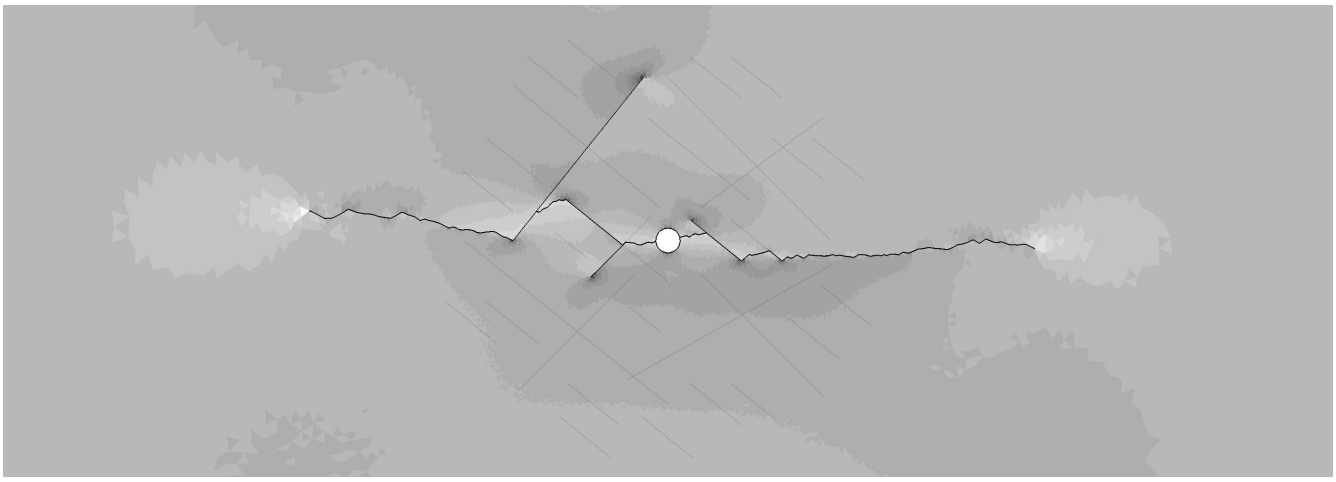
Short course on rock fracture process modeling: Fundamentals of the hybrid Finite-Discrete Element Method (FDEM) and its applications to hydraulic fracturing

GEOMECHANICA



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Prof. Giovanni Grasselli, University of Toronto

Introduction

The Hybrid Finite-Discrete Element method (FDEM) is an explicit numerical technology which combines continuum mechanics principles (FEM) with discrete element algorithms (DEM) to simulate multiple interacting deformable bodies. In FDEM, the progressive failure of rock material is captured using cohesive elements inserted at the interface of each FEM element. With this technique, fracturing can be explicitly modelled solely based on the strength degradation of these dedicated "crack" elements. Inherent to this approach, material damage emerges as a natural outcome of the deformation process without employing any additional macroscopic failure criterion. For this ability to closely reproduce failure processes in brittle materials, FDEM is gaining increasing importance in civil, mining, geological, and petroleum engineering applications where fracture and fragmentation processes are key to fully understand the studied phenomenon and to characterize the rock mass behaviour.

Learning goals

By attending this one-day course students and professionals will learn the basic concepts and algorithms embedded into FDEM and how to work with it. To achieve these learning objectives, the course will combine theoretical lectures to modelling sessions where the participants will be guided through several numerical simulations. Attendees should leave the course with a basic understanding of the FDEM technology, its strengths, limitations, and how it can be applied to model complex engineering problems such as hydraulic fracturing in discontinuous rock masses.

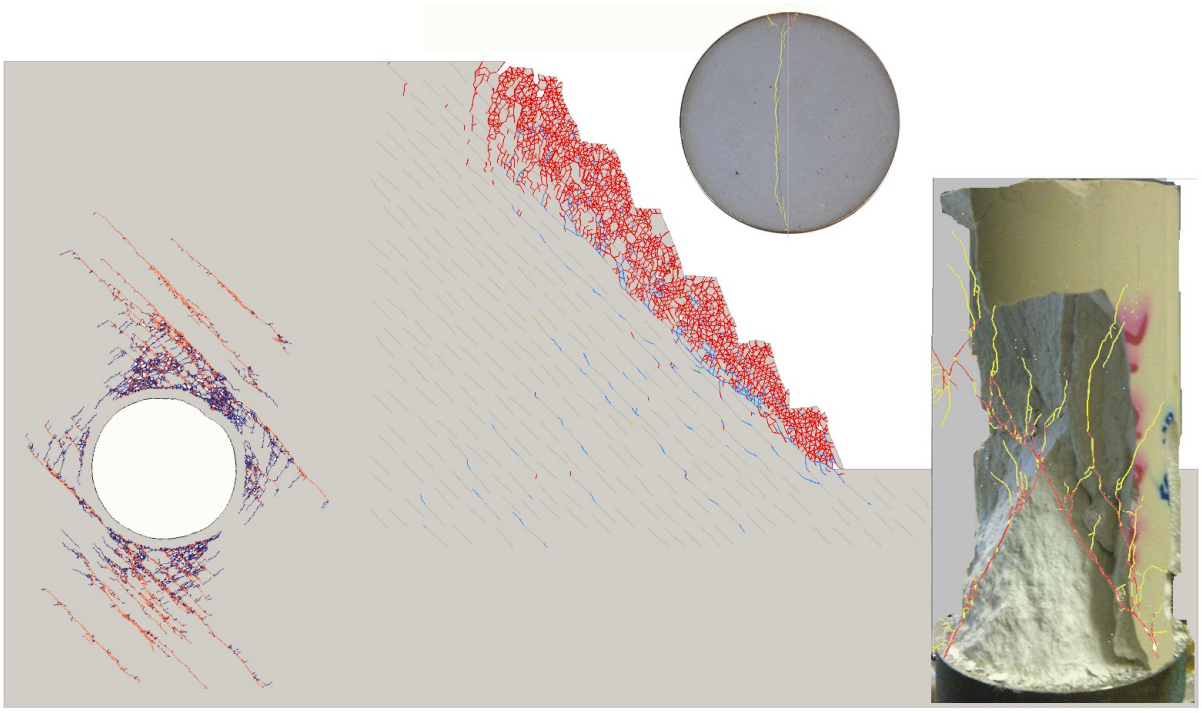
Course program overview

After introducing the main modelling philosophy and algorithms behind FDEM, emphasis will be placed on the role of fracture and fragmentation processes on the overall modelling results. The course will start with a general introduction to the FDEM technology and its application to rock mechanics, geophysics, and petroleum engineering problems. After a quick review of the basic algorithms, such as element deformation, contact detection, and contact interaction, the fracture model will be discussed in more depth. More advanced features of the FDEM code, including hydro-mechanical coupling, excavation function, and the incorporation of Discrete Fracture Networks will be introduced.

Next, the participants will learn how to build simple FDEM models in Geomechanica's FEMDEM software, assign correct inputs, and post process the results. This way, each participant will have the opportunity to gain “hands-on” experience with the FEMDEM code. Participants will also be provided with a copy of the open-source Y-Geo FDEM code*.

Target Audience

This course is specifically designed for petroleum, mining, geological and geotechnical engineers, graduate and post-graduate students who wish to use FDEM in their work and research.



* Mahabadi OK, Lisjak A, Munjiza A and Grasselli G (2012). "Y-Geo: a new combined finite-discrete element numerical code for geomechanical applications". International Journal of Geomechanics. 12(6), 676-688.