

Projeto de Mezaninos e Escadas

Curso de Projeto e Cálculo de Estruturas metálicas

Tipos usuais de piso para mezaninos

Painel Wall



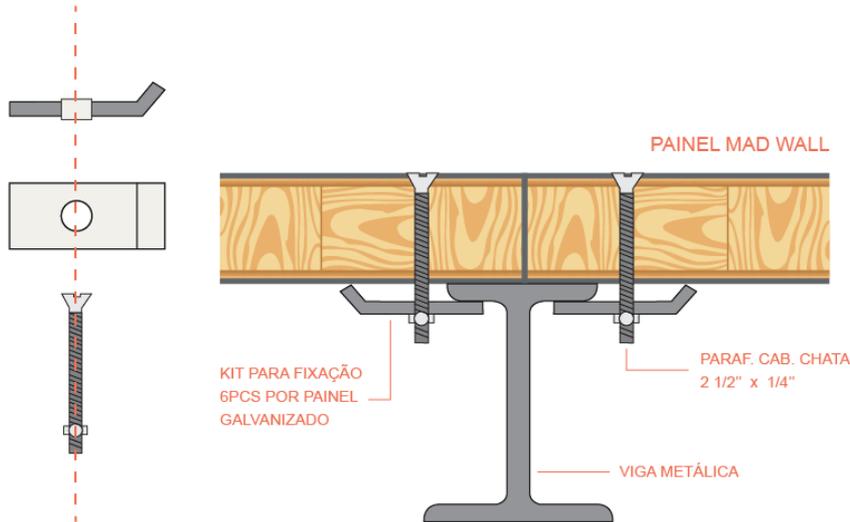
Medida mais comuns: 1200X2500X40mm

Sobrecarga para 300kgf/m² e 500kgf/m²

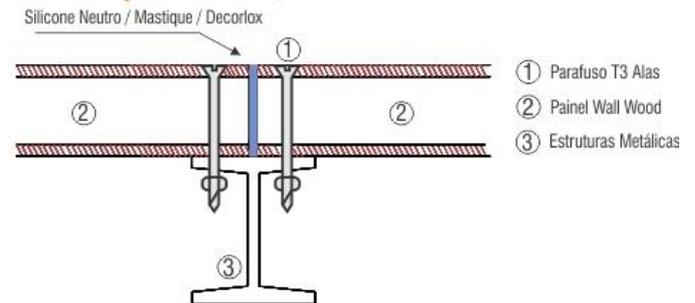
Tipos usuais de piso para mezaninos

Painel Wall - Fixação

(KIT DE FIXAÇÃO)

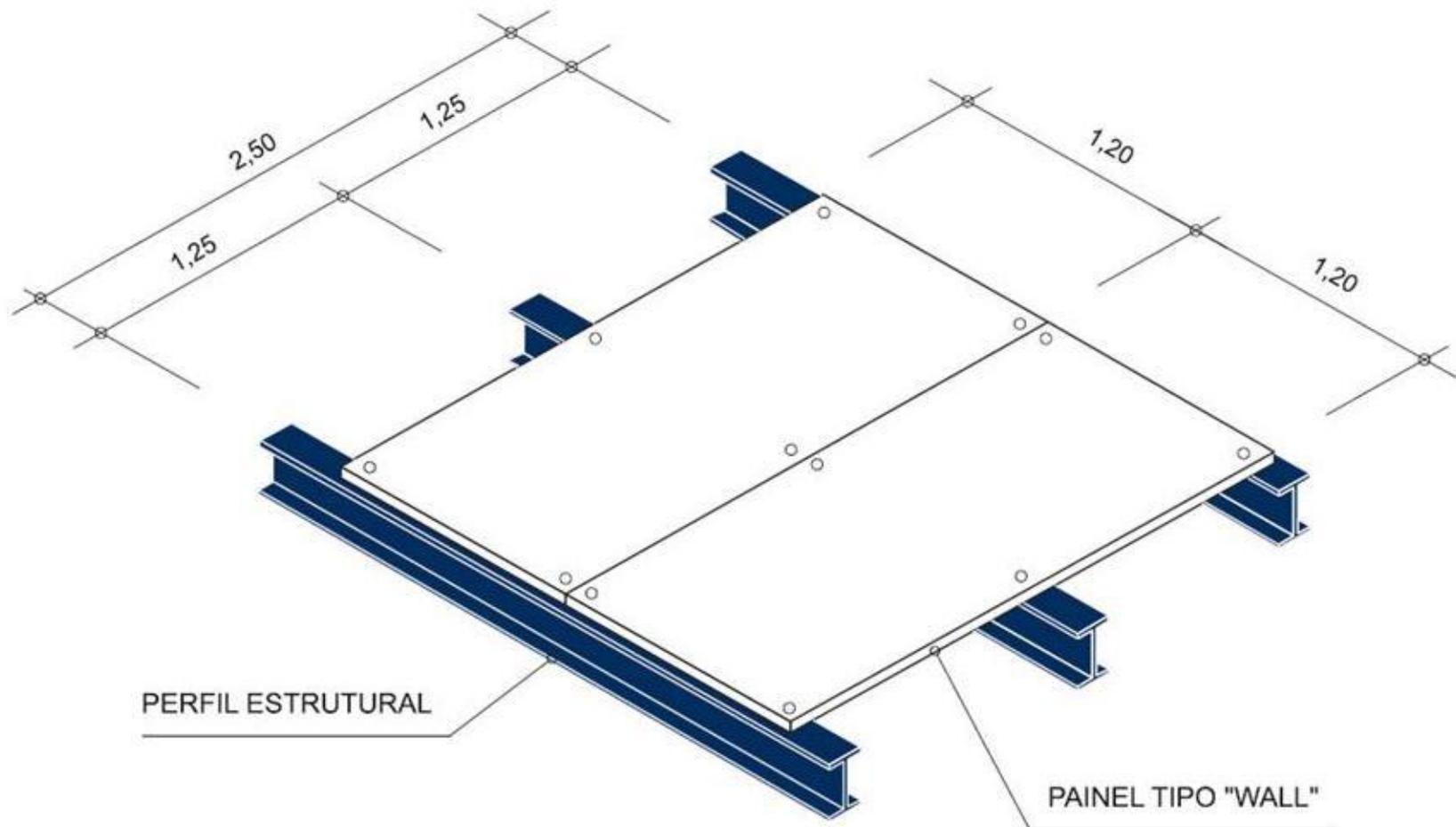


Amostra de Fixação em Perfil Tipo "I"



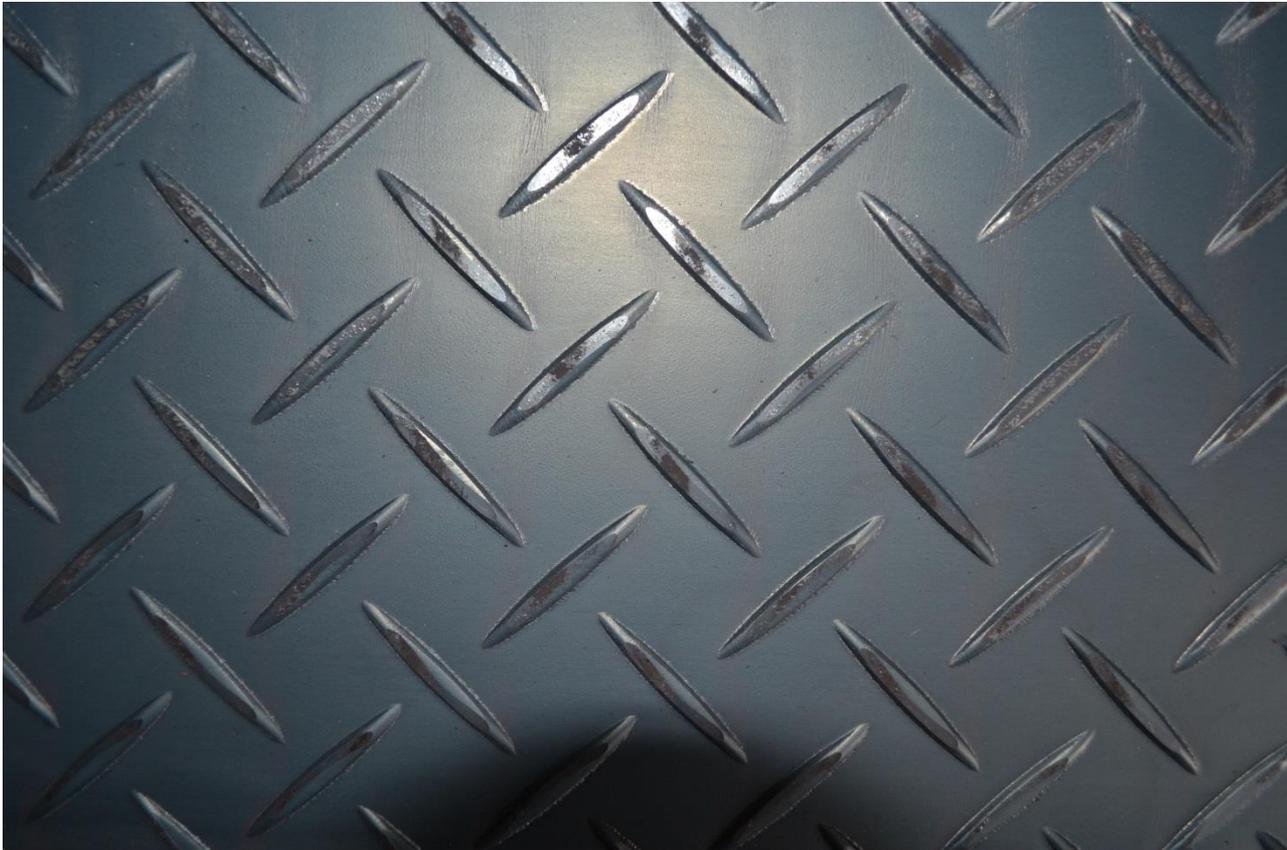
Tipos usuais de piso para mezaninos

Painel Wall - Modulações



Tipos usuais de piso para mezaninos

Chapa xadrez



CHAPA XADREZ

Carga admissível em Kg/m² para chapas de piso simplesmente apoiadas nas quatro bordas

$$\frac{A}{L} = \frac{1}{200}$$

Tensão: $\leq 1400 \text{ Kg/cm}^2$

Obs: Subtrair peso próprio da carga admissível dada na tabela

Exemplo: CH 1/4" com vão 1000 x 1000
 $608 - 58 = 550$
 - Sobrecarga Máxima = 550 Kg/m²

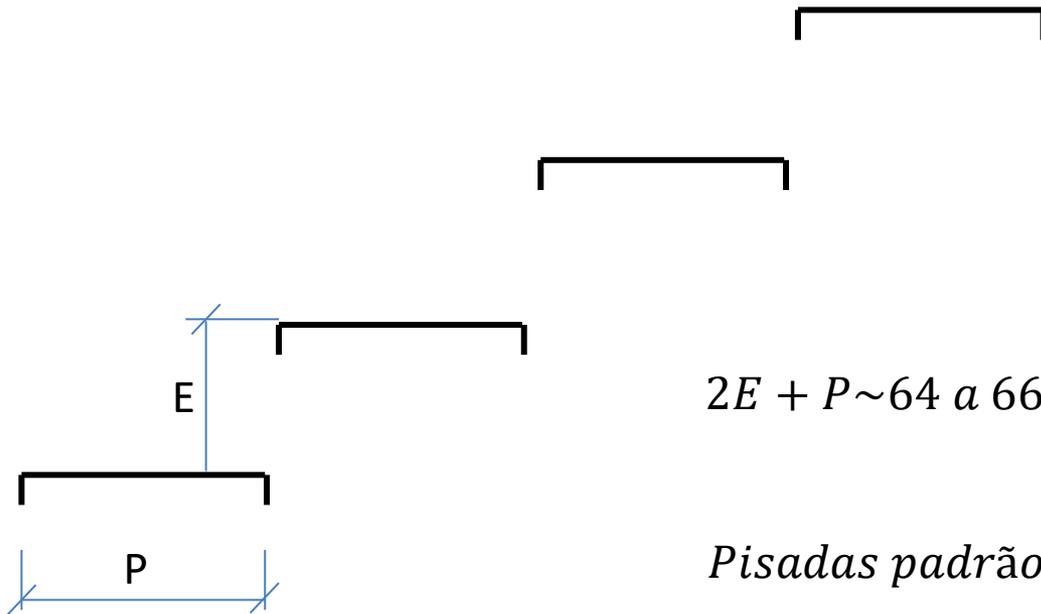
| t= 3/16" (42 Kg/m ²) | | | | | | | | | |
|----------------------------------|-------|------|------|------|------|------|------|------|------|
| | a / b | | | | | | | | |
| b | 1 | 1,2 | 1,4 | 1,6 | 1,8 | 2 | 3 | 4 | 5 |
| 400 | 3973 | 2864 | 2292 | 1948 | 1735 | 1590 | 1322 | 1260 | 1245 |
| 600 | 1182 | 853 | 682 | 580 | 517 | 473 | 393 | 375 | 370 |
| 800 | 499 | 360 | 288 | 244 | 218 | 200 | 166 | 158 | 156 |
| 1000 | 255 | 184 | 147 | 126 | 112 | 101 | | | |
| 1200 | 148 | 107 | | | | | | | |
| 1400 | 93 | | | | | | | | |

| t= 1/4" (58,33 Kg/m ²) | | | | | | | | | |
|------------------------------------|-------|------|------|------|------|------|------|------|------|
| | a / b | | | | | | | | |
| b | 1 | 1,2 | 1,4 | 1,6 | 1,8 | 2 | 3 | 4 | 5 |
| 400 | 9460 | 6820 | 5456 | 4637 | 4130 | 3785 | 3147 | 3000 | 2965 |
| 600 | 2814 | 2030 | 1623 | 1380 | 1230 | 1126 | 936 | 893 | 882 |
| 800 | 1187 | 856 | 685 | 582 | 518 | 475 | 395 | 377 | 372 |
| 1000 | 608 | 438 | 350 | 300 | 266 | 240 | 200 | | |
| 1200 | 352 | 254 | 203 | 173 | 154 | | | | |
| 1400 | 222 | 160 | 128 | | | | | | |
| 1600 | 150 | 107 | | | | | | | |

| t= 5/16" (67,43 Kg/m ²) | | | | | | | | | |
|-------------------------------------|-------|-------|-------|------|------|------|------|------|------|
| | a / b | | | | | | | | |
| b | 1 | 1,2 | 1,4 | 1,6 | 1,8 | 2 | 3 | 4 | 5 |
| 400 | 18497 | 13332 | 10665 | 9065 | 8075 | 7400 | 6150 | 5665 | 5796 |
| 600 | 5480 | 3950 | 3160 | 2686 | 2395 | 2194 | 1825 | 1740 | 1720 |
| 800 | 2315 | 1670 | 1335 | 1134 | 1010 | 926 | 770 | 734 | 726 |
| 1000 | 1185 | 854 | 683 | 580 | 518 | 474 | 394 | 376 | 370 |
| 1200 | 686 | 495 | 396 | 336 | 300 | 275 | 228 | 218 | 215 |
| 1400 | 432 | 312 | 250 | 212 | 190 | 173 | 144 | 137 | 136 |
| 1600 | 290 | 208 | 167 | 142 | 126 | | | | |

Projetos de escadas

Regra de Blondel:



$$2E + P \sim 64 \text{ a } 66 \text{ cm}$$

Pisadas padrão (em geral):

265mm, 280mm, 300mm

Projetos de escadas

Exemplo: Em um desnível de 3m, qual o espelho e a pisada ideais?

Se travarmos a pisada em 28cm, por exemplo teremos:

$$2E + P \sim 66cm$$

$$N = \frac{300}{19} = 15,78 \text{ espelhos} \sim 16 \text{ espelhos}$$

$$2 \cdot E + 28 = 66cm$$

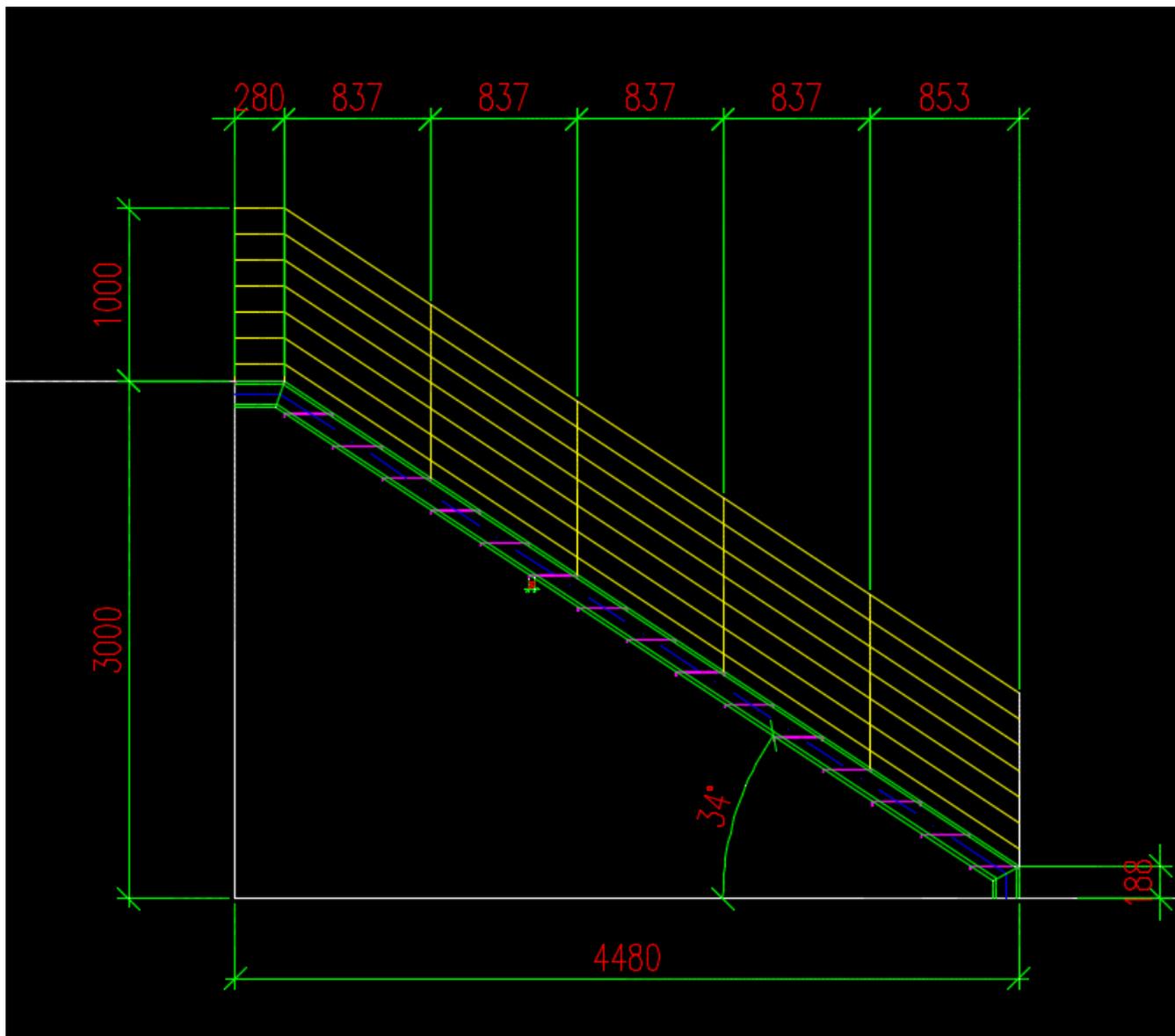
$$E = \frac{300}{16} = 18,75 \text{ cm cada espelho}$$

