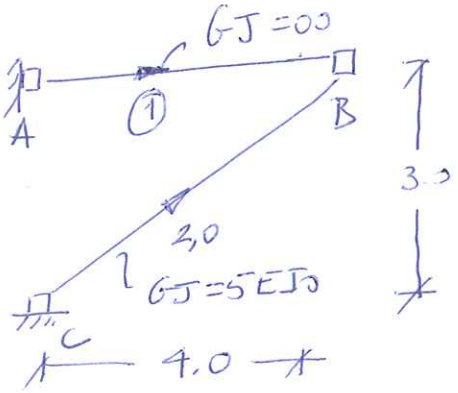
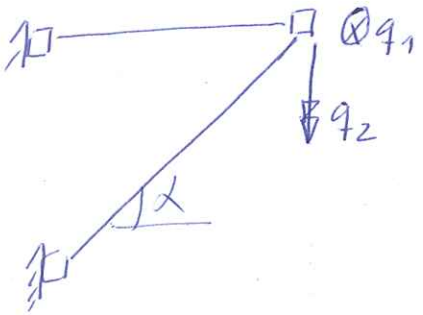
1 DISCRETIZAÇÃO E ORIENTAÇÃO



EJ = constante

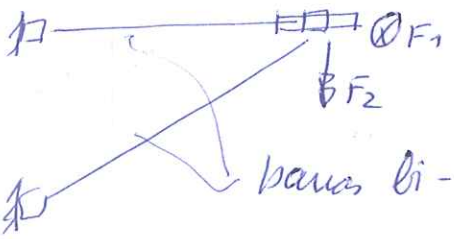
2 IDENTIFICAÇÃO DOS DESLOCAMENTOS INDEPENDENTES



$\operatorname{sen}\alpha = 3/5$

$\cos\alpha = 4/5$

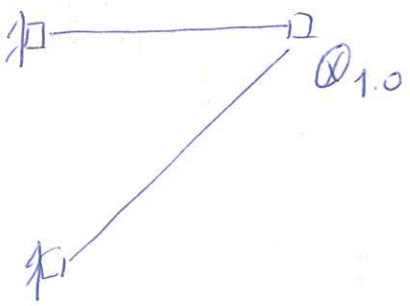
3 ESTRUTURA - BASE

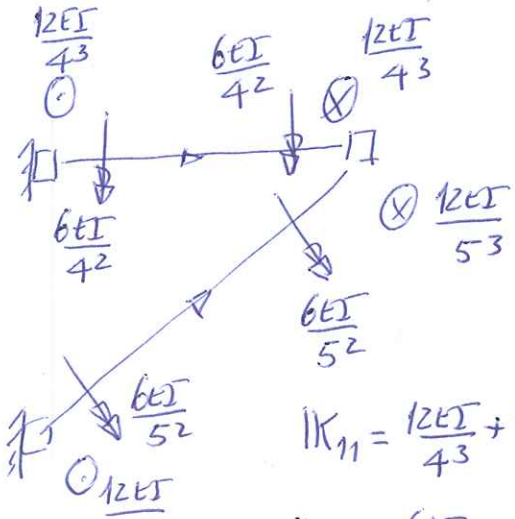


barras bi-encastradas

4 SOLUÇÃO COMPLEMENTAR

$q_1 = 1,0$; $q_2 = 0,0$

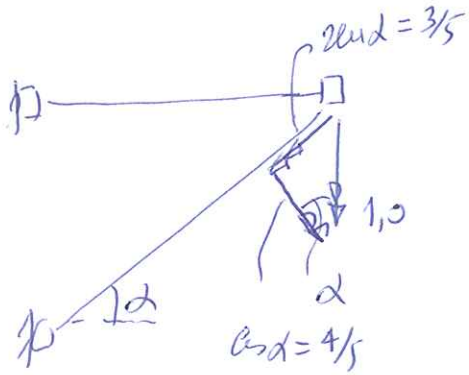


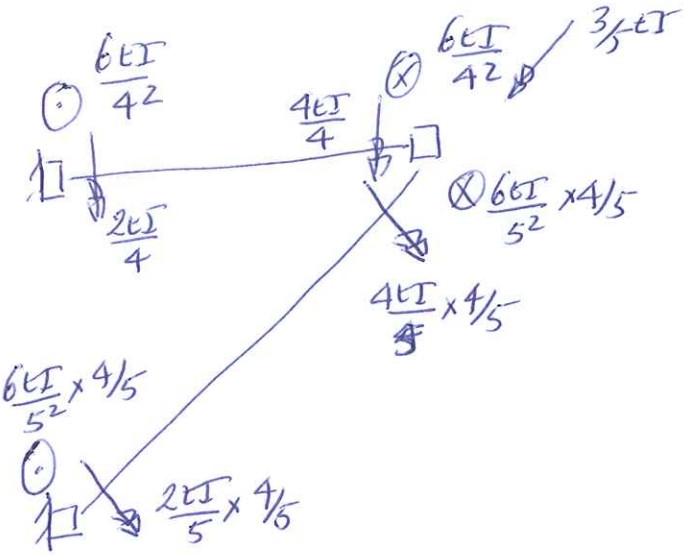


$$k_{11} = \frac{12EI}{4^3} + \frac{12EI}{5^3} = 0,2835\ EI$$

$$k_{21} = \frac{6EI}{4^2} + \frac{6EI}{5^2} \times 4/5 = 0,5670\ EI$$

$q_2 = 1.0$; $q_1 = 0.0$





$$K_{12} = \frac{6EI}{4^2} + \frac{6EI}{5^2} \times 4/5 = 0{,}5670\,EI \qquad \frac{GJ}{5} \times 3/5 = \frac{5EI}{5} \times 3/5 = 3/5\,EI$$

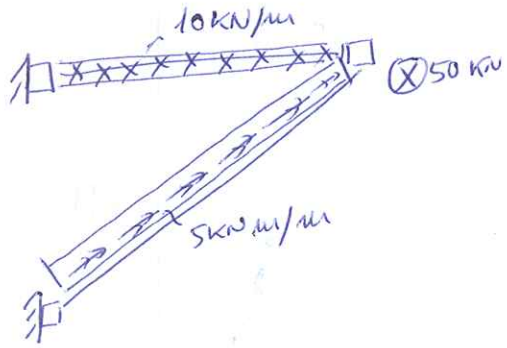
