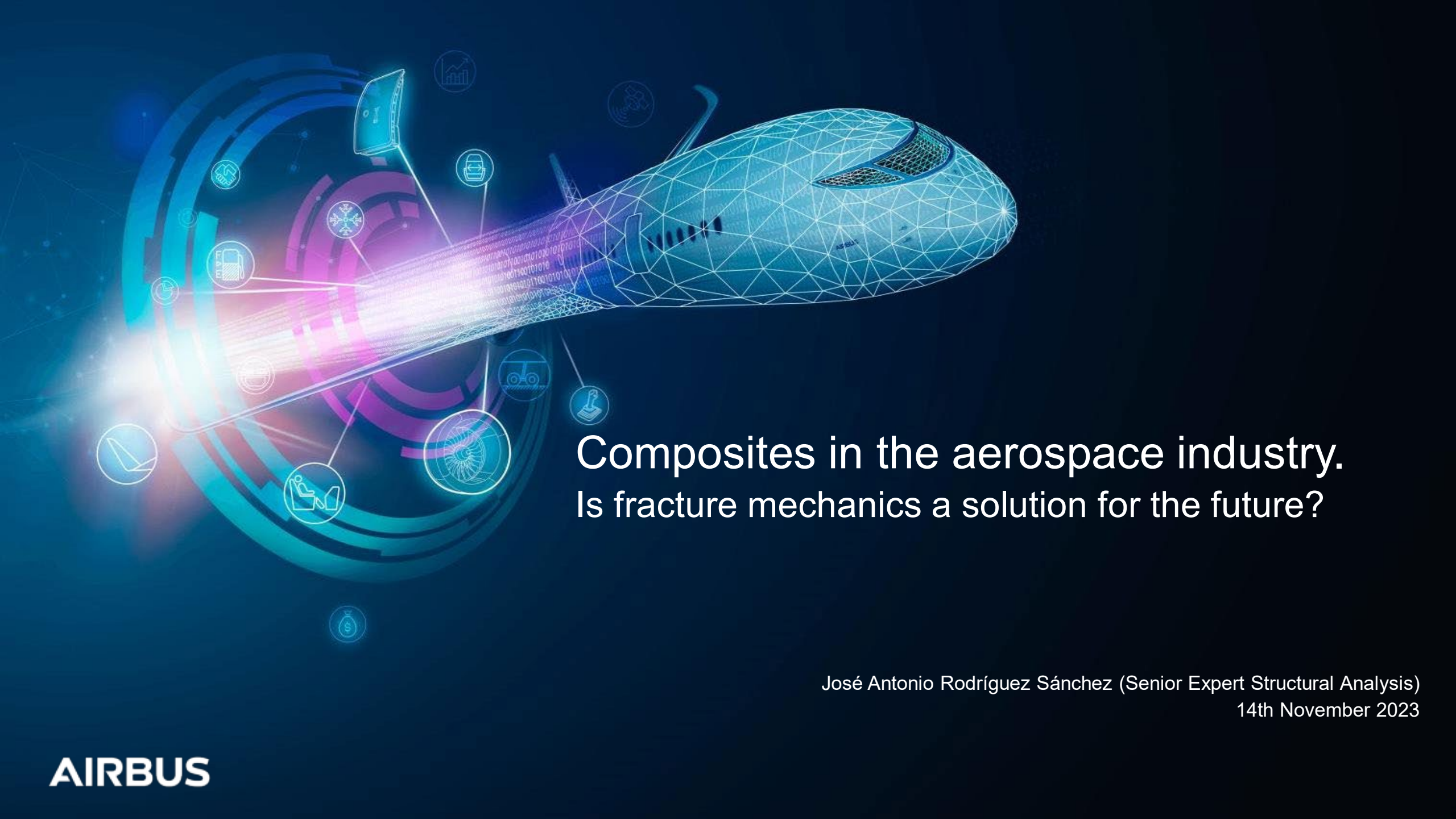


Composites in the aerospace industry.

Is fracture mechanics a solution for the future?

