

MSE 214 (Composites A)
Exercices-Constituants-Anisotropie
8 Octobre 2025

Question 1. Citez au moins 4 exemples de matériaux anisotropes.

le bois, le béton armé, les muscles, les composites à fibres orientées....

Question 2. Classez les fibres suivantes dans un ordre croissant de leur déformation à la rupture : coton, verre , Kevlar 49, carbone HS, carbone HM, lin

Carbone HM : 0.5-0.8% slide 34 Propriétés
Carbone HS: 1.4-1.8% slide 34 Propriétés
Verre : 2.5-4.5% slide 55
Kevlar 49: 2.8% slide 46
Lin: 2.7-3.2% slide 55
Coton: 7-8% slide 55

Question 3.

Le module d'un composite unidirectionnel à fibres continues est mesuré à 250 GPa. Les fibres sont en carbone avec un module de 400 GPa et la résine epoxy qui les entoure a un module de 3 GPa. Quelle est la quantité de fibres dans ce composite ?

Handwritten solution for Question 3:

$$E_c = 250 \text{ GPa}$$
$$E_f = 400 \text{ GPa} \quad V_f = ?$$
$$E_m = 3 \text{ GPa}$$
$$E_c = E_f \cdot V_f + E_m (1 - V_f)$$
$$V_f = \frac{E_c - E_m}{E_f - E_m} = \frac{250 - 3}{400 - 3} = 0,62 = 62\%$$

Question 4.

Propose 2 methods for determining the transverse modulus of a composite with 40% volume of continuous fibres (Modulus= 140 GPa) in an elastomeric polymer of 500 MPa modulus. Determine the 2 moduli with the 2 methods. Compare the 2 obtained values and explain the difference. Compare these transverse moduli with the longitudinal modulus of the same composite.

$$\begin{aligned}
 V_f &= 0,4 \\
 E_f &= 140 \text{ GPa} & E_T &= ? \\
 E_m &= 0,5 \text{ GPa}
 \end{aligned}$$

$$E_T = \frac{E_m \cdot E_f}{E_f(1-V_f) + E_m V_f} = \frac{0,5 \cdot 140}{140 \cdot 0,6 + 0,5 \cdot 0,4} = 0,83 \text{ GPa}$$

$$E_T = \frac{E_m (1 + \xi \chi V_f)}{1 - \chi V_f} = 1,48 \text{ GPa}$$

$$\xi = 2 \quad \chi = \frac{E_f - E_m}{E_f + 2 \cdot E_m} = 0,989$$

Halpin Tsai is better than mixture law

$$E_c = 56 \text{ GPa}$$

Method 1: Mixing law for transverse modulus

Method 2: Halpin Tsai

Halpin Tsai provides a better estimation for transverse and shear moduli than the mixing law which has hypotheses on lateral displacements of matrix and fibres, elastic behaviour of materials....

Question 5.

Glass fibres ($E=70\text{GPa}$) reinforce PP ($E= 1 \text{ GPa}$) in a bumper ($V_f=0.3$). They have an initial length of 3 mm and a diameter of 20 μm . After injection in the mould the fibre length is 400 μm . What is the reduction of modulus induced by the processing?

$$\begin{aligned}
 E_f &= 70 \text{ GPa} = 70'000 \text{ MPa} \\
 E_m &= 1 \text{ GPa} = 1000 \text{ MPa} \\
 l_i &= 3 \text{ mm} = 3 \text{ mm} \\
 d &= 20 \mu\text{m} = 0,020 \text{ mm} \\
 l_f &= 400 \mu\text{m} = 0,400 \text{ mm} \\
 V_f &= 0,3 \quad \text{injection moulding} \\
 \Delta E_c &= ?
 \end{aligned}$$

$$E_{ci} = \frac{E_m (1 + \xi_1 \chi_1 V_f)}{1 - \chi_1 V_f} = 18'833 \text{ MPa} = 18,8 \text{ GPa}$$

$$\xi_1 = \frac{2 \cdot l_i}{d} = 300$$

$$\chi_1 = \frac{E_f - E_m}{E_f + \frac{2}{3} E_m} = 0,186$$

$$E_{cf} = 10'504 \text{ MPa} = 10,5 \text{ GPa}$$

$$\xi_2 = 40$$

$$\chi_2 = 0,627$$

$$\Delta E_c = 18,8 - 10,5 = 8,3 \text{ GPa}$$