



# Scientific report

## Resistance and Tolerance Characterization of Impact Damage of Laminate Composite Materials

Francesc Puigvert



## Resistance and Tolerance Characterization of Impact Damage of Laminate Composite Materials

Laminate composite materials offer determinant advantages compared to the most traditional materials, especially in structural applications where weight is a limiting design factor. However, practice demonstrates that laminate composite materials are sensitive to multiple circumstances related to service. Susceptibility to impact damage is one of the most significant disadvantages.

The impact of foreign objects against the aircraft structure may occur during the processes of manufacture, assembly and maintenance operations such as bird strikes or small object impacts may occur during take-off or landing. Low-velocity impacts cause internal damage of laminates resulting in severe reductions of stiffness, strength and structural stability thus originating a collapse for unacceptable load levels. The great interest, motivation and concern caused by this phenomenon in recent years have resulted in intense research work.

A development of new numerical tools based in finite elements formulations has significantly progressed over the last decade offering estimations on the structural degradation state after impact to prevent failure or premature collapse. However, a precise experimental characterization of composite material behavior before, during and after an event of sudden load is an essential requirement to verify and validate numerical methodologies.

In this sense, the research group Laboratory for the Technological Innovation of Structures and Materials, LITEM, of Universitat Politècnica de Catalunya – BarcelonaTech, led by Prof. Dr. Lluís Gil is carrying out a research to experimentally evaluate the resistance and tolerance of impact damage at low-velocity in composite laminates. The methodology and procedure is based on drop-weight impact testing against multi-directional polymer matrix laminates with carbon fiber reinforcement, followed by a campaign testing to evaluate residual stiffness and strength at compression.

A main goal of impact testing is to characterize the propagation of stress waves inducing to interlaminar damage. For this purpose, the surface laminate has been prepared with HBM 1-LY41-6/350 gauges using X280 epoxy resin adhesive. Testing shows an optimal behavior of gauges. Since the nature of this issue requires high-speed data collection, the group has used a HBM MGCPlus equipment with a sampling nominal frequency of 2400 Hz per gauge. Strain data achieved is synchronized with images of a high-speed camera.

In the testing to evaluate damage tolerance, laminates withstand a compressive stress load until reaching collapse. A successful testing requires a perfect alignment of both the sample and the system to impede the effects of eccentric loads that may induce bending and therefore invalidating the result. Strain gauges will detect an unwanted buckling state and will provide measures of failure strain. Images sequence of the high-speed camera (see Figure 1) shows collapse details of degraded laminate and allows measurement of propagation velocity in surface crack.

