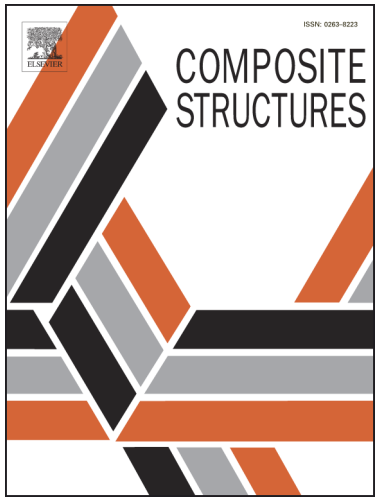

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A nonlinear finite element formulation for large deflection analysis of 2D composite structures

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Abstract

In this paper, we propose a finite element formulation based on a total Lagrangian approach to analyze two-dimensional (2D) fiber reinforced elastic solids undergoing large displacements. It allows the consideration of discrete short or long fibers embedded in a continuum matrix and the obtained system of equations size is equivalent to that of a non-reinforced medium. The matrix domain is discretized with four-node quadrilateral membrane elements while fibers crossing each matrix element are automatically detected and represented by two-node truss elements. A perfect bonding of fibers to the matrix is assumed and a projection technique is used to express the truss elements variables in terms of their corresponding matrix elements. Five nonlinear examples are presented to validate and demonstrate the capabilities of the proposed finite element formulation.

Keywords: 2D fiber reinforced composites, Geometric nonlinearity, Finite element analysis

1. Introduction

The applications of fiber reinforced composites have been rapidly increasing in lightweight engineering structures thanks to their interesting specific strength, low thermal conductivity, high corrosion and wear resistance in addition to the development of new manufacturing technologies and processes. To expand the use of composite materials, an accurate characterization of their macroscopic and ultimate properties is required. To this end, several analytical methods have been proposed in the literature to estimate the mechanical and thermal properties of composite materials. Among all the theoretical methods, the well known rule of mixtures law presents the simplest mathematical relations. Other more accurate micromechanics models based on the definition of a representative volume element (RVE) of the composite material have been also proposed. These include, among others, the concentric cylinder assemblage model proposed by Hashin and Rosen [5] for unidirectional continuous fiber composites, the method of cells introduced by Aboudi [2], the self-consistent method originally applied to unidirectional composites by Hill [6] and finally, the Mori-Tanaka method proposed by Mori and Tanaka [10].

The previously cited analytical methods provide reasonable prediction of the composite materials properties for simple configurations of the matrix and the reinforcement [11]. For complicated geometries, loading conditions and material properties, it is not straightforward to obtain analytical predictions of the composite materials properties. This is the reason why some numerical methods have been also proposed to obtain

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