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Finite-Volume Homogenization of Elastic/Viscoelastic Periodic Materials

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Abstract

In this contribution, the three-dimensional (3D) finite-volume direct averaging micromechanics (FVDAM) is reconstructed by incorporating parametric mapping capability into the theory's analytical framework, which allows using arbitrarily shaped and oriented hexahedral subvolumes in the material microstructure discretization. The technique is then further extended to include linear viscoelastic capability to investigate the creep and relaxation behavior of polymeric matrix composites and stress field evolution with either continuous or discontinuous reinforcements. Elastic-viscoelastic correspondence principle is employed in the unit cell solution to relate the governing relations between time domain and Laplace-Carson domain. After establishing the homogenized constitutive equations and solving the boundary value problems in Laplace-Carson domain, Zakian inversion scheme is used to invert the inexplicit homogenization functions to obtain both relaxation moduli and stress distributions during a relaxation history in real space. The FVDAM theory via correspondence principle is validated extensively by comparing with Mori-Tanaka, finite-element, locally exact solutions and experimental data. Good agreement between the present theory and other methods, along with a few numerical investigations, explains not only the accuracy of the 3D parametric FVDAM but also the validity and efficiency of the correspondence principle and Zakian inversion technique.