$$E = \frac{66 - 28}{2}$$

$$2 \cdot 18,75 + 28 = 65,5 \text{ OK}$$

$$E = \frac{66 - 28}{2} = 19cm$$

Projetos de escadas



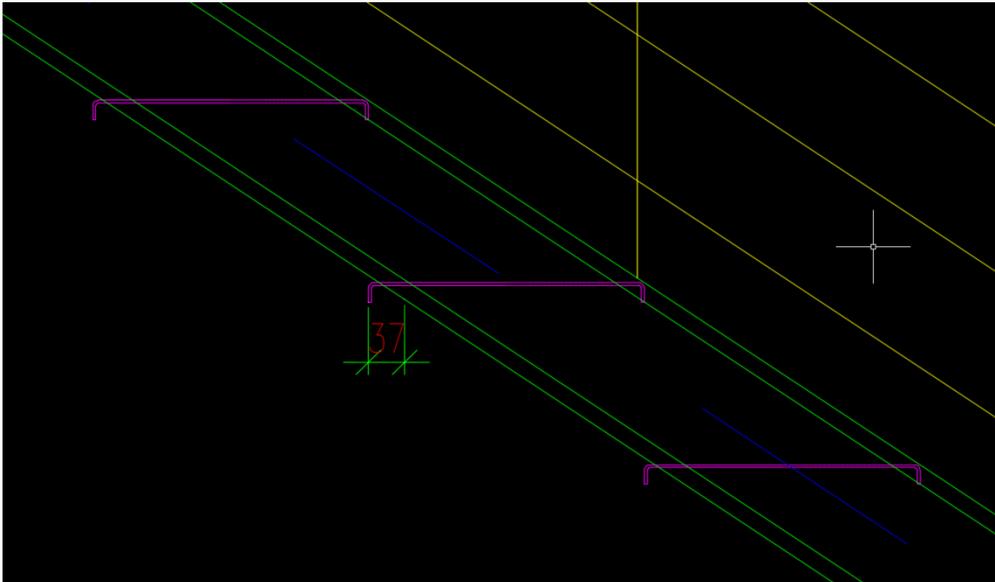
Cálculo da longarina

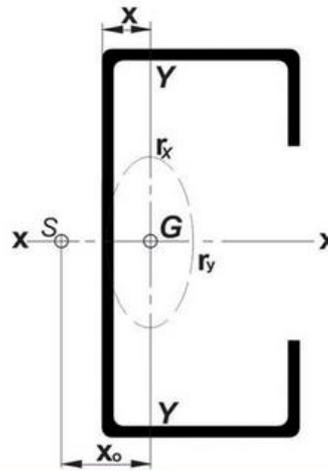
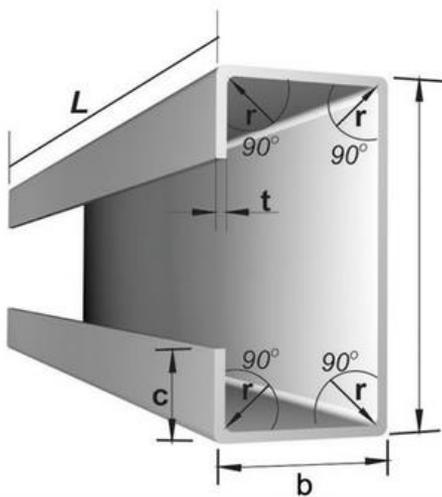
A viga da Escada deve suportar, além do peso próprio, a sobrecarga de 300kgf/m^2 (NBR6120)

Não há determinação específica para flechas, porém manteremos a limitação de $L/350$

Determina-se a altura da longarina (Viga da escada depois de desenhar os degraus para que não fique desproporcional)

2.2.1.7 Quando uma escada for constituída por degraus isolados, estes devem ser calculados para suportarem uma carga concentrada de $2,5\text{ kN}$, aplicada na posição mais desfavorável. Este carregamento não deve ser considerado na composição de cargas das vigas que suportam os degraus, as quais devem ser calculadas para carga indicada na Tabela 2.





PERFIL U ENRIJECIDO

| DIMENSÕES | | | | A | M | I _x | W _x | r _x | X | I _y | W _y | r _y | J | C _w | X ₀ |
|-----------|----|----|-------|-----------------|-------|-----------------|-----------------|----------------|------|-----------------|-----------------|----------------|-----------------|-----------------|----------------|
| a | b | c | t = r | cm ² | kg/m | cm ⁴ | cm ³ | cm | cm | cm ⁴ | cm ³ | cm | cm ⁴ | cm ⁶ | cm |
| mm | mm | mm | mm | cm ² | kg/m | cm ⁴ | cm ³ | cm | cm | cm ⁴ | cm ³ | cm | cm ⁴ | cm ⁶ | cm |
| 300 | 85 | 25 | 3.75 | 18.70 | 14.68 | 2420.9 | 161.4 | 11.38 | 2.21 | 163.8 | 26.1 | 2.96 | 0.876 | 29196.7 | -5.54 |
| | | | 3.35 | 16.78 | 13.17 | 2182.7 | 145.5 | 11.41 | 2.21 | 149.1 | 23.7 | 2.98 | 0.628 | 26605.5 | -5.57 |
| | | | 3.00 | 15.09 | 11.84 | 1970.4 | 131.4 | 11.43 | 2.21 | 135.7 | 21.6 | 3.00 | 0.453 | 24241.4 | -5.60 |
| | | | 2.65 | 13.38 | 10.50 | 1754.5 | 117.0 | 11.45 | 2.21 | 121.8 | 19.4 | 3.02 | 0.313 | 21785.1 | -5.63 |
| | | | 2.25 | 11.41 | 8.96 | 1503.2 | 100.2 | 11.48 | 2.21 | 105.3 | 16.7 | 3.04 | 0.193 | 18862.6 | -5.67 |
| | | | 2.00 | 10.17 | 7.98 | 1343.8 | 89.6 | 11.49 | 2.21 | 94.7 | 15.1 | 3.05 | 0.136 | 16972.4 | -5.69 |
| 250 | 85 | 25 | 3.75 | 16.82 | 13.20 | 1570.4 | 125.6 | 9.66 | 2.44 | 155.2 | 25.6 | 3.04 | 0.788 | 19549.4 | -5.99 |
| | | | 3.35 | 15.10 | 11.86 | 1417.2 | 113.4 | 9.69 | 2.44 | 141.3 | 23.3 | 3.06 | 0.565 | 17833.2 | -6.02 |
| | | | 3.00 | 13.59 | 10.66 | 1280.4 | 102.4 | 9.71 | 2.44 | 128.6 | 21.2 | 3.08 | 0.408 | 16263.6 | -6.05 |
| | | | 2.65 | 12.05 | 9.46 | 1141.0 | 91.3 | 9.73 | 2.44 | 115.5 | 19.1 | 3.09 | 0.282 | 14629.0 | -6.08 |
| | | | 2.25 | 10.29 | 8.07 | 978.4 | 78.3 | 9.75 | 2.44 | 99.8 | 16.5 | 3.12 | 0.174 | 12679.7 | -6.12 |
| | | | 2.00 | 9.17 | 7.20 | 875.1 | 70.0 | 9.77 | 2.44 | 89.8 | 14.8 | 3.13 | 0.122 | 11416.4 | -6.14 |
| 200 | 75 | 25 | 3.75 | 14.20 | 11.14 | 858.0 | 85.8 | 7.77 | 2.34 | 106.6 | 20.6 | 2.74 | 0.665 | 9015.7 | -5.65 |
| | | | 3.35 | 12.76 | 10.02 | 775.8 | 77.6 | 7.80 | 2.34 | 97.2 | 18.8 | 2.76 | 0.477 | 8251.1 | -5.68 |
| | | | 3.00 | 11.49 | 9.02 | 702.0 | 70.2 | 7.82 | 2.34 | 88.6 | 17.2 | 2.78 | 0.345 | 7546.2 | -5.72 |
| | | | 2.65 | 10.20 | 8.01 | 626.6 | 62.7 | 7.84 | 2.34 | 79.7 | 15.4 | 2.80 | 0.239 | 6806.8 | -5.75 |
| 200 | 75 | 20 | 2.25 | 8.49 | 6.66 | 524.8 | 52.5 | 7.86 | 2.21 | 63.2 | 11.9 | 2.73 | 0.143 | 5081.3 | -5.45 |
| | | | 2.00 | 7.57 | 5.94 | 470.0 | 47.0 | 7.88 | 2.21 | 56.9 | 10.7 | 2.74 | 0.101 | 4586.0 | -5.47 |
| 150 | 60 | 20 | 3.75 | 10.82 | 8.49 | 366.4 | 48.9 | 5.82 | 1.93 | 50.8 | 12.5 | 2.17 | 0.507 | 2436.0 | -4.56 |
| | | | 3.35 | 9.74 | 7.65 | 333.5 | 44.3 | 5.84 | 1.93 | 46.6 | 11.6 | 2.18 | 0.364 | 2245.0 | -4.60 |
| | | | 3.00 | 8.79 | 6.90 | 301.9 | 40.3 | 5.86 | 1.93 | 42.7 | 10.5 | 2.21 | 0.264 | 2066.0 | -4.63 |
| | | | 2.65 | 7.81 | 6.13 | 270.3 | 36.0 | 5.88 | 1.93 | 38.6 | 9.5 | 2.22 | 0.183 | 1874.8 | -4.66 |
| | | | 2.25 | 6.69 | 5.25 | 233.1 | 31.1 | 5.90 | 1.93 | 33.6 | 8.3 | 2.24 | 0.113 | 1641.3 | -4.70 |
| | | | 2.00 | 5.97 | 4.69 | 209.2 | 27.9 | 5.92 | 1.93 | 30.4 | 7.5 | 2.26 | 0.080 | 1487.0 | -4.72 |
| 127 | 50 | 17 | 3.35 | 8.10 | 6.36 | 195.1 | 30.7 | 4.91 | 1.60 | 26.2 | 7.7 | 1.80 | 0.303 | 899.4 | -3.78 |
| | | | 3.00 | 7.32 | 5.74 | 177.6 | 28.0 | 4.93 | 1.60 | 24.1 | 7.1 | 1.82 | 0.219 | 832.2 | -3.81 |
| | | | 2.65 | 6.51 | 5.11 | 159.5 | 25.1 | 4.95 | 1.60 | 21.9 | 6.4 | 1.83 | 0.153 | 759.4 | -3.85 |
| | | | 2.25 | 5.58 | 4.38 | 137.9 | 21.7 | 4.97 | 1.61 | 19.2 | 5.6 | 1.85 | 0.094 | 668.9 | -3.88 |
| | | | 2.00 | 4.99 | 3.92 | 124.0 | 19.5 | 4.98 | 1.61 | 17.4 | 5.1 | 1.87 | 0.067 | 608.3 | -3.90 |
| | | | 1.50 | 3.79 | 2.97 | 95.1 | 15.0 | 5.01 | 1.61 | 13.5 | 4.0 | 1.89 | 0.028 | 477.4 | -3.95 |

Como não há U enrijecido no ftool, devemos criar um perfil genérico inserindo informações básicas

Section Properties

UDC150X60X20X3,00 ▾

Integral Properties

| | | |
|-----|--------|-----------------|
| A: | 8.79 | cm ² |
| As: | 8.79 | cm ² |
| I: | 301.90 | cm ⁴ |
| d: | 150.00 | mm |
| ȳ: | 75.00 | mm |

Cálculo da longarina (largura 1000mm)

Corrimãos: 9kg/m

Longarina: 6,9kg/m

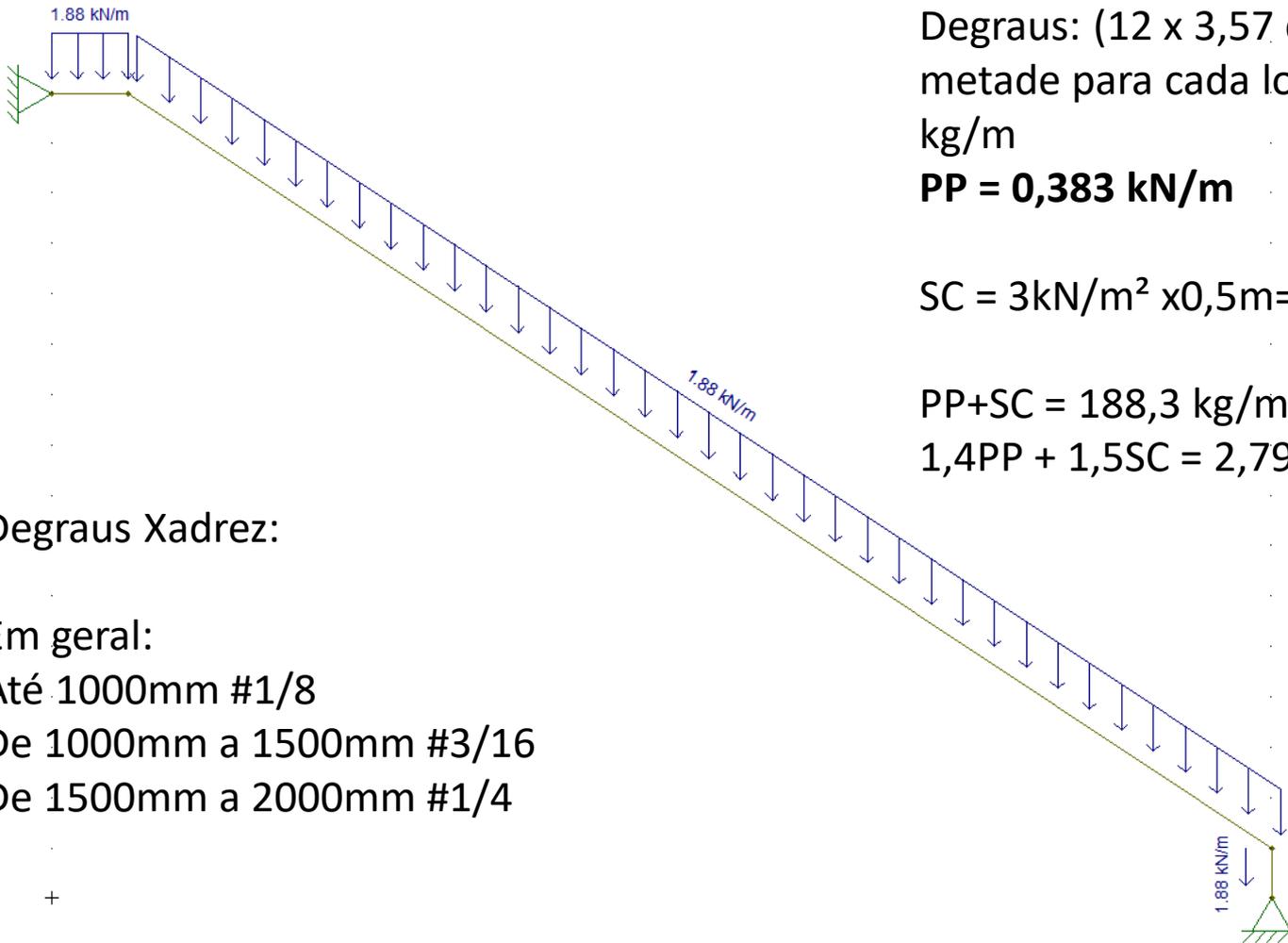
Degraus: (12 x 3,57 degraus,
metade para cada longarina = 22,4
kg/m

PP = 0,383 kN/m

SC = 3kN/m² x 0,5m = 1,5 kN/m

PP+SC = 188,3 kg/m (ELS)

1,4PP + 1,5SC = 2,79 kN/m (ELU)



Degraus Xadrez:

Em geral:

Até 1000mm #1/8

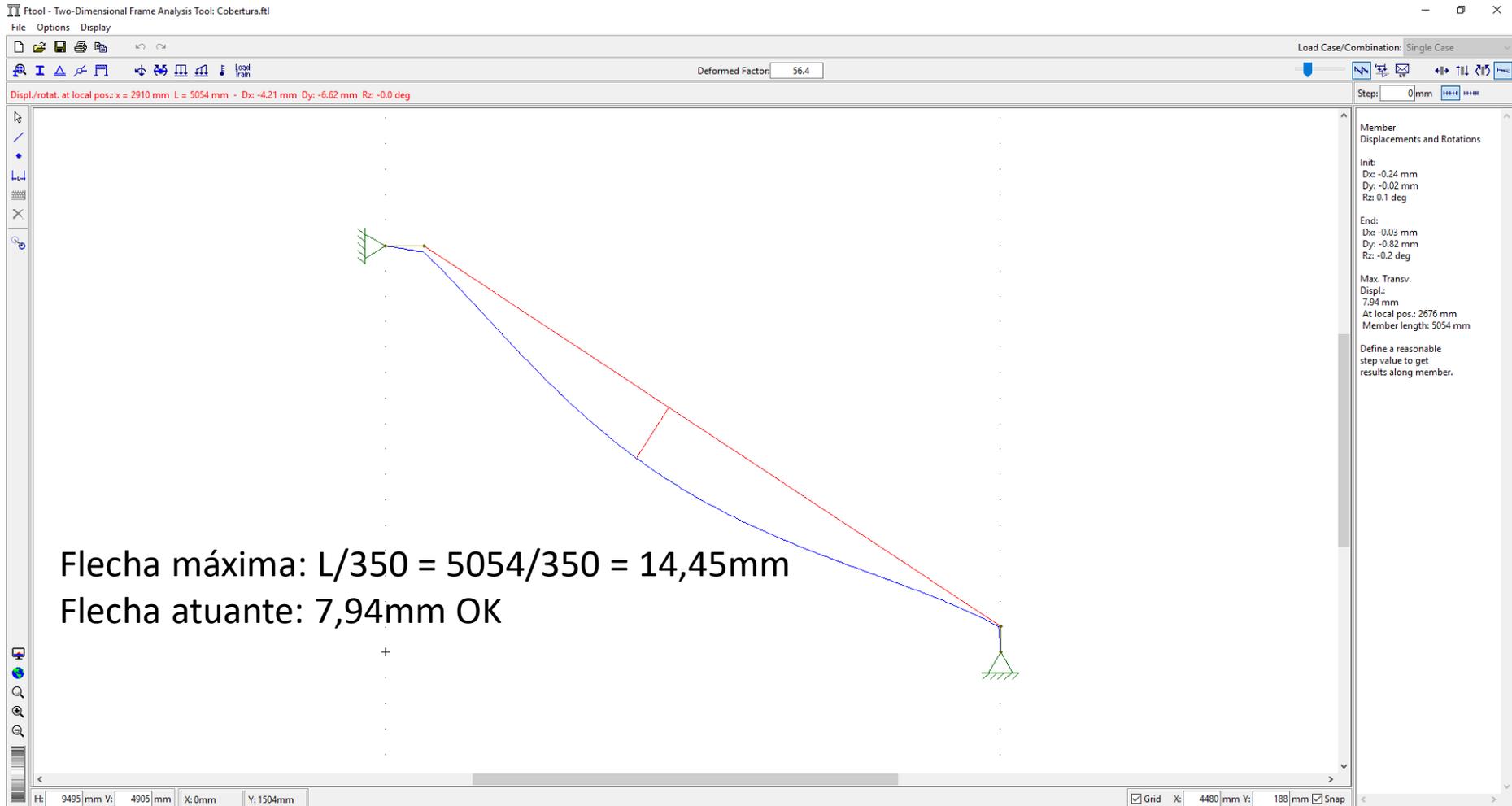
De 1000mm a 1500mm #3/16

De 1500mm a 2000mm #1/4

+

$$PP_{\text{degrau}} = ((20\text{mm} + 280\text{mm} + 20\text{mm})/1000) \times 0,00476\text{m} \times 7850 = 11,95 \text{ kg/m}$$

