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Editorial

Geotechnical Disaster Risk Mitigation and Sustainable Development in Complex Geo-Environments: An Editorial Note

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1. Introduction

With the advancement of human society, the demand for infrastructure and the exploitation of natural resources have increased significantly. Inevitably, this has led to complex geological environments being encountered in various engineering projects, such as urban construction, transportation tunnels, hydropower caverns, mining, and environmental protection. These encounters often come with the potential risk of geotechnical disasters. For instance, in regions with high stress and complex geological structures, deep underground construction processes may encounter threats due to various types of disasters, including rockbursts, large deformations, strong water inrush, and large-scale collapses [1–6]. Additionally, adverse topography, geological structures, and hydrological and meteorological factors can lead to disasters such as landslides and collapses in slope engineering [7,8]. The frequent occurrence of geological and soil engineering disasters not only results in significant economic losses but also poses a serious threat to the safety of people's lives and property. Therefore, studying the mitigation of geotechnical disaster risks and sustainable development in complex geological environments is of great practical significance and theoretical value.

However, in practice, mitigating the risk of geotechnical disasters and implementing sustainable development face numerous challenges. These include less advanced geotechnical disaster monitoring technologies, less accurate risk assessment methods, and an incomplete emergency warning system. These issues constrain the progress of mitigating geotechnical disaster risks and ensuring sustainable development. To address these challenges, it is necessary to strengthen or enhance the detection methods for geotechnical engineering disasters to timely identify potential hazards and provide data support for subsequent risk assessments and disaster reduction. Furthermore, it is essential to study the mechanisms and deformation analysis of geotechnical disasters to gain a deeper understanding of the causes and evolution of geotechnical disasters and provide a scientific basis for disaster prevention and control. Additionally, the monitoring, risk analysis, early warning, and assessment of geotechnical disasters are crucial for reducing and preventing disasters, thus requiring the enhancement of relevant technological methods and applications. Lastly, the relationship between geotechnical disasters and environmental sustainability is a current focus and challenge, necessitating an in-depth exploration of the impact of geotechnical disasters on the environment and the feedback mechanisms of the environment on geotechnical disasters to achieve the coordinated development of engineering construction alongside the environment. New theories, methods, and technologies related to the mechanisms, early warning, and risk mitigation of geotechnical engineering disasters will greatly benefit construction safety.

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2. Progress in the Research Topic

This Special Issue has an overarching focus on new theories, methods, and techniques that have been developed to analyze the deformation mechanisms and monitor, warn, and mitigate geotechnical disasters in complex geo-environments. The aim is to exchange views on how to make the construction of geotechnical projects more sustainable and prevent disasters. This Special Issue comprises 15 papers selected for publication divided into four parts according to their research fields.

3. Geotechnical Disaster Detection

Zhang et al. (Contribution 1) proposed a mountain area SAR image registration method to solve the problem of the traditional SAR image registration method, which has difficulties in obtaining an ideal SAR image registration effect due to complex geometric and radiometric distortions in the areas with large terrain relief. Popielski et al. (Contribution 2) introduced a design method of type selection for engineering object monitoring elements on the basis of finite element calculation. At the same time, the verification of the numerical model based on data obtained from DFOS, classic surveying measurements, and thermal monitoring were also presented. Yang et al. (Contribution 3) proposed a set of induced polarization analysis strategies for the extraction and interpretation of deep mineral geophysical information, using a tin polymetallic mine as an example. This strategy provides a reliable foundation for the rapid development of deep geological exploration.

4. Mechanisms and Deformation Analysis of Geotechnical Hazards

Ding et al. (Contribution 4) used the random field model to describe the spatial variability of surrounding rock parameters in an underground tunnel. Based on this model, the analysis of stability during underground tunnel excavation was carried out. Niu et al. (Contribution 5) used the research methods of theoretical analysis, numerical simulation, and field measurement to study the deformation characteristics of the retaining structure of a deep foundation pit in the affected area of a fault zone under the coupling action of excavation and dewatering. Yu et al. (Contribution 6) studied the influence of the soil-structure interaction on the seismic response of isolated structures with a small aspect ratio on a multi-layer soft soil foundation. The energy balance equation of the isolated structure system considering the SSI's effect was established, and the influence of the SSI on the energy dissipation response of isolated structures with a small aspect ratio on multi-layer soft soil foundations was analyzed. In order to study the influence of the focal mechanism on the spatial coherence of ground motion, a method based on deterministic physics was used to simulate the near-field ground motion under various focal mechanism scenarios by Wan et al. (Contribution 7).

5. Monitoring, Early Warning, and Mitigation of Geotechnical Disasters

Yang et al. (Contribution 8) performed statistical analysis on the accuracy of rockburst monitoring in TBM tunneling from the aspects of rockburst intensity and location. Its applicability was analyzed from the aspects of rockburst construction safety, advancing speed, preventive measures, and so on. Yamusa et al. (Contribution 9) carried out landslide susceptibility mapping in the study area of the highway from Taiping to Ipoh in Malaysia. Based on 10 landslide condition factors, AHP and fuzzy AHP were used to determine the factors that have the greatest influence on the occurrence of landslides.

6. Geotechnical Catastrophes and Environmental Sustainability

Frydrych et al. (Contribution 10) considered the common deep excavation execution method and suggested the use of the prestressing method as a sustainable way to construct underground walls. Frydrych et al. (Contribution 11) proposed the concept of the research–calculation methodology for a bonded prestressed diaphragm wall design, foreseeing unbonded prestress as an area for future research. Pei et al. (Contribution 12) used the cross-scale analysis method based on the DEM-FEM-coupled numerical method to study the performance of MPGS strengthening on the talus slope, which was verified using the centrifuge model test. Liu et al. (Contribution 13) proposed D.B.S./Henry's law to determine the constant of carbon dioxide and the concentration of free carbon dioxide. Henry's law was used to measure the constant of carbon dioxide in artificial seawater with salinities of 32, 33, 34, and 35‰ at temperatures ranging from 3 to 20 °C. Wang et al. (Contribution 14) calculated and analyzed the water saving and ecological water demand in the Bayan Obo mining area based on remote sensing, geographic information systems, and the Integrated Valuation of Ecosystem Services and Trade-Offs InVEST model. Shah et al. (Contribution 15) studied the effects of waste granite powder on the behavior of compacted clay soil in both field and laboratory environments.

7. Conclusions and Prospects

This Special Issue discusses risk mitigation and sustainable development in geotechnical disasters that take place within complex geological environments, involving many theories, methods, and technologies. It is hoped that through the introduction and discussion of this topic, a useful reference can be provided for research and practice in related fields. Facing future challenges and opportunities in the field of geotechnical engineering, first of all, we need to strengthen our understanding of complex geological environments; secondly, we need to promote scientific and technological innovation and engineering progress in the geotechnical field; and finally, we need to actively participate in international cooperation and share experiences and achievements.

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