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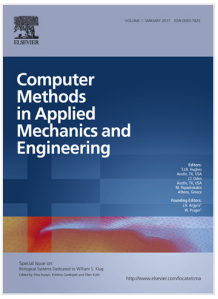

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A multi-field finite element approach for the modelling of fibre-reinforced composites with fibre-bending stiffness

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Abstract

The implementation of an enhanced modelling approach for fibre-reinforced composites is presented which may, in addition to the directional dependency induced by the fibres, allow the capturing of the fibre-bending stiffness. The theoretical framework is based on the introduction of higher-order gradients of the motion function as additional arguments of the energy function such that size effects can be taken into account. However, the application of higher-order gradients within a finite element framework requires particular care with respect to continuity requirements. In this contribution the usage of a mixed-type multi-field finite element formulation and the fulfilment of the continuity requirement only in a weak sense is proposed. Based on a particular specification of the energy function representative boundary value problems are discussed to assess the model's properties. It is then shown that a model which is based on one additional invariant compared to the classic structural tensor approach allows, in principle, to incorporate effects which are due to the fibre-bending stiffness.

Keywords: fibre-reinforced composites, fibre-bending stiffness, size effect, generalised continuum, multi-field finite element approach

1. Introduction

Due to their outstanding properties, fibre-reinforced composites are important for various areas of today's engineering applications, [1, 2, 3, 4, 5], and intense research is focussed on the development of new high-performance composites, [6, 7]. For composite materials with enhanced properties, it furthermore becomes increasingly important to provide material models which allow for an accurate simulation of their mechanical behaviour. In this context, the present contribution is focussed on the development of a computational framework for an enhanced modelling approach for fibre-reinforced composites including fibre-bending stiffness which is directly based on the modelling framework proposed in [8].

Besides taking the gradient of the deformation into account, the classical approach for the modelling of fibre-reinforced composites presented in [9] considers the fibre-direction as an additional argument of the energy function. By doing so, the energy function which was originally an anisotropic function of the deformation can be rewritten as an isotropic function in

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