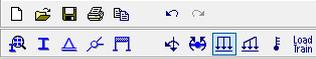
Cálculo da longarina (largura 1000mm)



Cálculo da longarina (largura 1000mm)

Ftool - Two-Dimensional Frame Analysis Tool

File Options Display



Editing Mode: Selection

Load Case/Combination: Single Case

Step: 0 mm

Uniform Loading

ELU: ESCADA

Direction

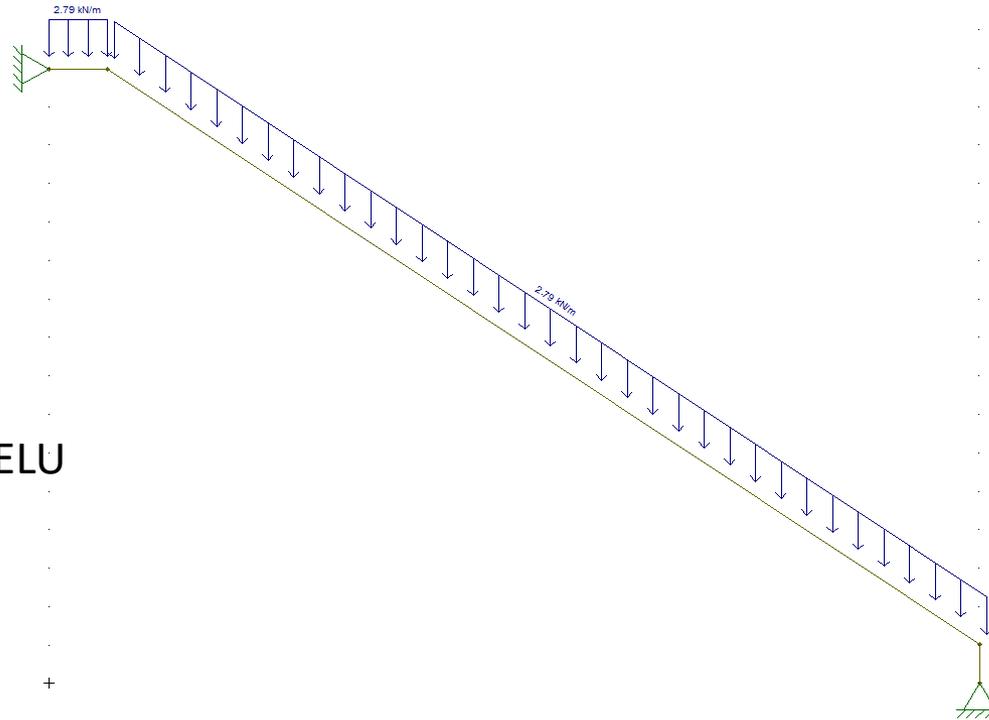
Global

Local

Qx: 0.00 kN/m

Qy: -2.79 kN/m

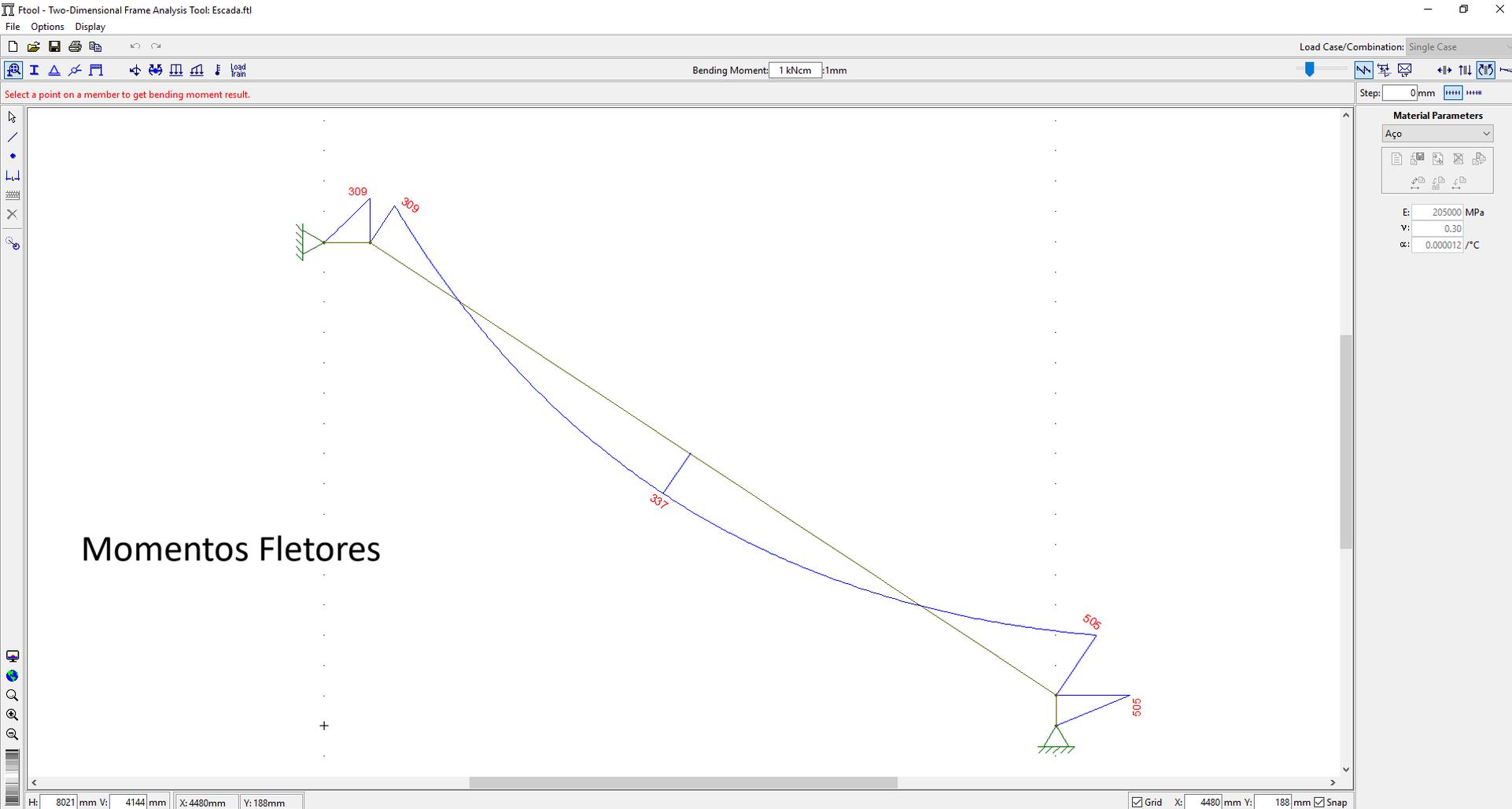
Lançamento ELU



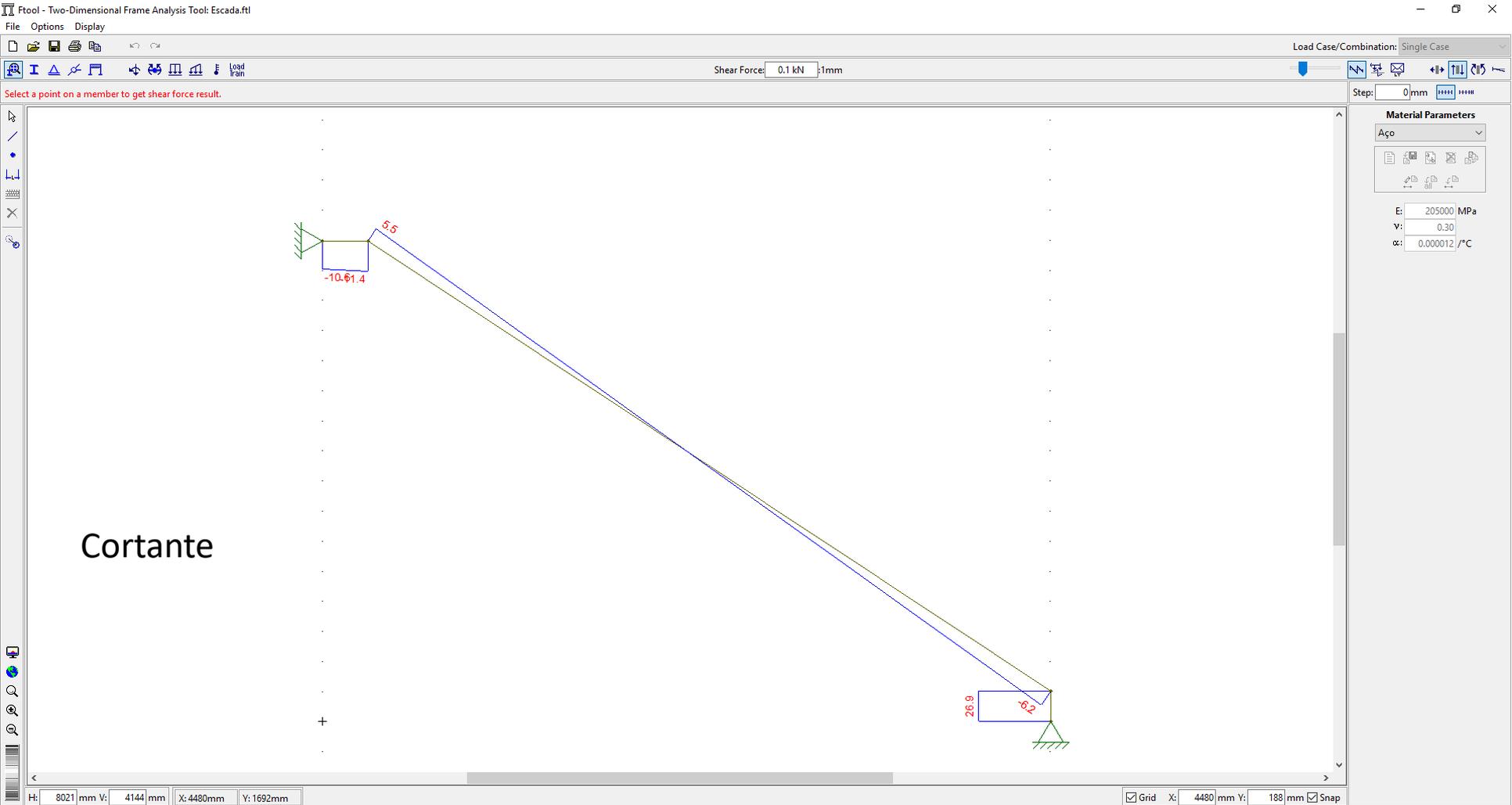
H: 8021 mm V: 4144 mm X: Y:

Grid X: 4480 mm Y: 188 mm Snap

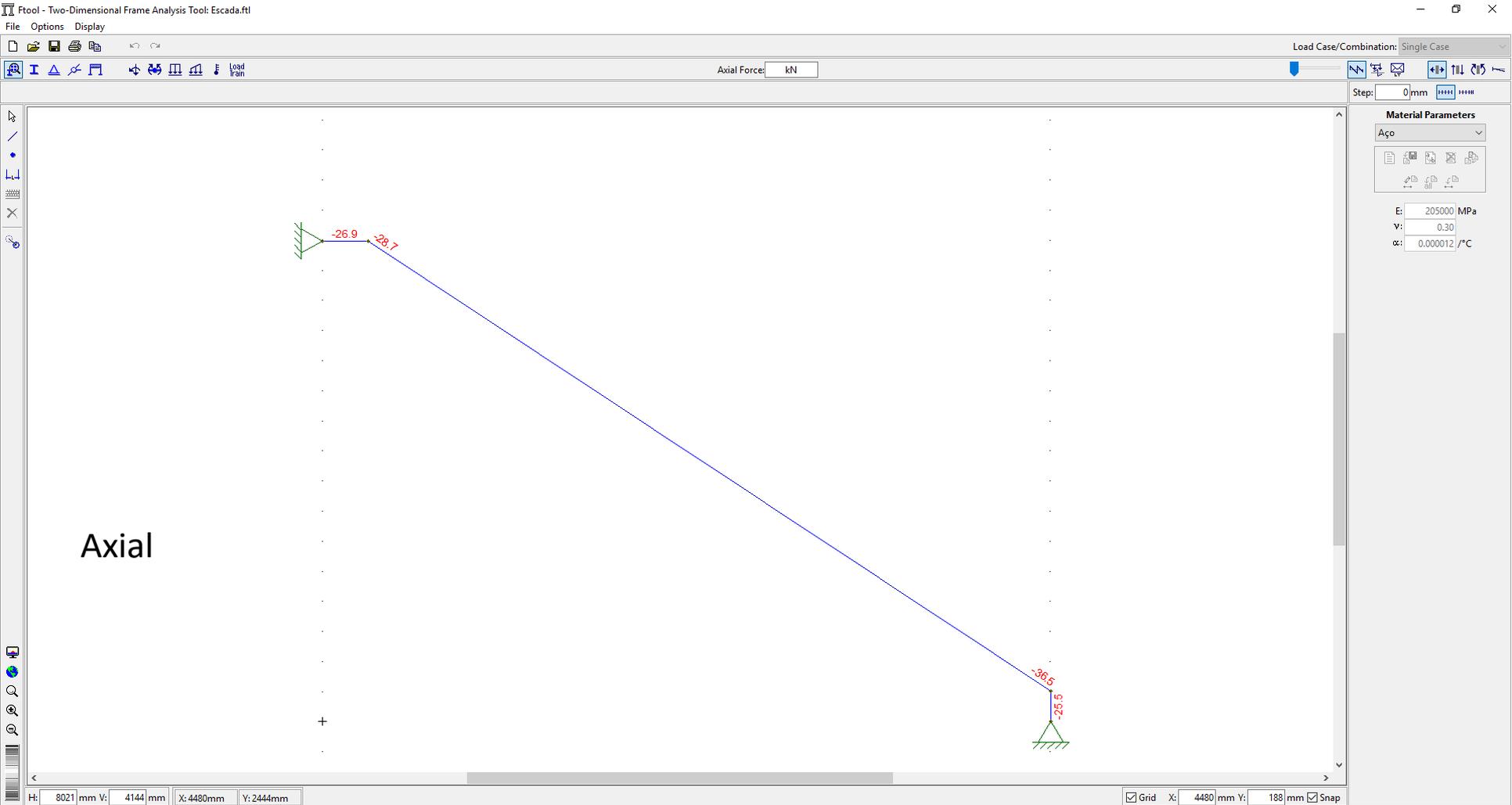
Cálculo da longarina (largura 1000mm)



Cálculo da longarina (largura 1000mm)



Cálculo da longarina (largura 1000mm)



Cálculo da longarina (largura 1000mm)

DimPerfil 4.0 - Dimensionamento de Perfis de Aço Formados a Frio

File Help

Escolha do Perfil Cálculo dos Esforços

Dimensões (cm)

$\alpha = 0$
 $b_w = 15$
 $b_f = 6$
 $D = 2$
 $\tau = 0.3$
 $\beta = 90$

Comprimentos (cm)

Lx: 553
Ly: 34
Lt: 34

Esforços Solicitantes

Nd: 37 kN
Mxd: 505 kN.cm
Myd: kN.cm
Vd: 27 kN

Coefficiente de Momento

Em X Cb: 1
Em Y Cb: 1

Ue

Resultados

Resultado:
Flexão Composta

NBR 14762:2001
0,92 (se ≤ 1 , ok!)

Relatório: Limpar anterior

CALCULAR

Abrir Relatório Salvar Relatório Gerar Tabela

Item a ser calculado: Var

Inequações de verificação p/
Flexão Composta

- NBR 14762:2010
 - Flexão Composta
 - Nrd
 - Mrd
 - Mxrd
 - Myrd
 - Flexão Composta**
 - Cortante
 - Flexão e Cisalhamento

Mostrar perfil

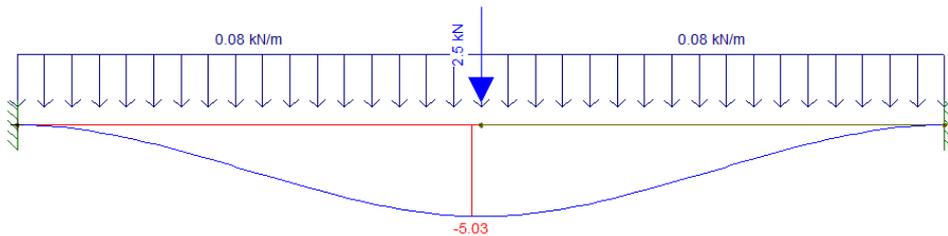
Esforços Solicitantes:
NSd= 37 kN
MxSd= 505 kN.cm
MySd= 0 kN.cm
Esforços Resistentes:
-> NcRd= 109,85 kN
-> MxRd= 865,63 kN.cm
-> MyRd= 224,6 kN.cm
Verificação a Flexão Composta [NBR 14762:2010 - 9.9]
Verificação de Flexo-Compressão
=> 0,34 + 0,58 + 0 = 0,92 \leq 1 - Ok!
4 - Verificação da Esbeltez Limite
barra submetida a esforço de compressão:
 $\lambda_{limite} = 200$
Verificação em Relação a X
 $r_x = 5,85$ cm
Lx= 553 cm
 $\lambda_x = 94,6$ cm - ok!
Verificação em Relação a Y
 $r_y = 2,2$ cm
Ly= 34 cm
 $\lambda_y = 15,48$ cm - ok!

**Atenção: No DIM PERFIL
Compressão é positivo**

By Edson Lubas Silva

Cálculo da degrau (largura 1000mm)

ELS:

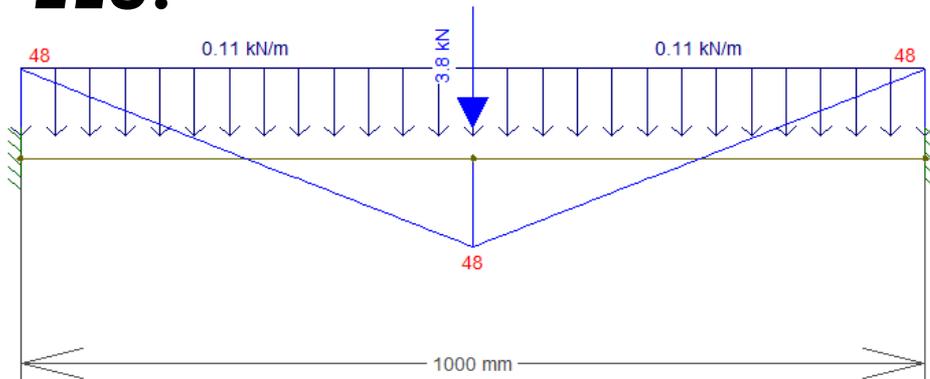


$$f_{max} = \frac{L}{350} = 1000 = 350 = 2,85mm$$

$$1,4PP = 0,112 \text{ kN/m}$$

$$1,5SC = 3,75 \text{ kN}$$

ELU:



**TENTATIVA 1:
Espessura de
3,2mm (1/8")**

| Section Properties | |
|--------------------|----------------------|
| degrau | |
| | |
| C-shape | |
| | |
| d: | 280.00 mm |
| b: | 20.00 mm |
| tw: | 3.18 mm |
| tf: | 3.18 mm |
| \bar{y} : | 17.34 mm |
| A: | 9.97 cm ² |
| As: | 1.27 cm ² |
| I: | 1.28 cm ⁴ |

Cálculo da degrau (largura 1000mm)

```
AutoCAD Text Window - Projeto Galpão Treliçado.dwg
Edit
Command: MASSPROP

Select objects: Specify opposite corner: 1 found

Select objects:

----- REGIONS -----
Area:                9.304
Perimeter:           62.627
Bounding box:        X: -14.000 -- 14.000
                    Y: -1.739 -- 0.261
Centroid:            X: 0.000
                    Y: 0.000
Moments of inertia:  X: 1.219
                    Y: 721.938
Product of inertia:  XY: 0.000
Radii of gyration:   X: 0.362
                    Y: 8.809
Principal moments and X-Y directions about centroid:
                    I: 1.219 along [1.000 0.000]
                    J: 721.938 along [0.000 1.000]

Write analysis to a file? [Yes/No] <N>:
```

Cálculo da degrau (largura 1000mm)

Na fibra Comprimida

$$Mrd = Wx \cdot \frac{Fy}{1,1} = \frac{Ix}{ycg} \cdot fy = \frac{1,219}{0,261} \cdot \frac{25}{1,1} = 106,14 \text{ kN.cm} > 48 \text{ kN.cm OK}$$

Na fibra Tracionada

$$Mrd = Wx \cdot Fy = \frac{Ix}{ycg} \cdot \frac{fy}{1,1} = \frac{1,219}{1,739} \cdot \frac{25}{1,1} = 15,92 \text{ kN.cm} < 48 \text{ Não OK!}$$

$$\text{É necessário: } W = \frac{M_{sd} \cdot 1,1}{F_y} \rightarrow W = \frac{48 \cdot 1,1}{25} \rightarrow W = 2,11 \text{ cm}^3$$

Cálculo da degrau (largura 1000mm)

Projet ?

