VERTICAL MULLION ANALYSIS
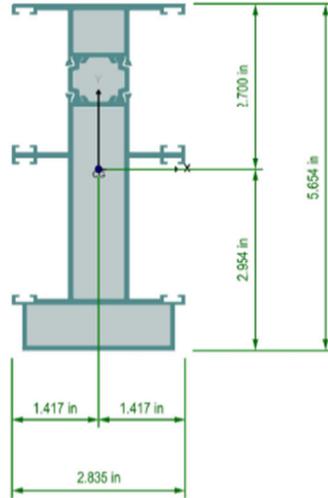
Geometric Properties

Area	2.221 in^2
Ix	7.833 in^4
Ixy	0.000 in^4
Iy	1.110 in^4
Sx+	2.901 in^3
Sx-	2.652 in^3
Sy+	0.783 in^3
Sy-	0.783 in^3
Xc	0.000 in
Yc	0.000 in
rx	1.878 in
ry	0.707 in

Principal Properties

I1	7.833 in^4
I2	1.110 in^4
S1+	2.901 in^3
S1-	2.652 in^3
S2+	0.783 in^3
S2-	0.783 in^3
r1	1.878 in
r2	0.707 in
a	0.004 deg

Torsion Properties

Cw	3.629 in^6
H	0.965
J	0.857 in^4
Xsc	0.000 in
Ysc	-0.382 in
ro	2.042 in
B1	0.468 in

Overall Properties

Depth	5.654 in
Perimeter	31.416 in
Weight	0.003 K/ft
Width	2.835 in

Polar Properties

Ip	8.943 in^4
rp	2.006 in

Plastic Properties

Xpna	0.000 in
Ypna	0.243 in
Zx	3.580 in^3
Zy	1.355 in^3

Properties of Glass

Coefficient of linear expansion

$$\alpha_g := \frac{8.8 \cdot 10^{-6}}{deg \cdot C}$$

Density

$$\rho_g := 0.09 \cdot \frac{lb}{in^3} \qquad \rho_g = 2.491 \times 10^3 \frac{kg}{m^3}$$

Poisson's Ratio

$$\nu_g := 0.22$$

Modulus of Elasticity

$$E_g := 10 \cdot 10^6 \cdot psi$$

Properties of Aluminum (6063-T5)

Modulus of Elasticity

$$E_a := 10100 \cdot ksi \qquad E_a = 6.964 \times 10^4 \cdot MPa$$

Shear Modulus of Elasticity

$$G_a := 3800 \cdot ksi \qquad G_a = 2.62 \times 10^4 \cdot MPa$$

Coefficient of linear expansion

$$\alpha_a := \frac{23.6 \cdot 10^{-6}}{deg \cdot C}$$

Density

$$\rho_a := 0.10 \cdot \frac{lb}{in^3} \qquad \rho_a = 2.768 \times 10^3 \frac{kg}{m^3}$$

Poisson's Ratio

$$\nu_a := 0.33$$

LOADS

Wind Load	$P := 70 \cdot psf$	
Length of mullion	$L_m := 5.79 \cdot ft$	
Tributray Width	$T_w := 4.14 \cdot ft$	
Unbraced Length	$L_b := 1.54 \cdot ft$	
Tensile yield strength	$F_{ty} := 16 \cdot \dfrac{kip}{in^2}$	$F_{ty} = 16 \cdot ksi$
Compressive yield strength	$F_{cy} := 16 \cdot \dfrac{kip}{in^2}$	$F_{cy} = 16 \cdot ksi$
Ultimate Tensile Strength	$F_{tu} := 22 \cdot \dfrac{kip}{in^2}$	$F_{tu} = 22 \cdot ksi$

BUCKLING CONSTANTS (UNWELDED) TABLE 1-1

$B_c := 17.3 \cdot ksi$	$D_c := 0.072 \cdot ksi$	$C_c := 98.9$
$B_p := 19.5 \cdot ksi$	$D_p := 0.086 \cdot ksi$	$C_p := 93.3$
$B_t := 19.2 \cdot ksi$	$D_t := 0.529 \cdot ksi$	$C_t := 275$
$B_{br} := 28.3 \cdot ksi$	$D_{br} := 0.184 \cdot ksi$	$C_{br} := 102.8$
$B_{tb} := 28.8 \cdot ksi$	$D_{tb} := 1.513 \cdot ksi$	$C_{tb} := 95.2$
$B_s := 11.8 \cdot ksi$	$D_s := 0.040 \cdot ksi$	$C_s := 120$

Allowable Stresses

Axial Compression - Table 1-5 (Axial Compression - Section E.2)

Slenderness Ratio

$$\lambda_a := \frac{k_t \cdot L_m}{r_{ym}} = 98.3$$

Slender Limit

$$\lambda_{1a} := \frac{B_c - F_{cy}}{D_c} = 18.1 \qquad \lambda_{2a} := C_c = 98.9$$

