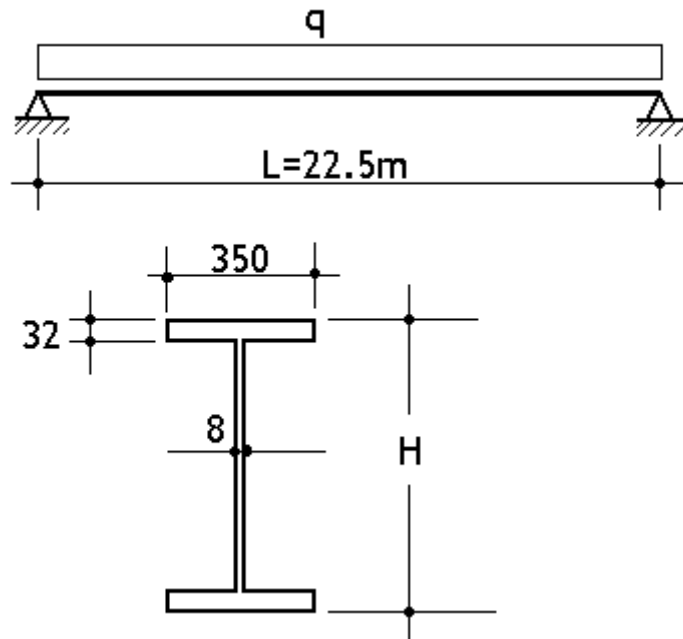


**CONTROL No. 2****Prof. A. Verdugo/ Aux. P. Correa****Problema Nº1.-**

Para la viga de la figura se pide determinar la sección de menor altura que cumple los requerimientos de diseño.

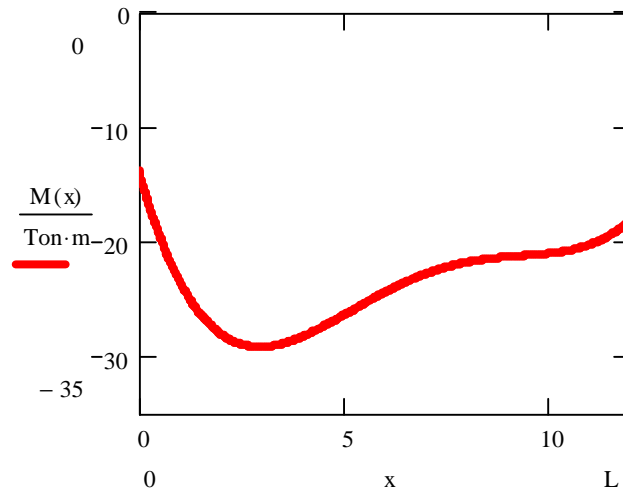
Datos:

- Viga doblemente simétrica
- Acero ASTM A36
- Deformación máxima por cargas de servicio =  $L/380$
- $q$  servicio = 3.8 t/m (incluye peso de la viga)
- $q_u = 1.5 q$  servicio
- DISEÑO por método LRFD AISC-2005
- Fijación al volcamiento en los cuartos de la luz



**CONTROL No. 2****Prof. A. Verdugo/ Aux. P. Correa****Problema N°2.-**

Se tiene una viga con el siguiente diagrama de momento mayorado.



Cuya ecuación es:

$$M(x) := \left( -0.012x^4 \cdot \frac{\text{Ton}}{\text{m}^3} + 0.35x^3 \cdot \frac{\text{Ton}}{\text{m}^2} - 3.51x^2 \cdot \frac{\text{Ton}}{\text{m}} + 12.82x \cdot \text{Ton} + 13.8 \text{Ton} \cdot \text{m} \right)$$

Los extremos de esta viga de 12 metros se encuentran fijos al volcamiento.  
El perfil de la viga es IN40x49.3

Se debe determinar la mínima cantidad de arrostramientos (ubicación tanto en el largo como en el alto de la viga) que es necesario colocar de manera que soporte las cargas solicitantes.

