

## Title

MULTISCALE MODELING OF THE COMPRESSIVE BEHAVIOUR OF CFRP STRUCTURES

## Abstract text

The intensive use of Carbon Fibers Reinforced Plastics in aeronautics or automotive applications implies to master the prediction of any behaviour up to final failure. The so-called virtual testing approach supports this goal and relies on the use of robust models for key physical mechanisms. Among them, the kinking phenomenon in compression along the fibers' direction is a major one since it is involved either in static or dynamic complex test cases. It can lead to a large amount of dissipated energy thanks to the fragmentation of the whole structure in the strongly nonlinear regime. While the physics of kinking are relatively well known at the scale of the fibers, its modeling at the mesoscale and its interaction with delamination is still a challenging issue.

Preliminary studies focus on quasi-static loadings of relatively small samples. A micro model of a representative unit cell incorporating carbon fibers in an epoxy matrix has been developed and is able to represent the main degradation mechanisms associated to kinking. It is based on Fleck & Budiansky's kinking theory. This micro model has been used to extract the most important characteristics (strength, dissipated energy, kink band size) and the associated scattering mainly due to the statistical waviness of the fibers. From that point on, a ply-scale model has been improved to account for compressive loadings. The chosen representative volume element relies on the fragment size at the micro scale. An approximate potential form, in which the associated state and evolution laws are identified using an energy equivalence principle between the scales has been proposed. The kink band size plays the role of a localization limiter. This constitutive law is parameterized by the fiber waviness angle and is able to represent material and geometrical nonlinearities under multi-axial loadings.

This work can be divided in three parts. The first one describes the kinking micro model and the main associated results. The second part focuses on the construction of a homogenized constitutive law at the mesoscale. The third part features an application of the strategy to the modeling of the degradation of holed plates in compression. For this purpose, the mesoscale model has been implemented in the virtual material model developed by Ladevèze. This hybrid description strategy allows the interaction between the micro buckling mechanism (kinking) and other classical degradation mechanisms, such as delamination and transverse cracking, to take place for any configuration. The different crack networks and degradation features obtained by simulation are compared to the experimental ones.

### Authors 4

BARANGER, EMMANUEL (PSA)

ALLIX, OLIVIER (LMT-CACHAN)

GUIMARD, JEAN-MATHIEU (EADS-IW)

HA-MINH, CUONG (LMT-CACHAN)