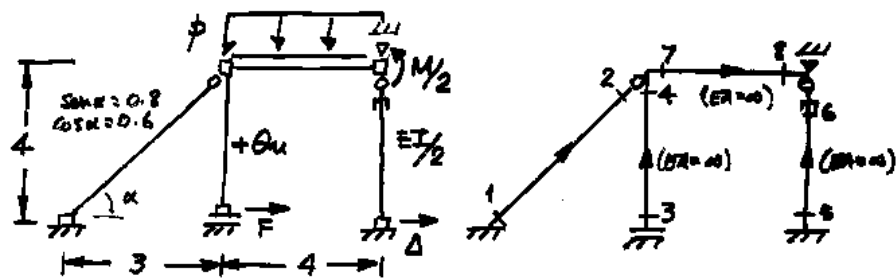
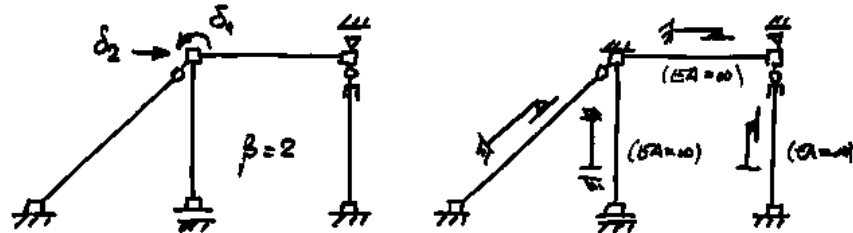


1

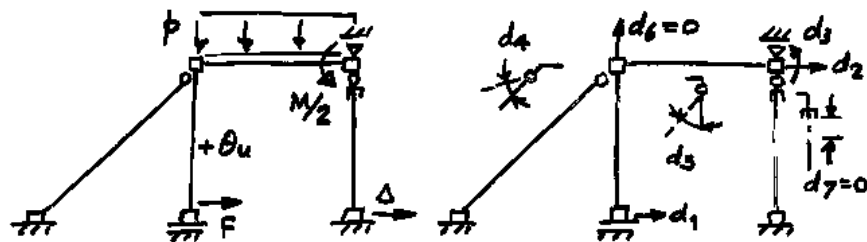
1. Simplificação de simetria, discretização e orientações



2. Indeterminações cinemática e estrutural base



3. Cargas de vão e deslocamentos dependentes



4. Expressões gerais da Equação do Método dos Deslocamentos

$$\begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix} \begin{Bmatrix} \delta_1 \\ \delta_2 \end{Bmatrix} + \begin{Bmatrix} f_1 \\ f_2 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_2 \end{Bmatrix}$$

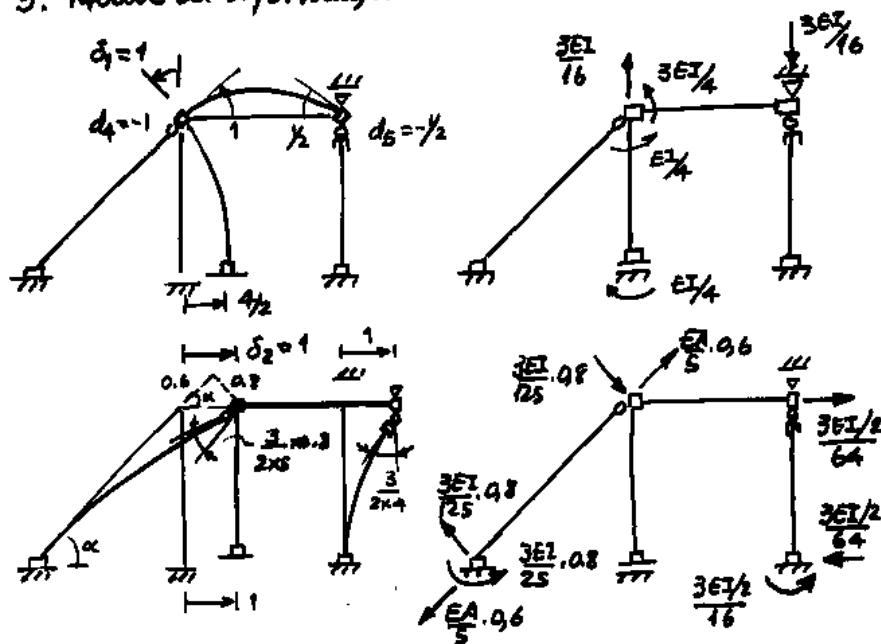
k_{ij} - trabalho das forças devidas a $\delta_j = 1$ na deformada $\delta_i = 1$