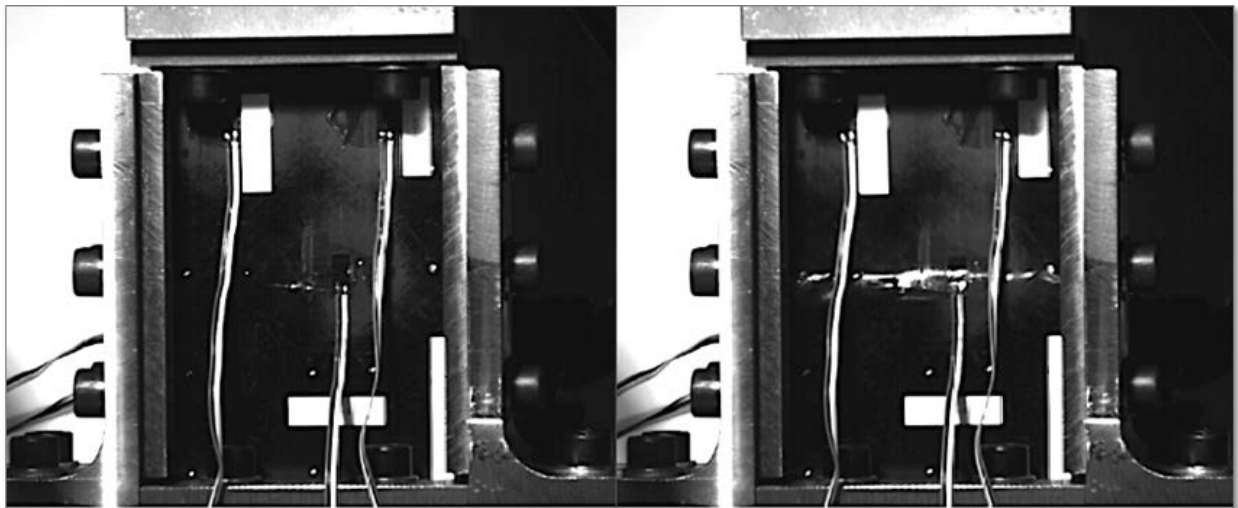


Fig. 1. Images sequence of compression testing on impacted sample

The characterization of internal strain state before and after an impact means a significant progress on the study of composite materials. The implementation of certain instrumentation such as optical strain gauges is presented as a potential alternative within the permanent instrumentation. In this sense, the new research lines of LITEM intend to open a development field in the structural health monitoring of structures and composite material components by using optical technology (see Figure 2).

Most recent studies experimentally characterize interlaminar phenomena to gain a deeper knowledge and to understand their complex behavior.



Fig. 2. Optical measurement equipment used to characterize deformations internal state

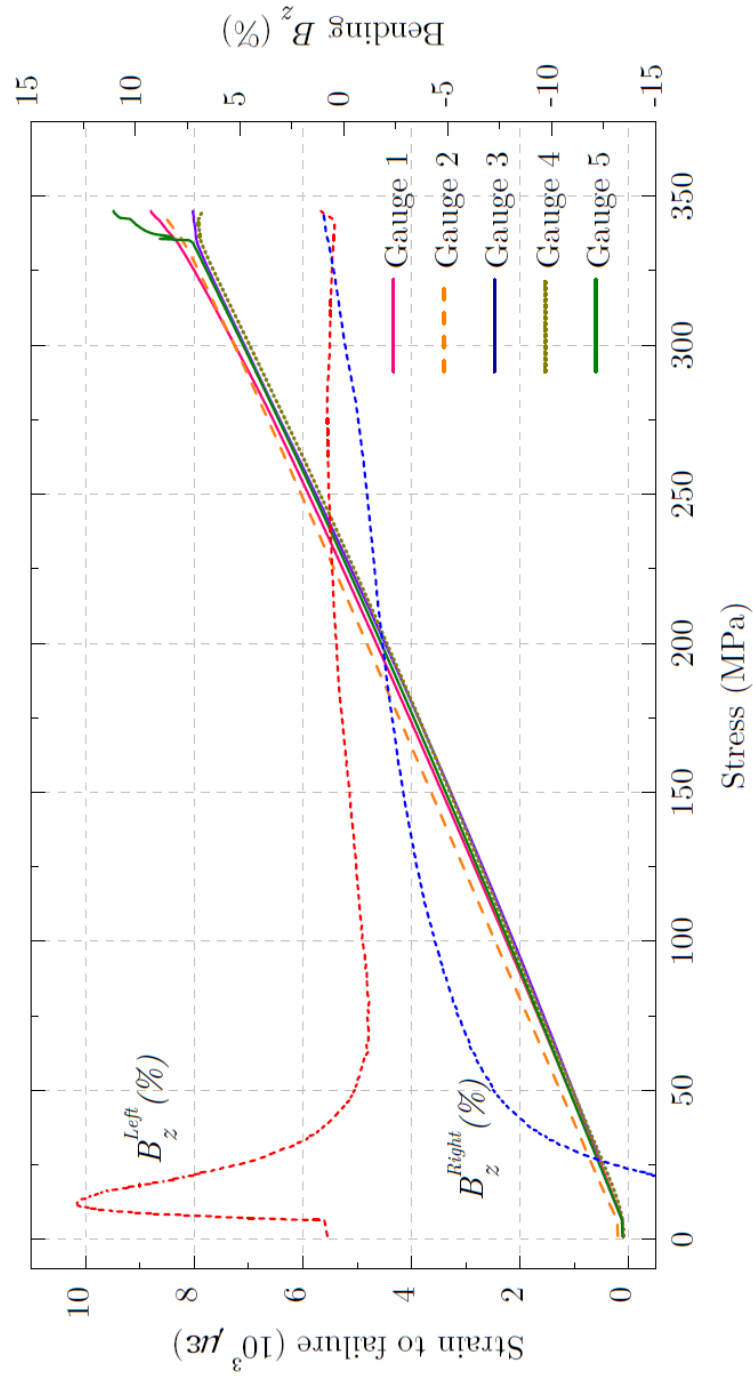


Fig. 3. Results of compression after impact test.