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GLOBAL AND LOCAL IDENTIFICATION ON COMPOSITE MATERIAL

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ABSTRACT: This work is about a methodology based on global and local identification on composite material.

One of the main challenges in composite design and development is to be able to compute the damage state at any point of a composite structure during a complex loading. In this context, knowledge of the spatial distribution of the material elastic properties provides a quantitative estimation of the damage level and localization. The work presented here intends to access to such distribution through the association of kinematic fields and finite element model updating method. Such iterative technique has many interesting advantages for structural analysis and industrial requirements, including the numerical framework, the ability to explore complex shapes and loads and a treatment based on surface measurement without any assumption on volume distribution [1, 3].

In this study, we propose to identify the local elastic properties of orthotropic carbon-epoxy laminates for aeronautics structures by means of kinematic fields obtained under tensile tests. The aim is to be able to predict the spatial variation of such properties and to deduce the damage effects. For this, we consider the case study of a composite structure including a defect that is modeled by an association of two zones with different material properties (Fig. 1); zone number 2 corresponds here to the “damaged” zone compared with the virgin material of zone 1.

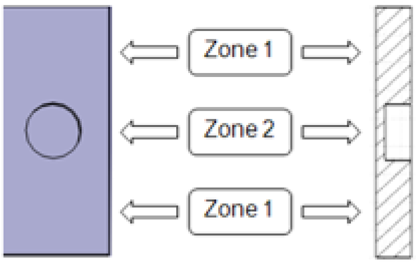

Fig.1 Composite structure with two zones of different material properties

The methodology is based on global and local identification steps by finite element model updating (FEMU) method.

To implement the FEMU technique, a specific algorithm in Python language following the flowchart in figure 2 has been established. A particular attention has been paid to the matching of the kinematic fields grid and numerical one through the determination of neighboring points and interpolation functions. The cost function minimization is based on the Levenberg-Marquardt algorithm.

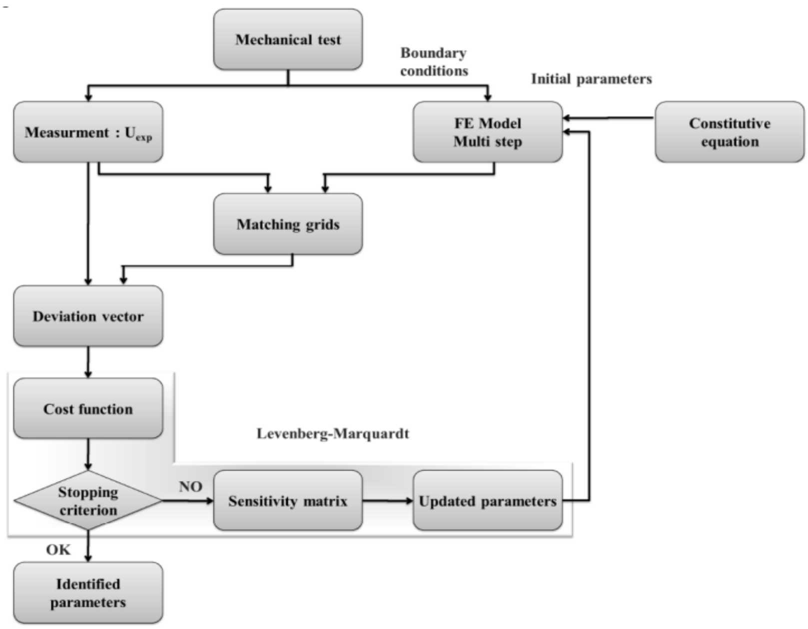

Figure 1: Identification procedure based on FEMU technique [2].

At first, a global identification of material properties is made to determine the constitutive parameters of the virgin material and then, a local identification is realized in order to obtain the damaged material properties. This procedure is illustrated in figure 3.

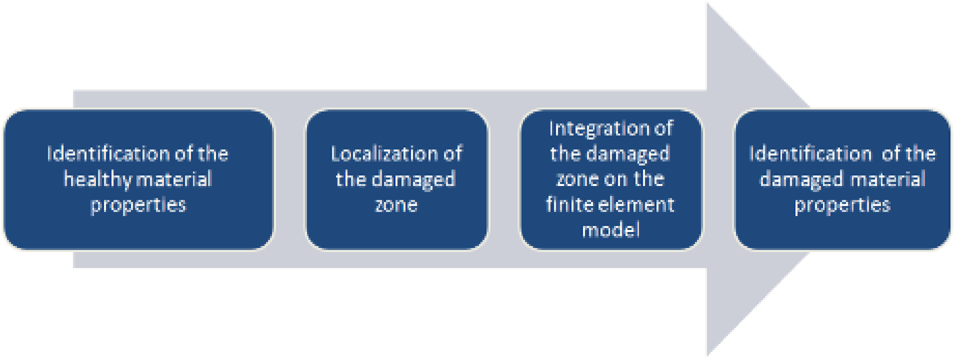

Fig.3 Global and local identification procedure

Regarding the first step, an open-hole tensile test is used to identify the in-plane elastic properties of the healthy orthotropic composite structure. Such mechanical solicitation generates an heterogeneous strain field localized near the hole that stimulate the whole strain components [4]. The displacement field measurements on the specimen surface are simulated with Abaqus finite element code as by experimental digital image stereo correlation measurements.

The second step in figure 3 corresponds to the evaluation of the gap between the healthy model derived from constitutive parameters identified at the first step and the response of the damaged structure. The representation of the equivalent strain error map (Fig.4) shows a localized zone with highly different response that corresponds to the part 2 on figure 1. From this, two image processings developed by a specific application in Python language allows to describe precisely the damaged zone outline, which is implemented in the finite element model (step 3 of Fig.3). Furthermore, this step gives the four coordinates of the zone 2 in the main axes of the material. At the end, a local identification is achieved since step 4 in figure 3 is realized with the same procedure as the healthy material identification to access to the properties of the zone 2 of the material.

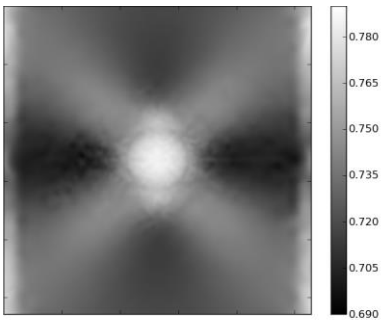

Fig.4 Equivalent strain error map

The capability of the procedure is validated for different configurations of the laminated composite (plies stacking and orientation, components properties).

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