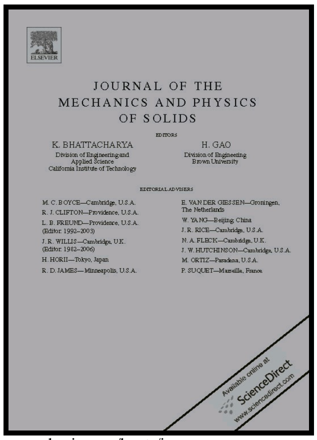

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Homogenization of long fiber reinforced composites including fiber bending effects

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Abstract

This paper presents a homogenization method, which accounts for intrinsic size effects related to the fiber diameter in long fiber reinforced composite materials with two independent constitutive models for the matrix and fiber materials. A new choice of internal kinematic variables allows to maintain the kinematics of the two material phases independent from the assumed constitutive models, so that stress-deformation relationships, can be expressed in the framework of hyper-elasticity and hyper-elastoplasticity for the fiber and the matrix materials respectively. The bending stiffness of the reinforcing fibers is captured by higher order strain terms, resulting in an accurate representation of the micro-mechanical behavior of the composite. Numerical examples show that the accuracy of the proposed model is very close to a non-homogenized finite-element model with an explicit discretization of the matrix and the fibers.

Keywords: long fiber reinforced composites, strain gradient, anisotropic plasticity, finite-element, large deformation, homogenization.

1 Introduction

The extensive use of long fiber reinforced materials, especially in lightweight mechanical constructions, has motivated intensive research efforts in the past decades, especially regarding the understanding of failure mechanisms and the prediction of mechanical strength limits. In particular, the case of failure under compressive loads has received special attention due to its vast practical importance. In this context, both experimental studies and analytical or numerical models, like e.g. in [1, 2, 3, 4, 5, 6], have contributed to the understanding and quantification of kink band formation and fiber micro-buckling phenomena.

Regarding the numerical modeling of long fiber reinforced composites, there are two main categories of models that can be found in the literature. Individual fiber models rely on an explicit discretization of the matrix and the reinforcing fiber materials by means of a corresponding finite element mesh. The accuracy of this approach, followed for instance in [2, 7, 8], in representing the real micro-mechanical behavior of a composite material is determined rather by the quality of the available material parameters than by any modeling simplifications. However, an explicit discretization of

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