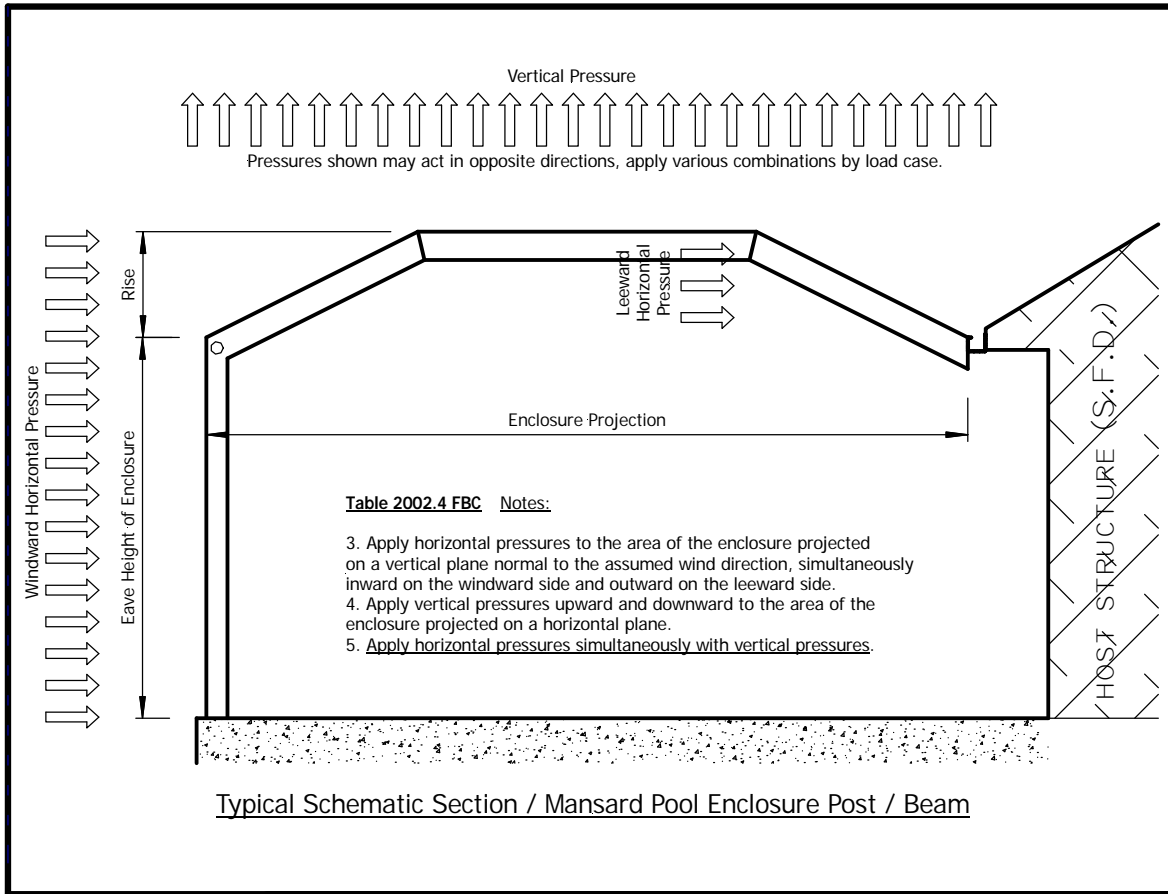


Allowable Span of Mansard Screen Enclosure Self-Mating Beams in accordance with requirements of Table 2002.4 (and the 2005 Aluminum Design Manual) using 6005T5 alloy:

Design pressures from Table 2002.4 for 130 mph Exposure B with a mean roof height not to exceed 30 ft using a 20/20 screen mesh:

	Horizontal design pressure (Windward):	$p_{w_wall} := 18 \cdot \text{psf}$
	Horizontal design pressure (Leeward):	$p_{l_wall} := 14 \cdot \text{psf}$
Deflection limit (L/60)	Vertical design pressure:	$p_{roof} := 5 \cdot \text{psf}$



