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ELASTO-DYNAMIC BEHAVIOR OF A 2D SQUARE LATTICE WITH ENTRAINED FLUID

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The objective of this paper is to investigate numerically elastic wave propagation in a cellular solid with a closed-cell configuration and entrained fluid. Cellular solids are different from porous media and are distinguished by their relative density ρ^*. Cellular solids are characterized by $\rho^* < 0.3$, whereas porous media are determined by $0.3 < \rho^* < 1$. The distinction is phenomenological and is based on the applicability of beam theory to describe the microstructure [1]. In addition to Bragg scattering from wavelengths comparable to characteristic size of the unit cell, resonance of lattice components can be a strong source of dispersion of specific waves that propagate in the medium. We show that resonances of internal members have significant effects on the propagation of waves in cellular solids, whereas in porous medium Bragg scattering is dominant.

We consider a medium composed of a solid matrix or skeleton bounding fluid-filled pores, where size the of each pore is assumed to be equal, and is determined by the porosity– the ratio of pore volume to total volume. As the porosity approaches unity, the porous medium transforms into a cellular solid with slender internal components and associated changes in the source of waves dispersion. Moreover for cellular solids, the solid matrix should not be considered rigid with respect to pores, as the dynamics of both phases interact. These conditions prove more difficult to describe with dynamic models for pores alone, and are modeled by Biot's theory instead [2, 3]. This theory is derived from a strain-energy functional defined at the macroscale, based on averaged microstructural quantities. Nevertheless Biot's theory requires mechanical properties of the solid matrix for both drained and undrained conditions, which are often not available analytically, in addition to a induced-mass effects.

In this session we employ a periodic 2D-square lattice as a prototypical two-phase medium whose mechanical properties are available [4] for both drained and undrained conditions . We explore the applicability of Biot's theory for low relative density cellular solids by using a numerical model which explicitly accounts fluid-structure interaction in a representative-volume element [5]. We propose homogenized models for equivalent-continuum behavior, based on microstructural deformations. We will also demonstrate that resonant scattering is associated with resonances of pores, skeleton, and the combination of the two. The propagation of longitudinal waves, moreover, is determined by three deformation mechanisms of the skeleton: bending, through-the-thickness deformations, and hybrid modes. Finally, we discuss physical mechanisms that lead to the slow pressure wave (the second of the possible longitudinal wavemodes) in agreement with Biot's theory, albeit this appears beyond the first resonant frequency of the skeleton members.

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