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Damage modelling of laminated composites: validation of the inter-laminar damage law of SAMCEF at the coupon level for UD plies

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In order to propose predictive simulation tools, it is important to use material models able to represent the different modes of degradation of the plies forming the laminated composite structure. Most of the time damage at the interface between the plies, that is delamination, must also be taken into account in the model. This last point is addressed in this paper.

The cohesive element approach available in the SAMCEF finite element code for the modeling of the inter-laminar damage of laminated composites is considered. The approach is based on the continuum damage mechanics and was initially developed by the Ladevèze's team in Cachan [1]. A damage model is assigned to some interface elements inserted between plies to represent their possible de-cohesion and a fracture criterion is used to decide on the inter-laminar crack propagation. Using such cohesive elements in the analysis allows to estimate not only the propagation load but also to predict the failure load, the crack propagation and the residual stiffness during the fracture process in an automatic way. With this information more accurate safety margins can be assessed.

In this paper, problems at the coupon level are addressed. The inter-laminar damage model is first presented. The basics of the parameter identification procedure of such a material model are briefly explained. Test results at the coupon level on DCB and ENF specimens are used to identify the parameters of the damage law. The obtained values are then validated on a MMB test. It is demonstrated that, in some cases, it is important to model not only the damage at the interface of the plies, but also the damage inside the plies [2]. This is illustrated for the ENF test case, as depicted in Figure 1.

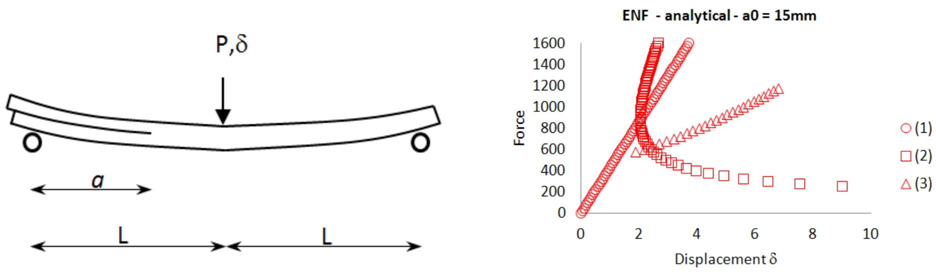

Figure 1. The ENF test problem

In Figure 2, simulation is compared to analytical solutions and test results for the ENF. It is seen that when only 0° plies are considered, the behavior is quasi-linear up to the crack propagation, which is the maximum point of the load/reaction curve. However, when 45°/-45° plies are considered, the non-linear behavior observed in the tests can only be reproduced when the damage inside the plies is modeled. We note a very good agreement between tests (light lines), analytical solution (red circles) and simulation (dark spots).

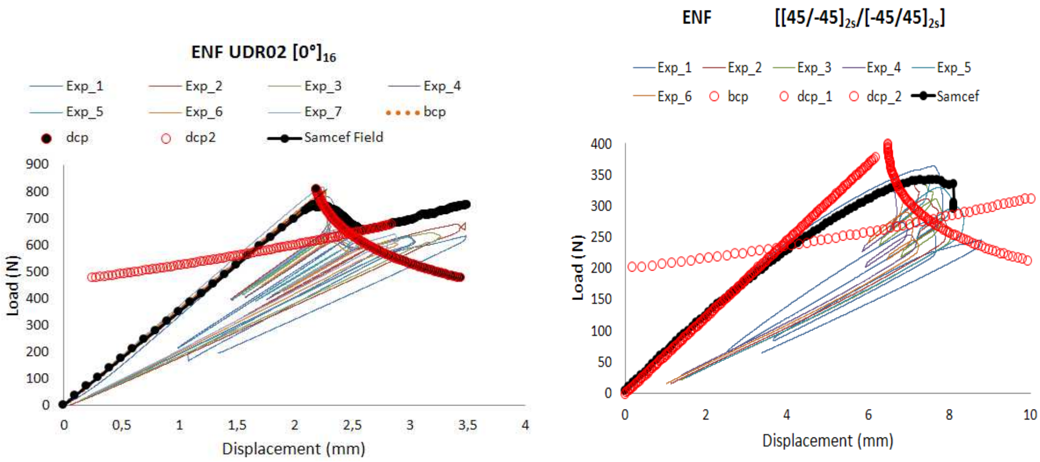

Figure 2. Simulation on the ENF test case

REFERENCES

[1] Allix O. and Ladevèze P. *Interlaminar interface modelling for the prediction of laminate delamination*, Composite Structures, 22, 235-242, 1992.

[2] Ladeveze P., and Le Dantec S. Damage modeling of the elementary ply for laminated composites, Composites Science and Technology, 43, 1992.