The role of the edge-effect in non-conventional failures of adhesive joints with cross-ply laminates

Alberto Barroso

Reference: CA18120_STS
Dates: from 2022-07-02 to 2022-07-07
Beneficiary Institution: University of Seville, Spain
Hosting Institution: University of Padova (in Vicenza), Italy
Contact Name: Paolo Andrea Carraro, Italy
Relevant Working Groups: WG2.

Objectives / Description / Main outcomes

Fatigue experiments, carried out at the University of Seville, using cross-ply laminates and their joints, has shown some non-conventional failures (Figure 1), in which the observed damage appears in the 90º ply, running parallel to the applied load direction. These failures seem to be favored by the use of ultra-thin plies in the 90º layer. The ultra-thin plies included in the study, for the 90º lamina, cover the thickness range from 0.06 mm (for a ply of 30 g/m^2) to 0.485 (for 3 plies of 150 g/m^2).

The edge-effect (Figure 2) has been analyzed as the potential responsible for this type of failure. Both, the mechanical mismatch (Poisson effect) and thermal mismatch (different thermal expansion coefficient value) associated to each layer have been evaluated separately. As an example, Figure 3, shows the thermal effect and the role of the 90º ply thickness on the σ_{yy} stress component at the free-edge (where the non-conventional failures have appeared).

The presence of the stress singularity at the joining between both plies has also been investigated. By using a semianalytical tool, the stress singularity has been calculated and slight geometrical modifications in the sample has been carried out to remove the pollution effect of the singularity.

By adding the stresses associated to the mechanical effect and the thermal effect, when reducing the 90º ply thickness, the stress level is high enough at the free-edge to generate the observed experimental failure in the samples.

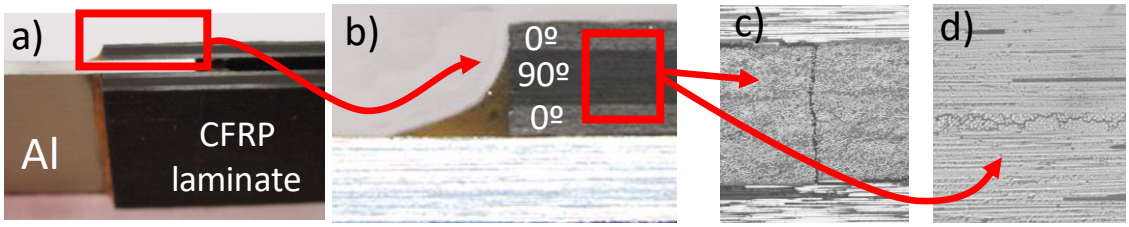

Figure 1: *a) Adhesive joint, b) detail of cross-ply, c) conventional transverse crack, d) non-conventional longitudinal cracking in cross-ply laminates with ultra-thin plies.*

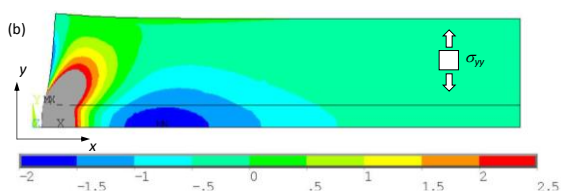

Figure 2: *Edge effect (σ_{yy} stress at the free-edge).*

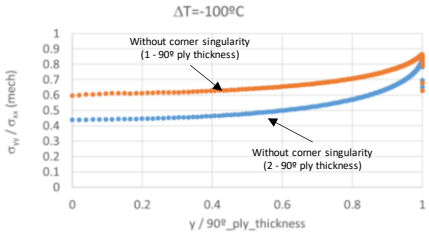

Figure 3: *Influence of the 90º ply thickness on the thermal effect (free-edge).*

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY
Funded by the Horizon 2020 Framework Programme of the European Union