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Editorial: Advances in modeling, assessment, and prevention of geotechnical and geological disasters

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Editorial on the Research Topic
Advances in modeling, assessment, and prevention of geotechnical and geological disasters

Introduction

The global climate change, rapid expansion of human activities, and continuous increase of engineering operations are creating a strong impact on the geological environment. A wide variety of geotechnical and geological disasters have occurred worldwide, including slope instability, tunnel damage, and deep excavation collapse, as well as natural geological disasters such as rock collapse, landslide, and debris flow. These hazards seriously affect economic development and human safety. Research on the modeling, assessment, and prevention techniques of the geotechnical and geological disasters is a key and difficult problem to be solved in the field of disaster control.

Considering the characteristics of geotechnical and geological disasters, a large number of new numerical methods, such as DEM (Discrete Element Method), DDA (Discontinuous Deformation Analysis), NMM (Numerical Manifold Method), SPH (Smoothed Particle Hydrodynamics), MPM (Material Point Method), and PD (PeriDynamics), have emerged after the classical FEM (Finite Element Method) and FVM (Finite Volume Method) in terms of modeling techniques. Different assessment methods for a single geotechnical project, linear geotechnical engineering, and territorial natural disasters have been proposed in terms of assessment techniques. In addition to active and passive engineering

reinforcement measures, advanced monitoring technologies including InSAR (Interferometric Synthetic Aperture Radar), Beidou, UAV (Unmanned Aerial Vehicle), Fiber Optics, and MEMS (Micro-Electro-Mechanical System) have been utilized in terms of prevention techniques. Significant progress has been made by researchers in the field of modeling, assessment, and prevention techniques.

Progress in the Research Topic

To attract scholars' attention to geotechnical and geological disasters, the current Research Topic, named "advances in modeling, assessment, and prevention of geological and geological disasters", was organized. The current Research Topic has been devoted to compiling the most recent and pertinent experience in the various domains of geotechnical and geological disasters.

Scholars from more than 80 institutions in four countries have published 43 papers. According to the keywords in those representative published papers, it is possible to roughly categorize the basic field of interest into four parts.

Mechanical properties and constitutive models of special geological materials

Zhou et al. established a granular thermodynamic model to describe the temperature/mechanical characteristics of sandy soil.

Ouyang et al. studied the influence of microbial content on engineering characteristics of expansive soil, which improved the microbially induced calcium carbonate method.

Jian et al. investigated the evolution of the compressibility of intact loess at different wetting stages by oedometer tests and characterized the microstructure and pore size distribution by SEM and MIP methods.

Liu et al. analyzed the energy evolution law in the rock failure process according to the relationship between mechanical parameters, AE parameters, and energy dissipation rate in the rock failure process.

Liu et al. studied the shear behavior of double rough parallel joints under constant normal stiffness boundary condition.

Applications of numerical simulation methods in geotechnical and geological disasters

Yu et al. presented the mixed integration scheme for embedded discontinuous interfaces by extended FEM, which solved two major challenges in employing the extended FEM in engineering applications.

Cheng et al. proposed a general block stability analysis algorithm based on the traditional block theory analysis framework, and a case studied proved that the key blocks of arbitrary shapes at any position can be find without the additional cost of interpreting graphs of block theory.

Zheng et al. studied the mechanism of flexural toppling failure in tock slopes using DEM, and introduced two new parameters to present a further understanding of flexural toppling.

Zheng et al. proposed a stochastic rockfall model related to random ground roughness based on 3-D DDA and examined the role of sphericity of the rock block travelling on bench slopes with different ground roughness levels.

Li et al. proposed the MLS-Based NMM to model cracked rock considering the contact of the crack surface.

Mechanism of geotechnical and geological disasters subjected to the environment factors and engineering load factors

Leng et al. explored the roles of rainfall and traffic load in fissure propagation and deformation development process of the loess slope.

Li et al. analyzed failure behavior based on the ring shear test in a bedding rock landslide of the Three Gorges reservoir.

Guo et al. studied the dynamic response laws of rock slopes with inverse non-persistent joints by the combination of different dip angles and spacing of joint and length of rock bridge under earthquake.

Lu et al. analyzed the dynamic response of twin circular unlined tunnels subjected to blasting P waves by indirect boundary integral equation method.

Qingke et al. studied the disturbance effect of shield tunneling on gravel layer and proposed a theoretical model to simulate the ground surface settlement above a double-track tunnel.

Yan et al. investigated the surface settlement and deformation laws of large-span shallow buried underground excavated stations.

Chen et al. summarized the mechanisms of both river blockage induced by debris flows and debris-flow dam failure.

Applications and developments of advanced assessment and prevention techniques in geotechnical or geological disasters

Chen et al. presented an approach for early warning of landslides based on the deep displacement theory.

Li et al. predicted uncertainties of collapse susceptibility based on remote sensing and GIS and discussed effectiveness of different machine learning models.

Tang et al. assessed debris flow risk at a catchment scale for an economic decision based on the LiDAR DEM and numerical simulation.

Shahani et al. developed an XGBoost regression model for predicting Young's modulus of intact sedimentary rocks for the stability of surface and subsurface structures.

Zhu et al. proposed a prediction method of coal burst based on analytic hierarchy process and fuzzy comprehensive evaluation.

Yu et al. proposed a multivariate early warning method for rockburst monitoring based on the comprehensive analysis of source parameters in the deep tunnel.

Huang et al. presented the multi-step combined control technology for karst and fissure water inrush disaster during shield tunneling in spring areas.

Liu et al. studied the mechanism of deep roadways in faulted zones and proposed a control technique named stages and combination control method.

Development trend

According to the major scientific and technological problems in the field of geotechnical and geological disasters, interdisciplinary integration is very urgent, as it could strengthen the interdisciplinary integration of geotechnical mechanics, structural geology, engineering geology and hydrogeology, seismic science, meteorological science, computational science, etc. Specifically, the future research in this field needs to focus on the following aspects.

Building a 3D digital deduction platform

A variety of numerical methods need to be cross-fused. The numerical simulation system reflecting the continuous-discontinuous, large deformation, and large displacement characteristics of rock and soil and the transformation mechanism of different disasters is urgent. Especially, the new constitutive relationship, numerical algorithm, and digital deduction system are necessary to form a general geotechnical and geological disaster analysis software. On this basis, multi-scale, whole process, and fine deduction of typical geotechnical and geological disaster scenes can be deduced.

Developing monitoring technology integrating multi-means

The detection and monitoring technologies integrating large-scale, all-space, all-weather multi-means is urgent, especially in geophysics, remote sensing, Beidou, UAV, Fiber Optics, and MEMS in no man's land. The developed detection and monitoring technology of geotechnical and geological disasters should be suitable for complex environments.

Exploring intelligent evaluation and prediction methods

Using high-precision measurement and monitoring technology, combined with big data, deep learning, and intelligent algorithms, to quickly obtain and analyze disaster information is the development trend. In the research process, it is necessary to propose and improve the machine learning algorithm based on the characteristics of geotechnical and geological disaster samples. The automatic recognition theory based on multi-source data (optical images, digital surface models, multispectral images and hyperspectral images, etc.) should be explored. A disaster monitoring platform based on expert systems and cloud computing also needs to be developed.

Author contributions

The idea of and concept of this Research Topic came from discussion amongst the guest editors. XF organized and wrote the manuscript. YY, MW, and ZZ provided critical feedback. All authors contributed to the submitted version of the article.

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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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