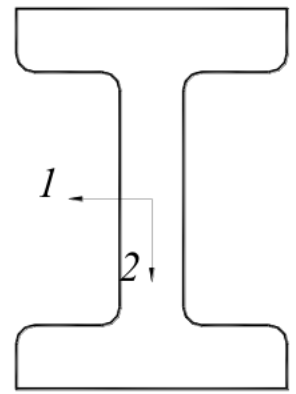


VIGA

IPE300



$$E=210 \text{ GPa}$$

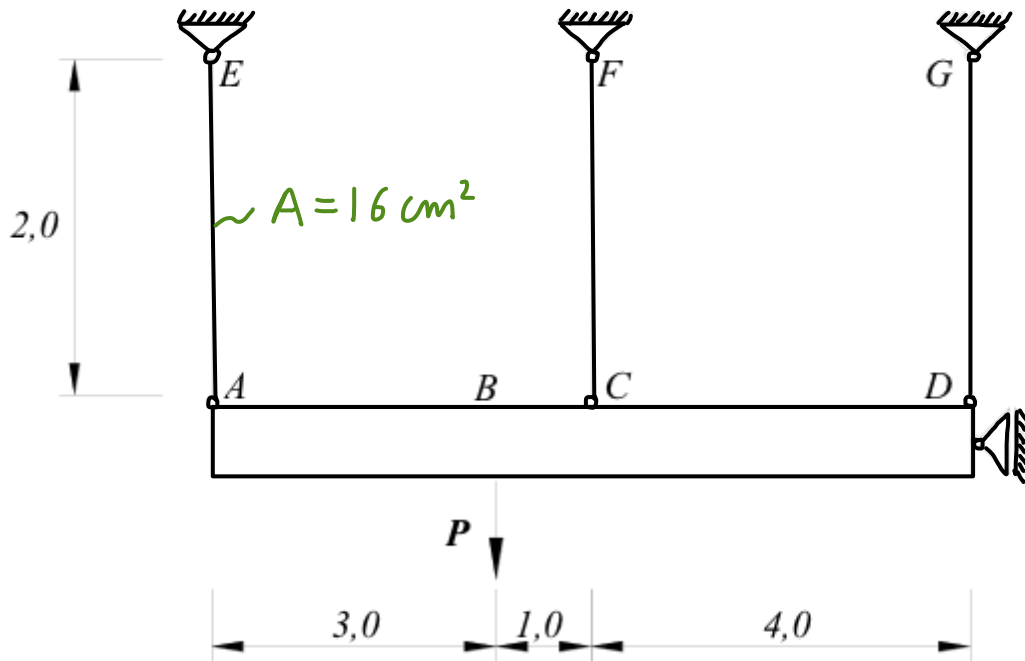
$$\sigma_c=235 \text{ N/mm}^2$$

$$I_1=83,6 \times 10^6 \text{ mm}^4$$

$$Z=\cancel{6,021} \times 10^5 \text{ mm}^3$$

6,284

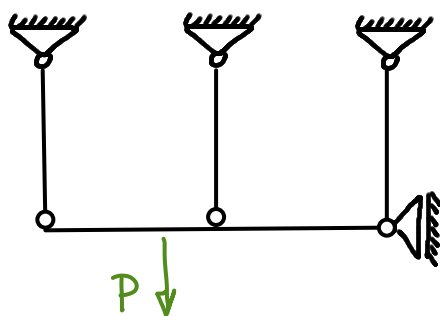
módulo flexão plástico



$$N_p = A \sigma_c = 376 \text{ kN}$$

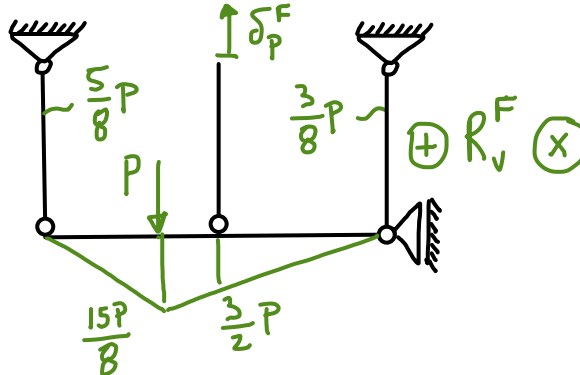
$$M_p = Z \sigma_c = 147,7 \text{ kNm}$$

a) diagramas de esforços:

