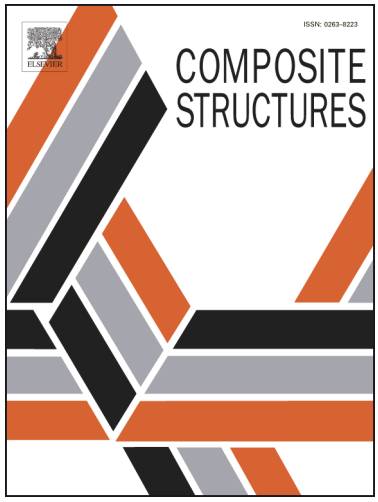

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Characterisation of composite elastic properties by means of a multi-scale two-level inverse approach

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Abstract

This work deals with the problem of characterising the elastic properties of a composite material at both mesoscopic (ply-level) and microscopic (constitutive phases-level) scales. This goal is attained by means of an adequate multi-scale identification strategy (MSIS) which aims at identifying the constitutive properties, at each relevant scale, by exploiting the information restrained in the macroscopic dynamic response of the composite. In this background, the multi-scale identification problem is split into two interdependent sub-problems which are stated, at both levels, as constrained minimisation inverse problems. At the first level the goal is the characterisation of the lamina properties by minimising the distance between the numerical and the reference harmonic responses of the composite. The second level problem aims at identifying the elastic properties of both fibre and matrix by minimising the distance between the effective elastic properties evaluated through a homogenisation process and those provided by the first-level inverse problem. The MSIS is based on a special global hybrid optimisation tool and on the strain energy homogenisation method of periodic media. Its effectiveness is proven through a meaningful benchmark.

Keywords: Composite material, Homogenisation, Optimisation, Harmonic analysis, Inverse problems, Identification

1. Introduction

Nowadays, composite materials are widely used in several fields, from automotive applications to aerospace ones. This is mainly due to their high stiffness/mass and strength/mass ratios when compared to steel or aluminium alloys. Furthermore, engineers are continuously looking for strategies that allow increasing performances, building integrated and lighter structures, designing complex geometry and providing stiffness and strength where needed.

Nevertheless, in order to properly conceive complex and optimised solutions, it is mandatory to characterise the full set of the composite material properties at each pertinent scale. One of the main issues of composite materials is related to the difficulty of characterising the full set of elastic properties at the lower scales, i.e. microscopic (that of the constitutive phases) and mesoscopic (the lamina level) ones.

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