F_{i0} - trabalho das forças devidas às cargas de vão na " "

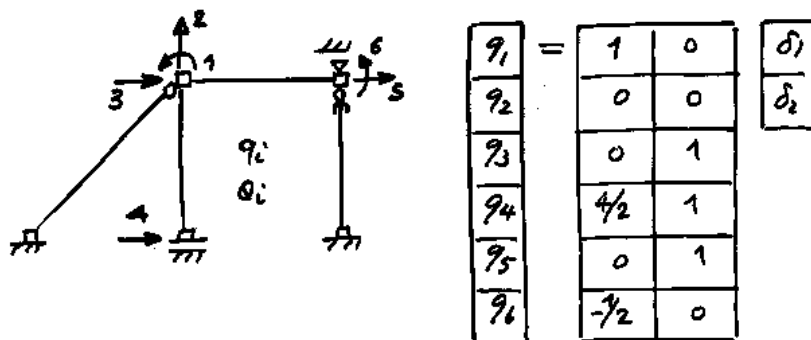
F_i - trabalho das forças nodais aplicadas na " "

5. Modos de deformação

(2)



6. Deslocamentos e forças nodais



$$\underline{F} = \underline{T}^T \underline{Q} \quad \Leftrightarrow \quad \underline{q} = \underline{T} \cdot \underline{d}$$



$$\begin{cases} F_1 = Q_1 + 2Q_4 - 1/2 Q_6 \\ F_2 = Q_3 + Q_4 + Q_5 \end{cases}$$

7. Matriz de rigidez $(A = \frac{12}{h^2} I = 48 I m^2, b = 0,40, h = 0,50 m)$ (3)

$$k_{11} = (3EI/4 + EI/4) \times 1 = EI$$

$$k_{12} = 0$$

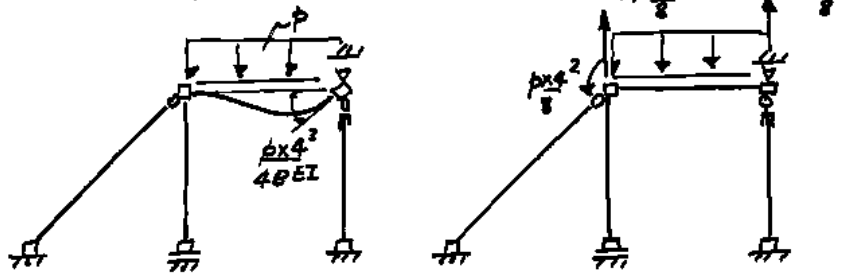
$$k_{21} = 0$$

$$k_{22} = \left(\frac{3EI}{125} \cdot 0,8\right) \times 0,8 + \left(\frac{EI}{5} \cdot 0,6\right) \times 0,6 + \left(\frac{3EI/2}{64}\right) \times 1 = 3.495 EI$$

