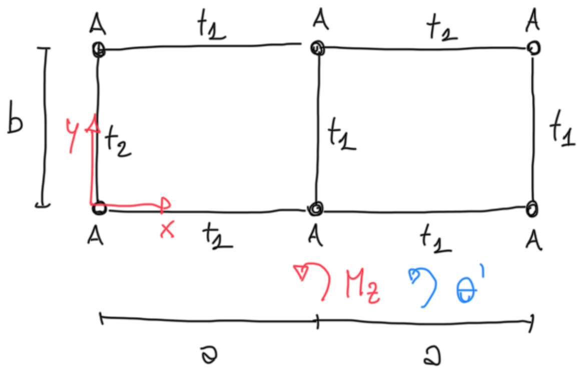
LAB 8 - Semi-monocoque II - Multicell Sections

1) EXAM 25/01/2023



DATA

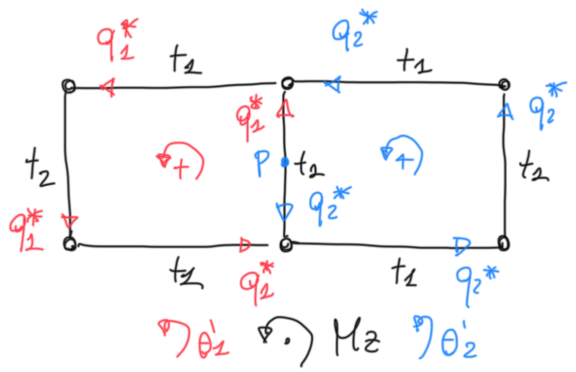
$a = 600$ mm
$b = 300$ mm
$A = 500$ mm^2
$t_1 = 1$ mm
$t_2 = 2$ mm
$E = 70$ GPa
$\nu = 0.3$
$M_z = 5 \cdot 10^6$ Nmm

Let's find θ'

- Open Cell Fluxes

$q_i' = \emptyset$ since $T_x = T_y = \emptyset$

- Close Cell Fluxes



- Moment Equivalence wrt P

$$M_z = 2 q_1^* \Omega_{CELL1} + 2 q_2^* \Omega_{CELL2} = 2ab(q_1^* + q_2^*)$$

- Angles

$$* \quad \theta_1' = \frac{d\theta_1}{dz} = \frac{1}{2\Omega_{cell1} \cdot G}\left(\frac{2 q_1^* \cdot a}{t_1} + \frac{q_1^* \cdot b}{t_2} + \frac{(q_1^* - q_2^*) b}{t_1} \right)$$

$$\theta_2' = \frac{1}{2\Omega_{cell2} \cdot G}\left(\frac{2 q_2^* \cdot a}{t_2} + \frac{q_2^* \cdot b}{t_1} + \frac{(q_2^* - q_1^*) b}{t_2} \right)$$

$$\boxed{G = \frac{E}{2(1+\nu)}}$$

- Compatibility

$$\theta_1' = \theta_2'$$

- Solution

$$\left\{ \begin{array}{l} \text{Mom. Eq.} \\ \text{Compatibility} \end{array} \right. \longrightarrow \text{solve to find } q_1^*, q_2^*$$

once we have them, we can use *

$$\Rightarrow \theta' = 1.019 \cdot 10^{-6} \ \frac{rad}{mm}$$

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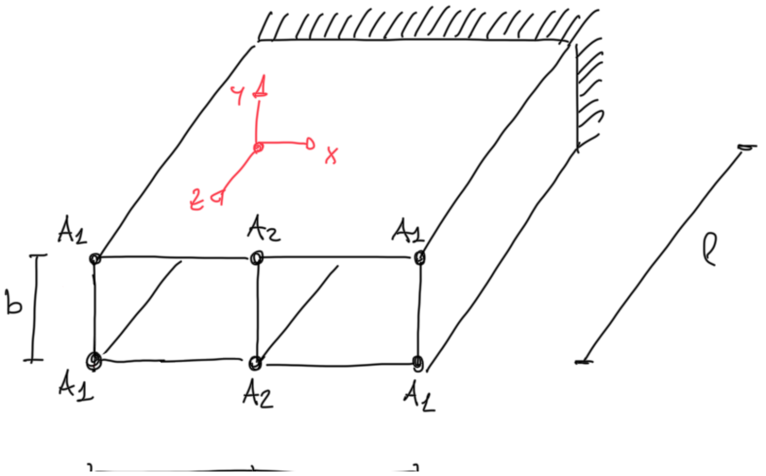
2) EXAM 05/07/2023