$$K_{22} = \frac{4EI}{4} + 3/5\,EI \times 3/5 + \frac{4EI}{5} \times 4/5 \times 4/5 = 1{,}872\,EI$$

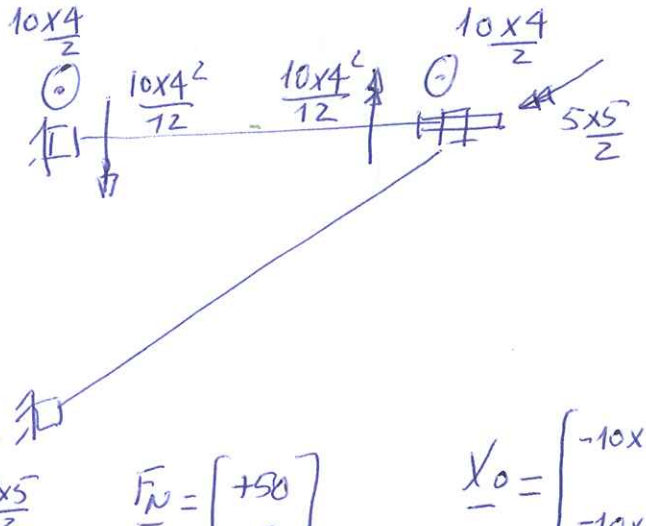
$$\underline{K}_X = EI \begin{bmatrix} 0{,}2835 & 0{,}5670 \\ 0{,}5670 & 1{,}872 \end{bmatrix}$$

$$\underline{X}_L = EI \left[\begin{array}{c|c} -6/16 & -2/4 \\ 6/16 & +4/4 \\ \hline -6/25 & -0{,}32 \\ +6/25 & +0{,}64 \\ 0 & -0{,}6 \end{array}\right]$$

(5) Solução particular

$q_1 = q_2 = 0.0$





$$\begin{cases} F_{N1} = +50 \\ F_{N2} = 0{,}0 \end{cases} \qquad \underline{F}_N = \begin{bmatrix} +50 \\ 0 \end{bmatrix}$$

$$\begin{cases} F_{01} = -10 \times \frac{4}{2} = -20 \\ F_{02} = -10\frac{x4^2}{12} + 5 \times \frac{5}{2} \times 3/5 = -5{,}8333 \end{cases} \qquad \underline{F}_0 = \begin{bmatrix} -20 \\ -5{,}8333 \end{bmatrix}$$

$$\underline{X}_0 = \left[\begin{array}{c} -10 \times 4^2/12 \\ -10 \times 4^2/12 \\ \hline 0 \\ 0 \\ -12{,}5 \end{array}\right]$$