## Control 2

### Pregunta 1 (Pauta)

$$\text{Tonf} := 1000 \cdot \text{kgf}$$

#### Propiedades del acero

$$E := 2100 \cdot \frac{\text{Tonf}}{\text{cm}^2}$$

Módulo de elasticidad

$$F_y := 2.53 \cdot \frac{\text{Tonf}}{\text{cm}^2}$$

Tensión de fluencia

#### Propiedades del perfil

$$H := 130 \cdot \text{cm}$$

Altura del perfil

$$b := 350 \cdot \text{mm}$$

Ancho del perfil

$$e := 32 \cdot \text{mm}$$

Espesor del ala

$$t := 8 \cdot \text{mm}$$

Espesor del alma

$$I_x := 2 \cdot \left[ \frac{1}{12} \cdot b \cdot e^3 + b \cdot e \cdot \left( \frac{H}{2} - \frac{e}{2} \right)^2 \right] + \frac{1}{12} \cdot t \cdot (H - 2 \cdot e)^3$$

Inercia del perfil

$$I_x = 1026455 \text{ cm}^4$$

$$W_x := \frac{I_x}{\frac{H}{2}}$$

$$W_x = 15792 \text{ cm}^3$$

Módulo de sección

$$Z_x := 2 \cdot b \cdot e \cdot \left( \frac{H}{2} - \frac{e}{2} \right) + t \cdot \left( \frac{H}{2} - e \right)^2$$

$$Z_x = 17257 \text{ cm}^3$$

Módulo plástico

#### Condiciones del problema

$$L := 22.5 \cdot \text{m}$$

Largo viga

$$q := 3.8 \cdot \frac{\text{Tonf}}{\text{m}}$$

Carga de servicio

#### Deformación máxima

$$\Delta_{\max} := \frac{L}{380}$$

$$\Delta_{\max} = 59.211 \text{ mm}$$

Deformación máxima

$$I_{\min} := \frac{5}{384} \cdot \frac{q \cdot L^4}{E \cdot \Delta_{\max}}$$

$$I_{\min} = 1019845 \text{ cm}^4$$

Inercia mínima

$$\frac{I_x}{I_{\min}} = 1.01$$

#### Pandeo local del ala

$$\lambda_{\text{ala}} := \frac{b}{2 \cdot e}$$

$$\lambda_{\text{ala}} = 5.469$$

$$\lambda_{\text{p.ala}} := 0.38 \cdot \sqrt{\frac{E}{F_y}}$$

$$\lambda_{\text{p.ala}} = 10.948$$

Por lo tanto el ala es COMPACTA

#### Pandeo local del alma

$$\lambda_{\text{alma}} := \frac{H - 2 \cdot e}{t}$$

$$\lambda_{\text{alma}} = 154.5$$

$$\lambda_{\text{p.alma}} := 3.76 \cdot \sqrt{\frac{E}{F_y}}$$

$$\lambda_{\text{p.alma}} = 108.327$$

$$\lambda_{\text{r.alma}} := 5.7 \cdot \sqrt{\frac{E}{F_y}}$$

$$\lambda_{\text{r.alma}} = 164.219$$

Por lo tanto el ala es NO COMPACTA

Por lo tanto el perfil debe diseñarse según F4

#### Sección F4

Estado límite 1

$$Z_x \cdot F_y = 436.602 \text{ Tonf} \cdot \text{m}$$

$$1.6 \cdot W_x \cdot F_y = 639.244 \text{ Tonf} \cdot \text{m}$$

$$M_p := \min(Z_x \cdot F_y, 1.6 \cdot W_x \cdot F_y)$$

$$M_p = 436.602 \text{ Tonf} \cdot \text{m}$$

$$M_{yc} := F_y \cdot W_x$$

$$M_{yc} = 399.528 \text{ Tonf} \cdot \text{m}$$

$$\lambda_{\text{alma}} = 154.5$$

$$\lambda_{p.alma} = 108.327$$

$$\frac{M_p}{M_{yc}} = 1.093$$

$$R_{pc} := \begin{cases} \frac{M_p}{M_{yc}} & \text{if } \lambda_{alma} \leq \lambda_{p.alma} \\ \frac{M_p}{M_{yc}} - \left( \frac{M_p}{M_{yc}} - 1 \right) \cdot \frac{\lambda_{alma} - \lambda_{p.alma}}{\lambda_{r.alma} - \lambda_{p.alma}} & \text{otherwise} \end{cases}$$

