TE16-AB-B1b

Problema A

restart

A01:
- Momento Fletor e Esforço Normal estão relacionados à **Tensão Normal**;

A02:

$d := 1.90$:
$L := 1.10$:
$E := 1.0e5$:
$fy := 250.0$:
$\varepsilon := 0.0015$:

$$A := \frac{\mathrm{Pi} \cdot (0.01 \cdot d)^2}{4} :$$

(1)

$$k := \frac{1000 \cdot E \cdot A}{L} :$$

$N := 1000 \cdot E \cdot A \cdot \varepsilon$:
$\delta := \varepsilon \cdot L$:
$Ny := A \cdot 1000 \cdot fy \cdot 0.1$:

$$print\left(\text{"k="}, k, \frac{kN}{m} \right)$$

$$\text{"k="}, 25775.33973, \frac{kN}{m} \quad \textbf{(2)}$$

$$print(\text{"N="}, N, kN)$$

$$\text{"N="}, 42.52931055, kN \quad \textbf{(3)}$$

$$print(\text{"δ="}, \delta, m)$$

$$\text{"δ="}, 0.001650, m$$

$$print(\text{"Ny="}, Ny, tf)$$

$$\text{"Ny="}, 7.088218425, tf \quad \textbf{(5)}$$

A03:
- Modelo de pórtico;
- 2 rótulas com 2 barras;
- 1 rótula com 4 barras;
- 1 rótula com 3 barras;
- Grau estático total: +3
- Grau estático interno: +6
- Grau estático externo: -3

A04:
- Modelo de treliça;
- Grau estático total: +1
- Grau estático interno: 0
- Grau estático externo: +1
- Impossível calcular as reações de apoio para qualquer tipo de carregamento;

Problema B

restart

with(LinearAlgebra) :

$L1 := 4.0$:
$L2 := 5.0$:
$L3 := 4.0$:
$H := 3.0$:
$q1 := 2.0$:
$q2 := 3.5$:
$q3 := 10.0$:
$P := 40.0$:
$EI := 30000.0$:

Determinação da Equação do Carregamento em AB

$$A := Matrix\left(\left[[1, 0, 0], \left[1, \frac{L1}{2}, \left(\frac{L1}{2}\right)^2\right], [1, L1, L1^2]\right]\right)$$

$$\begin{bmatrix} 1 & 0 & 0 \\ 1 & 2.000000000 & 4.000000000 \\ 1 & 4.0 & 16.00 \end{bmatrix} \quad (6)$$

$$B := Vector([0, q2, q1])$$

$$\begin{bmatrix} 0 \\ 3.5 \\ 2.0 \end{bmatrix} \quad (7)$$

$$Vetor_qAB := MatrixInverse(A)\,B$$

$$\begin{bmatrix} 0. \\ 3. \\ -0.625000000000000 \end{bmatrix} \quad (8)$$

$$qAB := Vetor_qAB[1] + Vetor_qAB[2]\cdot x + Vetor_qAB[3]\cdot x^2$$

$$-0.625000000000000\,x^2 + 3.\,x \quad (9)$$

$$RES_AB := int(qAB, x = 0..L1)$$

$$10.66666667 \quad (10)$$

$$x_AB := \frac{int(qAB\cdot x, x = 0..L1)}{int(qAB, x = 0..L1)}$$

$$2.249999999 \quad (11)$$

Cálculo da Reação de Apoio VE e do esforço interno VB

ΣMB_dir = 0 (antihorário)

$$VE := solve\left(VE\cdot(L2 + L3) - q3\cdot L3\cdot\left(L2 + \frac{L3}{2}\right) + \frac{P\cdot H}{2} = 0, VE\right)$$

$$24.44444444 \quad (12)$$

ΣMFV_BCDEF = 0 (para cima)

$VB := solve(VB - q3 \cdot L3 + \mathrm{VE} = 0, \mathrm{VB})$

$$15.55555556 \quad \textbf{(13)}$$

Cálculo do Momento MA e Corante VA (sinal conforme a convenção para diagramas)

$MA := -VB \cdot L1 - RES_AB \cdot x_AB$

$$-86.22222224 \quad \textbf{(14)}$$

$VA := VB + RES_AB$

$$26.22222223 \quad \textbf{(15)}$$

Integração da Equação de Carga até a Equação da Linha Elástica

$VAB := int(-qAB, x) + VA$

$$0.2083333333\, x^3 - 1.500000000\, x^2 + 26.22222223 \quad \textbf{(16)}$$

$MAB := int(VAB, x) + MA$

$$0.05208333332\, x^4 - 0.5000000000\, x^3 + 26.22222223\, x - 86.22222224 \quad \textbf{(17)}$$

