

冻结裂隙岩体静态压缩力学特征及破坏机制

Static compressive mechanical characteristics and failure mechanism of frozen fractured rock mass

王婷婷¹ 朱万成¹ 唐春安² 牛雷雷¹ 骆柯¹ 于江¹

Wang Tingting¹ Zhu Wancheng¹ Tang Chun'an² Niu Leilei¹ Luo Ke¹ Yu Jiang¹

(1. 东北大学资源与土木工程学院岩石破裂与失稳研究所, 辽宁沈阳, 110819;

2. 大连理工大学海岸和近海工程国家重点实验室, 辽宁大连, 116024)

(1. Center for Rock Instability and Seismicity Research, School of Resources and Civil Engineering, Northeastern University, Shenyang 110819, China;

2. State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology, 116024 Dalian, China)

摘要: 冻结裂隙岩体的高效爆破与灾害防治问题已成为高原寒区岩土工程施工中关注的焦点。为研究冻结裂隙岩体的静态力学特性及裂隙冰对于裂隙岩体的作用机制, 以冻结裂隙岩体为主要研究对象, 从西藏玉龙铜矿现场进行原岩钻取和加工, 制作人工冻结含裂隙冰大理岩试件, 先从室内试验分析了冻结裂隙岩体静态力学特性, 考虑不同裂隙冰几何特征的影响, 揭示了冰岩作用规律和裂纹萌生、扩展及贯通的力学机制; 并借助 RFPA^{3D} 深入分析了其裂纹萌生发育情况及能量积聚、释放过程, 研究结果表明: 冻结裂隙岩体抗压强度随裂隙冰角度增加呈现递增变化趋势, 随裂隙冰宽度、长度增加逐渐降低; 冻结裂隙岩体单轴压缩后的破裂模式受裂隙冰角度影响较为明显。与无裂隙冰试件相比, 含裂隙冰试件的抗压强度有所提高, 裂隙冰在压缩过程中起到了承载和固结作用。经试验和数值模拟结果对照, RFPA^{3D} 是一种行之有效的进行冻结裂隙岩体抗压特性研究的数值模拟工具。

关键词: 冻结裂隙岩体; 力学特性; 破裂模式; 寒区岩体力学; RFPA^{3D}

Abstract: Efficient blasting and disaster prevention in frozen fractured rock masses have become a focal point in alpine cold region geotechnical engineering. To study the static mechanical characteristics of frozen fractured rock masses and the mechanism of ice-filled flaws on fractured rock masses, frozen fractured rock masses were selected as the primary research object. Original rock samples were drilled and processed from the Yulong Copper Mine in Tibet, China, to create artificial frozen marble specimens containing ice-filled flaws. Initially, laboratory tests were conducted to analyze the static mechanical characteristics of frozen fractured rock masses, considering the impact of different geometric characteristics of ice-filled flaws. This revealed the interaction patterns between ice and rock and the mechanisms of crack initiation, propagation, and penetration. Additionally, the cracking process as well as energy accumulation and release were further analyzed using RFPA^{3D}. The research results indicate that the compressive strength of frozen fractured rock masses increases with the angle of the ice-filled flaw, showing an upward trend, while it gradually decreases with the increase in the width and length of the ice-filled flaw. The failure mode is significantly influenced by the angle of the ice-filled flaw. Compared to specimens without ice-filled flaws, those with ice-filled flaws exhibit improved compressive strength, as the ice-filled flaws provide bearing and consolidation during compression. The comparison between experimental and numerical simulation results confirms that RFPA^{3D} is an effective numerical method for studying the compressive characteristics of frozen fractured rock masses.

Keywords: frozen fractured rock mass; mechanical characteristics; failure mode; frozen rock mechanics; RFPA^{3D}