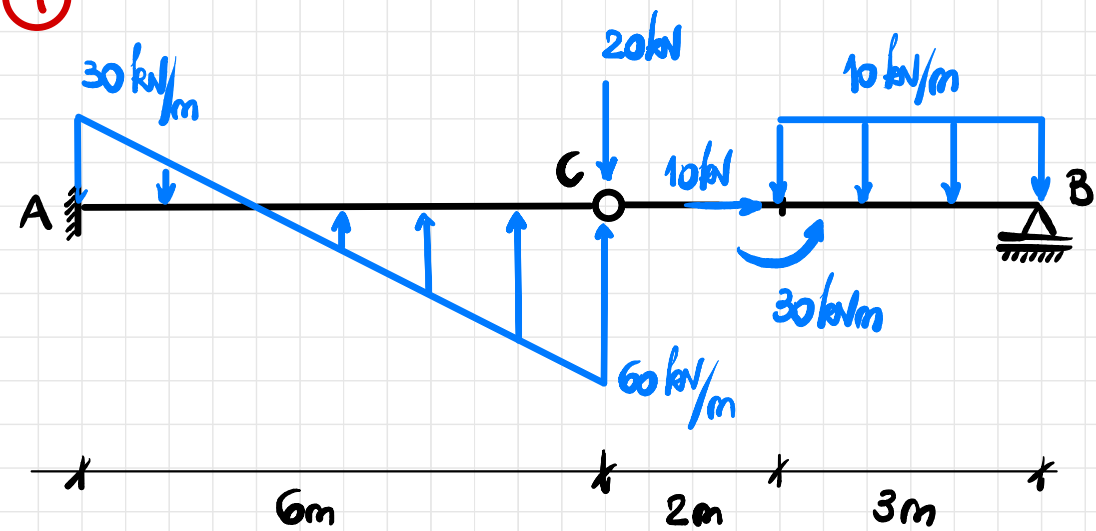
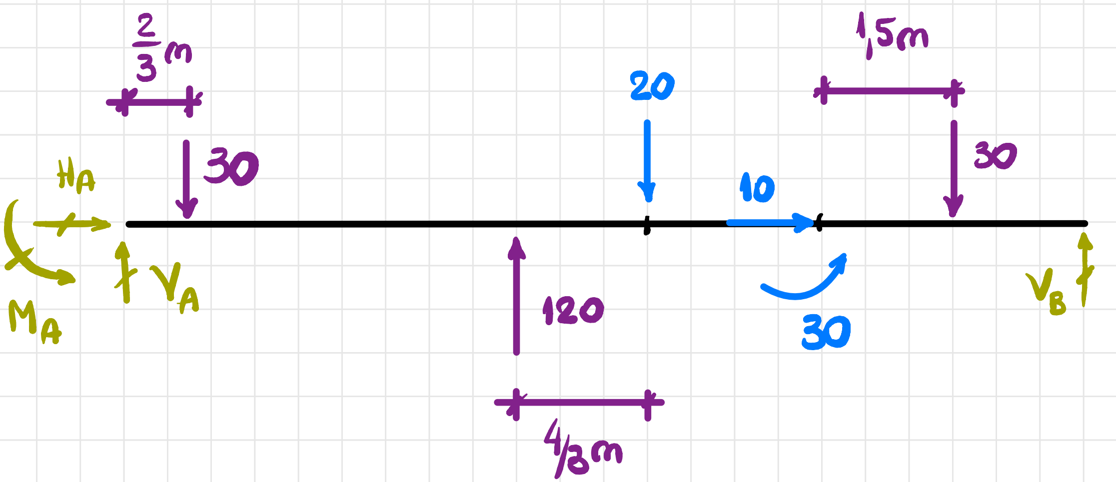
1



Reações de apoio:



