Interaction between a percolation network and a cubic cavity

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The intersection between a percolating network of fractures modeled as polygons and a cubic cavity is important for the safe storage of wastes in a fractured medium. The cavities where the wastes are stored should not intersect the percolating network of fractures which may exist, or these cavities should not enable a fracture network to percolate.

The fractures are hexagons inscribed in a circle of radius R which are uniformly distributed in space and isotropically oriented. \(N_{\text{fr}}\) is the number of fractures generated in a finite unit cell \(\Omega\) of size \(L^3\). The fracture density is conveniently represented by the dimensionless density \(\rho'\) which is the average number of intersections per fracture with the other fractures [1].

In addition, a cubic cavity \(C\) formed by six squares inscribed in a circle of radius \(R_s\) is randomly located in \(\Omega\).

\(N\) spatially periodic networks are generated. Generally, \(N\) is equal to 500. Among these \(N\) networks, \(N_p\) percolate and the cavity intersects one or more fractures in \(N_{\text{rc}}\) realizations; no fracture-cavity intersection occurs in \(N_{\text{nrc}}\) realizations.

Moreover, when the network alone does not percolate (which occurs in \(N_{\text{np}}\) realisations), the set composed by the hexagons and the cavity percolates \(N_{\text{npc}}\) times.

These quantities and the corresponding probabilities were systematically calculated as functions of \(L' = L/R, R'_s = R_s/R\) and \(\rho'\). An important quantity is the conditional probability \(P_{i,c}\) that the percolating cluster intersects the cavity when it exists. It could be extrapolated to an infinite cell size \(L'\). This conditional probability is an increasing function of \(\rho'\) and of \(R'_s\).

The probability \(P_i\) that an object \(X\) intersects the fracture network with the density \(\rho\) is given by the expression \(P_i=1-\exp(-\rho V)\) where \(V\) is the excluded volume for the object \(X\) and a fracture. This quantity is obtained for a cube.

This prediction is in good agreement with the conditional probability \(P_{i,c}\) for large \(\rho'\) or small \(R_s\). However, \(P_i\) and \(P_{i,c}\) are not totally comparable because \(P_i\) is the probability for the intersection with the whole network and not with the percolation cluster only.

Additional data will be presented and discussed.