Ejercicio 1

$h := 200\ mm$

$b_f := 75\ mm$

$t_f := 11.5\ mm$

$t_w := 8.5\ mm$

$A_g := 32.2\ cm^2$

$J_y := 1910\ cm^4$

$S_y := 191\ cm^3$ $e_y := 2.01\ cm$

$J_z := 148\ cm^4$ $e_c := 3.94\ cm$

$J_t := 11.23\ cm^4$

$N := 40\ kN$ $e_1 := 10\ cm$ $e_2 := 4\ cm$

$M_y := N \cdot e_1 = 4\ kN\ m$

$M_z := (-N) \cdot e_2 = -1.6\ kN\ m$

$Q_z := 5\ kN$

$M_t := (-1)\ kN\ m$

Tensiones normales:

$\sigma_N := \frac{N}{A_g} = 1.2422\ \frac{kN}{cm^2}$ $\sigma_{My}(z) := \frac{M_y \cdot z}{J_y}$ $\sigma_{Mz}(y) := -\frac{M_z \cdot y}{J_z}$

Tensiones tangenciales:

$M_{tQ} := Q_z \cdot e_c = 0.197\ kN\ m$ $M_T := M_t + M_{tQ} = -0.803\ kN\ m$

$\tau_{Mt}(t) := \frac{M_T \cdot t}{J_t}$

$S_1 := (b_f - t_w) \cdot t_f \cdot \left(\frac{h}{2} - \frac{t_f}{2}\right) = 72.0777\ cm^3$ $S_2 := b_f \cdot t_f \cdot \left(\frac{h}{2} - \frac{t_f}{2}\right) = 81.2906\ cm^3$

$\tau_{Q1} := \frac{Q_z \cdot S_1}{J_y \cdot t_f} = 0.1641\ \frac{kN}{cm^2}$ $\tau_{Q2} := \frac{Q_z \cdot S_2}{J_y \cdot t_w} = 0.2504\ \frac{kN}{cm^2}$ $\tau_{Q3} := \frac{Q_z \cdot S_y}{J_y \cdot t_w} = 0.5882\ \frac{kN}{cm^2}$

Punto A: $y_A := b_f - e_y = 5.49\ cm$ $z_A := -\frac{h}{2} = -10\ cm$

$\sigma_{xA} := \sigma_N + \sigma_{My}(z_A) + \sigma_{Mz}(y_A) = 5.0831\ \frac{kN}{cm^2}$

$$\tau_A := \tau_{Mt}\left(t_f\right) = -8.2231 \ \frac{kN}{cm^2}$$

$$\sigma_{VMA} := \sqrt{\sigma_{xA}^{\ 2} + 3 \cdot \tau_A^{\ 2}} = 15.1226 \ \frac{kN}{cm^2}$$

Punto B: $y_B := -e_y + t_w = -1.16 \ cm \qquad z_B := -\frac{h}{2} = -10 \ cm$

$$\sigma_{xB} := \sigma_N + \sigma_{My}\left(z_B\right) + \sigma_{Mz}\left(y_B\right) = -2.1061 \ \frac{kN}{cm^2}$$

$$\tau_B := \tau_{Mt}\left(t_f\right) - \tau_{Q1} = -8.3871 \ \frac{kN}{cm^2}$$

$$\sigma_{VMB} := \sqrt{\sigma_{xB}^{\ 2} + 3 \cdot \tau_B^{\ 2}} = 14.6788 \ \frac{kN}{cm^2}$$

Punto C: $y_C := -e_y = -2.01 \ cm \qquad z_C := -\frac{h}{2} + t_f = -8.85 \ cm$

$$\sigma_{xC} := \sigma_N + \sigma_{My}\left(z_C\right) + \sigma_{Mz}\left(y_C\right) = -2.7841 \ \frac{kN}{cm^2}$$

$$\tau_C := \tau_{Q2} - \tau_{Mt}\left(t_w\right) = 6.3283 \ \frac{kN}{cm^2}$$

$$\sigma_{VMC} := \sqrt{\sigma_{xC}^{\ 2} + 3 \cdot \tau_C^{\ 2}} = 11.309 \ \frac{kN}{cm^2}$$

Punto D: $y_D := -e_y = -2.01 \ cm \qquad z_D := 0 = 0 \ cm$

$$\sigma_{xD} := \sigma_N + \sigma_{My}\left(z_D\right) + \sigma_{Mz}\left(y_D\right) = -0.9307 \ \frac{kN}{cm^2}$$

$$\tau_D := -\tau_{Mt}\left(t_w\right) + \tau_{Q3} = 6.6662 \ \frac{kN}{cm^2}$$

$$\sigma_{VMD} := \sqrt{\sigma_{xD}^{\ 2} + 3 \cdot \tau_D^{\ 2}} = 11.5836 \ \frac{kN}{cm^2}$$