Type de profil

Profil type cornière
 Profil type U
 Profil type Cé
 Profil type Sigma
 Profil type Zed

Données

h = 280 mm
 t = 4.76 mm
 re = 9.52 mm
 b1 = 30 mm
 b2 = 30 mm

Galvanisation : Noir

Section : Section globale

Section en U
- les semelles peuvent être dissymétriques

Référence du projet : Degrau

Unités de calcul: cm & degré

Orientation du premier élément $\gamma_0 = 90^\circ$

| | | | | |
|---|--------|---------|----------|----------------------|
| 1 | droit | t=0,476 | b=2,048 | |
| 2 | courbe | t=0,476 | re=0,952 | $\gamma = -90^\circ$ |
| 3 | droit | t=0,476 | b=26,096 | |
| 4 | courbe | t=0,476 | re=0,952 | $\gamma = -90^\circ$ |
| 5 | droit | t=0,476 | b=2,048 | |

Développée théorique = 32,4351 cm

A = 15,439 cm²

p = 12,12 Kg/m

J = 1,1658 cm⁴

Caractéristiques par rapport aux axes de référence

Coordonnées du centre de gravité :

$Y_g = 0,474$ cm

$Z_g = 14$ cm

Coordonnées du centre de cisaillement :

$Y_c = -0,303$ cm

$Z_c = 14$ cm

$I_y = 1269,443$ cm⁴

$i_y = 9,0677$ cm

$v_y = 14$ cm

$W_{el,y} = 90,674$ cm³

$I_z = 6,072$ cm⁴

$i_z = 0,6271$ cm

$v_{z,max} = 2,526$ cm

$W_{el,z,min} = 2,404$ cm³

$v_{z,min} = 0,474$ cm

$W_{el,z,max} = 12,802$ cm³

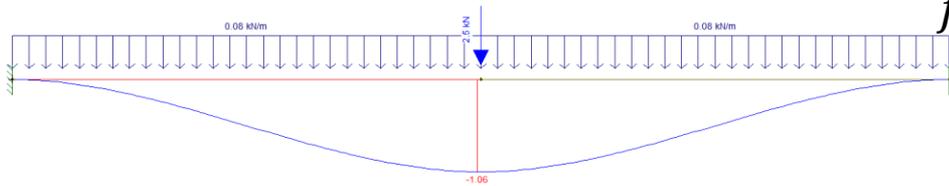
Moment d'inertie sectoriel = 873,8748 cm⁶

CameliaX

Cálculo da degrau (largura 1000mm)

ELS:

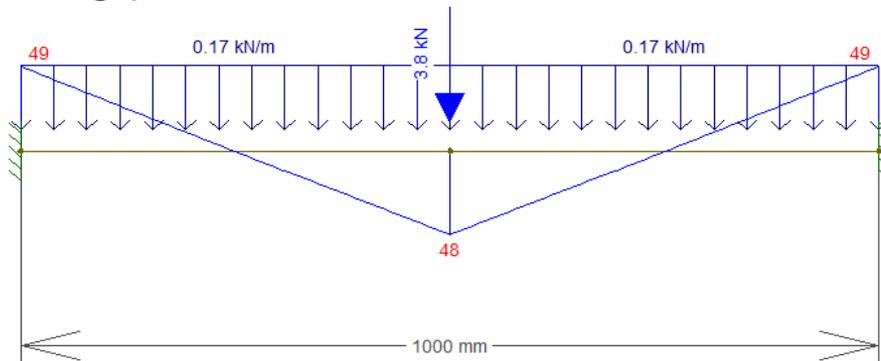
$$f_{max} = \frac{L}{350} = 1000 / 350 = 2,85mm$$



$$1,4PP = 0,17 \text{ kN/m}$$

$$1,5SC = 3,75 \text{ kN}$$

ELU:



**TENTATIVA 2:
Espessura de
4,76mm (3/16")**

| Section Properties | |
|--------------------|-----------------------|
| degrau | |
| | |
| d: | 280.00 mm |
| b: | 30.00 mm |
| tw: | 4.76 mm |
| tf: | 4.76 mm |
| ȳ: | 25.33 mm |
| A: | 15.73 cm ² |
| As: | 2.86 cm ² |
| I: | 6.11 cm ⁴ |

Cálculo da degrau (largura 1000mm)

Na fibra Comprimida

$$Mrd = Wx \cdot \frac{Fy}{1,1} = \frac{12,8 \cdot 25}{1,1} = 290,9 \text{ kN.cm} > 49 \text{ kN.cm OK}$$

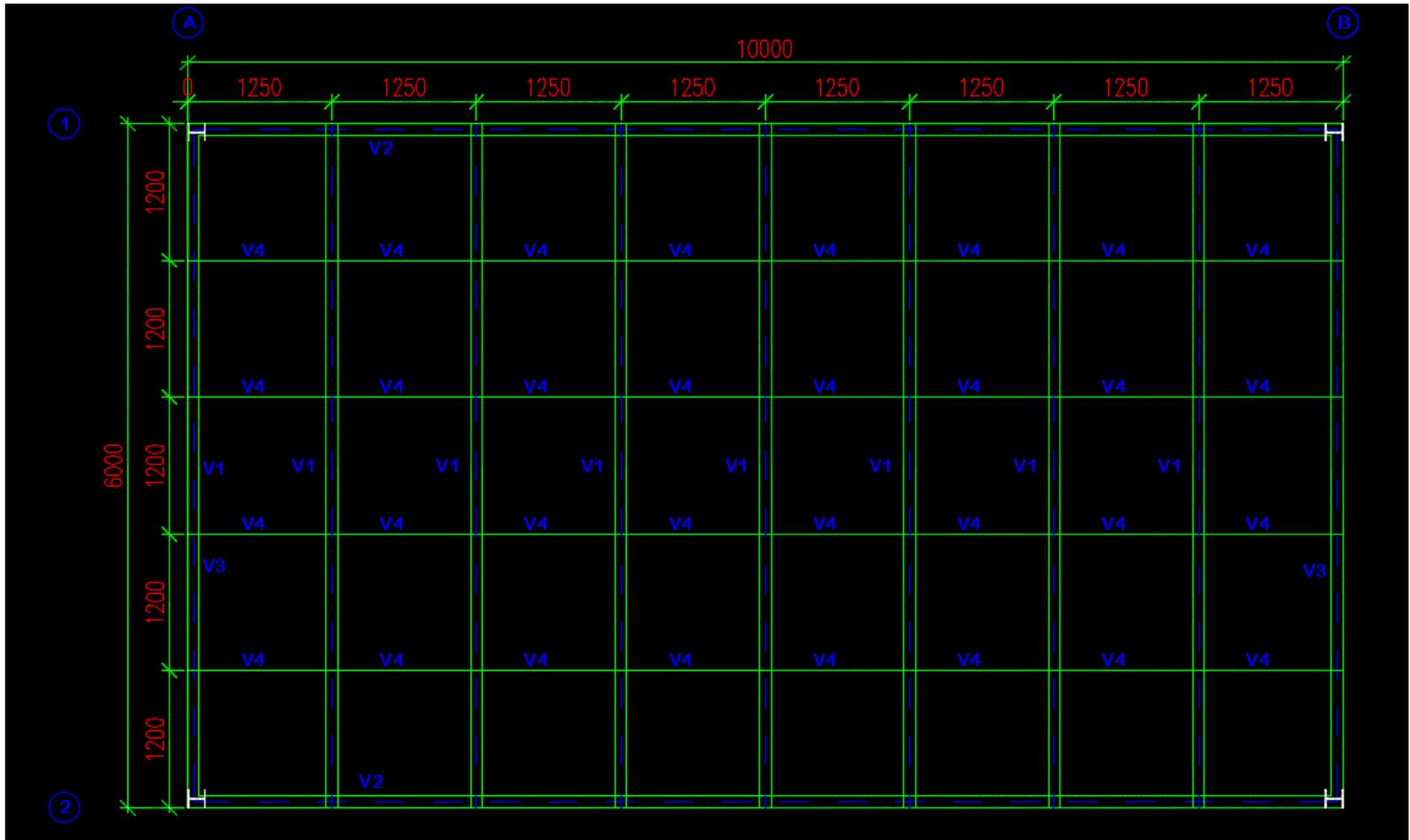
Na fibra Tracionada

$$Mrd = Wx \cdot Fy = \frac{2,4 \cdot 25}{1,1} = 54,5 \text{ kN.cm} > 48 \text{ OK!}$$

Dica: Para evitar problemas mantenha a aba abaixo de

$$FLM: \frac{b}{t} = \frac{30}{4,76} = 6,30 \quad \lambda = 0,38 \sqrt{\frac{E}{Fy}} \quad \lambda = 0,38 \sqrt{\frac{20500}{25}} \quad \lambda = 10,88$$

Calcular o Mezanino abaixo: Distância piso a piso= 3 m – Bases Engastadas SC = 500kg/m²



Cálculo de V1

PP

Painel Wall 34kg/m²

Peso da Viga (Aprox: 25kg/m)

PP Total = (0,34).1,25 + 0,25 = 0,675 kN/m (x1,4 = 0,945kN/m)

SC = 5kN/m² x 1,25 = 6,25 kN/m (x 1,5 = 9,375)

ELS: PP + SC = 0,675 + 6,25 = 6,925 kN/m

ELU: 1,4PP + 1,5SC = 10,32 kN/m

Cálculo de V1

Considerando V1 bi-apoia temos:

$$f_{max} = \frac{L}{350} = \frac{6000}{350} = 17,14mm$$

$$I_{nec} = \frac{5 \cdot q \cdot L^4}{384 \cdot E \cdot f_{max}} = \frac{5 \cdot 0,06925 \cdot 6000^4}{384 \cdot 20500 \cdot 1,714} = 3325cm^4$$

$$Msd = q \cdot \frac{L^2}{8} = \frac{0,1032 \cdot 6000^2}{8} = 4644kN \cdot cm$$