DATA

$t = 1$ mm for all the panels

$l = 6000$ mm

$a = 1000$ mm

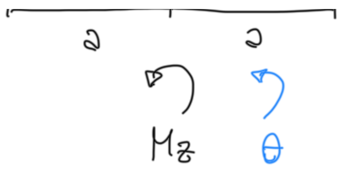
$b = 500$ mm

$A_1 = 500$ mm^2

$A_2 = 1000$ mm^2

$E = 70$ GPa

$\nu = 0.3$

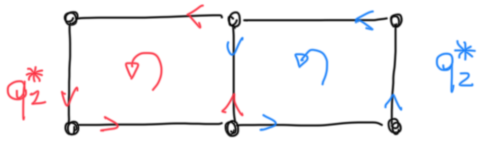


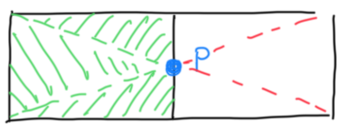
$M_z = 10^9$ Nmm

Let's find $\theta(z = \frac{\ell}{3})$

- Open Cell Fluxes $\quad T_x = T_y = \varnothing \rightarrow q_i' = \varnothing$

- Closed Cell Fluxes





- Moment Equivalence wrt P

$$M_z = 2 q_1^* \cdot \Omega_{cell1} + 2 \cdot q_2^* \cdot \Omega_{cell2} \qquad \Omega_{cell} = a \cdot b$$

- Angles

$$\theta_1' = \frac{1}{2\Omega_{cell1} \cdot G} \left(\frac{q_1^* (2a + 2b)}{t} - \frac{q_2^* b}{t} \right)$$

$$\theta_2' = \frac{1}{2\Omega_{cell2} \cdot G} \left(\frac{q_2^* (2a + 2b)}{t} - \frac{q_1^* \cdot b}{t} \right)$$

- Compatibility

We impose $\theta_1' = \theta_2'$

$$\cancel{\frac{1}{2\Omega_{cell1} G \cdot t}} \left(q_1^* (2a+2b) - q_2^* b \right) = \cancel{\frac{1}{2\Omega_{cell2} G \cdot t}} \left(q_2^* (2a+2b) - q_1^* b \right)$$

$$q_1^* (2a + 2b) + q_1^* b = q_2^* (2a + 2b) + q_2^* b$$

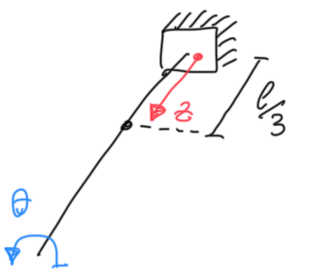
$$q_1^* (2a + 3b) = q_2^* (2a + 3b) \rightarrow q_1^* = q_2^* = q^*$$

$$q^* = \frac{M_z}{4\,\Omega_{CELL}} = \frac{M_z}{4ab}$$

$$\theta' = \frac{1}{2abGt} \cdot \frac{M_z}{4ab} \cdot (2a+b) \qquad \text{known}$$

- Compute the rotation

CLAMPED



$$\theta\left(\frac{l}{3}\right) - \cancel{\theta(0)} = \int_0^{\frac{l}{3}} \theta'\,dz = \theta' \cdot \frac{l}{3} = 0{,}0929 \text{ rad}$$

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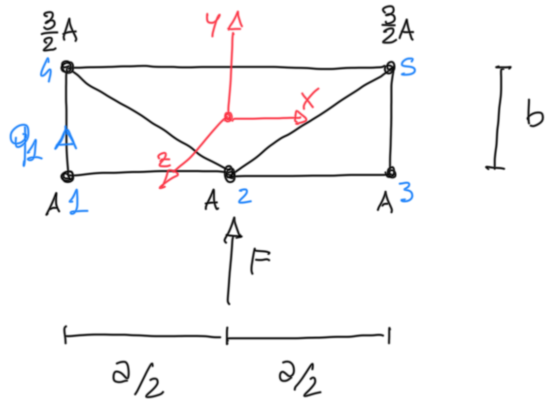
3) EXAM 05/09/2023



DATA

$a = 3000$ mm

$b = 300$ mm

$A = 500$ mm^2

$t = 3$ mm for all the panels

$F = 30$ kN

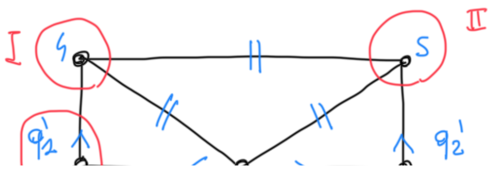
Let's find q_1

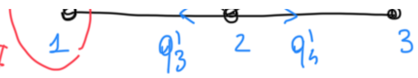
- Inertias

$$J_{xx} = 6A\left(\frac{b}{2}\right)^2 = \frac{3}{2}Ab^2$$

$$S_{x1} = S_{x2} = S_{x3} = -\frac{Ab}{2} \qquad S_{x4} = S_{x5} = \frac{3}{4}Ab$$