$\theta AB := \frac{1}{_EI} \cdot (int(MAB, x) + 0)$

$$\frac{0.01041666666\, x^5 - 0.1250000000\, x^4 + 13.11111112\, x^2 - 86.22222224\, x}{_EI} \quad \textbf{(18)}$$

$vAB := int(\theta AB, x) + 0$

$$\frac{0.001736111110\, x^6 - 0.02500000000\, x^5 + 4.370370373\, x^3 - 43.11111112\, x^2}{_EI} \quad \textbf{(19)}$$

Rotação do ponto situado no meio da barra AB

$\theta AB_meioAB := subs\left(x = \frac{L1}{2}, _EI = EI, \theta AB\right)$

$$-0.004055555556 \quad \textbf{(20)}$$

Deflexão do ponto B

$vAB_B := subs(x = L1, _EI = EI, vAB)$

$$-0.01428543210 \quad \textbf{(21)}$$

Problema C _____

restart
$L1 := 3.0$:
$L2 := 6.0$:
$L3 := 3.0$:
$H := 4.0$:
$q1 := 40.0$:
$q2 := 15.0$:
$P := 45.0$:
$M := 60.0$:

Cálculo das Reações de Apoio VG, VA e HH;

ΣMD_dir = 0 (antihorário)

$$VG := solve\left(VG\cdot(L1+L3) - \frac{P\cdot H}{2} + M - q2\cdot L3\cdot\left(L1+\frac{L3}{2}\right) - \frac{q1\cdot L1}{2}\cdot\frac{1}{3}\cdot L1 = 0, VG\right)$$

$$48.75000000 \quad \textbf{(22)}$$

ΣMFV_DEFG = 0 (para cima)

$$VD := solve\left(\mathrm{VD} - \frac{\mathrm{q1}\cdot\mathrm{L1}}{2} - \mathrm{q2}\cdot\mathrm{L3} + \mathrm{VG} = 0, \mathrm{VD}\right)$$

$$56.25000000 \quad \textbf{(23)}$$

ΣMFH_DEFG = 0 (para direita)

$$HD := solve(\mathrm{HD} - \mathrm{P} = 0, \mathrm{HD})$$

$$45. \quad \textbf{(24)}$$

ΣFH_ABCDH = 0 (para direita)

$$HH := solve(\mathrm{HH} + \mathrm{P} + \mathrm{q2}\cdot\mathrm{H} - \mathrm{HD} = 0, \mathrm{HH})$$

$$-60. \quad \textbf{(25)}$$

ΣFMD_ABCDH = 0 (horário)

$$VA := solve\left(\mathrm{VA}\cdot(\mathrm{L1}+\mathrm{L2}) - \frac{\mathrm{q2}\cdot\mathrm{H}^2}{2} - P\cdot\frac{\mathrm{H}}{2} - \mathrm{HH}\cdot\mathrm{H} = 0, \mathrm{VA}\right)$$

$$-3.333333333 \quad \textbf{(26)}$$

Equação de Esforços Axiais da Barra AB:

$$h1 := \sqrt{H^2 + L1^2}$$

$$5.000000000 \quad \textbf{(27)}$$

$$cos\alpha := \frac{L1}{h1}$$

$$0.6000000000 \quad \textbf{(28)}$$

$$sen\alpha := \frac{H}{h1}$$

$$0.8000000000 \quad \textbf{(29)}$$

$$FA_paral := -VA\cdot sen\alpha$$

$$2.666666666 \quad \textbf{(30)}$$

$$q2_paral := -q2\cdot sen\alpha\cdot cos\alpha$$

$$-7.200000000 \quad \textbf{(31)}$$

$$NAB_x := FA_paral + q2_paral\cdot x$$

$$-7.200000000\,x + 2.666666666 \quad \textbf{(32)}$$

Equação de Esforços Cortante da Barra BC:

