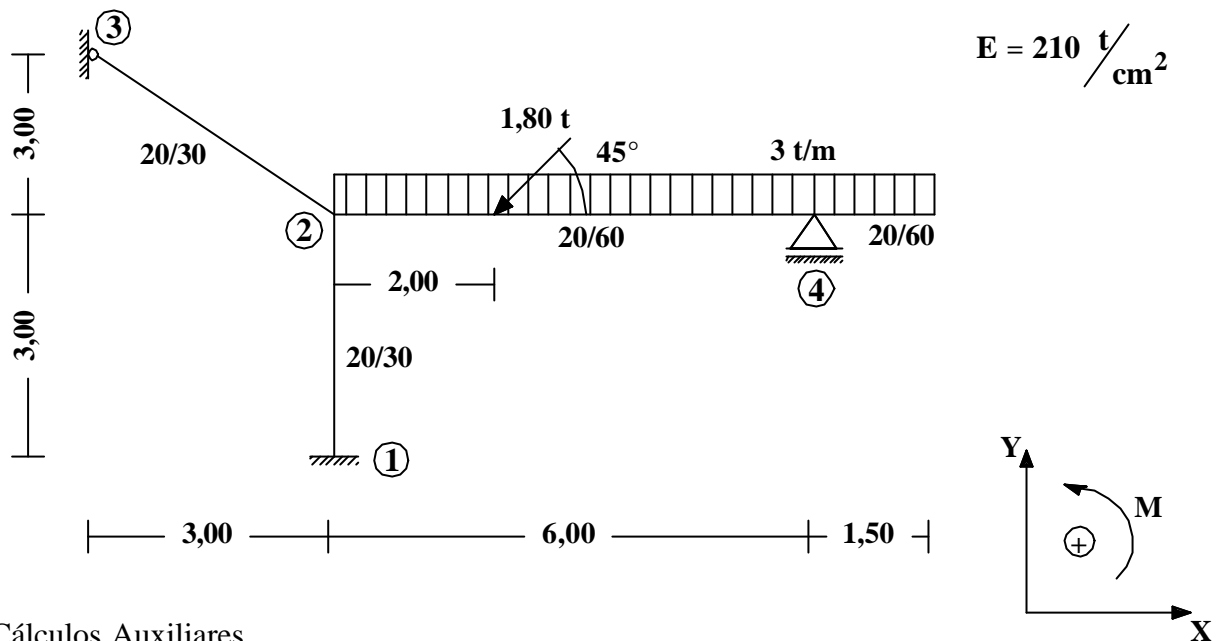
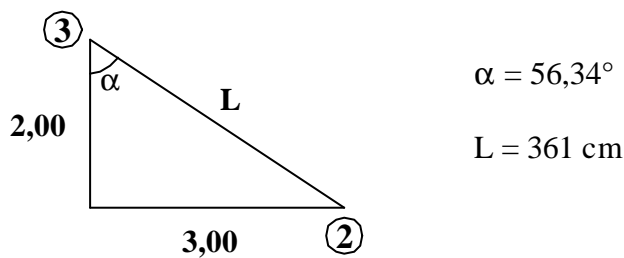