8. Soluções complementares para os deslocamentos dependentes

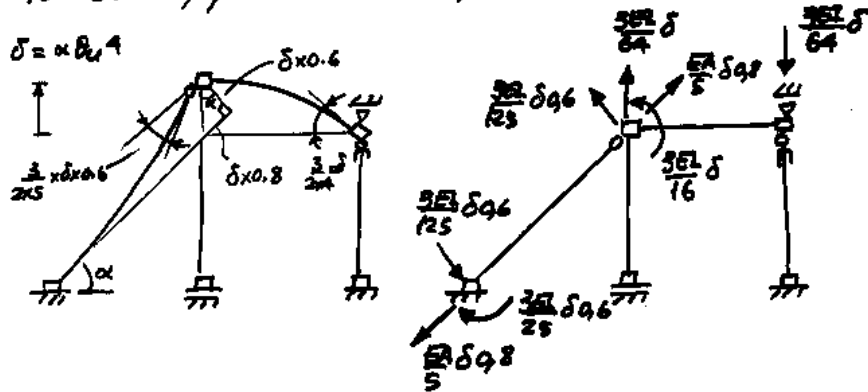
M_1	=	0	$-\frac{3EI}{25} 0,8$	δ_1	d_1	=	2	1	δ_1
M_2		0	0	δ_2	d_2		0	1	δ_2
N_2		0	$\frac{EI}{5} 0,6$		d_3		$-\frac{1}{2}$	0	
M_3		$\frac{EI}{4}$	0		d_4		-1	$\frac{3}{25} 0,8$	
M_4		$\frac{EI}{4}$	0		d_5		$-\frac{1}{2}$	$\frac{3}{8}$	
M_5		0	$-\frac{3EI/2}{16}$						
M_6		0	0						
M_7		$-\frac{3EI}{4}$	0						
M_8		0	0						

9. Soluções particulares: ações de p

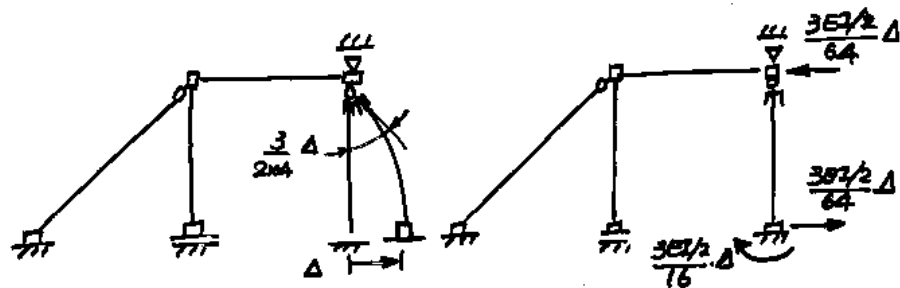


④

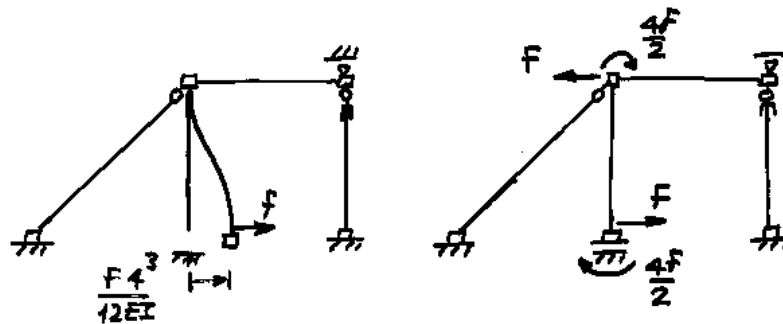
10. Soluções particular: accas de δu



11. Soluções particular: accas de Δ

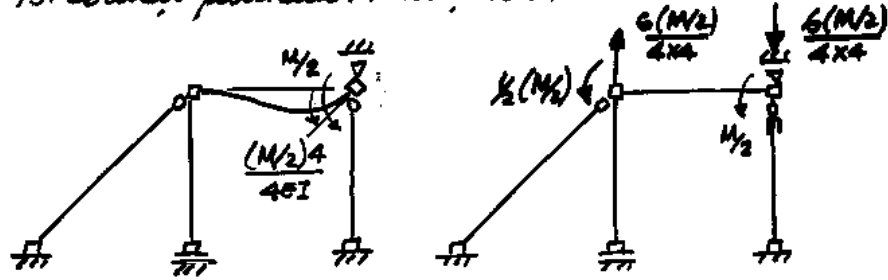


12. Soluções particular: accas de f



⑤

13. Soluções particulares: acent de M



14. Vetor das forças de fixação

$$F_1 = \left(\frac{4^2}{8}\right) p + \left(\frac{3EI}{16}\right) \delta + (0) \cdot \Delta + \left(-\frac{4}{2}\right) F + \left(\frac{1}{2}\right) M/2$$

$$F_2 = (0) p + \left(\frac{EI}{5} - \frac{3EI}{125}\right) 0,8 \delta + \left(-\frac{3EI}{64}\right) \Delta + (-1) F + (0) M/2$$

