CertBond
COST Action CA18120

# Analytical implementation of the non-conventional failures in cross-ply laminates under fatigue loading to predict the initiation of the fibre/matrix interface debonding

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**Reference:** CA18120_STS_M00
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**Beneficiary Institution:** University of Seville, Spain
**Hosting Institution:** University of Padova (located at Vicenza), Italy
**Contact Name:** Paolo Andrea Carraro, Italy
**Relevant Working Groups:** WG2

## Objectives / Description / Main outcomes

The *edge effect* phenomenon has been studied by University of Seville after an experimental programme in which fatigue experiments were carried out on cross-ply laminates and their adhesive joints (Figure 1.(a)). The 90º ply block in a cross-ply laminate was made of ultra-thin plies. This phenomenon causes non-conventional damages on the samples' free edges when ultra-thin plies are involved. These fibre/matrix bonded interface cracks are longitudinal to the loading direction and appear both after sanding and polishing process and during fatigue testing (Figure 1.(b)).

The *edge effect* phenomenon which has been numerically analysed has corroborated a biaxial stress state (Figure 2) that causes these non-conventional debonding damages.

A new stress component in the thickness direction of the cross-ply laminate has been added to the numerical tool by the host research group (in which Dr. Carraro is involved at University of Padova). For that reason, the calculation of the Local Hydrostatic Stress which is the effective stress that causes the fibre/matrix bonded interface cracks has been performed taking the new stress in the thickness direction into consideration.

In Figure 3, only experimental values of transverse cracking (which is the conventional damage that appears in a thick 90º ply block) has been charted as markers. It can be seen how the predictions for the failure onset in CP-30 (cross-ply laminate with an ultra-thin 90º ply block) does not correlate with experimental results. The reason of this disagreement is that non-conventional damages are predicted by the model after considering the stress in the thickness direction in the calculation of LHS.

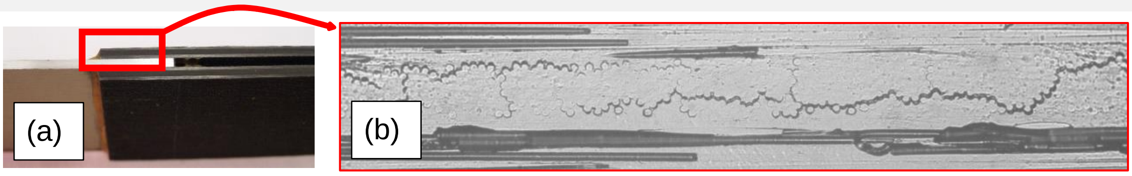


***Figure 1:*** *(a) Adhesive-materials interface, (b) Detail of the ultra-thin 90º ply block in the cross-ply laminate after fatigue testing*

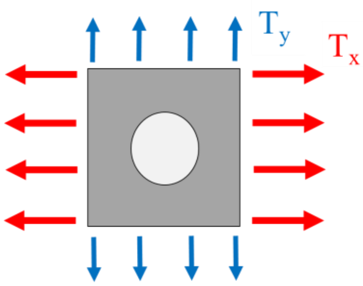


***Figure 3:*** *Biaxial stress state along the samples' free edges.*

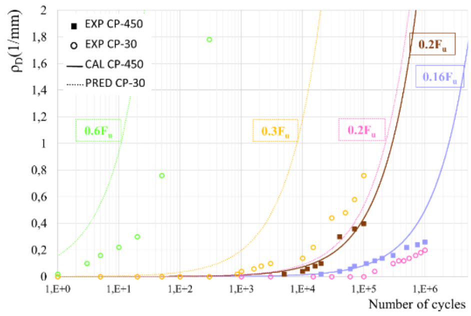


***Figure 4:*** *Predictions of the onset of fibre/matrix debonding with Dr. Carraro's tool.*

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