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A homogenization approach for effective drained viscoelastic properties of 2D porous media and an application for cortical bone

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Abstract:

Closed-form solutions for effective rheological properties of a 2D viscoelastic drained porous medium made of a Generalized Maxwell viscoelastic matrix and pore inclusions are developed and applied for cortical bone. The in-plane (transverse) effective viscoelastic bulk and shear moduli, of the Generalized Maxwell rheology of the homogenized medium, are expressed as functions of the porosity and the viscoelastic properties of the solid phase. When deriving these functions, the classical inverse Laplace-Carson transformation technique is avoided, due to its complexity, by considering the short and long terms approximations. The approximated results are validated against exact solutions obtained from the inverse Laplace-Carson transform for a simple configuration when the later is available. An application for cortical bone with assumption of circular pore in the transverse plane shows that the proposed approximation fit very well with experimental data.

Keywords:

cortical bone; viscoelastic; porous materials; homogenization; Generalized Maxwell; inverse Laplace-Carson transform

1. Introduction

Natural and man-made materials such as cement, concrete, bone, rock, polymers, etc exhibit time dependent mechanical behaviors (creep or relaxation), i.e. their mechanical moduli evolve during time (Bazant and Prasannan, 1989; Bernard et al., 2003; Sasaki et al., 1993; Scholz, 1968). The nature of time dependent properties is believed to be due to the sliding of the internal interfaces at nano-scale and the diffusion of fluid through the pore network (Vandamme and Ulm, 2009; Eberhardsteiner et al., 2014). Studying the time