$$Z_x = Msd \cdot \frac{1,1}{F_y} = 4644 \cdot \frac{1,1}{34,5} = 148cm^3$$

$$ELS: R_y = \frac{6,925 \cdot 6}{2} = 20,775kN$$

$$ELU: R_y = \frac{10,32 \cdot 6}{2} = 30,96kN$$

Cálculo de V1

| BITOLA mm x kg/m | Massa Linear kg/m | d mm | b ₁ mm | ESPESSURA | | h mm | d' mm | Área cm ² | EIXO X - X | | | | EIXO Y - Y | | | | r _i cm | I _x cm ⁴ | ESBELTEZ | | C _w cm ⁴ | u m ² /m | BITOLA mm x kg/m |
|---------------------|-------------------------|---------|----------------------|----------------------|----------------------|---------|----------|-------------------------|-----------------------------------|-----------------------------------|----------------------|-----------------------------------|-----------------------------------|-----------------------------------|----------------------|-----------------------------------|----------------------|-----------------------------------|---|--|-----------------------------------|------------------------|---------------------|
| | | | | t _m mm | t _i mm | | | | I _x cm ⁴ | W _x cm ³ | r _x cm | Z _x cm ³ | I _y cm ⁴ | W _y cm ³ | r _y cm | Z _y cm ³ | | | ABA - λ ₁ b ₁ /2t ₁ | ALMA - λ ₂ d'/t ₁ | | | |
| | | | | | | | | | | | | | | | | | | | | | | | |
| W 150 x 13,0 | 13,0 | 148 | 100 | 4,3 | 4,9 | 138 | 118 | 16,6 | 635 | 85,8 | 6,18 | 96,4 | 82 | 16,4 | 2,22 | 25,5 | 2,60 | 1,72 | 10,20 | 27,49 | 4.181 | 0,67 | W 150 x 13,0 |
| W 150 x 18,0 | 18,0 | 153 | 102 | 5,8 | 7,1 | 139 | 119 | 23,4 | 939 | 122,8 | 6,34 | 139,4 | 126 | 24,7 | 2,32 | 38,5 | 2,69 | 4,34 | 7,18 | 20,48 | 6.683 | 0,69 | W 150 x 18,0 |
| W 150 x 22,5 (H) | 22,5 | 152 | 152 | 5,8 | 6,6 | 139 | 119 | 29,0 | 1.229 | 161,7 | 6,51 | 179,6 | 387 | 50,9 | 3,65 | 77,9 | 4,10 | 4,75 | 11,52 | 20,48 | 20.417 | 0,88 | W 150 x 22,5 (H) |
| W 150 x 24,0 | 24,0 | 160 | 102 | 6,6 | 10,3 | 139 | 115 | 31,5 | 1.384 | 173,0 | 6,63 | 197,6 | 183 | 35,9 | 2,41 | 55,8 | 2,73 | 11,08 | 4,95 | 17,48 | 10.206 | 0,69 | W 150 x 24,0 |
| W 150 x 29,8 (H) | 29,8 | 157 | 153 | 6,6 | 9,3 | 138 | 118 | 38,5 | 1.739 | 221,5 | 6,72 | 247,5 | 556 | 72,6 | 3,80 | 110,8 | 4,18 | 10,95 | 8,23 | 17,94 | 30.277 | 0,90 | W 150 x 29,8 (H) |
| W 150 x 37,1 (H) | 37,1 | 162 | 154 | 8,1 | 11,6 | 139 | 119 | 47,8 | 2.244 | 277,0 | 6,85 | 313,5 | 707 | 91,8 | 3,84 | 140,4 | 4,22 | 20,58 | 6,64 | 14,67 | 39.930 | 0,91 | W 150 x 37,1 (H) |
| W 200 x 15,0 | 15,0 | 200 | 100 | 4,3 | 5,2 | 190 | 170 | 19,4 | 1.305 | 130,5 | 8,20 | 147,9 | 87 | 17,4 | 2,12 | 27,3 | 2,55 | 2,05 | 9,62 | 39,44 | 8.222 | 0,77 | W 200 x 15,0 |
| W 200 x 19,3 | 19,3 | 203 | 102 | 5,8 | 6,5 | 190 | 170 | 25,1 | 1.686 | 166,1 | 8,19 | 190,6 | 116 | 22,7 | 2,14 | 35,9 | 2,59 | 4,02 | 7,85 | 29,11 | 11.098 | 0,79 | W 200 x 19,3 |
| W 200 x 22,5 | 22,5 | 206 | 102 | 6,2 | 8,0 | 190 | 170 | 29,0 | 2.029 | 197,0 | 8,37 | 225,5 | 142 | 27,9 | 2,22 | 43,9 | 2,63 | 6,18 | 6,38 | 27,42 | 13.868 | 0,79 | W 200 x 22,5 |
| W 200 x 26,6 | 26,6 | 207 | 133 | 5,8 | 8,4 | 190 | 170 | 34,2 | 2.611 | 252,3 | 8,73 | 282,3 | 330 | 49,6 | 3,10 | 76,3 | 3,54 | 7,65 | 7,92 | 29,34 | 32.477 | 0,92 | W 200 x 26,6 |
| W 200 x 31,3 | 31,3 | 210 | 134 | 6,4 | 10,2 | 190 | 170 | 40,3 | 3.168 | 301,7 | 8,86 | 338,6 | 410 | 61,2 | 3,19 | 94,0 | 3,60 | 12,59 | 6,57 | 26,50 | 40.822 | 0,93 | W 200 x 31,3 |
| W 200 x 35,9 (H) | 35,9 | 201 | 165 | 6,2 | 10,2 | 181 | 161 | 45,7 | 3.437 | 342,0 | 8,67 | 379,2 | 764 | 92,6 | 4,09 | 141,0 | 4,50 | 14,51 | 8,09 | 25,90 | 69.502 | 1,03 | W 200 x 35,9 (H) |
| W 200 x 41,7 (H) | 41,7 | 205 | 166 | 7,2 | 11,8 | 181 | 157 | 53,5 | 4.114 | 401,4 | 8,77 | 448,6 | 901 | 108,5 | 4,10 | 165,7 | 4,53 | 23,19 | 7,03 | 21,86 | 83.948 | 1,04 | W 200 x 41,7 (H) |
| W 200 x 46,1 (H) | 46,1 | 203 | 203 | 7,2 | 11,0 | 181 | 161 | 58,6 | 4.543 | 447,6 | 8,81 | 495,3 | 1.535 | 151,2 | 5,12 | 229,5 | 5,58 | 22,01 | 9,23 | 22,36 | 141.342 | 1,19 | W 200 x 46,1 (H) |
| W 200 x 52,0 (H) | 52,0 | 206 | 204 | 7,9 | 12,6 | 181 | 157 | 66,9 | 5.298 | 514,4 | 8,90 | 572,5 | 1.784 | 174,9 | 5,16 | 265,8 | 5,61 | 33,34 | 8,10 | 19,85 | 166.710 | 1,19 | W 200 x 52,0 (H) |
| HP 200 x 53,0 (H) | 53,0 | 204 | 207 | 11,3 | 11,3 | 181 | 161 | 68,1 | 4.977 | 488,0 | 8,55 | 551,3 | 1.673 | 161,7 | 4,96 | 248,6 | 5,57 | 31,93 | 9,16 | 14,28 | 155.075 | 1,20 | HP 200 x 53,0 (H) |
| W 200 x 59,0 (H) | 59,0 | 210 | 205 | 9,1 | 14,2 | 182 | 158 | 76,0 | 6.140 | 584,8 | 8,99 | 655,9 | 2.041 | 199,1 | 5,18 | 303,0 | 5,64 | 47,69 | 7,22 | 17,32 | 195.418 | 1,20 | W 200 x 59,0 (H) |
| W 200 x 71,0 (H) | 71,0 | 216 | 206 | 10,2 | 17,4 | 181 | 161 | 91,0 | 7.660 | 709,2 | 9,17 | 803,2 | 2.537 | 246,3 | 5,28 | 374,5 | 5,70 | 81,66 | 5,92 | 15,80 | 249.976 | 1,22 | W 200 x 71,0 (H) |
| W 200 x 86,0 (H) | 86,0 | 222 | 209 | 13,0 | 20,6 | 181 | 157 | 110,9 | 9.498 | 855,7 | 9,26 | 984,2 | 3.139 | 300,4 | 5,32 | 458,7 | 5,77 | 142,19 | 5,07 | 12,06 | 317.844 | 1,23 | W 200 x 86,0 (H) |
| W 250 x 17,9 | 17,9 | 251 | 101 | 4,8 | 5,3 | 240 | 220 | 23,1 | 2.291 | 182,6 | 9,96 | 211,0 | 91 | 18,1 | 1,99 | 28,8 | 2,48 | 2,54 | 9,53 | 45,92 | 13.735 | 0,88 | W 250 x 17,9 |
| W 250 x 22,3 | 22,3 | 254 | 102 | 5,8 | 6,9 | 240 | 220 | 28,9 | 2.939 | 231,4 | 10,09 | 267,7 | 123 | 24,1 | 2,06 | 38,4 | 2,54 | 4,77 | 7,39 | 37,97 | 18.629 | 0,89 | W 250 x 22,3 |
| W 250 x 25,3 | 25,3 | 257 | 102 | 6,1 | 8,4 | 240 | 220 | 32,6 | 3.473 | 270,2 | 10,31 | 311,1 | 149 | 29,3 | 2,14 | 46,4 | 2,58 | 7,06 | 6,07 | 36,10 | 22.955 | 0,89 | W 250 x 25,3 |
| W 250 x 28,4 | 28,4 | 260 | 102 | 6,4 | 10,0 | 240 | 220 | 36,6 | 4.046 | 311,2 | 10,51 | 357,3 | 178 | 34,8 | 2,20 | 54,9 | 2,62 | 10,34 | 5,10 | 34,38 | 27.636 | 0,90 | W 250 x 28,4 |
| W 250 x 32,7 | 32,7 | 258 | 146 | 6,1 | 9,1 | 240 | 220 | 42,1 | 4.937 | 382,7 | 10,83 | 428,5 | 473 | 64,8 | 3,35 | 99,7 | 3,86 | 10,44 | 8,02 | 36,03 | 73.104 | 1,07 | W 250 x 32,7 |
| W 250 x 38,5 | 38,5 | 262 | 147 | 6,6 | 11,2 | 240 | 220 | 49,6 | 6.057 | 462,4 | 11,05 | 517,8 | 594 | 80,8 | 3,46 | 124,1 | 3,93 | 17,63 | 6,56 | 33,27 | 93.242 | 1,08 | W 250 x 38,5 |
| W 250 x 44,8 | 44,8 | 266 | 148 | 7,6 | 13,0 | 240 | 220 | 57,6 | 7.158 | 538,2 | 11,15 | 606,3 | 704 | 95,1 | 3,50 | 146,4 | 3,96 | 27,14 | 5,69 | 28,95 | 112.398 | 1,09 | W 250 x 44,8 |
| HP 250 x 62,0 (H) | 62,0 | 246 | 256 | 10,5 | 10,7 | 225 | 201 | 79,6 | 8.728 | 709,6 | 10,47 | 790,5 | 2.995 | 234,0 | 6,13 | 357,8 | 6,89 | 33,46 | 11,96 | 19,10 | 417.130 | 1,47 | HP 250 x 62,0 (H) |
| W 250 x 73,0 (H) | 73,0 | 253 | 254 | 8,6 | 14,2 | 225 | 201 | 92,7 | 11.257 | 889,9 | 11,02 | 983,3 | 3.880 | 305,5 | 6,47 | 463,1 | 7,01 | 56,94 | 8,94 | 23,33 | 552.900 | 1,48 | W 250 x 73,0 (H) |
| W 250 x 80,0 (H) | 80,0 | 256 | 255 | 9,4 | 15,6 | 225 | 201 | 101,9 | 12.550 | 980,5 | 11,10 | 1.088,7 | 4.313 | 338,3 | 6,51 | 513,1 | 7,04 | 75,02 | 8,17 | 21,36 | 622.878 | 1,49 | W 250 x 80,0 (H) |
| HP 250 x 85,0 (H) | 85,0 | 254 | 260 | 14,4 | 14,4 | 225 | 201 | 108,5 | 12.280 | 966,9 | 10,64 | 1.093,2 | 4.225 | 325,0 | 6,24 | 499,6 | 7,00 | 82,07 | 9,03 | 13,97 | 605.403 | 1,50 | HP 250 x 85,0 (H) |
| W 250 x 89,0 (H) | 89,0 | 260 | 256 | 10,7 | 17,3 | 225 | 201 | 113,9 | 14.237 | 1.095,1 | 11,18 | 1.224,4 | 4.841 | 378,2 | 6,52 | 574,3 | 7,06 | 102,81 | 7,40 | 18,82 | 712.351 | 1,50 | W 250 x 89,0 (H) |
| W 250 x 101,0 (H) | 101,0 | 264 | 257 | 11,9 | 19,6 | 225 | 201 | 128,7 | 16.352 | 1.238,8 | 11,27 | 1.395,0 | 5.549 | 431,8 | 6,57 | 656,3 | 7,10 | 147,70 | 6,56 | 16,87 | 828.031 | 1,51 | W 250 x 101,0 (H) |
| W 250 x 115,0 (H) | 115,0 | 269 | 259 | 13,5 | 22,1 | 225 | 201 | 146,1 | 18.920 | 1.406,7 | 11,38 | 1.597,4 | 6.405 | 494,6 | 6,62 | 752,7 | 7,16 | 212,00 | 5,86 | 14,87 | 975.265 | 1,53 | W 250 x 115,0 (H) |
| W 310 x 21,0 | 21,0 | 303 | 101 | 5,1 | 5,7 | 292 | 272 | 27,2 | 3.776 | 249,2 | 11,77 | 291,9 | 98 | 19,5 | 1,90 | 31,4 | 2,42 | 3,27 | 8,86 | 53,25 | 21.628 | 0,98 | W 310 x 21,0 |
| W 310 x 23,8 | 23,8 | 305 | 101 | 5,6 | 6,7 | 292 | 272 | 30,7 | 4.346 | 285,0 | 11,89 | 333,2 | 116 | 22,9 | 1,94 | 36,9 | 2,45 | 4,65 | 7,54 | 48,50 | 25.594 | 0,99 | W 310 x 23,8 |
| W 310 x 28,3 | 28,3 | 309 | 102 | 6,0 | 8,9 | 291 | 271 | 36,5 | 5.500 | 356,0 | 12,28 | 412,0 | 158 | 31,0 | 2,08 | 49,4 | 2,55 | 8,14 | 5,73 | 45,20 | 35.441 | 1,00 | W 310 x 28,3 |
| W 310 x 32,7 | 32,7 | 313 | 102 | 6,6 | 10,8 | 291 | 271 | 42,1 | 6.570 | 419,8 | 12,49 | 485,3 | 192 | 37,6 | 2,13 | 59,8 | 2,58 | 12,91 | 4,72 | 41,12 | 43.612 | 1,00 | W 310 x 32,7 |
| W 310 x 38,7 | 38,7 | 310 | 165 | 5,8 | 9,7 | 291 | 271 | 49,7 | 8.581 | 553,6 | 13,14 | 615,4 | 727 | 88,1 | 3,82 | 134,9 | 4,38 | 13,20 | 8,51 | 46,66 | 163.728 | 1,25 | W 310 x 38,7 |
| W 310 x 44,5 | 44,5 | 313 | 166 | 6,6 | 11,2 | 291 | 271 | 57,2 | 9.997 | 638,8 | 13,22 | 712,8 | 855 | 103,0 | 3,87 | 158,0 | 4,41 | 19,90 | 7,41 | 41,00 | 194.433 | 1,26 | W 310 x 44,5 |
| W 310 x 52,0 | 52,0 | 317 | 167 | 7,6 | 13,2 | 291 | 271 | 67,0 | 11.909 | 751,4 | 13,33 | 842,5 | 1.026 | 122,9 | 3,91 | 188,8 | 4,45 | 31,81 | 6,33 | 35,61 | 236.422 | 1,27 | W 310 x 52,0 |
| HP 310 x 79,0 (H) | 79,0 | 299 | 306 | 11,0 | 11,0 | 277 | 245 | 100,0 | 16.316 | 1.091,3 | 12,77 | 1.210,1 | 5.258 | 343,7 | 7,25 | 525,4 | 8,20 | 46,72 | 13,91 | 22,27 | 1.089.258 | 1,77 | HP 310 x 79,0 (H) |
| HP 310 x 93,0 (H) | 93,0 | 303 | 308 | 13,1 | 13,1 | 277 | 245 | 119,2 | 19.682 | 1.299,1 | 12,85 | 1.450,3 | 6.387 | 414,7 | 7,32 | 635,5 | 8,26 | 77,33 | 11,76 | 18,69 | 1.340.320 | 1,78 | HP 310 x 93,0 (H) |
| W 310 x 97,0 (H) | 97,0 | 308 | 305 | 9,9 | 15,4 | 277 | 245 | 123,6 | 22.284 | 1.447,0 | 13,43 | 1.594,2 | 7.286 | 477,8 | 7,68 | 725,0 | 8,38 | 92,12 | 9,90 | 24,77 | 1.558.682 | 1,79 | W 310 x 97,0 (H) |
| W 310 x 107,0 (H) | 107,0 | 311 | 306 | 10,9 | 17,0 | 277 | 245 | 136,4 | 24.839 | 1.597,3 | 13,49 | 1.768,2 | 8.123 | 530,9 | 7,72 | 806,1 | 8,41 | 122,86 | 9,00 | 22,48 | 1.754.271 | 1,80 | W 310 x 107,0 (H) |
| HP 310 x 110,0 (H) | 110,0 | 308 | 310 | 15,4 | 15,5 | 277 | 245 | 141,0 | 23.703 | 1.539,1 | 12,97 | 1.730,6 | 7.707 | 497,3 | 7,39 | 763,7 | 8,33 | 125,66 | 10,00 | 15,91 | 1.646.104 | 1,80 | HP 310 x 110,0 (H) |

Cálculo de V4

PP

Painel Wall 34kg/m²

Peso da Viga (Aprox: 15kg/m)

PP Total = (0,34).1,20 + 0,15 = 0,56 kN/m (x1,4 = 0,78kN/m)

SC = 5kN/m² x 1,20 = 6,0 kN/m (x 1,5 = 9,00)

ELS: PP + SC = 0,56 + 6,00 = 6,56 kN/m

ELU: 1,4PP + 1,5SC = 9,78 kN/m

Cálculo de V4

Considerando V4 bi-apoiada temos:

$$f_{max} = \frac{L}{350} = \frac{1250}{350} = 3,57mm$$

$$Inec = \frac{5 \cdot q \cdot L^4}{384 \cdot E \cdot f_{max}} = \frac{5 \cdot 0,06 \cdot 125^4}{384 \cdot 20500 \cdot 0,357} = 26 \text{ cm}^4$$

$$M_{sd} = q \cdot \frac{L^2}{8} = \frac{0,0978 \cdot 125^2}{8} = 191kN \cdot cm$$

$$M_{Rd} = \frac{W_x \cdot F_y}{1,1} \rightarrow W_x = \frac{1,1 \cdot M_{sd}}{F_y} \rightarrow \frac{1,1 \cdot 191}{25} \rightarrow 8,4cm^3$$

$$FLM: \frac{b}{t} = \frac{76,2}{6,35} = 12$$

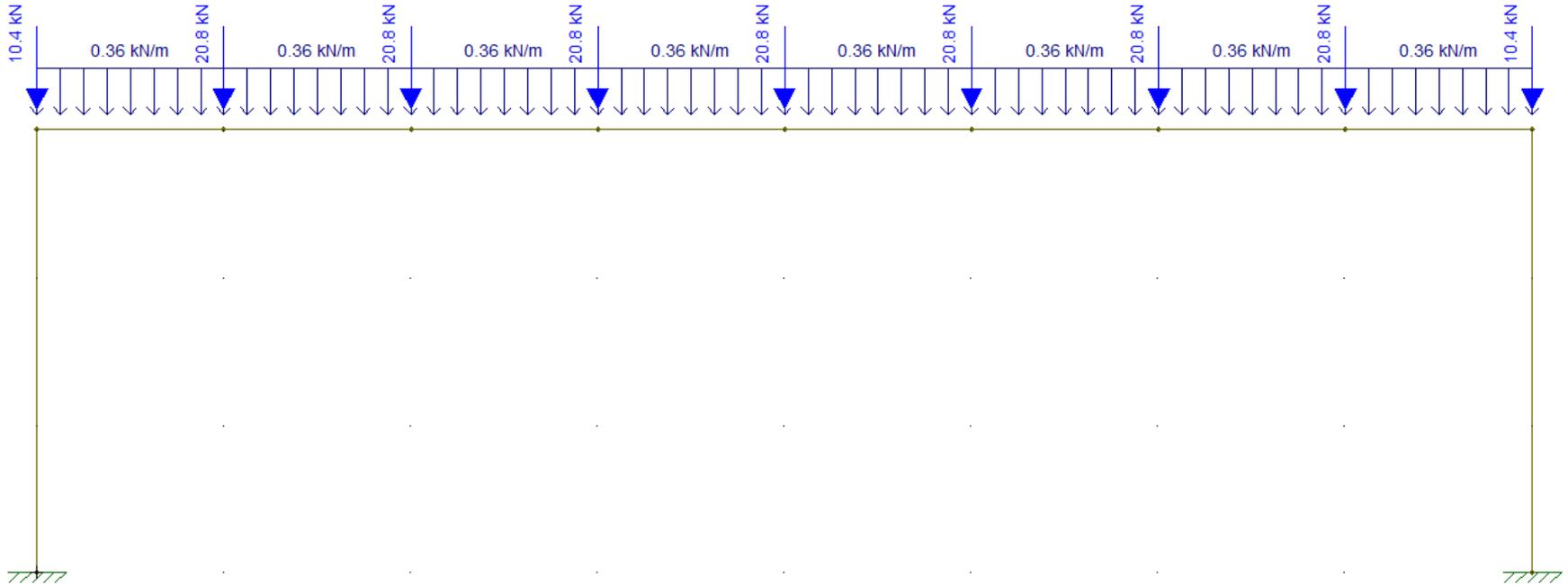
$$\lambda = 0,56 \sqrt{\frac{20500}{25}} = 16$$

| Cantoneira em Polegadas | | | | | | | | | | |
|-------------------------|--------------|-------|-------|--------------------------------|--------------------------------|--------------------------------|---------------------|------|------|------|
| b | Peso Nominal | t | Área | I _x =I _y | W _x =W _y | r _x =r _y | r _z min. | x | | |
| pol | mm | kg/m | pol | mm | cm ² | cm ⁴ | cm ³ | cm | cm | |
| 5/8" | 15,88 | 0,57 | | 2,5 | | | | | | |
| 3/4" | 19,05 | 0,71 | | 2,5 | | | | | | |
| 1/2" | 12,70 | 0,55 | 1/8" | 3,18 | 0,70 | 0,10 | 0,11 | 0,37 | 0,25 | 0,43 |
| 5/8" | 15,88 | 0,71 | 1/8" | 3,18 | 0,90 | 0,20 | 0,19 | 0,47 | 0,32 | 0,51 |
| 3/4" | 19,05 | 0,87 | 1/8" | 3,18 | 1,11 | 0,36 | 0,27 | 0,57 | 0,38 | 0,59 |
| 7/8" | 22,20 | 1,04 | 1/8" | 3,18 | 1,32 | 0,58 | 0,38 | 0,66 | 0,46 | 0,66 |
| 1" | 25,40 | 1,19 | 1/8" | 3,18 | 1,48 | 0,83 | 0,49 | 0,79 | 0,48 | 0,76 |
| | | 1,73 | 3/16" | 4,76 | 2,19 | 1,25 | 0,66 | 0,76 | 0,48 | 0,81 |
| | | 2,22 | 1/4" | 6,35 | 2,84 | 1,66 | 0,98 | 0,76 | 0,48 | 0,86 |
| 1.1/4" | 31,75 | 1,50 | 1/8" | 3,18 | 1,93 | 1,67 | 0,82 | 0,97 | 0,64 | 0,89 |
| | | 2,20 | 3/16" | 4,76 | 2,77 | 2,50 | 1,15 | 0,97 | 0,61 | 0,97 |
| | | 2,86 | 1/4" | 6,35 | 3,62 | 3,33 | 1,47 | 0,94 | 0,61 | 1,02 |
| 1.1/2" | 38,10 | 1,83 | 1/8" | 3,18 | 2,32 | 3,33 | 1,15 | 1,17 | 0,76 | 1,07 |
| | | 2,68 | 3/16" | 4,76 | 3,42 | 4,58 | 1,64 | 1,17 | 0,74 | 1,12 |
| | | 3,48 | 1/4" | 6,35 | 4,45 | 5,83 | 2,13 | 1,15 | 0,74 | 1,19 |
| 1.3/4" | 44,45 | 2,14 | 1/8" | 3,18 | 2,71 | 5,41 | 1,15 | 1,40 | 0,89 | 1,22 |
| | | 3,15 | 3/16" | 4,76 | 4,00 | 7,50 | 2,30 | 1,37 | 0,89 | 1,30 |
| | | 4,12 | 1/4" | 6,35 | 5,22 | 9,57 | 3,13 | 1,35 | 0,86 | 1,35 |
| 2" | 50,80 | 2,46 | 1/8" | 3,18 | 3,10 | 7,91 | 2,13 | 1,60 | 1,02 | 1,40 |
| | | 3,63 | 3/16" | 4,76 | 4,58 | 11,70 | 3,13 | 1,58 | 1,02 | 1,45 |
| | | 4,74 | 1/4" | 6,35 | 6,06 | 14,60 | 4,10 | 1,55 | 0,99 | 1,50 |
| | | 5,83 | 5/16" | 7,94 | 7,42 | 17,50 | 4,91 | 1,53 | 0,99 | 1,55 |
| 2.1/2" | 63,50 | 6,99 | 3/8" | 9,52 | 8,76 | 20,00 | 5,73 | 1,50 | 0,99 | 1,63 |
| | | 4,57 | 3/16" | 4,76 | 5,80 | 23,00 | 4,91 | 1,98 | 1,24 | 1,75 |
| | | 6,10 | 1/4" | 6,35 | 7,67 | 29,00 | 6,40 | 1,96 | 1,24 | 1,83 |
| | | 7,44 | 5/16" | 7,94 | 9,48 | 35,00 | 7,87 | 1,93 | 1,24 | 1,88 |
| 3" | 76,20 | 8,78 | 3/8" | 9,52 | 11,16 | 41,00 | 9,35 | 1,91 | 1,22 | 1,93 |
| | | 5,52 | 3/16" | 4,76 | 7,03 | 40,00 | 7,21 | 2,39 | 1,50 | 2,08 |
| | | 7,29 | 1/4" | 6,35 | 9,29 | 50,00 | 9,50 | 2,36 | 1,50 | 2,13 |
| | | 9,07 | 5/16" | 7,94 | 11,48 | 62,00 | 11,60 | 2,34 | 1,50 | 2,21 |
| | | 10,71 | 3/8" | 9,52 | 13,61 | 75,00 | 13,60 | 2,31 | 1,47 | 2,26 |
| 3.1/2" | 88,90 | 14,00 | 1/2" | 2,7 | 17,74 | 91,00 | 18,00 | 2,29 | 1,47 | 2,36 |
| | | 8,56 | 1/4" | 6,35 | 10,90 | 83,70 | 13,00 | 2,77 | 1,76 | 2,46 |
| | | 10,59 | 5/16" | 7,94 | 13,50 | 102,00 | 16,00 | 2,75 | 1,75 | 2,52 |
| | | 12,58 | 3/8" | 9,52 | 16,00 | 121,00 | 19,20 | 2,75 | 1,75 | 2,58 |
| 4" | 101,60 | 9,81 | 1/4" | 6,35 | 12,51 | 125,00 | 16,40 | 3,17 | 2,00 | 2,77 |
| | | 12,19 | 5/16" | 7,94 | 15,48 | 154,00 | 21,30 | 3,15 | 2,00 | 2,84 |
| | | 14,57 | 3/8" | 9,52 | 18,45 | 183,00 | 24,60 | 3,12 | 2,00 | 2,90 |
| | | 16,80 | 7/16" | 11,11 | 21,35 | 208,00 | 29,50 | 3,12 | 1,98 | 2,95 |
| 5" | 127,00 | 19,03 | 1/2" | 12,7 | 24,19 | 233,00 | 32,80 | 3,10 | 1,98 | 3,00 |
| | | 12,34 | 1/4" | 6,35 | 15,73 | 251,63 | 27,09 | 4,00 | 2,53 | 3,41 |
| | | 15,31 | 5/16" | 7,94 | 19,50 | 308,00 | 33,40 | 3,97 | 2,53 | 3,47 |
| | | 18,30 | 3/8" | 9,52 | 23,29 | 362,00 | 39,50 | 3,94 | 2,51 | 3,53 |
| | | 24,10 | 1/2" | 12,7 | 30,64 | 470,00 | 52,50 | 3,91 | 2,49 | 3,63 |
| 6" | 152,40 | 29,80 | 5/8" | 15,88 | 37,80 | 566,00 | 64,00 | 3,86 | 2,46 | 3,76 |
| | | 23,52 | 7/16" | 11,11 | 26,96 | 416,68 | 45,71 | 3,93 | 2,50 | 3,58 |
| | | 22,20 | 3/8" | 9,52 | 28,10 | 641,00 | 57,40 | 4,78 | 3,02 | 4,17 |
| 8" | 203,20 | 29,20 | 1/2" | 12,7 | 37,09 | 828,00 | 75,40 | 4,72 | 3,00 | 4,27 |
| | | 36,00 | 5/8" | 15,88 | 45,86 | 1007,00 | 93,50 | 4,67 | 2,97 | 4,39 |
| | | 42,70 | 3/4" | 19,05 | 54,44 | 1173,00 | 109,90 | 4,65 | 2,97 | 4,52 |
| | | 48,70 | 5/8" | 15,88 | 62,90 | 2472,40 | 168,90 | 6,31 | 4,01 | 5,66 |
| | | 57,90 | 3/4" | 19,05 | 73,81 | 2901,10 | 199,90 | 6,27 | 3,99 | 5,79 |