$$R_{pc} = 1.016$$

$$M_{n1} := R_{pc} \cdot M_{yc}$$

$$M_{n1} = 405.975 \text{ Tonf} \cdot \text{m}$$

Estado límite 2

$$h_c := H - 2 \cdot e$$

$$h_c = 1.236 \text{ m}$$

$$h := h_c$$

$$h = 1.236 \text{ m}$$

$$a_w := \frac{h_c \cdot t}{b \cdot e}$$

$$a_w = 0.883$$

$$d := H$$

$$d = 1.3 \text{ m}$$

$$h_o := H - e$$

$$h_o = 1.268 \text{ m}$$

$$r_t := \frac{b}{\sqrt{12 \cdot \left( \frac{h_o}{d} + \frac{1}{6} \cdot a_w \cdot \frac{h^2}{h_o \cdot d} \right)}}$$

$$r_t = 0.096 \text{ m}$$

$$L_p := 1.1 \cdot r_t \cdot \sqrt{\frac{E}{F_y}}$$

$$L_p = 3.037 \text{ m}$$

$$L_v := \frac{L}{4}$$

$$L_v = 5.625 \text{ m}$$

$$F_L := 0.7 \cdot F_y$$

$$F_L = 1.771 \frac{\text{Tonf}}{\text{cm}^2}$$

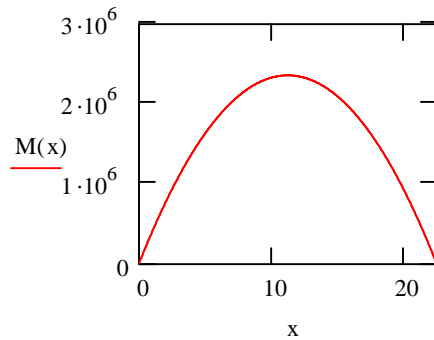
$$J := \frac{2 \cdot b \cdot e^3 + t^3 \cdot (H - e)}{3}$$

$$J = 786.227 \text{ cm}^4$$

$$L_T := 1.95 \cdot r_t \cdot \frac{E}{F_L} \cdot \sqrt{\frac{J}{W_x \cdot h_o}} \cdot \sqrt{1 + \sqrt{1 + 6.76 \cdot \left( \frac{F_L}{E} \cdot \frac{W_x \cdot h_o}{J} \right)^2}}$$

$$L_T = 11.342 \text{ m}$$

$$M(x) := \frac{q \cdot L}{2} \cdot x - \frac{q \cdot x^2}{2}$$



Tramo 1

$$L1 := 0 \cdot \text{m}$$

$$L2 := 5.625 \cdot \text{m}$$

$$\text{Max} := L2$$

$$\text{Max} = 5.625 \text{ m}$$

$$A := \frac{1}{4} \cdot (L2 - L1) + L1$$

$$A = 1.406 \text{ m}$$

$$B := \frac{2}{4} \cdot (L2 - L1) + L1$$

$$B = 2.813 \text{ m}$$

$$C := \frac{3}{4} \cdot (L2 - L1) + L1$$

$$C = 4.219 \text{ m}$$

$$C_{b1} := \frac{12.5 \cdot M(\text{Max})}{2.5 \cdot M(\text{Max}) + 3 \cdot M(A) + 4 \cdot M(B) + 3 \cdot M(C)}$$

$$C_{b1} = 1.523$$

$$M_{\text{max}1} := M(\text{Max})$$

$$M_{\text{max}1} = 180.352 \text{ Tonf} \cdot \text{m}$$

Tramo 2

$$L1 := 5.625 \cdot \text{m}$$

$$L2 := 11.25 \cdot \text{m}$$

$$\text{Max} := L2$$

$$\text{Max} = 11.25 \text{ m}$$

$$A := \frac{1}{4} \cdot (L2 - L1) + L1 \quad A = 7.031 \text{ m}$$

$$B := \frac{2}{4} \cdot (L2 - L1) + L1 \quad B = 8.438 \text{ m}$$

$$C := \frac{3}{4} \cdot (L2 - L1) + L1 \quad C = 9.844 \text{ m}$$

$$C_{b2} := \frac{12.5 \cdot M(\text{Max})}{2.5 \cdot M(\text{Max}) + 3 \cdot M(A) + 4 \cdot M(B) + 3 \cdot M(C)} \quad C_{b2} = 1.061$$

$$M_{\max 2} := M(\text{Max}) \quad M_{\max 2} = 240.469 \text{ Tonf} \cdot \text{m}$$

