Modèles micromécaniques du dommage intra-laminaire dans les stratifiés avec couches fines

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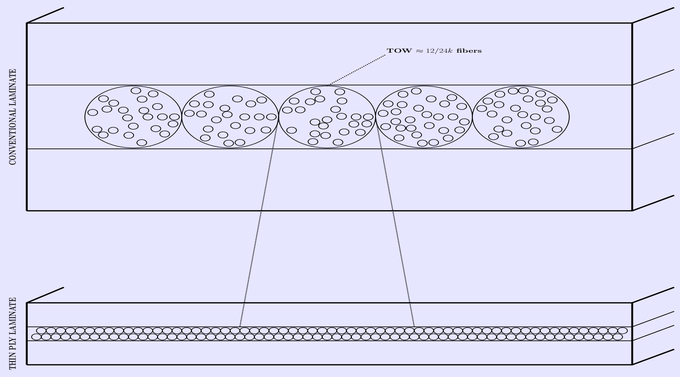
Ultra-thin Fiber Reinforced Polymer Composite (FRPC) Laminates: an Introduction

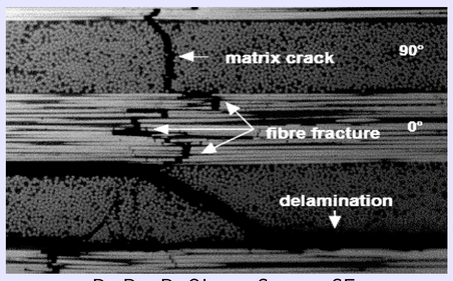
Technological origins and applications



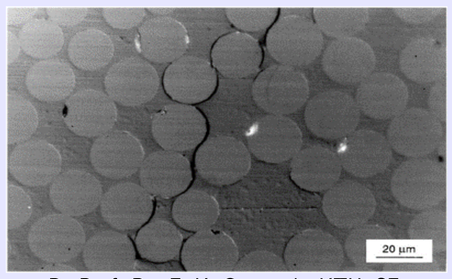
Solar Impulse 2, from [1].

Nuon Solar team's car, from [2].

Damage in FRPCs: a visual introduction

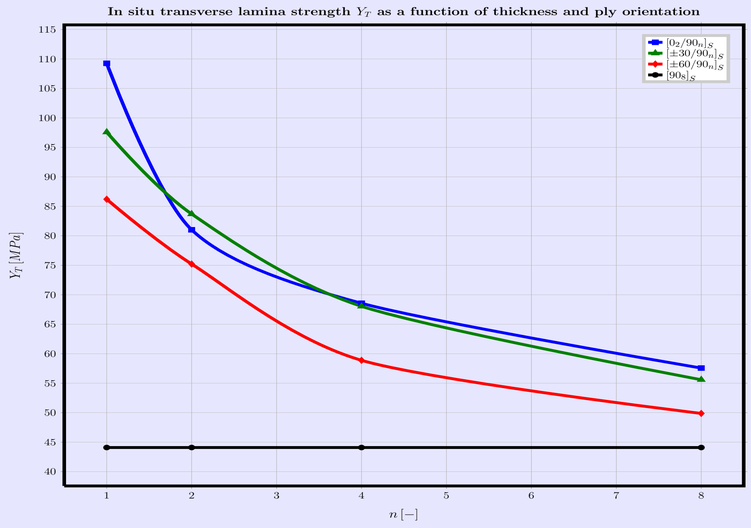


By Dr. R. Olsson, Swerea, SE.



By Prof. Dr. E. K. Gamstedt, KTH, SE.

The thin ply effect



Measurements of in-situ transverse strength from Flaggs & Kural, 1982 [3].

Objectives & Approach

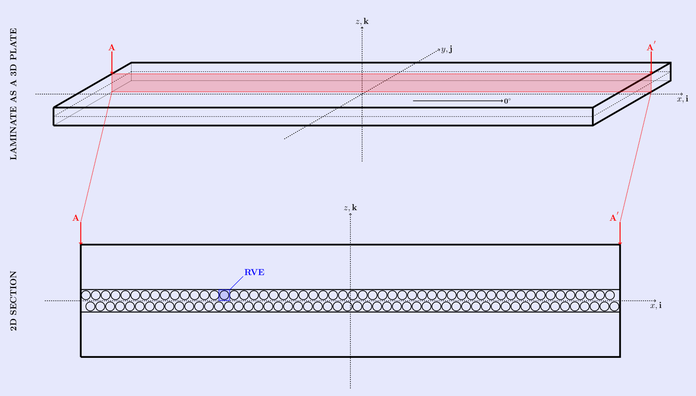
What do we want to achieve?

