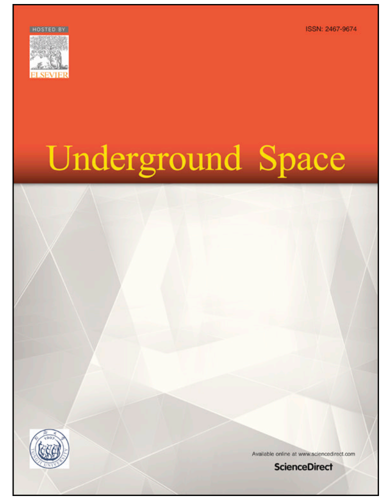

Adaptive phase field simulation of quasi-static crack propagation in rocks

Shuwei Zhou, Xiaoying Zhuang

PII: S2467-9674(18)30015-1
DOI: https://doi.org/10.1016/j.undsp.2018.04.006
Reference: UNDSP 56

To appear in: *Underground Space*

Received Date: 4 February 2018
Revised Date: 16 April 2018
Accepted Date: 29 April 2018

Please cite this article as: S. Zhou, X. Zhuang, Adaptive phase field simulation of quasi-static crack propagation in rocks, *Underground Space* (2018), doi: https://doi.org/10.1016/j.undsp.2018.04.006

Adaptive phase field simulation of quasi-static crack propagation in rocks

Shuwei Zhou[a, b*], Xiaoying Zhuang[b, c]

[a] *Institute of Structural Mechanics, Bauhaus-University Weimar, Weimar 99423, Germany*
[b] *Department of Geotechnical Engineering, College of Civil Engineering, Tongji University, Shanghai 200092, P.R. China*
[c] *Institute of Continuum Mechanics, Leibniz University Hannover, Hannover 30167, Germany*

Abstract

In this study, we present an adaptive phase field method (APFM) for modeling quasi-static crack propagation in rocks. Crack initiation due to positive strains is considered, and a numerical simulation is implemented using a commercial software, COMSOL Multiphysics. Two benchmark tests are first examined, namely, a single-edge-notched square plate subjected to respective tension and shear loadings. The crack propagation in Brazil splitting tests, 2D notched semi-circular bend (NSCB) tests, and 3D NSCB tests are subsequently simulated and analyzed. All the numerical examples indicate that the propagation of the cracks is autonomous and external fracture criteria are not required for phase field modeling. Furthermore, the adaptive remeshing scheme reduces unnecessary global mesh refinement and exhibits good adaptability for fracture modeling. The simulations are in good agreement with the experimental observations, and thereby indicate the feasibility and practicability of the APFM in rocks (even in 3D cases).

Keywords: Phase field; Adaptive scheme; Rock; Crack propagation

1 Introduction

Fracture mechanics is extensively applied in rock engineering because fracture-induced failure is an important threat to engineering safety (Anderson, 2005). However, the prediction of fracture propagation in rocks is challenging because rock masses correspond to a material that has several pre-existing flaws such as micro cracks, voids and soft minerals. A few studies that examined crack propagation in rocks include Bobet and Einstein (1998); Wong et al. (2001); Sagong and Bobet (2002); Wong and Einstein (2009); Park and Bobet (2009, 2010); Lee and Jeon (2011); and Zhou et al. (2014). All the aforementioned studies focus on laboratory tests with only simple loads because it is difficult to implement increasingly complicated load cases in practical tests. Therefore, numerical methods are a good alternative to examine fracture problems in rocks. It is essential to introduce a few cutting-edge numerical technologies in rock mechanics because they are less expensive than experimental tests and can provide new physical insights that are difficult to gain through 'pure' experimental testing.

Numerical methods for fracture can be classified into discrete and continuous approaches. Classical representatives of the first approach include efficient remeshing techniques (Areias and Rabczuk, 2017; Areias et al., 2013; Areias and Rabczuk, 2013), strain-softening elements (Areias et al., 2014), extended finite element method (Nanthakumar et al., 2014; Möes and Belytschko, 2002), phantom node method (Rabczuk et al., 2008b; Chau-Dinh et al., 2012; Vu-Bac et al., 2013), and specific meshfree methods (Rabczuk et al., 2007a; Rabczuk and Zi, 2007; Rabczuk et al., 2007b, 2008b; Rabczuk and Samaniego, 2008;