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Editorial: Microscopic structure effect on the macroscopic property of geomaterials

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Editorial on the Research Topic
Microscopic structure effect on the macroscopic property of geomaterials

1 Introduction

It is widely believed that the microscopic structure affects the macroscopic property of the material. The long geological period leads to a complex micro-structure in geomaterials. Therefore, the microstructure's effect on the macroscopic property has been a hot topic for many years. This Research Topic includes 62 papers, grouped under the "*Microscopic Structure Effect on the Macroscopic Property of Geomaterials.*" This editorial highlights the papers, which relate to three significant aspects and five sub-aspects, including experimental investigation, microstructure characterization, advanced numerical methods and engineering applications.

2 Microscopic structure effect on the macroscopic property

2.1 Experimental investigation

2.1.1 Microscopic structure characterization

The microscopic structure of geomaterials is exceptionally complex with different types of minerals, porosity and fractures. With the development of measuring equipment like scanning electron microscope and micro-CT, the quantitative analysis of the microstructure is possible [1]. Hui Liang proposed a precise and digitized reconstruction of sand particles using high-resolution X-ray micro-computed tomographic (X-CT) scanning Liang et al. Liu and Ren analyze the sandstone pore geometry based on a digital core.

The present micro-structure characterization represented in this Research Topic proposed the state-of-art techniques. Employing these quantitative parameters, it is helpful to explain the effect of microstructure on macroscopic properties like elastic modulus, conductivity and strength.

2.1.2 Experimental test of heterogeneous geomaterial

A laboratory or *in-situ* test is a common technique to analyze the physical parameters of geomaterials [2]. Experimental studies can be categorized into two types in this Research Topic. The first is the natural geomaterials with heterogeneous structures. The microscopic structure of natural geomaterial has apparent diversity. Zhang et al. implemented a triaxial experiment for rock samples with different sampling angles and got the relationship between strength parameters and inherent anisotropy.

Another type of test is for the artificial materials with different components. Li et al. proposed a polyvinyl alcohol (PVA) reinforcement method to improve the stability of sand slopes in Southeast Tibet. Cao et al. presented a Brazilian compression test incorporating a scanning electron microscope for sandstone containing pre-existing cracks. Compared with natural geomaterials, the artificial material is more appropriate in designing geomaterial with high physical properties.

2.2 Multiscale numerical method

The multiscale analysis between the macroscopic behavior and microscopic structure is highly significant in civil engineering. The past several decades witnessed a significant development of multiscale simulation. For analyzing macroscopic behavior like slopes, dams and tunnels, two typical solutions, the multiscale constitution model and the advanced numerical method, are most widely used [3, 4], Chen et al.].

2.2.1 Multiscale constitution model

The constitution model to describe the mechanical behavior of the material can date back to the 17th century. Incorporating the microscopic structure in the constitution model is an efficient solution that can be easily used in many commercial and open-source codes. Chao et al. presents a simple homogenized-based elastoplastic damage constitutive model of porous rock material consider the heterogeneities of the studied porous rock. Based on the proper assumption, this kind of model can predict the primary mechanical behavior of heterogeneous geomaterial.

2.2.2 Advanced numerical method

Due to the limitation of analytical solutions, most multiscale constitution models are established based on the simple assumption. For example, the shape of the pore is spherical, and the crack is penny-shaped in these models. Compared with the multiscale constitution model, a numerical method is applicable for complex shapes. Yan et al. presented a numerical simulation of irregular columnar jointed rock mass mechanical properties based on the Voronoi random graph generation algorithm and contact surface elements. It is noted that the numerical method often consumes a huge amount of computation cost for complex structures.

2.3 Engineering application

The main purpose of microscopic structure study is for engineering application. Many famous projects like the Kala hydropower station, Three Gorges reservoir and Changqing oil field are involved in this topic. Xu et al. presented a three-dimensional finite-difference simulation to analyze the mechanical responses of the stilling basin structure and the foundation rock mass under various working conditions. Wang et al. studied the characteristics of Chang 8 reservoir of Triassic Yanchang Formation using a polarizing microscope, field emission scanning electron microscope, image particle size, X-ray diffraction analysis of clay, and constant pressure Mercury intrusion. These studies provide important references for related engineerings.

Author contributions

QM, WS, and HW summarized the experimental investigation; WW and CZ summarized the multiscale numerical method and engineering application.

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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.

Publisher's note

References

1. Li C, Kong L, An R. Evolution of cracks in the shear bands of granite residual soil. *J Rock Mech Geotechnical Eng* (2022). doi:10.1016/j.jrmge.2021.12.028

2. Ren D, Wang X, Kou Z, Wang S, Wang H, Wang X, et al. Feasibility evaluation of CO2 eor and storage in tight oil reservoirs: A demonstration project in the ordos basin. *Fuel* (2023) 331. doi:10.1016/j.fuel.2022.125652

3. Meng Q, Wang H, Cai M, Xu W, Zhuang X, Rabczuk T. Three-dimensional mesoscale computational modeling of soil-rock mixtures with concave particles. *Eng Geol* (2020) 277:105802. doi:10.1016/j.enggeo.2020.105802

4. Meng Q-X, Wang H-L, Xu W-Y, Chen Y-L. Numerical homogenization study on the effects of columnar jointed structure on the mechanical properties of rock mass. *Int J Rock Mech Min Sci (1997)* (2019) 124:104127. doi:10.1016/j.ijrmms.2019.104127