CHAPTER 2

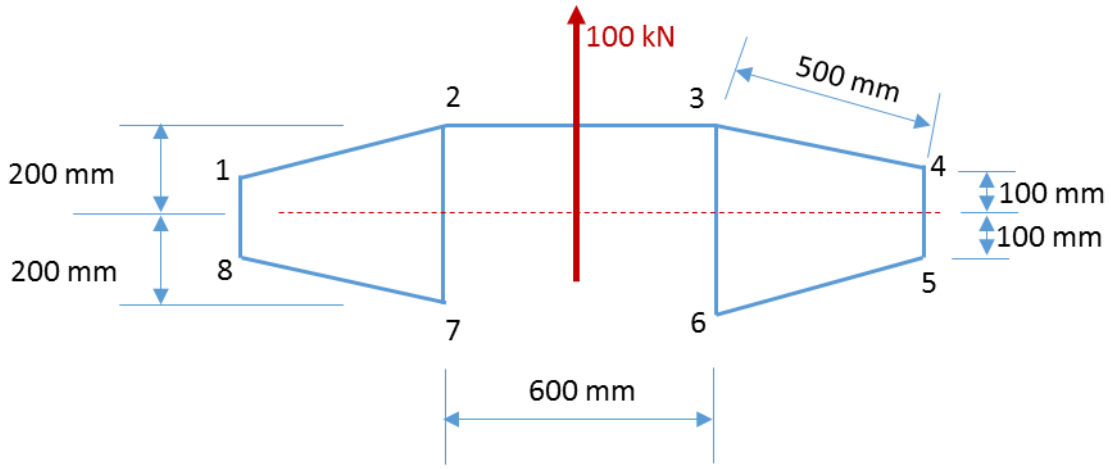
AUTO EVALUATION EXERCISE

A wing box has the cross-section shown diagrammatically in the next figure and it is subjected to the following loads:

a. A bending moment in a vertical plane of 20 kN m
b. A shear load of 100 kN in its vertical plane of symmetry
c. A torque of 100 kN m

The thickness of the skins is 2 mm and the shear modulus *G* is 25000 N/mm^2.
Calculate:

a. The maximum normal stress.
b. The shear stress at the mid-point of the web 3-6.
c. The rate of twist of the section and the maximum shear stress.



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SOLUTION:

Centre of mass

$$y_{COM} \cdot 2 \cdot (4 \cdot 500 + 2 \cdot 200 + 2 \cdot 400 + 600) = 2 \cdot (2 \cdot 500 \cdot 50 + 2 \cdot 500 \cdot 350 + 2 \cdot 400 \cdot 200 + 2 \cdot 200 \cdot 200)$$

Second moment of inertia

$$I_{xx} = 4 \cdot \frac{1}{12} 2 \cdot 500^3 \cdot (\frac{100}{500})^2 + 2 \cdot (2 \cdot 500)(50 - y_{COM})^2 + 2 \cdot (2 \cdot 500)(350 - y_{COM})^2 + 2 \cdot (2 \cdot 600)(y_{COM})^2 + 2 \cdot \frac{1}{12} 2 \cdot 400^3 + 2 \cdot (2 \cdot 400)(200 - y_{COM})^2 + 2 \cdot \frac{1}{12} 2 \cdot 200^3 + 2 \cdot (2 \cdot 200)(200 - y_{COM})^2 = 157.8 \cdot 10^6 mm^4$$

Maximum normal stress (tensile)

$$\sigma_{max} = \frac{M_x}{I_{xx}} y_{max} = 21.34\ MPa$$

Maximum normal stress (compressive)

$$\sigma_{max} = \frac{M_x}{I_{xx}} y_{min} = -29.35\ MPa$$

Shear flow

$$q(0) = -\frac{\int_0^s \frac{q(s)_{op}}{G \cdot e(s)} ds}{\int_0^s \frac{1}{G \cdot e(s)} ds} y_{min} = 98.36\ KN/mm$$

Polar moment of inertia

$$J = 2 \cdot J_{close} + J_{open} = 2.16 \cdot 10^8\ mm^4$$

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Rate of twist

$$\omega = \frac{M_T}{G \cdot J} = 1.85 \cdot 10^{-5}\ rad/mm$$

Shear stress

$$\tau_{max} = \frac{G \cdot J_{close} \cdot \omega}{2 \cdot \Omega \cdot t} = 85\ MPa$$