JOSE A MARTINEZ P.E
Civil Structural Engineers
Lic. # PE-031509

DESIGN FOR ALUMINUM RAILING

FOR

18-29 851 MERIDIAN AVE, MIAMI BEACH, FL

24 E. 5th St. Hialeah, FL 33010
Phone: (305)887 4417
Fax: (305)884 3967

ALUMINUM RAILING DESIGN

STRUCTURAL CALCULATIONS

CONTENTS:

1.) MATERIALS

Reference: Aluminum Design Manual 2005 Edition Table 2-22 6061 - T6

1.a) Members: Aluminum Alloy 6061-T6

Allowable Stress for components:

Bending:

-Round or oval tubes:

Fb = 24000 psi Unwelded Metal

Fb = 10500 psi Welded Metal

-Symetric Shapes:

Fb = 19000 psi Unwelded Metal

Fb = 12000 psi Welded Metal

Shear

Fs = 12000 psi Unwelded Metal

Fs = 5000 psi Welded Metal

Elasticity Modulus E = 10100 Ksi

1.b) Welding: Aluminum Filler Alloy 5356

Allowable Stress for Welding:

Fw = 7000 psi

2.) DESIGN INFORMATION

- Florida Building Code 2014

-Alumninum Design Manual, 2005

-Minimum Design Loads for Building and Others Structures, ASCE 7- 10

3.) DESIGN LOADS

-Handrail Design Loads: (FBC 2014)

Concentrated Load = 200 lbs applied at any point in any direction.

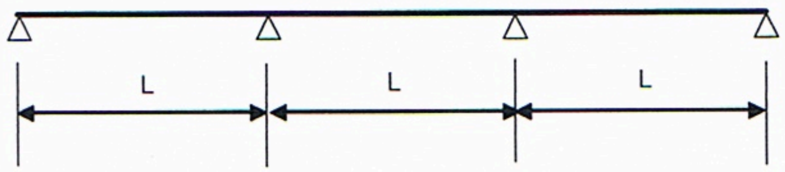
Uniform Load = 50 plf applied in any direction

-Guardrail System Loads: (FBC 2014)

Uniform Hor. Load= 25 psf over the gross area of the guard, including the area of any openings in the guard.

4.) HANDRAIL DESIGN

Consider three equal continuos Span $L := 4 \cdot ft$ (Maximum Span)



4.a) Maximum Moment:

Concentrated Load $P := 200 \cdot lb$

$$Mpmax := \frac{P \cdot L}{5} \qquad \boxed{Mpmax = 160\,ft \cdot lb}$$

Uniform Load $\omega := 50 \cdot plf$

$$M\omega max := 0.1012\omega \cdot L^2 \qquad \boxed{M\omega max = 80.96\,ft \cdot lb}$$

$$Mmax := max(Mpmax, M\omega max) \qquad \boxed{Mmax = 160\,ft \cdot lb}$$

4.b) Maximum Shear:

Concentrated Load $P := 200 \cdot lb$

$$Vpmax := P \qquad \boxed{Vpmax = 200\,lb}$$

Uniform Load $\omega := 50 \cdot plf$

$$V\omega max := 0.6\omega \cdot L \qquad \boxed{V\omega max = 120\,lb}$$

$$Vmax := max(Vpmax, V\omega max) \qquad \boxed{Vmax = 200\,lb}$$

4.c) Section Required:

Bending Design: $Fb := 12000 \cdot psi$

Section Modulus Required:

$$Shr := \frac{Mmax}{Fb} \qquad \boxed{Shr = 0.16 \cdot in^3}$$

Shear Design: $Fs := 5000 \cdot psi$

Section Modulus Required:

$$Ahr := \frac{1.5Vmax}{Fs} \qquad \boxed{Ahr = 0.06 \cdot in^2}$$

4.d) Section Provided:

ALUMINUM DIXIE CAP 2 5/8"

Section Provided:

$Sprov := 0.39 \cdot in^3$ $\qquad Sprov = 0.39 \cdot in^3$

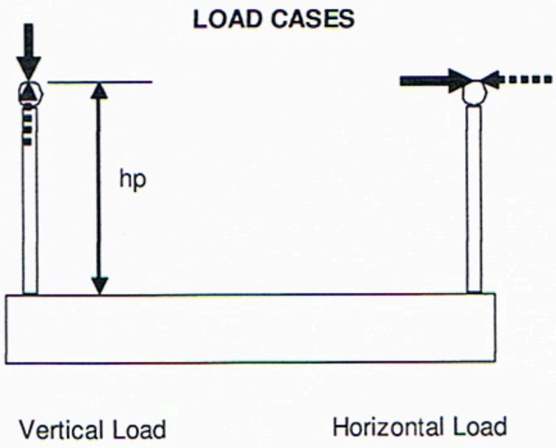
$Aprov := 0.834 \cdot in^2$ $\qquad Aprov = 0.83 \cdot in^2$

Control := if (Shr > Sprov, "NOT O.K." , " O.K.") $\boxed{\text{Control = " O.K."}}$

Control := if (Ahr > Aprov, "NOT O.K." , " O.K.") $\boxed{\text{Control = " O.K."}}$

USE ALUMINUM DIXIE CAP 2 5/8"

