

ASE440 Composites Technology
Mechanics of composites
Exo connections

①

$$\begin{aligned} E_c &= 250 \text{ GPa} \\ E_f &= 400 \text{ GPa} \\ E_m &= 3 \text{ GPa} \end{aligned} \quad V_f = ?$$

$$E_c = E_f \cdot V_f + E_m (1 - V_f)$$

$$V_f = \frac{E_c - E_m}{E_f - E_m} = \frac{250 - 3}{400 - 3} = 0,62 = 62\%$$

②

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

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

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

$$\xi = 2$$

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

Halpin Tsai is
better than mixture law

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

③

$$E_f = 70 \text{ GPa} = 70'000 \text{ NPa}$$

$$E_m = 1 \text{ GPa} = 1000 \text{ NPa}$$

$$d_i = 3 \text{ mm} = 3 \text{ mm}$$

$$d = 20 \text{ } \mu\text{m} = 0,020 \text{ mm}$$

$$d_{fi} = 400 \text{ } \mu\text{m} = 0,400 \text{ mm}$$

$$V_f = 0,3$$

injection moulding

$$\Delta E_c = ?$$

$$E_{ci} = \frac{E_m (1 + \xi_1 \chi_1 V_f)}{1 - \chi_1 V_f} = 18'838 \text{ NPa} = 18,8 \text{ GPa}$$

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

$$\chi_1 = \frac{E_f - E_m}{E_f + \xi_1 E_m} = 0,186$$

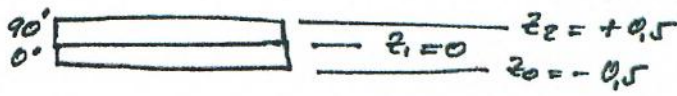
$$E_{cfi} = 10'504 \text{ NPa} = 10,5 \text{ GPa}$$

$$\xi_2 = 40$$

$$\chi_2 = 0,627$$

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

④



$$\begin{aligned} A_{11} &= 7.5 \cdot 10^4 \text{ N/mm} \\ E_2 &= 10 \text{ GPa} = 10^{10} \text{ N/mm}^2 \\ \nu_{12} &= 0.2 \\ \nu_{21} &= 0.014 \end{aligned}$$

$$A_{ij} = \bar{Q}_{ij}/_{00} (0 - (-0.5)) + \bar{Q}_{ij}/_{90} (0.5 - 0)$$

$$= \frac{1}{2} \bar{Q}_{ij}/_{00} + \frac{1}{2} \bar{Q}_{ij}/_{90}$$

$$A_{11} = \frac{1}{2} \bar{Q}_{11}/_{00} + \frac{1}{2} \bar{Q}_{11}/_{90}$$

$$= \frac{1}{2} (\cos^4 0 \cdot Q_{11} + \dots + \sin^4 0) + \frac{1}{2} (\cos^4 90 \cdot Q_{11} + \dots + \sin^4 90 \cdot Q_{22})$$

$$A_{11} = \frac{1}{2} Q_{11} + \frac{1}{2} Q_{22}$$

$$A_{11} = \frac{1}{2} \frac{E_1}{(1 - \nu_{12} \nu_{21})} + \frac{1}{2} \frac{E_2}{(1 - \nu_{12} \nu_{21})}$$

$$\rightarrow E_1 = 2 \left(A_{11} - \frac{1}{2} \frac{E_2}{(1 - \nu_{12} \nu_{21})} \right) (1 - \nu_{12} \nu_{21})$$

$$E_1 = 1.5 \cdot 10^{11} = 150 \text{ GPa}$$

$$E_1 = 140 \text{ GPa}$$

$$(5) \quad [M] = [B] \{E\} + [D] \cdot \{K\}$$

Symmetric laminate $\Rightarrow [B] = 0$

$$M_{xy} = D_{16} K_x + D_{26} K_y + D_{66} K_{xy}$$

only 3 out-of-plane deformations

(6) Design mgs of slide 23

$$\alpha = 0.83 \cdot 10^{-5} \text{ K}^{-1}$$