Vamos usar uma cantoneira L3" X6,35mm

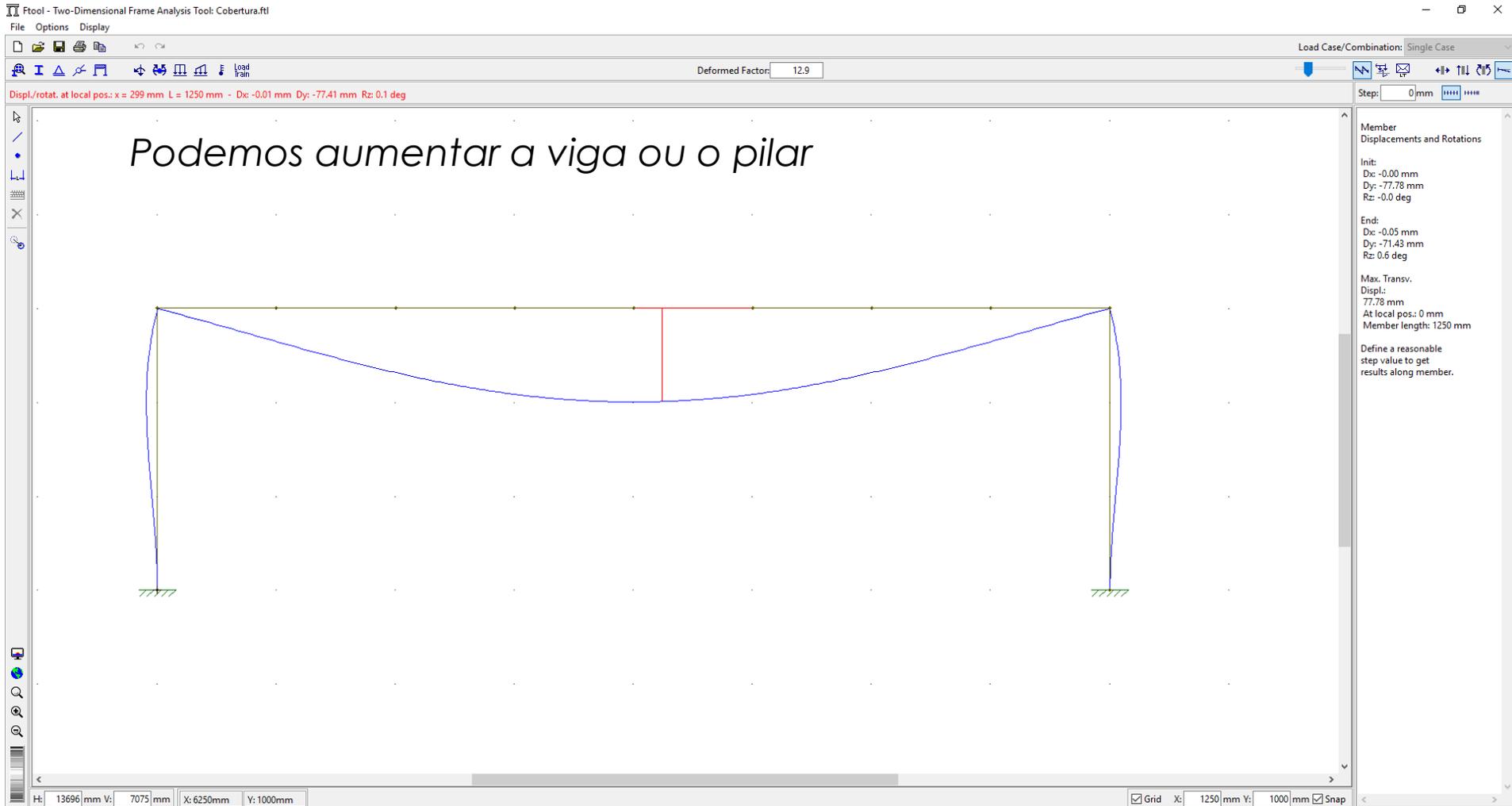
Cálculo de V2

Tentativa 1: Viga W360X32,9 Pilar W150X22,5 H



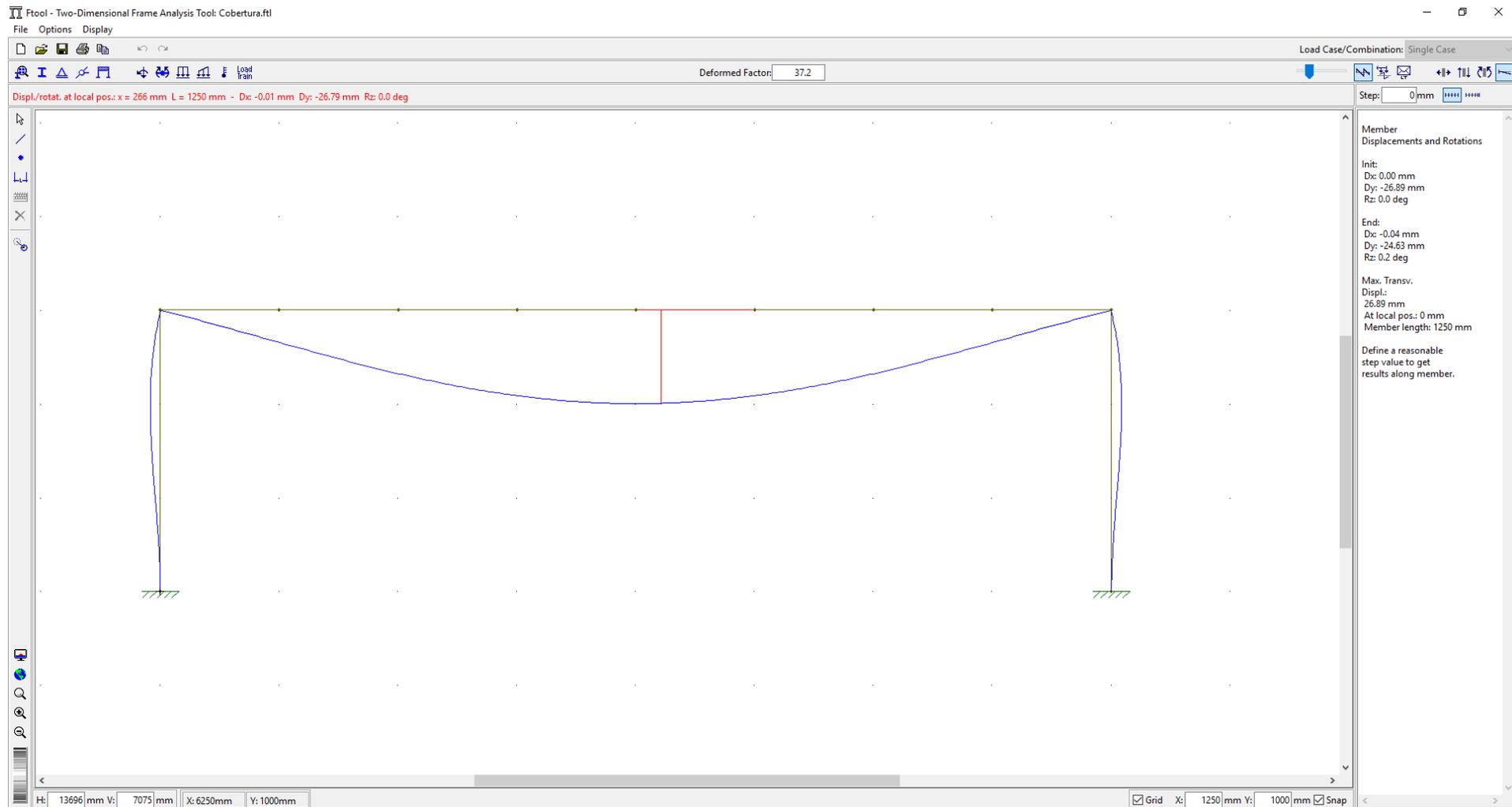
Cálculo de V2

Flecha muito elevada.



