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Short Course: Realistic Failure Process Analysis

Summary: Many rock engineering problems involve potential and actual unstable rock failure, such as rockbursts, slope instability, and crack development in hydraulic fracturing. For this reason, the brittle failure of rock needs to be investigated. Various models and fracture criteria have been invoked in attempts to capture the essential features of the mechanisms which lead to brittle fracture in intact rock and the rock mass. Although much progress has been made and theories and models, such as fracture mechanics and damage mechanics, have provided techniques to solve fracture problems in rock, few approaches are capable of capturing fracture initiation, propagation, and coalescence and hence investigating fracture-induced progressive failure of rock satisfactorily.

A major difficulty in modeling the fracture mechanisms of rocks subjected to various loads is the fact that rocks are a natural, composite material, which is Discontinuous, Inhomogeneous, Anisotropic and Not Elastic (DIANE). It is not possible to analytically examine and evaluate the mechanical behavior of a DIANE rock exhibiting an unstable failure process. In most of the cases, analytical models have to be simplified, ignoring important factors influencing the mechanical behavior of rock.

Numerical models that simulate the detailed fracturing process are useful for understanding rock failure mechanisms on both the small and large scales. In this short course, a numerical code, the Realistic Failure Process Analysis (RFPA) model, will be introduced. Examples are presented to illustrate how the overall macroscopic response of a brittle rock can be simulated by integration of the interactions between smaller-scale elements. In addition, through the modeling examples of slope and tunnel instability, Dr. Tang will demonstrate how RFPA can be used to analyze large-scale practical problems.

Many operational questions in engineering practice, such as those listed below, will be addressed during the course:

- Why the rock behaves in a nonlinear fashion?
- What makes RFPA different from other FEM codes?
- How is material heterogeneity considered in the RFPA model?
- Why RFPA can model rock failure like a particle model?
- How can the RFPA model parameters be selected based on experimental or field data?

A clear and logical approach to such issues is provided through the course. Participants will gain a good understanding of the physics and mechanics involved in RFPA. The course also provides brief training of using RFPA to benefit all the attendants.

Course Outline: This RFPA Short Course includes five parts. The first part provides a brief introduction of the RFPA principle. The second, third, and fourth parts demonstrate various applications of RFPA in modeling rock failure under laboratory condition, modeling rock failure considering realistic rock properties, and modeling rock failure under field conditions. The fifth part provides a quick training of RFPA code.

PART I: INTRODUCTION

PART II: MODELING ROCK FAILURE UNDER LABORATORY CONDITIONS

2.1 Uniaxial tensile failure
2.2 Indirect tensile failure
2.3 Uniaxial compressive failure
2.4 Factors affecting the failure behavior
2.5 Confinement and shear
2.6 Loading and unloading
2.7 Dynamic loading

PART III: MODELLING ROCK FAILURE CONSIDERING ROCK REALISTIC ROCK PROPERTIES

3.1 Effects of heterogeneity
3.2 Coalescence of fractures
3.3 Anisotropy of layered and jointed rocks
3.4 Time dependent
3.5 Fluid flow and coupled behavior
3.6 Thermal effects and coupled modeling

PART IV: MODELLING ROCK FAILURE UNDER ENGINEERING CIRCUMSTANCES

4.1 Slope failure
4.2 Tunnel and cavern failure
4.3 Strata movement adjacent to coal mines
4.4 Gas outbursts in coal mines
4.5 Rock cutting
4.6 Particle breakage and communication
4.7 Fracture spacing
4.8 Polygon

PART V: BRIEF TRAINING OF RFPA AND CONCLUDING REMARKS