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Editorial

Advancing Sustainability in Geotechnical Engineering

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1. Introduction

Geotechnical engineering is a key element for all engineering construction that establishes contact with the earth, including foundation engineering, slope engineering, tunnel engineering, mining engineering, etc. To promote the sustainable development of geotechnical engineering, it is necessary to fully utilize the bearing capacity of rock and soil masses, reduce the amount of building materials with high carbon emissions, such as concrete and reinforcement, and minimize the workload [1,2]. To achieve engineering construction objectives, it has become a hot topic of global concern to modify the rock and soil masses, improve the anti-floating, anti-flood, and anti-seismic capabilities of geotechnical engineering, and avoid the pollution of, damage to, and influence on the ecological environment around the geotechnical engineering site [3,4].

The aim of this Special Issue is to enable geotechnical engineers to actively respond to various natural disasters, implement energy conservation and emission reduction, and achieve the friendly, coordinated, and sustainable development of geotechnical engineering and the ecological environment during the investigation, design, and construction processes. In addition, in this Special Issue, we hope to showcase original and innovative research papers highlighting the most important new methods, materials, equipment, and techniques relevant to promoting sustainable development in geotechnical engineering.

2. Progress in the Research Topic

We provided a forum for professionals and academics to communicate their impactful research, resulting in the publication of 17 papers in this Special Issue, mainly covering the following five aspects: the physical and mechanical properties of sandstone samples under different conditions, the prediction and control methods of surface subsidence, the solidification of wastes and their safe utilization, safety analysis and its control for engineering structures, and the application of innovative technology and methods in geotechnical engineering. Please visit the following website for more information: https://www.mdpi.com/journal/sustainability/special_issues/WD20A552B4 (accessed on 15 August 2023).

The physical and mechanical properties of sandstone samples under different conditions: To study the effects of deep-rock drilling and pressure relief under high stress conditions in enhanced geothermal systems, Lu et al. conducted two types of sandstone drilling–pressure relief experiments: the staged drilling of pressure relief holes before peak stress and one-time drilling. To reveal the physical and mechanical properties of sandstone under high-temperature water-cooling cycling conditions, Wang et al. conducted uniaxial compression acoustic emission tests on sandstone after high-temperature water-cooling cycles using an RMT-150B electrohydraulic servo rock testing system and a DS-5 acoustic emission detection system. They analyzed the deformation, strength, and acoustic emission characteristics of sandstone under different temperatures and cycle times. To investigate the influence of the water content on the mechanical properties of sandstone and the evolution

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of crack propagation, Huang et al. carried out laboratory compression tests and discrete element method numerical simulations of sandstone under different conditions.

The prediction and control methods of surface subsidence: Excessive surface settlement poses significant challenges to shield tunneling construction, resulting in damage to adjacent buildings, infrastructure, and underground pipelines. Luo et al. investigated the surface settlement induced by shield tunneling during the construction of the Qingdao Metro Line 6 between Haigang Road Station and Chaoyang Road Station, China. In fracture zones, tunneling with a double-shield Tunnel Boring Machine (TBM) presents significant challenges. To assure the tunnel construction's safety and efficiency, it was necessary to conduct a stability analysis of the tunnel's surrounding rock when a TBM passed through the fracture zones. Ji et al. analyzed the stability of the tunnel's surrounding rock when the TBM passed through fracture zones in the Qingdao Metro Line 8 (China) with different deterioration levels and dip angles. Working out appropriate load–settlement relationships is considered to be a very difficult geomechanical task. Kacprzak et al. proposed a 1-D rheological model, which accounted for the complex behavior of soil related to the settlement process.

The solidification of wastes and their safe utilization: To reduce the pollution caused by paper sludge in the environment and overcome issues of poor water resistance and brittleness in Magnesium Oxychloride Cement (MOC), Wang et al. modified the MOC by adding different dosages of paper sludge and studied the mechanical properties and damage modes of composite MOC materials containing paper sludge through uniaxial compression tests. They verified the effect of paper sludge on the mechanical properties of the MOC materials and the change in damage modes from the perspective of energy dissipation. The governance of uranium tailings aims to improve their stability and reduce radionuclide uranium release. In order to achieve this goal, Hu et al. successively carried out a uranium removal solution test and a uranium tailings grouting test using microbially induced calcium carbonate precipitation (MICP) technology. They discussed the effect of the MICP on the reinforcement of the uranium tailings and the synchronous control of radionuclide uranium in the tailings. This study provides valuable insights and references for safely disposing of uranium tailings.