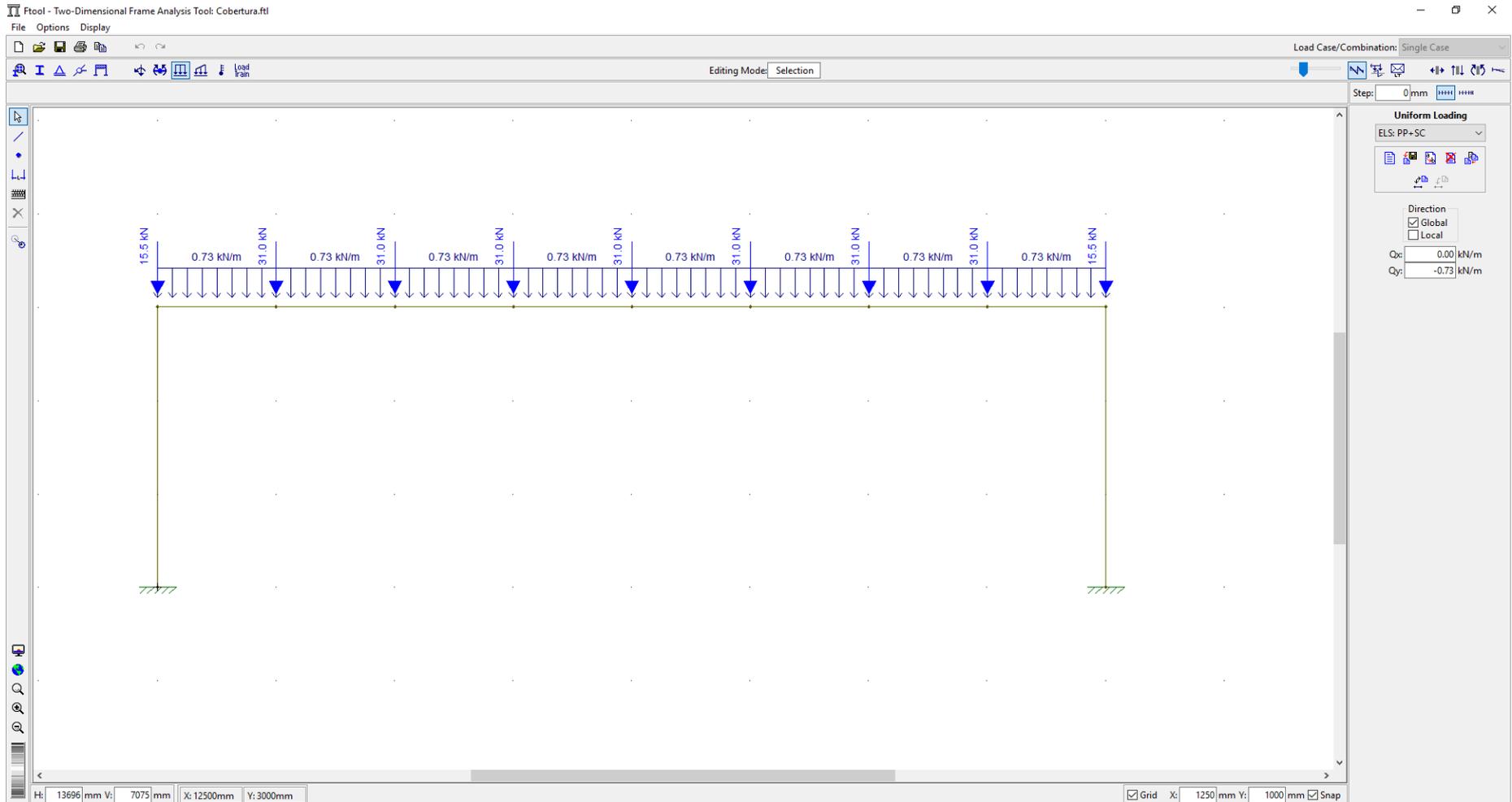
Cálculo de V2

Atingiu-se a flecha ideal com:
Viga W460X53 Pilar W200X46,1



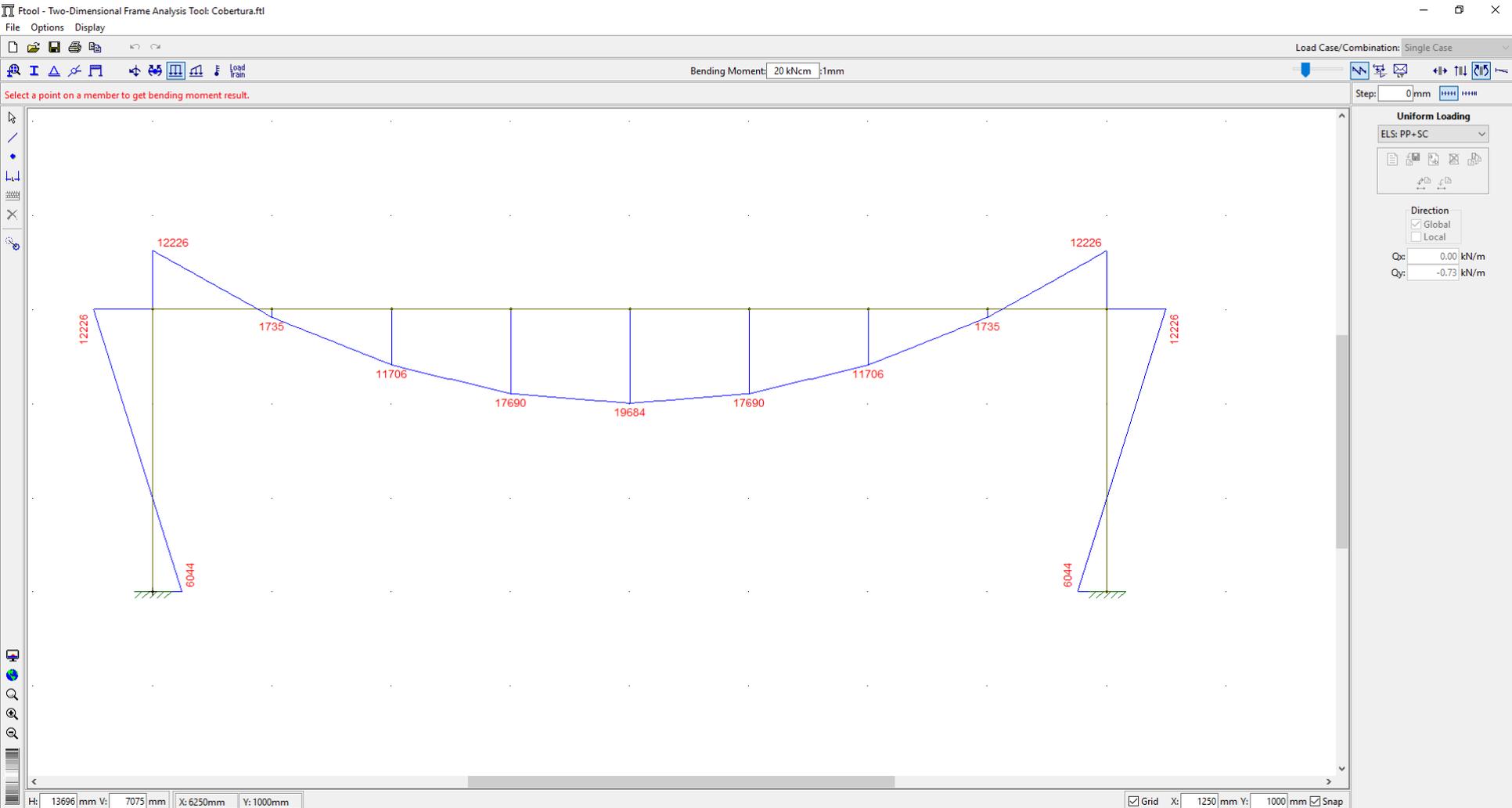
Cálculo de V2 Carregamentos para ELU

Atingiu-se a flecha ideal com:
Viga W460X52 Pilar W200X46,1



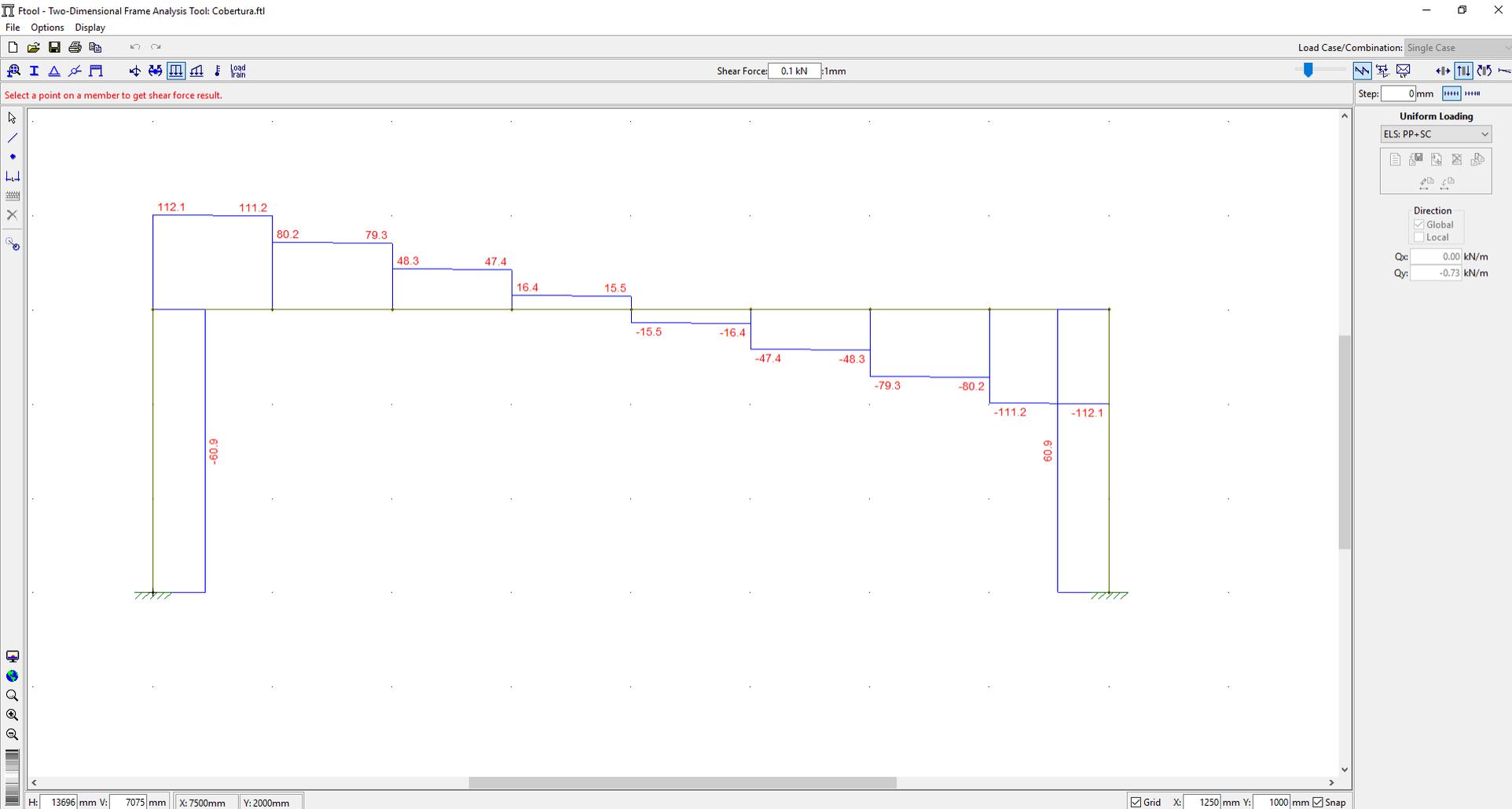
Cálculo de V2

Atingiu-se a flecha ideal com:
Viga W460X52 Pilar W200X46,1



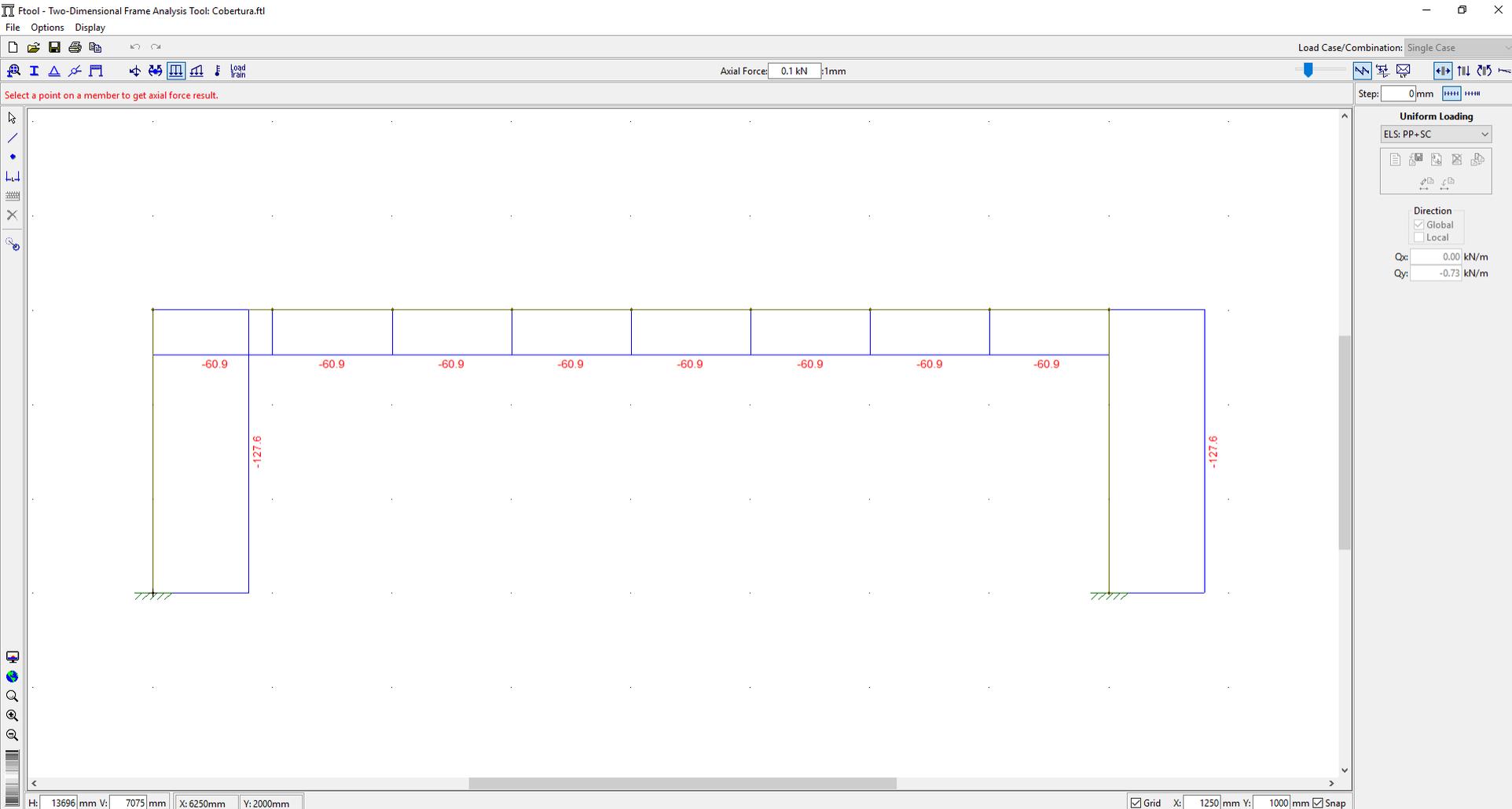
Cálculo de V2

Atingiu-se a flecha ideal com:
Viga W460X52 Pilar W200X46,1



Cálculo de V2

Atingiu-se a flecha ideal com:
Viga W460X52 Pilar W200X46,1



Cálculo de V2

Atingiu-se a flecha ideal com:
Viga W460X52 Pilar W200X46,1

Perfis Laminados Gerdaul NBR8800-081 - Excel

Arquivo Página Inicial Inserir Layout da Página Fórmulas Dados Revisão Exibir Desenvolvedor Team Diga-me o que você deseja fazer Compartilhar

Recortar Copiar Pincel de Formatação Área de Transferência

Arial 11

Quebrar Texto Automaticamente

Normal 2 Vírgula 2 Normal Bom

Incorreto Neutra Cálculo Célula de Ve...

AutoSoma Preencher Limpar Classificar e Filtrar Localizar e Selecionar Edição

C13 19684

Dimensionamento de Perfis I e H Laminados Padrão Açominas

Ativar Planilha

Resultado: **59,1%**

W 460 x 52,0

| | | | | | |
|--------|-------|----------------------|--------|------------------------|-------|
| d(mm) | 450 | Wx(cm ²) | 949,8 | rx(cm) | 17,91 |
| bf(mm) | 152 | Wy(cm ²) | 83,5 | ry(cm) | 3,09 |
| d'(mm) | 404 | Zx(cm ³) | 1095,9 | Área(cm ²) | 66,6 |
| tw(mm) | 7,6 | Zy(cm ³) | 131,7 | ho/tw | 53,2 |
| tf(mm) | 10,8 | Ix(cm ⁴) | 21370 | b/tf | 7,0 |
| h(mm) | 428,4 | Iy(cm ⁴) | 634 | Peso (kg/m) | 52,0 |

Limite: 36,3 Esbelta
Limite: 13,7 25,1 Compacta

1. Verificação da Esbeltez do perfil

| Limite | Real | Status | % | |
|--------|------|--------|-------|----|
| 200 | 56 | OK | 27,9% | lx |
| 200 | 40 | OK | 20,2% | ly |

2. Resistência à tração

| Nrd(kN) | Nsd(kN) | Status | % | Coef. S |
|---------|---------|--------|------|---------|
| N.A | 0 | N.A | 0,0% | 1,1 |

3. Resistência à Compressão

| Nrd(kN) | Nsd(kN) | Status | % | Coef. S |
|---------|---------|--------|------|---------|
| 1672 | 60,9 | OK | 3,6% | 1,1 |

4. Resistência à Flexão eixo X-X

| Mrd(kN.cm) | Msd(kN.cm) | Status | % | Coef. S |
|------------|------------|--------|-------|---------|
| 34371 | 19684 | OK | 57,3% | 1,1 |

Esforços e Distâncias

| | |
|-----------|-------|
| Lx (mm) | 10000 |
| Ly (mm) | 1250 |
| N(kN) | -60,9 |
| Vx(kN) | 0 |
| Vy(kN) | 112 |
| Mx(kN.cm) | 19684 |
| My(kN.cm) | 0 |
| kx | 1 |
| ky | 1 |
| kz | 1 |
| d (mm) | 0 |
| Lb (mm) | 1250 |

Material

ASTM A572GR50

Fy (kN/cm²) 34,5

Dados para Cálculo de NRd

| | | | |
|---------|--------|---------|----------|
| Qa | 1,00 | | |
| Qs | 1,00 | | |
| Q | 1,00 | | |
| Nex(kN) | 4323,7 | r0(cm) | 18,2 |
| Ney(kN) | 8209,6 | Nez(kN) | 12458,04 |
| λ0 | 0,73 | | |
| χ | 0,801 | | |

Listar Perfis que atendem

| Perfil | Peso | % |
|------------------|-------|--------|
| W 250 x 25,3 | 25,30 | 82,50% |
| W 200 x 26,6 | 26,60 | 71,61% |
| W 310 x 28,3 | 28,30 | 66,66% |
| W 250 x 28,4 | 28,40 | 69,00% |
| W 150 x 29,8 (H) | 29,80 | 72,87% |
| W 200 x 31,3 | 31,30 | 58,21% |
| W 250 x 32,7 | 32,70 | 47,54% |
| W 310 x 32,7 | 32,70 | 54,29% |
| W 360 x 32,9 | 32,90 | 44,08% |
| W 200 x 35,9 (H) | 35,90 | 48,47% |
| W 150 x 37,1 (H) | 37,10 | 56,69% |
| W 250 x 38,5 | 38,50 | 38,52% |
| W 310 x 38,7 | 38,70 | 32,69% |
| W 410 x 38,8 | 38,80 | 65,99% |
| W 360 x 39,0 | 39,00 | 34,95% |
| W 200 x 41,7 (H) | 41,70 | 40,61% |
| W 360 x 44,0 | 44,00 | 26,11% |
| W 310 x 44,5 | 44,50 | 27,95% |
| W 250 x 44,8 | 44,80 | 32,42% |
| W 200 x 46,1 (H) | 46,10 | 35,48% |
| W 410 x 46,1 | 46,10 | 29,66% |
| W 360 x 51,0 | 51,00 | 22,61% |
| W 200 x 52,0 (H) | 52,00 | 30,60% |
| W 310 x 52,0 | 52,00 | 23,40% |

Perfis I-H Laminados

Calcular Lista Tabela de Perfis Aços Plan5

Pronto

Cálculo dos pilares

Eixo A ou B

Lança-se a Carga no ELU para extrair a compressão e o momento fletor oriundos desse eixo

The screenshot displays the Ftool software interface. The main window shows a structural model of a frame with two vertical columns and a horizontal beam. A uniform load of 5.32 kN/m is applied to the beam. The columns are fixed at their bases. The software interface includes a menu bar (File, Options, Display), a toolbar, and a status bar. The status bar shows dimensions: H: 9641 mm, V: 4981 mm, X: 0 mm, Y: 2000 mm. The right sidebar shows the 'Uniform Loading' settings, with 'Direction' set to 'Global' and 'Qy' set to -5.32 kN/m. A large text overlay in the center of the model reads: *Não se esqueça de virar a direção dos pilares* (Don't forget to turn the direction of the columns).

File Options Display

Editing Mode: Selection

Load Case/Combination: Single Case

Step: 0/mm

Uniform Loading

ELS: PP+SC

Direction

Global

Local

Qx: 0.00 kN/m

Qy: -5.32 kN/m

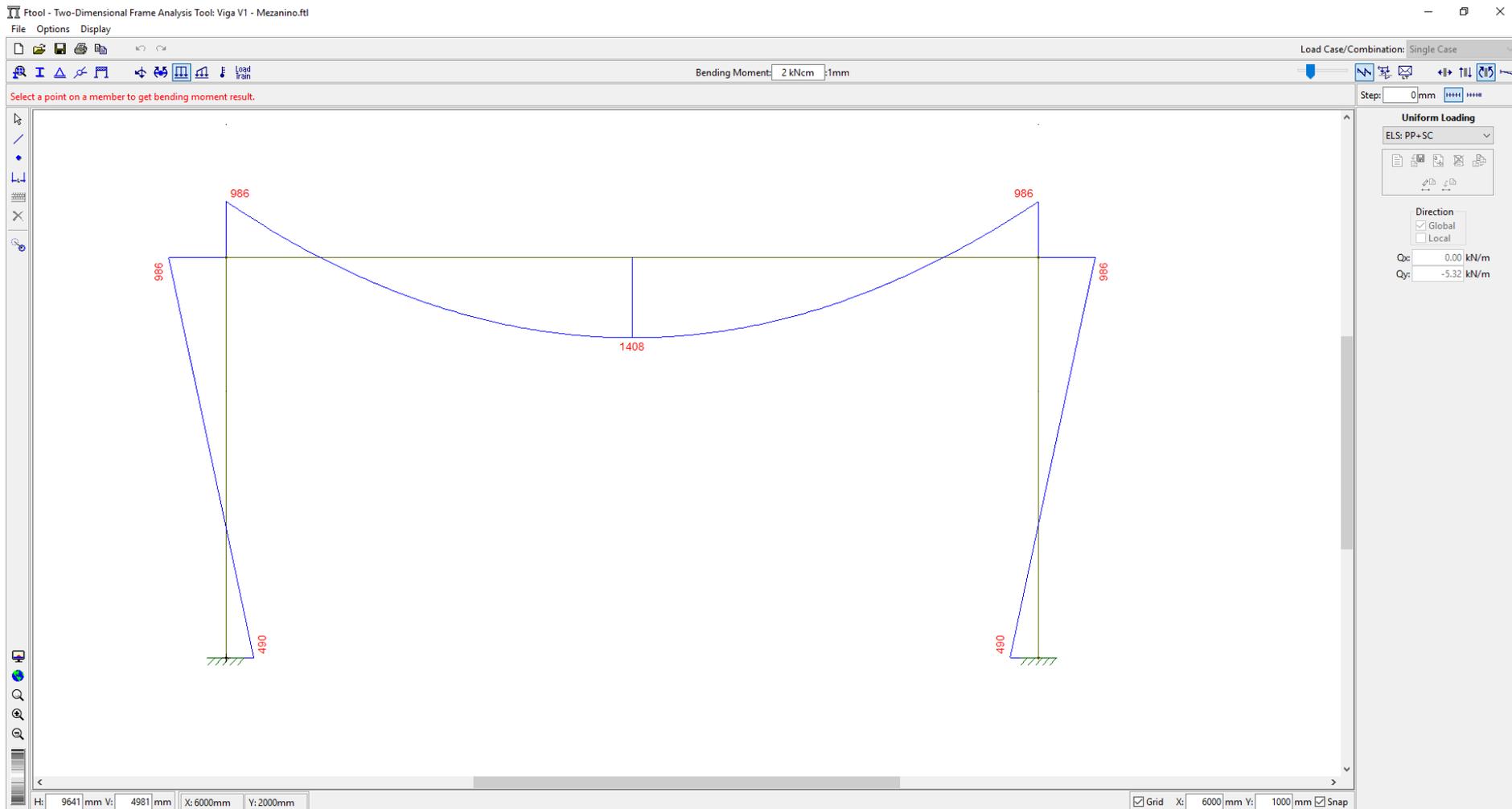
5.32 kN/m

Não se esqueça de virar a direção dos pilares

H: 9641 mm V: 4981 mm X: 0 mm Y: 2000 mm

Grid X: 6000 mm Y: 1000 mm Snap

Cálculo dos pilares



Cálculo dos pilares

Ptool - Two-Dimensional Frame Analysis Tool: Viga V1 - Mezanino.ftl

File Options Display

Load Case/Combination: Single Case

Axial Force: 0.0 kN >1mm

Step: 0mm

Select a point on a member to get axial force result.

