Solutions to Chapter 22 Problems

S.22.1

The direct stresses in the booms are obtained from Eq. (16.18) in which $I_{xy} = 0$ and $M_y = 0$. Thus

$$\sigma_z = \frac{M_x}{I_{xx}} y \tag{i}$$

From Fig. P.22.1 the y coordinates of the booms are

$$y_1 = -y_6 = 750\,\text{mm}$$
$$y_2 = y_{10} = -y_5 = -y_7 = 250 + 500 \sin 45° = 603.6\,\text{mm}$$
$$y_3 = y_9 = -y_4 = -y_8 = 250\,\text{mm}$$

Then $I_{xx} = 2 \times 150(750^2 + 2 \times 603.6^2 + 2 \times 250^2) = 4.25 \times 10^8\,\text{mm}^4$. Hence, from Eq. (i)

$$\sigma_z = \frac{100 \times 10^6}{4.25 \times 10^8} y$$

i.e.

$$\sigma_z = 0.24y$$

Thus

Boom	1	2 10	3 9	4 8	5 7	6
σ_z(N/mm^2)	180.0	144.9	60.0	−60.0	−144.9	−180.0

From Eq. (20.11)

$$q_s = -\frac{S_y}{I_{xx}} \sum_{r=1}^{n} B_r y_r + q_{s,0}$$

i.e.

$$q_s = -\frac{50 \times 10^3 \times 150}{4.25 \times 10^8} \sum y_r + q_{s,0}$$

so that

$$q_s = -0.018 y_r + q_{s,0} \tag{ii}$$

'Cut' the wall 89. Then, from the first term on the right-hand side of Eq. (ii)

$$q_{\text{b},89} = 0$$
$$q_{\text{b},9\,10} = -0.018 \times 250 = -4.5\,\text{N/mm}$$
$$q_{\text{b},10\,1} = -4.5 - 0.018 \times 603.6 = -15.4\,\text{N/mm}$$

$$q_{b,12} = -15.4 - 0.018 \times 750 = -28.9\,\text{N/mm}$$
$$q_{b,23} = -28.9 - 0.018 \times 603.6 = -39.8\,\text{N/mm}$$
$$q_{b,34} = -39.8 - 0.018 \times 250 = -44.3\,\text{N/mm}$$

The remaining q_b distribution follows from symmetry and the complete distribution is shown in Fig. S.22.1. The moment of a constant shear flow in a panel about a specific point is given by Eq. (20.10). Thus, taking moments about C (see Eq. (17.17))

$$50 \times 10^3 \times 250 = 2(-2 \times 4.5A_{9\,10} - 2 \times 15.4A_{10\,1} - 2 \times 28.9A_{12} - 2 \times 39.8A_{23} - 2 \times 44.3A_{34}) - 2Aq_{s,0} \qquad \text{(iii)}$$

in which

$$A_{34} = \tfrac{1}{2} \times 500 \times 250 = 62\,500\,\text{mm}^2$$
$$A_{23} = A_{9\,10} = 62\,500 + \tfrac{45}{360} \times \pi \times 500^2 - \tfrac{1}{2} \times 250 \times 353.6 = 116\,474.8\,\text{mm}^2$$
$$A_{12} = A_{10\,1} = \tfrac{1}{2} \times 250 \times 353.6 + \tfrac{45}{360} \times \pi \times 500^2 = 142\,374.8\,\text{mm}^2$$