- Investigate the influence of volume fraction, material properties, thin ply thickness and bounding plies' thicknesses on crack initiation
- $G_{*c} = G_{*c}\left(\theta_{debond}, \Delta\theta_{debond}, E_{(..)}, \nu_{(..)}, G_{()}, VF_f, t_{ply}, \frac{t_{ply}}{t_{bounding\ \ plies}}\right)$

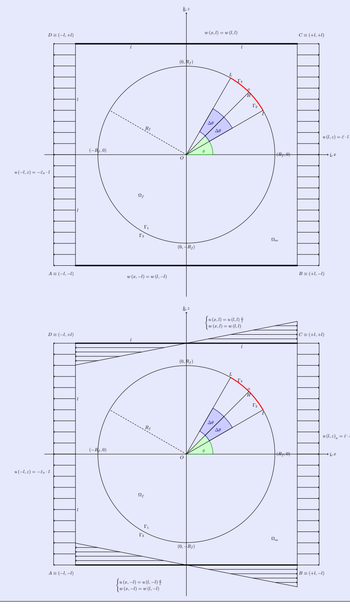
How do we want to achieve it?

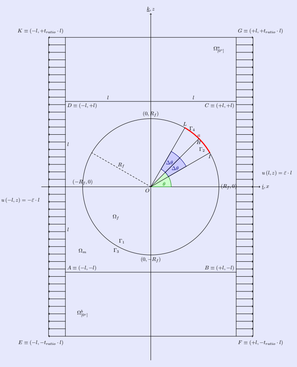
- Design and categorization of several Representative Volume Elements (RVEs)
- Automated generation of RVEs geometry and FEM model
- Finite Element Simulations (in Abaqus)

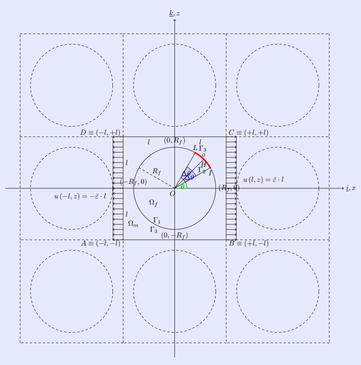
Design & Analysis of Representative Volume Elements (RVEs)

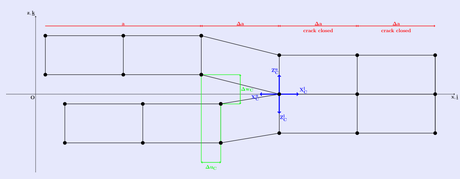


- ✓ 2D space
- ✓ Linear elastic materials
- ✓ Displacement control
- ✓ Dirichlet-type boundary conditions
- ✓ Linear elastic fracture mechanics
- ✓ Contact interaction

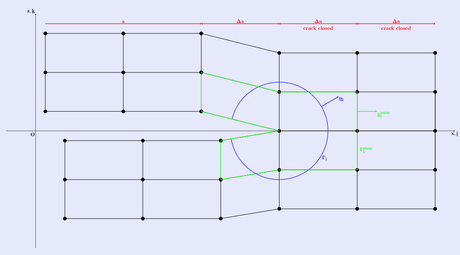






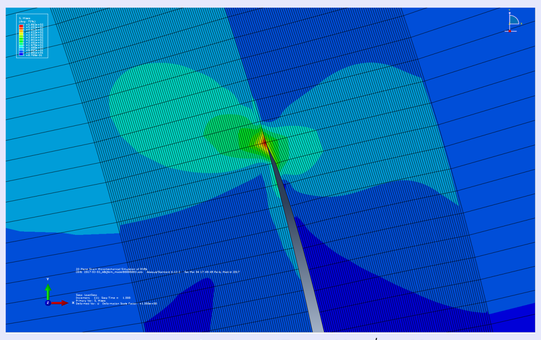


VCCT: $G_I = \frac{Z_C \Delta w_C}{2B\Delta a} \quad G_{II} = \frac{X_C \Delta u_C}{2B\Delta a}$

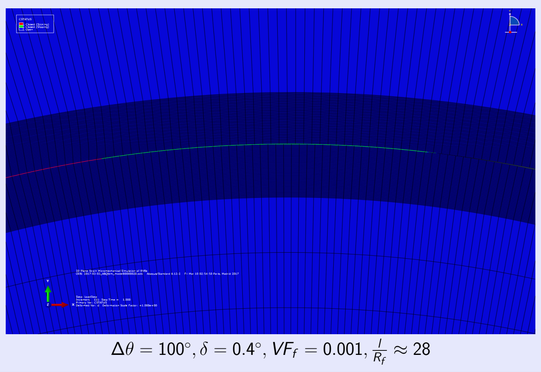


J-Integral: $J_i = \lim_{\varepsilon \to 0} \int_{\Gamma_\varepsilon} \left(W(\Gamma)\, n_i - n_j \sigma_{jk} \frac{\partial u_k(\Gamma, x_j)}{\partial x_i} \right) d\Gamma$

