Analytical solution for the poroelastic responses in pulse decay permeability tests

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The pulse decay method has been widely used for the permeability measurement for the low permeable rocks. In existing studies, the poroelastic coupled responses caused by the sudden pore pressure change have been discussed only by numerical simulations such as finite element method because an analytical solution was not known. In this study, an analytical solution for the poroelastic coupled equations in the Laplace-space is obtained by the method of separation of variable. The pore pressure distribution in the rock sample is expressed with the superposition of products of hyperbolic functions with respect to z-coordinate and Dini series with respect to r-coordinate, products of Fourier series with respect to z-coordinate and modified Bessel function with respect to r-coordinate, a linear function with respect to z-coordinate. All the integral constants are determined by boundary conditions in the laboratory test. The time-domain solution can be stably calculated by Stehfest's algorithm and the characteristics of coupled responses are demonstrated.

The obtained analytical solution is expected to contribute to the validation of numerical codes as well as the evaluation of experimental results.