Safety analysis and its control for engineering structure: Laboratory testing of raw coal samples is the dominant research method for disaster prediction. Chen et al. studied the failure characteristics and dynamic disaster propensities of coal-like burst-prone briquettes under different gas pressures. They developed a self-made multi-function rock–gas coupling experimental device and synthesized burst-prone briquettes. Hao et al. revealed the distribution law of the surrounding rock stress and the displacement of the surrounding rock after roof cutting and pressure relief of a reserved roadway with a hard roof using numerical simulation. Zhou and Yang studied the influence of the distance from the pile foundation to the partition wall as well as the stiffness of the retaining wall on the displacement and bending moment of the pile foundation during excavation. Soft soils with unfavorable properties can be improved using various ground-improvement methods. To overcome the limitations of current design methods that do not fully account for all interactions, Alsirawan et al. developed a simplified design method for geosynthetic-reinforced pile-supported embankments.

The application of innovative technology and methods in geotechnical engineering: Gravel and sediment frequently build up in holes during the anchor cable installation process, which makes it harder to install the anchor cable and causes the reinforcement to fail. Gao et al. proposed a bit–anchor setup approach to set up a drill bit at the front of the anchor cable to aid the anchor cable drilling. The feasibility of this approach was established with the DEM-MBD joint simulation and proved the correctness of the model. The precipitation of calcium carbonate induced by Bacillus subtilis has garnered considerable attention as a novel rock and soil reinforcement technique. The content and structure of calcium carbonate produced through this reaction play a crucial role in determining the rocks' and soil's reinforcement effects. Deng et al. investigated the effects of electrification on the physical and chemical characteristics, such as the growth and reproduction of Pasteurii. Using datasets obtained from igneous, sedimentary, and metamorphic rock slopes from various regions worldwide, Narimani et al. investigated different relationships between the geological strength index and the Q-system and Q-slope.

We hope that these articles provide readers with valuable information on recent developments in science, technology, and related research for achieving the goals of this Special Issue.

Author Contributions: The idea for and concept of this research topic came from discussion among the guest editors. S.W. organized and wrote the manuscript. C.C. and H.Y. provided critical feedback. All authors have read and agreed to the published version of the manuscript.

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List of Contributions

1. Huang, X.; Wang, T.; Luo, Y.; Guo, J. Study on the Influence of Water Content on Mechanical Properties and Acoustic Emission Characteristics of Sandstone: Case Study from China Based on a Sandstone from the Nanyang Area. *Sustainability* **2022**, *15*, 552. https://doi.org/10.3390/su15010552.
2. Kacprzak, G.; Zbiciak, A.; Józefiak, K.; Nowak, P.; Frydrych, M. One-Dimensional Computational Model of Gyttja Clay for Settlement Prediction. *Sustainability* **2023**, *15*, 1759. https://doi.org/10.3390/su15031759.
3. Alnmr, A.; Ray, R.P.; Alsirawan, R. A State-of-the-Art Review and Numerical Study of Reinforced Expansive Soil with Granular Anchor Piles and Helical Piles. *Sustainability* **2023**, *15*, 2802. https://doi.org/10.3390/su15032802.
4. Hua, J.; Wang, X.; Liu, H.; Sun, H. Nonlinear Finite Element Analysis of a Composite Joint with a Blind Bolt and T-stub. *Sustainability* **2023**, *15*, 4790. https://doi.org/10.3390/su15064790.
5. Ji, M.; Wang, X.; Luo, M.; Wang, D.; Teng, H.; Du, M. Stability Analysis of Tunnel Surrounding Rock When TBM Passes through Fracture Zones with Different Deterioration Levels and Dip Angles. *Sustainability* **2023**, *15*, 5243. https://doi.org/10.3390/su15065243.
6. Deng, J.; Li, M.; Tian, Y.; Zhang, Z.; Wu, L.; Hu, L. Using Electric Field to Improve the Effect of Microbial-Induced Carbonate Precipitation. *Sustainability* **2023**, *15*, 5901. https://doi.org/10.3390/su15075901.
7. Gao, K.; Liu, J.; Chen, H.; Li, X.; Huang, S. Dynamic Characteristics of Rock Holes with Gravel Sediment Drilled by Bit Anchor Cable Drilling. *Sustainability* **2023**, *15*, 5956. https://doi.org/10.3390/su15075956.
8. Alsirawan, R.; Koch, E.; Alnmr, A. Proposed Method for the Design of Geosynthetic-Reinforced Pile-Supported (GRPS) Embankments. *Sustainability* **2023**, *15*, 6196. https://doi.org/10.3390/su15076196.
9. Chen, Y.; Wang, Z.; Hui, Q.; Zhang, Z.; Zhang, Z.; Huo, B.; Chen, Y.; Liu, J. Influence of Gas Pressure on the Failure Mechanism of Coal-like Burst-Prone Briquette and the Subsequent Geological Dynamic Disasters. *Sustainability* **2023**, *15*, 7856. https://doi.org/10.3390/su15107856.
10. Zhou, N.; Yang, J. Spatial Effect Analysis of a Long Strip Pit Partition Wall and Its Influence on Adjacent Pile Foundations. *Sustainability* **2023**, *15*, 10409. https://doi.org/10.3390/su151310409.
11. Narimani, S.; Davarpanah, S.M.; Bar, N.; Török, Á.; Vásárhelyi, B. Geological Strength Index Relationships with the Q-System and Q-Slope. *Sustainability* **2023**, *15*, 11233. https://doi.org/10.3390/su151411233.
12. Hu, L.; Zhang, Z.; Wu, L.; Yu, Q.; Zheng, H.; Tian, Y.; He, G. Experimental Study on the Solidification of Uranium Tailings and Uranium Removal Based on MICP. *Sustainability* **2023**, *15*, 12387. https://doi.org/10.3390/su151612387.