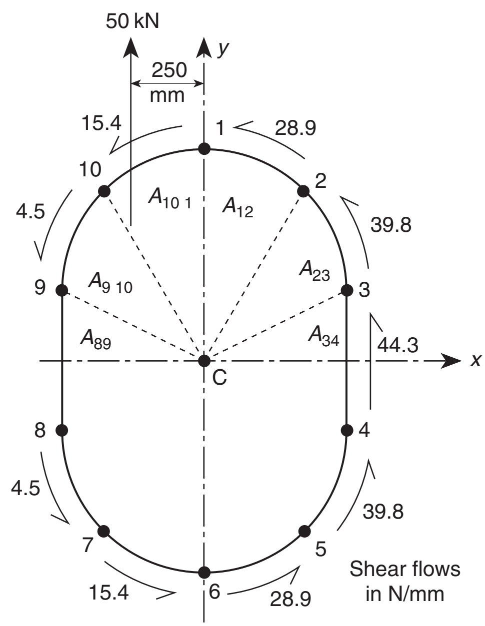

Fig. S.22.1

Also the total area, A, of the cross-section is

$$A = 500 \times 1000 + \pi \times 500^2 = 1\,285\,398.2\,\text{mm}^2$$

Eq. (iii) then becomes

$$50 \times 10^3 \times 250 = -2 \times 2(4.5 \times 116\,474.8 + 15.4 \times 142\,374.8 + 28.9 \times 142\,374.8 + 39.8 \times 116\,474.8 + 44.3 \times 62\,500) - 2 \times 1\,285\,398.2q_{s,0}$$

from which

$$q_{s,0} = -27.0\,\text{N/mm} \quad \text{(clockwise)}$$

Then

$$q_{89} = 27.0\,\text{N/mm}, \quad q_{9\,10} = q_{78} = 22.5\,\text{N/mm}, \quad q_{10\,1} = q_{67} = 11.6\,\text{N/mm},$$
$$q_{21} = q_{65} = 1.9\,\text{N/mm}, \quad q_{32} = q_{54} = 12.8\,\text{N/mm}, \quad q_{43} = 17.3\,\text{N/mm}$$

Solutions to Chapter 23 Problems

S.23.1

The beam section is unsymmetrical and $M_x = -120\,000\,\text{Nm}$, $M_y = -30\,000\,\text{Nm}$. Therefore, the direct stresses in the booms are given by Eq. (16.18), i.e.

$$\sigma_z = \left(\frac{M_y I_{xx} - M_x I_{xy}}{I_{xx} I_{yy} - I_{xy}^2}\right) x + \left(\frac{M_x I_{yy} - M_y I_{xy}}{I_{xx} I_{yy} - I_{xy}^2}\right) y \tag{i}$$

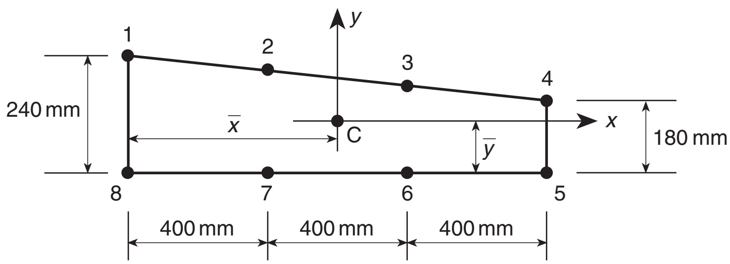

Fig. S.23.1

In Fig. S.23.1 $\bar{x} = 600\,\text{mm}$ by inspection. Also, taking moments of area about the line of the bottom booms

$$(4 \times 1000 + 4 \times 600)\bar{y} = 1000 \times 240 + 1000 \times 180 + 600 \times 220 + 600 \times 200$$

from which

$$\bar{y} = 105\,\text{mm}$$

Then

$$I_{xx} = 2 \times 1000 \times 105^2 + 2 \times 600 \times 105^2 + 1000 \times 135^2 + 1000 \times 75^2 + 600 \times 115^2$$
$$+ 600 \times 95^2 = 72.5 \times 10^6\,\text{mm}^4$$

$$I_{yy} = 4 \times 1000 \times 600^2 + 4 \times 600 \times 200^2 = 1536.0 \times 10^6\,\text{mm}^4$$

$$I_{xy} = 1000[(-600)(135) + (600)(75)] + 600[(-200)(115) + (200)(95)]$$
$$= -38.4 \times 10^6\,\text{mm}^4$$