

Projetos de Iniciação Científica

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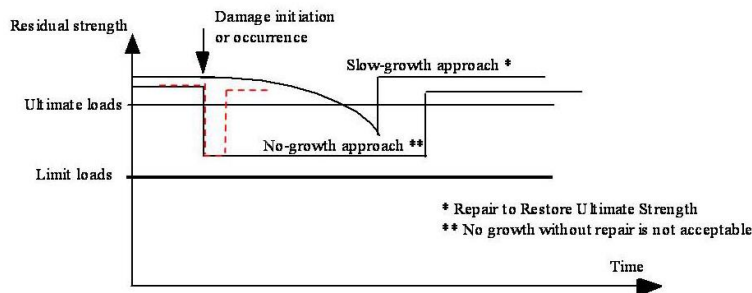
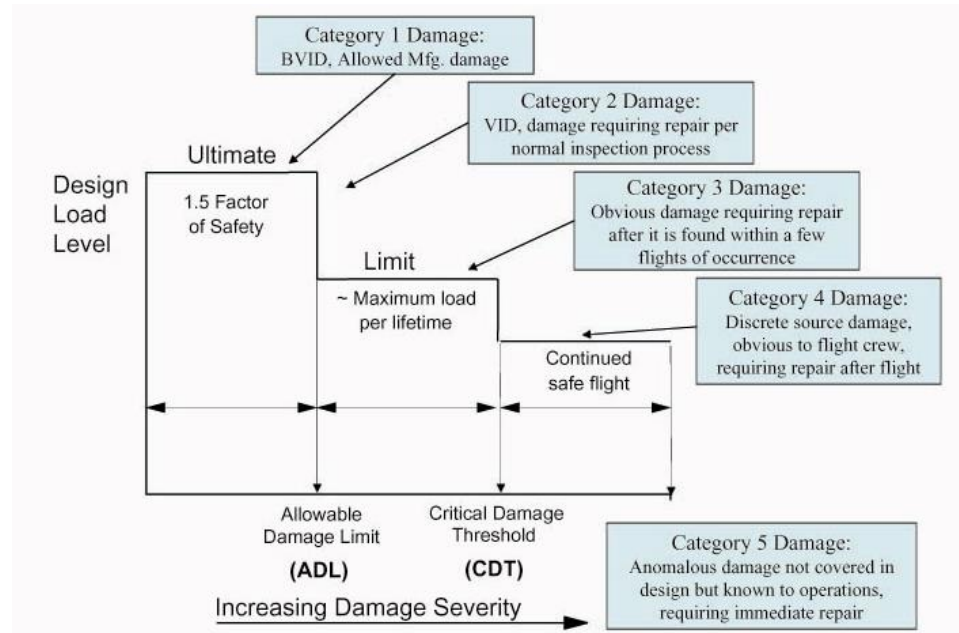
Linhas de Pesquisa

- Modelos de delaminação
- Formulação de Elementos Finitos
- Juntas Coladas
- SHM
- Termo formação de termoplásticos
- Biocompósitos
- Biomateriais

Modelos de Delaminação



Fuselagem do 787



AC 20-107B

----- Shows Acceptable Interval at reduced RS before being repaired (No-growth case).
 ——— Shows Unacceptable Interval at reduced RS before being repaired (No-growth case).

Modelos de Delaminação

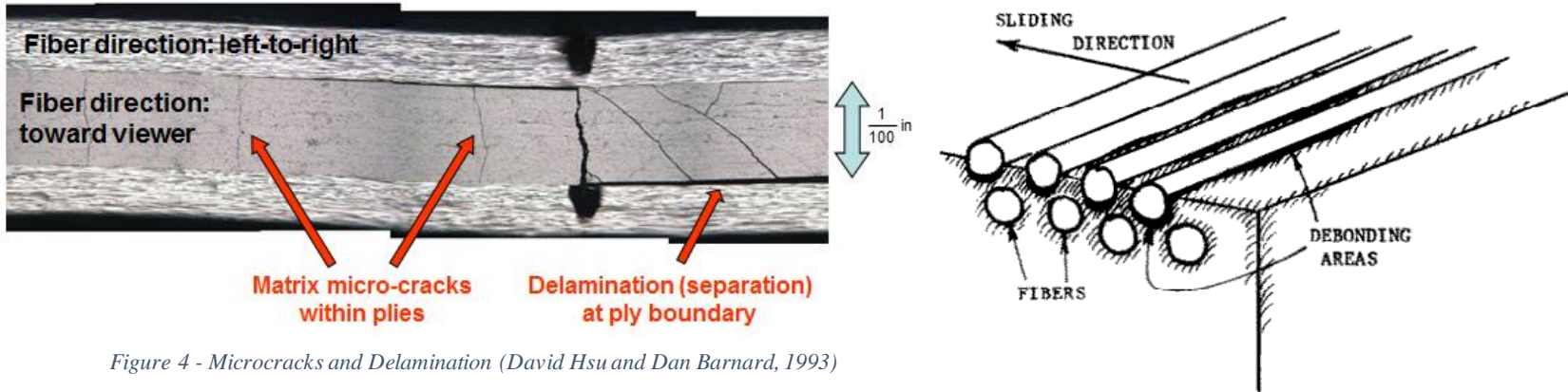
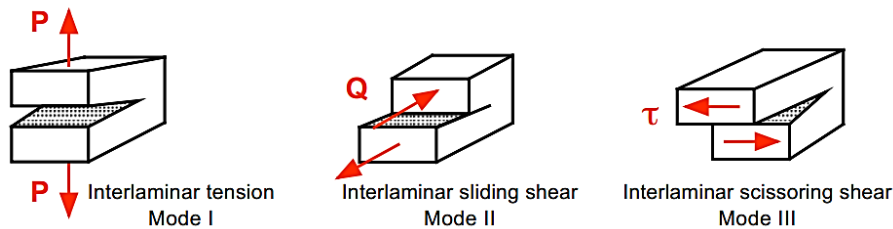


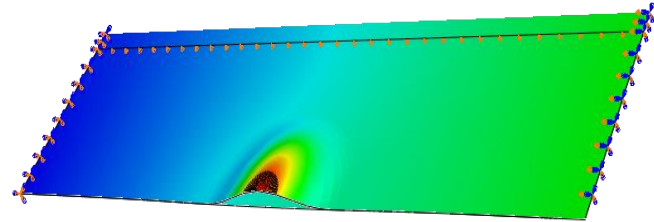
Figure 4 - Microcracks and Delamination (David Hsu and Dan Barnard, 1993)



Modelos de Delaminação

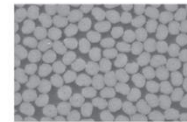
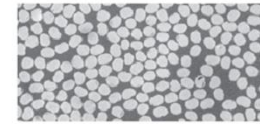
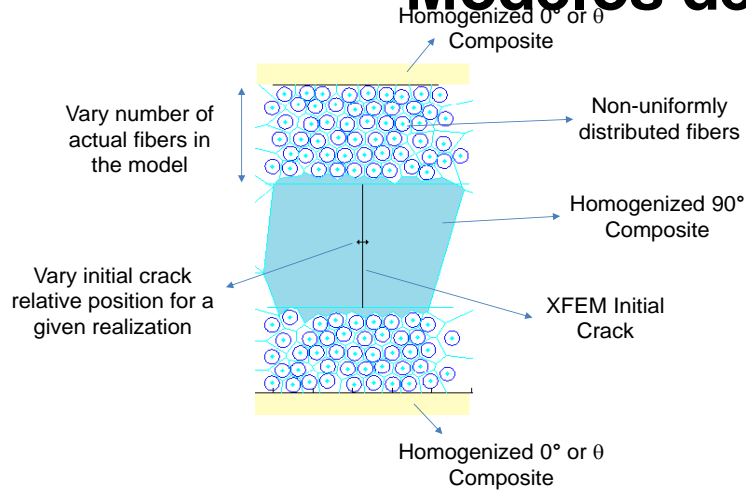


Delaminação em um corpo de prova submetido a flexão 3 pontos.

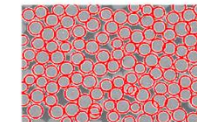
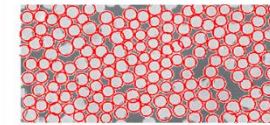


Modelo em elementos finitos de uma delaminação – Elemento de coesão.

