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岩石类脆性材料损伤演化分析及其模型方法研究

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Investigation of damage evolution and its model of rock-like brittle materials

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摘要/Abstract

摘要： 为了合理解决岩石类脆性材料损伤状态的描述及其演化问题，探讨了基于应变等效假设的弹性模量法各参数物理含义及其模型应用的局限性，进行了灰岩三轴循环加卸载试验过程中模量变化研究，讨论了卸荷模量替代法以及统计损伤演化模型在损伤演化分析中存在的缺陷。研究结果表明，现有弹性模量法仅能够用于反映单轴压缩条件下岩石损伤演化过程，卸荷模量替代法无法正确描述岩石损伤状态及其演化规律，统计损伤本构模型仅可视为统计损伤演化模型数值[0，1]范围下的理论自洽解决办法。根据上述研究，提出了考虑损伤应变阈值影响的岩石损伤表征变量及其演化模型，建立了损伤应变阈值前本构模型以及损伤应变阈值后损伤本构模型，进行了模型参数敏感性分析。研究结果表明，新模型和方法不仅能够合理阐释三轴压缩条件下岩石损伤破坏机制，也能够准确模拟岩石全应力?应变过程，具有较好的合理性与可行性。
关键词: 岩石, 弹性模量法, 损伤演化, 本构模型, 敏感性
Abstract: To investigate the description and evolution of the damage state of rock-like brittle materials, the physical meaning of each elastic modulus method parameter based on the strain equivalence hypothesis and the limitations of the model application are discussed. The modulus change during the triaxial cyclic loading and unloading test of limestone is studied. Moreover, the defects of the unloading modulus substitution method and the statistical damage evolution model in damage evolution analysis are discussed. The results show the existing elastic modulus method can only be used to reflect the damage evolution process of rock under uniaxial compression, and the unloading modulus substitution method cannot correctly describe the damage state and its evolution law. In addition, the statistical damage constitutive model can only be regarded as a theoretical self-consistent solution under the numerical range [0, 1] of the statistical damage evolution model. Based on the above research, a damage characterization variable and its evolution model considering the effects of damage strain threshold are proposed. Additionally, the constitutive model below the damage strain threshold and the damage constitutive model above the damage strain threshold are established, respectively. The sensitivity of model parameters is also analyzed in this study. The final results show that the proposed model and method can not only reasonably explain the damage mechanism of rocks under triaxial compression, but also accurately simulate the full stress-strain process, which is rationable and feasible.
Key words: rock, elastic modulus method, damage evolution, constitutive model, sensitivity
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