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Editorial

Deep Rock Mass Engineering: Excavation, Monitoring, and Control

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1. Introduction

With the continuing development of the global economy and society, the exploitation of underground space is undergoing an unprecedented prosperity period. The extensive and fascinating underground spatial resources play a momentous role in the modern world. Deeper and longer tunnels are developed to meet the demands of transportation, energy storage, shelter, dwelling, and so on. However, deep rock mass excavation and construction present a great number of challenges, which urgently need to be addressed, such as rock bursts and squeezing. Therefore, this Special Issue, titled "Deep Rock Mass Engineering: Excavation, Monitoring, and Control", was launched by a group of scholars from all over the world to resolve the challenges of deep rock mass engineering. Thirty-nine manuscripts were submitted to the Special Issue, and twenty-two papers were accepted for publication (i.e., 69% acceptance rate).

In these papers, numerical simulation, theoretical analysis, field monitoring, field application, and laboratory-based experiments have been conducted by many scholars to study the evolutionary law of deep rock mass engineering. Looking back on the Special Issues, it is evident that various challenges regarding deep rock mass and tunnels have been resolved.

2. Research on Deep Rock Mass Engineering

Thirteen papers mainly focus on numerical simulations and the theoretical analysis of deeply buried tunnels. Firstly, three papers researched deeply buried tunnels by numerical simulation. The first paper, authored by H. He and Z. Li [1], studied the optimal joint distribution of the assembled subway station structure under seismic action by the finite element software ABAQUS. The second paper, prepared by J. Du, Q. Fang, J. Wang, and G. Wang [2], divided the process of a high-speed train passing through a railway tunnel into three stages, according to the spatial relationship between the train and the tunnel. For the third paper, authored by H. Li, X. Li, Y. Yang, Y. Liu, and M. Ma [3], the authors established a three-dimensional fault-tunnel numerical model to explore the mechanical response characteristics of shield tunnels crossing active faults. Additionally, the following two papers carried out research on deep tunnels using full formula analysis. The fourth paper, written by D. Huang, H. Jiang, W. Luo, H. Xiong, B. Tang, and J. Xu, proposed an algorithm to calculate the effective ratio of the transverse bending stiffness of shield joints [4]. The results suggested that the modified model was simpler than the beam–spring model. Next, for the fifth paper, the authors Y. Dong, X. Liu, R. Zhang, and C. Yang [5] presented an analytical method for calculating the deflection and bending moment of underground jointed pipelines. Furthermore, for the sixth paper to the thirteenth paper, the authors investigated deep rock mass engineering through the combination of theoretical analysis and numerical simulation. The sixth paper, authored by X. Liu, A. Jiang, Q. Fang, Y.

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Wan, J. Li, and X. Guo [6], used the virtual image method, Mindlin's solution, and subgrade reaction analysis to analyze the deformation of an existing pipeline, which was located directly above the new shield tunnel. The seventh paper, written by J. Zhang, Y. Wang, B. Yao, D. Chen, C. Sun, and B. Jia [7], analyzed the peak strain-softening properties of rock mass based on the equivalent joint strain-softening theories. In the eighth paper, C. Huang, X. Li, and M. Wen [8] proposed a modified double-K fracture criterion and created an XFEM-FCM algorithm to carry out the fracture process of concrete linings. G. Wang, Q. Fang, J. Du, X. Yang, and J. Wang [9] proposed a prediction method to calculate the volume loss of the tunnel face based on the principle of minimum potential energy. The method more directly measured the volume loss of the tunnel surface from an energy perspective. W. Chen, D. Zhang, Q. Fang, X. Chen, and T. Xu [10], based on the MC strain-softening rock with non-relevant flow criteria, established a new finite strain program for circular tunnels. X. Luo, Y. Xiang, and C. Yu [11] proposed an analytical model to analyze the realistic drainage conditions in parallel tunnels during operation. The research provides a beneficial reference for the optimization of drainage in deeply buried tunnels. L. Yu, D. Zhang, Q. Fang, Y. Li, G. Wang, and L. Cao [12] proposed a new analytical method to predict the mechanical response of strip foundations generated by the tunneling process. Following this, the results obtained by their theoretical analysis were verified by comparing the results with the finite element code PLAXIS 3D. Ultimately, for the thirteenth paper, Xu, H. Wen, C. Sun, C. Yang, and G. Rui [13] used the developed nonlinear generalized Nishihara rheological model (NGNRM) and the numerical software ABAQUS to explore large deformation mechanisms of soft rocks.

Besides the numerical simulations and theoretical analysis approaches, nine papers on field monitoring, field application, and laboratory-based experiments have been used to investigate deep rock mass engineering. The first paper, authored by X. Li, Y. Yang, X. Li, and H. Liu [14], introduced three shield tunnel construction cases to acquire the main driving parameters for the evaluation of cutting head clogging. The second paper, prepared by Y.-J. Wang, L.-S. Zhao, and Y.-S. Xu [15], reported a coal mine collapse and discussed the potential causes of the accident. Based on the engineering accident, the suggestion was put forward to develop a new ground-pressure monitoring system. X. Liu, A. Jiang, X. Guo, and L. Hai [16] analyzed the dynamic response characteristics of existing pipelines induced by blasting excavation with the arch cover method. The results indicated that blasting must be performed at the appropriate moment to ensure the security of the structures. Y. Wu, Z. Zhou, S. Shao, Z. Zhao, K. Hu, and S. Wang [17] used 3D laser scanning technology to monitor the large deformation law of the loess tunnel based on the Yulinzi Tunnel and their results provided a reference for loess tunnel deformation control. Q. Huang, S. Liu, Y. Lv, D. Ji, and P. Li [18] applied a modified routine method and beam–spring model to their project based on a shield tunnel in Changsha. J. Li, Q. Fang, X. Liu, J. Du, G. Wang, and J. Wang [19] analyzed the mechanical responses of double line tunnels crossing under large-diameter shield tunnels using field monitoring data. Their results indicated that under-crossing construction will induce the opening of joints. Thus, secondary grouting of the existing tunnel should be carried out promptly before the tunnel underpass excavation. Z. Sun, X. Yang, S. Lu, Y. Chen, and P. Li [20] studied the influence of loess-bedrock landslides through a tunnel based on the laboratory model test and numerical simulations, and the results hold a certain reference value for the control of tunnel-crossing landslides. X. Li, D. Zhang, and Y. Hou [21] monitored ground deformation during the excavation process of shield tunnels in water-rich strata and verified the results using the numerical software FLAC 3D. The results indicated that the settlement values were at an acceptable level during the engineering stage. Moreover, timely grouting can reduce the damage to shield tunnels. K. Ma, L.-P. Chen, and Q. Fang [22] proposed a transfer method using tunnel surrounding rock loads to optimize the bearing capacity of the initial support, which was verified by Miaoshan tunnel engineering. Their research findings provided guidelines for the design of tunnel support.

3. Prospect

Although the Special Issue has been closed, more in-depth research related to deep rock mass engineering is expected. It can be forecasted that more opportunities and challenges will be presented in the future as scholars continue to explore underground engineering. Therefore, more strategies should be developed to respond to the challenges of excavation, monitoring, and control technologies for underground construction.

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