

## MEK 4540 Autumn 2009: Compulsory Assignment no. 1

To be delivered to Brian's mail pigeon-hole on the 7th Floor or directly by email by 09.15 on 02.10.2009.

A glass fibre laminate consists of the following materials:

Glass fibres:	E-modulus:	$E = 72.4 \text{ GPa}$
	Poisson's ratio:	$\nu = 0.2$
	Density:	$\rho = 2.54 \text{ g/cm}^3$
Vinylester:	E-modulus:	$E = 3.5 \text{ GPa}$
	Poisson's ratio:	$\nu = 0.3$
	Density:	$\rho = 1.12 \text{ g/cm}^3$

Each ply consists of a fibre fabric that weighs  $800 \text{ g/m}^2$ . After a burn-off test on 100 g of laminate, 72.5 g of glass is left.

- Calculate the density of the composite, the fibre volume fraction and the thickness of a single ply.
- Estimate  $E_L$ ,  $E_T$ ,  $G_{LT}$  and  $\nu_{LT}$ . Use the simple combination laws and, where appropriate, also the Halpin-Tsai formulae. Explain the differences.
- With the elastic properties derived in (c) above (taking the Halpin-Tsai values for  $E_T$  and  $G_{LT}$ ), set up the stiffness matrix ( $Q$ ) in the  $L$ - $T$  axes. Use the transformation matrix  $T$  to calculate the stiffness matrices ( $\bar{Q}$ ) in directions  $0^\circ$ ,  $90^\circ$ ,  $45^\circ$  and  $-45^\circ$ . Explain briefly how these matrices express the relationship between stress and strain for a single ply, indicating whether you are using the tensor shear strain or the engineering shear strain.
- Study the Matlab script provided and modify it to calculate the A-, B- and D-matrices for laminates consisting of the above plies in the four lay-ups:
  - $(0/45)_s$
  - $(0/45/-45/0)_s$
  - $(0/45/-45/90)_s$  and
  - $(0/45/-45/0)$ .

Comment on the differences.

Note: The Matlab script may also be used to check the ply stiffness matrices ( $\bar{Q}$ ) calculated in part (c).

- Calculate the total thickness of each of the laminates (ii) and (iii). Modify the same Matlab script to calculate the strains for each of these two laminates when they are exposed to a tensile stress in the  $0^\circ$  direction of 1 MPa (which must first be converted to a force per unit length). Hence find the effective E-modulus  $E_x$  and Poisson's ratio  $\nu_{xy}$  for each of these two laminates. By similar means, find the effective  $E_y$ ,  $\nu_{yx}$  and  $G_{xy}$ .

Comment on the differences between the results for the two laminates..

The Matlab script that is developed to solve parts (d) and (e) is to be handed in together with the solution. Even if the main solution is handed in on paper, the script should be sent in digital format by email to the undersigned.

Brian Hayman, 11.09.2009