

EXAMEN OF MECHANICS OF COMPOSITES

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December 2 2020 - Nb of pages **2** - Allowed documents: *all*

1 Knowledge and understanding (8 pts)

1. Cite 4 key parameters that influence the behavior of fiber reinforced composite materials ?
/1
2. Why is the reinforcement by short fiber less efficient than by continuous ones ? /1
3. How is the fourth order tensor of elasticity introduced when describing the constitutive equations of a general elastic material ? /1
4. Define a monoclinic material ? /1
5. How many elastic constants are necessary to define an orthotropic behavior ? Same question for the case of a plate in the plane stress assumption ? /2
6. How is it possible to obtain a quasi-isotropic behavior of a layered plate made of UD plies ? /1
7. What is the most commonly used failure criteria used for composite plates ? /1

2 Anisotropic bending (12pts)

A square plate of dimensions $100mm \times 100mm \times 3mm$ made of 8 composite layers with the following orientations $[30^\circ/-30^\circ/30^\circ/-30^\circ/-30^\circ/30^\circ/-30^\circ/30^\circ]$. Plies are made of a woven carbon textile with a PEEK matrix (see figure 2) and the following planar stiffness matrix was identified experimentally and is given here in the natural frame :

$$[Q] = \begin{bmatrix} 103 & 15 & 0 \\ 15 & 35 & 0 \\ 0 & 0 & 10 \end{bmatrix} (GPa)$$

1. Describe a possible series of experimental tests that enabled to obtain the coefficients of matrix $[Q]$. /1
2. Calculate in the matrices $[Q^{30}]$ and $[Q^{-30}]$ in the physical frame. /2
3. Give matrices $[A]$, $[B]$ and $[D]$ of the integrated behavior of this plate. /3
4. The plate is submitted to two loading cases : (1) bending moment $M_0 = 12N.m$ around the x-axis imposed (inducing M_{xx}), (2) same bending moment around the y-axis. Justify by a resistance of materials approach that the curvature is going to be constant all over the sample (homogeneous bending). /1
5. After calculating the two corresponding integrated forces and moments, you will calculate numerically the values of the induced curvatures for both cases and corresponding radii of curvature (see Fig 2). Comment on the bending anisotropy of this material. /3

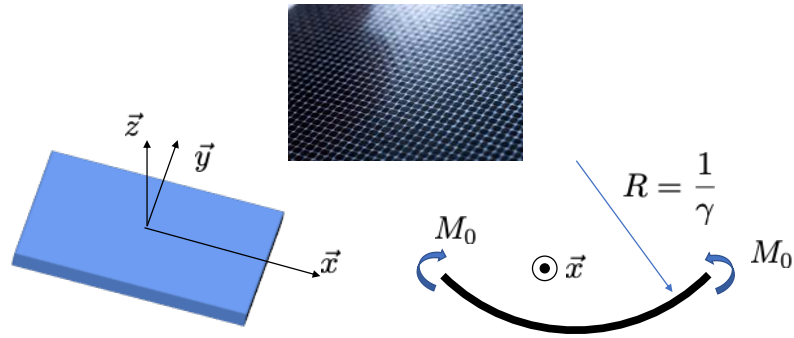
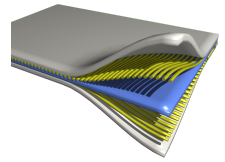


FIGURE 1 – Composite plate submitted to a pure bending load.

6. For case (2) only (moment around y), calculate the stress components in the most loaded location of the plate. It is reminded that the stress-strain relationship is given here by :

$$\{\sigma_k\} = [Q_k](\{\varepsilon_m\} + z \{\gamma\})$$

Do you think that this load can be critical for the composite in practice? How could we better answer this question?

/2