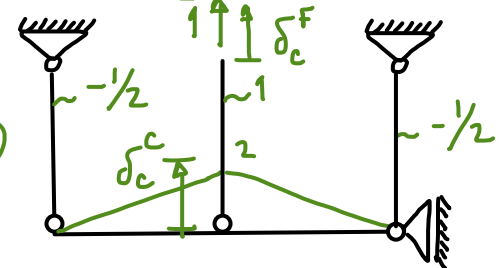


=

SOL. PARTICULAR



SOL. COMPLEMENTAR...



$$\delta_p^F = \frac{1}{EI} \int \left(\frac{15P}{8} \right) \left(\frac{1}{4} \right) dx + \frac{1}{EA} \int \left(\frac{1}{2} \right) \left(\frac{5}{8}P + \frac{3}{8}P \right) dx =$$

$$= -\frac{39}{4} \frac{P}{EI} - \frac{P}{EA} = -\frac{P}{E} \left(\frac{39}{4 \times 8356 \times 10^{-8}} + \frac{1}{16 \times 10^{-4}} \right) = -\frac{P}{E} 117,3 \times 10^{-3}$$

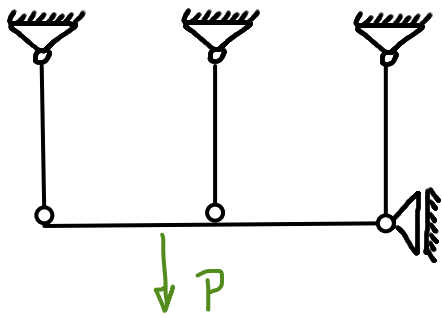
$$\delta_c^F = \frac{1}{EI} \int \left(\frac{1}{4} \right)^2 dx + \frac{1}{EA} \left[2 \int \left(\frac{1}{2} \right)^2 dx + \int \left(\frac{1}{2} \right)^2 dx \right] = \frac{32}{3EI} + \frac{3}{EA} = \frac{1}{E} 129,6 \times 10^3$$

$$\delta_p^F + R_v^F \times \delta_c^F = 0 \Rightarrow 129,6 \times 10^3 R_v^F = 117,3 \times 10^3 \Rightarrow R_v^F = \underline{0,906 P}$$

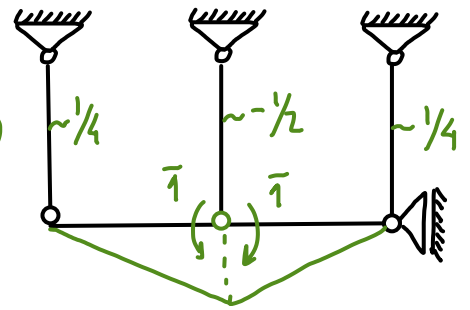
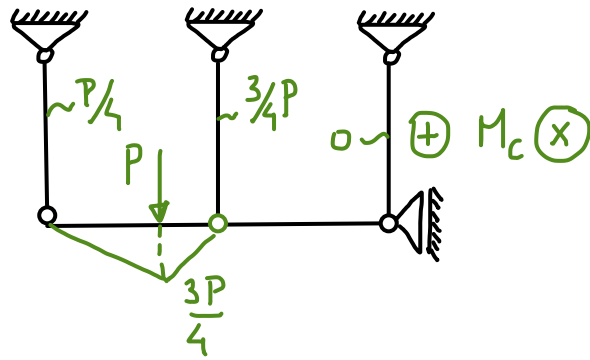
(SISTEMA BASE ALTERNATIVO)

SOL. PARTICULAR

SOL. COMPLEMENTAR



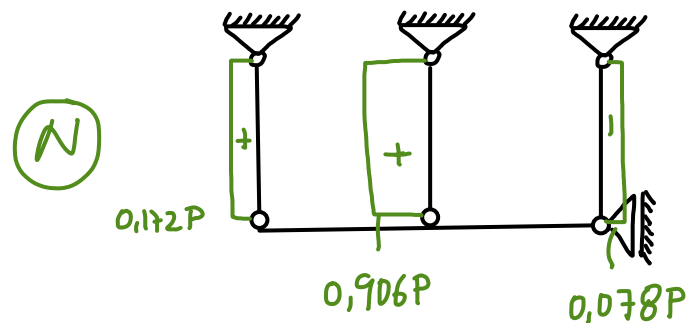
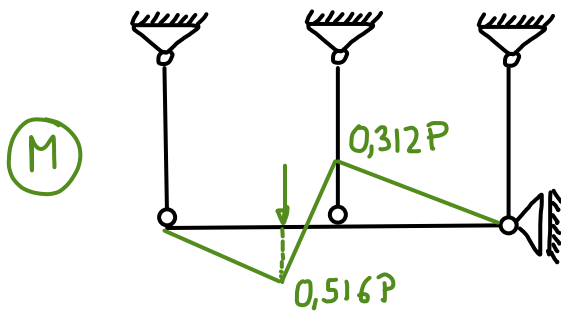
(=)



