Numerical investigation of the interaction between hydraulic fractures and natural fractures in porous media based on an enriched FEM

Yun Zhou[1,2], *Diansen Yang*[1,2,*], *Xi Zhang*[3], *Weizhong Chen*[1,2]

[1]*State Key Laboratory of Geomechanics and Geotechnical Engineering, Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Wuhan, Hubei, China*

[2]*University of Chinese Academy of Sciences, Beijing, China*

[3]*CSIRO Energy, Clayton, Vic, Australia*

A fully coupled enriched-FEM (XFEM) model is proposed to investigate the interaction between hydraulic fractures and natural fractures in finite 2D porous media. The weak forms of both equilibrium and continuity equations are discretized in an enriched form in the space and by the Newmark scheme in the time domain. The Newton-Raphson method is adopted to solve these discretized equations. To account for the fluid flow in the porous matrix, 2D fluid leakage from the fractures to the matrix is considered by imposing internal flux boundary conditions on the fracture surfaces. A posteriori analysis is carried out to determine the equivalent leak off coefficient of the 1D Carter's leak off law. The frictional contact of the fracture surface is modeled by the penalty method in the model. The junction ridge function is adopted to describe the weak discontinuities of the pressure field in the elements containing fracture intersection points. A crack initiation criterion based on the average tensile stress along the natural fracture is used to determine whether a hydraulic fracture can cross a natural fracture. The presented model is first validated against the analytical solutions of the KGD model and then several numerical examples are simulated to investigate the effects of the natural fracture properties, treatment parameters, matrix permeability and approaching angle on the interaction between hydraulic fractures and natural fractures. The numerical results suggest the acceptable accuracy and robustness of the presented model on modeling fracture interaction behaviors in the presence of fluid leakage into matrix.

The work was supported by the National Natural Science Foundation of China (Grant Nos. 41572290, 51879260, 51879258, and 11672099), the Chinese Fundamental Research (973) Program through the Grant No. 2015CB057906, and Hubei Provincial Natural Science Foundation of China (Grant No. 2018CFA012).

Email:
Yun Zhou: zhouyun17@mails.ucas.edu.cn
Diansen Yang: dsyang@whrsm.ac.cn
Xi Zhang: xi.zhang@csiro.au
Weizhong Chen: wzchen@whrsm.ac.cn