Title: **Realistic Failure Process Analysis**

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Time: Start at 09:00, end at 17:00, lunch from 12:30-13:30

Course Description:

Many rock engineering problems involve potential and actual unstable rock failure, such as rockbursts, coal and gas outbursts and crack development in hydraulic fracturing. For this reason, the brittle failure of rock has received considerable attention. 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 of investigating fracture-induced progressive failure of rock.

A major difficulty in modeling the fracture mechanisms for rock subjected to various loads is the fact that rock is 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. The problem becomes more intractable if gas or fluid, as in coal and gas outbursts, hydraulic fracturing, etc., is involved. 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 sequence are thus useful for understanding rock failure mechanisms on both the small and large scales. In this short course, a newly developed numerical code, the Realistic Failure Process Analysis (RFPA) model, is firstly introduced. Then, examples are presented in the course illustrating how the overall macroscopic response of a brittle rock can be simulated by integration of the interactions between smaller-scale elements. Also, through the modeling of mining sequences, it will demonstrate that RFPA is possible to analyze large-scale practical problems.

This RFPA Short Course includes five parts. The first part gives a brief introduction of the RFPA principle. The second, third and fourth parts demonstrate varies of potential applications of RFPA in modeling rock failure under laboratory condition, modeling rock failure considering rock reality and modeling rock failure under field circumstances. The fifth part provides a fast training of using RFPA code to basic and specific rock mechanics problems.

Many operational questions, such as listed below, regarding RFPA can be face to face answered during the course:

- Why is it nonlinear for rock or concrete behaviour?
- What makes RFPA different from other FEM code?
- How does heterogeneity be 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 with the five parts including RFPA principle, RFPA application and RFPA fast training. Participants will gain a good understanding of the physics and mechanics involved in RFPA.

Audience:

This course is intended for Geoscientists, Material scientist, Engineers, Technologists, students working in the filed of rock mechanics, geomechanics, civil engineering and material science. Mechanics experts in university and institutes, engineers and post-graduate students who are involved in rock or brittle material failure process analysis, design and construction activities associated with rock and concrete failure problems in or on fractured materials or structures will benefit from the short-course. A basic understanding of rock or concrete mechanics and computational mechanics is desirable for participants, but the course is self-contained; those never exposed to computational mechanics will rapidly pick up the major principles and become skillful in using RFPA code because materials are presented from a mechanical and physical point of view. Even those specialized in numerical methods will find new ideas and methods that will affect how they approach well analysis for complicated rock and concrete failure problems.

Course Objective:

The objective of the short course is to describe the features of RFPA method, to show how it can be used for failure process analysis of materials such as rock or concrete, and to train attendants how to use it.

Course Outline:

The course consists of five parts, which are roughly one and half hour for each part. Discussions and questions during the presentations are encouraged.

Part I: RFPA PRINCIPLE

1.1 Introduction
1.2 RFPA model

PART II: MODELING ROCK FAILURE UNDER LABORATORY CONDITIONS

2.1 Compression
2.2 Tension
2.3 Confinement and shear
2.4 Sequential loading
2.5 Loading and unloading
2.6 Dynamic loading
2.7 Particle breakage
2.8 Mechanical cutting

PART III: MODELLING ROCK FAILURE CONSIDERING ROCK REALITY

3.1 Influence of pre-existing fractures
3.2 Influence of inhomogeneity
3.3 Influence of anisotropy
3.4 Influence of non-elasticity

3.5 Influence of water flow
3.6 Influence of time dependent behaviour

PART IV: MODELLING ROCK FAILURE UNDER FIELD CIRCUMSTANCES

4.1 Pillar failure and rockburst
4.2 Slope stability
4.3 Tunnel stability
4.4 Mining excavation and coal strata movement
4.5 Gas outburst

PART V: RFPA FAST TRAINING

5.1 RFPA installation
5.2 Start up with a simple model
5.3 Practice

Biography:

Dr. Tang, as a chair Professor (funded by Cheung Kong Scholar Programme from State Education Ministry), was the Director of the Center for Rock Instability and Seismisity Research (CRISR) of Northeastern University, P.R.China. In 2006, as a full Professor, he moved to School of Civil & Hydraulic Engineering, Dalian University of Technology. He is also the Vice President of the Chinese Society of Rock Mechanics CSRM. In 1984, he started his Ph.D research, in Northeastern University, Shenyang, P.R.China, and got his Ph.D in 1988. In 1991, he continued his post-doctoral work in Imperial College, London, UK (work with Prof. J.A.Hudson). Then, as an academic visitor, he had lots of experience working in Canada (work with Prof. Peter Kaiser), Sweden (work with Prof. P-A. Linqvist), Singapore (work with Prof. J.Zhao) and Hong Kong. He leads several major research projects in rock mechanics, especially on rock failure mechanisms in civil engineering. His work is funded by the "Trans-Century Training Programme Foundation for Outstanding Young Scholars in China" from the State Education Ministry and by the "Special Natural Science Foundation for Outstanding Young Scholars in China" from National Nature Science Foundation. So far, he has published about 130 technical papers on rock failure mechanisms and civil engineering, and is the author of three Chinese books of rock mechanics and the principle author of "Rock Failure Instability and Related Aspects of Earthquake Mechanisms" published by a major publisher in China.
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