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Numerical evaluation of the equivalent permeability of randomly cracked porous media

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Evaluation of the equivalent permeability of cracked porous media has a great interest in geotechnical and petroleum engineering. In such media, the matrix is permeable and the presence of the cracks, which are usually more permeable than the matrix, creates preferential paths for water flow. When the cracks density is below the percolation threshold, the equivalent permeability of the cracked porous material is a function of the matrix permeability, crack density and transmissivity and the statistical distribution of length and orientation of the cracks. Pouya and Courtois (2002) and Pouya (2005) showed that the equivalent permeability tensor of a fractured media is symmetric and positive-definite. They proposed a rigorous method for determining the mean flux and the mean pressure gradient from pressure and flux values on the boundary of the media. Based on closed-from and semi-analytical solutions for the problem of a single crack in an infinite porous body, Pouya and Ghabezloo (2010) presented closed-form estimations of the equivalent permeability of cracked porous media with weak crack density, derived from a self-consistent upscaling scheme. To evaluate the equivalent permeability of a cracked porous media with higher cracks density, a 2D finite element program is developed for solving the equations of fluid transfer in a double porosity medium. A four-node zero-thickness joint element is integrated into the program for modelling of the cracks. The statistical distribution is limited to randomly oriented cracks for which the equivalent permeability is isotropic. The numerical simulations are performed for geometries with different cracks densities and for different values of matrix permeability and cracks conductivity, but the cracks length are taken equal to one. The method used for determination of the equivalent permeability resulted in a perfectly symmetric equivalent permeability tensor for each case. Based on the obtained results a simple relation is presented for the equivalent permeability of a randomly cracked porous media as a function of the matrix permeability and the cracks density and conductivity. This relation is then generalized for the cracks of any length using a linear transformation.

References

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