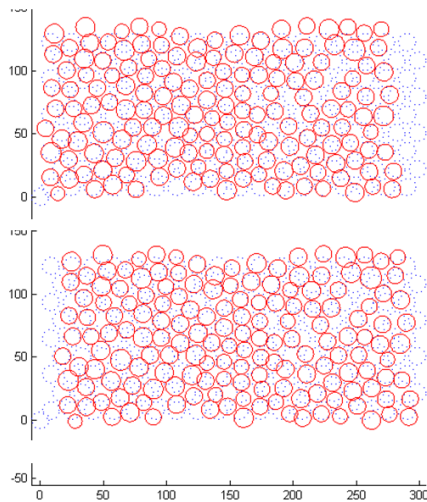
Modelos de Delaminação



Matlab



Optimization of the distances



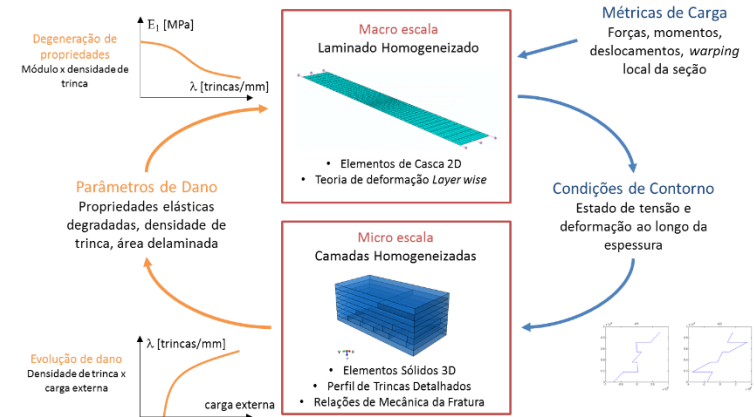
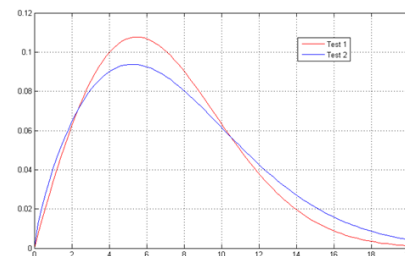
3rd Maximum likelihood estimator

$$\hat{k}^{-1} = \frac{\sum_{i=1}^n x_i^k \ln x_i}{\sum_{i=1}^n x_i^k} - \frac{1}{n} \sum_{i=1}^n \ln x_i$$

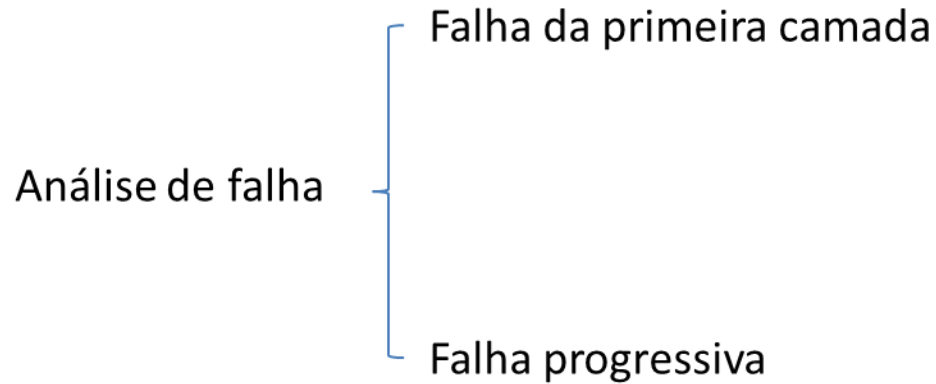
$$\hat{\lambda}^k = \frac{1}{n} \sum_{i=1}^n x_i^k$$

$$k=1.9611, \lambda=7.8591$$

$$k=1.7533, \lambda=8.4591$$



Formulação de Elementos Finitos



Degradação criteriosa dos componentes da matriz de rigidez.

- MEF é normalmente utilizado.
- Não é raro ocorrer problemas de convergência.
- Grandes descontinuidades.

Formulação de Elementos Finitos

XFEM – Conceitos Básicos

Partição da unidade: $\sum_i \phi_i = 1 \longrightarrow \sum_i \phi_i \psi = \psi$

Fundamento matemático para desenvolvimento do enriquecimento



Graus de liberdade adicionais;

$$u \approx \sum_{i=1}^n N_i u_i + \sum_{l=1}^{np} \sum_{k=1}^m N_k \psi^l a_k^l$$

Graus de liberdade regulares;

Funções de enriquecimento;

OBS: São escolhidas de modo a representar o fenômeno físico

Funções de forma XFEM



$$\phi_{i\alpha} = \varphi_\alpha L_{i\alpha}$$

$$\varphi_\alpha = f(\xi, \eta) \qquad L_{i\alpha} = f(\xi, \eta)$$

Formulação de Elementos Finitos

$$\underline{\underline{\mathbf{K}}}\underline{\underline{\mathbf{u}}} = \underline{\underline{\mathbf{f}}}$$

$$\mathbf{K}_{ij}^e = \begin{bmatrix} \mathbf{K}_{ij}^{uu} & \mathbf{K}_{ij}^{ua} \\ \mathbf{K}_{ij}^{au} & \mathbf{K}_{ij}^{aa} \end{bmatrix}$$

$$\mathbf{u} = \{\mathbf{u} \ \mathbf{a}\}^t$$

$$\mathbf{f}_i^e = \{\mathbf{f}_i^u \ \mathbf{f}_i^a\}^t$$

$$\mathbf{K}_{ij}^e = \int_{\Omega} (\mathbf{B}_i^r)^t \mathbf{D} (\mathbf{B}_j^s) d\Omega \quad (r, s = u, a)$$

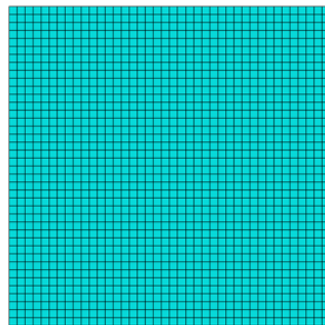
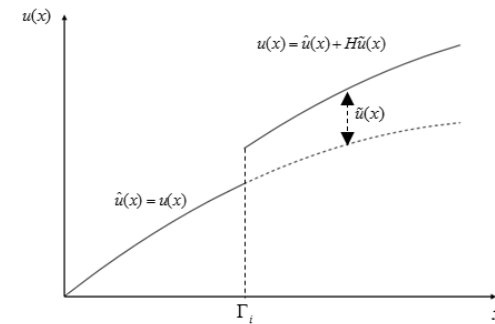
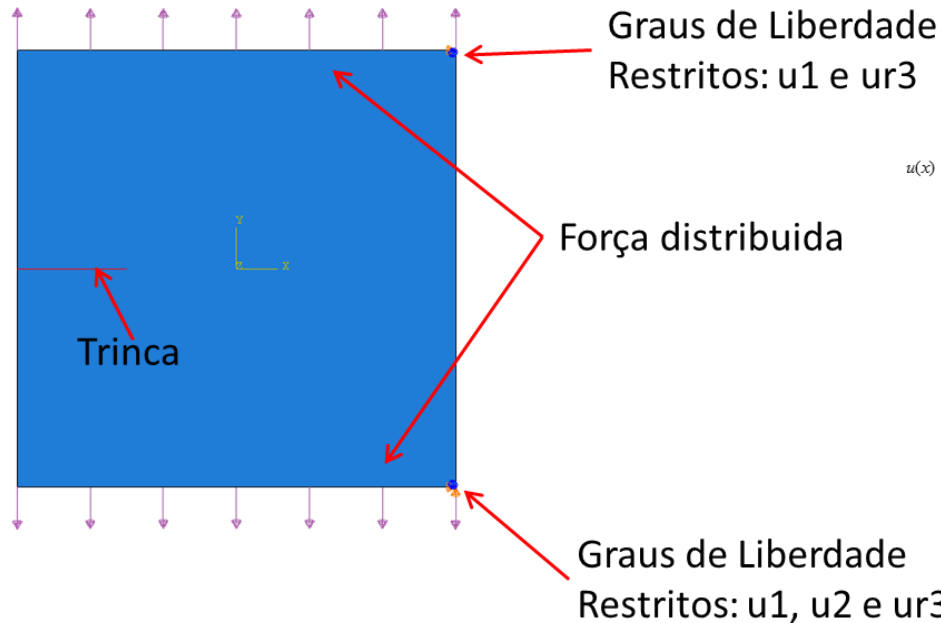
$$\mathbf{B}_i^u = \begin{bmatrix} N_{i,\xi} & 0 \\ 0 & N_{i,\eta} \\ N_{i,\eta} & N_{i,\xi} \end{bmatrix}$$

$$\mathbf{f}_i^u = \int_{\Gamma} N_i \mathbf{f} d\Gamma + \int_{\Omega} N_i \mathbf{Q} d\Omega$$

$$\mathbf{B}_i^a = \begin{bmatrix} (N_i \psi)_{,\xi} & 0 \\ 0 & (N_i \psi)_{,\eta} \\ (N_i \psi)_{,\eta} & (N_i \psi)_{,\xi} \end{bmatrix}$$

$$\mathbf{f}_i^a = \int_{\Gamma} N_i \psi \mathbf{f} d\Gamma + \int_{\Omega} N_i \psi \mathbf{Q} d\Omega$$