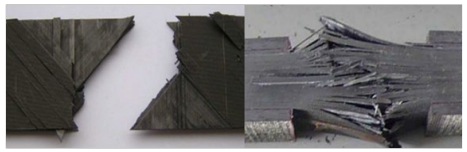
José Antonio Rodríguez Sánchez (Senior Expert Structural Analysis)

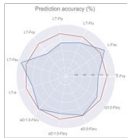
14th November 2023

AIRBUS

As-Is

DESIGN VALUES

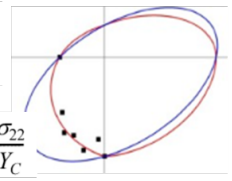




FAILURE CRITERIA

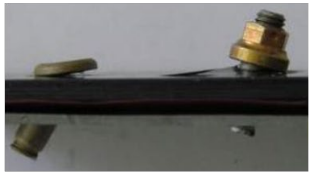
$$\left(\frac{\sigma_{yy}}{Y_T}\right)^2+\left(\frac{\sigma_{xy}}{S_{xy}}\right)^2+\left(\frac{\sigma_{yz}}{S_{yz}}\right)^2=1$$

$$\left(\frac{\sigma_{22}}{2S_T}\right)^2+\left[\left(\frac{Y_C}{2S_T}\right)^2-1\right]\frac{\sigma_{22}}{Y_C}$$

