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Twoscale Simulation of Damage Evolution in Composite Structures

*** Matzenmiller, A.[1], Köster, B. [1]**

[1] University of Kassel Institute of Mechanics, Numerical Methods Group
Mönchebergstrasse 7, D-34125 Kassel,Germany
amat@ifm.maschinenbau.uni-kassel.de

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ABSTRACT

The stress and strain analysis of structures made of heterogeneous composite materials is treated as a twoscale problem, defined as a mechanical investigation on different length scales. Reinforced composites show by definition a heterogeneous texture on the microlevel determined by the constitutive behaviour of the matrix material and the embedded fibres as well as the characteristics of the bonding. All these heterogeneities are neglected by the finite element analysis of structural elements on the macroscale, since a ficticious and homogeneous continuum with averaged properties is assumed. Therefore, the constitutive equations of the substitute material should well reflect the mechanical behaviour of the existing composite in an average sense. The evolution of the non-isotropic damage within the different layers of laminated structures is microscopically caused by void nucleations like the debonding of the embedded fibres, the growth of microcracks inside the matrix phase or the breakage of the fibres. Since the development of damage depends on the local loading history, the effective tangential stiffness tensor varies in time for different material points on the macroscale. The analysis of composite structures is executed by applying a twoscale approach. The average material properties, needed for the macroscale finite element simulations, are obtained by modelling the discontinuous and damaged microstructure based on the concept of the representative volume element. The *Generalized Method of Cells* (GMC) is used in order to discretise the representative volume element and to compute the process depending tangential constitutive tensor as well as the average stress response in a closed form manner for each integration point individually.The numerical efficiency of the GMC approach allows for the simultaneous twoscale simulation of engineering composite structures, which is hardly feasible with micromechanical models based on the finite element technique.

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