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应变敏感的裂隙及裂隙岩体水力传导特性研究

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摘要 通过将岩体单裂隙视为非关联理想弹塑性体，导出单裂隙在压剪荷载作用下，其机械开度和水力传导度的解析模型，并采用已有相关试验研究成果对解析模型进行验证。在此基础上，通过将岩体概化为含一组或多组优势裂隙的等效连续介质，给出一种描述裂隙岩体在复杂加载条件下考虑非线性变形特征及滑动剪胀特性的等效非关联理想弹塑性本构模型。基于该模型，给出裂隙岩体在扰动条件下应变敏感的渗透张量的计算方法，该计算方法不仅考虑裂隙的法向压缩变形，而且反映材料非线性及峰后剪胀效应对裂隙岩体渗透特性的影响。该模型通过引入滑动剪胀角和非关联理想塑性，较为逼真地反映了真实裂隙及裂隙岩体峰后的剪胀特性、变形行为和水力传导度变化特征。通过数值算例，研究了裂隙岩体在力学加载及开挖条件下渗透特性的演化规律。

关键词 岩石力学；裂隙；裂隙岩体；水力传导度；应变；水力耦合

分类号

STRAIN-DEPENDENT HYDRAULIC CONDUCTIVITY FOR SINGLE ROCK FRACTURE AND FRACTURED ROCK MASS

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Abstract

Regarding single rock fracture as a non-associated elastic-perfectly plastic medium，an analytical model of the mechanical aperture and the hydraulic conductivity is developed for the fracture subjected to normal and shear loadings，and the model is validated by an existing shear-flow coupling test under wide range of constant normal stress and increasing shear displacement. On this basis，by regarding rock mass as an anisotropic continuum with one or multiple sets of critically oriented fractures，a methodology is developed to address the change in hydraulic conductivity resulted from engineering disturbance under the framework of material nonlinearity. An equivalent non-associated elastic-perfectly plastic constitutive model with mobilized dilatancy is presented to describe the global nonlinear response of the rock system under complex loading conditions. By resolving the deformation of fractures from the equivalent medium，a strain-dependent hydraulic conductivity tensor suitable for numerical analysis is formulated，where the normal compressive deformations of the fractures are considered；and more importantly， the effects of material nonlinearity and post-peak shear dilatancy are integrated. The proposed model is capable of describing the reality of the post-peak dilatancy behavior，deformation characteristic and changes in hydraulic conductivity of a real fracture and fractured rock mass by using non-associated flow rule with a mobilized dilatancy angle. Numerical simulations are performed to investigate the changes in hydraulic conductivities of rock masses under mechanical loading or excavation.

Key words rock mechanics；fracture；fractured rock mass；hydraulic conductivity；strain；hydromechanical coupling

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