13. Wang, S.; Wang, Z.; Gong, J.; Liu, Q. Damage Mode and Energy Consumption Characteristics of Paper-Sludge-Doped Magnesium Chloride Cement Composites. *Sustainability* **2023**, *15*, 13051. https://doi.org/10.3390/su151713051.
14. Wang, W.; Hong, L.; Cao, X.; Lu, X.; Wang, F.; Zhang, T.; Zhu, W. Experimental Study of the Mechanical and Acoustic Emission Characteristics of Sandstone by Using High-Temperature Water-Cooling Cycles. *Sustainability* **2023**, *15*, 13358. https://doi.org/10.3390/su151813358.
15. Hao, Y.; Li, M.; Wang, W.; Zhang, Z.; Li, Z. Study on the Stress Distribution and Stability Control of Surrounding Rock of Reserved Roadway with Hard Roof. *Sustainability* **2023**, *15*, 14111. https://doi.org/10.3390/su151914111.
16. Luo, M.; Wang, D.; Wang, X.; Lu, Z. Analysis of Surface Settlement Induced by Shield Tunnelling: Grey Relational Analysis and Numerical Simulation Study on Critical Construction Parameters. *Sustainability* **2023**, *15*, 14315. https://doi.org/10.3390/su151914315.
17. Lu, X.; Jiang, J.; Wang, W.; Cao, X.; Hong, L. Laboratory Experimental Study on the Pressure Relief Effect of Boreholes in Sandstone under High-Stress Conditions. *Sustainability* **2023**, *15*, 15557. https://doi.org/10.3390/su152115557.

References

1. von der Tann, L.; Basu, D.; Ritter, S.; Capellen, P.S.; Stordal, I.F. Sustainability in geotechnical engineering: What does it mean and why does that matter? *Proc. Inst. Civ. Eng.-Eng. Sustain.* **2023**, *176*, 247–259. [CrossRef]
2. Pathmanandavel, S.; MacRobert, C.J. Digitisation, sustainability, and disruption-promoting a more balanced debate on risk in the geotechnical community. *Georisk Assess. Manag. Risk Eng. Syst. Geohazards* **2020**, *14*, 246–259. [CrossRef]
3. Jorge-Arturo, P.J.; César-Augusto, G.U.; Rodrigo-Elías, E.R. Assessment of geotechnical hazard due to deep excavations in Bogota clays: A contribution for sustainability in urban environments. *Rev. Fac. Ing.* **2020**, *29*, e11373. [CrossRef]
4. Wang, Y.; Tang, Y.F.; Zhang, F.; Guo, J.L. Laboratory model tests of seismic strain response of anti-seismic anchor cables. *Front. Earth Sci.* **2022**, *10*, 863511. [CrossRef]