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PROGRESSIVE DAMAGE MODELLING OF OPEN-HOLE CARBON/EPOXY LAMINATES UNDER TENSION-TENSION FATIGUE LOADING

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Topic:
- Experimental characterization of materials, structures and assemblies;
- Damage mechanics and damage mechanisms, property degradation;

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Abstract
This works aims to simulate the initiation and propagation of intralaminar and interlaminar damage in open-hole carbon/epoxy laminates subjected to tension-tension fatigue loadings. The model is defined in the framework of damage mechanics and implemented as user material subroutine in Abaqus/Explicit. The intra-ply damage constitutive model is based on the previous work of Maimí [1], [2] but extended to work under fatigue loadings, whereas the cohesive fatigue model from Turon [3] is implemented into the explicit formulation following the work of González [4]. Both damage models are controlled by a cycle jump strategy within the finite element code thereby improving the computational efficiency of high-cycle fatigue analysis.

The experimental observations revealed that the fatigue response of notched carbon/epoxy laminates is governed by the progressive failure of the matrix, consisting of mainly longitudinal matrix splitting and delamination. These forms of damage alleviate the stress concentration at the hole and thus suppress fibre fracture [5]–[8]. As a consequence, the mechanical properties are significantly degraded but complete failure is never reached before 10^6 cycles even at stress levels of 75% of the static strength. The effect of the notch blunting contributes to the increase in the tensile residual strength with the number of cycles and confirms the importance of modelling sub-critical damage to predict the eventual collapse of composite structures. The damage patterns obtained from X-ray radiographies at different cycle intervals and severities are compared with the numerical results to show the model capability.

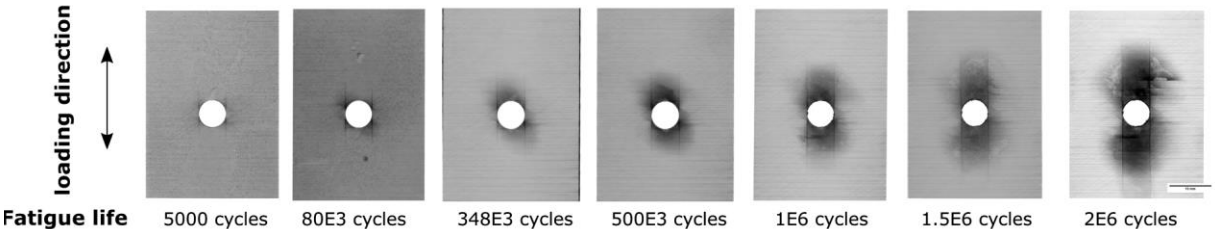

Figure 1. X-ray images of a quasi-isotropic laminate showing the damage evolution at a severity of 75% and different cycle intervals.

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