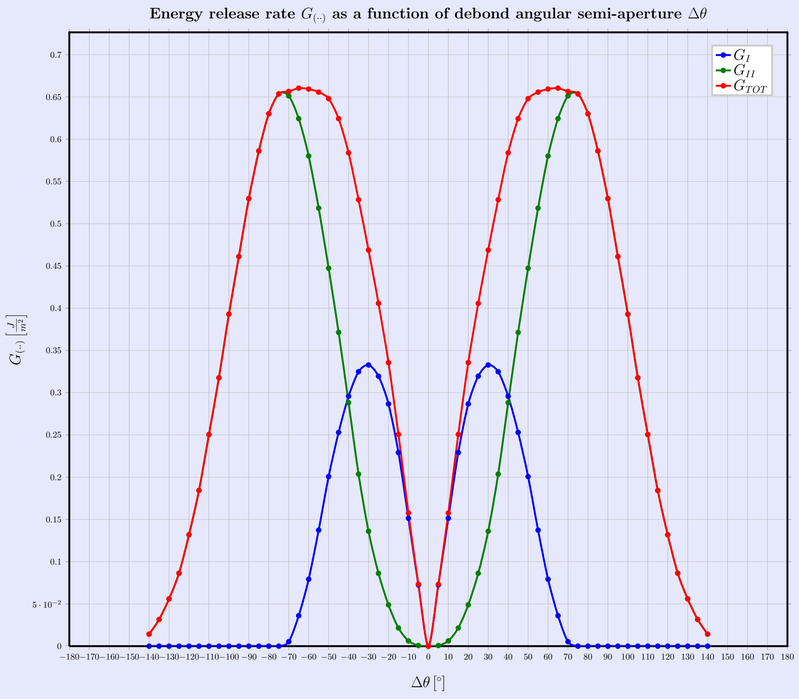
Preliminary Results & Validation



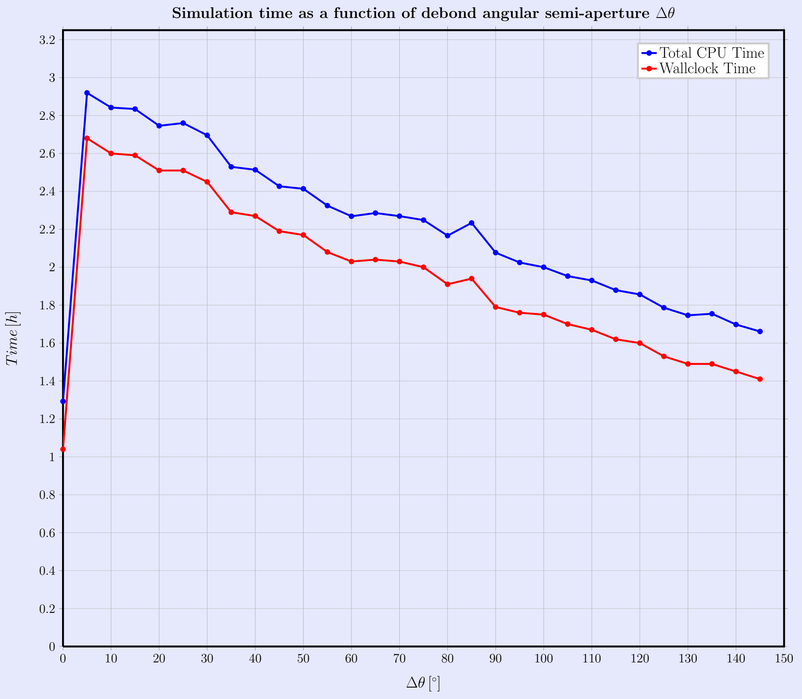
$\Delta\theta = 15°, \delta = 0.4°, VF_f = 0.001, \frac{l}{R_f} \approx 28$



$\Delta\theta = 100°, \delta = 0.4°, VF_f = 0.001, \frac{l}{R_f} \approx 28$



$\delta = 0.4°, VF_f = 0.001, \frac{l}{R_f} \approx 28$



$\delta = 0.4°, VF_f = 0.001, \frac{l}{R_f} \approx 28$

Conclusions & Perspectives

What has been accomplished?

- 2D micromechanical models have been developed to investigate crack initiation in thin ply laminates
- A numerical procedure has been devised and implemented to automatize the creation of FEM models
- Validation for $VF_f \to 0$ (matrix dominated RVE) with respect to previous literature [4, 5]

What's next?

- Investigate the dependence on VF_f, t_{ply}, $t_{ply}/t_{bounding\ \ plies}$ and different material systems
- Study numerical performances with respect to model's parameters
- Repeat for different RVEs and compare

Remerciements

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Références

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