Determine the allowable beam span based upon the following project frame geometry:

Wall height (eave height):	$h_{eave} := 10 \cdot \text{ft}$
Vertical distance, height overall less eave height:	$\text{Rise} := 3.5 \cdot \text{ft}$
Center to center spacing of mansard frames:	$\text{Spacing} := 7.5 \cdot \text{ft}$

Approximate allowable span based upon frame geometry and allowable major axis bending moments for various industry beams (preliminary span):

Horizontal force applied inward at screen eave:

$$P_{\text{eave}} := \frac{h_{\text{eave}}}{2} \cdot p_{\text{W_wall}} \cdot \text{Spacing}$$

$$P_{\text{eave}} = 675 \text{ lbf}$$

Induced beam moment (from P):

$$M_{\text{P}} := P_{\text{eave}} \cdot \text{Rise}$$

$$M_{\text{P}} = 28.35 \cdot \text{kip} \cdot \text{in}$$

Induced beam moment from windward and leeward mansard legs:

$$M_{\text{Rise}} := \frac{\text{Rise}^2}{2} \cdot \text{Spacing} \cdot (p_{\text{W_wall}} + p_{\text{L_wall}})$$

$$M_{\text{Rise}} = 17.64 \cdot \text{kip} \cdot \text{in}$$

Sum of moments induced into beam from horizontal pressures:

$$M_{\text{P}} + M_{\text{Rise}} = 45.99 \cdot \text{kip} \cdot \text{in}$$

By inspection of induced moment from horizontal force at the eave and the allowable major axis bending moments, determine preliminary span for design check and final allowable span:

Major Axis Allowable Bending Moments			
Section	S_x (in ³)	F_b (ksi)	M_a (in kip)
2X4 SMB	1.000	8.7	8.7
2X5 SMB	1.510	9.2	13.9
2X6 SMB	1.944	9.0	17.4
2X7 SMB	2.425	9.2	22.3
2X8 SMB	4.441	15.0	66.7
2X9 SMB	6.123	17.5	107.0
2X10 SMB	8.462	17.4	147.5

By inspection, **SELECT trial member** for span calculation & enter allowable moment:

$$M_a := 107 \cdot \text{kip} \cdot \text{in}$$

ENTER beam depth of member selected:

$$d := 9 \cdot \text{in}$$

Net moment from allowable less moment induced at shoulder:

$$M_{\text{preliminary}} := M_a - (M_{\text{P}} + M_{\text{Rise}})$$

$$M_{\text{preliminary}} = 61.01 \cdot \text{kip} \cdot \text{in}$$

Preliminary allowable span:

$$L_{\text{preliminary}} := \sqrt{\frac{8 \cdot M_{\text{preliminary}}}{\text{Spacing} \cdot p_{\text{roof}}}}$$

$$L_{\text{preliminary}} = 395.203 \text{ in}$$

Profile :=

	Depth	ID	t_w	t_f	Area	I_x	I_y
	0	1	2	3	4	5	6
0	4	"2X4 SMB"	0.046	0.1	0.782	2	0.47
1	5	"2X5 SMB"	0.05	0.116	0.917	3.644	0.592
2	6	"2X6 SMB"	0.05	0.12	1.022	5.66	0.685
3	7	"2X7 SMB"	0.055	0.12	1.229	8.472	0.849
4	8	"2X8 SMB"	0.072	0.224	1.847	16.577	1.215
5	9	"2X9 SMB"	0.082	0.306	2.357	27.16	1.524
6	10	"2X10 SMB"	0.092	0.374	3.013	42.282	1.926

Self-Mating Beam trial member selected (values from standard sections listed above): Row := $\frac{d}{in} - 4$

Extrusion profile nomenclature: ID := Profile_{Row,1} ID = "2X9 SMB"
 Width: $b := 2.00 \cdot in$ Flange Thickness: $t_f := Profile_{Row,3} \cdot in = 0.306 in$
 Web Thickness: $t_w := Profile_{Row,2} \cdot in = 0.082 in$

X-axis support: $L_d := L_{preliminary}$ is the strong-axis support distance.

