Effective viscoelastic rheology for fluid-saturated porous media

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Abstract

This work presents a poroelastic multiphasic model employed to describe the propagation of waves in partially frozen materials subject to freezing and thawing.

The coupled motion of a fluid phase and an elastic frame is assumed to obey Biot's equations of motion describing the displacements of the two phases under a given external excitation.

The phase velocities and attenuation coefficients of the bulk material are functions of the amount of unfrozen water, which is determined using the Kelvin model. On the other hand, the bulk and shear moduli of the ice-crystal porous matrix are obtained employing a percolation model of ice formation.

The differential model determined in this fashion is discretized for the 2D case using a Galerkin finite element procedure formulated in the space-frequency domain. For each frequency, we solve the algebraic problem associated with a Helmholtz-like bounday value problem giving the behavior of the multiphasic material at that frequency.

The numerical experiments show the the application of the finite element procedure to simulate the propagation of ultrasound waves in partially frozen orange juice.

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