$$VER_B := VA$$

$$-3.333333333 \quad \textbf{(33)}$$

$$HOR_B := \frac{q2\cdot H}{2} + P$$

$$75.00000000 \quad \textbf{(34)}$$

$$FB_perp := VER_B\cdot cos\alpha - HOR_B\cdot sen\alpha$$

$$-62.00000000 \quad \textbf{(35)}$$

$q2_perp := -q2 \cdot sen\alpha^2$

$VBC_x := FB_perp + q2_perp \cdot x$

$$-9.600000000\,x - 62.00000000 \quad \textbf{(36)}$$

Cortante no Ponto F da barra EF

$h2 := \sqrt{H^2 + L3^2}$

$$5.000000000 \quad \textbf{(37)}$$

$cos\beta := \frac{L3}{h2}$

$$0.6000000000 \quad \textbf{(38)}$$

$sen\beta := \frac{H}{h2}$

$$0.8000000000 \quad \textbf{(39)}$$

$VER_F_EF := VG - \frac{q2 \cdot L3}{2}$

$$26.25000000 \quad \textbf{(40)}$$

$HOR_F_EF := -P$

$$-45.0 \quad \textbf{(41)}$$

$\mathrm{RVF_esq} := -\mathrm{HOR_F_EF} \cdot \mathrm{sen}\beta - \mathrm{VER_F_EF} \cdot \mathrm{cos}\beta$

$$20.25000000 \quad \textbf{(42)}$$

Axial no Ponto F da barra EF

$VER_F_FG := VG - \frac{q2 \cdot L3}{2}$

$$26.25000000 \quad \textbf{(43)}$$

$HOR_F_FG := 0$

$$0 \quad \textbf{(44)}$$

$\mathrm{NFdir} := +\mathrm{HOR_F_FG} \cdot \mathrm{cos}\beta - \mathrm{VER_F_FG} \cdot \mathrm{sen}\beta$

$$-21.00000000 \quad \textbf{(45)}$$

Diagrama de Momentos Fletores Trechos GF e FE:

$ME := VD \cdot L1 - \frac{q1 \cdot L1}{2} \cdot \frac{2}{3} \cdot L1$

$$48.7500000 \quad \textbf{(46)}$$

$VE := +VD - \frac{q1 \cdot L1}{2}$

$$-3.75000000 \quad \textbf{(47)}$$

$HE := HD$

$$45. \quad \textbf{(48)}$$

$MEF := ME + VE \cdot cos\beta \cdot x + HE \cdot sen\beta \cdot x - \frac{q2 \cdot cos\beta^2 \cdot x^2}{2}$

$$48.7500000 + 33.75000000\,x - 2.700000000\,x^2 \quad \textbf{(49)}$$

$$MFG := MEF - M - P \cdot sen\beta \cdot \left(x - \frac{h2}{2} \right)$$

$$78.75000000 - 2.25000000\,x - 2.700000000\,x^2 \quad \textbf{(50)}$$

$$MEFG := piecewise\left(\frac{h2}{2} > x, MEF, MFG \right)$$

$$\begin{cases} 48.7500000 + 33.75000000\,x - 2.700000000\,x^2 & x < 2.500000000 \\ 78.75000000 - 2.25000000\,x - 2.700000000\,x^2 & otherwise \end{cases} \quad \textbf{(51)}$$

$$\begin{cases} 48.7500000 + 33.75000000\,x - 2.700000000\,x^2 & x < 2.500000000 \\ 78.75000000 - 2.25000000\,x - 2.700000000\,x^2 & otherwise \end{cases} \quad \textbf{(52)}$$

$$\begin{cases} 48.7500000 + 33.75000000\,x - 2.700000000\,x^2 & x < 2.500000000 \\ 78.75000000 - 2.25000000\,x - 2.700000000\,x^2 & otherwise \end{cases} \quad \textbf{(53)}$$

$$\begin{cases} 48.7500000 + 33.75000000\,x - 2.700000000\,x^2 & x < 2.500000000 \\ 78.75000000 - 2.25000000\,x - 2.700000000\,x^2 & otherwise \end{cases} \quad \textbf{(54)}$$

Diagrama de Esforços Cortantes Trechos GF e FE:

$$VEF := diff(MEF, x)$$

$$33.75000000 - 5.400000000\,x \quad \textbf{(55)}$$

$$VFG := diff(MFG, x)$$

$$-2.25000000 - 5.400000000\,x \quad \textbf{(56)}$$

$$VEFG := piecewise\left(\frac{h2}{2} > x, VEF, VFG \right)$$

$$\begin{cases} 33.75000000 - 5.400000000\,x & x < 2.500000000 \\ -2.25000000 - 5.400000000\,x & otherwise \end{cases} \quad \textbf{(57)}$$

