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Transmissivity and conductivity of single fractures

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A single fracture can be represented as a void space between two rough surfaces which touch one another. Transmissivity and conductivity can be determined numerically by solving the Stokes and the Laplace equations between these two rough surfaces.
These problems were first solved and published by the same authors between 1995 and 2001 (see the corresponding references in [1]). The major purpose of this presentation is to provide updated, complete and more precise results for fractures with surfaces of two different types.
Each surface of a fracture can be schematized as a random surface which oscillates around an average plane; this surface is characterized by the probability density of the heights and the autocorrelation function C(u) of these heights; the standard deviation of the height is the roughness sigma. In addition a fracture requires the knowledge of the distance b_m between the two average planes and the intercorrelation coefficient theta between the heights. There are two major classes of autocorrelation functions, namely the Gaussian and the self-affine autocorrelation which are both characterized by a length scale l_c, which is a typical scale for the surface features in the Gaussian case and a cut-off length in the self-affine case. There is a major difference between these two classes since the first one corresponds to statistically homogeneous surfaces and the second one to self-affine surfaces; in the latter case which necessitates the introduction of another parameter which is the Hurst exponent, the average properties of the fracture depend on the size of the sample in contrast with the former case.
Systematic calculations were performed for these two classes and master curves are provided and discussed.
Systematic results for Gaussian fractures are displayed as functions of b_m/sigma, l_c/sigma and theta; the influence of theta is negligible when the ratio l_c/sigma is small enough. It is also shown that the Reynolds approximation does not depend on l_c/sigma; this approximation may overestimate the true transmissivity by almost an order of magnitude.
For self-affine fractures, the dimensionless equivalent aperture is essentially a power function of the fractional open area with an exponent which depends on the Hurst exponent of the surfaces.
Similar calculations were performed for conductivity in both classes of fractures.
The whole work can be summarized by a series of master curves which can be used to estimate properties of real fractures.

[1]] Adler P.M. et al, Fractured porous media, Oxford U. Press, 2012.