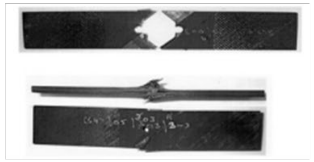


METHODS

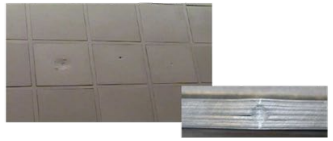
Bolted joint



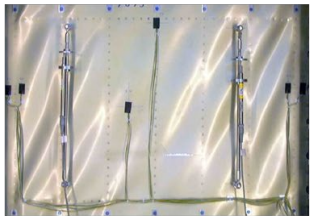
Open hole



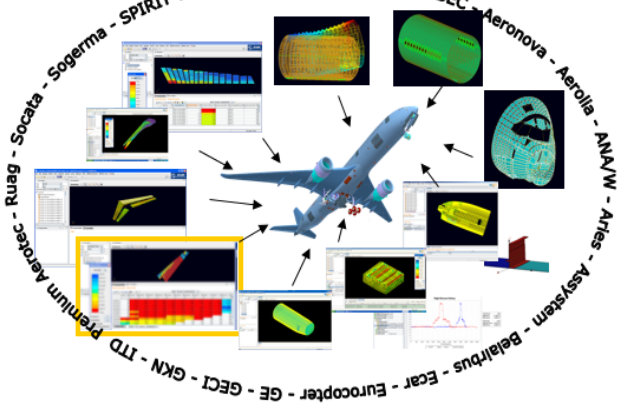
Damage Tolerance



Stability

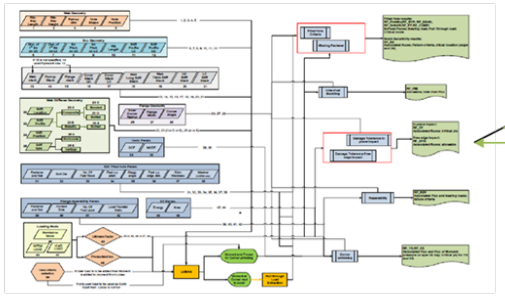


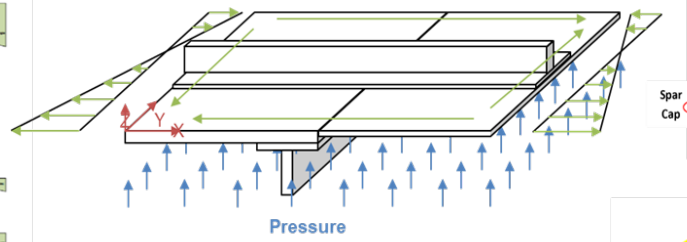
Unfolding

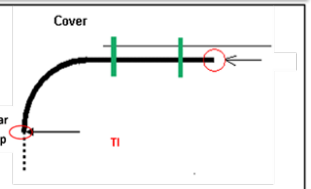


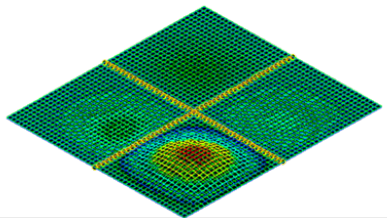
ISAMI
AIRBUS STRESS TOOL

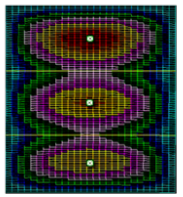
STRESS PROCESSES

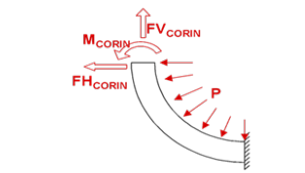


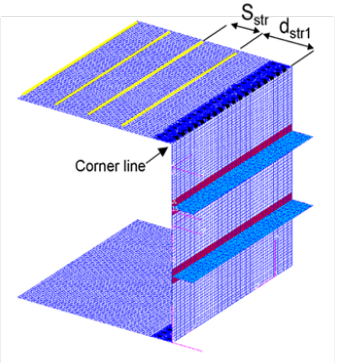




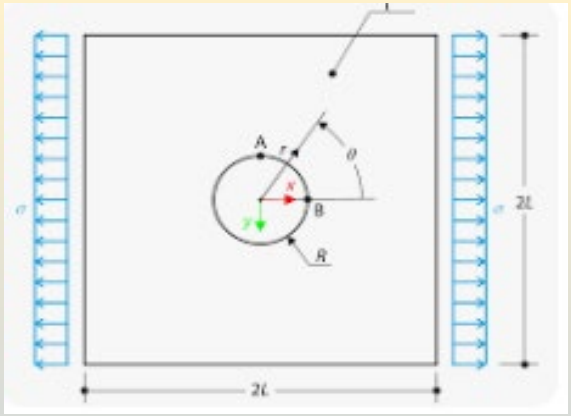








Failure Mechanism. Open hole

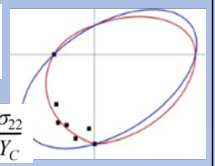


$$a_{22}\frac{\partial^4 F}{\partial x^4} - 2a_{26}\frac{\partial^4 F}{\partial x^3 \partial y} + (2a_{12} + a_{66})\frac{\partial^4 F}{\partial x^2 \partial y^2} - 2a_{16}\frac{\partial^4 F}{\partial x \partial y^3} + a_{11}\frac{\partial^4 F}{\partial y^4} = 0$$

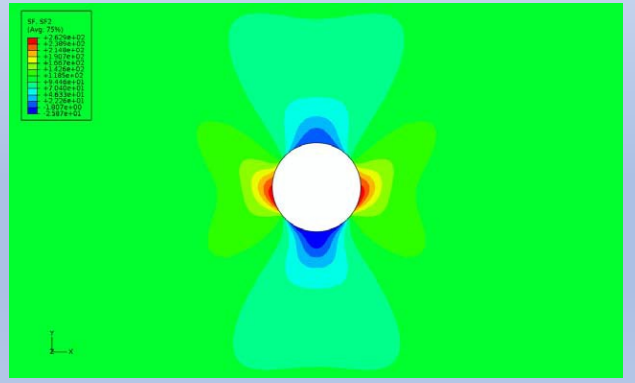
FAILURE CRITERIA

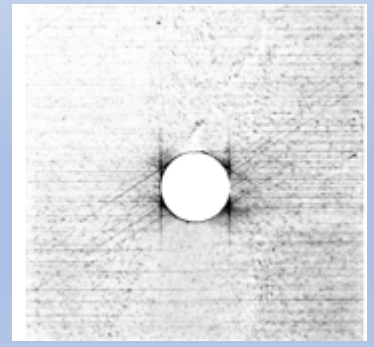
$$\left(\frac{\sigma_{yy}}{Y_T}\right)^2 + \left(\frac{\sigma_{xy}}{S_{xy}}\right)^2 + \left(\frac{\sigma_{yz}}{S_{yz}}\right)^2 = 1$$

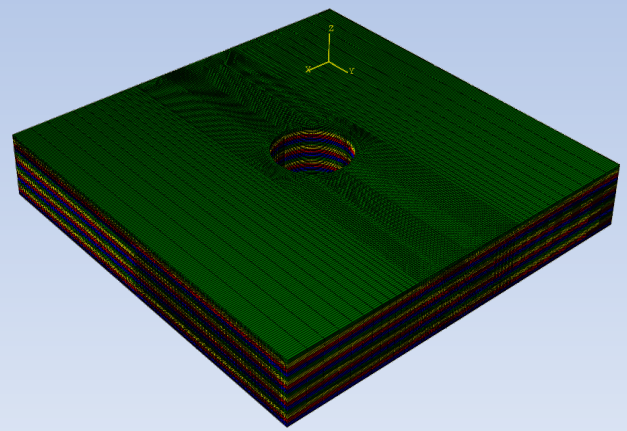
$$\left(\frac{\sigma_{22}}{2S_T}\right)^2 + \left[\left(\frac{Y_C}{2S_T}\right)^2 - 1\right]\frac{\sigma_{22}}{Y_C}$$

