Uncertainty quantification and management in the analysis of a low velocity impact and compression after impact tests using progressive damage models

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The analysis of impact and loading after impact events in composite structures have devoted the attention of the scientific and industrial community for several decades. The virtual test of these kind of events is a hard task due to their dynamic nature and the onset, progression and interaction of different damage mechanisms. Therefore, the methods available require the use complex models with high computational costs associated and several parameters to be defined. Although there are different approaches to reduce the computational cost and/or obtain more efficient simulation methods, the calibration of the parameters required to feed the computational models is in many cases not well defined. The uncertainty associated to their experimental determination depends on many parameters such as the manufacturing process or the experimental setup and/or the data reduction methods used. How the uncertainty associated to the definition of the model parameters is then translated to the numerical predictions have been marginally addressed in the case of impact and loading after impact events.

The objective of this work is to provide an envelope of uncertainty associated to the results accounting for variations on the model parameters. An efficient finite element model based on shell elements of a composite subjected to a low velocity event followed by a compression after impact test has been implemented [1]. The material nonlinearities are captured by using a progressive damage model for intralaminar failure [2] and a cohesive zone model for interlaminar [3]. The uncertainty quantification and management procedure implemented has been done in two steps. First, a sensitivity analysis to determine the model parameters with a higher influence. Then, several simulations changing the model parameters according to a Latin hypercube sampling. The results obtained are used to create a surrogate model which is used in a Montecarlo analysis to provide the mean value and covariance predicted for the total delamination area and the compression after impact strength. The analysis is performed for three different layups configurations. The results obtained are compared with experimental data available.

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[2] Maimí, P., Camanho, P., Mayugo, J., & Dávila, C. (2007). A continuum damage model for composite laminates: Part I - Constitutive model. *Mechanics of Materials, 39*(10), 897-908.

[3] Turon, A., González, E.V., Sarrado, C. , Guillamet, G., & Maimí, P. (2018). Accurate simulation of delamination under mixed-mode loading using a cohesive model with a mode-dependent penalty stiffness. Composite Structures 184, 506–511