LNCA
get into new ideas
laboratory
of new concepts
in aeronautics

Research Topics in Composite Materials @ ITA

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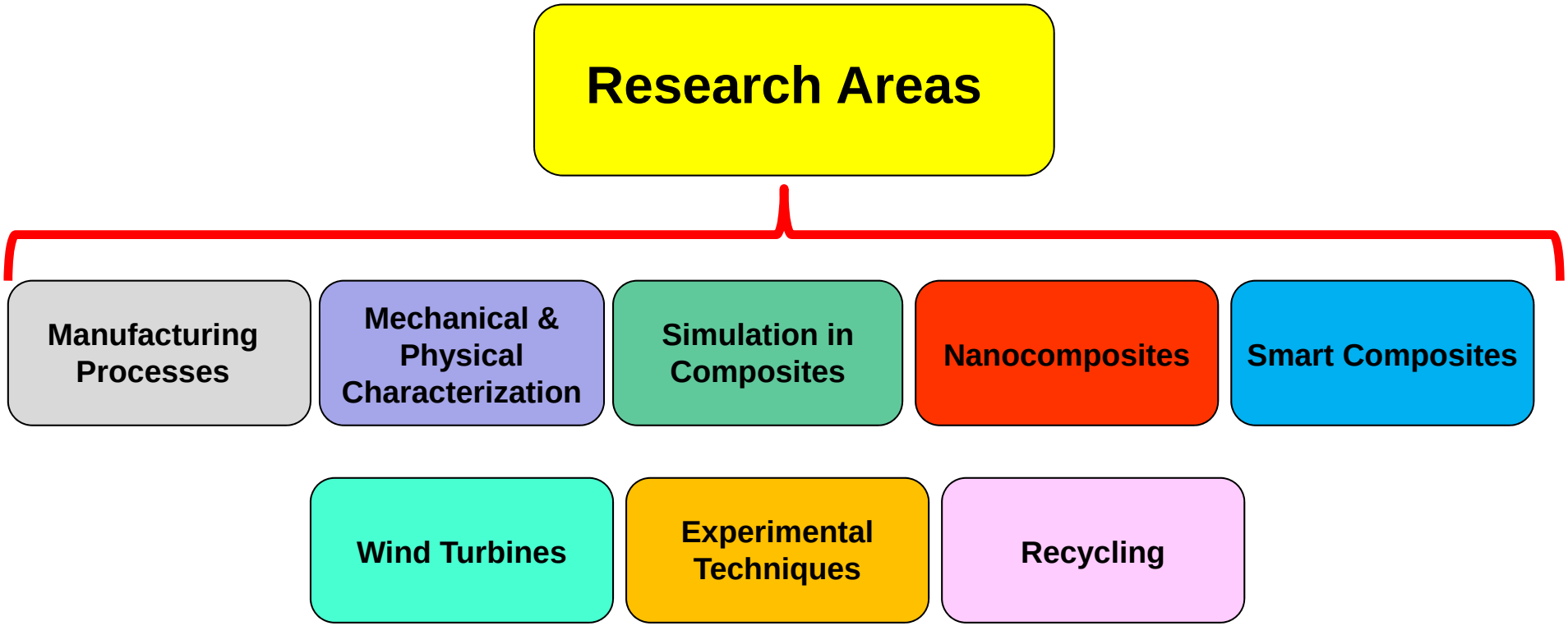
Department of Aeronautics

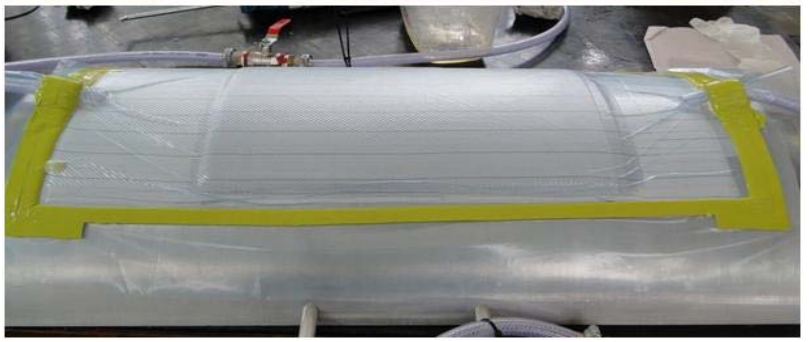

Research Areas
Manufacturing Processes
Mechanical & Physical Characterization
Simulation in Composites
Nanocomposites
Smart Composites
Wind Turbines
Experimental Techniques
Recycling