Allowable Stress

$$F_a := \begin{vmatrix} F_{cy} & \text{if } \lambda_{1a} \geq \lambda_a \\ (B_c - D_c \cdot \lambda_a) \cdot \left[0.85 + 0.15 \cdot \dfrac{(C_c - \lambda_a)}{(C_c - \lambda_{1a})} \right] & \text{if } \lambda_{1a} < \lambda_a < \lambda_{2a} \\ \dfrac{0.85 \cdot \pi^2 \cdot E_a}{\lambda_a^2} & \text{if } \lambda_a \geq \lambda_{2a} \end{vmatrix} \qquad F_a = 8.702 \cdot ksi$$

$$F_{ax} := \frac{F_a}{\Omega_y} \qquad\qquad F_{ax} = 5.274 \cdot ksi$$

Elements Shear (Flat elements supported on both edges - Section G.2)

Clear height of web and web thickness

$$d_w := 58.4 \cdot mm \qquad\qquad d_w = 2.299 \cdot in$$
$$t_w := 2.3 \cdot mm \qquad\qquad t_w = 0.091 \cdot in$$

Slenderness Ratio

$$\lambda_v := \frac{d_w}{t_w} = 25.391 \qquad\qquad F_{sy} := 0.6 \cdot F_{ty} = 9.6 \cdot ksi$$

Slender Limit

$$\lambda_{1v} := \frac{(B_s - F_{sy})}{1.25 \cdot D_s} = 44 \qquad\qquad \lambda_{2v} := \frac{C_s}{1.25}$$

Allowable Stress

$$F_v := \begin{vmatrix} F_{sy} & \text{if } \lambda_{1v} \geq \lambda_v \\ B_s - (1.25 \cdot D_s \cdot \lambda_v) & \text{if } \lambda_{1v} < \lambda_v < \lambda_{2v} \\ \dfrac{\pi^2 \cdot E_a}{(1.25 \cdot \lambda_v)^2} & \text{if } \lambda_v > \lambda_{2v} \end{vmatrix} \qquad F_{vs} := \frac{F_v}{\Omega_y} = 5.818 \cdot ksi$$

Flexural Compression (Flat elements supported on both edges - Section B.5.5.1)

Distance from NA to element with the greatest compressive stress	$c_c := -2.7 \cdot in$	$k_1 := 0.35$
Distance from NA to to other extreme fiber	$c_o := 2.954 \cdot in$	$k_2 := 2.27$

Ratio of extreme fibers

$$\frac{c_o}{c_c} = -1.094$$

$$m := \begin{Vmatrix} \dfrac{1.3}{1 - \dfrac{c_o}{c_c}} & \text{if } -1 \geq \dfrac{c_o}{c_c} \\ \\ 1.15 + \dfrac{c_o}{2 \cdot c_c} & \text{if } -1 < \dfrac{c_o}{c_c} < 1 \end{Vmatrix} \qquad m = 0.621$$

Flanges $\qquad b_f := 59.5 \cdot mm \qquad\qquad t_f := 2 \cdot mm$

Slenderness Ratio $\qquad \lambda_F := \dfrac{b_f}{t_f} = 29.75$

Slender Limit $\qquad \lambda_{1F} := \dfrac{B_{br} - (1.5 \cdot F_{cy})}{m \cdot D_{br}} = 37.644 \qquad\qquad \lambda_{2F} := \dfrac{k_1 \cdot B_{br}}{m \cdot D_{br}} = 86.713$

Allowable Stress $\quad F_F := \begin{vmatrix} 1.5 \cdot F_{cy} & \text{if } \lambda_{1F} \geq \lambda_F \\ B_{br} - (m \cdot D_{br} \cdot \lambda_F) & \text{if } \lambda_{1F} < \lambda_F < \lambda_{2F} \\ \dfrac{k_2 \cdot (B_{br} \cdot E_a)^{0.5}}{m \cdot \lambda_F} & \text{if } \lambda_F \geq \lambda_{2F} \end{vmatrix} \qquad F_F = 24 \cdot ksi$

$$F_{FC} := \frac{F_F}{\Omega_y} \qquad\qquad F_{FC} = 14.545 \cdot ksi$$

Elements uniform compression (Flat elements supported on both edges-Section B.5.4.2)

Slenderness Ratio $\qquad \lambda_C := \dfrac{d_w}{t_w} = 25.391$

Slender Limit $\qquad \lambda_{1C} := \dfrac{B_p - F_{cy}}{1.6 \cdot D_p} = 25.436 \qquad\qquad \lambda_{2C} := \dfrac{k_1 \cdot B_p}{1.6 \cdot D_p} = 49.6$

Allowable Stress $\quad F_C := \begin{vmatrix} F_{cy} & \text{if } \lambda_{1C} \geq \lambda_C \\ B_p - (1.6 \cdot D_p \cdot \lambda_C) & \text{if } \lambda_{1C} < \lambda_C < \lambda_{2C} \\ \dfrac{k_2 \cdot (B_p \cdot E_a)^{0.5}}{1.6 \cdot \lambda_C} & \text{if } \lambda_C \geq \lambda_{2C} \end{vmatrix}$

$$F_{CC} := \frac{F_C}{\Omega_y} \qquad\qquad F_{CC} = 9.697 \cdot ksi$$

Yielding and Rupture (F2)