**METODO MATRICIAL**

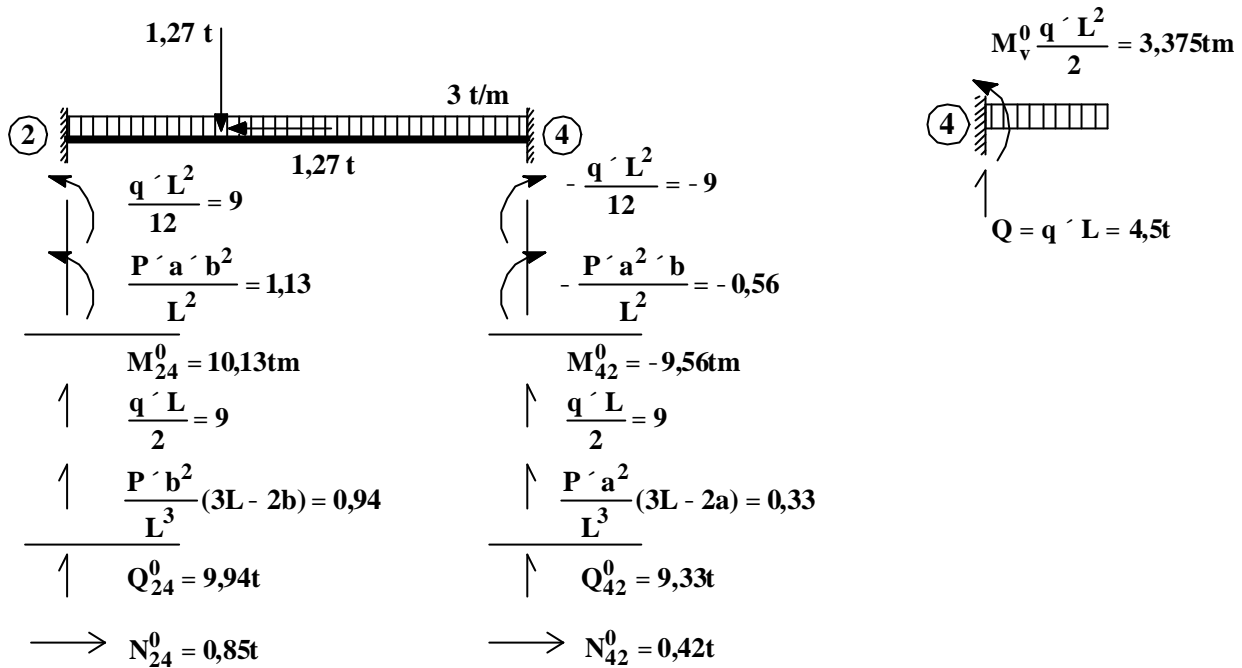


Cálculos Auxiliares



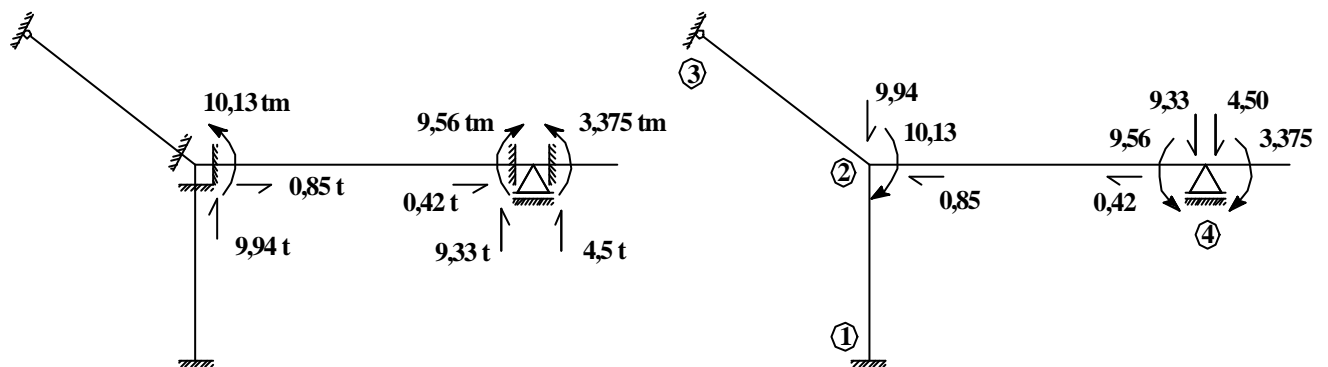
Barra	W (cm <sup>2</sup> )	L (cm)	I (cm <sup>4</sup> )	q	Cos q	Sen q	$\frac{E' A}{L}$	$\frac{E' I}{L}$	$\frac{E' I}{L^2}$	$\frac{E' I}{L^3}$
1-2	600	300	45000	90°	0	1	420	31500	105	0,35
2-3	600	361	45000	146,31°	- 0,832	0,555	349,03	26177,29	72,513	0,200867
2-4	1200	600	360000	0°	1	0	420	126000	210	0,35