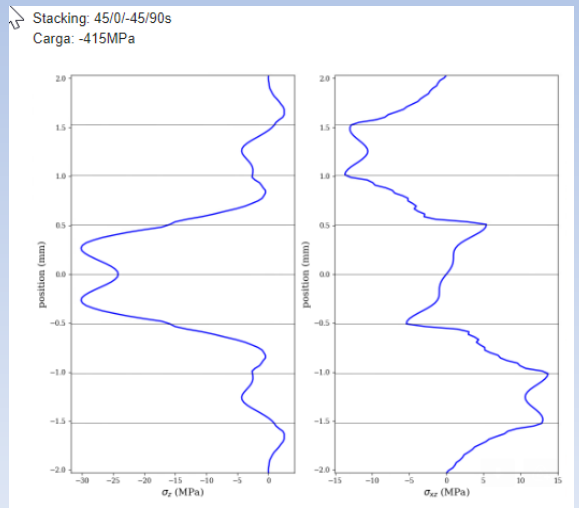


DESIGN VALUE









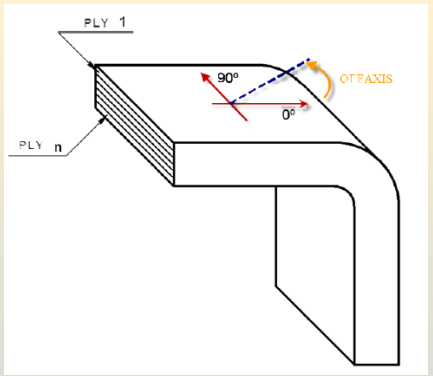
Damage Initiation

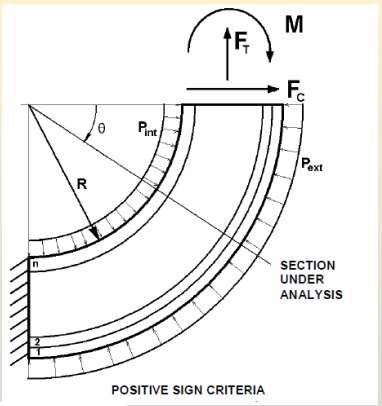
Intra-laminar +
Inter-laminar +
Curing remaining stress

→ **Damage growth** → **Collapse**

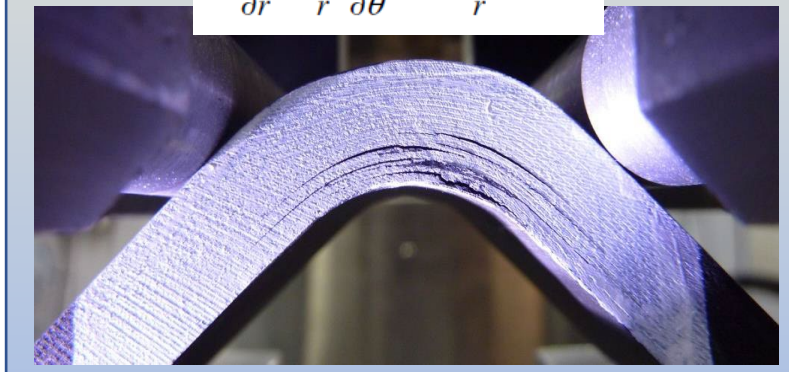
* Anisotropic plates. Lekhnitskii

Failure Mechanism. Unfolding





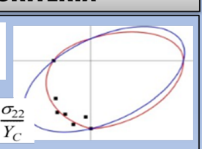
$$\frac{\partial \sigma_r}{\partial r} + \frac{1}{r}\frac{\partial \tau_{r\theta}}{\partial \theta} + \frac{\sigma_r - \sigma_\theta}{r} = 0$$



FAILURE CRITERIA

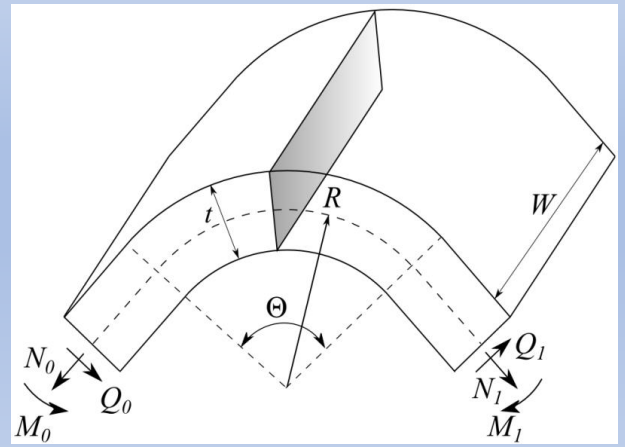
$$\left(\frac{\sigma_{yy}}{Y_T}\right)^2 + \left(\frac{\sigma_{xy}}{S_{xy}}\right)^2 + \left(\frac{\sigma_{yz}}{S_{yz}}\right)^2 = 1$$

