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EXPERIMENTAL CHARACTERIZATION AND NUMERICAL MODELING OF DAMAGES INDUCED BY LOW-VELOCITY IMPACTS IN RECENT COMPOSITE MATERIALS

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ABSTRACT

In aeronautics, composite laminates are used for the manufacturing of primary structures, such as wings and fuselages. These structures can be subjected to low-velocity impact threats, such as tool drops, which induce damages within the parts. Thus, the sizing of composite structures must be damage tolerant for satisfying safety requirements. However, it is currently based on long and costly experimental test campaigns due to the use of phenomenological criteria for sizing in industry.

Therefore, this work is dealing with an experimental and numerical study [1] regarding the global response and strength of a new generation of carbon/epoxy toughened composite material subjected to low-velocity/low energy impact. The major objective is to provide a robust model able to predict the response of composite laminates subjected to low-velocity impact in an industrial context based on fine experimental evidences.

Experimental testing on coupons have been performed with advanced instrumentation technologies (such as infrared thermography and digital images correlation associated with superfast cameras) to monitor real time in-situ damage, which enhances the understanding of the chronology of damage events [2]. Additionally, 3D non-destructive evaluation methods (X-ray tomography, ultrasonic scans) have been considered in order to assess and understand the damage mechanisms in such an enhanced carbon/epoxy composite material.

In parallel, an impact damage and failure model has been developed and consists in a 3D finite element model using an implicit solver, which considers contacts (impactor/composite and set-up/composite), geometrical non-linearity, transverse cracking thanks to a continuum damage model, delamination using cohesive elements and fibre failure considering a phase-field approach. A special attention has been paid to the couplings between the different damage and failure mechanisms, which have been clearly experimentally observed. Moreover, the impact tests have also been simulated with the Discrete Ply Model (DPM) developed for many years in ICA [3] in order to define the complementarity between those two damage models, considering either a continuum or a discrete damage modelling strategy.

Comparisons between the experimental results and simulations for both models are very promising, as reported in Figure 1., considering the load/displacement curves, the dissipated energy, the projected damaged area, but also considering the distribution of the damage/failure mechanisms within the composite plates.

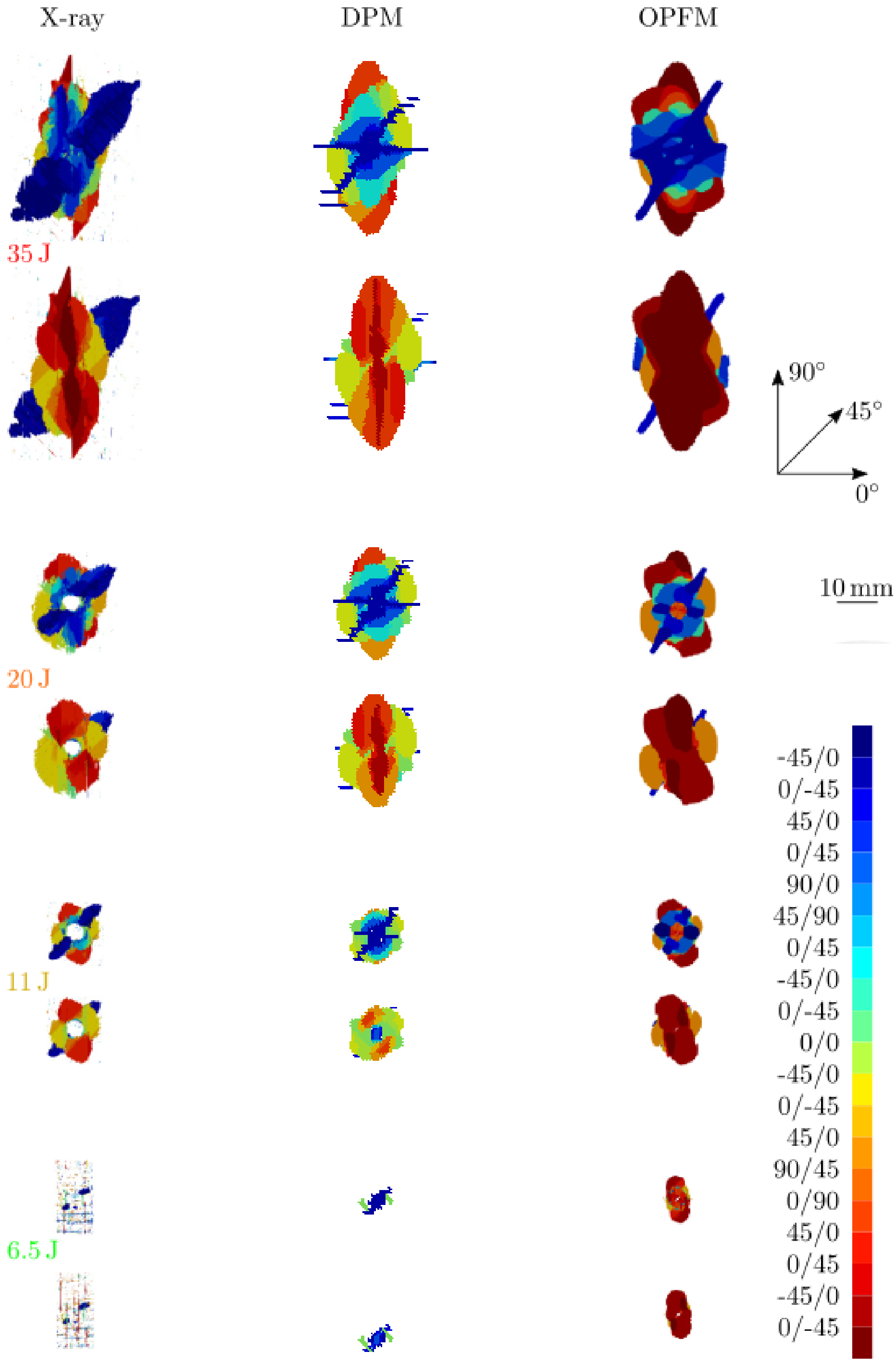

Figure 1: Projected damaged areas measured and predicted for an oriented laminate.

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