- Open Cell Fluxes



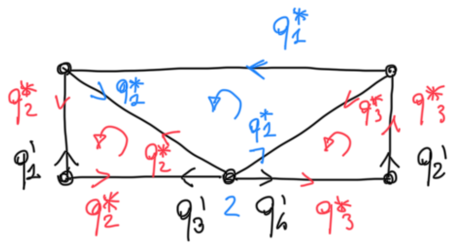
III 

I $\quad +q_1' = +F\cdot\frac{S_{x4}}{J_{xx}} = F\cdot\frac{\cancel{\frac{3}{4}A}b}{\frac{3}{2}\cancel{A}b^2} = \frac{F}{2b}$

II $\quad q_2' = q_1' = \frac{F}{2b}$

III $\quad q_3' = q_2' + F\,\frac{S_{x1}}{J_{xx}} = \frac{F}{2b} - \frac{F}{3b} = \frac{F}{6b} = q_4'$

- Closed Cell Fluxes



- Moment Equivalence wrt 2

$$\phi = 2\,q_1^*\,\Omega_{cell\,1} + 2\,q_2^*\cdot\Omega_{cell\,2} + 2q_3^*\cdot\Omega_{cell\,3} + \cancel{2q_2'\,\Omega_{cell\,3}} - \cancel{2q_2'\,\Omega_{cell\,2}}$$

$$\Omega_{cell\,1} = \frac{ab}{2} \qquad \Omega_{cell\,2} = \Omega_{cell\,3} = \frac{ab}{4}$$

$$\phi = q_1^* + \frac{1}{2}q_2^* + \frac{1}{2}q_3^*$$

- Angles

$\sqrt{\left(\frac{a}{2}\right)^2 + b^2}$ length of the diagonal

$$\theta_1' = \frac{1}{2\cdot\frac{1}{2}ab\cdot Gt}\left(a\cdot q_1^* + (2q_1^* - q_2^* - q_3^*)\,l_d\right)$$

$$\theta_2' = \frac{1}{2\cdot\frac{1}{4}ab\cdot G\cdot t}\left(b(q_2^* - q_1') + \frac{a}{2}(q_2^* - q_3') + (q_2^* - q_1^*)\cdot l_d\right)$$

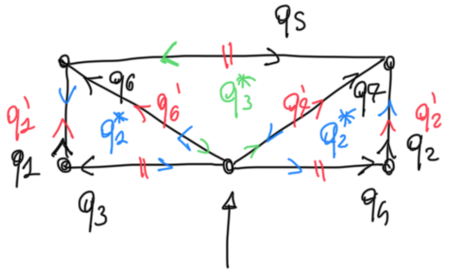
$$\theta_3' = \frac{1}{2\cdot\frac{1}{4}ab\cdot G\cdot t}\left(b(q_3^* + q_2') + \frac{a}{2}(q_3^* + q_4') + (q_3^* - q_2^*)\cdot l_d\right)$$

solve $\begin{cases} \text{MOM. EQ.} \\ \theta_1' = \theta_2' \\ \dots \end{cases} \rightarrow q_1^*,\ q_2^*,\ q_3^*$

$\circlearrowleft \ \theta_3' = \theta_2'$

$$q_1 = q_2' - q_2^* = 37.9869 \ \frac{N}{mm}$$

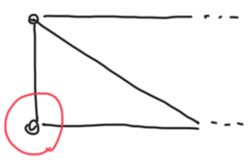
Let's try exploiting the symmetry



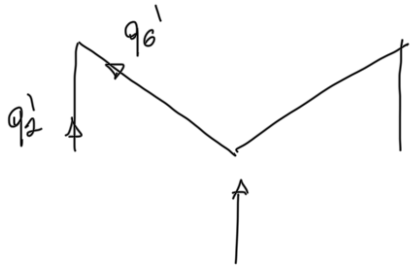
$$q_1 = q_2$$
$$q_3 = q_4$$
$$q_6 = q_7$$
$$\rightarrow q_5 = \emptyset \qquad q_5 = -q_3^* = \emptyset$$

$$\theta_i' = \emptyset$$
$$q_1^* = -q_2^* = q^*$$

- Open Cell Fluxes



$$\mathrm{I} \quad q_1' = -F\,\frac{-\frac{Ab}{2}}{\frac{3}{2}Ab^2} = \frac{F}{3b}$$



$$F = b\,(2q_1' + 2q_6')$$

$$q_6' = \frac{F}{2b} - q_1' = \frac{F}{6b}$$

$$\theta_1' = \emptyset = \frac{1}{2\Omega_1 Gt}\left(q^*\left(b + \ell d + \frac{a}{2}\right) + q_6'\cdot \ell d - q_1' b\right) = \emptyset$$

$$q^* = \frac{-q_6'\,\ell d + q_1' b}{b + \ell d + \frac{a}{2}} \qquad q_1 = q_1' - q^* = 37.9869 \ \frac{N}{mm}$$