Reacciones de Empotramientos Perfectos



Estructura Bloqueada

Estructura con Cargas Nodales Equivalentes



Cálculo de Matrices de Rigideces Globales de Cada Barra

Barra 1-2

$$K_{11} = \begin{vmatrix} 4,2 & 0 & -630 \\ 0 & 420 & 0 \\ -630 & 0 & 126000 \end{vmatrix}$$

$$K_{12} = \begin{vmatrix} -4,2 & 0 & -630 \\ 0 & -420 & 0 \\ 630 & 0 & 63000 \end{vmatrix}$$

$$K_{21} = \begin{vmatrix} -4,2 & 0 & 630 \\ 0 & -420 & 0 \\ -630 & 0 & 63000 \end{vmatrix}$$

$$K_{22} = \begin{vmatrix} 4,2 & 0 & 630 \\ 0 & 420 & 0 \\ 630 & 0 & 126000 \end{vmatrix}$$

Barra 2-3

$$K_{22} = \begin{vmatrix} 242,38 & -159,98 & -241,34 \\ -159,98 & 109,06 & -362,01 \\ -241,34 & -362,01 & 104709,14 \end{vmatrix} \quad K_{23} = \begin{vmatrix} -242,38 & 159,98 & -241,34 \\ 159,98 & -109,06 & -362,01 \\ 241,34 & 362,01 & 52354,57 \end{vmatrix}$$

$$K_{32} = \begin{vmatrix} -242,38 & 159,98 & 241,34 \\ 159,98 & -109,06 & 362,01 \\ -241,34 & -362,01 & 52354,57 \end{vmatrix} \quad K_{33} = \begin{vmatrix} 242,38 & -159,98 & 241,34 \\ -159,98 & 109,06 & 362,01 \\ 241,34 & 362,01 & 104709,14 \end{vmatrix}$$

Barra 2-4

$$K_{22} = \begin{vmatrix} 420 & 0 & 0 \\ 0 & 4,20 & 1260 \\ 0 & 1260 & 504000 \end{vmatrix} \quad K_{24} = \begin{vmatrix} -420 & 0 & 0 \\ 0 & -4,20 & 1260 \\ 0 & -1260 & 252000 \end{vmatrix}$$

$$K_{42} = \begin{vmatrix} -420 & 0 & 0 \\ 0 & -4,20 & -1260 \\ 0 & 1260 & 252000 \end{vmatrix} \quad K_{44} = \begin{vmatrix} 420 & 0 & 0 \\ 0 & 4,20 & -1260 \\ 0 & -1260 & 504000 \end{vmatrix}$$

Matriz de Rigidez Global de la Estructura

Por condición de vínculos:

$$\begin{array}{lll} \Delta_{X1} = 0 & \Delta_{X3} = 0 & \Delta_{X4} \neq 0 \\ \Delta_{Y1} = 0 & \Delta_{Y3} = 0 & \Delta_{Y4} = 0 \\ \theta_{Z1} = 0 & \theta_{Z3} \neq 0 & \theta_{Z4} \neq 0 \end{array}$$