COMPOSITE MATERIALS-RESEARCH TOPICS

Manufacturing processes

RTM

RIFT



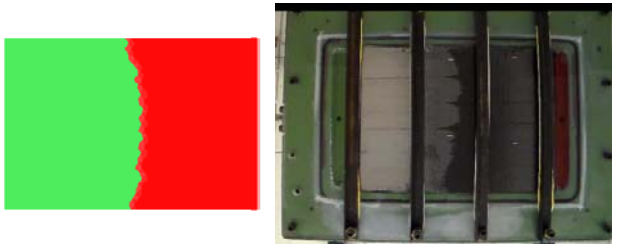
COMPOSITE MATERIALS-RESEARCH TOPICS

Manufacturing processes

CLEAN ROOM ISO 10000

RIFT/RTM PROCESSES

Resin infusion stacking



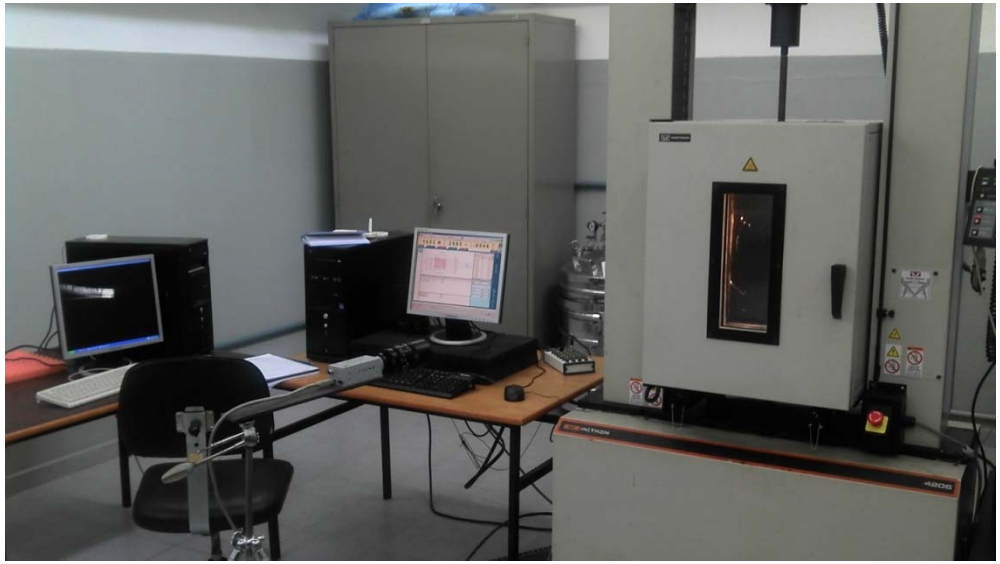
Mould filling simulation

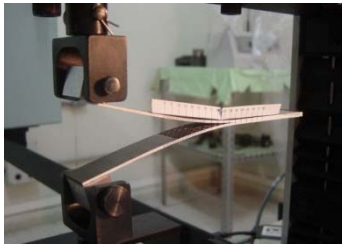
COMPOSITE MATERIALS-RESEARCH TOPICS

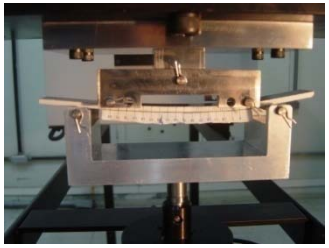
Mechanical & Physical Characterization

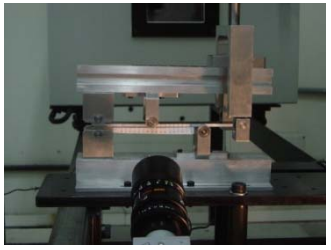
In-plane ply properties

Fracture Toughness Characterization









COMPOSITE MATERIALS-RESEARCH TOPICS

Simulation in Composites

Intralaminar failure modes

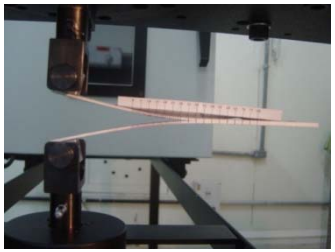
(a) Numerical prediction

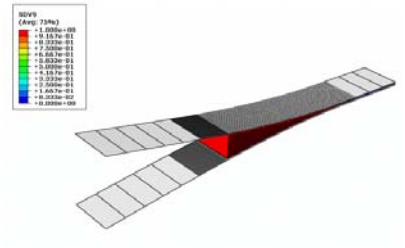
(b) Experimental

(a) Numerical prediction

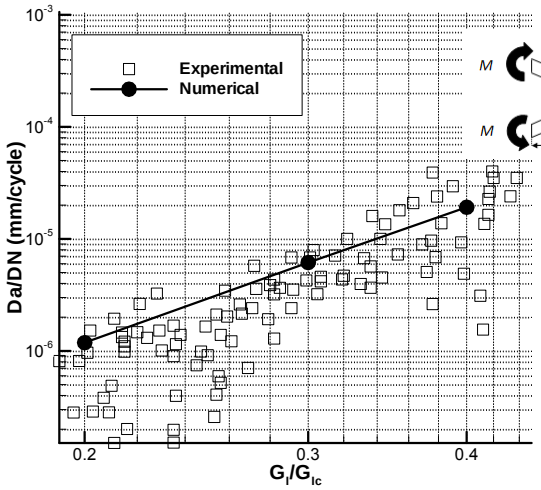
(b) Experimental

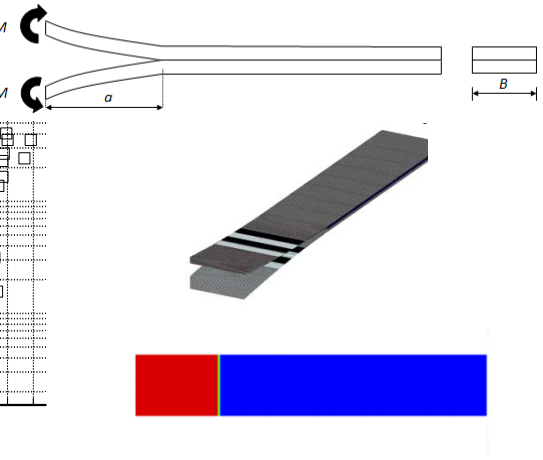
Interlaminar failure (Delamination)





Fatigue induced damage

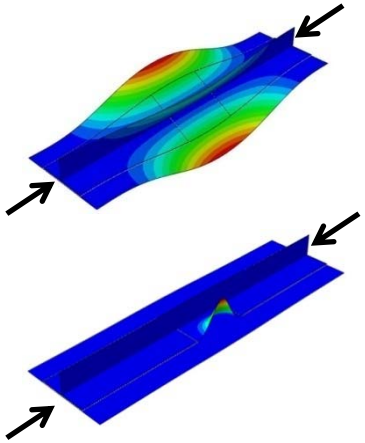


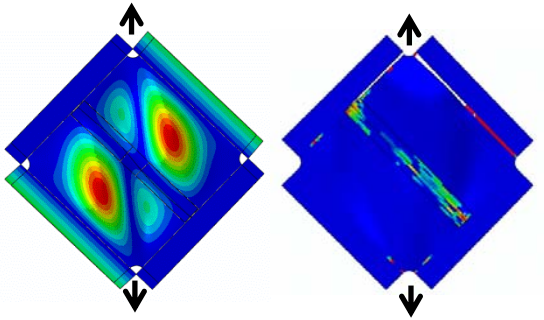


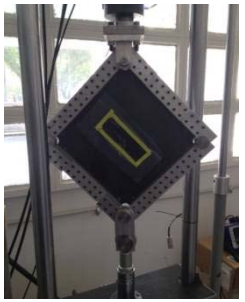
COMPOSITE MATERIALS-RESEARCH TOPICS

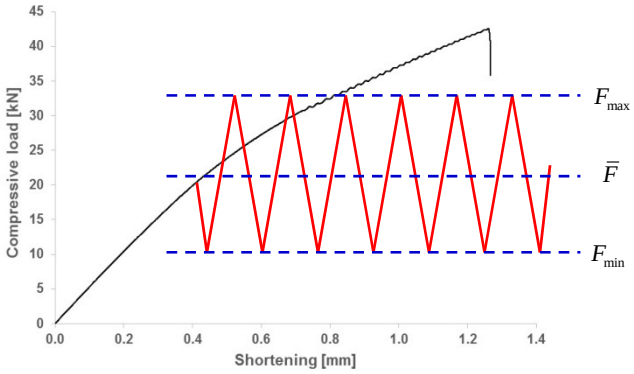
Simulation in Composites

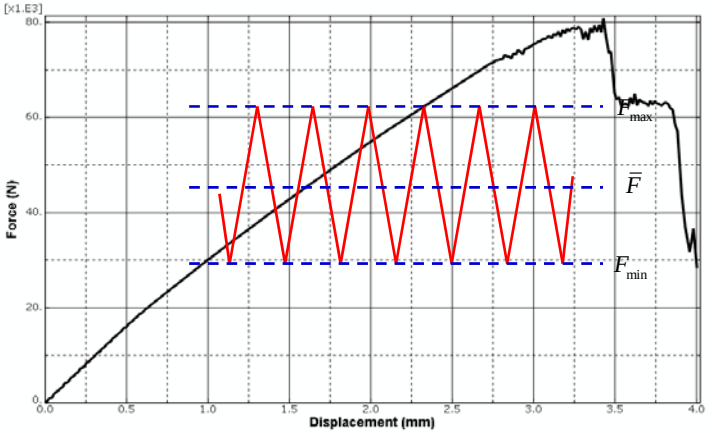
Life prediction/Durability











COMPOSITE MATERIALS-RESEARCH TOPICS

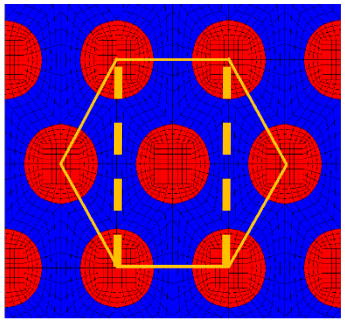
Simulation in Composites

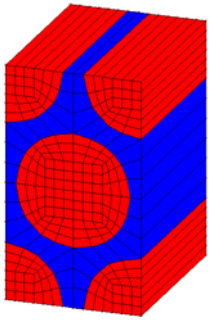
Micromechanics - Asymptotic Homogenization