Weak-axis Support: $L_b := 84 \cdot in$ is the weak-axis support distance (purlins spacing)

Flange Support: Spacing_{stitching} := 24 · in

Self-Mating Beams of alloys 6061T6 OR 6005T5 Aluminum; Development of Properties and Allowable Stresses for the specified profile (i.e. properties by formula and table above from Autocad) in accordance with the 2005 Aluminum Design Manual Specifications:

Channel Flange Width: $b_c := 1.560 \cdot in$

Safety Factor: $n_\mu := 1.95$

Modulus of Elasticity: $E := 10.100 \cdot 10^3 \cdot ksi$

Open-channel Properties (one side of SMB)

Channel Flange Width used for Buckling: $b_f := b_c - (t_w)$ $b_f = 1.478 in$

Web Height used for Buckling: $h_w := d - (2 \cdot t_f)$ $h_w = 8.388 in$

Member Flange Width: $b_m := b - 2 \cdot t_w$ $b_m = 1.836 in$

Total Area: $Area := (b \cdot d) - [h_w \cdot (b - 2 \cdot t_w)]$

Web Area: $Area_{web} := 2 \cdot t_w \cdot h_w$

Flange Area: $Area_{flange} := 2 \cdot t_f \cdot b$

Check the area equations: $\text{Area} = \text{Area}_{\text{web}} + \text{Area}_{\text{flange}}$

$$\text{i.e., } \left| \text{Area}_{\text{web}} + \text{Area}_{\text{flange}} - \text{Area} \right| \quad \text{Area} = 2.6 \text{ in}^2$$

$$\text{Torsional Constant: } J := \frac{2 \cdot t_f \cdot t_w \cdot (b - t_w)^2 \cdot (d - t_f)^2}{(b \cdot t_w) + (d \cdot t_f) - t_w^2 - t_f^2}$$

Moments Of Inertia

Section Modulus

Radius of Gyration

$$I_x := \text{Profile}_{\text{Row}, 5} \cdot \text{in}^4$$

$$S_x := \frac{I_x}{\frac{d}{2}}$$

$$r_x := \sqrt{\frac{I_x}{\text{Area}}}$$

$$I_y := \text{Profile}_{\text{Row}, 5} \cdot \text{in}^4$$

$$S_y := \frac{I_y}{\frac{b}{2}}$$

$$r_y := \sqrt{\frac{I_y}{\text{Area}}}$$

Open Channel properties - In weak axis

$$\text{Channel-width in buckling: } b_{cf} := b_c - t_w$$

$$\text{Channel Height: } d_c := d - \left(\frac{t_f}{2} \right)$$

$$\text{Center of Gravity to Outer Fiber Distance: } C_1 := \frac{t_f \cdot b_c^2 + (d_c - t_f) \cdot t_w^2}{2 \cdot [t_f \cdot b_c + [(d_c - t_f) \cdot t_w]]} \quad C_1 = 0.341 \text{ in}$$

$$C_2 := b_c - C_1 \quad C_2 = 1.219 \text{ in}$$

$$\text{Channel Moment of Inertia: } I_{yc} := \frac{d_c \cdot C_1^3 - (d_c - t_f) \cdot (C_1 - t_w)^3 + t_f \cdot C_2^3}{3} \quad I_{yc} = 0.252 \text{ in}^4$$

$$\text{Radius of Gyration: } r_{yc} := \sqrt{\frac{I_{yc}}{(d_c \cdot t_w) + t_f \cdot (b_c - t_w)}} \quad r_{yc} = 0.463 \text{ in}$$

$$\text{Area}_{\text{channel}} := (d_c \cdot b_c) - (d_c - t_f) \cdot (b_c - t_w) \quad \text{Area}_{\text{channel}} = 1.178 \text{ in}^2$$

Allowable Axial Tension

Specification 3.4.2 Tension: $F_{btf} := 19 \cdot \text{ksi}$ (Flat elements in uniform tension)