	$D_{X1}$	$D_{Y1}$	$q_{Z1}$	$D_{X2}$	$D_{Y2}$	$q_{Z2}$	$D_{X3}$	$D_{Y3}$	$q_{Z3}$	$D_{X4}$	$D_{Y4}$	$q_{Z4}$	<b>T.I</b>
$D_{X1}$	----	----	----	----	----	----	----	----	----	----	----	----	----
$D_{Y1}$	----	----	----	----	----	----	----	----	----	----	----	----	----
$q_{Z1}$	----	----	----	----	----	----	----	----	----	----	----	----	----
$D_{X2}$	----	----	----	666,58	-159,98	388,06	----	----	-241,34	-420	----	0	-0,85 t
$D_{Y2}$	----	----	----	-159,98	533,26	897,99	----	----	-362,01	0	----	1260	-9,94 t
$q_{Z2}$	----	----	----	388,66	897,99	734709,14	----	----	52354,57	0	----	0	-1013 t
$D_{X3}$	----	----	----	----	----	----	----	----	----	----	----	----	----
$D_{Y3}$	----	----	----	----	----	----	----	----	----	----	----	----	----
$q_{Z3}$	----	----	----	-241,34	-362,01	52354,57	----	----	104707,14	0	----	0	0
$D_{X4}$	----	----	----	-420	0	0	----	----	0	420	----	0	-0,42 t
$D_{Y4}$	----	----	----	----	----	----	----	----	----	----	----	----	----
$q_{Z4}$	----	----	----	0	1260	252000	----	----	0	0	----	504000	+ 618,5 t



$$K_{22} = K_{\sim 22}^{\text{Barra 1-2}} + K_{\sim 22}^{\text{Barra 2-3}} + K_{\sim 22}^{\text{Barra 2-4}}$$

$$K_{22} = \begin{vmatrix} 4,20 & 0 & 630 \\ 0 & 420 & 0 \\ 630 & 0 & 126000 \end{vmatrix} + \begin{vmatrix} 242,38 & -159,98 & -241,34 \\ -159,98 & 109,06 & -362,01 \\ -241,34 & -362,01 & 104709,14 \end{vmatrix} + \begin{vmatrix} 420 & 0 & 0 \\ 0 & 4,20 & 1260 \\ 0 & 1260 & 504000 \end{vmatrix}$$

$$K_{22} = \begin{vmatrix} 666,58 & -159,98 & 388,66 \\ -159,98 & 533,26 & 897,99 \\ 388,66 & 897,99 & 734709,14 \end{vmatrix}$$

### Sistema de Ecuaciones

$$\begin{array}{rcccccccc} 666,58 & -159,98 & 388,66 & -241,34 & -420 & 0 & = & -0,85 \\ -159,98 & 533,26 & 897,99 & -362,01 & 0 & 1260 & = & -9,94 \\ 388,66 & 897,99 & 734709,14 & 52354,57 & 0 & 252000 & = & -1013 \\ -241,34 & -362,01 & 52354,57 & 104709,14 & 0 & 0 & = & 0 \\ -420 & 0 & 0 & 0 & 420 & 0 & = & -0,42 \\ 0 & 1260 & 252000 & 0 & 0 & 504000 & = & 618,5 \end{array}$$

### Resolución de Incógnitas

$$\Delta_{X2} = -0,0168354$$

$$\Delta_{Y2} = -0,02494$$

$$\theta_{Z2} = -0,00223589$$

$$\theta_{Z3} = 0,00992917$$

$$\Delta_{X4} = -0,0178354$$

$$\theta_{Z4} = 0,00240748$$

### Cálculo de Solicitaciones en extremos de barras

#### Barra 1-2

##### Nudo 1:

$$F_{12} = K_{11} \times D_1 + K_{12} \times D_2 + A_{12}^{\circ 1}$$

$$\begin{vmatrix} F_X \\ F_Y \\ M \end{vmatrix} = \begin{vmatrix} 4,20 & 0 & -630 \\ 0 & 420 & 0 \\ -630 & 0 & 126000 \end{vmatrix} \times \begin{vmatrix} 0 \\ 0 \\ 0 \end{vmatrix} + \begin{vmatrix} -4,20 & 0 & -630 \\ 0 & -420 & 0 \\ 630 & 0 & 63000 \end{vmatrix} \times \begin{vmatrix} -0,0168354 \\ -0,02494 \\ -0,00223589 \end{vmatrix} + \begin{vmatrix} 0 \\ 0 \\ 0 \end{vmatrix}$$

