Evaluation of Rock Slope Model Parameters under the Influence of Anisotropic Inherent Joints

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Abstract

The formation of inherent fractures is governed by geostress and rock mass structure, significantly influencing the permeability and strength anisotropy of fractured rock masses. However, existing models primarily focus on the geometric distribution of fractures, with limited consideration of joint mechanical properties and their effects on the farbic tensor and connectivity parameter (λ). This study extends Oda's (1985, 1987) permeability tensor theory to develop a numerical model that integrates joint strength, fabric tensor, permeability connectivity, and strength anisotropy. The research aims to establish a stress-fabric joint coupling relationship and conduct 3D numerical simulations using FLAC3D, applying triaxial test conditions to determine Young's modulus (E,E′), Poisson's ratio (v,v′), shear modulus (G,G′), equivalent cohesion, and friction angle for different fabric tensor anisotropic models. Additionally, this study examines the variation of the connectivity parameter (λ) as fractures progressively close under increasing normal stress. Currently, our laboratory utilizes the fabric tensor to calculate the equivalent anisotropic permeability coefficient, which serves as the initial parameter for the model. This approach allows for investigating pore water pressure variations and conduct slope stability analyses. However, the current permeability coefficient calculations assume fully connected joints. In future work, we will further incorporate the effects of joint connectivity into our modeling. Additionally, we will conduct numerical experiments to determine the mechanical parameters of fabric tensors with different degrees of anisotropy and analyze the stability variations of rock slope models exhibiting strength anisotropy This research holds significant implications for rock slope stability assessment and tunnel engineering applications, with future work focusing on validation and optimization through field data integration.

Keywords: Fabric tensor, Fracture density, Strength anisotropy, Numerical simulation, Permeability tensor, Stress-structure joints coupling

異向性原生節理對岩石邊坡模型參數之影響與探討

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摘要

原生裂隙的形成受大地應力與岩石結構控制，進而影響裂隙岩體的滲透性與強度異向性。然而，現有模型多聚焦於裂隙幾何分佈，較少考慮節理力學特性對組構張量（Fabric Tensor）與連通性係數（Connectivity parameter, λ）的影響。本研究基於 Oda (1985, 1987) 提出的滲透率張量理論，發展一套結合節理強度、組構張量、滲透連通性與強度異向性的數值模型。預計建立應力−組構節理的耦合關係，並透過 FLAC3D 進行三維數值模擬三軸試驗方式求取不同組構張量異向性模型下的楊氏係數（E,E’）、泊松比（v,v\`）、剪切模數（$G$,$G$\`）、等效凝聚力與摩擦角，並探討裂隙受正向應力影響至閉合過程中連通性係數 λ 的變化。

目前本研究室使用組構張量計算等效異向性滲透係數，以此做為模型之原始參數，進而探討其孔隙水壓的變化及進行邊坡穩定分析，但此等效滲透係數的計算，皆假設節理為完全連通之情形，未來我們將進一步考慮節理連通性的影響。此外，我們將透過數值試驗求取不同異向性程度組構張量之力學參數，並探討各種具強度異向性岩石邊坡模型之穩定性差異。本研究成果對於岩石邊坡穩定性評估與隧道工程應用具有重要意義，未來可進一步結合現場數據進行驗證與優化。

關鍵字： 組構張量、裂隙密度、強度異向性、數值模擬、滲透率張量、應力-組構節理耦合。