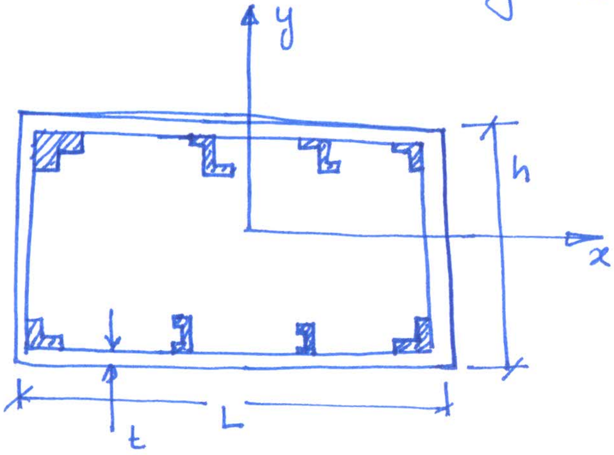
Skin-stringer idealization

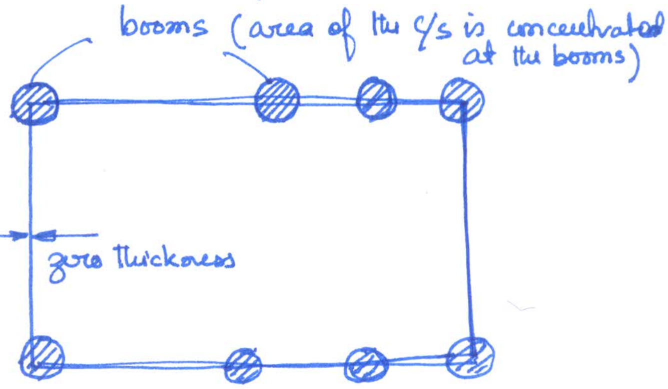
(i) The stringers (longitudinal stiffening members) will resist only normal (direct) stresses (resulting from bending)

(ii) The skin panel resists only shear stress, the shear stress is constant across the wall thickness. The shear stress is also constant along the arc-length of a skin panel between stringers.

(iii) Transverse members are rigid within their own plane.



I_{xx}, I_{yy}, I_{xy}



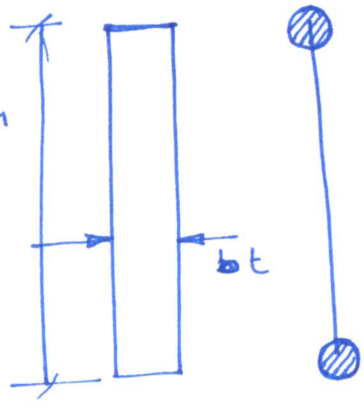
I^a_{xx}, I^a_{yy}, I^a_{xy}

For cases, where, M_x is predominant, $I_{xx} \approx I^a_{xx}$

For other forms of loading, the corresponding sectional properties should be equated.

A boom is usually placed at the location of a stringer.

Web



$I_{xx} = \frac{1}{12} th^3$

$A_{web} = th$

$I^a_{xx} = 2A_{boom}\left(\frac{h}{2}\right)^2$

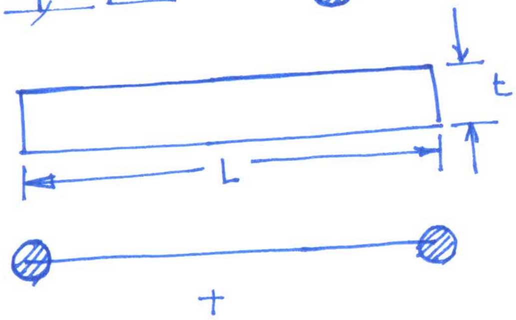
$I_{xx} = I^a_{xx}$

$\Rightarrow 2A_{boom}\left(\frac{h}{2}\right)^2 = \frac{1}{12} th^3$

$\Rightarrow A_{boom} = \frac{1}{6} th = \frac{1}{6} A_{web}$.