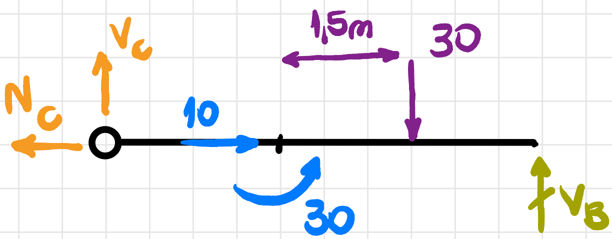
$$\sum F_H = 0: \; H_A + 10 = 0 \longrightarrow \underline{H_A = -10 \text{ kN}}$$

$$\sum F_V = 0: \; V_A - 30 + 120 - 20 - 30 + V_B = 0 \rightarrow V_A + V_B = -40$$

$$\circlearrowleft + \sum M_{(A)} = 0: \; M_A - 30.\frac{2}{3} + 120.\frac{14}{3} - 20.6 + 30 - 30.9{,}5 + V_B.11 = 0$$

$$M_A + 11V_B - 20 + 560 - 120 + 30 - 285 = 0 \rightarrow M_A + 11V_B = -165$$

Fazendo um corte em C:

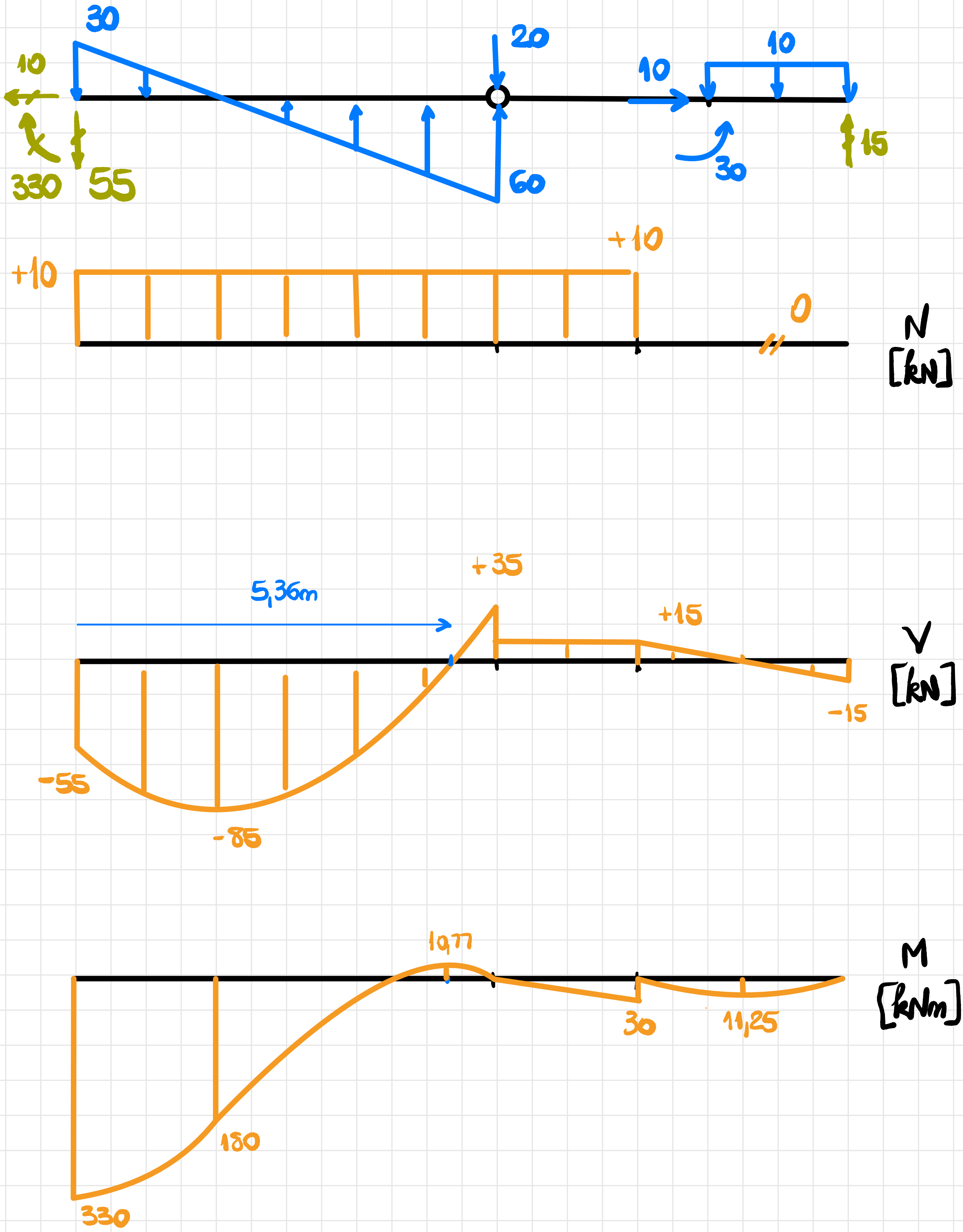


$$\circlearrowleft + \sum M_C = 0: \; 30 - 30.3{,}5 + V_B.5 = 0$$

$$5V_B = 75 \longrightarrow \underline{V_B = 15 \text{ kN}}$$

$$M_A = -165 - 11.V_B \rightarrow \underline{M_A = -330 \text{ kNm}}$$