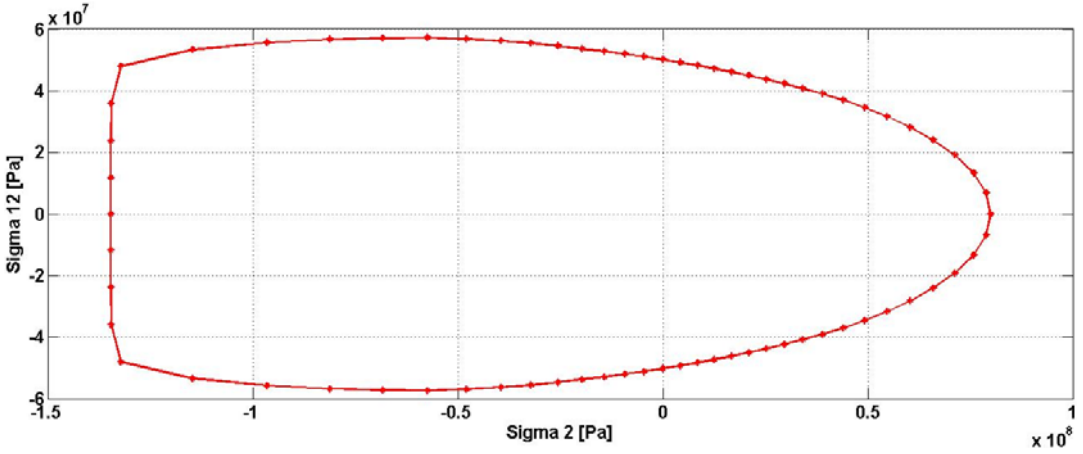
Fibre +

Matrix +

Interface Properties



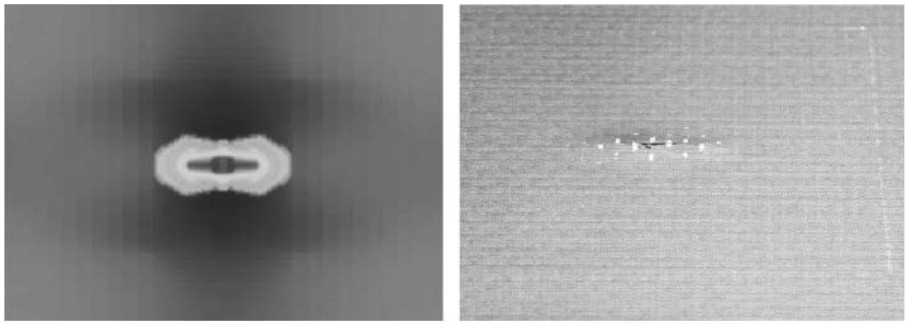




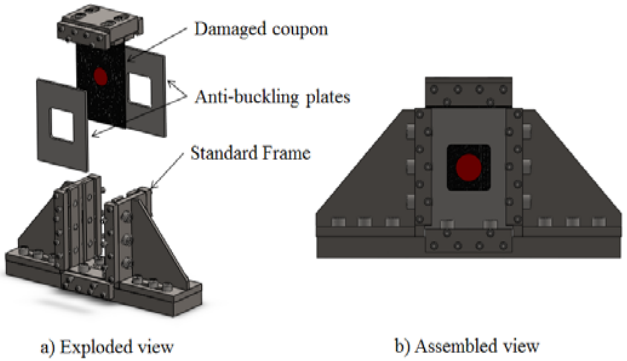
COMPOSITE MATERIALS-RESEARCH TOPICS

Simulation in Composites

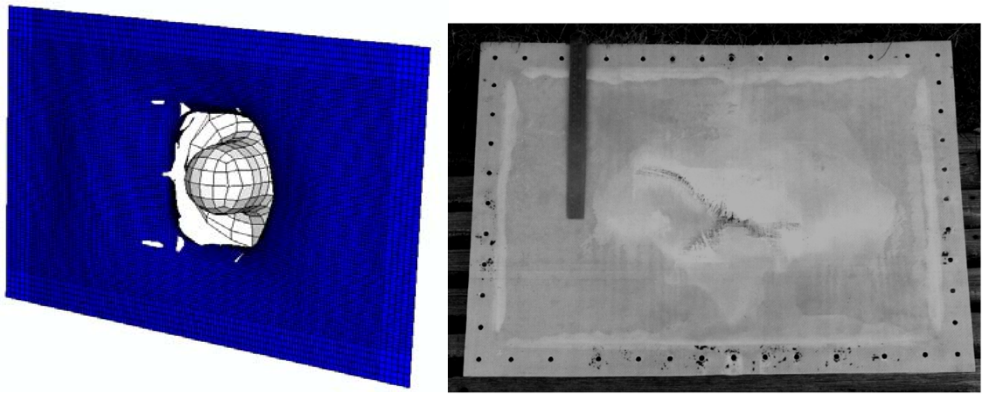
LV Impact Induced Damage

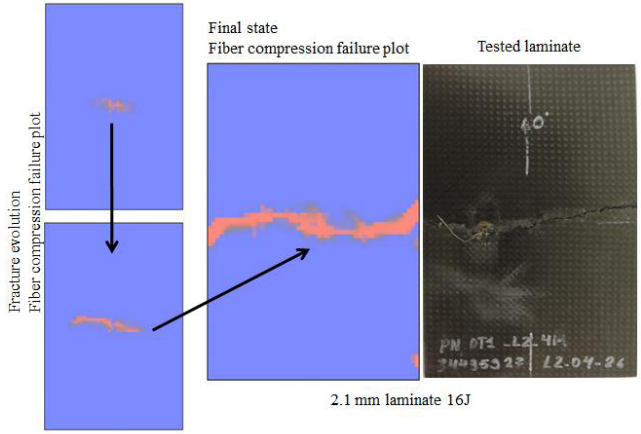


CAI Strength Prediction



Bird-Strike

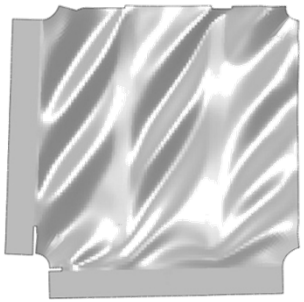
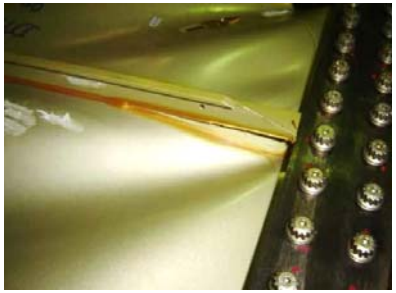
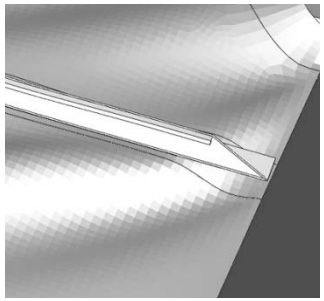




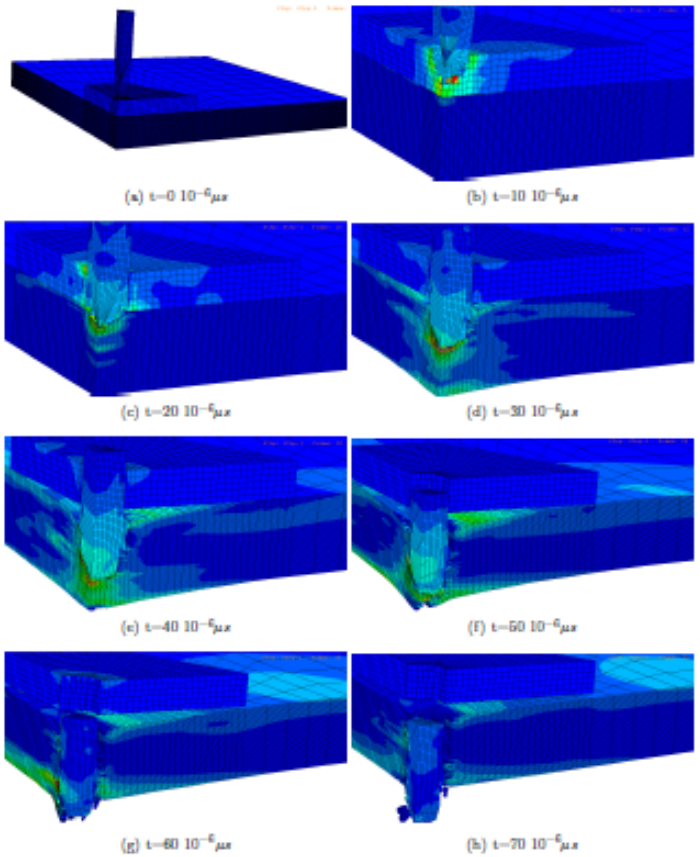
COMPOSITE MATERIALS-RESEARCH TOPICS

Simulation in Composites

Buckling, Postbuckling & Collapse (Fiber-Metal Laminates)

Experiment	FE Prediction
	
	