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with(plots) :
mp := plot(-MEFG, x = 0..h2) :
M0 := subs(x = 0, -MEF) :
M1 := subs(x = h2/2, -MEF) :
M2 := subs(x = h2/2, -MFG) :
M3 := subs(x = h2, -MFG) :
mt0 := textplot([0, M0, 'typeset'(-M0)]) :
mt1 := textplot([h2/2, M1, 'typeset'(-M1)]) :
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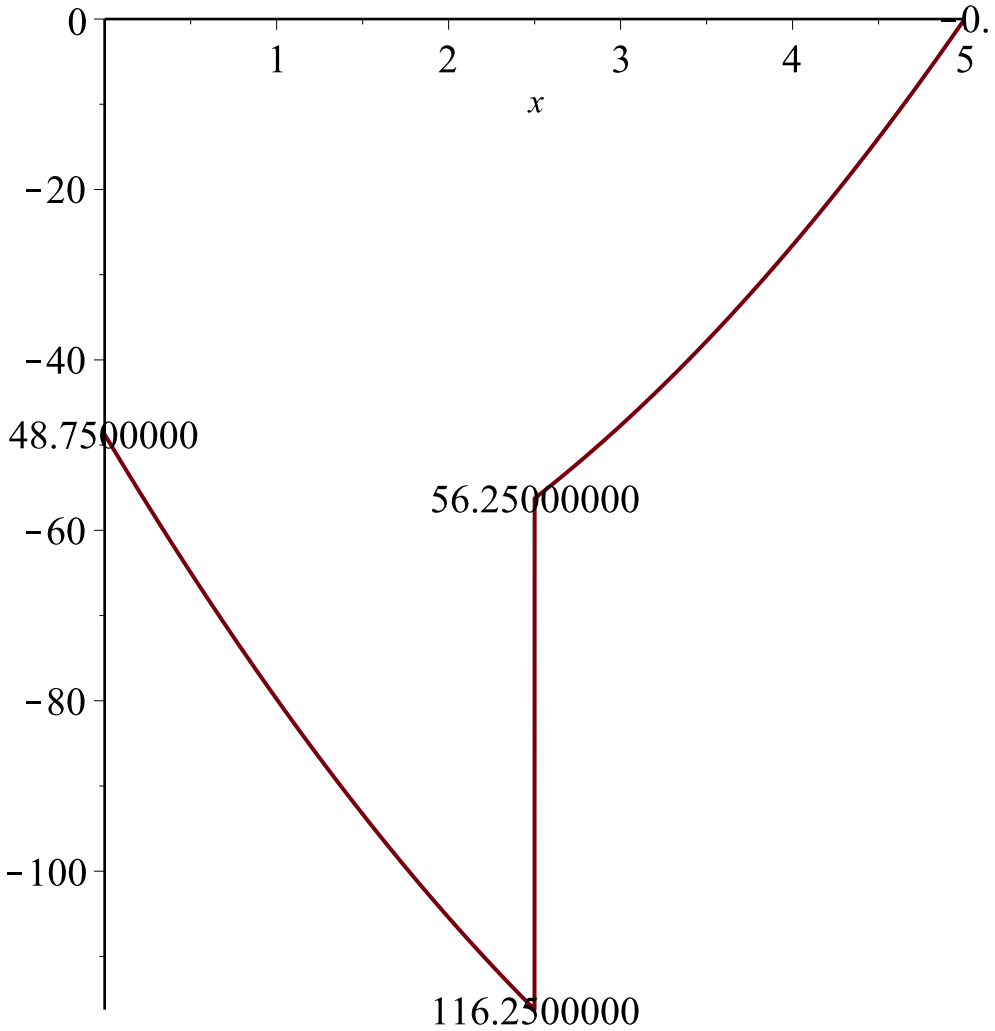
$$mt2 := textplot\left(\left[\frac{h2}{2}, M2, 'typeset'(-M2) \right] \right) :$$
$$mt3 := textplot([h2, M3, 'typeset'(-M3)]) :$$

$$vp := plot(VEFG, x = 0..h2) :$$
$$V0 := subs(x = 0, VEF) :$$
$$V1 := subs\left(x = \frac{h2}{2}, VEF \right) :$$
$$V2 := subs\left(x = \frac{h2}{2}, VFG \right) :$$
$$V3 := subs(x = h2, VFG) :$$
$$vt0 := textplot([0, V0, 'typeset'(V0)]) :$$
$$vt1 := textplot\left(\left[\frac{h2}{2}, V1, 'typeset'(V1) \right] \right) :$$
$$vt2 := textplot\left(\left[\frac{h2}{2}, V2, 'typeset'(V2) \right] \right) :$$
$$vt3 := textplot([h2, V3, 'typeset'(V3)]) :$$

$$display(\{mp, mt0, mt1, mt2, mt3\})$$



display({ *vp*, *vt0*, *vt1*, *vt2*, *vt3* })

