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TOWARDS MEAN-FIELD POTENTIALS FOR ELASTOPLASTIC COMPOSITES

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Abstract. More often than not, mean-field descriptions for random composites neglect microscopic interactions between elastic and plastic processes. They do so by homogenizing purely elastic and purely plastic deformations separately to compound them additively. While appealing simplifications in the structure of macroscopic constitutive relations naturally ensue, discomforting complications in accompanying aspects of the descriptions unfortunately arise; macroscopic strain hardening and microscopic residual stresses being sensitive examples. When cast within the framework of generalized standard materials with internal variables, the problem is to seek approximate mean-field potentials based on reduced sets of effective internal variables that provide a partial but hopefully accurate characterization of the evolving microscopic state of the composite and that, at the same time, comply with the generalized standard structure. One of the simplest approximations compatible with this line of thinking consists in assuming intraphase plastic homogeneity and then identifying effective internal variables with the plastic deformation within each constituent phase. Experience has recurrently shown, however, that intraphase plastic heterogeneity is an ineludible ingredient of any worthy approximation. Against this state of affairs, a formalism leading to mean-field potentials for random composites that account for elastic and plastic deformations concomitantly is elaborated. For simplicity, multi-phase composites are considered broadly but only two-phase composites are considered thoroughly. Deformations within constituent phases are described by archetypical potentials for rate-dependent elastoplasticity with combined isotropic and kinematical hardening. Plastic deformation fields are then additively decomposed into irrotational and solenoidal fields in such a way that variational approximations available for purely elastic and purely plastic potentials become applicative to elastoplastic potentials. The resulting mean-field potentials exhibit a generalized standard structure with a finite set of effective internal variables containing the phase averages of the irrotational and solenoidal fields. Crucially, these potentials are sensitive to intraphase plastic heterogeneities. Illustrative results for particulate composites with isotropic phases are presented to highlight the role of these effective internal variables in elastoplastic transitions and residual stresses.

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