

4. Na estrutura de aço ( $E=210 \text{ GPa}$  e  $G=84 \text{ GPa}$ ) da figura, os apoios **A** e **C** impedem a torção, **D** é uma rótula esférica e o nó **B** está impedido de se deslocar na direcção perpendicular ao plano da estrutura.

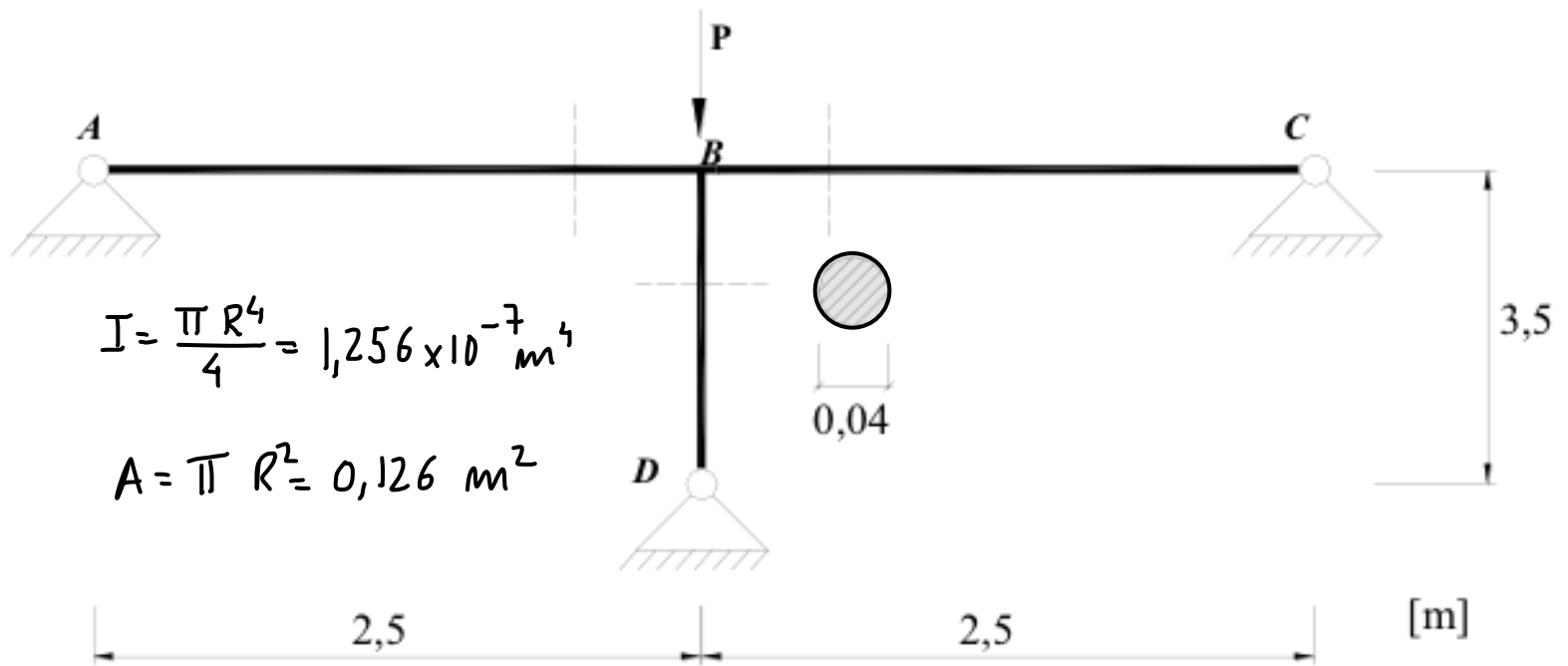
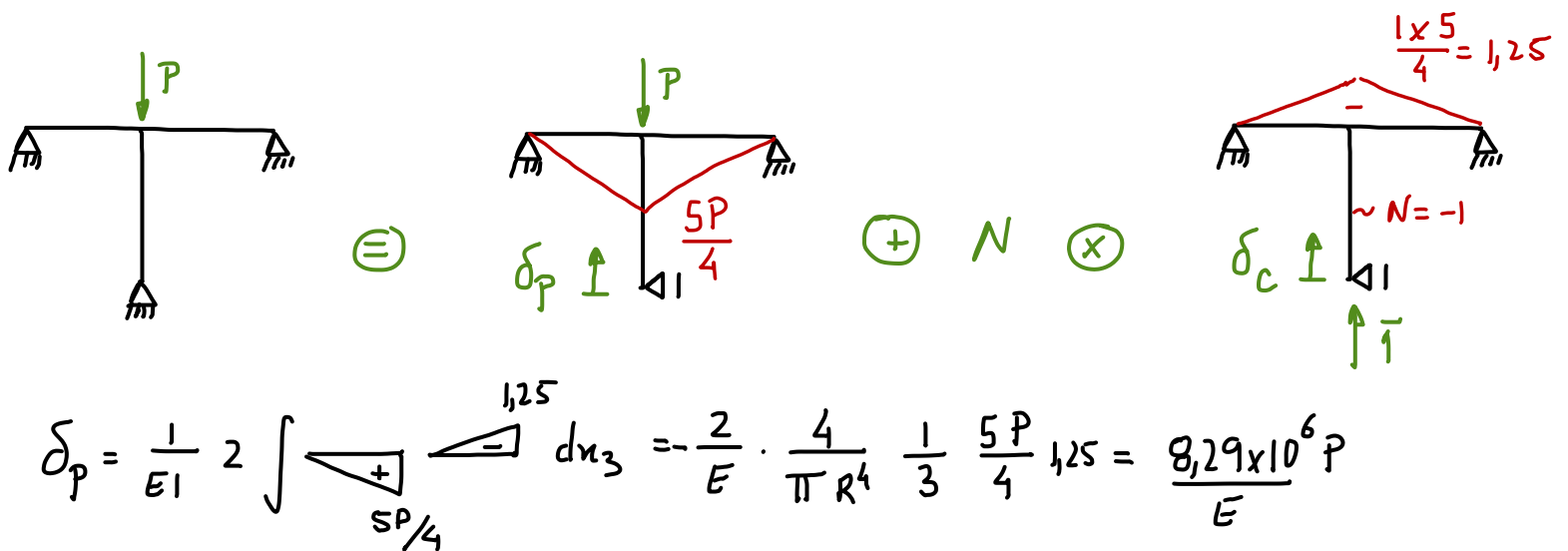