$$F_X = 1,479 \text{ t}$$

$$F_Y = 10,475 \text{ t}$$

$$M = -151,467 \text{ tcm} = -1,515 \text{ tm}$$



Nudo 2:

$$\tilde{F}_{21} = \tilde{K}_{22} \times \tilde{D}_2 + \tilde{K}_{21} \times \tilde{D}_1 + \tilde{A}_{21}^{\circ 2}$$

$$\begin{vmatrix} F_X \\ F_Y \\ M \end{vmatrix} = \begin{vmatrix} 4,20 & 0 & 630 \\ 0 & 420 & 0 \\ 630 & 0 & 126000 \end{vmatrix} \times \begin{vmatrix} -0,0168354 \\ -0,02494 \\ -0,00223589 \end{vmatrix} + \begin{vmatrix} -4,20 & 0 & 630 \\ 0 & -420 & 0 \\ -630 & 0 & 63000 \end{vmatrix} \times \begin{vmatrix} 0 \\ 0 \\ 0 \end{vmatrix} + \begin{vmatrix} 0 \\ 0 \\ 0 \end{vmatrix}$$

$$F_X = -1,479 \text{ t}$$

$$F_Y = -10,475 \text{ t}$$

$$M = -292,328 \text{ tcm} = -2,923 \text{ tm}$$

Barra 2-3Nudo 2:

$$\tilde{F}_{23} = \tilde{K}_{22} \times \tilde{D}_2 + \tilde{K}_{23} \times \tilde{D}_3 + \tilde{A}_{23}^{\circ}$$

$$\begin{vmatrix} F_X \\ F_Y \\ M \end{vmatrix} = \begin{vmatrix} 242,38 & -159,98 & -241,34 \\ -159,98 & 109,06 & -362,01 \\ -241,34 & -362,01 & 104709,14 \end{vmatrix} \times \begin{vmatrix} -0,0168354 \\ -0,02494 \\ -0,00223589 \end{vmatrix} + \begin{vmatrix} -242,38 & 159,98 & -241,34 \\ 159,98 & -109,06 & -362,01 \\ 241,34 & 362,01 & 52354,57 \end{vmatrix} \times \begin{vmatrix} 0 \\ 0 \\ 0 \end{vmatrix} + \begin{vmatrix} 0 \\ 0 \\ 0,000992917 \end{vmatrix}$$

$$F_X = 0,209 \text{ t}$$

$$F_Y = 0,423 \text{ t}$$

$$M = -169,043 \text{ tcm} = -1,69 \text{ tm}$$

Nudo 3:

$$\tilde{F}_{32} = \tilde{K}_{33} \times \tilde{D}_3 + \tilde{K}_{32} \times \tilde{D}_2 + \tilde{A}_{32}^{\circ}$$

$$\begin{vmatrix} F_X \\ F_Y \\ M \end{vmatrix} = \begin{vmatrix} 242,38 & -159,98 & 241,34 \\ -159,98 & 109,06 & 362,01 \\ 241,34 & 362,01 & 104709,14 \end{vmatrix} \times \begin{vmatrix} 0 \\ 0 \\ 0,000992917 \end{vmatrix} +$$



$$+ \begin{vmatrix} -242,38 & 159,98 & 241,34 \\ 159,98 & -109,06 & 362,01 \\ -241,34 & -362,01 & 52354,57 \end{vmatrix} \times \begin{vmatrix} -0,0168354 \\ -0,02494 \\ -0,00223589 \end{vmatrix} + \begin{vmatrix} 0 \\ 0 \\ 0 \end{vmatrix}$$

$$F_X = -0,209 \text{ t}$$

$$F_Y = -0,423 \text{ t}$$

$$M = 0,00 \text{ tcm}$$

Barra 2-4Nudo 2:

