Proposed Short Course at 52nd U.S. Rock Mechanics/Geomechanics Symposium (Seattle, WA, 17–20 June 2018)
KEYWORDS: *Bonded-Particle Model, Bonded-Block Model, Rock Fracture*

Microstructural Modeling of Rock Fracture: Bonded-Particle Modeling with PFC and Bonded-Block Modeling with 3DEC

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Bonded-particle models (BPMs; [1]) represent a solid as a bonded collection of particles, while bonded-block models (BBMs; [2] & [3]) represent a solid as a bonded collection of polyhedral blocks. Such models provide a synthetic material with mechanical behavior ranging from that of a solid material (such as rock) when the bonds are intact to that of a granular material when the bonds have all broken. These models provide a wide range of rock behaviors at both an intact and rock-mass scale. The mechanical behavior of these models is simulated by the distinct-element method. The BPMs are simulated using the *PFC2D* and *PFC3D* codes, in which the particles are rigid disks and spheres, respectively. The BBMs are simulated using the *3DEC* code, in which the blocks are rigid or deformable polyhedra.

Bonded-Particle Modeling is the focus of the morning, while Bonded-Block Modeling is the focus of the afternoon. The methodology by which a synthetic rock is constructed, assigned properties, and then subjected to boundary conditions is described. The methodology includes a calibration process in which the model microproperties are chosen to match a relevant set of macroproperties. Examples of how these models have been applied to simulate rock fracture are presented. The BPM example models a rock-cut test (at the mm scale), during which a cylindrical cutter is moved across the rock surface while monitoring forces on the cutter and damage in the rock as shown in Fig. 1. The rock is a sandstone, with the particles and bonds representing grains and cement, respectively. The BBM example models the excavation of a tunnel at depth (at the 1-10 m scale) under high stress conditions; after excavation, the tunnel is subjected to a loading and unloading cycle associated with cave mining. As the stresses redistribute, cracks initiate and propagate, producing an emergent damage pattern with associated bulking as shown in Fig. 2. The rock mass is heavily veined and massive with blocks representing intact rock, and the cemented contacts representing a network of intact rock, veins and discontinuities.

The course combines lectures with hands-on model manipulation; thus, each participant should have their own laptop computer on which the codes can be installed.

REFERENCES

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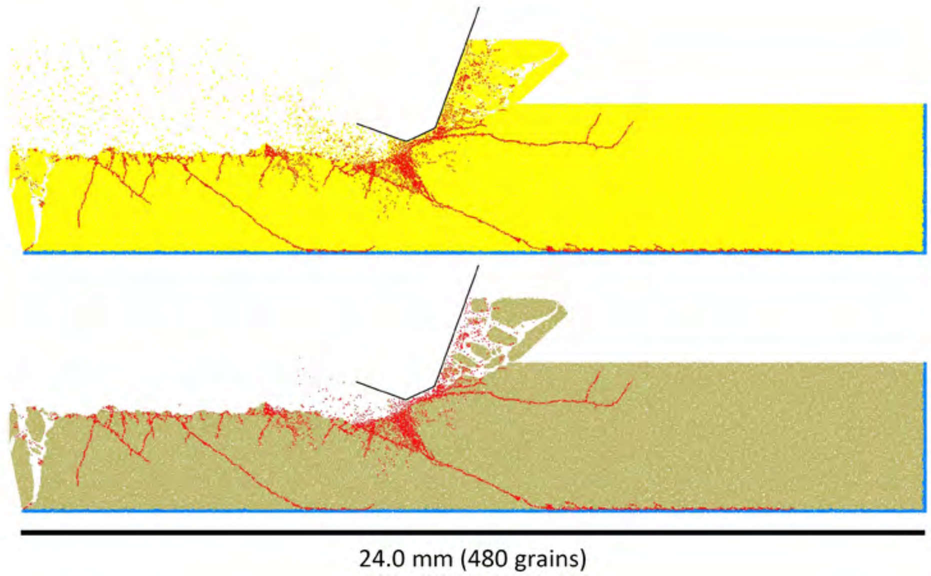

Fig. 1. Rock-cutting test behavior of a bonded-particle model of a sandstone after 11.2 mm of cutter displacement showing cracks with gap less than 50 microns (in red) as well as grains (top image, in yellow) and cement (bottom image, in tan). Rock damage consists of bond-breakage events, which we denote as cracks, and cracks may link up to form fractures that break the material into fragments.

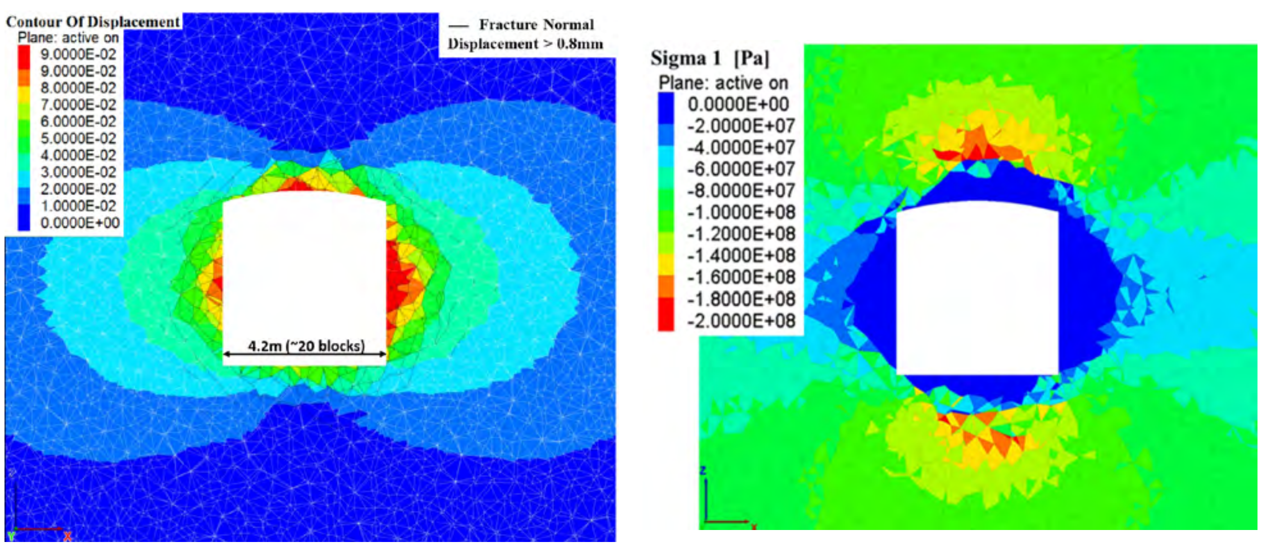

Fig. 2. Tunnel response at depth of a three-dimensional bonded-block model after being subjected to a caving-induced loading and unloading cycle. Displacement contour (left image) shows high bulking near the excavation surface. As stresses redistribute, surface-parallel fractures form and coalesce to create debonded fragments, resulting in an inner shell of highly damaged ground with a 2-m thickness. Fractures with normal displacement greater than 0.8 mm are shown as black lines. Rapid confinement build-up outside the inner shell allows the rock mass to sustain high induced stress concentrations (right image).