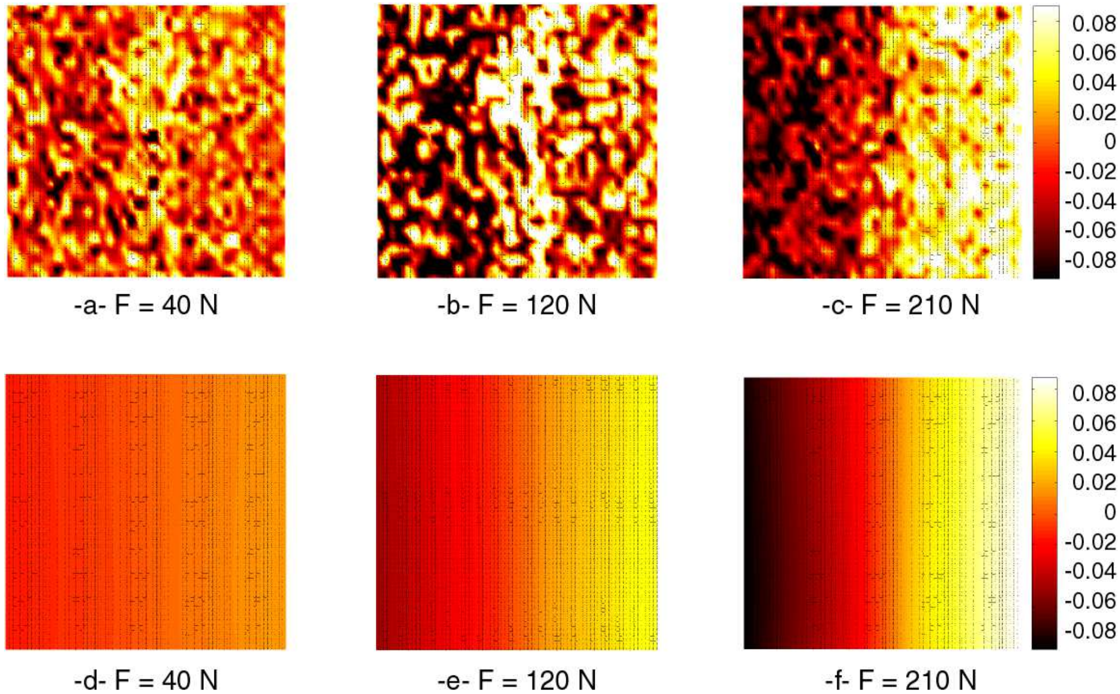


Figure 7. Comparison of experimental U_y (in pixel) displacement field (a), (b), (c) and computed U_y (in pixel) displacement field (d), (e), (f) when 1 pixel = 0.33 µm and E_{joint} = 150 GPa and ν_{joint} = 0.4. The correlation parameters are l = 32 pixels and δ = 32 pixels.

DAMAGE SCENARIO IN A SHEAR EXPERIMENT

A biaxial shear test is developed within the context of a study on the modeling and identification of the mechanical behavior of Multirex® materials submitted to complex loading conditions in the ply planes. Multirex® materials are Carbon/Carbon composites manufactured by SNECMA Engine Division. Multirex® preforms are either planar or axisymmetric. They are obtained by stacking either unidirectional plies or satin layers made of carbon yarns. Yarn fibers can be continuous or discontinuous. A needling process transfers some fibers along the third direction, perpendicular to the layer. The fiber reinforcements avoid delamination propagation to occur. A Chemical Vapor Infiltration deposits the matrix in the preform; satin composites made of discontinuous fibers are studied herein (Fig. 8). This type of composite material is especially designed for thermostructural applications such as brakes or structural parts of a rocket engine.

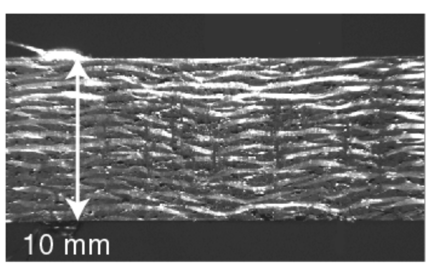
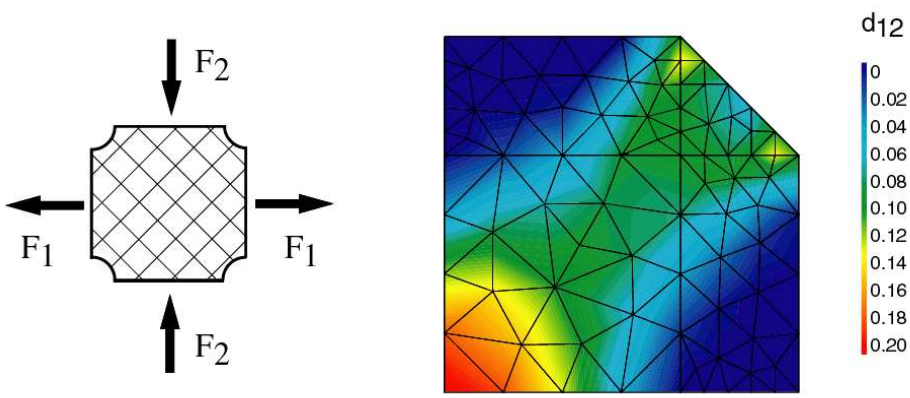


Figure 8. View of the material mesostructure.

The investigation concerning the thermomechanical behavior of a Carbon/Carbon composite material focuses on three main stages. In the first one, a series of uniaxial tension and compression tests in different directions was performed on a $[0,90]_n$ satin composite.[5,30] These tests have shown an anisotropic behavior with damage and inelastic strains for tensile tests at 0° and ±45°.[31] Constitutive equations based on an anisotropic damage model[32] written on a mesoscale (i.e., that of a ply) is used to describe the main degradation mechanisms. The model is based on the laminate theory and accounts for non linearities in each ply. Because the laminate thickness is negligible in comparison with other dimensions, a state of plane stress and a Kirchhoff-Love kinematics is assumed. Satin plies are modeled by a stacking of two orthogonal unidirectional elementary plies made of discontinuous fibers. For each ply, the degradation is assumed to be anisotropic, one related to a shear mechanism in the matrix, and one along the fiber direction related to fiber breakage.[30] The constitutive equation is used to analyze the biaxial shear test discussed herein (Fig. 9a). The different degradation mechanisms are modeled by the damage variables. An *a priori* finite element analysis of this geometry, using the above-mentioned damage model, shows that the shear damage field d_{12} is confined in the central part of the specimen (Fig. 9b). Because of the initial anisotropy of the material with respect to the loading axes, the central part of the specimen is the most loaded zone in terms of damage d_{12} as well as strains.[30]



-a- -b-

Figure 9. Schematic of the shear experiment (a) and shear damage contours in one quarter of either ply of the specimen (b).

To evaluate the performances of the correlation technique, a practical situation is considered again. A shear experiment on a composite plate, in which the strain field is heterogeneous, is analyzed (Fig. 10a). Tabs are glued on the face of each connecting arm of the specimen. The yarns are parallel to the bisectors of the loading directions. An 8-bit digital CCD camera (resolution = 1008 × 1016 pixels) is mounted along an axis perpendicular to the loading plane. For comparison purposes, two strain gages are glued on one specimen surface. Figure 10b shows the gauge response and the average strain over the same active surface deduced from the digital image correlation for a cyclic load history. A mean error of 2×10^{-4} is obtained for this heterogeneous strain field when $l = 64$ pixels and $\delta = 32$ pixels.