# Light Aircraft Structures

# **Shear of Idealised Closed Sections**

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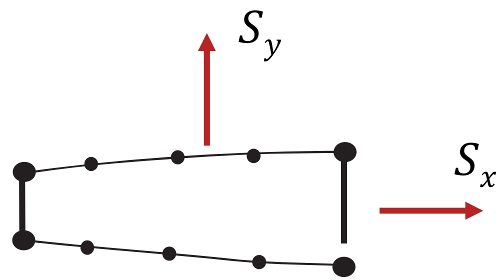
# Shear of Closed Sections

- Consider a single-cell beam subjected to shear loads $S_x$ , $S_y$ with lines of action not necessarily through the shear centre
  - The resulting shear flow distribution arises from the combination of transverse shear loading and torsion




- Analysis is similar to open section beams but again the starting value of $q$ may now be non-zero, *i.e.* $q_0 \neq 0$

# Shear of Closed Sections

- The basic shear flow equation for a semi-monocoque beam becomes:

$$-q_s = \left(\frac{S_x\, I_{xx} + S_y\, I_{xy}}{I_{xy}^2 - I_{xx}\, I_{yy}}\right)\sum_{i=1}^{n_s} x_i\, A_i + \left(\frac{S_y\, I_{yy} + S_x\, I_{xy}}{I_{xx}\, I_{yy} - I_{xy}^2}\right)\sum_{i=1}^{n_s} y_i\, A_i - q_0$$

- To solve for the extra $q_0$ term we 'cut' the section at an arbitrary position then consider the torsional equivalence of externally applied transverse loads and the resultant shear flow:

$$0 = \oint q_s^{\text{open}}\, r\, \mathrm{d}s + 2A\, q_0 \quad \Rightarrow \quad 2A\, q_0 = -\oint q_s^{\text{open}}\, r\, \mathrm{d}s$$

$$q_0 = \frac{-\oint q_s^{\text{open}}\, r\, \mathrm{d}s}{2A}$$

$$q_s^{\text{closed}} = q_s^{\text{open}} + q_0$$

# Torsion of Idealised Sections

- Pure torsion does not generate direct stresses, therefore:
  - Torsional stiffness / stresses are dictated by the **skin only**
  - Booms are assumed not to affect torsion
- So for torsion – exactly same theory as before:

$$\frac{T}{J} = \frac{G\,\theta}{L}$$

$$q_0 = \frac{\oint q_s^{\text{open}}\,\mathrm{d}s}{\oint \mathrm{d}s}$$

$$J = \frac{1}{3}\int t^3\,\mathrm{d}s = \sum\left(\frac{b_i\,t_i^3}{3}\right)$$

$$J = \frac{4\,A^2}{\oint \frac{\mathrm{d}s}{t}} \qquad \bar{q} = \frac{T}{2\,A}$$

$$T = \bar{q}\oint r_s\,\mathrm{d}s = 2\,A\,\bar{q}$$