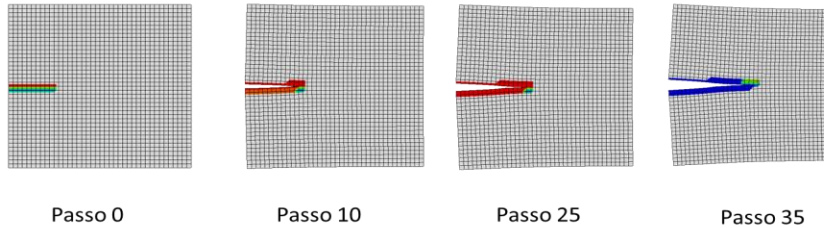
Formulação de Elementos Finitos



Malha estruturada;
1600 elementos;
Elementos de 4 nós para estado
plano de tensão com função de
forma linear, integração reduzida.

Formulação de Elementos Finitos

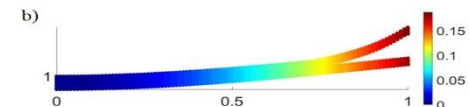
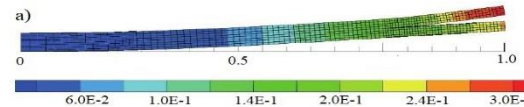
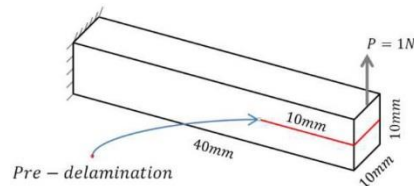
Resultados:



Resultado: PHILSM
Signed distance function to describe the crack surface.

ANALYSIS OF DELAMINATION OF COMPOSITE LAMINATES VIA XFEM BASED ON THE LAYERWISE DISPLACEMENT THEORY AND COHESIVE ZONE METHOD

$$\sum_{k=1}^L \int_{\Omega} \int_{z_{bot}}^{z_{top}} B_{ji}^k D_{jm}^k B_{mn}^k dz d\Omega + \int_{\Gamma_d} (N_i \phi_m Th_m)(t_j(\tilde{u}) \phi_n Th_n) d\Gamma_d = \int_{\Gamma_t} N_i \phi_m \bar{t} d\Gamma_t + \int_{\Gamma_t} N_i \phi_m Th_m \bar{t} d\Gamma_t$$



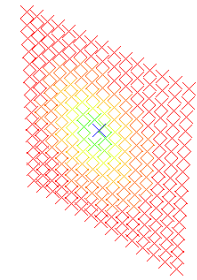
Formulação de Elementos Finitos

Formulação Unificada – HSDT e Layer Wise

$$\begin{aligned}
 K_{xx}^{kz\beta} &= Z_{pp11}^{kz\beta} \langle N_{i,x} N_{j,x} \rangle_n + Z_{pp15}^{kz\beta} \langle N_{i,y} N_{j,x} \rangle_n + Z_{pp16}^{kz\beta} \langle N_{i,x} N_{j,y} \rangle_n + \\
 &\quad + Z_{pp66}^{kz\beta} \langle N_{i,y} N_{j,y} \rangle_n + Z_{nn55}^{kz\beta} \langle N_i N_j \rangle_n \\
 K_{yy}^{kz\beta} &= Z_{pp12}^{kz\beta} \langle N_{i,x} N_{j,y} \rangle_n + Z_{pp14}^{kz\beta} \langle N_{i,y} N_{j,y} \rangle_n + Z_{pp15}^{kz\beta} \langle N_{i,x} N_{j,x} \rangle_n + \\
 &\quad + Z_{pp66}^{kz\beta} \langle N_{i,y} N_{j,x} \rangle_n + Z_{nn55}^{kz\beta} \langle N_i N_j \rangle_n \\
 K_{zz}^{kz\beta} &= Z_{pp33}^{kz\beta} \langle N_{i,x} N_j \rangle_n + Z_{pp36}^{kz\beta} \langle N_{i,y} N_j \rangle_n + Z_{nn55}^{kz\beta} \langle N_i N_{j,x} \rangle_n + \\
 &\quad + Z_{nn45}^{kz\beta} \langle N_i N_{j,y} \rangle_n \\
 K_{yx}^{kz\beta} &= Z_{pp12}^{kz\beta} \langle N_{i,y} N_{j,x} \rangle_n + Z_{pp25}^{kz\beta} \langle N_{i,x} N_{j,x} \rangle_n + Z_{pp26}^{kz\beta} \langle N_{i,y} N_{j,y} \rangle_n + \\
 &\quad + Z_{pp66}^{kz\beta} \langle N_{i,x} N_{j,y} \rangle_n + Z_{nn45}^{kz\beta} \langle N_i N_j \rangle_n \\
 K_{xy}^{kz\beta} &= Z_{pp22}^{kz\beta} \langle N_{i,y} N_{j,y} \rangle_n + Z_{pp25}^{kz\beta} \langle N_{i,x} N_{j,y} \rangle_n + Z_{pp26}^{kz\beta} \langle N_{i,y} N_{j,x} \rangle_n + \\
 &\quad + Z_{pp66}^{kz\beta} \langle N_{i,x} N_{j,x} \rangle_n + Z_{nn44}^{kz\beta} \langle N_i N_j \rangle_n \\
 K_{xz}^{kz\beta} &= Z_{pp33}^{kz\beta} \langle N_{i,y} N_j \rangle_n + Z_{pp36}^{kz\beta} \langle N_{i,x} N_j \rangle_n + Z_{nn45}^{kz\beta} \langle N_i N_{j,x} \rangle_n + \\
 &\quad + Z_{nn44}^{kz\beta} \langle N_i N_{j,y} \rangle_n \\
 K_{zx}^{kz\beta} &= Z_{nn55}^{kz\beta} \langle N_{i,x} N_j \rangle_n + Z_{nn45}^{kz\beta} \langle N_{i,y} N_j \rangle_n + Z_{nn33}^{kz\beta} \langle N_i N_{j,x} \rangle_n + \\
 &\quad + Z_{pp36}^{kz\beta} \langle N_i N_{j,y} \rangle_n \\
 K_{zy}^{kz\beta} &= Z_{nn55}^{kz\beta} \langle N_{i,x} N_j \rangle_n + Z_{nn44}^{kz\beta} \langle N_{i,y} N_j \rangle_n + Z_{nn33}^{kz\beta} \langle N_i N_{j,y} \rangle_n + \\
 &\quad + Z_{pp36}^{kz\beta} \langle N_i N_{j,x} \rangle_n \\
 K_{zz}^{kz\beta} &= Z_{nn55}^{kz\beta} \langle N_{i,x} N_{j,x} \rangle_n + Z_{nn45}^{kz\beta} \langle N_{i,y} N_{j,x} \rangle_n + Z_{nn45}^{kz\beta} \langle N_{i,x} N_{j,y} \rangle_n + \\
 &\quad + Z_{nn44}^{kz\beta} \langle N_{i,y} N_{j,y} \rangle_n + Z_{nn33}^{kz\beta} \langle N_i N_j \rangle_n
 \end{aligned}$$