Specification 3.4.4 (Tension): $F_{btw} := 28 \cdot \text{ksi}$ (Flat elements bending in their own plane)

Allowable Axial Compression

Specification 3.4.7 Member Buckling

Assume most severe case: $k \equiv 1$

$$\text{Slenderness7}_x := k \cdot \frac{L_d}{r_x}$$

$$\text{Slenderness7}_y := \frac{k \cdot L_b}{r_y}$$

$$\text{Slenderness7} := \max(\text{Slenderness7}_x, \text{Slenderness7}_y) \quad \text{Slenderness7} = 122.268$$

$$F_{cm} := \begin{cases} (20.2 - 0.126 \cdot \text{Slenderness7}) \cdot \text{ksi} & \text{if } \text{Slenderness7} < 66 \\ \left(\frac{51100}{\text{Slenderness7}^2} \right) \cdot \text{ksi} & \text{if } \text{Slenderness7} \geq 66 \end{cases} \quad F_{cm} = 3.418 \cdot \text{ksi}$$

Member Buckling between stitch screws (beam half) [ADM 3.4.7]

$$k_{\text{channel}} := 0.5$$

$$\text{Slenderness}_{\text{channel}} := \frac{k_{\text{channel}} \cdot \text{Spacing}_{\text{stitching}}}{r_{yc}}$$

$$F_{ch} := \begin{cases} (20.2 - .126 \cdot \text{Slenderness}_{\text{channel}}) \cdot \text{ksi} & \text{if } \text{Slenderness}_{\text{channel}} < 66 \\ \frac{51100 \cdot \text{ksi}}{\text{Slenderness}_{\text{channel}}^2} & \text{otherwise} \end{cases} \quad F_{ch} = 16.93 \cdot \text{ksi}$$

Specification 3.4.9 Local Web Buckling:

$$\text{Slenderness9}_W := \frac{h_W}{t_W}$$

$$F_{CW} := \begin{cases} 21 \cdot \text{ksi} & \text{if } \text{Slenderness9}_W \leq 7.6 \\ \frac{491}{\text{Slenderness9}_W} \cdot \text{ksi} & \text{if } \text{Slenderness9}_W \geq 33 \\ (23.1 - 0.247 \cdot \text{Slenderness9}_W) \cdot \text{ksi} & \text{otherwise} \end{cases} \quad F_{CW} = 4.800 \cdot \text{ksi}$$

Specification 3.4.8.1 Local Buckling, Flange:

$$\text{Slenderness8} := \frac{2 \cdot b_f}{t_f}$$

$$F_{CF} := \begin{cases} 21 \cdot \text{ksi} & \text{if } \text{Slenderness8} \leq 2.4 \\ \frac{1970}{\text{Slenderness8}^2} \cdot \text{ksi} & \text{if } \text{Slenderness8} \geq 12 \\ (23.1 - 0.787 \cdot \text{Slenderness8}) \cdot \text{ksi} & \text{otherwise} \end{cases} \quad \begin{aligned} \text{Slenderness8} &= 9.66 \\ F_{CF} &= 15.50 \cdot \text{ksi} \end{aligned}$$

Member Elastic Buckling (ADM Eq. 4.7.4-3):

$$F_{EC} := \left(\frac{\pi}{\text{Slenderness7}} \right)^2 \cdot E \quad F_{EC} = 6.668 \cdot \text{ksi}$$

Specification 4.7.1 Local Elastic Buckling of the Web: $F_{CRW} := \frac{\pi^2 \cdot E}{(1.6 \cdot \text{Slenderness9}_W)^2}$

Local Elastic Buckling, Flange: $F_{CRF} := \frac{\pi^2 \cdot E}{(5.1 \cdot \text{Slenderness8})^2}$ $F_{CRF} = 41.1 \cdot \text{ksi}$

Weighted Average: Web / Flange Local Buckling: $F_{CA} := \frac{F_{CW} \cdot \text{Area}_{\text{web}} + F_{CF} \cdot \text{Area}_{\text{flange}}}{\text{Area}}$