$$V_A = -40 - V_B \longrightarrow \underline{V_A = -55 \text{ kN}}$$



30
20
10
10
10
330
55
60
30
15
+10
+10
0
N
[kN]
5,36m
+35
+15
V
[kN]
-15
-55
-85
10,77
M
[kNm]
30
11,25
180
330

Trecho AC:

$$q(x) = 30 - 15x \quad ; \quad V(0) = -55 \quad ; \quad M(0) = +330$$

$$\frac{dV}{dx} = -q(x) = 15x - 30$$

$$\boxed{V(x) = 7{,}5x^2 - 30x - 55}$$

$$\frac{dM}{dx} = 7{,}5x^2 - 30x - 55$$

$$\boxed{M(x) = 2{,}5x^3 - 15x^2 - 55x + 330}$$

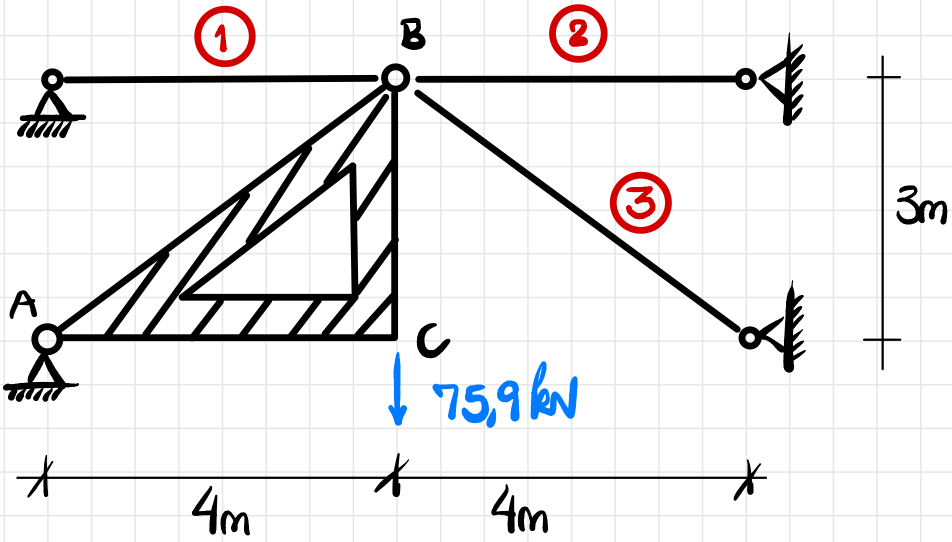
$$V(\bar{x}) = 0 \rightarrow 7{,}5x^2 - 30x - 55 = 0$$

$$x = \frac{30 \pm \sqrt{30^2 - 4 \cdot 7{,}5 \cdot (-55)}}{15} = \frac{30 \pm 50{,}5}{15}$$