Resumen

Resumen

Tramo 1

Tramo 2

$$C_{b1} = 1.523 \quad C_{b2} = 1.061$$

$$M_{\max 1} = 180.352 \text{ Tonf} \cdot \text{m} \quad M_{\max 2} = 240.469 \text{ Tonf} \cdot \text{m}$$

$$L_v = 5.625 \text{ m} \quad L_v = 5.625 \text{ m}$$

Por lo tanto solo se analiza el tramo 2

$$C_b := C_{b2} \quad C_b = 1.061$$

$$M_{n2} := C_b \cdot \left[ R_{pc} \cdot M_{yc} - (R_{pc} \cdot M_{yc} - F_L \cdot W_x) \cdot \left( \frac{L_v - L_p}{L_r - L_p} \right) \right] \quad M_{n2} = 388.978 \text{ Tonf} \cdot \text{m}$$

$$R_{pc} \cdot M_{yc} = 405.975 \text{ Tonf} \cdot \text{m}$$

$$M_{n2} := \min(M_{n2}, R_{pc} \cdot M_{yc}) \quad M_{n2} = 388.978 \text{ Tonf} \cdot \text{m}$$

Estado límite 3

No aplica

Estado límite 4

No aplica

**Factor de utilización**

$$M_n := \min(M_{n1}, M_{n2})$$

$$M_n = 388.978 \text{ Tonf} \cdot \text{m}$$

$$M_u := 1.5 \cdot M(11.25 \cdot \text{m})$$

$$M_u = 360.703 \text{ Tonf} \cdot \text{m}$$

$$FU := \frac{M_u}{0.9 \cdot M_n}$$

$$FU = 1.03$$



$$\text{Ton} := 1000 \cdot \text{kgf}$$

$$Z := 997 \cdot \text{cm}^3$$

$$W := 898 \cdot \text{cm}^3$$

$$F_y := 3.52 \cdot \frac{\text{Ton}}{\text{cm}^2}$$

$$E := 2100 \cdot \frac{\text{Ton}}{\text{cm}^2}$$

$$M_p := Z \cdot F_y$$

$$M_p = 35.094 \text{ Ton} \cdot \text{m}$$

$$b := 200 \cdot \text{mm}$$

$$e := 10 \cdot \text{mm}$$

$$h := 400 \cdot \text{mm}$$

$$t := 6 \cdot \text{mm}$$

$$\lambda_{alma} := \frac{h - 2 \cdot e}{t}$$

$$\lambda_{alma} = 63.333$$

$$\lambda_{palma} := 3.76 \cdot \sqrt{\frac{E}{F_y}}$$

$$\lambda_{palma} = 91.839$$

Compacta

$$\lambda_{ala} := \frac{b}{2 \cdot e}$$

$$\lambda_{ala} = 10$$

$$\lambda_{pala} := 0.38 \cdot \sqrt{\frac{E}{F_y}}$$

$$\lambda_{pala} = 9.282$$

$$k_c := \frac{4}{\sqrt{\lambda_{alma}}}$$

$$k_c = 0.503$$

$$\lambda_{\text{r}ala} := 0.95 \cdot \sqrt{\frac{E}{0.7 \cdot F_y}} \cdot k_c$$

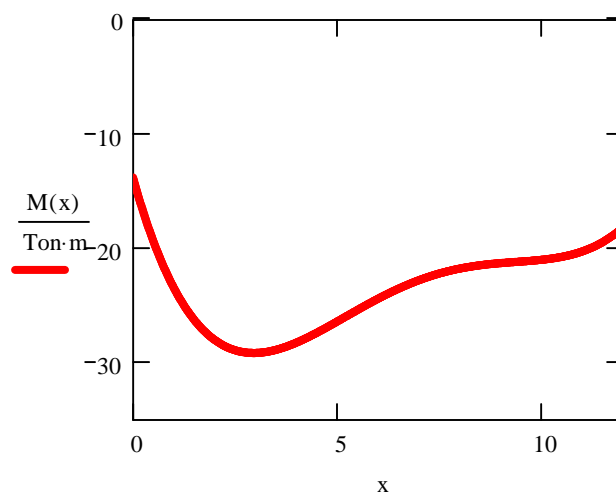
$$\lambda_{\text{r}ala} = 19.662$$

$$M_n := M_p - (M_p - 0.7 \cdot F_y \cdot W) \cdot \frac{\lambda_{ala} - \lambda_{pala}}{\lambda_{rala} - \lambda_{pala}}$$

