PFC2D/PFC3D Training Course

Itasca Consulting Group, Inc.

This four-day course provides guidance in the use of the Itasca codes PFC2D and PFC3D to simulate the mechanical behavior of granular and solid materials. The focus is on simulating the fracture and flow of brittle rock-like materials. Fluid-particle interaction modeled with the Coupled CFD add-on for PFC3D and the Basic Fluid Analysis option is also presented. PFC2D and PFC3D contain the embedded language FISH, which provides full access to the internal variables of the model and allows one to implement a user-defined solution procedure (e.g., couple the PFC code with a continuum code); thus, users must become proficient in the use of FISH. After FISH is mastered and the discrete-element framework that forms the theoretical basis for PFC is understood, then the codes can be used to simulate any physical process whose physics can be described in a discrete sense.

TOPIC 1: Code Overviews and Applications

- Itasca (consulting & software, history of PFC codes)
- Theoretical bases of discrete-element method and PFC

The items in the next two bullets will be overviewed and returned to throughout the course to illustrate specific concepts.

- Focus on *Bonded-Particle Model for Rock* [1]
  - Emergent behaviors are quantitatively similar to rock
  - Quantitative predictions require calibration process
  - Capabilities and limitations of the model
- Selected engineering applications of PFC
  - Tool-rock interaction during rock cutting
  - Back-fill stability, pull-out test of concrete anchor, proppant stability, physics of shaving, . . .
  - Excavation-induced damage in granite and lithophysal tuff

TOPIC 2: PFC and FISH Tutorials

- General code description and features
- PFC tutorial (simple data files, no FISH)
- FISH description and tutorial (implement ball-generation algorithm)

[1] Potyondy, D.O., and P.A. Cundall. "A Bonded-Particle Model for Rock," *Int. J. Rock Mech. & Min. Sci.*, ***41***(8), 1329–1364 (2004).

TOPIC 3: Creation and Testing of PFC Material

- PFC FishTank (FISH functions for bonded-particle modeling)
  - Material-genesis procedure (create material)
  - Biaxial, triaxial and Brazilian tests (test material)
- Calibration of PFC material
  - Example 1a: PFC2D/3D models of granite (solid and granular)
  - Example 1b: Embed joints in the PFC2D granite model using smooth-joint contacts

TOPIC 4: Problem Solving with PFC

- Boundary-value modeling
  - Examples to be developed interactively based on student interests. Potential examples include: studying the effect of varying the microstructure or microproperties on compression-test response, or creating a shear-box test environment that includes a servo-controlled top wall.

TOPIC 5: Fluid-Particle Interaction

- Introduction to fluid dynamics
- Overview of coupling concepts
  - Coarse-grid method
  - Fine-grid method (Lattice Boltzmann)
- CCFD package (coarse-grid scheme, Coupled CFD add-on for PFC3D)
  - Solid modeling
  - CFD concepts
  - Example applications

TOPIC 6: Focus on Client Applications

- Discuss modeling goals, formulate strategies
- Review previous material or cover it in greater depth, if desired
- Review the final exam from Potyondy's graduate course