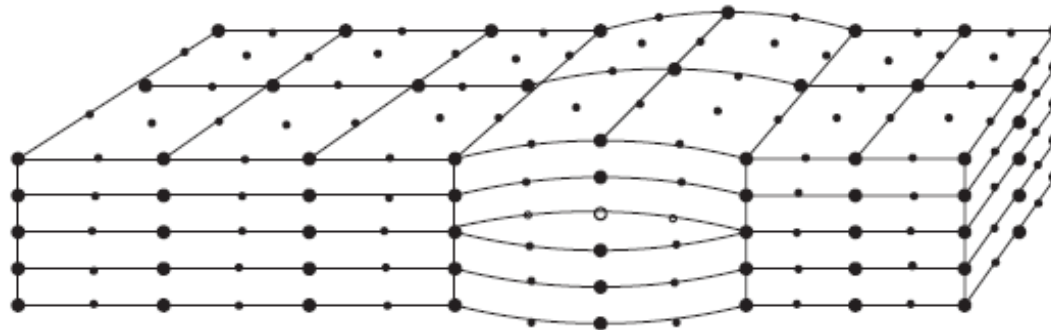
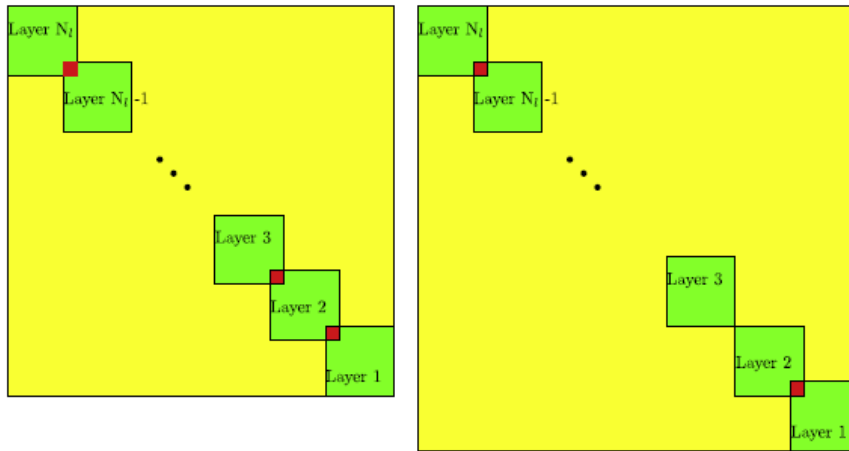
$$\text{kernel}_{CGF} \rightarrow \mathbf{K}_{CGF}^{krsij} = \begin{bmatrix} [\mathbf{K}_{uu}^{krs}] & [\mathbf{K}_{uw}^{krs}] \\ [\mathbf{K}_{wu}^{krs}] & [\mathbf{K}_{ww}^{krs}] \end{bmatrix}_{ij}^{(e)} =$$

$$\left[\begin{array}{cccccc}
 \mathbf{K}_{uu}^{kr_u s_u} & \mathbf{K}_{uv}^{kr_u s_v} & \mathbf{K}_{uw}^{kr_u s_w} & \mathbf{K}_{uw,x}^{kr_u s_w} & \mathbf{K}_{uw,y}^{kr_u s_w} & \mathbf{K}_{uw,xy}^{kr_u s_w} \\
 & \mathbf{K}_{vv}^{kr_v s_v} & \mathbf{K}_{vw}^{kr_v s_w} & \mathbf{K}_{vw,x}^{kr_v s_w} & \mathbf{K}_{vw,y}^{kr_v s_w} & \mathbf{K}_{vw,xy}^{kr_v s_w} \\
 & & \mathbf{k}_{ww}^{kr_w s_w} & \mathbf{K}_{ww,x}^{kr_w s_w} & \mathbf{K}_{ww,y}^{kr_w s_w} & \mathbf{K}_{ww,xy}^{kr_w s_w} \\
 & & & \mathbf{K}_{w,x}^{kr_w s_w} & \mathbf{K}_{w,x}^{kr_w s_w} & \mathbf{K}_{w,x}^{kr_w s_w} \\
 & & & & \mathbf{K}_{w,y}^{kr_w s_w} & \mathbf{K}_{w,y}^{kr_w s_w} \\
 & & & & & \mathbf{K}_{w,xy}^{kr_w s_w}
 \end{array} \right]_{ij}^{(e)}$$

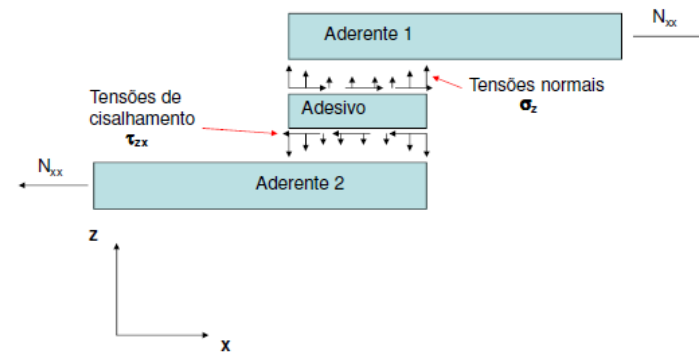
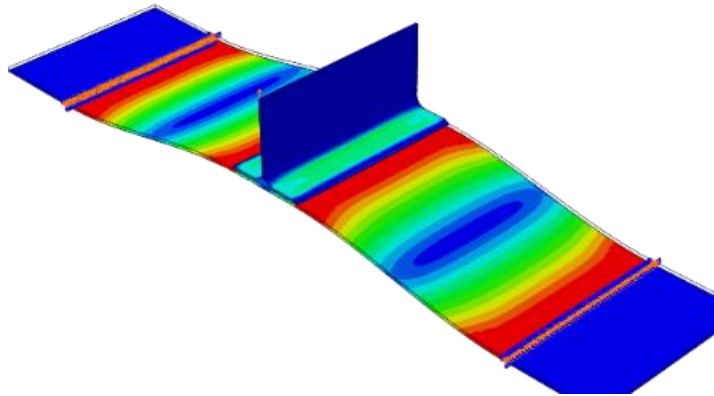
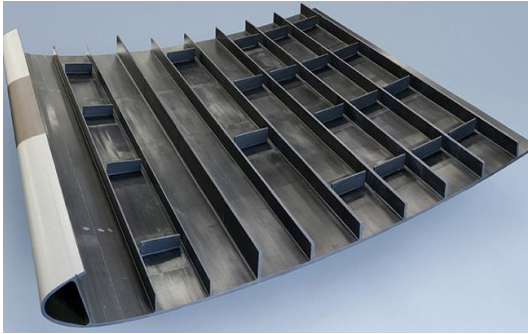