6 EQUAÇÃO DO MÉTODO DOS DESLOCAMENTOS

$$K_* \, q + F_0 = F_N$$

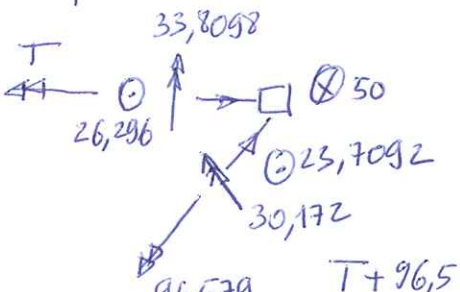
$$EI \begin{bmatrix} 0{,}2835 & 0{,}5670 \\ 0{,}5670 & 1{,}872 \end{bmatrix} \begin{Bmatrix} q_1 \\ q_2 \end{Bmatrix} + \begin{bmatrix} -20 \\ -5{,}8333 \end{bmatrix} = \begin{bmatrix} +50 \\ 0 \end{bmatrix} \Rightarrow \begin{Bmatrix} q_1 \\ q_2 \end{Bmatrix} = \frac{1}{EI} \begin{Bmatrix} 610{,}509 \\ -181{,}798 \end{Bmatrix}$$

7 SOBREPOSIÇÃO DE ESFORÇOS

$$X_f = X_c \, q + X_0 = EI \left[\begin{array}{cc} -6/16 & -2/4 \\ +6/16 & +4/4 \\ \hline -6/25 & -0{,}32 \\ +6/25 & +0{,}64 \\ 0 & -0{,}6 \end{array}\right] \frac{1}{EI} \begin{bmatrix} 610{,}509 \\ -181{,}798 \end{bmatrix} + \left[\begin{array}{c} -10 \times 16/12 \\ -10 \times 16/12 \\ \hline 0 \\ 0 \\ -12{,}5 \end{array}\right]$$

$$X_f = \left[\begin{array}{c} -151{,}375 \\ +33{,}8098 \\ \hline -88{,}347 \\ 30{,}172 \\ 96{,}579 \end{array}\right] \begin{array}{l} \} X_1 \\ \\ \\ \} X_2 \end{array}$$

Equilíbrio no Nó D

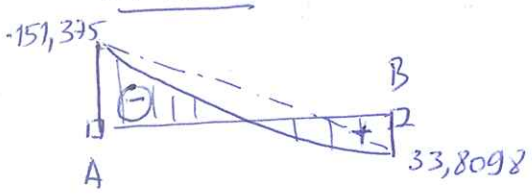


$T + 96{,}579 \times 4/5 + 30{,}175 \times 3/5 = 0$

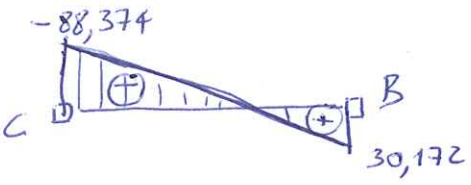
$T = -95{,}366$ kN

8 DIAGRAMAS DE ESFORÇOS

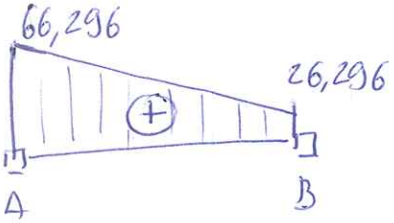
BARRA 1

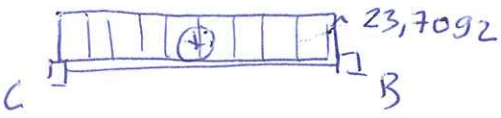


BARRA 2

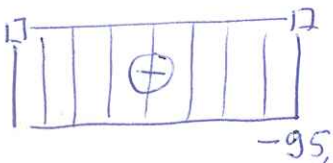


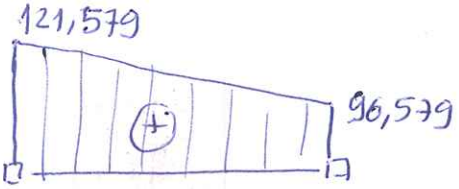
(M) (kN m)





(V) (kN)





(T) (kN)