

Ejercicio 1

$$h := 300 \text{ mm}$$

$$N := (-200) \text{ kN}$$

$$e_1 := (-5) \text{ cm}$$

$$e_2 := (-0.5) \text{ cm}$$

$$b_f := 100 \text{ mm}$$

$$M_y := N \cdot e_1 = 10 \text{ kN m}$$

$$t_f := 16 \text{ mm}$$

$$M_z := (-N) \cdot e_2 = -1 \text{ kN m}$$

$$t_w := 10 \text{ mm}$$

$$Q_z := 20 \text{ kN}$$

$$A_g := 58.8 \text{ cm}^2$$

$$M_t := (-2) \text{ kN m}$$

$$J_y := 8030 \text{ cm}^4$$

$$S_y := 316 \text{ cm}^3 \quad e_y := 2.70 \text{ cm}$$

$$J_z := 495 \text{ cm}^4 \quad e_c := 5.41 \text{ cm}$$

$$J_t := 36.24 \text{ cm}^4$$

Tensiones normales:

$$\sigma_N := \frac{N}{A_g} = -3.4014 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{My}(z) := \frac{M_y \cdot z}{J_y}$$

$$\sigma_{Mz}(y) := -\frac{M_z \cdot y}{J_z}$$

$$\sigma_{My}\left(\frac{h}{2}\right) = 1.868 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{Mz}(b_f - 2.7 \text{ cm}) = 1.4747 \frac{\text{kN}}{\text{cm}^2}$$

Tensiones tangenciales:

$$M_{tQ} := Q_z \cdot e_c = 1.082 \text{ kN m}$$

$$M_T := M_t + M_{tQ} = -0.918 \text{ kN m}$$

$$\sigma_{Mz}(2.7 \text{ cm}) = 0.5455 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_{Mt}(t) := \frac{M_T \cdot t}{J_t} \quad \tau_{Mt}(t_w) = -2.5331 \frac{\text{kN}}{\text{cm}^2} \quad \tau_{Mt}(t_f) = -4.053 \frac{\text{kN}}{\text{cm}^2}$$

$$S_1 := (b_f - t_w) \cdot t_f \cdot \left(\frac{h}{2} - \frac{t_f}{2}\right) = 204.48 \text{ cm}^3 \quad S_2 := b_f \cdot t_f \cdot \left(\frac{h}{2} - \frac{t_f}{2}\right) = 227.2 \text{ cm}^3 \quad S_y = 316 \text{ cm}^3$$

$$\tau_{Q1} := \frac{Q_z \cdot S_1}{J_y \cdot t_f} = 0.3183 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_{Q2} := \frac{Q_z \cdot S_2}{J_y \cdot t_w} = 0.5659 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_{Q3} := \frac{Q_z \cdot S_y}{J_y \cdot t_w} = 0.787 \frac{\text{kN}}{\text{cm}^2}$$

Punto A:

$$y_A := b_f - e_y = 7.3 \text{ cm} \quad z_A := -\frac{h}{2} = -15 \text{ cm}$$

$$\sigma_{xA} := \sigma_N + \sigma_{My}(z_A) + \sigma_{Mz}(y_A) = -3.7946 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_A := \tau_{Mt} \left(t_f \right) = -4.053 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMA} := \sqrt{\sigma_{xA}^2 + 3 \cdot \tau_A^2} = 7.9799 \frac{\text{kN}}{\text{cm}^2}$$

$$CS_A := \frac{24 \frac{\text{kN}}{\text{cm}^2}}{\sigma_{VMA}} = 3.0076$$

Punto B:

$$y_B := -e_y + t_w = -1.7 \text{ cm} \quad z_B := -\frac{h}{2} = -15 \text{ cm}$$

$$\sigma_{xB} := \sigma_N + \sigma_{My} \left(z_B \right) + \sigma_{Mz} \left(y_B \right) = -5.6128 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_B := \tau_{Mt} \left(t_f \right) - \tau_{Q1} = -4.3713 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMB} := \sqrt{\sigma_{xB}^2 + 3 \cdot \tau_B^2} = 9.4249 \frac{\text{kN}}{\text{cm}^2}$$

$$CS_B := \frac{24 \frac{\text{kN}}{\text{cm}^2}}{\sigma_{VMB}} = 2.5465$$

Punto C:

$$y_C := -e_y = -2.7 \text{ cm} \quad z_C := -\frac{h}{2} + t_f = -13.4 \text{ cm}$$