Nominal Flexural Strength for limit state of yielding $\qquad M_{np} := \dfrac{\min(Z_{xm} \cdot F_{cy}, 1.5 \cdot S_{xm} \cdot F_{cy})}{g} \qquad M_{np} = 4.773 \times 10^3 \cdot lb \cdot ft$

Nominal Flexural Strength for limit state of rupture $\qquad M_{nu} := \dfrac{Z_{xm} \cdot F_{tu}}{k_t \cdot g} \qquad\qquad M_{nu} = 6.563 \times 10^3 \cdot lb \cdot ft$

Flexure lateral torsional buckling (Closed Shapes F.4)

Bending Coefficient for members supported on both edges

$$C_b := 1.0$$

Slenderness Ratio

$$\lambda_{TB} := 2.3 \cdot \sqrt{\frac{L_b \cdot S_{xm}}{C_b \cdot \sqrt{I_{ym} \cdot J}}} = 16.304 \qquad \lambda_{2TB} := C_c = 98.9$$

Nominal Flexural Strength

$$M_{nmb} := \left\| \begin{array}{l} M_{np} \cdot \left(1 - \dfrac{\lambda_{TB}}{C_c}\right) + \dfrac{\pi^2 \cdot E_a \cdot \lambda_{TB} \cdot S_{xm}}{C_c^3 \cdot g} \quad \text{if } \lambda_{TB} < C_c \\[2em] \dfrac{\pi^2 \cdot E_a \cdot S_{xm}}{\lambda_{TB}^2 \cdot g} \quad \text{if } \lambda_{TB} \geq C_c \end{array} \right. \qquad M_{nmb} = 4.358 \times 10^3 \cdot lb \cdot ft$$

$$F_{LTB} := \frac{\dfrac{M_{nmb}}{S_{xm}} \cdot g}{\Omega_y} \qquad\qquad F_{LTB} = 11.95 \cdot ksi$$

Thickness of Glass

$$t_g := 18 \cdot mm$$

Total Dead load

$$D_L := \rho_g \cdot t_g \cdot T_w \cdot L_m \cdot g = 220.152 \cdot lbf$$

Maximum moment

$$M := \frac{P \cdot T_w \cdot L_m^2}{8} = 1.214 \times 10^3 \cdot lbf \cdot ft$$

Maximum shear

$$V_f := \frac{P \cdot T_w \cdot L_m}{2} = 838.971 \cdot lbf$$

Actual Stresses

Maximum axial stress

$$f_a := \frac{D_L}{A_m} = 0.099 \cdot ksi$$

Allowable axial stress

$$F_{ax} = 5.274 \cdot ksi$$

Maximum Bending Stress

$$F_b := \frac{M}{S_{xm}} = 5.495 \cdot ksi$$

Allowable Bending Stress

$$F_{ba} := \min\left(F_{FC}, F_{CC}, F_{LTB}\right) \qquad F_{ba} = 9.697 \cdot ksi$$

Reduction factor

$$\Phi := 0.90$$

Maximum shear stress

$$f_v := \frac{V_f}{d_w \cdot t_w} = 4.03 \cdot ksi$$

Allowable Shear Stress

$$F_{vs} \cdot \Phi = 5.236 \cdot ksi$$

$$\text{Shear\_Check} := \text{if}\left(F_{vs} > f_v, \text{"SAFE"}, \text{"NOT SAFE"}\right) \qquad\qquad \text{Shear\_Check} = \text{"SAFE"}$$

Combined axial and bending stress

Reduction due to Thermal Break

$$\Phi_{TB} := 0.80$$

$$\left(\frac{f_a}{F_{ax} \cdot \Phi_{TB}} + \frac{F_b}{F_{ba} \cdot \Phi_{TB}}\right) \cdot \Phi = 0.659$$

$$\text{Stress\_Capacity} := \text{if}\left(\frac{f_a}{F_a} + \frac{F_b}{F_{ba}} < 1.0, \text{"SAFE"}, \text{"NOT SAFE"}\right) \qquad \text{Stress\_Capacity} = \text{"SAFE"}$$

Deflection Analysis

Allowable deflection

$$y_a := \min\left(\frac{L_m}{175}, 19 \cdot mm\right) = 0.397 \cdot in \qquad y_a = 10.085 \cdot mm$$

Maximum deflection

$$y_{max} := \frac{5 \cdot (P \cdot T_w) \cdot L_m^4}{384 \cdot E_a \cdot I_{xm}} = 0.093 \cdot in \qquad y_{max} = 2.353 \cdot mm$$

$$\text{deflection} := \text{if}\left(y_a > y_{max}, \text{"SAFE"}, \text{"NOT SAFE"}\right) \qquad\qquad \text{deflection} = \text{"SAFE"}$$