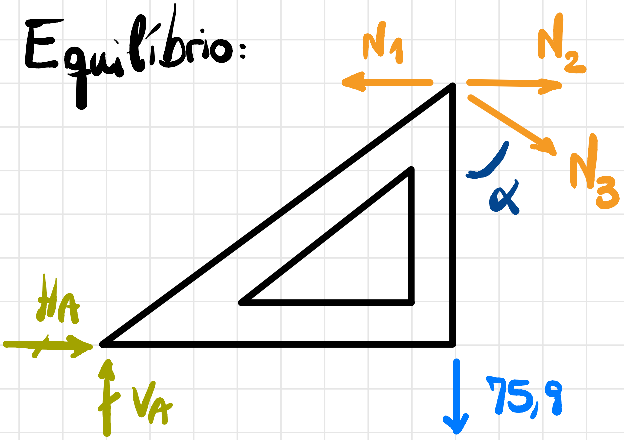
$\bar{x} = 5{,}36\ m$ ou $\bar{x} = -1{,}36\ m$ (fora do intervalo)

$$M(\bar{x}) = -10{,}77\ kNm$$

2



Equilíbrio:



$\operatorname{sen}\alpha = 4/5$

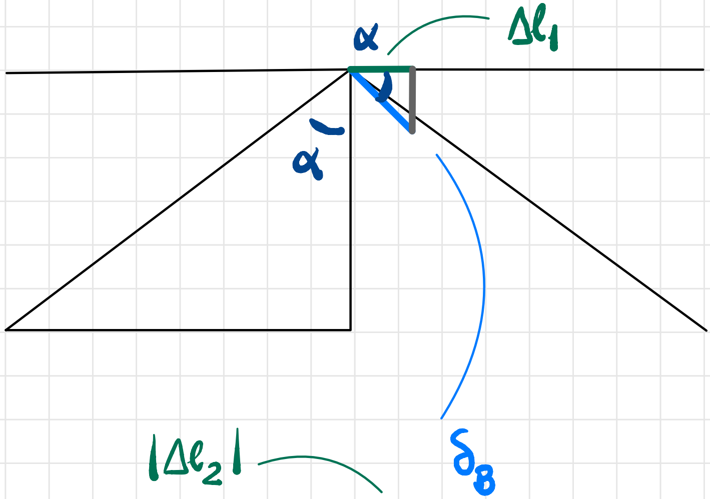
$\cos\alpha = 3/5$

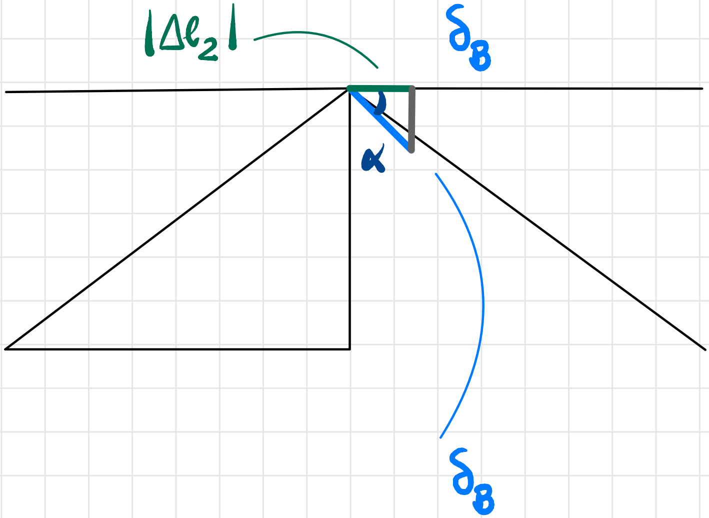
$$\circlearrowleft + \ \sum M_A = 0 : 75{,}9 \cdot 4 + N_1 \cdot 3 - N_2 \cdot 3 - N_3 \cos\alpha \cdot 4$$

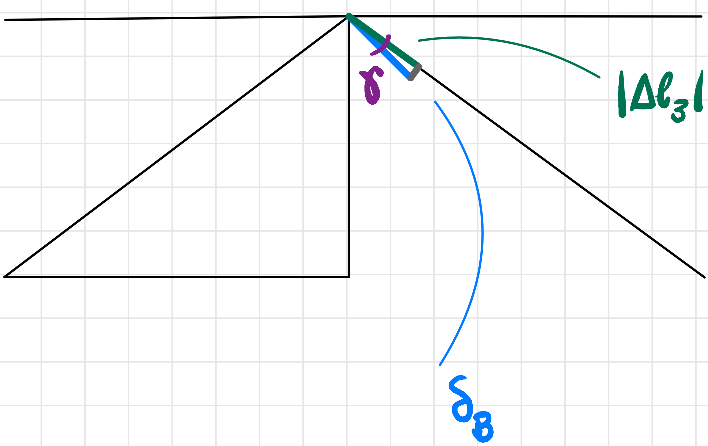
$$- N_3 \operatorname{sen}\alpha \cdot 3 = 0$$

