NONLOCAL ELASTICITY FOR MATERIALS WITH MULTISCALE DAMAGES

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The concept of nonlocality is essential in investigating the size effects on material strength and the spatial correlation of the macroscopic quantities. In this work, a multiscale nonlocal model is developed in order to predict the behavior of materials with particles which are recognized at different levels of resolution. Nonlocal interactions between particles are considered in terms of the two-point potential of energy as in the Eringen's model, yet the concept of the potential is generalized for the multiscale case. In the framework of thermodynamics, the free energy is assumed to be contributed by particle-particle interactions at both mesoscale and microscale, and between the scales. The introduction of nonlocalities at the macroscale and the mesoscale enables ones to describe the two behaviors simultaneously. The macroscale nonlocality describes the spatial correlation of the global response, while the meso-macro-scale nonlocality personalizes the behavior of mesoscale particles that is implicit at the macroscale level. Consequently, the constitutive equations are derived following the nonlocal Gibbsian arguments. The attenuation functions for state variables at the macroscale and the mesocale are obtained by their sub-scale interactions, respectively. The boundary value problem is represented by coupled differential-integral equations and the numerical solution procedure is discussed.

The theory is exemplified by considering materials with multiple damage mechanisms. In this problem, the nonlocality of macroscopic variables is enhanced by interactions between the mesoscale cracks. The opening of cracks is determined by the surrounding stress level and the distribution of dislocations near the crack tips. Therefore the state of a crack is further nonlocalized by the interaction between the crack tip and its vicinity.

References

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