Specification 4.7.4: Local and Member Buckling Interaction:

$$F_{cr} := \min(F_{crf}, F_{crw})$$

Structural factor of safety: $n_{\mu} = 1.95$

$$F_{rc} := \begin{cases} \frac{F_{ec}^{\frac{1}{3}} \cdot F_{cr}^{\frac{2}{3}}}{n_{\mu}} & \text{if } \frac{F_{cr}}{n_{\mu}} < F_{ec} \\ F_{cm} & \text{otherwise} \end{cases} \quad F_{rc} = 2.318 \cdot \text{ksi}$$

Maximum allowable Axial compressive stress and Corresponding Axial Load:

$$F_c := \min(F_{rc}, F_{ca}, F_{ch}, F_{crf}, F_{ec}, F_{cm}) \quad F_c = 2.318 \cdot \text{ksi}$$

$$F_a := F_c \cdot \text{Area} \quad F_a = 6.026 \cdot \text{kip}$$

Specification 3.4.2 Allowable Major Axis Bending:

$$\text{Member Buckling (3.4.14): } \text{Slenderness}_{14} := \frac{2 \cdot L_b \cdot S_x}{\sqrt{I_y \cdot J}} \quad \text{Slenderness}_{14} = 87.429$$

$$F_{bcx} := \begin{cases} 21 \cdot \text{ksi} & \text{if } \text{Slenderness}_{14} \leq 123 \\ \frac{23600}{\text{Slenderness}_{14}} \cdot \text{ksi} & \text{if } \text{Slenderness}_{14} \geq 1680 \\ \left[23.9 - \left(0.238 \cdot \sqrt{\text{Slenderness}_{14}} \right) \right] \cdot \text{ksi} & \text{otherwise} \end{cases} \quad F_{bcx} = 21.00 \cdot \text{ksi}$$

Member Buckling between stitch screws (3.4.11):

$$\text{Slenderness}_{ch} := \frac{\text{Spacing}_{\text{stitching}}}{r_{yc}}$$

$$F_{bcxh} := \begin{cases} 21 \cdot \text{ksi} & \text{if } \text{Slenderness}_{ch} \leq 21 \\ \frac{87000}{\text{Slenderness}_{ch}^2} \cdot \text{ksi} & \text{if } \text{Slenderness}_{ch} \geq 79 \\ \left[23.9 - \left(0.124 \cdot \text{Slenderness}_{ch} \right) \right] \cdot \text{ksi} & \text{otherwise} \end{cases} \quad F_{bcxh} = 17.47 \cdot \text{ksi}$$

Local Buckling, Web (3.4.18): $\text{Slenderness}_{18} := \frac{h_w}{t_w}$

$$F_{bcxw} := \begin{cases} 28 \cdot \text{ksi} & \text{if } \text{Slenderness}_{18} \leq 48 \\ \frac{1520}{\text{Slenderness}_{18}} \cdot \text{ksi} & \text{if } \text{Slenderness}_{18} \geq 75 \\ [40.5 - (0.270 \cdot \text{Slenderness}_{18})] \cdot \text{ksi} & \text{otherwise} \end{cases} \quad F_{bcxw} = 14.859 \cdot \text{ksi}$$

Local Buckling, Flange (3.4.15): $\text{Slenderness}_{15} := \frac{2 \cdot b_f}{t_f}$ $\text{Slenderness}_{15} = 9.66$

$$F_{bcxf} := \begin{cases} 21 \cdot \text{ksi} & \text{if } \text{Slenderness}_{15} \leq 6.5 \\ \frac{182}{\text{Slenderness}_{15}} \cdot \text{ksi} & \text{if } \text{Slenderness}_{15} \geq 10 \\ [27.3 - (0.930 \cdot \text{Slenderness}_{15})] \cdot \text{ksi} & \text{otherwise} \end{cases} \quad F_{bcxf} = 18.316 \cdot \text{ksi}$$

Allowable Bending Moment per Section 4.7.3 (Weighted Average Bending Strength):