$$3N_1 - 3N_2 - \frac{24}{5} N_3 = 303{,}6$$

Diagrama de Williot:







$$2\alpha = \pi/2 + \gamma \longrightarrow \gamma = 2\alpha - \pi/2$$

$$\cos\gamma = \cos(2\alpha - \pi/2) = \operatorname{sen} 2\alpha = 2 \operatorname{sen}\alpha\cos\alpha = 24/25$$

$$\cos\alpha = \frac{\Delta l_1}{\delta_B}$$

$$\cos\alpha = \frac{|\Delta l_2|}{\delta_B}$$

$$\cos\gamma = \frac{|\Delta l_3|}{\delta_B}$$

$$\therefore \quad \Delta l_1 = -\Delta l_2$$

$$\frac{\Delta l_1}{\cos\alpha} = \frac{|\Delta l_3|}{\cos\gamma} \longrightarrow \frac{\Delta l_1}{3/5} = \frac{|\Delta l_3|}{24/25}$$

$$\therefore \Delta l_1 = -\frac{5}{8}\Delta l_3$$

Se os fios tem mesmo módulo de elasticidade e mesma área, então:

$$\begin{cases} \dfrac{N_1 \ell_1}{\cancel{EA}} = -\dfrac{N_2 \ell_2}{\cancel{EA}} \\[2ex] \dfrac{N_1 \ell_1}{\cancel{EA}} = -\dfrac{5}{8}\dfrac{N_3 \ell_3}{\cancel{EA}} \end{cases} \longrightarrow \begin{cases} N_1 \cdot 4 = -N_2 \cdot 4 \\[2ex] N_1 \cdot 4 = -\dfrac{5}{8} N_3 \cdot 5 \end{cases}$$

$$\therefore \begin{cases} N_2 = -N_1 \\[2ex] N_3 = -\dfrac{32}{25} N_1 \end{cases}$$

$$3N_1 - 3(-N_1) - \frac{24}{5}\left(-\frac{32}{25} N_1\right) = 303{,}6$$

$$\frac{1518}{125} N_1 = 303{,}6 \longrightarrow$$

$$\underline{N_1 = 25\,kN} \longrightarrow \underline{N_2 = -25\,kN}$$

$$\underline{N_3 = -32\,kN}$$

① Tensão máxima admissível:

$$\text{máx}\left(|\sigma_1|, |\sigma_2|, |\sigma_3|\right) \leq \bar{\sigma}$$

$$|\sigma_3| \leq \bar{\sigma} \rightarrow \frac{|N_3|}{A} \leq \frac{\sigma_e}{5}$$

$$A \geq \frac{|N_3| . 5}{\sigma_e} \rightarrow A \geq \frac{32.10^3 . 3}{140.10^6}$$

$$\therefore \boxed{A \geq 6{,}85.10^{-4}\ m^2}$$

logo

$$A_{min} = 6{,}85.10^{-4}\ m^2$$

② Deslocamento máximo:

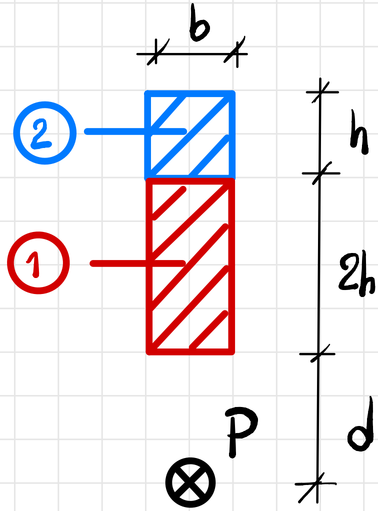
$$\delta_C \leq \bar{\delta}$$

como $\dfrac{\delta_C}{4} = \dfrac{\delta_B}{5} \rightarrow \delta_C = \dfrac{4}{5}\delta_B$