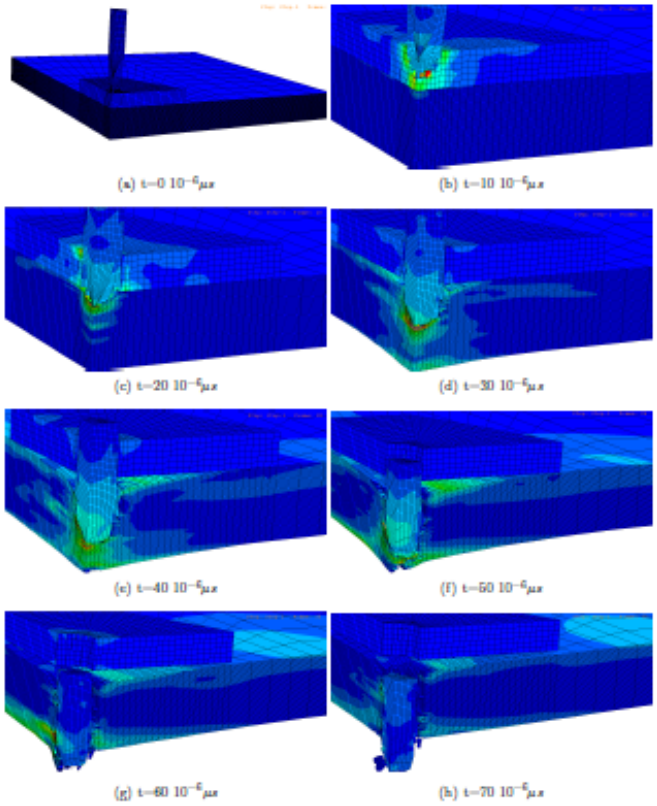
Ballistic Impact Dynamics

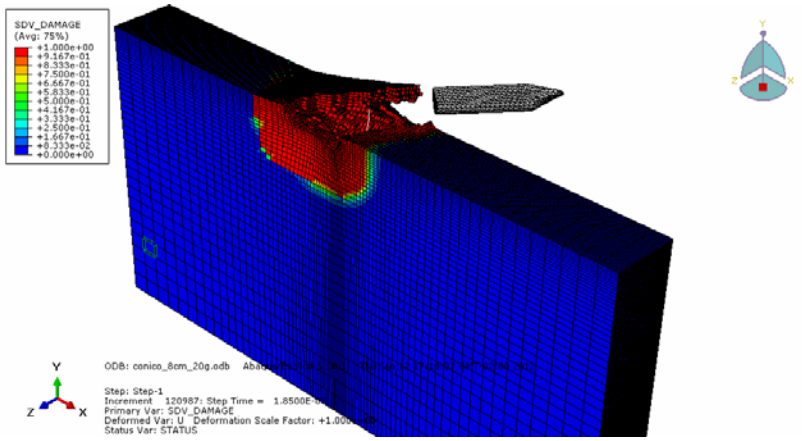


COMPOSITE MATERIALS-RESEARCH TOPICS

Simulation in Composites

Ballistic Impact Dynamics





COMPOSITE MATERIALS-RESEARCH TOPICS

Simulation in Composites

Topological and Parametric Optimization of Stiffened Composite Panels for Aeronautical Applications

Laminate with N layers

m possible orientation angles: $\theta^1, \theta^2, \ldots, \theta^m$

Each ply k may assume m values for θ_k

A laminate is defined by $\Theta_0 = \{\theta_{10}\ \theta_{20} \ldots \theta_{N0}\}$ and its lamination parameters ξ_0

For another laminate Θ one has $\xi = \{\xi_1^A\ \xi_2^A \ldots \xi_3^D\ \xi_4^D\ \xi_5^A\ \xi_6^A\}$

Objective function $f = f(\xi)$

$$\tilde{f}(\xi) = f(\xi_0) + \mathbf{s}^T(\xi - \xi_0)$$

$$\mathbf{s} = \left\{ \frac{\partial f}{\partial \xi_1^A} \quad \frac{\partial f}{\partial \xi_2^A} \quad \cdots \quad \frac{\partial f}{\partial \xi_3^D} \quad \frac{\partial f}{\partial \xi_4^D} \quad \frac{\partial f}{\partial \xi_5^A} \quad \frac{\partial f}{\partial \xi_6^A} \right\}^T$$

$$\Delta f = \mathbf{s}^T(\xi - \xi_0)$$

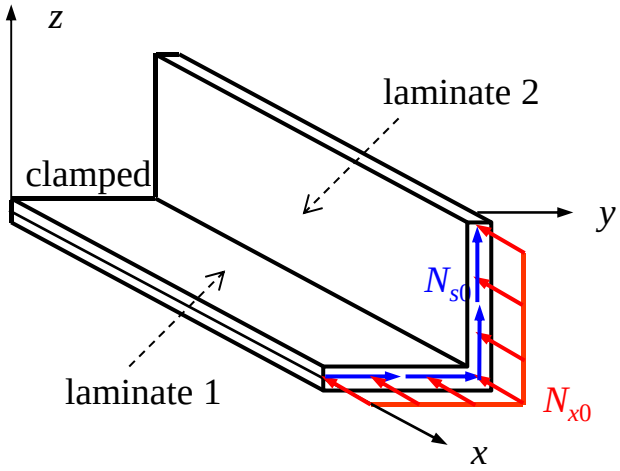
Maximize Δf with ξ restricted to lie in the feasible region.

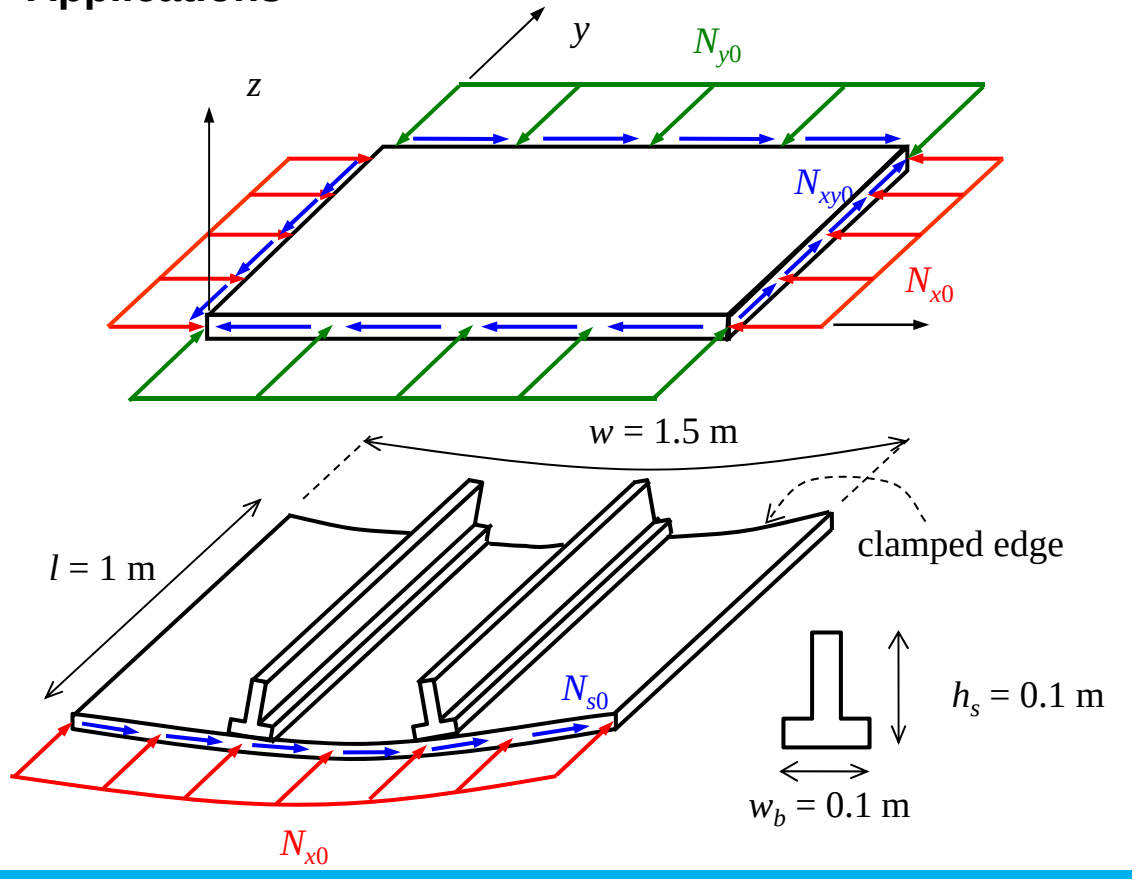
Searching all the m^N possibilities is not doable