$$\theta_P^{rel,c} = \frac{1}{EA} \left(\int \frac{P}{2} \frac{1}{2} dx + \int \frac{3P}{2} \frac{1}{2} dx \right) + \frac{1}{EI} \int \frac{3}{4} \frac{1}{4} dx$$

$$\theta_c^{rel,c} = \frac{1}{EA} \left[2 \int \left(\frac{1}{2} \right)^2 dx + \int \left(\frac{1}{2} \right)^2 dx \right] + \frac{2}{EI} \int \left(\frac{1}{4} \right)^2 dx$$

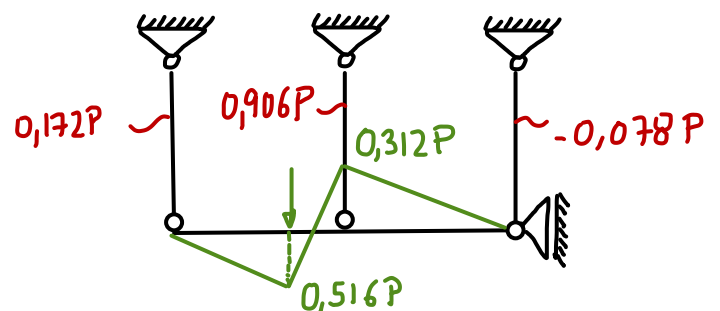
$$\theta_P^{rel,c} + M_c \times \theta_c^{rel,c} = 0 \Rightarrow M_c = -0,312P$$



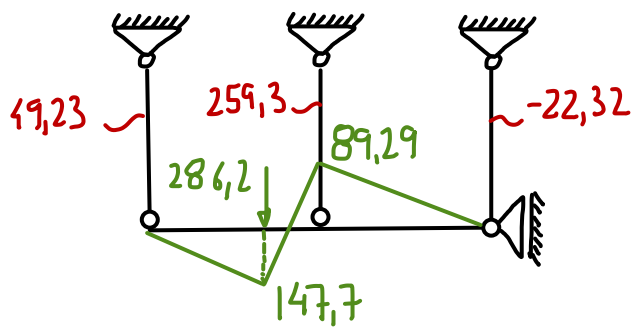
b) determinar carga cedência:

$$0,906P = 376 \Rightarrow P = 415$$

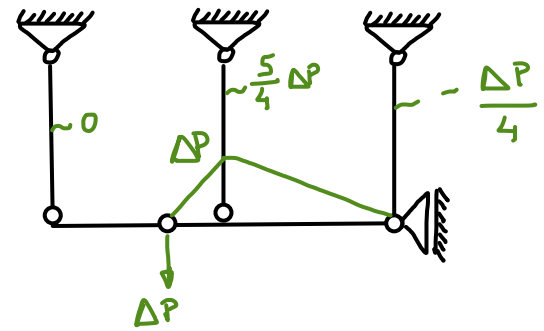
$$0,516P = 147,7 \Rightarrow P = 286,2 \text{ kN} = P_c$$



c1) carga de colapso através de análise incremental:



(+)



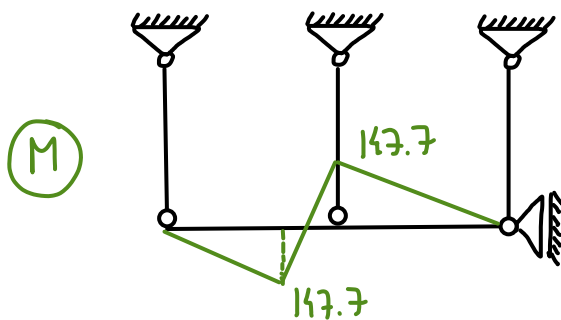
$$259,3 + \frac{5}{4} \Delta P = 376 \Rightarrow \Delta P = 93,36 \text{ kN}$$