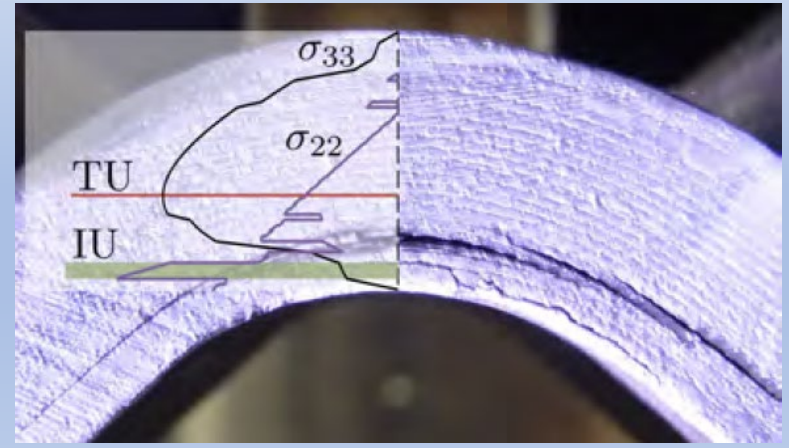
$$\left(\frac{\sigma_{22}}{2S_T}\right)^2 + \left[\left(\frac{Y_C}{2S_T}\right)^2 - 1\right]\frac{\sigma_{22}}{Y_C}$$

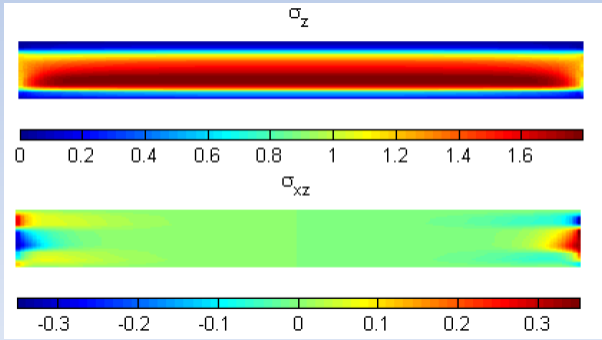


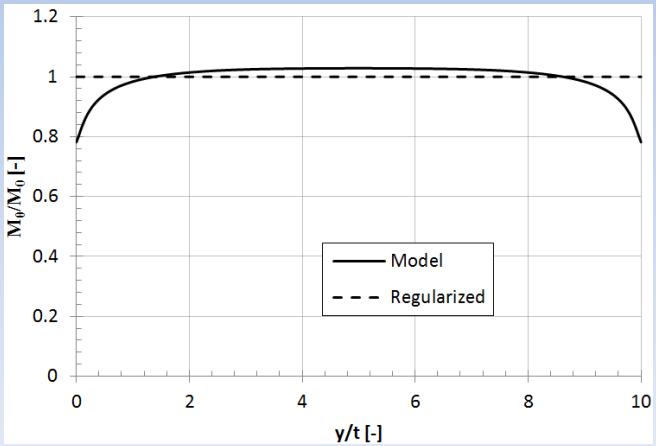
DESIGN VALUE

* Anisotropic plates. Lekhnitiskii









Damage Initiation

Intra-laminar +
Inter-laminar +
Curing remaining stress

→ **Damage growth**
Boundary conditions

→ **Collapse**

Study of the unfolding failure of curved composite laminates. Cantero et al. Univ Sevilla with Airbus partnership

To be:

Micro-scale

Meso-scale

Macro-scale

1. NDT Methodology on test real time
2. Instrumentation. Interlaminar
3. Test coupons redefinition
4. Idealization techniques

References.

González Cantero, J.M. (2017). *Study of the unfolding failure of curved composite laminates. Phd Universidad de Sevilla. Airbus partnership*

Pastorino Junquero D. (2021). *Closed form methodology for the structural análisis of composite plates with cutouts. PhD Universidad de Sevilla. Airbus partnership*

Thanks