$$M_n = 34.197 \text{ Ton} \cdot \text{m}$$

$$L := 12 \cdot \text{m}$$

$$M(x) := - \left( -0.012 \cdot x^4 \cdot \frac{\text{Ton}}{\text{m}^3} + 0.35 \cdot x^3 \cdot \frac{\text{Ton}}{\text{m}^2} - 3.51 \cdot x^2 \cdot \frac{\text{Ton}}{\text{m}} + 12.82 \cdot x \cdot \text{Ton} + 13.8 \cdot \text{Ton} \cdot \text{m} \right)$$



$$M(x) := -M(x)$$

$$r_y := 4.61 \cdot \text{cm}$$

$$L_p := 1.76 \cdot r_y \cdot \sqrt{\frac{E}{F_y}}$$

$$L_p = 198.176 \text{ cm}$$

$$I_y := 1334 \cdot \text{cm}^4$$

$$C_w := 507260 \cdot \text{cm}^6$$

$$r_{ts} := \sqrt{\frac{\sqrt{I_y \cdot C_w}}{W}}$$

$$r_{ts} = 5.382 \text{ cm}$$

$$h_o := h - e$$

$$h_o = 39 \text{ cm}$$

$$c := 1$$

$$J := 16.1 \cdot \text{cm}^4$$

$$L_r := 1.95 \cdot r_{ts} \cdot \frac{E}{0.7 \cdot F_y} \cdot \sqrt{\frac{J \cdot c}{W \cdot h_o}} \cdot \sqrt{1 + \sqrt{1 + 6.76 \cdot \left( \frac{0.7 \cdot F_y}{E} \cdot \frac{W \cdot h_o}{J \cdot c} \right)^2}}$$

$$L_r = 532.56 \text{ cm}$$

$$L1 := 0 \cdot \text{m} \quad L2 := 3.5 \cdot \text{m}$$

$$Lv := L2 - L1 \quad Lv = 3.5 \text{ m}$$

$$x := \frac{L2 - L1}{2}$$

Given

$$x \geq L1$$

$$x \leq L2$$

$$x0 := \text{Maximize}(M, x)$$

$$x0 = 2.958 \text{ m}$$

$$M(x0) = 29.15 \text{ Ton} \cdot \text{m}$$

$$A := \frac{1}{4} \cdot (L2 - L1) + L1$$

$$B := \frac{2}{4} \cdot (L2 - L1) + L1$$

$$C := \frac{3}{4} \cdot (L2 - L1) + L1$$

$$Cb := \frac{12.5 \cdot M(x0)}{2.5 \cdot M(x0) + 3 \cdot M(A) + 4 \cdot M(B) + 3 \cdot M(C)}$$

$$Cb = 1.082$$

$$Mn2 := \begin{cases} Mp & \text{if } Lv \leq Lp \\ Cb \cdot \left[ Mp - (Mp - 0.7 \cdot Fy \cdot W) \cdot \frac{Lv - Lp}{Lr - Lp} \right] & \text{if } Lp < Lv \leq Lr \\ Cb \cdot \frac{\pi^2 \cdot E}{\left( \frac{Lv}{rts} \right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{W \cdot ho} \cdot \left( \frac{Lv}{rts} \right)^2} \cdot W & \text{if } Lv > Lr \end{cases}$$

