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The hydraulic conductivity of shaped fractures with permeable walls[1] DAIHUI LU, IVAN C. CHRISTOV, School of Mechanical Engineering, Purdue University, West Lafayette, Indiana, 47907 — We derive the hydraulic conductivity K, i.e., the proportionally constant between the width-averaged velocity field and the pressure gradient in Darcy's law, for shaped fractures with permeable walls. As a model, we study a tapered Hele-Shaw cell, with a width gradient $dh/dx = \alpha$ in the flow direction, and porous boundaries. The permeable walls are treated using the Beavers–Joseph slip boundary condition. Using lubrication theory, we obtain K, accounting for geometric non-uniformity and leakage into the bounding surfaces. The approach is perturbative, giving both the leading-order term (independent of the Reynolds number Re) and the first correction in Re. Thus, our theory gives K in terms of hydraulic parameters such as Re, geometric parameters such as the fracture's width $h(x)$ and α, and the dimensionless slip coefficient ϕ at the porous walls. Previous research has not addressed the joint dependence on Re and α. Specifically, our calculations show that, quantitatively, Re has a comparable effect to ϕ on the value of K, for $\alpha \neq 0$. Finally, we use the open-source computational fluid dynamics software, OpenFOAM, to perform 3D direct numerical simulations to benchmark and verify our mathematical predictions.

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Ivan C. Christov
Purdue University

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