$$F_{24} = K_{22} \times D_2 + K_{21} \times D_4 + A_{24}^{\circ}$$

$$\begin{vmatrix} F_X \\ F_Y \\ M \end{vmatrix} = \begin{vmatrix} 420 & 0 & 0 \\ 0 & 4,2 & 1260 \\ 0 & 1260 & 504000 \end{vmatrix} \times \begin{vmatrix} -0,0168354 \\ -0,02494 \\ -0,00223589 \end{vmatrix} +$$

$$+ \begin{vmatrix} -420 & 0 & 0 \\ 0 & -4,2 & 1260 \\ 0 & -1260 & 252000 \end{vmatrix} \times \begin{vmatrix} -0,0178354 \\ 0 \\ 0,00240748 \end{vmatrix} + \begin{vmatrix} 0,85 \\ 9,94 \\ 1013 \end{vmatrix}$$

$$F_X = 0,42 \text{ t} + 0,85 \text{ t} = 1,27 \text{ t}$$

$$F_Y = 0,111 \text{ t} + 9,94 \text{ t} = 10,05 \text{ t}$$

$$M = -551,628 + 1013 = 461,372 \text{ tcm} = 4,61 \text{ tm}$$

Nudo 4:

$$F_{42} = K_{44} \times D_4 + K_{42} \times D_2 + A_{42}^{\circ}$$

$$\begin{vmatrix} F_X \\ F_Y \\ M \end{vmatrix} = \begin{vmatrix} 420 & 0 & 0 \\ 0 & 4,2 & -1260 \\ 0 & -1260 & 504000 \end{vmatrix} \times \begin{vmatrix} -0,0178354 \\ 0 \\ 0,00240748 \end{vmatrix} +$$

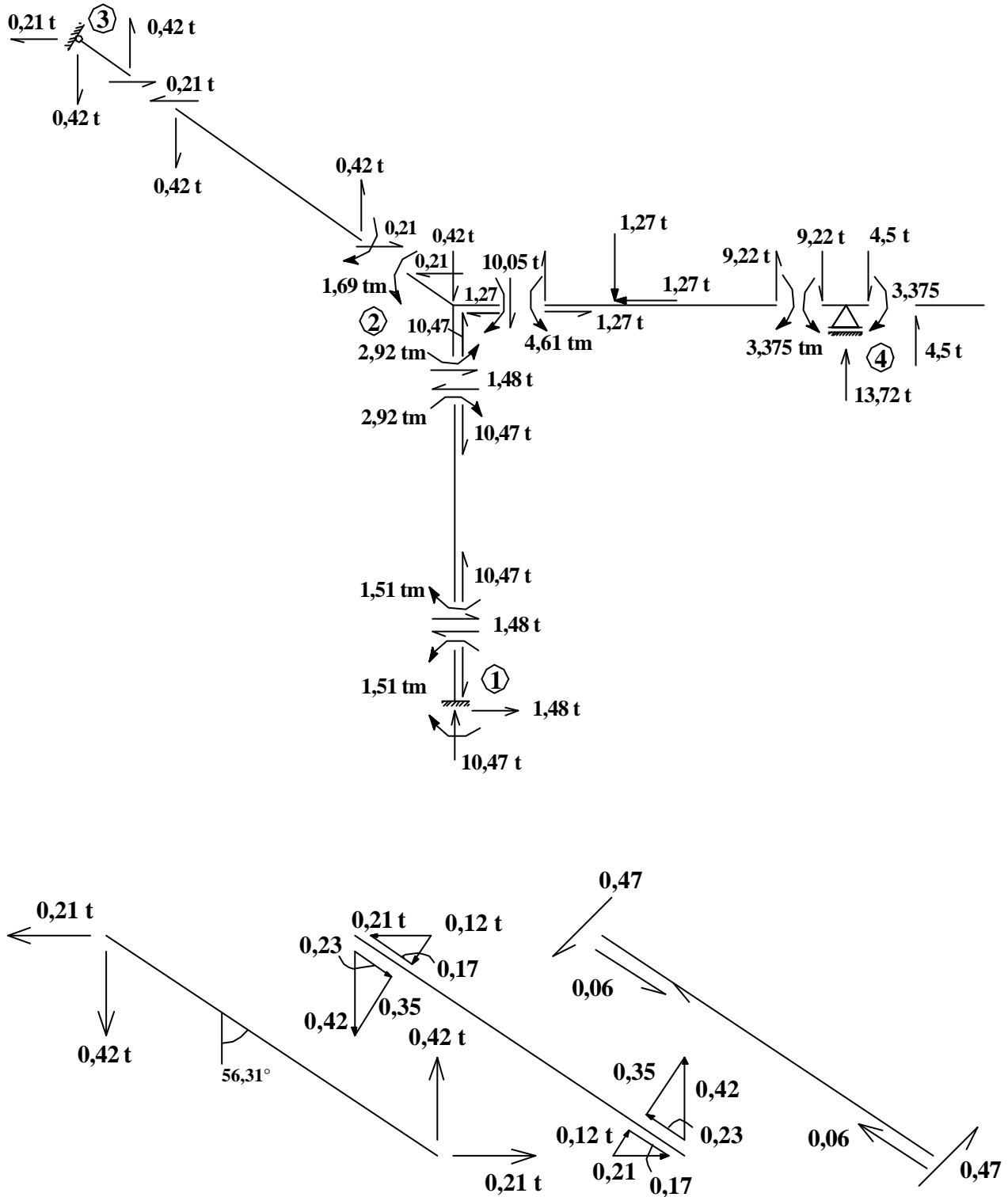
$$+ \begin{vmatrix} -420 & 0 & 0 \\ 0 & -4,2 & -1260 \\ 0 & 1260 & 252000 \end{vmatrix} \times \begin{vmatrix} -0,0168354 \\ -0,02494 \\ -0,00223589 \end{vmatrix} + \begin{vmatrix} 0,42 \\ 9,33 \\ -956 \end{vmatrix}$$