COMPOSITE MATERIALS-RESEARCH TOPICS

Simulation in Composites

Topological and Parametric Optimization of Stiffened Composite Panels for Aeronautical Applications



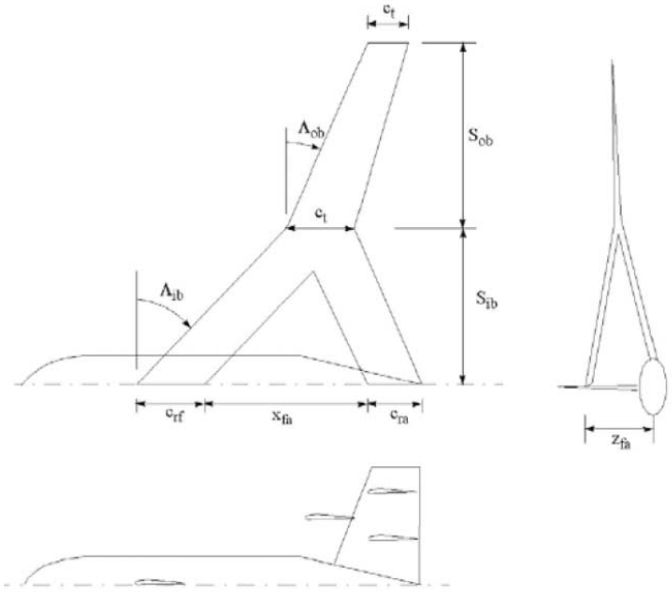


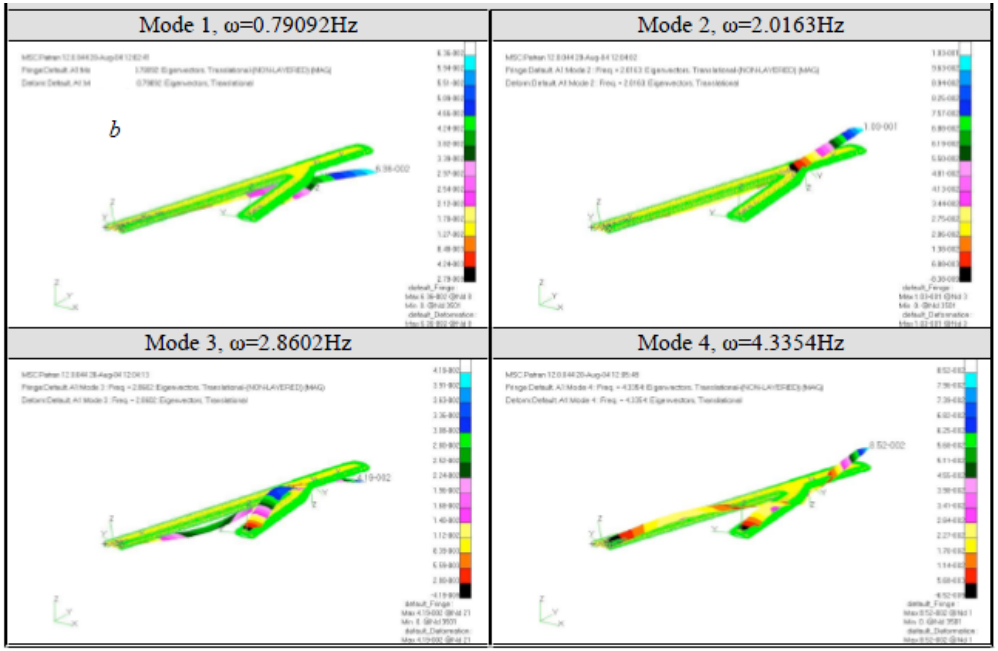
COMPOSITE MATERIALS-RESEARCH TOPICS

Simulation in Composites

Structural synthesis for prescribed frequencies and mode shapes

- The need to advance in algorithms to deal with target mode shapes in the optimization process.
- This inverse problem is of great interest for the synthesis under aeroelastic constraints or model updating algorithms (based on modal test data).
- Proposed method (without eigenvector derivatives) is under study for the joined wing aircraft.

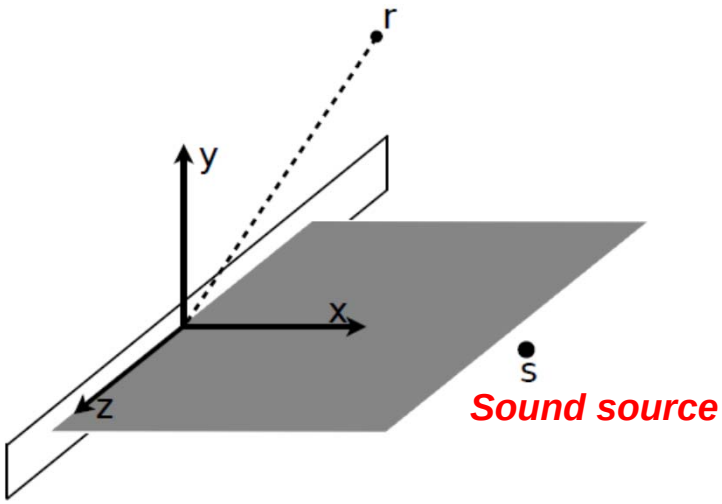




COMPOSITE MATERIALS-RESEARCH TOPICS

Simulation in Composites

Aero acoustic scattering by finite composite plates



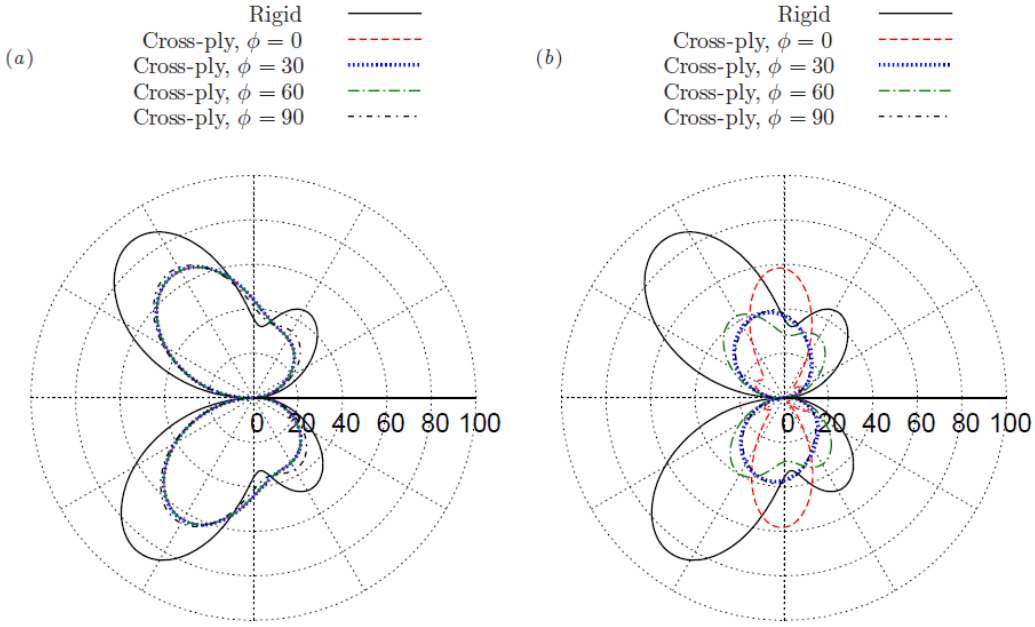
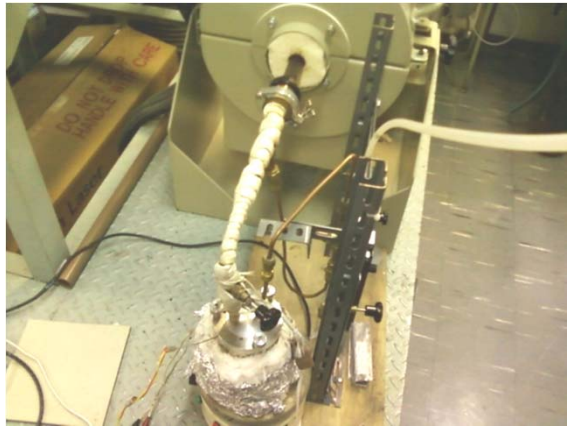