(one-sixth rule for vertical web)

Flanges



$I_{xx} = Lt\left(\frac{h}{2}\right)^2$

$I^a_{xx} = 2A_{boom}\left(\frac{h}{2}\right)^2$

$A_{boom} = \frac{1}{2} Lt = \frac{1}{2} A_{web}$

(one-half rule for horz. flange)

+

Area of a boom

$\frac{1}{6}$ of the area of the vertical web adjacent to the boom

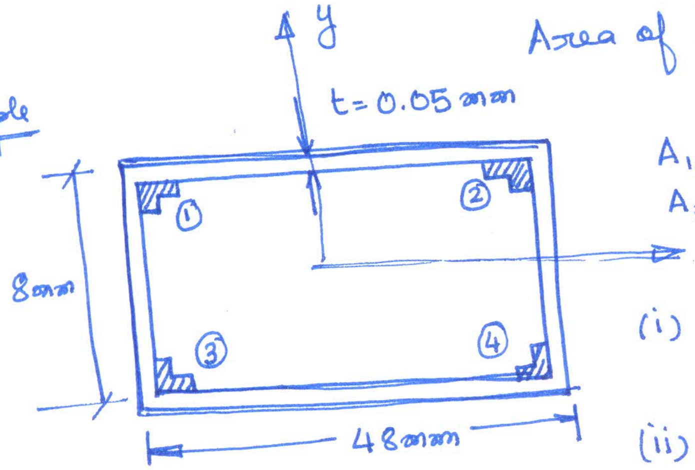
$+$

$\frac{1}{2}$ of the area of the ~~horizonatal~~ horizontal flange adjacent to the boom

$+$

Area of the stringer

Example



$A_{1,2} = 0.5\ mm^2$

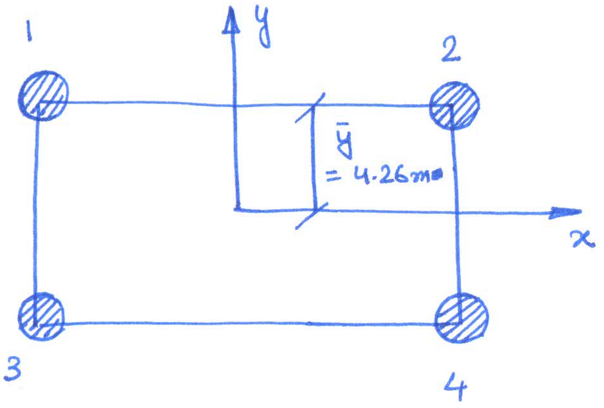
$A_{3,4} = 0.75\ mm^2$

(i) Idealize the c/s as skin-stringer model

(ii) Find the normal stress in B_1

if $M_x = 500{,}000$ N-mm

$M_y = 100{,}000$ N-mm.



$$B_1 = 0.5 + \frac{1}{6} \times 8 \times 0.05 + \frac{1}{2} \times 48 \times 0.05 = 1.767\ mm^2 = B_2$$

$$B_3 = 0.75 + \frac{1}{6} 8 \times 0.05 + \frac{1}{2} \times 48 \times 0.05 = 2.017\ mm^2 = B_4.$$

$$\bar{y} = \frac{2.017 \times 2 \times (-8)}{2 \times 2.017 + 2 \times 1.767} = -4.26\ mm$$

(from the top flange)

$$I_{xx} = 2 \times 1.767 \times (4.26)^2 + 2 \times 2.017 \times (3.74)^2 = 120.8\ mm^4$$

$$I_{yy} = 2 \times 1.767\, (24)^2 + 2 \times 2.017\, (24)^2 = 4359\ mm^4$$

$M_x = 500\,000$ N-mm $\quad M_y = 100\,000$ N-mm

$$\sigma_z = \left[\frac{M_y I_{xx} - M_x I_{xy}}{I_{xx} I_{yy} - I_{xy}^2}\right] x + \left[\frac{M_x I_{yy} - M_y I_{xy}}{I_{xx} I_{yy} - I_{xy}^2}\right] y$$

$I_{xy} = 0$ for symmetry

$$\sigma_z = \frac{M_y}{I_{yy}} x + \frac{M_x}{I_{xx}} y = \frac{5 \times 10^6}{120.8}(4.26) + \frac{1 \times 10^6}{4359}(-24)$$