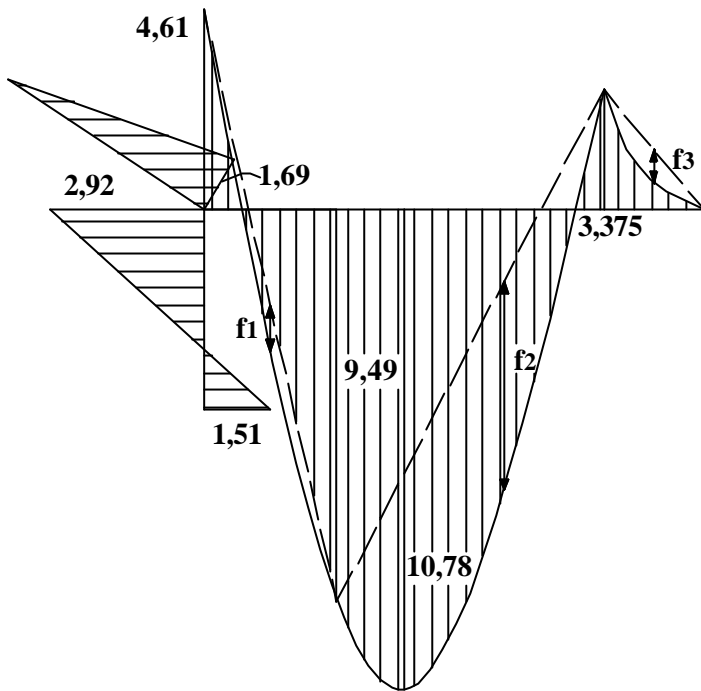
$$F_X = - 0,42 \text{ t} + 0,42 \text{ t} = 0,00 \text{ t}$$