Figure 4. Acoustic directivity for $k_0 = 5$, ϵ_0=0.0021 and (*a*) $\Omega_0 = 0.1$ and (*b*) $\Omega_0 = 0.05$

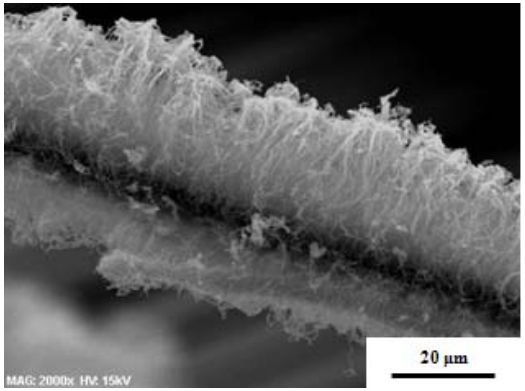
COMPOSITE MATERIALS-RESEARCH TOPICS

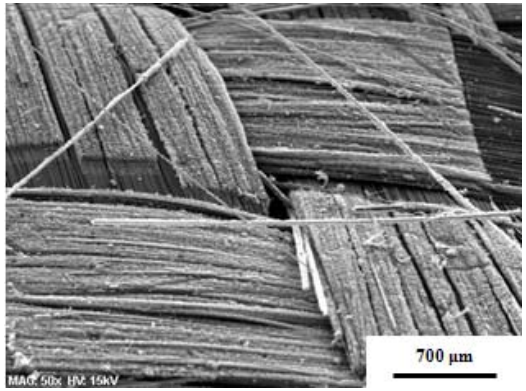
Nanocomposites

CVD reactor @ INPE

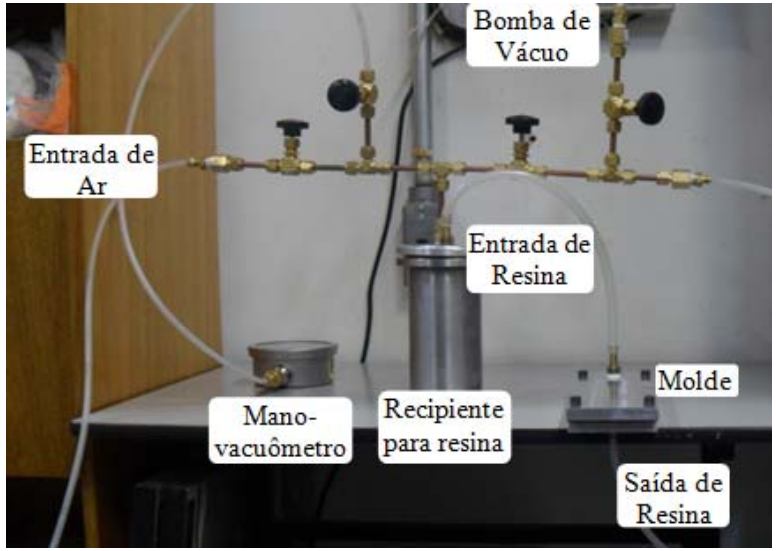


CNT growth on the fabric surface





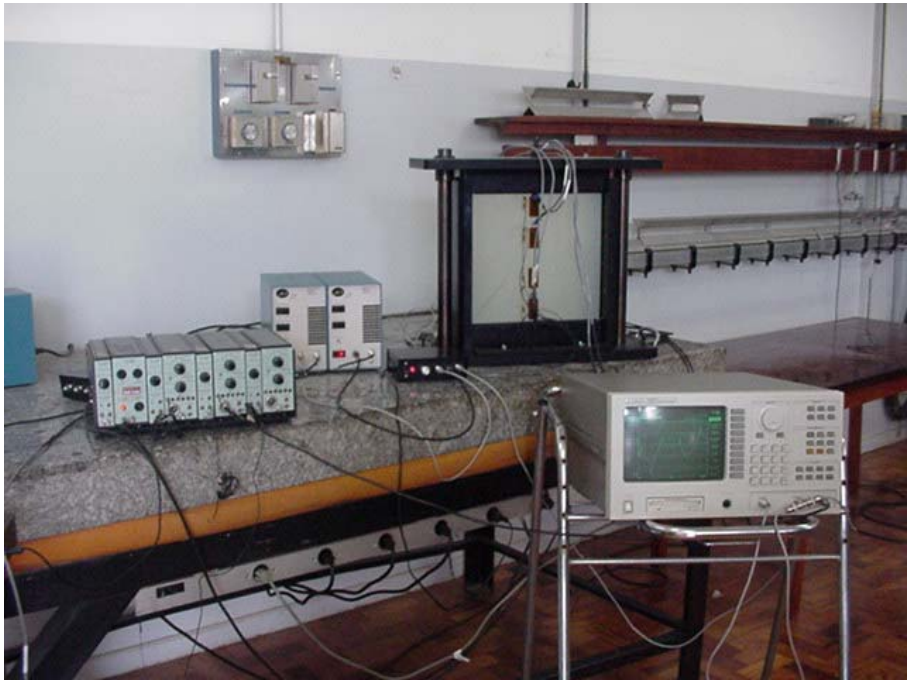
RTM Setup for Nanostructured composite manufacturing

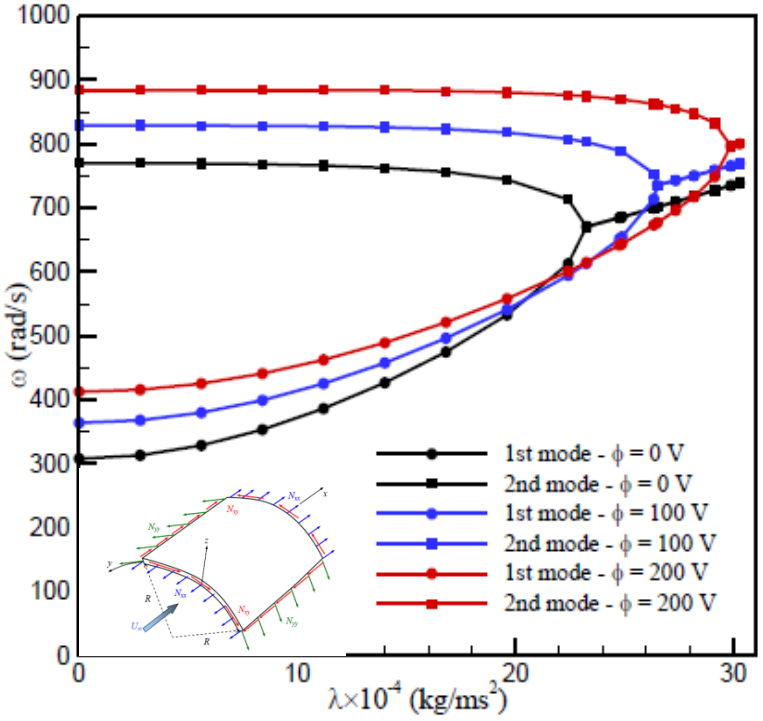


COMPOSITE MATERIALS-RESEARCH TOPICS

Smart Composites

Piezoelectric & Viscoelastic materials applied to natural frequencies, buckling load and flutter control