$$Mn2 = 31.614 \text{ Ton} \cdot \text{m}$$

$$M_{n2} := \min(M_{n2}, M_p)$$

$$M_{n2} = 31.614 \text{ Ton}\cdot\text{m}$$

$$M_n := \min(M_n, M_{n2})$$

$$M_n = 31.614 \text{ Ton}\cdot\text{m}$$

$$FU := \frac{M(x_0)}{0.9 \cdot M_n}$$

$$FU = 1.02$$

$$L1 := 3.5 \cdot \text{m} \quad L2 := 7 \cdot \text{m}$$

$$Lv := L2 - L1 \quad Lv = 3.5 \text{ m}$$

$$x := \frac{L2 - L1}{2}$$

Given

$$x \geq L1$$

$$x \leq L2$$

$$x0 := \text{Maximize}(M, x)$$

$$x0 = 3.5 \text{ m}$$

$$M(x0) = 28.878 \text{ Ton} \cdot \text{m}$$

$$A := \frac{1}{4} \cdot (L2 - L1) + L1$$

$$B := \frac{2}{4} \cdot (L2 - L1) + L1$$

$$C := \frac{3}{4} \cdot (L2 - L1) + L1$$

$$Cb := \frac{12.5 \cdot M(x0)}{2.5 \cdot M(x0) + 3 \cdot M(A) + 4 \cdot M(B) + 3 \cdot M(C)}$$

$$Cb = 1.09$$

$$Mn2 := \begin{cases} Mp & \text{if } Lv \leq Lp \\ Cb \cdot \left[ Mp - (Mp - 0.7 \cdot Fy \cdot W) \cdot \frac{Lv - Lp}{Lr - Lp} \right] & \text{if } Lp < Lv \leq Lr \\ Cb \cdot \frac{\pi^2 \cdot E}{\left( \frac{Lv}{rts} \right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{W \cdot ho} \cdot \left( \frac{Lv}{rts} \right)^2} \cdot W & \text{if } Lv > Lr \end{cases}$$

$$Mn2 = 31.838 \text{ Ton} \cdot \text{m}$$

$$M_{n2} := \min(M_{n2}, M_p)$$

$$M_{n2} = 31.838 \text{ Ton}\cdot\text{m}$$

$$M_n := \min(M_n, M_{n2})$$

$$M_n = 31.838 \text{ Ton}\cdot\text{m}$$

$$FU := \frac{M(x_0)}{0.9 \cdot M_n}$$

$$FU = 1.01$$

$$L1 := 7 \cdot \text{m} \quad L2 := 12 \cdot \text{m}$$

$$Lv := L2 - L1 \quad Lv = 5 \text{ m}$$

$$x := \frac{L2 - L1}{2}$$

Given

$$x \geq L1$$

$$x \leq L2$$

$$x0 := \text{Maximize}(M, x)$$

$$x0 = 7 \text{ m}$$

$$M(x0) = 22.788 \text{ Ton} \cdot \text{m}$$

$$A := \frac{1}{4} \cdot (L2 - L1) + L1$$

$$B := \frac{2}{4} \cdot (L2 - L1) + L1$$

$$C := \frac{3}{4} \cdot (L2 - L1) + L1$$

$$Cb := \frac{12.5 \cdot M(x0)}{2.5 \cdot M(x0) + 3 \cdot M(A) + 4 \cdot M(B) + 3 \cdot M(C)}$$

$$Cb = 1.063$$

$$Mn2 := \begin{cases} Mp & \text{if } Lv \leq Lp \\ Cb \cdot \left[ Mp - (Mp - 0.7 \cdot Fy \cdot W) \cdot \frac{Lv - Lp}{Lr - Lp} \right] & \text{if } Lp < Lv \leq Lr \\ Cb \cdot \frac{\pi^2 \cdot E}{\left( \frac{Lv}{rts} \right)^2} \cdot \sqrt{1 + 0.078 \cdot \frac{J \cdot c}{W \cdot ho} \cdot \left( \frac{Lv}{rts} \right)^2} \cdot W & \text{if } Lv > Lr \end{cases}$$

$$Mn2 = 24.859 \text{ Ton} \cdot \text{m}$$



$$M_{n2} := \min(M_{n2}, M_p)$$

$$M_{n2} = 24.859 \text{ Ton}\cdot\text{m}$$

$$M_n := \min(M_n, M_{n2})$$

$$M_n = 24.859 \text{ Ton}\cdot\text{m}$$

$$FU := \frac{M(x_0)}{0.9 \cdot M_n}$$

$$FU = 1.02$$