Punto E: $y_E := -e_y = -2.01 \ cm \qquad z_E := \frac{h}{2} - t_f = 8.85 \ cm$

$$\sigma_{xE} := \sigma_N + \sigma_{My}\left(z_E\right) + \sigma_{Mz}\left(y_E\right) = 0.9227 \ \frac{kN}{cm^2}$$

$$\tau_E := -\tau_{Mt}\left(t_w\right) + \tau_{Q2} = 6.3283 \ \frac{kN}{cm^2}$$

$$\sigma_{VME} := \sqrt{\sigma_{xE}^{\ 2} + 3 \cdot \tau_E^{\ 2}} = 10.9997 \ \frac{kN}{cm^2}$$

Punto F:

$$y_F := -e_y + t_w = -1.16\ \text{cm} \qquad z_F := \frac{h}{2} = 10\ \text{cm}$$

$$\sigma_{xF} := \sigma_N + \sigma_{My}\left(z_F\right) + \sigma_{Mz}\left(y_F\right) = 2.0824\ \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_F := \tau_{Mt}\left(t_f\right) + \tau_{Q1} = -8.059\ \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMF} := \sqrt{\sigma_{xF}^{\ 2} + 3 \cdot \tau_F^{\ 2}} = 14.1131\ \frac{\text{kN}}{\text{cm}^2}$$

Punto G:

$$y_G := -e_y + b_f = 5.49\ \text{cm} \qquad z_G := \frac{h}{2} = 10\ \text{cm}$$

$$\sigma_{xG} := \sigma_N + \sigma_{My}\left(z_G\right) + \sigma_{Mz}\left(y_G\right) = 9.2716\ \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_G := \tau_{Mt}\left(t_f\right) = -8.2231\ \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMG} := \sqrt{\sigma_{xG}^{\ 2} + 3 \cdot \tau_G^{\ 2}} = 16.9947\ \frac{\text{kN}}{\text{cm}^2}$$

Punto H:

$$y_H := -e_y + t_w = -1.16\ \text{cm} \qquad z_H := 0 = 0\ \text{cm}$$

$$\sigma_{xH} := \sigma_N + \sigma_{My}\left(z_H\right) + \sigma_{Mz}\left(y_H\right) = -0.0118\ \frac{\text{kN}}{\text{cm}^2}$$

$$\tau_H := \tau_{Mt}\left(t_w\right) = -6.0779\ \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{VMH} := \sqrt{\sigma_{xH}^{\ 2} + 3 \cdot \tau_H^{\ 2}} = 10.5273\ \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xA} = 5.0831\ \frac{\text{kN}}{\text{cm}^2} \qquad \tau_A = -8.2231\ \frac{\text{kN}}{\text{cm}^2} \qquad \sigma_{VMA} = 15.1226\ \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xB} = -2.1061\ \frac{\text{kN}}{\text{cm}^2} \qquad \tau_B = -8.3871\ \frac{\text{kN}}{\text{cm}^2} \qquad \sigma_{VMB} = 14.6788\ \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xC} = -2.7841\ \frac{\text{kN}}{\text{cm}^2} \qquad \tau_C = 6.3283\ \frac{\text{kN}}{\text{cm}^2} \qquad \sigma_{VMC} = 11.309\ \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xD} = -0.9307\ \frac{\text{kN}}{\text{cm}^2} \qquad \tau_D = 6.6662\ \frac{\text{kN}}{\text{cm}^2} \qquad \sigma_{VMD} = 11.5836\ \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xE} = 0.9227\ \frac{\text{kN}}{\text{cm}^2} \qquad \tau_E = 6.3283\ \frac{\text{kN}}{\text{cm}^2} \qquad \sigma_{VME} = 10.9997\ \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xF} = 2.0824\ \frac{\text{kN}}{\text{cm}^2} \qquad \tau_F = -8.059\ \frac{\text{kN}}{\text{cm}^2} \qquad \sigma_{VMF} = 14.1131\ \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xG} = 9.2716\ \frac{\text{kN}}{\text{cm}^2} \qquad \tau_G = -8.2231\ \frac{\text{kN}}{\text{cm}^2} \qquad \sigma_{VMG} = 16.9947\ \frac{\text{kN}}{\text{cm}^2}$$

$$\sigma_{xH} = -0.0118\ \frac{\text{kN}}{\text{cm}^2} \qquad \tau_H = -6.0779\ \frac{\text{kN}}{\text{cm}^2} \qquad \sigma_{VMH} = 10.5273\ \frac{\text{kN}}{\text{cm}^2}$$