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Overall viscoelastic properties of 2D and two-phase periodic composites constituted of elliptical and rectangular heterogeneities

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Abstract

This paper presents analytical solutions for the effective rheological viscoelastic properties of 2D periodic structures. The solutions, based on Fourier series analysis, are derived first in the Laplace-Carson (LC) space for different inclusion shapes (rectangle or ellipse) and arrangements. The effective results are obtained in the form of rational functions of the LC transform variable. Two inversion methods are used to find the relaxation behavior. The first one is based on the exact inverse of the LC transform while the second approximates the overall behavior by using a Standard Linear Solid model, which yields very simple analytical formulas for the coefficients entering the constitutive equations. Results of the two methods are compared in the case of an application to real materials.

Keywords: anisotropic viscoelasticity; homogenization; Laplace-Carson transform; 2D periodic structure; Fourier analysis.

1. Introduction

Viscoelasticity is a class of mechanical models that can describe effectively the time dependent behaviors of many materials like cement, concrete, polymer, glass or biomaterials, to name a few. At constant loading, those materials are deformed with time (creep) and vice versa, at constant strain, the internal stress changes with time (relaxation). These phenomena are more pronounced under high temperature conditions. Moreover, most materials are heterogeneous in nature, i.e. they are mixtures of ingredients of different characteristics, shapes and sizes. Materials that are both heterogeneous and viscoelastic are numerous, for