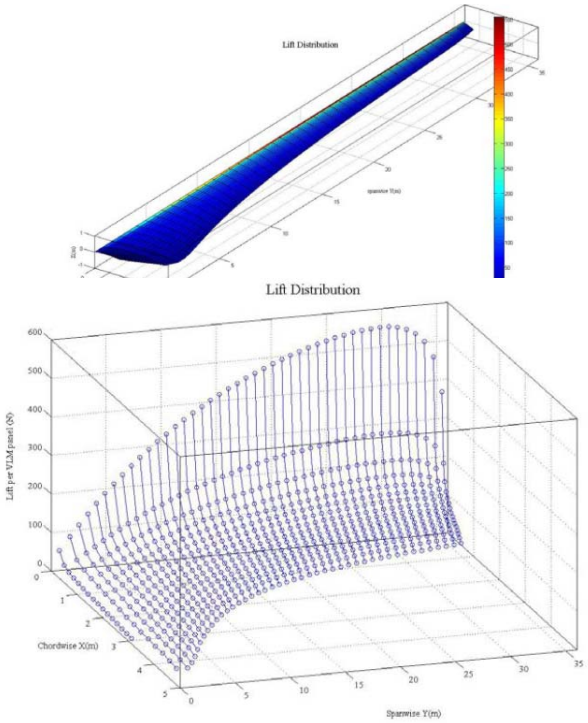


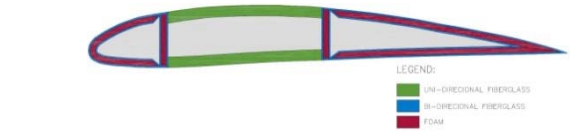


COMPOSITE MATERIALS-RESEARCH TOPICS

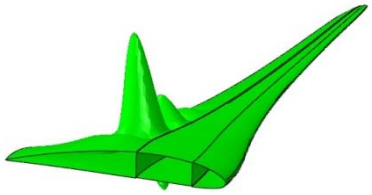
Wind Turbines

- **Development of numerical tools for steady & unsteady aerodynamic/aeroelastic analyses of wind turbines;**
- **Blade design optimization**