Figura 5-4

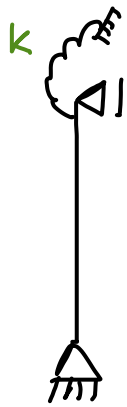
a. Determine a carga crítica ideal.



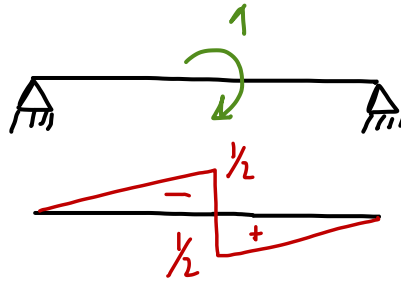
$$\delta_C = \frac{\delta_P}{P} + \frac{3,5}{E \cdot \pi R^2} = \frac{1}{E} (8,29 \times 10^6 + 2,785 \times 10^3)$$

$$N \delta_C + \delta_P = 0 \Rightarrow N = \underline{\underline{0,999 P \approx P}} \quad (\text{compressão})$$

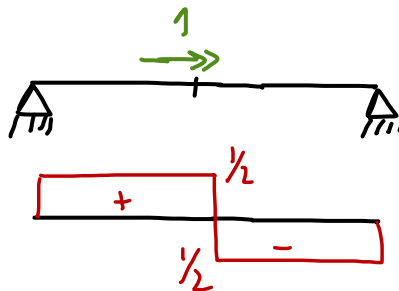
mós fixos



$$0,7L < L_e < L$$



$$\frac{1}{k} = \frac{2}{EI} \int \left( \frac{1/2}{2,5} \right)^2 = \frac{1}{EI} \frac{2}{3} \left( \frac{1}{2} \right)^2 \times 2,5 \Rightarrow k = 2,4 EI$$

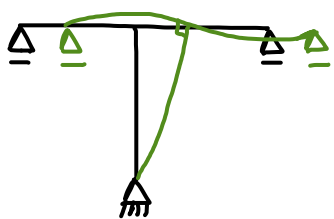


$$\frac{1}{k} = \frac{2}{GJ} \int \left( \frac{1/2}{2,5} \right)^2 = \frac{2}{2I_G \underset{0,4E}{\parallel}} \left( \frac{1}{2} \right)^2 \times 2,5 \Rightarrow k = \underline{\underline{0,64 EI}}$$

$$\left| \begin{array}{l} h_1 = 1 \\ h_2 = \frac{1}{1 + 0,64 \frac{3,5}{4}} = 0,64 \end{array} \right. \Rightarrow \frac{L_e}{L} = 0,5 + 0,14 (\eta_1 + \eta_2) + 0,055 (\eta_1 + \eta_2)^2 \simeq 0,88$$

$$P_{cn} = \frac{\pi^2 \times 210 \times 10^6 \times 1,256 \times 10^{-7}}{(0,88 \times 3,5)^2} = \underline{\underline{27,46 \text{ kN}}}$$

b. Admita agora que os apoios A e C permitem deslocamentos horizontais no plano da estrutura. Para esta situação determine a carga crítica ideal.



$$\left| \begin{array}{l} h_1 = 1 \\ h_2 = \frac{1}{1 + 2,4 \frac{3,5}{4}} = 0,313 \end{array} \right. \Rightarrow \frac{L_e}{L} = \left[ \frac{1 - 0,2 (\eta_1 + \eta_2) - 0,12 \eta_1 \eta_2}{1 - 0,8 (\eta_1 + \eta_2) + 0,6 \eta_1 \eta_2} \right]^{0,5} \simeq 2,2$$

$$P_{cn} = \min \left( 27,46; 27,46 \frac{0,88^2}{2,2^2} \right) = \underline{\underline{4,39 \text{ kN}}}$$