Homogenized descriptions for elasto-(visco)plastic composites based on a linear viscoelastic comparison composite

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This work reports new homogenized descriptions for two-phase elastoplastic composites under complex loadings. The matrix response is characterized by archetypical elastoplastic relations with rate-dependent isotropic and kinematic hardening, while the inclusions are elastic. The macroscopic response is characterized by the effective free-energy density and dissipation potential in terms of the macroscopic deformation of the composite and the microscopic plastic deformation field within it. Two approximations are then performed in the context of an incremental variational principle governing plastic flow in accordance with these effective potentials [1]. The first approximation relies on a variational linearization which produces an alternative functional containing secant moduli of the nonlinear constitutive relations evaluated at the second moments of the pertinent mechanical fields within the matrix phase [2]; as such, it characterizes the viscous flow of a viscoelastic linear-comparison composite (VLCC) with the same microstructure as the elastoplastic composite. The second approximation consists in the estimation of this linear-comparison functional with effective potentials of the Hashin-Shtrikman type recently derived by means of the Correspondence Principle [3]. Crucially, these potentials depend on a finite number of effective internal variables characterizing the inelastic state of the composite. Unlike previous descriptions based on the intraphase uniformization of plastic deformations advocated in [1], this description is found to produce cyclic stress-strain curves with the expected shape, consistent with bounds, and free of spurious transients. The descriptions can be regarded as an extension of those proposed in [4] to composites with more complex rheologies allowing for plastic hardening.

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