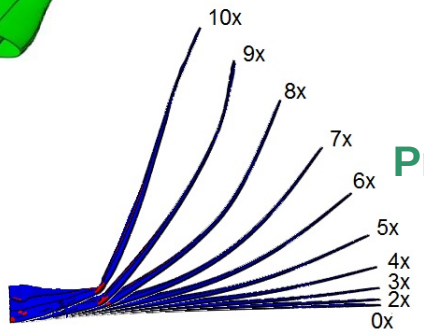




Vibration



Buckling

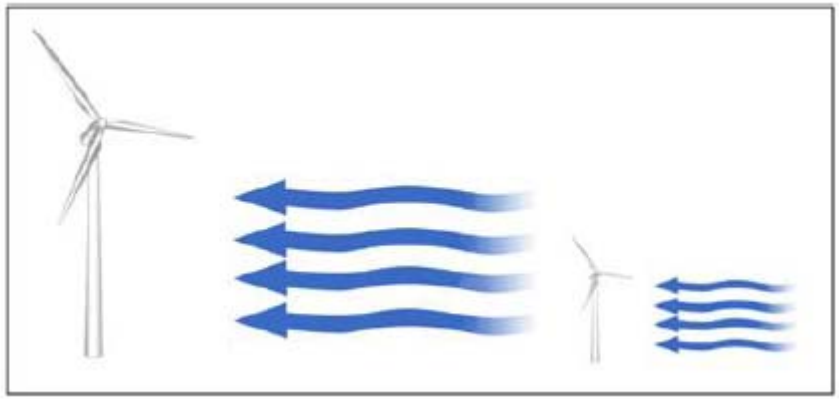


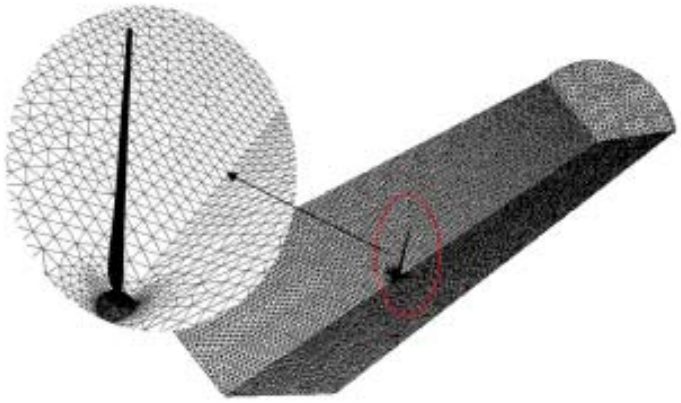
Progressive failure

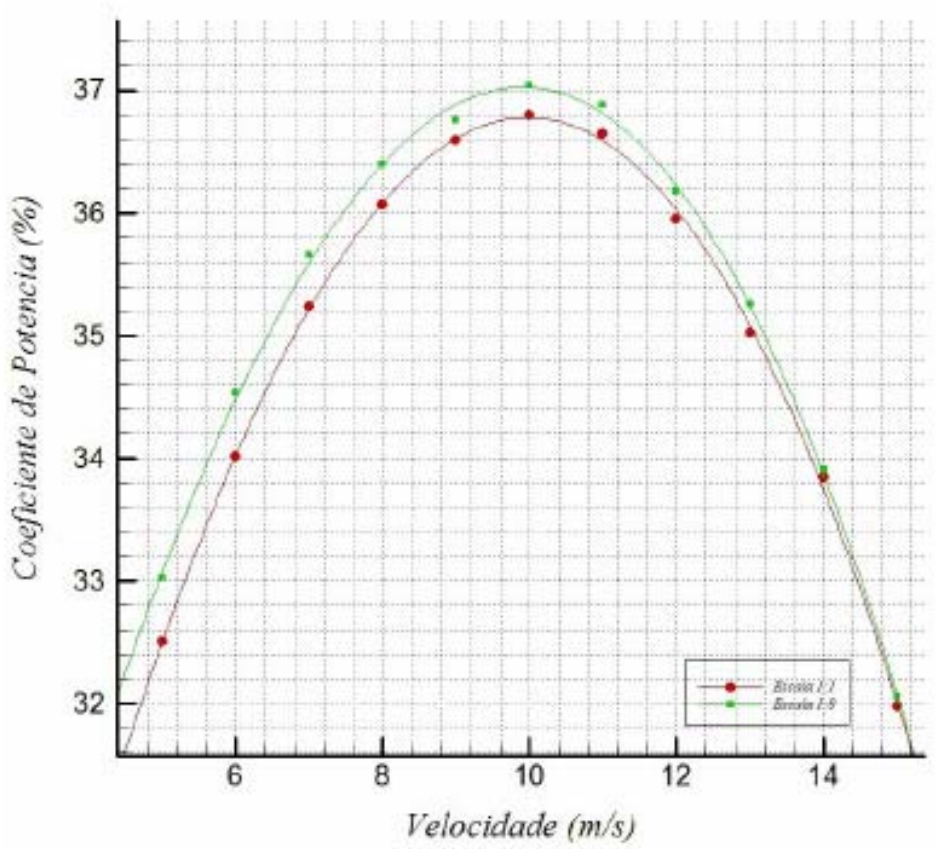
COMPOSITE MATERIALS-RESEARCH TOPICS

Wind Turbines

- **Development & validation of similarity rules for wind tunel testing**



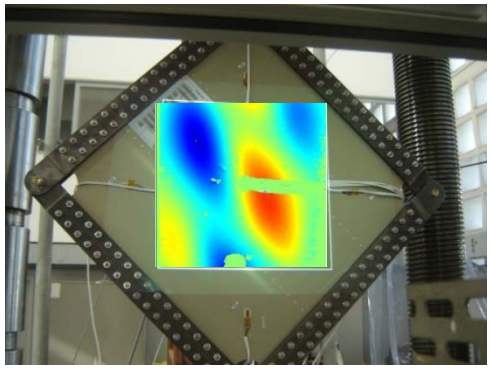




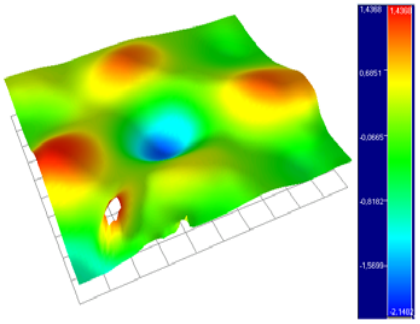
COMPOSITE MATERIALS-RESEARCH TOPICS

Experimental Techniques

Post-buckling due to shear loading



Post-buckling/Crippling in compression



Combined Shear-Bending Post-buckling

COMPOSITE MATERIALS-RESEARCH TOPICS

Experimental Techniques

Drop test tower – Impact tests

COMPOSITE MATERIALS-RESEARCH TOPICS
Experimental Techniques

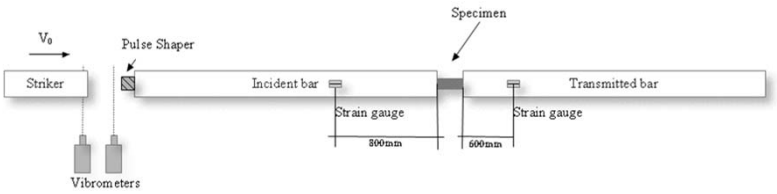
Split Hopkinson Pressure Bar testing apparatus – Strain rate effects/HVI

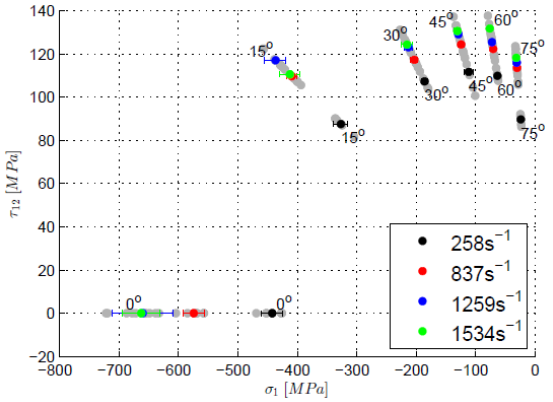
•Incident/transmitted bars dimensions: 2m, Φ1”.

•Striker : 0,3m , Φ1”. Aluminum Pulse shaper used;

•Bar material : Carbon Steel /Aluminum alloy 7075T651

•Specimen dimensions (b x h x L) : 15mm x 10mm x 10mm

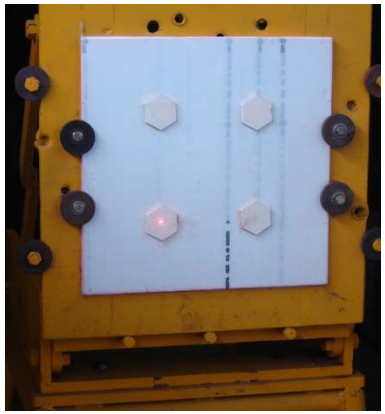


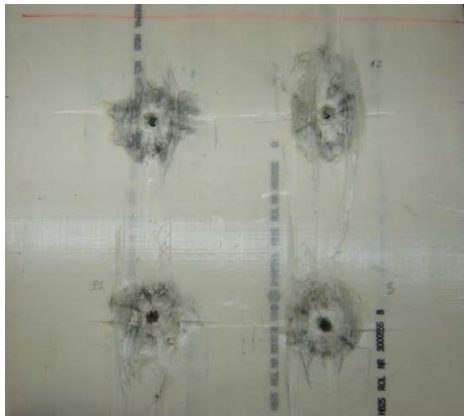


COMPOSITE MATERIALS-RESEARCH TOPICS

Experimental Techniques

HVI/Ballistic impact setup – Gas-gun

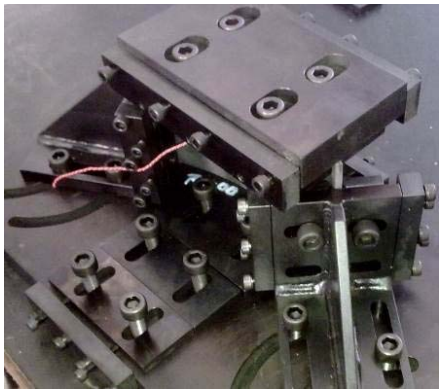




COMPOSITE MATERIALS-RESEARCH TOPICS

Experimental Techniques

CAI test rig for plates & shells



COMPOSITE MATERIALS-RESEARCH TOPICS

Experimental Techniques

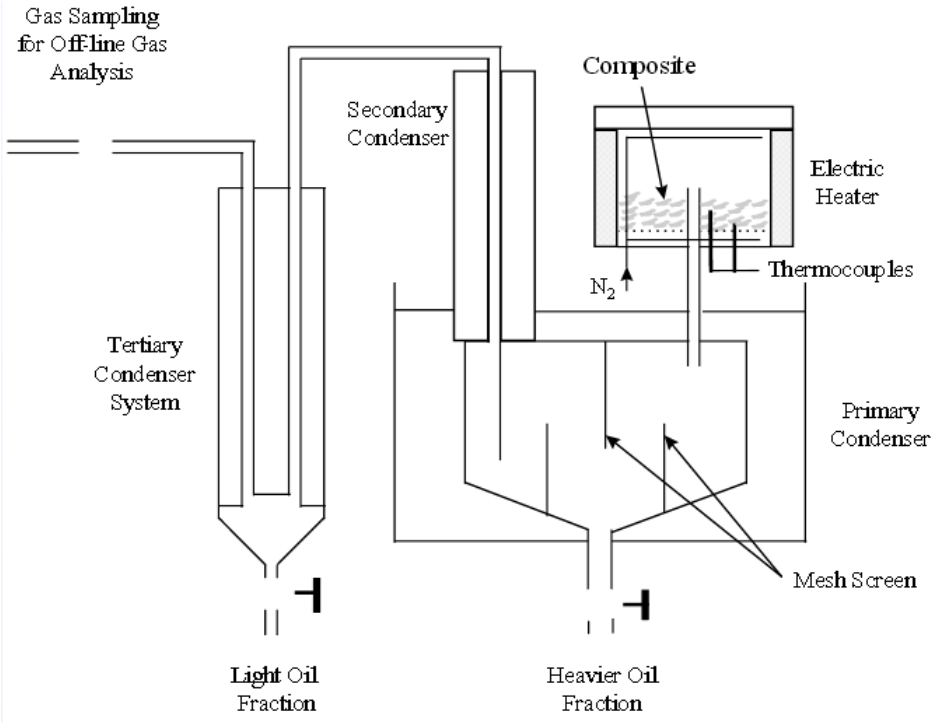
Aging & Environmental Effects

Temp./Humidity & Thermal Shock Chambers

DCB at -54 ^{0}C

COMPOSITE MATERIALS-RESEARCH TOPICS
Composites Recycling

Schematic diagram of the pyrolysis reactor



COMPOSITE MATERIALS

Research Collaboration Topics

1) Topological and Parametric Optimization of Stiffened Composite Panels for Aeronautical Applications;
2) Co-cured, co-bonded and secondary bonding composite joints;
3) Repair of Aeronautical Composite Structures;
4) Hygro-Thermo-Mechanical Fatigue of Composite Structures;
5) Impact resistance and damage tolerance of aeronautical composite panels;
6) Buckling, post-buckling and collapse of composite stiffened panels (static & dynamic (crushing))
7) Smart materials applied to aeroelasticity of composite panels (passive/active)
8) Progressive failure analysis of composite structures (multi-scale modeling)
9) Sustainable recycling processes applied to aeronautical composite structures

COMPOSITE MATERIALS

Research Collaboration Topics

10) Sandwich structures:

- Local & Global Buckling;
- Static & Dynamic Responses;
- Uncertainties quantification & validation;
- Fatigue.

THANK YOU

Questions?

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