Delamination Analysis with Cohesive Interface Elements in Finite Element Applications

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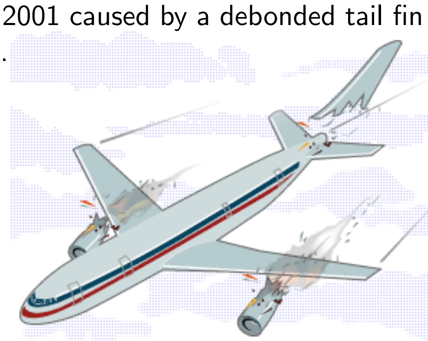
Delamination Risks in Fibre-Reinforced Plastics

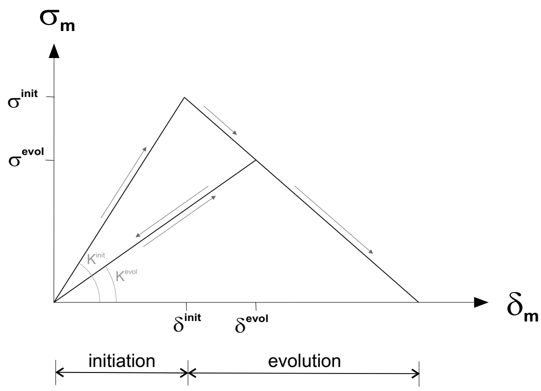
Plastics in combination with reinforcing fibers build low-weight material especially used in aerospace structures. Damage tests and unfortunate aircraft accidents show delamination risks of fibre-reinforced plastics in particular cases of load impact. The crash of Flight 587 in 2001 caused by a debonded tail fin is a famous example.



The finite element method is here an interesting tool to model the delamination process. In this work, the Finite Element Application ABAQUS© 6.5-3 was especially used. It provides the therefore applicable cohesive interface elements.

Interlaminar Damage Modelling

Damage is modelled by degradation of material-stiffnesses. The typical stress-strain relation of non-brittle material is reduced to a basic model with linear elasticity followed by linear degradation.



This bi-linear failure mechanism shows two distinct parts: *initiation* and *evolution*. A scalar damage indicator D maps the degradation and appears in the actual stress tensor $\mathbf{t}$ in order to relate to the initial stress tensor $\bar{\mathbf{t}}$.

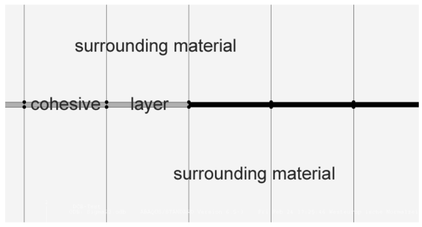
$$t_n = \begin{cases} (1 - D)\bar{t}_n & , \bar{t}_n \geq 0 \\ \bar{t}_n & , other \end{cases}$$

$$t_s = (1 - D)\bar{t}_s$$

$$t_t = (1 - D)\bar{t}_t$$

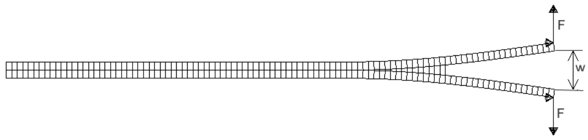
How to include Cohesive Elements

Cohesive elements can be inserted where cracks are expected. They build an interfacial zone between two parts which are supposed to separate.

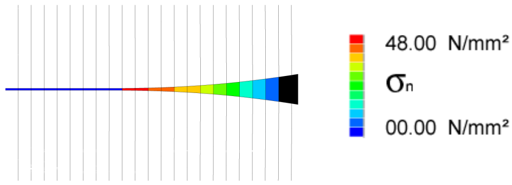


Application to a Test Specimen

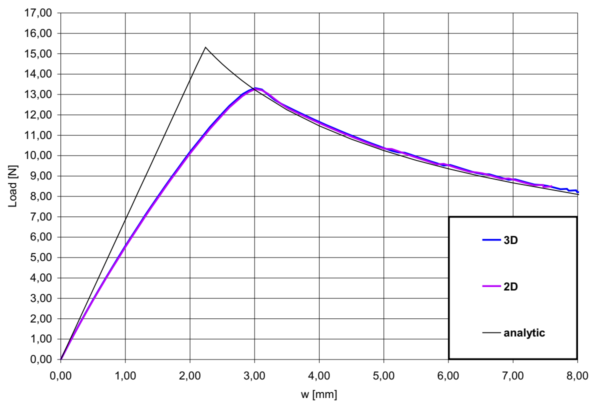
A numerical simulation of a delamination test specimen called Double Cantilever Beam was executed in ABAQUS©.



A view on the stresses near the crack tip shows degradation of the cohesive layer by increment of F.



During the simulations convergence problems occured that only were overcome by assuming viscous material behaviour to the cohesive elements. The achieved load/crack-opening curve $F(w)$ shows good agreement to an analytical approach.



Further development and improvement of cohesive elements are necessary for an application to more complex problems of practical engineering.