$$\sigma_{Mz} \left(y_B \right) = -0.3434 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xC} := \sigma_N + \sigma_{My} \left(z_C \right) + \sigma_{Mz} \left(y_C \right) = -5.6156 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{My} \left(z_B \right) = -1.868 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_C := \tau_{Q2} - \tau_{Mt} \left(t_w \right) = 3.099 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_{Mt} \left(t_w \right) = -2.5331 \frac{\text{kN}}{\text{cm}^2}$$

$$t_w = 1 \text{ cm}$$

$$\sigma_{VMC} := \sqrt{\sigma_{xC}^2 + 3 \cdot \tau_C^2} = 7.7683 \frac{\text{kN}}{\text{cm}^2}$$

$$CS_C := \frac{24 \frac{\text{kN}}{\text{cm}^2}}{\sigma_{VMC}} = 3.0895$$

Punto D:

$$y_D := -e_y = -2.7 \text{ cm} \quad z_D := 0 = 0 \text{ cm}$$

$$\sigma_{xD} := \sigma_N + \sigma_{My} \left(z_D \right) + \sigma_{Mz} \left(y_D \right) = -3.9468 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_D := -\tau_{Mt} \left(t_w \right) + \tau_{Q3} = 3.3202 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMD} := \sqrt{\sigma_{xD}^2 + 3 \cdot \tau_D^2} = 6.9748 \frac{\text{kN}}{\text{cm}^2}$$

$$CS_D := \frac{24 \frac{\text{kN}}{\text{cm}^2}}{\sigma_{VMD}} = 3.441$$

Punto E:

$$y_E := -e_y = -2.7 \text{ cm} \quad z_E := \frac{h}{2} - t_f = 13.4 \text{ cm}$$

$$\sigma_{xE} := \sigma_N + \sigma_{My} \left(z_E \right) + \sigma_{Mz} \left(y_E \right) = -2.2781 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_E := -\tau_{Mt} \left(t_w \right) + \tau_{Q2} = 3.099 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VME} := \sqrt{\sigma_{xE}^2 + 3 \cdot \tau_E^2} = 5.831 \frac{\text{kN}}{\text{cm}^2}$$

$$CS_E := \frac{24 \frac{\text{kN}}{\text{cm}^2}}{\sigma_{VME}} = 4.1159$$

Punto F:

$$y_F := -e_y + t_w = -1.7 \text{ cm} \quad z_F := \frac{h}{2} = 15 \text{ cm}$$

$$\sigma_{xF} := \sigma_N + \sigma_{My}(z_F) + \sigma_{Mz}(y_F) = -1.8768 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_F := \tau_{Mt}(t_f) + \tau_{Q1} = -3.7347 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMF} := \sqrt{\sigma_{xF}^2 + 3 \cdot \tau_F^2} = 6.7354 \frac{\text{kN}}{\text{cm}^2}$$

Punto G:

$$y_G := -e_y + b_f = 7.3 \text{ cm} \quad z_G := \frac{h}{2} = 15 \text{ cm}$$

$$CS_F := \frac{24 \frac{\text{kN}}{\text{cm}^2}}{\sigma_{VMF}} = 3.5633$$

$$\sigma_{xG} := \sigma_N + \sigma_{My}(z_G) + \sigma_{Mz}(y_G) = -0.0586 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_G := \tau_{Mt}(t_f) = -4.053 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMG} := \sqrt{\sigma_{xG}^2 + 3 \cdot \tau_G^2} = 7.0202 \frac{\text{kN}}{\text{cm}^2}$$

Punto H:

$$y_H := -e_y + t_w = -1.7 \text{ cm} \quad z_H := 0 = 0 \text{ cm}$$

$$\sigma_{xH} := \sigma_N + \sigma_{My}(z_H) + \sigma_{Mz}(y_H) = -3.7448 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_H := \tau_{Mt}(t_w) = -2.5331 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMH} := \sqrt{\sigma_{xH}^2 + 3 \cdot \tau_H^2} = 5.7683 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xA} = -3.7946 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_A = -4.053 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMA} = 7.9799 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xB} = -5.6128 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_B = -4.3713 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMB} = 9.4249 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xC} = -5.6156 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_C = 3.099 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMC} = 7.7683 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xD} = -3.9468 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_D = 3.3202 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMD} = 6.9748 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xE} = -2.2781 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_E = 3.099 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VME} = 5.831 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xF} = -1.8768 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_F = -3.7347 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMF} = 6.7354 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xG} = -0.0586 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_G = -4.053 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMG} = 7.0202 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xH} = -3.7448 \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_H = -2.5331 \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMH} = 5.7683 \frac{\text{kN}}{\text{cm}^2}$$