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THE SMOOTH-JOINT CONTACT MODEL

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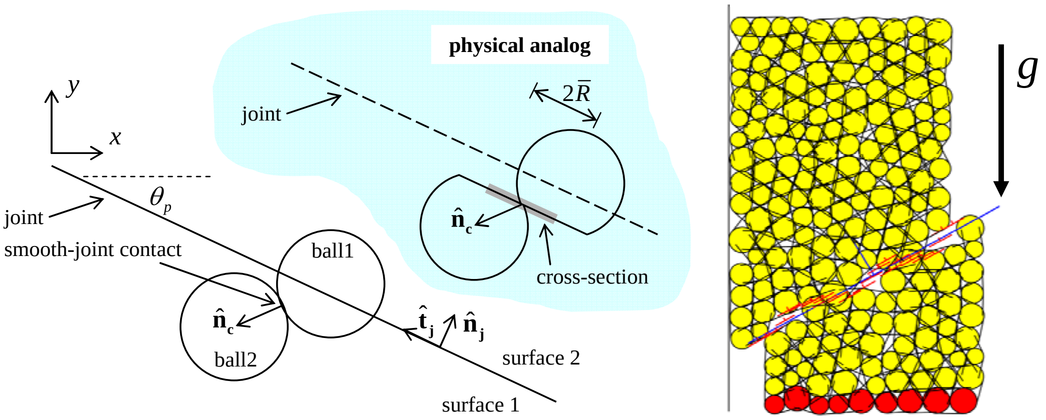
ABSTRACT

The representation of interfaces in numerical models consisting of assemblies of bonded disks or spheres is problematic because of the inherent roughness (bumpiness) of the interface surfaces. Small particles may be used to represent a band of low-strength material, with several particles across the band, but this is not feasible when the model requires a large number of interfaces.

The smooth-joint contact model (proposed by Cundall in 2005) simulates the behavior of an interface regardless of the local particle contact orientations along the interface. The behavior of a frictional or bonded joint can be modeled by assigning smooth-joint models to all contacts between particles that lie upon opposite sides of the joint. Particle pairs joined by a smooth-joint contact may overlap and "slide" past each other, instead of being forced to move around one another (see Figure 1). The effective joint geometry consists of two planar surfaces. During each time step, the relative translational displacement increment between the two particle surfaces is decomposed into components normal and tangential to the joint surfaces. These components are multiplied by the smooth-joint normal and shear stiffnesses to produce increments of joint force. The force-displacement law operates in the joint coordinate system and provides either Coulomb sliding with dilation or bonded behavior.



a) b)

Figure 1. (a) Effective joint geometry, and (b) 2D specimen with frictionless through-going joint loaded by gravity — large shearing motion results in the creation of new smooth-joint contacts along the joint plane.

The smooth-joint contact model has been used successfully to study rock behavior at both large and small scales. Both applications add a large number of interfaces to a bonded-particle model (BPM, [1]) representation of the rock. The large-scale application, denoted as the Synthetic Rock Mass (SRM) approach, adds a discrete-fracture network to study the effect of block angularity and interlocking on rock strength, dilatancy and brittleness (see Figure 2 and [2]). The small-scale application, denoted as the grain-based approach, adds a polygonal grain structure to study rock spalling whereby thin slabs form near the free surface of highly stressed rock (see Figure 3 and [3]).

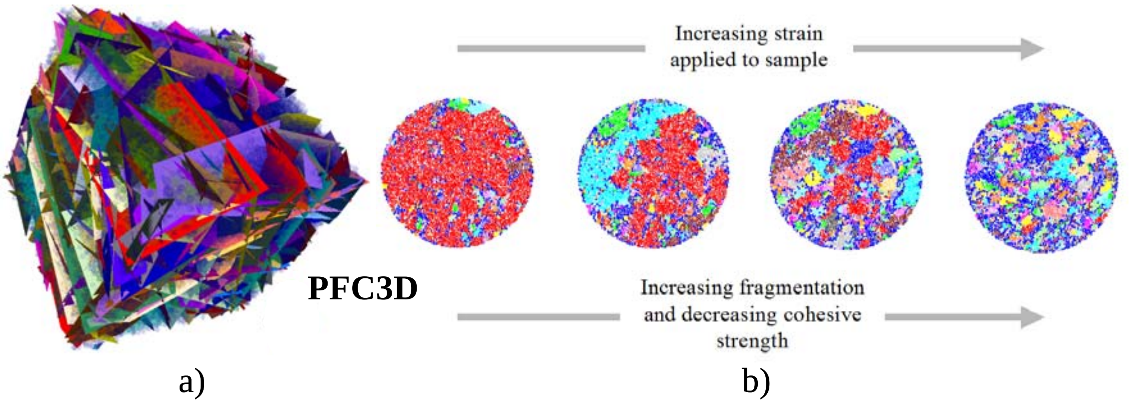


Figure 2. 3D SRM samples: (a) cubic region of 80-m side length, and (b) evolving disintegration in a planar cross section through a spherical region of 12-m diameter.

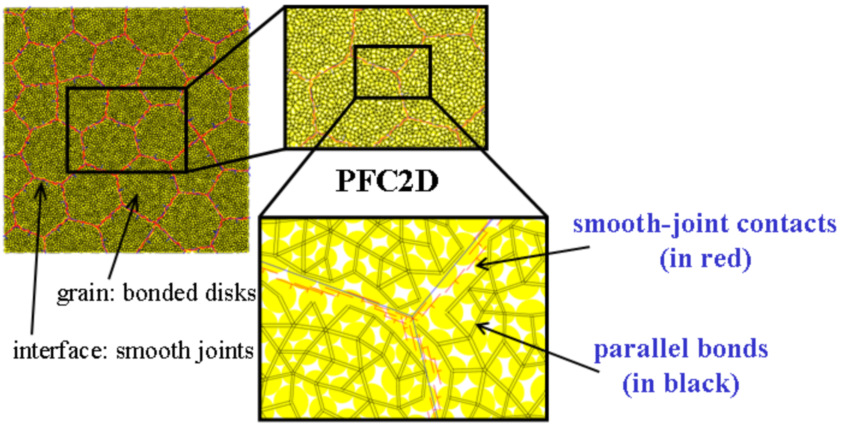


Figure 3. 2D grain-based model that mimics deformable, breakable polygonal grains cemented along adjoining sides.

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