Application of a homogenization method for poro-elastic media for sound absorption

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In this study, a homogenization approach based on the method of asymptotic expansions is extended to poro-elastic sound-absorbing media. Poro-elastic material is two-phase material and has the fluid phase saturated by air and the solid phase that is composed of elastic material.

Sound energy is absorbed within the material by viscous dissipation in the vicinity of the boundary between the solid and fluid phase, thermal dissipation from the fluid phase to the solid phase, and structural damping of linear elastic material which the solid phase is composed of.

As fundamental governing equations, linearized Navier-Stokes equation, Fourier's law for thermal conduction, mass conservation, and gas state equation are applied. The coupled effects between the elastic solid and the fluid pressure, and the temperature and the fluid pressure are also considered.

By solving boundary value problems in microscopic scale and averaging over a unit cell, the macroscopic properties, equivalent density and bulk modulus for the fluid phase and equivalent elastic tensor for the solid phase are derived.

To verify the proposed method, calculated sound absorption coefficients, which are one of the typical macroscopic physical properties, are compared with those obtained by analytical approach and by measurement using periodic porous material made by 3D printer.