Simulating energy method for grout-induced crack analysis of rock structures at Chadormalu mine by extended finite element method

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Received 25 April 2018; received in revised form 28 July 2018; accepted 28 July 2018

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Abstract
Fracture mechanics is a vital component involved in studying the exact behavior of rock materials. Detection and assessment of the behavior of rock joints injected by grout plays an important role in numerical modelling in rock mechanic projects. The importance of mechanisms associated with initiation and propagation of cracks due to hydraulic fracturing has led to a considerable interest in investigation and analysis of this phenomenon. In this work, the process of propagation of cracks on the wall of boreholes, drilled in single and bi-material structures, was simulated in ABAQUS software employing the extended finite element method. The energy method was implemented to obtain the stress intensity factor and energy release rate through applying J integral around the crack tip. The method was applied to two rock types, diorite and granite at the Chadormalu iron mine located in the central part of Iran. It was concluded that assuming the same geometry, the possibility of crack propagation at the boundary between two materials was more than the single material medium. Therefore, in dealing with a bi-material medium, if the purpose is to measure the in situ stresses, the measurement should not be performed on the boundary between the two materials.

Keywords: Fracture Mechanics, Bi-Material, Energy Methods, Extended Finite Element Method.

1. Introduction
The application of rock mechanics and geotechnical concepts in mining engineering plays a dominant role, especially in the slope design of open-pit mines, in the stability analysis and support design of underground openings as well as in situ stress measurements [1-3]. In general, there exist three main approaches for such an analysis: analytical, numerical, and empirical. The analytical methods have achieved an extensive reputation among researchers for predicting highly accurate stress and strain field around openings [4-6]. However, in terms of fracture mechanism, there still exist deficiencies owing to the complexity of the geometry of cracks combined with the complicated constitutive behavior for rock materials. To this aim, in parallel to numerical modeling, the use of physical modeling has obtained an international acceptance [7]. Especially, by development of geotechnical centrifuge machine in solving the problem of scale effect, the results of physical modeling are more reliable [8-10]. However, due to the complexity of the failure mechanism in heterogeneous and anisotropic media, numerical modeling is still more applicable than physical modeling for those media [11, 12].

Discontinuities and fractures are the natural structural drawbacks of rocks that exist at different scales (several millimeters to several thousands of meters) and determine the behavior of rock masses. The large-scale behavior of the fracture process in rocks is widely affected by the behavior of micro-cracks. Therefore, the initiation and propagation mechanisms of the cracks among the rocks are diverse in different conditions. Therefore, the necessity of knowledge on the mechanism of initiation and propagation of the hydraulic cracks in various engineering fields has