Formulação de Elementos Finitos

Formulação Unificada – HSDT e Layer Wise

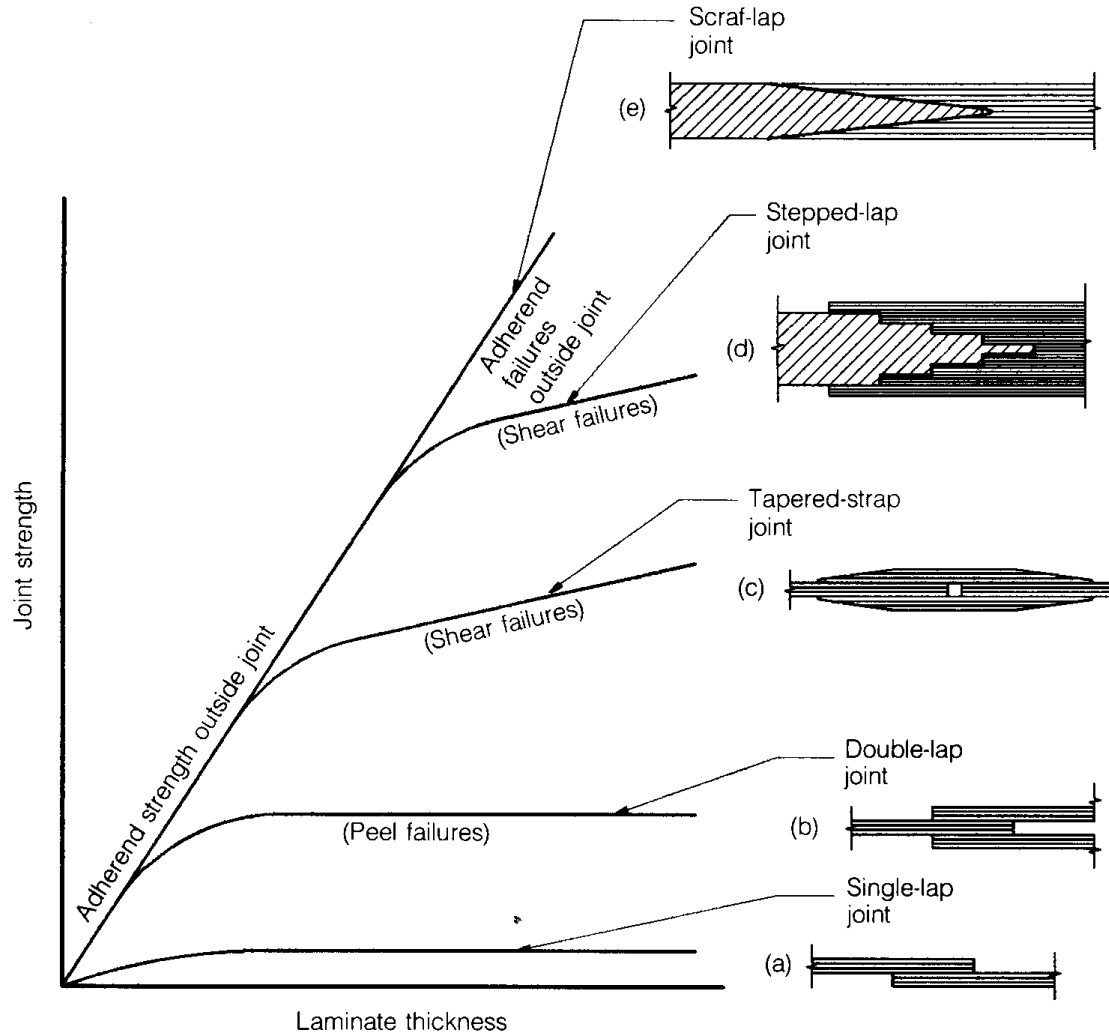


Juntas Coladas

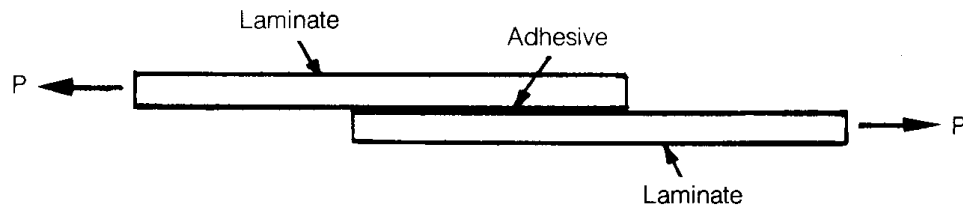


Juntas Coladas

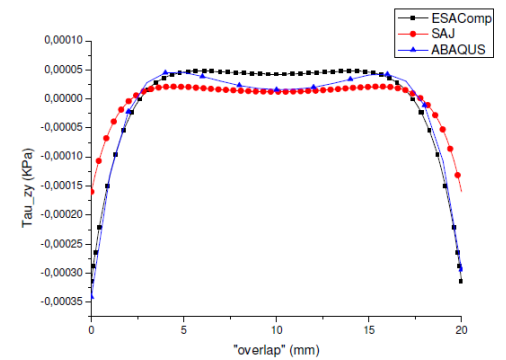
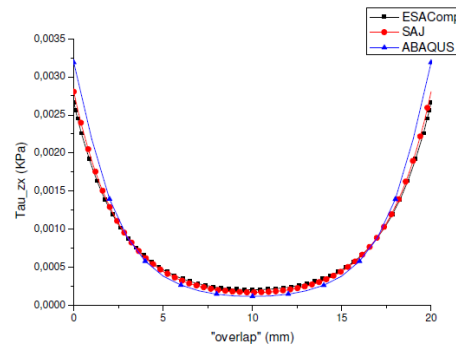
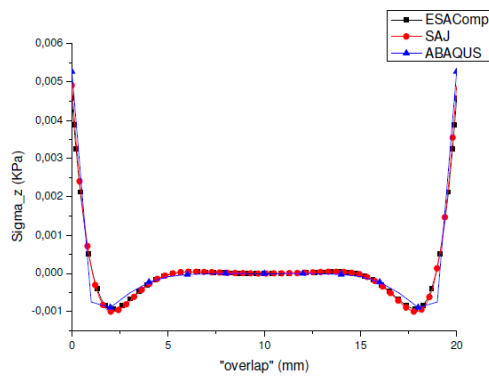
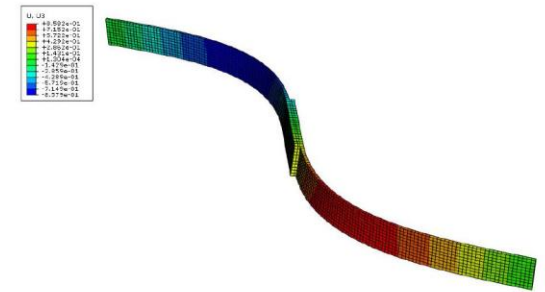
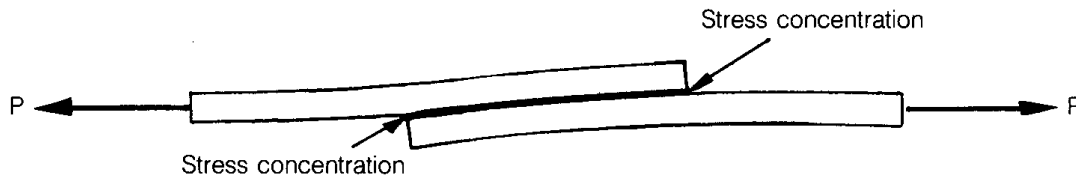
Joining



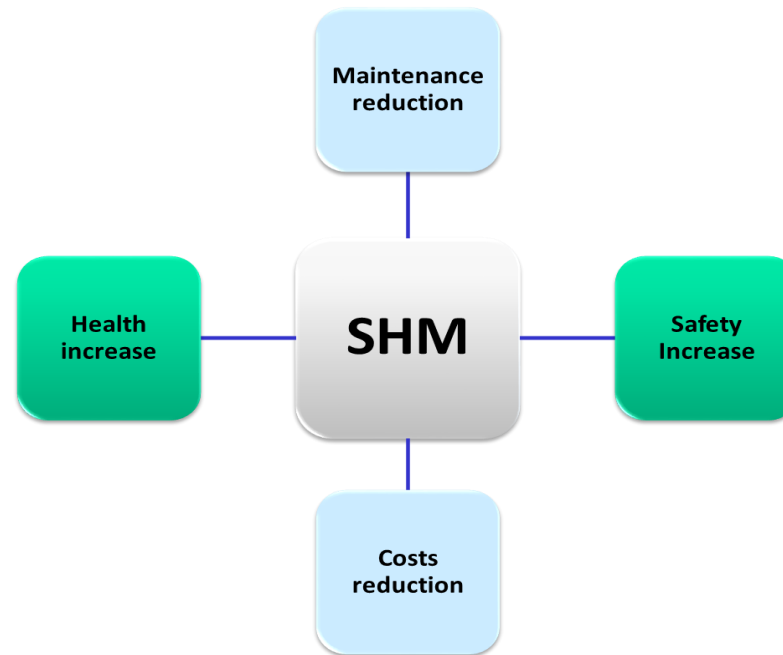
Juntas Coladas



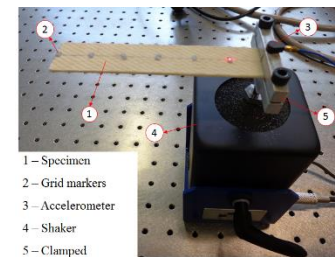
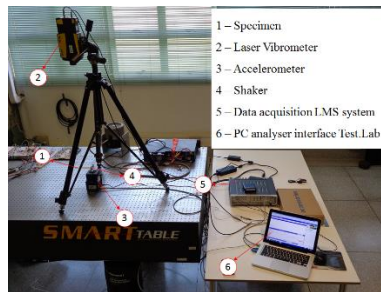
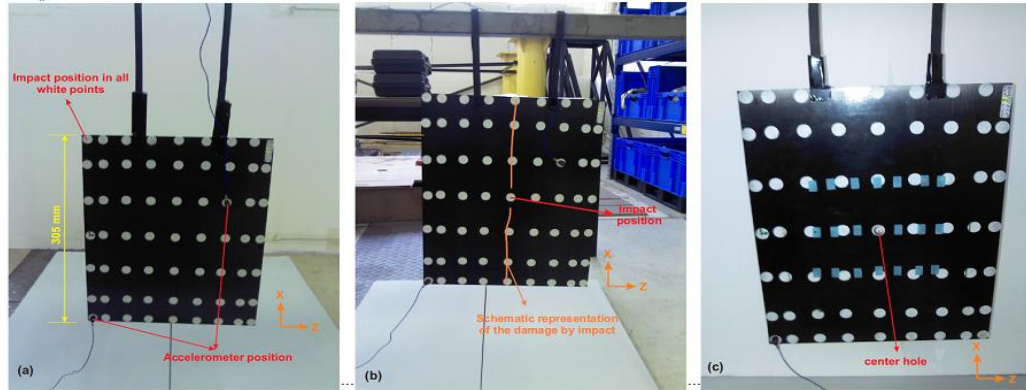
(a) Low load case



