Laminar and Turbulent Flow in Rock Fissures and Fissure Networks

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ABSTRACT

The effects of laminar and mixed laminar/turbulent flow in rock fissure systems are evaluated. The primary unit used in the analysis is a single, parallel sided conduit. Expressions are developed to describe nontortuous and tortuous flow in idealised rock fissure geometries. Sinusoidal and sawtooth forms for wall roughness are chosen. The methods are extended to cases of normal closure and shear dilational opening. The semi-analytical expressions for tortuous flow are found to show favourable agreement with the results of "numerical testing" for the laminar case. Fissure shear strengths and storativity parameters are similarily obtained.

Methods capable of analytically accommodating plane and axisymmetric, laminar/turbulent flow in a single fissure are presented. These solutions are used to validate finite difference (FDM), finite element (FEM) and boundary integral (BEM) methods for the general problem of potential flow. The domain FDM and FEM analyses are cast for full laminar/turbulent flow in three dimensional fissure networks. Both steady and unsteady states are treated. Inertial effects are neglected. BEM formulations are used as a convenient and economical alternative to domain methods for multiple fissure, linear flow problems. Coupled BEM/FEM procedures are formulated for nonlinear flow analyses. The far field is represented by an equivalent linear model.

Experimental results are reported for convergent flow within a

simulated rock fissure. Comparison with numerical simulation yields excellent correspondence between predicted and measured flow rates. Inertial effects lead to less conclusive comparisons between measured and predicted potential heads.

Parametric studies are completed for arbitrary examples of three dimensional fissure networks. The influence of conductivity changes in component fissures are evaluated. Transient response curves are produced for mixed laminar/turbulent flow. Cases of rigid radial fissures with open or closed boundaries are examined.