechanics.

Traditional theory of soil mechanics is primarily based on homogeneous sand or clay, with relatively simple and predictable mechanical properties. However, the mechanical behavior of special soils is complex and variable due to its distinct geological origin and microstructure. In order to achieve a comprehensive understanding of the engineering behavior of special soils and effectively guide engineering practice, it is imperative to conduct a multiscale characterization that encompasses *in-situ* investigation, laboratory testing, microscopic observation, and cross-scale analysis. Through this process, researchers have the potential to unveil the structural characteristics and mechanical mechanisms of special soils, thereby enabling accurate predictions of their behavior under diverse engineering conditions and environmental circumstances.

2 Progress in the Research Topic

To advance the development of theory, testing, and simulation of soil mechanics, as well as to facilitate global collaboration among peers in this field, we initiated a special Research Topic titled "*Multiscale Characterizations of Special Soils and the Geotechnical Implications*" on 4 September 2023. The aim of this Research Topic was to gather the latest discoveries from theoretical, experimental, and numerical simulation studies on the mechanical characteristics of diverse special soils, with a particular focus on investigating the interconnected relationships across various study scales. The Research Topic has captured considerable interest within the academic community. This topic consists of 6 original papers accepted and published, successfully attaining the predetermined objective. This editorial provides a thorough overview of these publications covering the mechanical, physical, and chemical properties at different scales within soil-rock composite medium, coral sand, interlayered soil, and so forth. These papers not only propelled the progression of soil mechanics, but also laid a vital scientific groundwork for practical engineering implementations. Please visit the following website for further information: https://www.frontiersin.org/research-topics/58916/multiscale-characterizations-of-special-soils-and-the-geotechnical-implications/overview.

3 Multiscale effects of soil behavior

The comprehensive understanding of the underlying physical processes across different scales is necessary due to the complex and interconnected multiscale effects on soil mechanics. Integrating data from various scales into advanced modeling techniques can help engineers and researchers improve their comprehension of soil behavior and develop more effective strategies for addressing soil-related challenges in engineering projects.

Huang et al. investigated the spatiotemporal impacts of wind-blown sand transport through extensive field monitoring and computational fluid dynamics (CFD) numerical simulation along the Ganquan Railway for their recent scholarly publication. Liu et al., from Xinjiang Institute of Architectural Sciences, conducted biaxial tests on coral sand using a two-dimensional discrete element method to investigate the effects of particle shape and particle crushing on its mechanical behavior. The findings indicated that the impact of particle shape and inherent anisotropy on shear strength is diminished by crushing, highlighting the governing role of microstructure in macroscopic behavior.

4 Application of advanced experiments and simulations

The application of advanced experiments and simulations in soil mechanics greatly enhanced our understanding of soil behavior and improved the accuracy of predicting soil responses under various conditions. As modern methodologies in soil mechanics continue to evolve and innovative approaches emerged, they were expected to play a more crucial role in the advancement of this field and in improving the safety and effectiveness of geotechnical engineering projects. Liu et al. from Zhejiang Institute of Communications Co., Ltd., demonstrated that the dynamic shear modulus of interlayered soil was influenced by the initial effective confining pressure, consolidation ratio, and degree of consolidation. The conclusion was established through advanced dynamics experiments on undisturbed interlayer soil in the Yangtze River floodplain. Through the integration of electromagnetic test parameters and an artificial neural network prediction model, An et al. conducted a sensitivity analysis to discuss the intricate mechanism governing the electrical properties of soil-rock composite medium.

5 Utilization of modified soil in engineering applications

The utilization of modified and enhanced special soils in engineering applications has become increasingly imperative as the need for sustainable and efficient construction continues to escalate. The special soils treated with reinforcement and modification, such as those exhibiting high strength, low permeability, or enhanced environmental performance, have the potential to significantly enhance the functionality and durability of various engineering structures. Sheng et al. from Nanchang University, investigated the optimization method of slurry filling construction and filter cake by conducting physical modeling tests and numerical simulations. The results indicated that an increase in grouting flow rate and tailings slurry concentration leads to a thicker filter cake with a denser structure, which subsequently reduces the dewatering performance of the geotextile.

6 Conclusions and prospects

The publications included in this Research Topic offer a comprehensive overview of the advancements in engineering properties and applications of special soils from various perspectives. It is concluded that recent progress is expected in critical areas such as microscale characterization techniques, integration of machine learning and AI, development of multiscale constitutive models, improved geo-mechanical modeling, and sustainable utilization of special soils. Our sincere hope is that the Research Topic will provide fresh insights for professionals working in relevant fields.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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