Advances in Testing Methods and Characterization Models for Rock Effective Stress Coefficient: Postprint

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Abstract

The principle of effective stress is an important method for investigating the fluid-solid coupling behavior of rocks. As a key parameter for analyzing effective stress, accurate determination of the effective stress coefficient is of great significance for analyzing rock deformation and failure. This paper summarizes domestic and international research on testing methods, characterization models, and influencing factors of rock effective stress coefficients. The article systematically reviews the characteristics and applicable scopes of isotropic measurement methods, anisotropic measurement methods, fractured rock measurement methods, and dense rock testing methods. Different testing methods have different applicable scopes: the drainage method features high precision and is applicable to rocks of all porosities, and can be used to verify the validity of other methods; the stiffness matrix method can obtain anisotropic effective stress coefficients; for fractured and low-permeability rocks, the equivalent effective stress coefficient method and Cross-plotting method are recommended. Characterization models for effective stress coefficients include the critical porosity model, effective medium model, BISQ model, etc. Model evaluation using data from existing studies reveals that the BISQ model and equal-frame model exhibit high precision and can be applied to precise calculations, but require numerous parameters and involve relatively cumbersome computations; the critical porosity model requires only two parameters and demonstrates high precision, and is therefore recommended for engineering calculations. Influencing factors of effective stress coefficients include internal factors such as pore structure, mineral composition, and pore fluid, as well as external factors such as temperature and stress. Internal factors constitute the fundamental causes, while external factors induce changes in the internal structure of rocks, thereby affecting the effective stress coefficient. Future research trends include testing methods for real-time effective stress coefficients under complex stress disturbances, evolution mechanisms of effective stress coefficients under ultra-high temperature and

pressure conditions, and determination methods for effective stress coefficients in engineering rock masses.

Full Text

Research Progress on Testing Methods and Characterization Models of Rock Effective Stress Coefficient

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Abstract

The effective stress principle is fundamental to studying fluid-solid coupling behavior in rocks. As a key parameter in effective stress analysis, accurate determination of the effective stress coefficient is essential for understanding rock deformation and failure. This paper systematically reviews research progress on testing methods, characterization models, and influencing factors of the rock effective stress coefficient. The characteristics and applicability of various testing approaches—including isotropic, anisotropic, fractured rock, and tight rock methods—are examined. Among these, the drainage method offers high accuracy for rocks of all porosities and serves as a validation benchmark for other techniques. The stiffness matrix method enables determination of anisotropic effective stress coefficients, while the equivalent effective stress coefficient method and Cross-plotting method are recommended for fractured and low-permeability rocks.

Characterization models such as the critical porosity model, effective medium model, and BISQ model are evaluated using existing experimental data. The BISQ and equal frame models demonstrate high accuracy for precise calculations but require numerous parameters and involve complex computations. In contrast, the critical porosity model achieves high accuracy with only two parameters, making it recommended for engineering applications. The effective stress coefficient is influenced by internal factors (pore structure, mineral composition, pore fluid) and external factors (temperature, stress). While internal factors are fundamental, external factors alter rock microstructure and thereby affect the coefficient. Future research should focus on real-time measurement under complex stress disturbances, evolution mechanisms under ultra-high temperature and pressure conditions, and determination methods for engineering rock masses.

Keywords: rock mechanics; effective stress coefficient; testing method; characterization model; influencing factor