Solution to Example 5.8 *The fabric XM2408 has 400 g/m^2 at 45°, 400 g/m^2 at −45° and 225 g/m^2 of chopped strand mat. Even though these are three distinct laminas, which are not woven, it is usual to treat them as a unit with specially orthotropic properties. The contribution of each fiber orientation to the [Q] matrix is proportional to its weight.*

First, compute the properties of the unidirectional lamina using (4.23), (4.29), (4.35), and (4.31)

$$E_1 = 37867\ MPa$$
$$E_2 = 11224\ MPa$$
$$G_{12} = 3317\ MPa$$
$$\nu_{12} = 0.3$$

Then, compute the properties of the chopped strand mat lamina using (9.67)

$$E = 21215\ MPa$$
$$G = 7539\ MPa$$
$$\nu = 0.407$$

Now, compute the [Q] matrices, for the unidirectional and for the continuous strand mat (CSM) material, using (5.24)

$$[Q]_{UNI} = \begin{bmatrix} 38904 & 3460 & 0 \\ 3460 & 11532 & 0 \\ 0 & 0 & 3317 \end{bmatrix} MPa; \quad [Q]_{CSM} = \begin{bmatrix} 25426 & 10347 & 0 \\ 10347 & 25426 & 0 \\ 0 & 0 & 7539 \end{bmatrix}$$

Next, compute the $[\bar{Q}]$ matrix for each lamina using (5.54)

$$[\bar{Q}]_{45} = \begin{bmatrix} 17665 & 11022 & 6843 \\ 11022 & 17665 & 6843 \\ 6843 & 6843 & 10879 \end{bmatrix} MPa; \quad [\bar{Q}]_{-45} = \begin{bmatrix} 17665 & 11022 & -6843 \\ 11022 & 17665 & -6843 \\ -6843 & -6843 & 10879 \end{bmatrix}$$

Note that rotations do not affect the CSM lamina, so

$$[\bar{Q}]_{CSM} = [Q]_{CSM}$$

Finally, the $[\bar{Q}]$ matrix for XM2408 with 50% of epoxy is

$$[\bar{Q}]_{XM2408} = \begin{bmatrix} 19361 & 10874 & 0 \\ 10874 & 19361 & 0 \\ 0 & 0 & 10146 \end{bmatrix} MPa$$

Since the fabric ±45 fibers are balanced, the resulting composite lamina is specially orthotropic ($\bar{Q}_{16} = \bar{Q}_{26} = 0$).

SCILAB *code for this example is available on the Website [4].*

Problems

Problem 5.1 *Explain contracted notation for stresses and strains.*

Problem 5.2 *Complete the table below with the contracted notation symbols for the component of stress and strain shown in the table. Use engineering notation for strains.*

Tensor notation (given)	σ_{11}	σ_{12}	σ_{13}	$2\epsilon_{21}$	σ_{22}	σ_{23}	$2\epsilon_{31}$	$2\epsilon_{32}$	ϵ_{33}
Contracted notation									