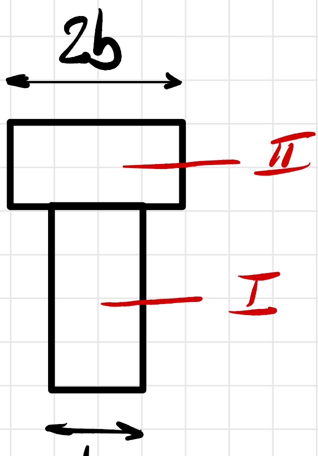
$$\frac{4}{5}\frac{\Delta\ell_1}{\cos\alpha} \leq \bar{\delta} \rightarrow \frac{4}{\cancel{5}} . \frac{\cancel{5}}{3} . \frac{N_1\ell_1}{EA} \leq \bar{\delta}$$

$$A \geq \frac{4N_1\ell_1}{3E\bar{\delta}} \rightarrow A \geq \frac{4.25.10^3.4}{3.200.10^9.0{,}05} \rightarrow \boxed{A \geq 1{,}33.10^{-5}\ m^2}$$

3



$$\frac{E_2}{E_1} = 2$$



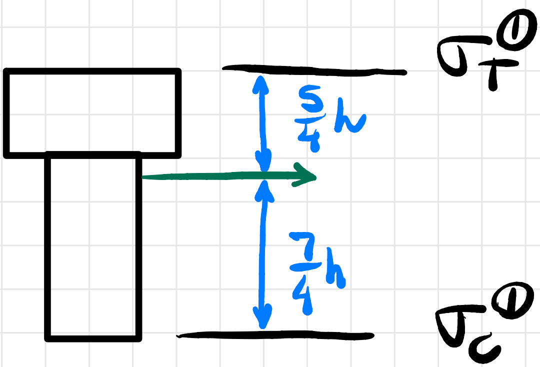
	y	A	I_{z0}	d
I	h	$2bh$	$\frac{2}{3} bh^3$	$\frac{3}{4} h$
II	$\frac{5}{2} h$	$2bh$	$\frac{1}{6} bh^3$	$\frac{3}{4} h$

$$y_G = \frac{h \cdot 2\cancel{bh} + \frac{5}{2}h \cdot 2\cancel{bh}}{2\cancel{bh} + 2\cancel{bh}} = \frac{7}{4}h$$

$$I_{z0} = \left[\frac{2bh^3}{3} + \left(\frac{3h}{4}\right)^2 \cdot 2bh\right] + \left[\frac{1}{6}bh^3 + \left(\frac{3h}{4}\right)^2 \cdot 2bh\right]$$

$$I_{z0} = \frac{2bh^3}{3} + \frac{9bh^3}{8} + \frac{1}{6}bh^3 + \frac{9bh^3}{8} = \frac{37}{12}bh^3$$

$$A = 4bh$$



$$N = -P, \quad M = -Pe$$

$$\text{com } e = \frac{7}{4}h + d$$

$$\sigma_T^{①} = -\frac{P}{A} - \frac{Pe}{I_{z0}} \cdot \left(-\frac{5}{4}h\right)$$

$$\sigma_C^{①} = -\frac{P}{A} - \frac{Pe}{I_{z0}} \cdot \frac{7}{4}h$$

$$\sigma_T^{②} = |\sigma_C^{①}|$$

$$2\left(-\frac{P}{A} + \frac{5h}{4}\frac{Pe}{I_{z_0}}\right) = \left| -\frac{P}{A} - \frac{7h}{4}\frac{Pe}{I_{z_0}} \right|$$

$$-\frac{2P}{A} + \frac{5h}{2}\frac{Pe}{I_{z_0}} = \frac{P}{A} + \frac{7h}{4}\frac{Pe}{I_{z_0}}$$

$$\frac{\cancel{3}h\cancel{P}e}{4I_{z_0}} = \frac{\cancel{3}\cancel{P}}{A} \longrightarrow e = \frac{4I_{z_0}}{Ah}$$

$$\therefore e = \cancel{4} \cdot \frac{37}{12} bh^3 \cdot \frac{1}{\cancel{4}bh} \cdot \frac{1}{h}$$

$$\boxed{e = \frac{37}{12}h}$$