Multi-scale modelling of fibre enforced composite with non-local damage variable

L. Wu*, L. Noels*, L. Adam† and I. Doghri†+

* University of Liège – CM3
B52, Liège, Belgium
e-mail: L.Wu,L.Noels@ulg.ac.be

† e-Xstream Engineering
Rue du Bosquet, 7, 1348 Louvain-la-Neuve, Belgium
Email: laurent.adam@e-xstream.com - Web page: http://www.e-xstream.com

+ Université Catholique de Louvain
Bâtiment Euler, 1348 Louvain-la-Neuve, Belgium
Email: issam.doghri@uclouvain.be

Classical finite element simulations face the problems of losing uniqueness and strain localization when the strain softening of materials is involved. Thus, when using continuum damage model or plasticity softening model, numerical convergence will not be obtained with the refinement of the finite element discretization when strain localization occurs.

Gradient-enhanced softening and non-local continua models have been proposed by several researchers in order to solve this problem. In such approaches, the spatial gradients of state variables are incorporated in the macroscopic constitutive equation [1, 2]. However, when dealing with complex heterogeneous materials, a direct simulation of the macroscopic structures is unreachable, motivating the development of non-local homogenization schemes [3].

In our work, a gradient-enhanced homogenization procedure is proposed for fiber reinforced materials. In the approach, the fiber is assumed to remain linear elastic while the matrix material is modeled as elasto-plastic [4] coupled with damage and is described by a non-local constitutive model [5]. Toward this end, the mean-field homogenization is based on the knowledge of the macroscopic deformation tensors, internal variables and their gradients, which are applied to a micro-structural representative volume element (RVE). Macro-stress is then obtained from a homogenization process.

This procedure is applied to simulate damage process occurring in unidirectional carbon-fiber reinforced epoxy composites submitted to different loading histories.

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