

Roughness effects of crack surfaces on the elastic moduli of cracked rocks

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Abstract:

Crack surfaces are usually rough on various scales, and are sensitive to loading stresses and hence significantly affecting the mechanical properties of cracked rocks. We design a number of dry- and fluid-saturated numerical crack samples to investigate the roughness influence of crack surfaces on the elastic stiffness. The fracture surface roughness is characterized by non-uniform fracture radii. We calculate the elastic moduli of crack samples by finite-element simulation. Comparisons with the theoretical predictions by Gassmann¹ and C&S (Ciz & Shapiro)² substitution equations demonstrate that the rough crack surfaces for both dry- and fluid-saturated samples can induce a stress concentration around the crack that reduces the elastic moduli and decreases the stiffness of rocks. For the fluid/solid-saturated cracks under the normal (shear) loading stresses, because the stress-concentration can induce shear (normal) strains around fracture, shear (bulk) modulus of the filling material will have contributions to the effective bulk (shear) modulus of rocks. The extra contribution, however, makes the Gassmann equation and C&S equation invalid.

¹ Gassmann, F. (1951). *Über die elastizität poröser medien*. Vierteljahrsschrift der Naturforschenden Gesellschaft in Zurich. 96, 1-23.

² Ciz, R., and Shapiro, S. A. (2007). *Generalization of Gassmann equations for porous media saturated with a solid material*. Geophysics. 72(6), A75-A79.