$$F_Y = - 0,111 \text{ t} + 9,33 \text{ t} = 9,22 \text{ t}$$

$$M = 618,501 - 956 \text{ tcm} = - 337,499 \text{ tcm} = - 3,375 \text{ tm}$$



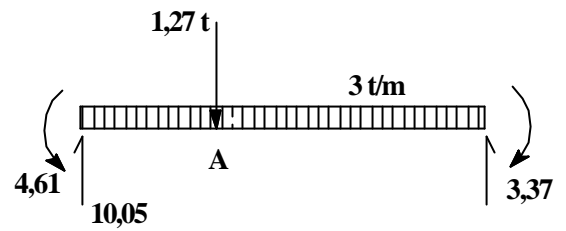
**M (tm)**



$$f_1 = \frac{q \times L^2}{8} = 1,5 \text{tm}$$

$$f_2 = \frac{q \times L^2}{8} = 6,0 \text{tm}$$

$$f_3 = \frac{q \times L^2}{8} = 0,84 \text{tm}$$

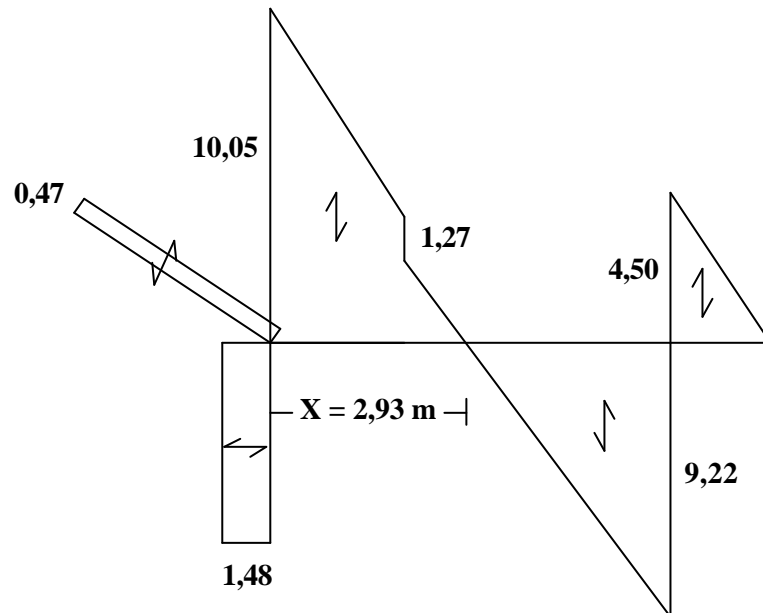


$$X = 2,93 \text{ m}$$

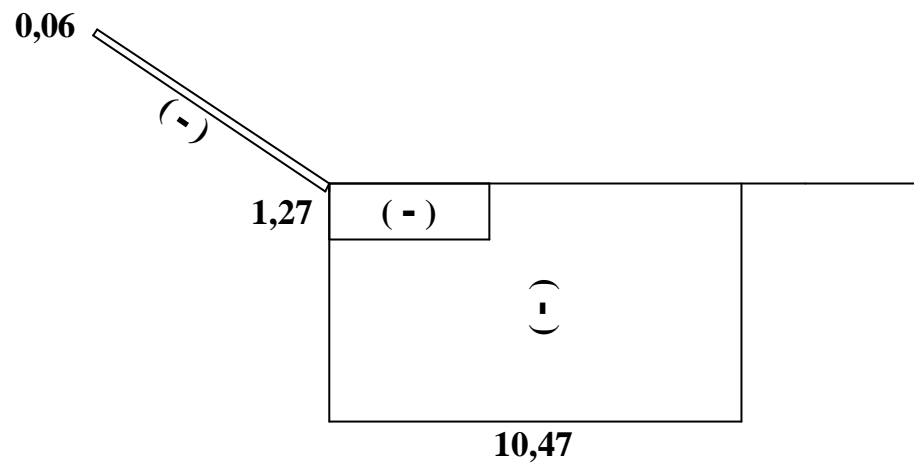
$$M_{\text{Máx}} = 10,78 \text{ tm}$$

$$M_A = 9,49 \text{ tm}$$

**Q (t)**





N (t)D.C.L