On Regularized Models Leading to Full Localization at Incomplete Damage

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ABSTRACT

Regularized formulations of constitutive models with softening aim at an objective description of localized failure. The minimal goal is to correctly capture the global response characteristics by eliminating spurious sensitivity to the size of finite elements. Ideally, one would also like to describe local features such as the thickness of a localized band, or the distribution of strain and internal variables across this band.

It is widely accepted that the initial thickness of the localized process zone is related to a certain characteristic length of the material, dictated by the size and spacing of major heterogeneities in the microstructure. However, for many materials, the initially formed process zone gets thinner as microdefects grow and coalesce. Eventually, a fully localized failure pattern may develop. Proper description of the transition from a localized band of finite thickness to a fully localized fracture pattern still remains a challenge.

The present study is focused on localization analysis of selected regularized models that exhibit a somewhat unusual type of behavior. After the formation of a localized band of a finite thickness, the active part of the band in which dissipative processes occur gets progressively thinner and, when a critical state is attained, failure localizes into a surface of zero thickness. The peculiar feature is that this happens before the damage process is complete, i.e., at damage levels below the value that corresponds to a full disintegration of the material.

Localization behavior of the special type described above has been detected for a certain formulation of a micromorphic damage model [1], which can be derived in a variational setting. Localization properties of this model will be analyzed in detail and the role of two independent characteristic lengths that control the behavior will be revealed. Moreover, two other regularized formulations that exhibit qualitatively a similar behavior will be presented. Both of them are special variants of the integral-type nonlocal damage approach. One of these formulations is inspired by the modification of the nonlocal averaging scheme originally proposed in [2] for treatment of averaging near boundaries, and the other is the so-called eikonal nonlocal damage model [3] with the weight of nonlocal interaction affected by damage between the interacting points.

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