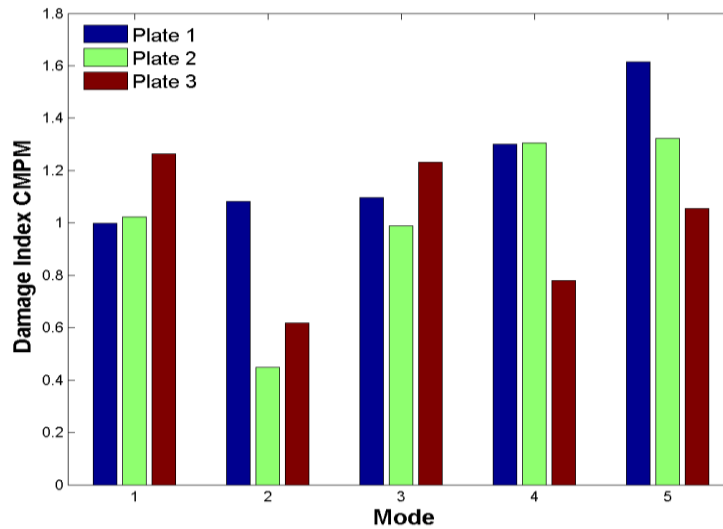
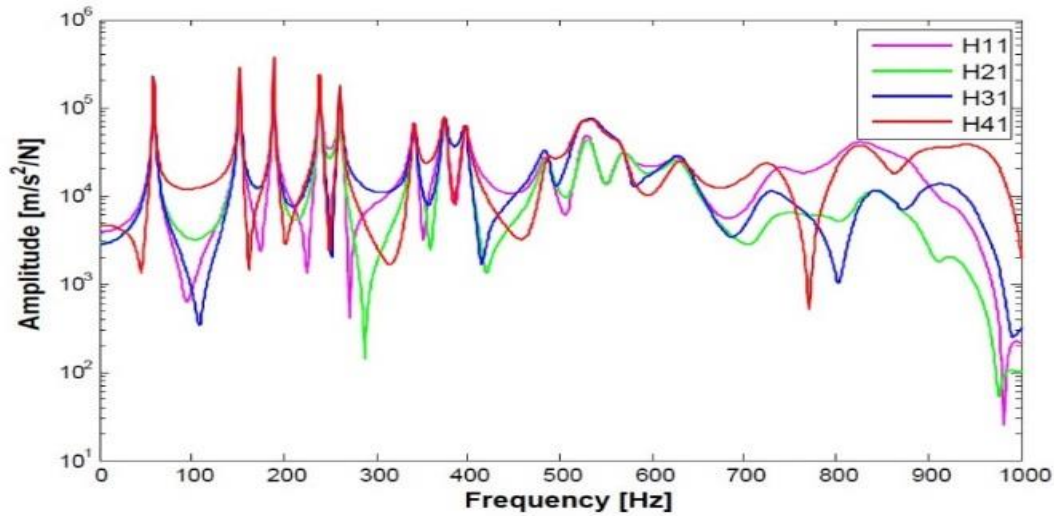
Monitoramento da integridade Estrutural - SHM



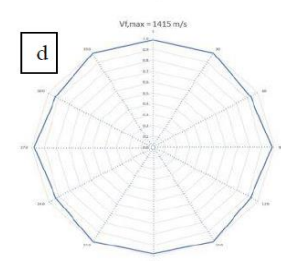
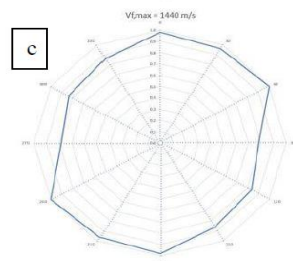
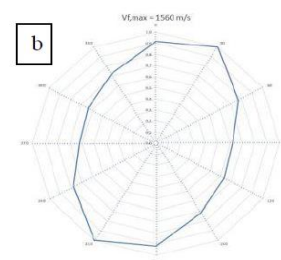
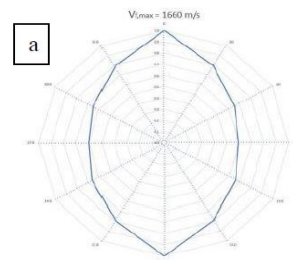
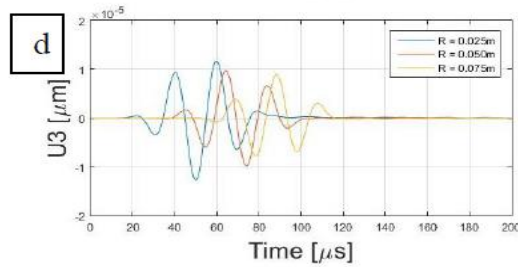
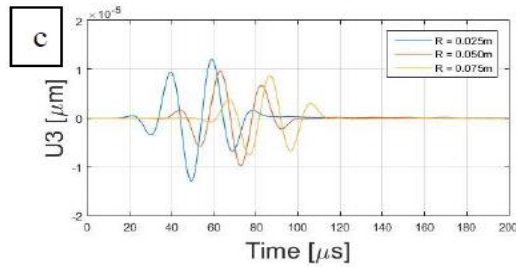
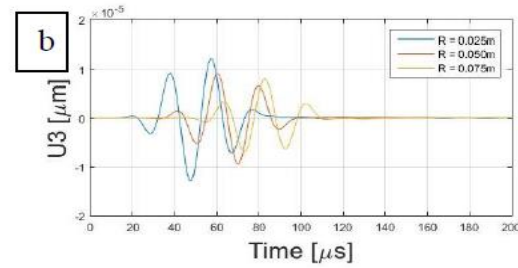
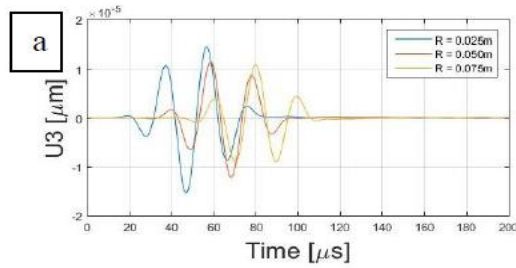
Monitoramento da integridade Estrutural - SHM



