A Non-Local Damage-Enhanced Incremental-Secant Mean-Field-Homogenization For Composite Laminate Failure Predictions

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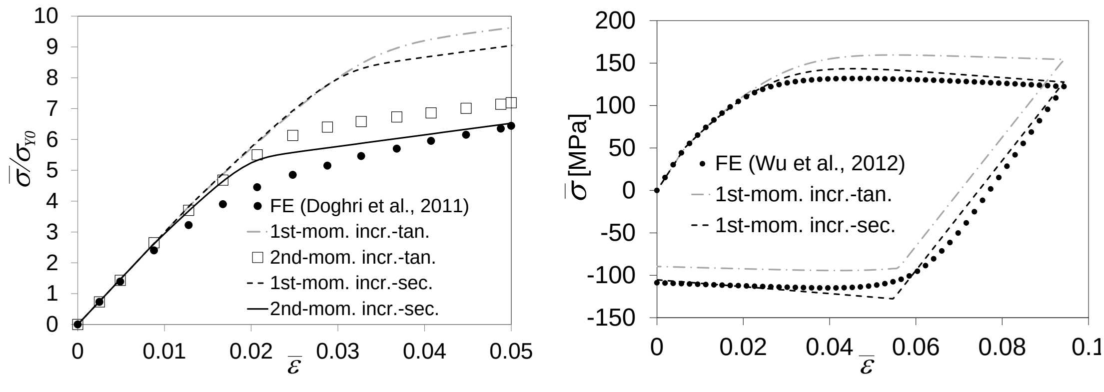
ABSTRACT

Recently, the authors have presented an incremental-secant mean-field homogenisation (MFH) process for non-linear composite materials [4]. In this formulation, a virtual elastic unloading is applied to evaluate the virtual residual stress and strain states reached in each elasto-plastic phase. These virtual states are then used as a starting point to apply a secant homogenization method. This incremental-secant MFH process can handle non-proportional and non-monotonic loadings, and naturally possesses an isotropic instantaneous stiffness operator to be used in the Eshelby tensor.



(a) elasto-plastic GFRP

(b) UD-reinforced damage-enhanced elasto-plastic matrix

Figure 1: Predictions comparison with the incremental-tangent and incremental-scant MFH schemes. (a) In the case of short-glass fiber reinforced polyamide (GFRP). Reproduced from [6]. (b) In the case of uni-directional (UD)-reinforced damage-enhanced elasto-plastic matrix. Reproduced from [5].

This incremental-secant MFH homogenization can account for the first and second statistical moment estimation of the current yield stress in the composite phases during the computation of the plastic flow. When accounting for a second statistical moment estimation, the plastic yield in the composite material phases is captured with a higher accuracy, improving the predictions, mainly in the case of short fiber composite materials [6], see Fig. 1(a).

The incremental MFH can handle material softening when extended to include a damage model. Indeed, as the secant formulation is applied from an unloaded state, the inclusion phase can be elastically unloaded during the softening of the matrix phase, contrarily to the case of the incremental-tangent method [3, 5], see Fig. 1(b). Moreover, when formulating the damage model in the composite phases in a non-local way, as with the non-local implicit approach, [1, 2], the MFH scheme can be used to model strain localization in composite structures [5], without suffering from the loss of the solution uniqueness.

Acknowledgement. The research has been funded by the Walloon Region under the agreement SIMUCOMP n^{o} 1017232 (CT-EUC 2010-10-12) in the context of the ERA-NET +, Matera + framework, and by the F. R. S. - F. N. R. S. under the project number T.1015.14.

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