Dimensions:

$$C_{cf} := \frac{d}{2} - t_w \quad C_{cf} = 4.418 \text{ in}$$

$$C_{cw} := \frac{d}{2} - (2 \cdot t_w) \quad C_{cw} = 4.336 \text{ in}$$

$$C_{if} := \frac{d}{2} \quad C_{if} = 4.5 \text{ in}$$

$$C_{tw} := C_{cw} \quad C_{tw} = 4.336 \text{ in}$$

Flange Group Moment of Inertia: $I_f := 2 \cdot \left[\left(\frac{b \cdot t_f^3}{12} \right) + b \cdot t_f \cdot \left(\frac{d}{2} - \frac{t_f}{2} \right)^2 \right]$ $I_f = 23.139 \text{ in}^4$

Web Group Moment of Inertia: $I_w := 2 \cdot \left[\frac{t_w \cdot (d - 2 \cdot t_f)^3}{12} \right]$ $I_w = 8.066 \text{ in}^4$

$$M_{ac} := \left(\frac{F_{bcxf} \cdot I_f}{C_{cf}} \right) + \left(\frac{F_{bcxw} \cdot I_w}{C_{cw}} \right) \quad M_{ac} = 123.569 \cdot \text{kip} \cdot \text{in}$$

$$M_{at} := \left(\frac{F_{btf} \cdot I_f}{C_{if}} \right) + \left(\frac{F_{btw} \cdot I_w}{C_{cw}} \right) \quad M_{at} = 149.781 \cdot \text{kip} \cdot \text{in}$$

Major Axis Allowable Bending Stress per Section 4.7.3:

$$F_{bma} := \frac{\min(M_{ac}, M_{at})}{S_x} \quad F_{bma} = 20.473 \cdot \text{ksi}$$

Weighted Average for Web/Flange Local Buckling (Section 3.4):

$$F_{bcxa} := \frac{F_{bcxf} \cdot \text{Area}_{flange} + F_{bcxw} \cdot \frac{\text{Area}_{web}}{6}}{\text{Area}_{flange} + \frac{\text{Area}_{web}}{6}} \quad F_{bcxa} = 17.771 \cdot \text{ksi}$$

Maximum Allowable Bending Stress for sections 3.4 & 4.7.3:

$$F_{bx} := \min(F_{bcx}, F_{bcxh}, \max(F_{bma}, F_{bcxw}, F_{bcxf})) \quad F_{bx} = 17.469 \cdot \text{ksi}$$

Major Axis Allowable Bending Moment:

$$M_x := F_{bx} \cdot S_x = 105.437 \cdot \text{kip} \cdot \text{in}$$

Beam net stress capacity based upon axial stress utilization:

Axial compression in beam due to horizontal windward pressure at screen eave and windward mansard rise:

$$f_a := P_{w_wall} \cdot \text{Spacing} \cdot (h_{eave} + \text{Rise})$$

$$\frac{f_a}{F_a} = 0.302$$

Net allowable bending moment:

$$M_n := M_x \cdot \left(1 - \frac{f_a}{F_a} \right) - (M_P + M_{\text{Rise}})$$

$$M_n = 27.557 \cdot \text{kip} \cdot \text{in}$$

Note: If M_n is negative, trial section N.G., select a deeper beam.

$$w := \text{Spacing} \cdot p_{\text{roof}}$$

Allowable span per M_n :

$$L_M := \sqrt{\frac{8 \cdot M_n}{w}}$$

$$L_M = 265.605 \text{ in}$$

Check span limit based upon allowable deflection:

Since deflection limit = $L/60$, then let:

$$\text{Limit}_{\Delta} := 60$$

$$L_{\Delta} := \sqrt[3]{\frac{384 \cdot E \cdot I_x}{\text{Limit}_{\Delta} \cdot 5 \cdot w}}$$

$$L_{\Delta} = 482.544 \text{ in}$$

Allowable beam span based upon frame conditions specified:

$$\text{AllowableSpan} := \min(L_M, L_{\Delta})$$

$$\text{AllowableSpan} = 22.134 \cdot \text{ft}$$