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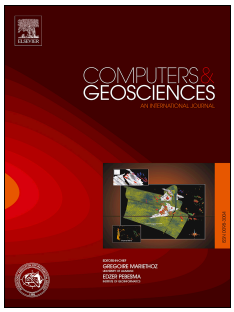

Intersection statistics and percolation criteria for fractures of mixed shapes and sizes

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Intersection statistics and percolation criteria for fractures of mixed shapes and sizes

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Abstract

A model that has been widely applied to fractured rock comprises randomly distributed and oriented plates. Formulae are given for the intersection statistics of infinite systems of such plates of mixed shapes and sizes with lines, planes and each other; the results are expressed in terms of the number density, n, and of the average area $\langle A \rangle$ and perimeter $\langle P \rangle$ of the plates. From Monte-Carlo studies it has been found that a mixture of elliptical plates, each of area A and perimeter P, at the dimensionless density $\rho = \langle A^k P^{3-2k} \rangle \, n$ with $k = 0.774$ is approximately invariant at the percolation threshold with a critical value of about $\rho_c = 8.2 \pm 0.2$ for aspect ratios up to 16. The same result is found to apply to any mixture of convex plate shapes and sizes provided that for each plate A and P are replaced by the area and perimeter of an ellipse with the same aspect ratio and product AP. The results should be of particular value in the interpretation of observed fracture statistics and in the construction of discrete fracture network models.

Keywords: fracture; percolation; intersections; continuum model; ellipse; mixture.

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