PROPOSITION AND VALIDATION OF A DAMAGE AND FAILURE APPROACH FOR 3D WOVEN COMPOSITE MATERIALS WITH CERAMIC MATRIX: FROM ELEMENTARY COUPONS TO COMPOSITE STRUCTURES

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This study deals with the proposition of the Onera Damage Model developed for the predictions of damage and failure of 3D woven Ceramic Matrix Composites (CMC) and its validation through comparisons with multi-instrumented tests from elementary coupons to complex composite structures. Firstly, the main principles of the Onera Damage Model are presented. This damage and failure approach, thermodynamically consistent, is defined at the macroscopic scale in order to be used for the design of composite structures representative of aeronautical problems. This approach assumes that the different matrix damages are oriented by the applied loading, because of the low contrast between the mechanical properties of the constituents. The unilateral aspect of damage is also taken into account to predict accurately the behaviour and damages of structures subjected to complex non-proportional loadings. Finally, the failure patterns are assumed to be oriented by the architecture of the considered woven material. Then, in order to validate the proposed approach, some torsion tests, off-axis incremental tensile tests and ILSS tests on CMC samples have been conducted at UTC, SAFRAN and ONERA. These tests have been multi-instrumented with digital images correlation, SEM observations, CT-Scan, acoustic emission. The use of these complementary instrumentation methods have allowed proposing damage scenarii specific to this CMC and to increase the confidence into the different measurements. Finally, the predictions of the proposed approach in terms of non-linear behaviour, damage pattern and final failure have been successfully compared with the different available tests (see Figure 1), even for 3D complex loading tests.

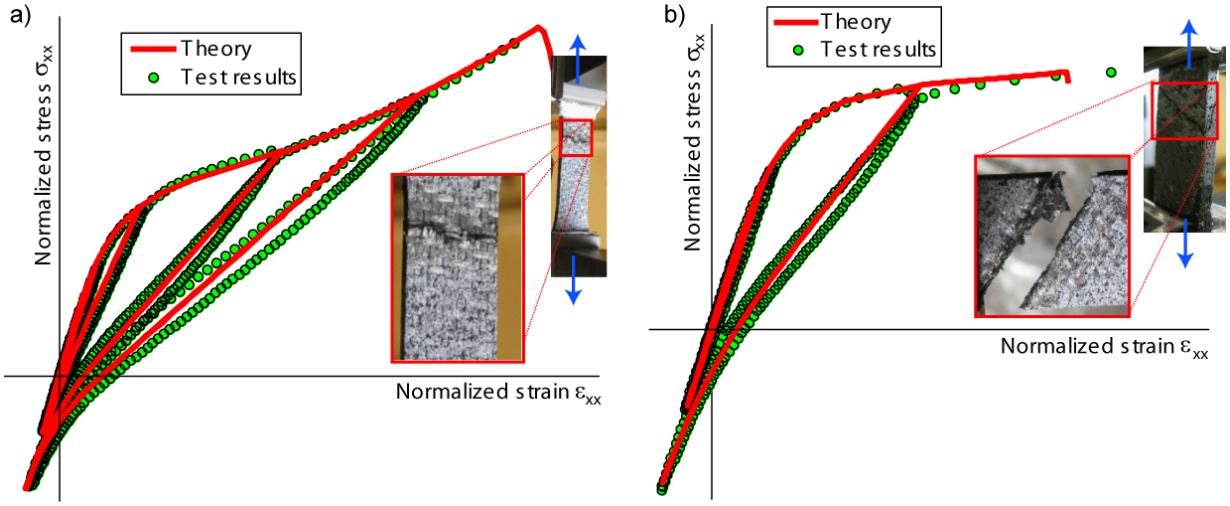

Figure 1 – Comparison between simulations and tests for (a) 0° tensile tests and (b) 45° off-axis tensile on a CMC material