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GLOBAL HYBRID STRATEGY FOR MULTI-SCALE CHARACTERIZATION OF COMPOSITE MATERIAL PROPERTIES WITH NON-DESTRUCTIVE TESTS

L. Cappelli[1], M. Montemurro[1,*], F. Dau[1] and L. Guillaumat[2]

[1] Arts et Métiers ParisTech, I2M CNRS UMR 5295, F-33405 Talence cedex, France
[2] Laboratoire angevin de mécanique, procédés et innovation (LAMPA) - Arts et Métiers ParisTech - 2, boulevard du Ronceray, 49035 Angers Cédex 01, France
[*] Corresponding author: marco.montemurro@ensam.eu

One of the main issues of composite materials is related to the difficulty of characterizing the full set of material properties at both mesoscopic and microscopic scales.
Indeed, classical mechanical tests (traction/compression, 3 and 4 points bending tests, etc.) are not able to provide the full set of 3D material properties of composites. Furthermore, these tests can usually provide only the in-plane elastic properties of the constitutive lamina (i.e. at. the mesoscopic scale). Therefore, to go beyond the main restrictions imposed by standard destructive tests, this work deals with the desire of characterizing the material properties of a composite plate, at each characteristic scale, through a single non-destructive dynamic test performed at the macroscopic scale, i.e. that of the specimen.
To face such a problem a general multi-scale identification strategy (MSIS) is proposed.
The MSIS aims at identifying the constitutive properties at both micro and meso-scales by exploiting the information restrained in the laminate macroscopic dynamical response. In this context it is possible to characterize both elastic and viscoelastic micro-scale properties. The MSIS relies on the one hand on the strain energy homogenization technique of periodic media (to get the effective material properties of the lamina as a function of the geometrical and material properties of the microscopic constitutive phases) and on the other hand on a specific hybrid algorithm (genetic + gradient-based algorithm) to perform the solution search for the problem.
The identification problem is stated as a constrained inverse problem (a least-square constrained problem), where the objective function depends upon both the measured (from experiments) and numerical (from FE analysis) dynamic response of the plate.
In order to validate the effectiveness of the MSIS, the measured dynamic response is obtained, in a first time, by using a numerical test conducted on a *reference structure*, to check the robustness and the reliability of the proposed methodology. The optimization variables are both geometrical and material properties of the constitutive phases composing the representative volume element of the composite.
In the end, the effectiveness of the MSIS is then validated through a campaign of experimental/numerical tests conducted on composite laminates.