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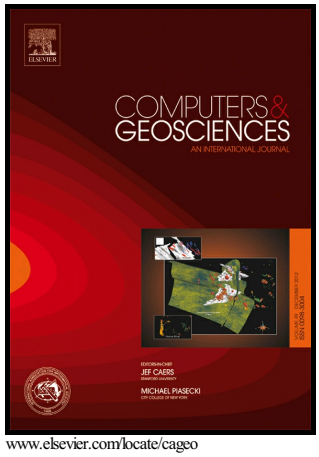

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Development of a parallel FE simulator for modeling the whole trans-scale failure process of rock from meso- to engineering-scale

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Abstract

Multi-scale high-resolution modeling of rock failure process is a powerful means in modern rock mechanics studies to reveal the complex failure mechanism and to evaluate engineering risks. However, multi-scale continuous modeling of rock, from deformation, damage to failure, has raised high requirements on the design, implementation scheme and computation capacity of the numerical software system. This study is aimed at developing the parallel finite element procedure, a parallel rock failure process analysis (RFPA) simulator that is capable of modeling the whole trans-scale failure process of rock. Based on the statistical meso-damage mechanical method, the RFPA simulator is able to construct heterogeneous rock models with multiple mechanical properties, deal with and represent the trans-scale propagation of cracks, in which the stress and strain fields are solved for the damage evolution analysis of representative volume element by the parallel finite element method (FEM) solver. This paper describes the theoretical basis of the approach and provides the details of the parallel implementation on a Windows - Linux interactive platform. A numerical model is built to test the parallel performance of FEM solver. Numerical simulations are then carried out on a laboratory-scale uniaxial compression test, and field-scale net fracture spacing and engineering-scale rock slope examples, respectively. The simulation results indicate that relatively high speedup and computation efficiency can be achieved by the parallel FEM solver with a reasonable boot process. In laboratory-scale simulation, the well-known physical phenomena, such as the macroscopic fracture pattern and stress-strain responses, can be reproduced. In field-scale simulation, the formation process of net fracture spacing from initiation, propagation to saturation can be revealed completely. In engineering-scale simulation, the whole progressive failure process of the rock slope can be well modeled. It is shown that the parallel FE simulator developed in this study is an efficient tool for modeling the whole trans-scale failure process of rock from meso- to engineering-scale.

Keywords: Trans-scale; RVE; Failure process; Parallel computation; Rock; Meso-damage