$$-22,32 - \frac{\Delta P}{4} = -376 \Rightarrow \Delta P = 1593 \text{ kN}$$

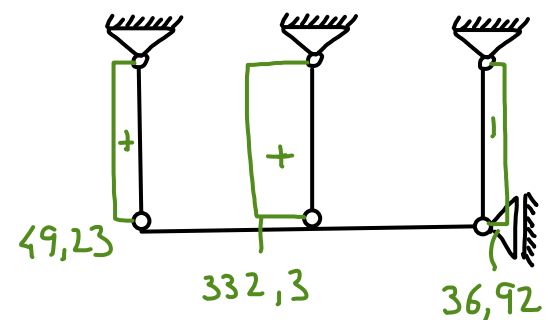
$$89,29 + \Delta P = 147,7 \Rightarrow \Delta P = \underline{\underline{58,41 \text{ kN}}}$$

$$P_m = P_c + \Delta P = 286,2 + 58,41 = \underline{\underline{344,6 \text{ kN}}}$$

d) diagramas de esforços no colapso:

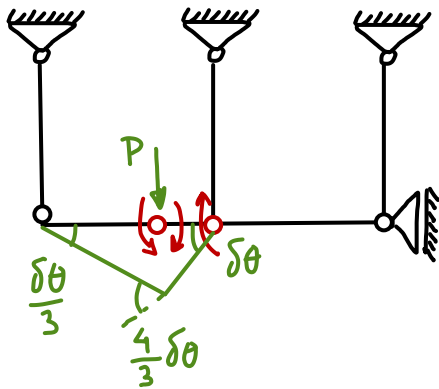


(N)



c2) carga de colapso através de análise limite:

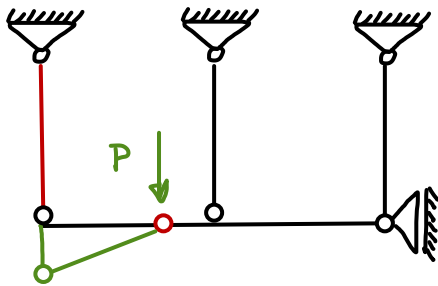
consideram-se apenas mecanismos associados à rótula plástica em B



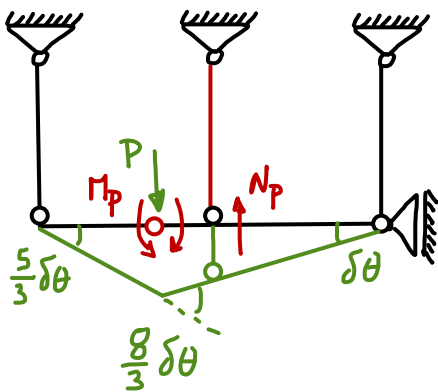
$$\bar{U}_e = P \delta \theta$$

$$\bar{U}_D = M_p \left(\delta \theta + \frac{4}{3} \delta \theta \right) = M_p \frac{7}{3} \delta \theta$$

$$\bar{U}_e \geq \bar{U}_D \Rightarrow P \geq \frac{7}{3} \times 147,7 = \underline{\underline{344,6 \text{ kN}}}$$



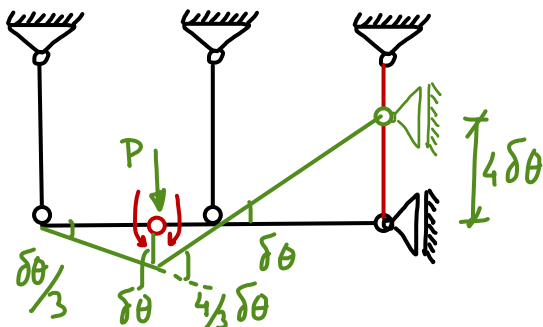
$$\bar{U}_e = 0 \Rightarrow \text{mecanismo impossível}$$



$$\bar{U}_e = 5 \delta \theta P$$

$$\bar{U}_D = \left(\frac{8}{3} M_p + 4 N_p \right) \delta \theta = \left(\frac{8}{3} 147,7 + 4 \times 376 \right) \delta \theta = 1898 \delta \theta$$

$$\bar{U}_e \geq \bar{U}_D \Rightarrow P \geq 379,6 \text{ kN}$$



$$\bar{U}_e = P \delta \theta$$

$$\bar{U}_D = M_p \left(\delta \theta + \frac{\delta \theta}{3} \right) + 4 N_p \delta \theta = 1701 \delta \theta$$

$$\bar{U}_e \geq \bar{U}_D \Rightarrow P \geq 1701 \text{ kN}$$