Uniform Loading

ELS: PP+SC

Direction

Global

Local

Qx: 0.00 kN/m

Qy: -5.32 kN/m

H: 9641 mm V: 4981 mm X: 6000 mm Y: 4000 mm

Grid X: 6000 mm Y: 1000 mm Snap

Cálculo dos pilares

Dimensionamento de Perfis I e H Laminados Padrão Açominas

| Esforços e Distâncias | |
|-----------------------|--------|
| Lx (mm) | 3000 |
| Ly (mm) | 3000 |
| N(kN) | -143,6 |
| Vx(kN) | 0 |
| Vy(kN) | 60,9 |
| Mx(kN.cm) | 12226 |
| My(kN.cm) | 986 |
| kx | 0,7 |
| ky | 0,7 |
| d (mm) | 0 |
| Lb (mm) | 3000 |
| Material | |
| ASTM A572GR50 | |
| Fy (kN/cm²) | 34,5 |

| Dados para Cálculo de NRd | | | |
|---------------------------|---------|-------------------------|---------|
| Q | 1,00 | | |
| Nex(kN) | 20842,9 | r0(cm) | 10,2 |
| Ney(kN) | 7042,4 | Nez(kN) | 4692,50 |
| λ0 | 0,66 | | |
| χ | 0,835 | | |
| Esbeltez Limite FLA X-X | | Esbeltez Limite FLA Y-Y | |
| λalma | 25,14 | λalma | 25,14 |
| λb | 91,85 | λb | 97,20 |

Resultado:

101,7%

W 200 x 46,1 (H)

| | | | | | |
|--------|-----|---------|-------|-------------|------|
| d(mm) | 203 | Wx(cm²) | 447,6 | rx(cm) | 8,81 |
| bf(mm) | 203 | Wy(cm²) | 151,2 | ry(cm) | 5,12 |
| d'(mm) | 161 | Zx(cm³) | 495,3 | Área(cm²) | 58,6 |
| tw(mm) | 7,2 | Zy(cm³) | 229,5 | ho/tw | 22,4 |
| tf(mm) | 11 | Ix(cm4) | 4543 | b/tf | 9,2 |
| h(mm) | 181 | Iy(cm4) | 1535 | Peso (kg/m) | 46,1 |

Limite: 36,3 Compacta
Limite: 13,7 25,1 Compacta

1. Verificação da Esbeltez do perfil

| Limite | Real | Status | % | |
|--------|------|--------|-------|-------|
| | | | | 20,5% |
| 200 | 24 | OK | 11,9% | λx |
| 200 | 41 | OK | 20,5% | λy |

2. Resistência à tração

| Nrd(kN) | Nsd(kN) | Status | % | Coef. S |
|---------|---------|--------|------|---------|
| N.A | 0 | N.A | 0,0% | 1,1 |

3. Resistência à Compressão

| Nrd(kN) | Nsd(kN) | Status | % | Coef. S |
|---------|---------|--------|------|---------|
| 1535 | 143,6 | OK | 9,4% | 1,1 |

4. Resistência à Flexão eixo X-X

| Mrd(kN.cm) | Msd(kN.cm) | Status | % | Coef. S |
|------------|------------|--------|-------|---------|
| 14700 | 12226 | OK | 83,2% | 1,1 |

5. Resistência à Flexão eixo Y-Y

| Mrd(kN.cm) | Msd(kN.cm) | Status | % | Coef. S |
|------------|------------|--------|-------|---------|
| 7442 | 986 | OK | 13,2% | 1,1 |

| | |
|-----|--------|
| bef | 21,2 |
| Iy | 1534,3 |
| Wx | 447,6 |

Listar Perfis que atendem

| Perfil | Peso | % |
|-------------------|-------|--------|
| W 310 x 38,7 | 38,70 | 99,31% |
| W 360 x 44,0 | 44,00 | 83,22% |
| W 310 x 44,5 | 44,50 | 85,42% |
| W 250 x 44,8 | 44,80 | 94,95% |
| W 200 x 46,1 (H) | 46,10 | 89,90% |
| W 410 x 46,1 | 46,10 | 88,30% |
| W 360 x 51,0 | 51,00 | 71,67% |
| W 200 x 52,0 (H) | 52,00 | 77,77% |
| W 310 x 52,0 | 52,00 | 71,75% |
| W 460 x 52,0 | 52,00 | 75,05% |
| HP 200 x 53,0 (H) | 53,00 | 81,06% |
| W 410 x 53,0 | 53,00 | 65,66% |
| W 360 x 57,8 | 57,80 | 63,15% |
| W 200 x 59,0 (H) | 59,00 | 67,95% |
| W 410 x 60,0 | 60,00 | 56,59% |
| W 460 x 60,0 | 60,00 | 61,88% |
| HP 250 x 62,0 (H) | 62,00 | 65,81% |
| W 360 x 64,0 | 64,00 | 51,15% |
| W 530 x 66,0 | 66,00 | 57,03% |
| W 410 x 67,0 | 67,00 | 49,71% |
| W 460 x 68,0 | 68,00 | 52,95% |
| W 200 x 71,0 (H) | 71,00 | 55,42% |
| W 360 x 72,0 | 72,00 | 45,41% |
| W 530 x 72,0 | 72,00 | 45,83% |
| W 250 x 73,0 (H) | 73,00 | 49,23% |
| W 460 x 74,0 | 74,00 | 42,42% |
| W 530 x 74,0 | 74,00 | 49,99% |

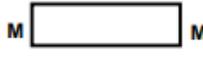
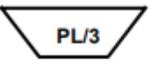
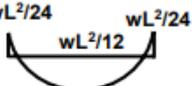
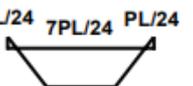
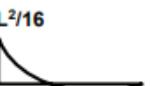
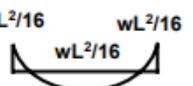
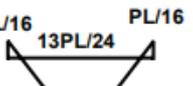
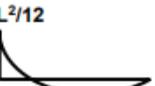
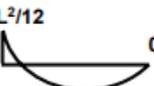
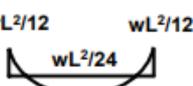
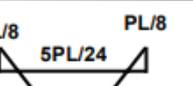
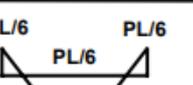
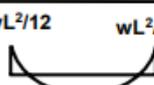
Atenção: PILAR REPROVADO COM $C_b = 1,0$

Porém, o gráfico de momentos se iguala aproximadamente ao da figura seguinte

Cálculo dos pilares

C_b Values for Different Load Cases

AISC Equation F1-1

| | | | | | |
|---|---|---|---|---|---|
|  $C_b = 1.18$ |  $C_b = 1.00$ |  $C_b = 1.32$ |  $C_b = 1.14$ |  $C_b = 1.18$ |  $C_b = 1.23$ |
|  $C_b = 1.22$ |  $C_b = 1.25$ |  $C_b = 1.47$ |  $C_b = 1.16$ |  $C_b = 1.21$ |  $C_b = 1.23$ |
|  $C_b = 1.32$ |  $C_b = 1.67$ |  $C_b = 1.56$ |  $C_b = 1.17$ |  $C_b = 1.26$ |  $C_b = 1.26$ |
|  $C_b = 2.38$ |  $C_b = 2.17$ |  $C_b = 1.92$ |  $C_b = 1.24$ |  $C_b = 2.08$ |  $C_b = 1.61$ |
|  $C_b = 3.00$ |  $C_b = 2.27$ |  $C_b = 2.08$ |  $C_b = 1.32$ |  $C_b = 3.00$ |  $C_b = 2.38$ |



Cálculo dos pilares

Dimensionamento de Perfis I e H Laminados Padrão Açominas

| Esforços e Distâncias | |
|-----------------------|--------|
| Lx (mm) | 3000 |
| Ly (mm) | 3000 |
| N(kN) | -143,6 |
| Vx(kN) | 0 |
| Vy(kN) | 60,9 |
| Mx(kN.cm) | 12226 |
| My(kN.cm) | 986 |
| kx | 0,7 |
| ky | 0,7 |
| d (mm) | 0 |
| Lb (mm) | 3000 |
| Material | |
| ASTM A572GR50 | |
| Fy (kN/cm²) | 34,5 |

| Dados para Cálculo de Nrd | | | |
|---------------------------|---------|-------------------------|---------|
| Q | 1,00 | | |
| Nex(kN) | 20842,9 | r0(cm) | 10,2 |
| Ney(kN) | 7042,4 | Nez(kN) | 4692,50 |
| λ0 | 0,66 | | |
| χ | 0,835 | | |
| Esbeltez Limite FLA X-X | | Esbeltez Limite FLA Y-Y | |
| λalma | 25,14 | λalma | 25,14 |

Resultado:

90,1%

| W 200 x 46,1 (H) | | | | | |
|------------------|-----|---------|-------|-------------|------|
| d(mm) | 203 | Wx(cm²) | 447,6 | rx(cm) | 8,81 |
| bf(mm) | 203 | Wy(cm²) | 151,2 | ry(cm) | 5,12 |
| d'(mm) | 161 | Zx(cm³) | 495,3 | Área(cm²) | 58,6 |
| tw(mm) | 7,2 | Zy(cm³) | 229,5 | ho/tw | 22,4 |
| tf(mm) | 11 | Ix(cm4) | 4543 | b/tf | 9,2 |
| h(mm) | 181 | Iy(cm4) | 1535 | Peso (kg/m) | 46,1 |

Limite: 36,3 Compacta
Limite: 13,7 25,1 Compacta

1. Verificação da Esbeltez do perfil

| Limite | Real | Status | % | |
|--------|------|--------|-------|----|
| 200 | 24 | OK | 11,9% | λx |
| 200 | 41 | OK | 20,5% | λy |

2. Resistência à tração

| Nrd(kN) | Nsd(kN) | Status | % | Coef. S |
|---------|---------|--------|------|---------|
| N.A | 0 | N.A | 0,0% | 1,1 |

3. Resistência à Compressão

| Nrd(kN) | Nsd(kN) | Status | % | Coef. S |
|---------|---------|--------|------|---------|
| 1535 | 143,6 | OK | 9,4% | 1,1 |

4. Resistência à Flexão eixo X-X

| Mrd(kN.cm) | Msd(kN.cm) | Status | % | Coef. S |
|------------|------------|--------|-------|---------|
| 17088 | 12226 | OK | 71,5% | 1,1 |

5. Resistência à Flexão eixo Y-Y

| Mrd(kN.cm) | Msd(kN.cm) | Status | % | Coef. S |
|------------|------------|--------|-------|---------|
| 7412 | 986 | OK | 13,3% | 1,1 |

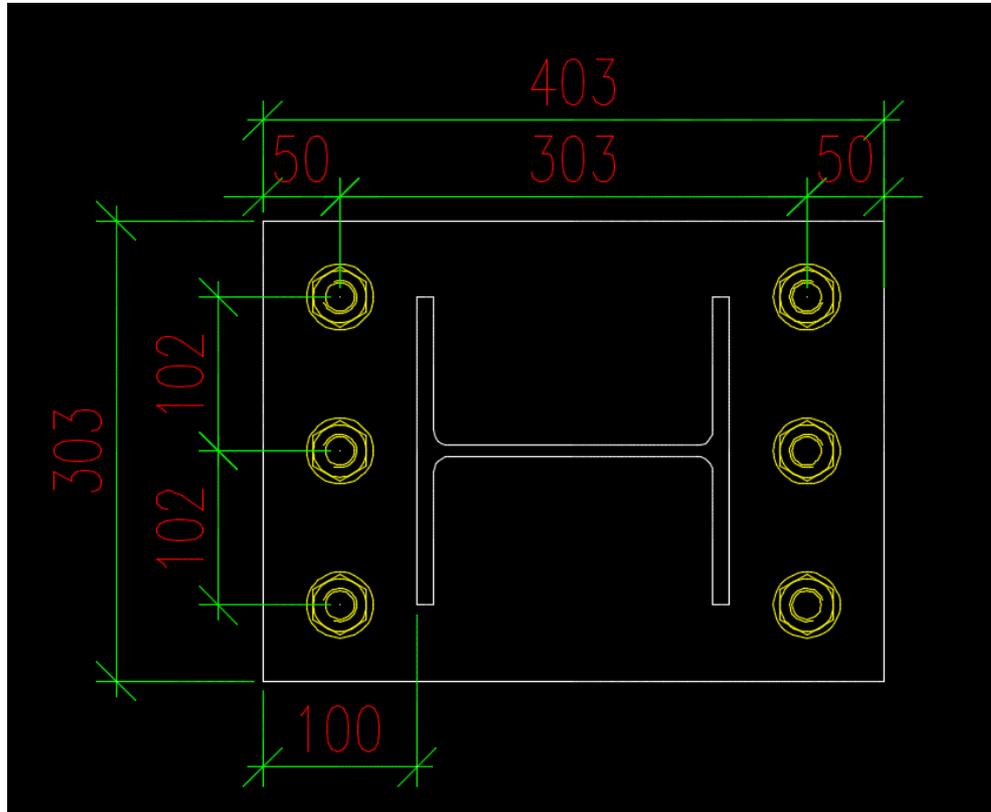
| | |
|-----|--------|
| bef | 21,2 |
| Iy | 1534,3 |
| Wef | 142,4 |

Listar Perfis que atendem

| Perfil | Peso | % |
|-------------------|-------|--------|
| W 310 x 38,7 | 38,70 | 99,31% |
| W 360 x 44,0 | 44,00 | 83,22% |
| W 310 x 44,5 | 44,50 | 85,42% |
| W 250 x 44,8 | 44,80 | 94,95% |
| W 200 x 46,1 (H) | 46,10 | 89,90% |
| W 410 x 46,1 | 46,10 | 88,30% |
| W 360 x 51,0 | 51,00 | 71,67% |
| W 200 x 52,0 (H) | 52,00 | 77,77% |
| W 310 x 52,0 | 52,00 | 71,75% |
| W 460 x 52,0 | 52,00 | 75,05% |
| HP 200 x 53,0 (H) | 53,00 | 81,06% |
| W 410 x 53,0 | 53,00 | 65,66% |
| W 360 x 57,8 | 57,80 | 63,15% |
| W 200 x 59,0 (H) | 59,00 | 67,95% |
| W 410 x 60,0 | 60,00 | 56,59% |
| W 460 x 60,0 | 60,00 | 61,88% |
| HP 250 x 62,0 (H) | 62,00 | 65,81% |
| W 360 x 64,0 | 64,00 | 51,15% |
| W 530 x 66,0 | 66,00 | 57,03% |
| W 410 x 67,0 | 67,00 | 49,71% |
| W 460 x 68,0 | 68,00 | 52,95% |
| W 200 x 71,0 (H) | 71,00 | 55,42% |
| W 360 x 72,0 | 72,00 | 45,41% |
| W 530 x 72,0 | 72,00 | 45,83% |
| W 250 x 73,0 (H) | 73,00 | 49,23% |
| W 460 x 74,0 | 74,00 | 42,42% |
| W 530 x 74,0 | 74,00 | 49,99% |

Pilar aprovado com $C_b = 2,17$

Placas de Base com carga excêntrica – Momentos fletores



$$\sigma_c = \frac{N}{A_p} + \frac{M}{W} = \frac{Nsd}{A \cdot B} + \frac{6 \cdot Msd}{B \cdot A^2}$$

$$\sigma_c = \frac{143,6}{30,3 \cdot 40,3} + \frac{6 \cdot 6044}{30,3 \cdot 40,3^2} = 0,86 \text{ kN/cm}^2$$

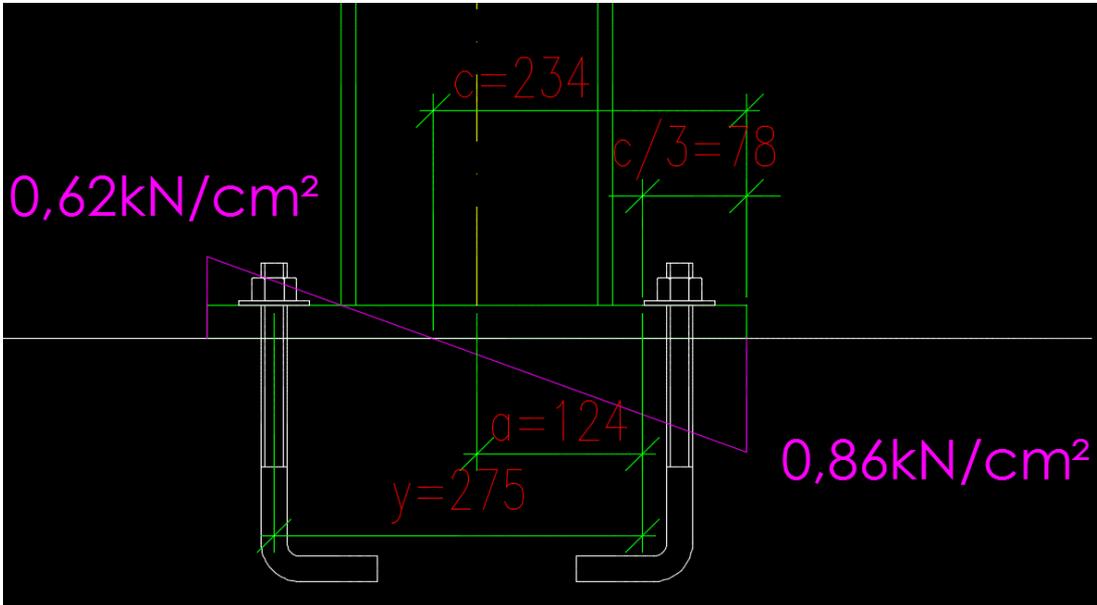
$$\sigma_t = \frac{N}{A_p} - \frac{M}{W} = \frac{Nsd}{B \cdot A} - \frac{6 \cdot Msd}{B \cdot A^2}$$

$$\sigma_t = \frac{143,6}{30,3 \cdot 40,3} - \frac{6 \cdot 6044}{30,3 \cdot 40,3^2} = -0,62 \text{ kN/cm}^2$$

**Devemos proteger o concreto contra a carga de compressão
(Considerando f_{ck} 20MPa)**

$$\sigma_{adm} = 0,51 F_{ck} = 0,51 \cdot 2,0 = 1,02 \text{ kN/cm}^2 \quad \text{OK!}$$

Placas de Base com carga excêntrica – Momentos fletores



$$T = (M - N \cdot a) / y$$

$$T = \frac{6044 - 143,6 \cdot 12,4}{27,5} = 155 \text{ kN}$$

Como são 3 chumbadores tracionados
 $\rightarrow T = 51,66 \text{ kN}$

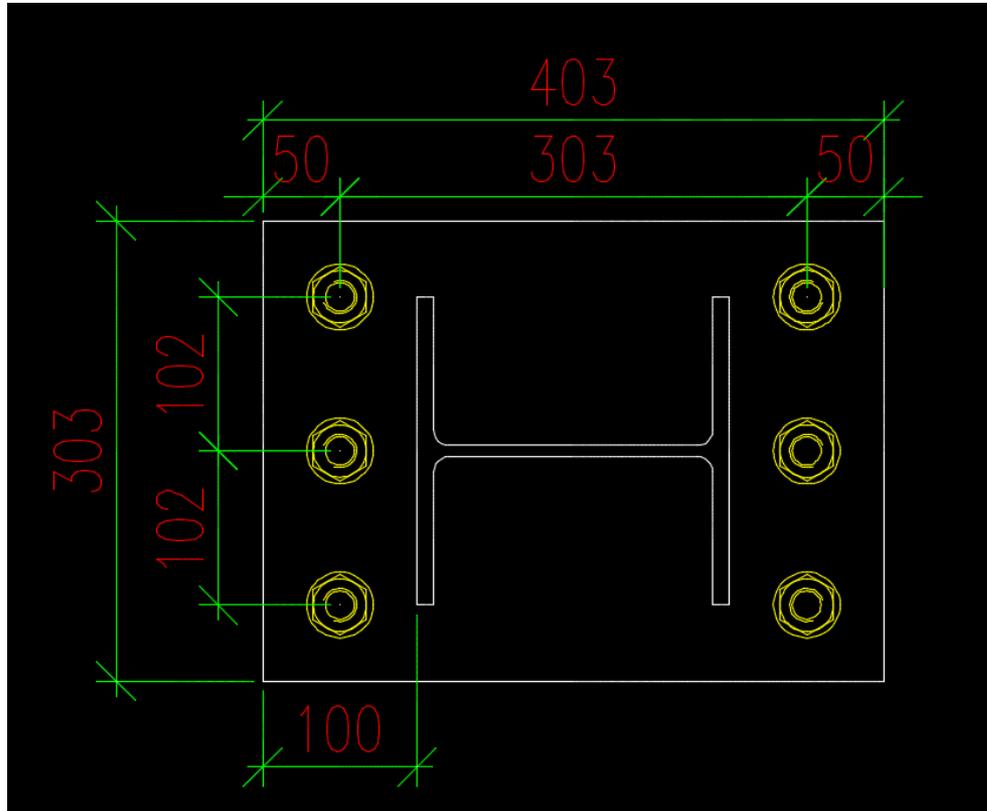
$$\text{Esforço Cortante Máximo} = \frac{60,2}{6} = 10 \text{ kN}$$

$$d_{chu} = \sqrt{1,27 \cdot \sqrt{\frac{11,39 \cdot V_{sd}^2 + 3,24 \cdot N_{sd}^2}{Fu^2}}}$$

$$d_{chu} = \sqrt{1,27 \cdot \sqrt{\frac{11,39 \cdot 10^2 + 3,24 \cdot 51,66^2}{40^2}}}$$

$$d_{chu} = 1,77 \text{ cm} \sim 19 \text{ mm}$$

Placas de Base com carga excêntrica – Momentos fletores



$$M_{ch} = \frac{0,86 \cdot 10^2}{2} = 43 \text{ kN.cm}$$

$$t = \sqrt{\frac{6 \cdot M_{ch}}{1,35 \cdot F_y}} = \sqrt{\frac{6 \cdot 43}{1,35 \cdot 25}} = 2,76 \text{ cm} \sim 32 \text{ mm}$$