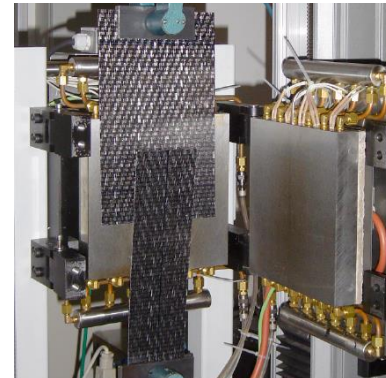
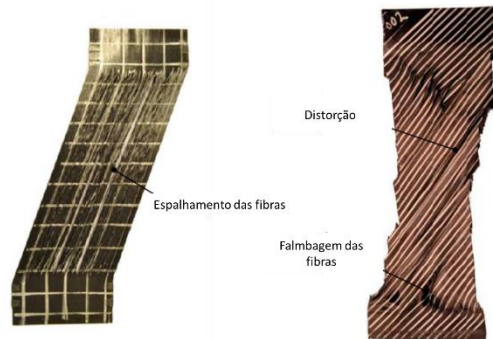
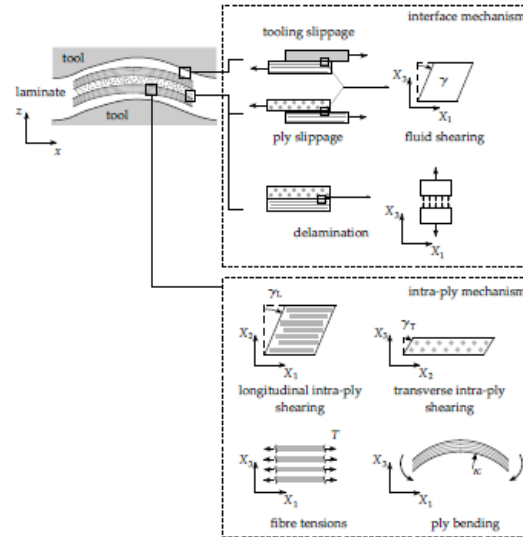
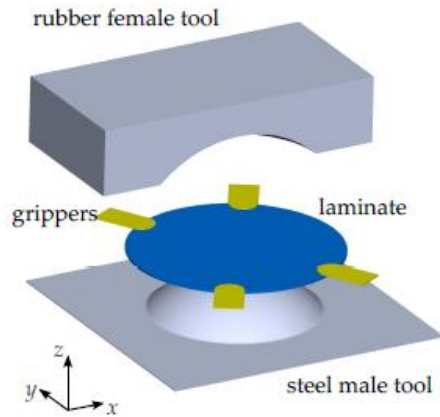
Monitoramento da integridade Estrutural - SHM



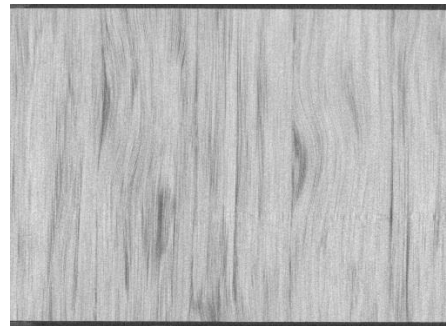
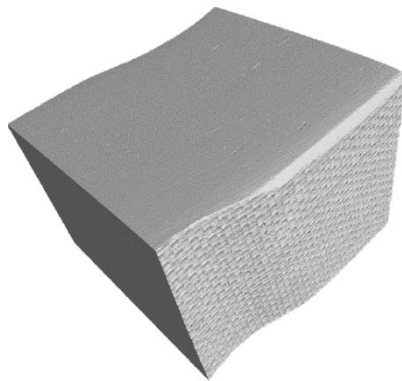
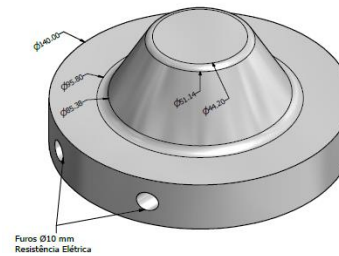
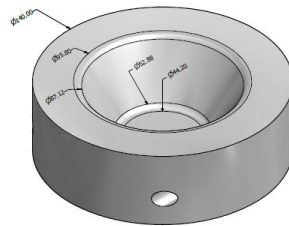
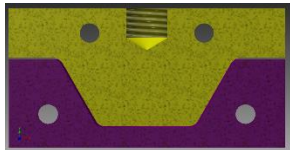
Monitoramento da integridade Estrutural - SHM



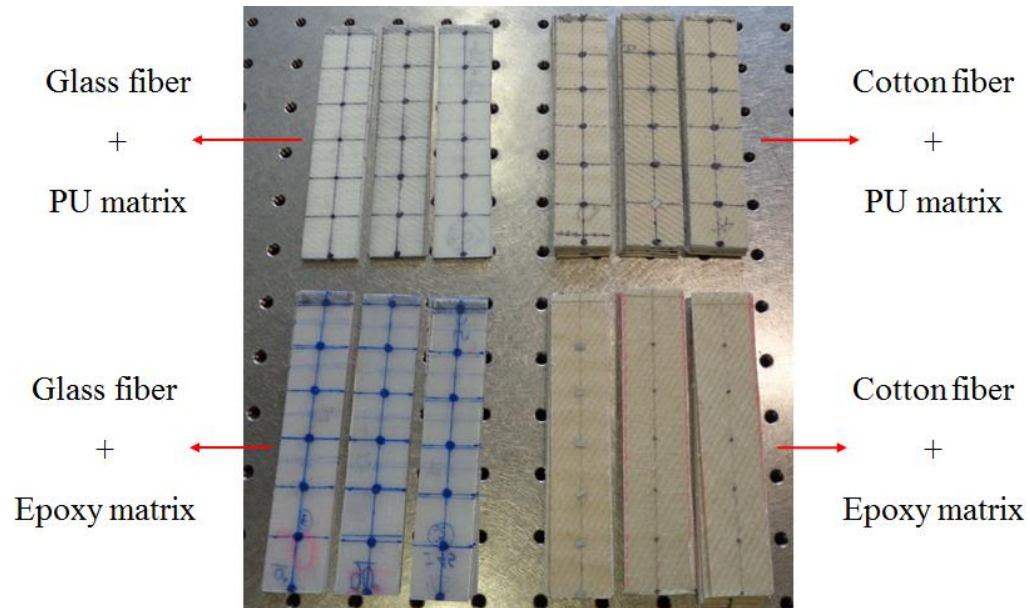
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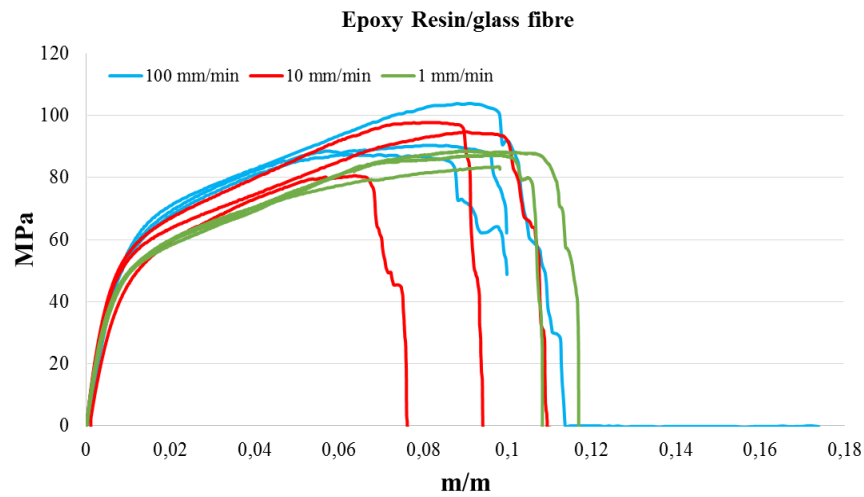
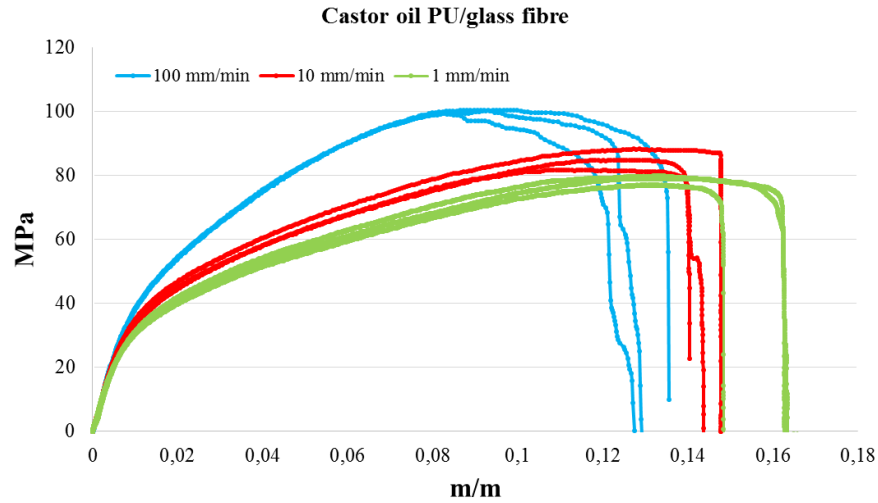
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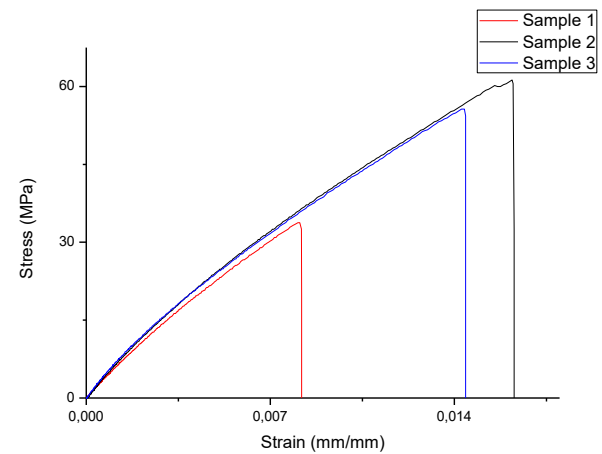
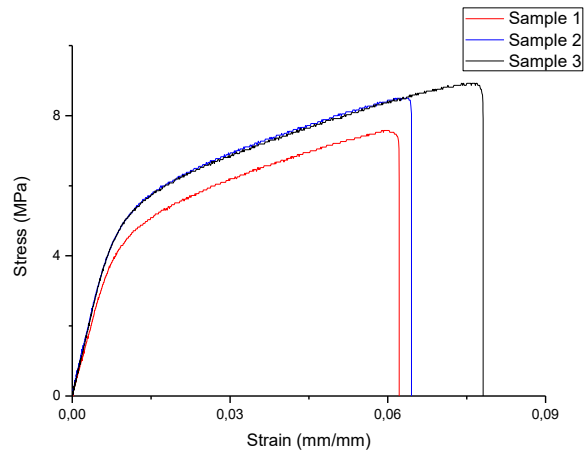
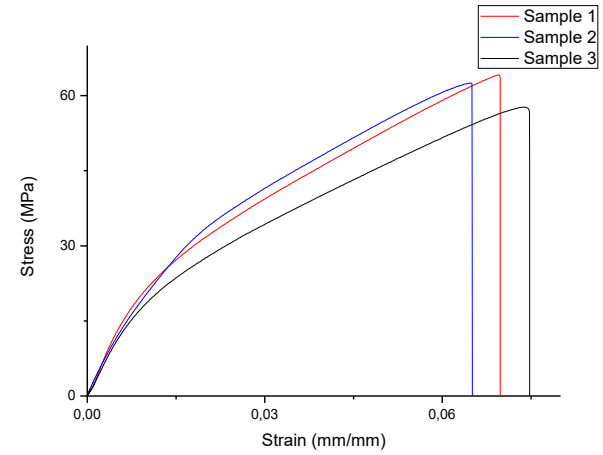
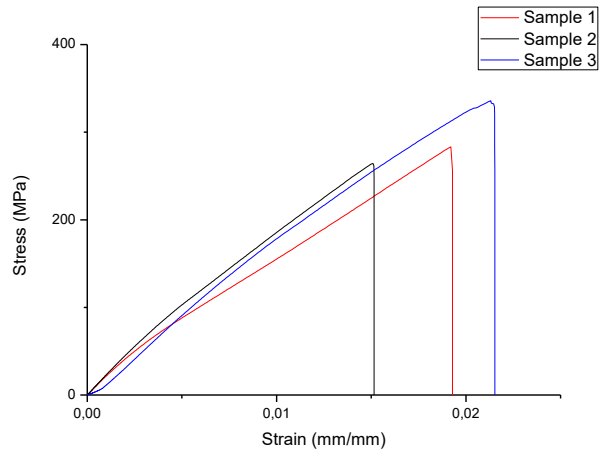
Biocompósitos



