Summary

Composite materials show several interacting failure modes whose description and evolution prediction constitute a very complex task. The lack of a proper combination of progressive damage models and nondestructive evaluation techniques results in inefficient designs of composite structures from both cost and safety point of view. In this work, an innovative experimental methodology is proposed and validated for the nondestructive assessment of local elastic properties in composites. The methodology aims at isolating the vibrational response of a planar region of the component by clamping its contour. The mechanical vibrations induced through impulse are thus function of only the elastic characteristics of the inspected region. As a demonstrator of the methodology developed here, a preliminary clamping system, which invokes the use of testing machine equipped with compression blocks, is tested on a unidirectional composite plate. After showing the capability of the setup in isolating the vibrational response, local elastic properties are assessed through an optimization problem based on Finite Element analysis. Robustness of the optimization problem is also addressed. Numerical investigations based on a Rayleigh-Ritz formulation developed here show that the robustness can be increased by retaining information related to the modal shape. The effect of an additional concentrated mass is exploited and only two mass positions, i.e., two measures of the first resonant frequency are sufficient to assess the modal shape. Finally, the assessment of the residual elastic properties in damaged composites is also shown. As observations of any nondestructive evaluation techniques are constrained to the exposed surface, an innovative clamping system was designed which exploited the vacuum technique to clamp the boundaries of the inspected region. Complementarily, a new analytical approach is derived and validated for the assessment of the residual elastic properties of the damaged area.