15. Vetor das forças nodais

$$F_1 = 0$$

$$F_2 = 0$$

16. Soluções particulares para os modos independentes

M_1	=	0	p +	$\frac{3EI}{25} 0,6$	$\delta +$	0	$\Delta +$	0	f +	0	$M/2$
M_2		0		0		0		0		0	
N_2		0		$\frac{EI}{5} 0,8$		0		0		0	
M_3		0		0		0		$+4/2$		0	
M_4		0		0		0		$-4/2$		0	
M_5		0		0		$\frac{3EI}{16}$		0		0	
M_6		0		0		0		0		0	
M_7		$-4/8$		$-\frac{3EI}{16}$		0		0		$-1/2$	
M_8		0		0		0		0		1	

17. Solução particular para o deslocamento dependente

⑥

$$\begin{array}{|c|} \hline d_1 \\ \hline d_2 \\ \hline d_3 \\ \hline d_4 \\ \hline d_5 \\ \hline \end{array} = \begin{array}{|c|} \hline 0 \\ \hline 0 \\ \hline \frac{4^3}{48EI} \\ \hline 0 \\ \hline \frac{4^3}{48EI} \\ \hline \end{array} \delta + \begin{array}{|c|} \hline 0 \\ \hline 0 \\ \hline -\frac{3}{8} \\ \hline -\frac{3}{25} \cdot 0,6 \\ \hline -\frac{3}{8} \\ \hline \end{array} \delta + \begin{array}{|c|} \hline 0 \\ \hline 0 \\ \hline 0 \\ \hline 0 \\ \hline -\frac{3}{8} \\ \hline \end{array} \Delta + \begin{array}{|c|} \hline \frac{4^3}{12EI} \\ \hline 0 \\ \hline 0 \\ \hline 0 \\ \hline 0 \\ \hline \end{array} F + \begin{array}{|c|} \hline 0 \\ \hline 0 \\ \hline \frac{4}{48EI} \\ \hline 0 \\ \hline \frac{4}{48EI} \\ \hline \end{array} M/2$$

18. Solução para o momento aplicado (M/2)

18.1 Equação do Método dos deslocamentos

$$EI \begin{bmatrix} 1 & 0 \\ 0 & 3,495 \end{bmatrix} \begin{Bmatrix} \delta_1 \\ \delta_2 \end{Bmatrix} + \begin{Bmatrix} 1/4 \\ 0 \end{Bmatrix} M = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix} \quad \begin{cases} \delta_1 = -M/48EI \\ \delta_2 = 0 \end{cases}$$

18.2 Esforço independente

$$\begin{array}{|c|} \hline M_1 \\ \hline M_2 \\ \hline N_2 \\ \hline M_3 \\ \hline M_4 \\ \hline M_5 \\ \hline M_6 \\ \hline M_7 \\ \hline M_8 \\ \hline \end{array} = \begin{array}{|c|c|} \hline 0 & / \\ \hline 0 & / \\ \hline 0 & / \\ \hline EI/4 & / \\ \hline EI/4 & / \\ \hline 0 & / \\ \hline 0 & / \\ \hline -3EI/4 & / \\ \hline 0 & / \\ \hline \end{array} + \begin{array}{|c|} \hline -M/48EI \\ \hline 0 \\ \hline \end{array} + \begin{array}{|c|} \hline 0 \\ \hline 0 \\ \hline 0 \\ \hline 0 \\ \hline 0 \\ \hline 0 \\ \hline -1/4 \\ \hline 1/2 \\ \hline \end{array} M = \begin{array}{|c|} \hline 0 \\ \hline 0 \\ \hline 0 \\ \hline -1/16 \\ \hline -1/16 \\ \hline 0 \\ \hline 0 \\ \hline -1/16 \\ \hline 1/2 \\ \hline \end{array} M$$

⑦