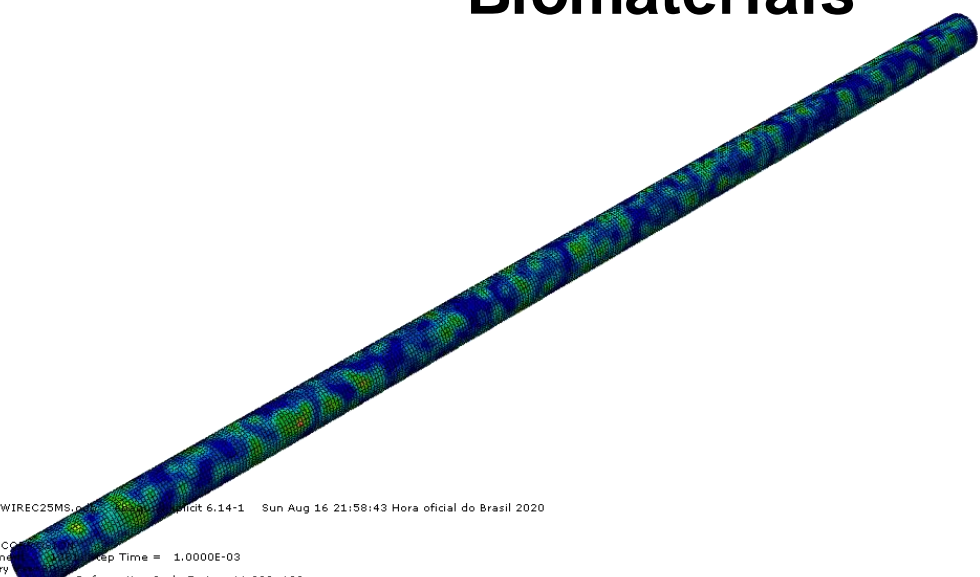
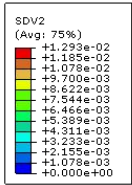
Bio compósitos



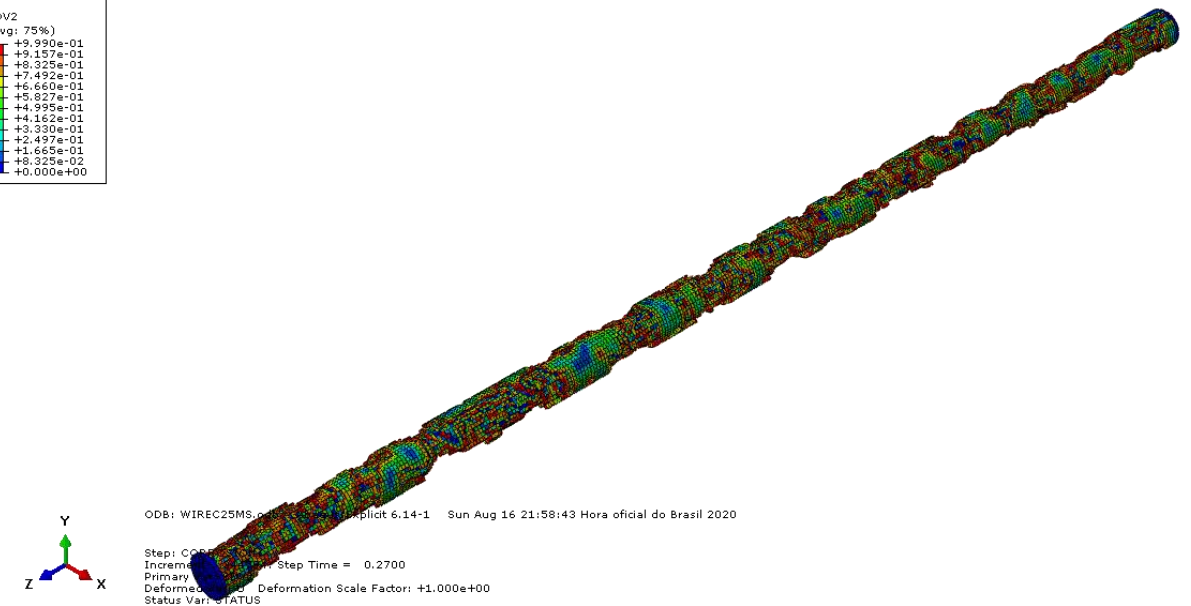
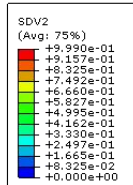
Biocompósitos



Biomaterials



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Primary...
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ODB: WIREC25MS... explicit 6.14-1 Sun Aug 16 21:58:43 Hora oficial do Brasil 2020
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