5.) POST DESIGN



5.a) Maximum Reaction

Concentrated Load $Rpmax := P$ $Rpmax = 200\,lb$

Uniform Load $R\omega max := \omega \cdot L$ $R\omega max = 200\,lb$

$Rmax := if(Rpmax > R\omega max, Rpmax, R\omega max)$ $\boxed{Rmax = 200\,lb}$

5.b) Maximum Moment

$hp := 42 \cdot in$

$Mpost := Rmax \cdot hp$ $\boxed{Mpost = 8400\,lb \cdot in}$

5.c) Maximum Shear

$Vpost := Rmax$ $\boxed{Vpost = 200\,lb}$

5.d Section Required:

Bending:

$Fb := 12000 \cdot psi$ $\quad Fv := 5000 \cdot psi$

$$Spostreq := \frac{Mpost}{Fb} \qquad \boxed{Spostreq = 0.7 \cdot in^3}$$

Shear:

$$Apostreq := 1.5 \frac{Vpost}{Fv} \qquad Apostreq = 0.06 \cdot in^2$$

5.d Section Provided:

Square Tube Section $\quad b := 2 \cdot in \quad t := \frac{1}{4} \cdot in$

Square Section Tube exterior $\quad t := 2$ in $\quad tw := \frac{1}{4}$ in

$$Ipt := \frac{1}{12} \cdot \left[t^4 - (t - 2tw)^4 \right] \qquad Ipt = 0.911 \quad in^4$$

$$Spt := \frac{Ipt}{\frac{t}{2}} \qquad Spt = 0.911 \quad in^3$$

$$Apt := t^2 - (t - 2 \cdot tw)^2 \qquad Apt = 1.75 \quad in^2$$

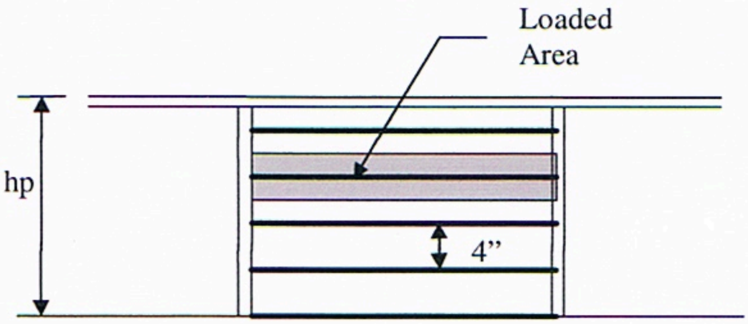
$$Aptw := 2 \cdot t \cdot tw \qquad Aptw = 1 \quad in^2$$

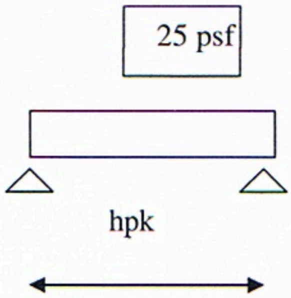
Sprov = 0.75 in^3 $\quad$ Aprov = 0.75 in^2

USE 2" x 2" x 1/4" Aluminum Tube

6.) PICKET DESIGN:

$hpk := 48 \cdot in \qquad hpk = 48 \cdot in$





$psf := \frac{lb}{ft^2}$

$w := 25 \cdot psf \cdot 4.75 \cdot in \qquad w = 0.82 \cdot \frac{lb}{in}$

$Mmaxpk := \frac{1}{8} \cdot w \cdot hpk^2 \qquad Mmaxpk = 237.5 \cdot lb \cdot in$

$Vmaxpk := \frac{w \cdot hpk}{2} \qquad Vmaxpk = 19.79 \cdot lb$

Section Required:

$Fb := 12000 \cdot psi$ $Fv := 5000 \cdot psi$

Bending Design:

$psi := \frac{lb}{in^2}$

Section Modulus Required:

$$Spkreq := \frac{Mmaxpk}{Fb} \qquad Spkreq = 0.02 \cdot in^3$$

Shear Design:

Area Required:

$$Apktreq := \frac{1.5 \cdot Vmaxpk}{Fv} \qquad Apktreq = 0.006 \cdot in^2$$

Section Provided:

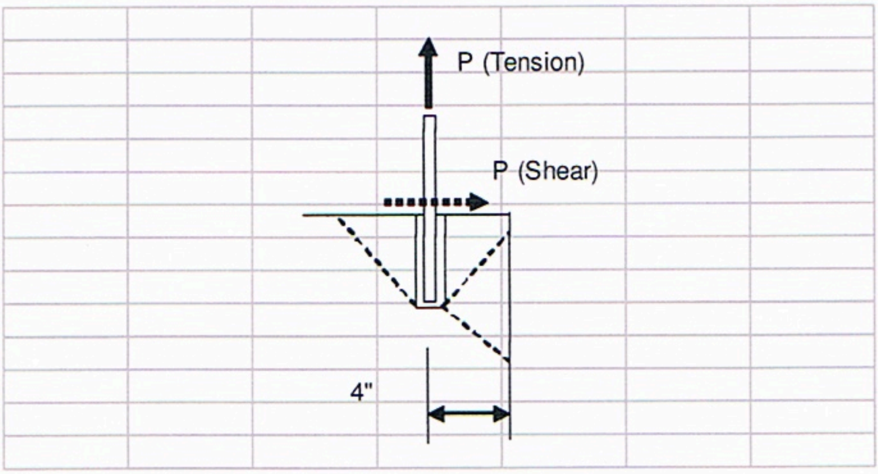
ALUMINUM TUBE 1"X2"X1/8" ALUMINUN TUBE

Spt =0.114 in^3 Apt=0.312 in^2

USE ALUMINUM TUBE PICKET 1"X2"X1/8"

7.) ANCHORAGE, WELDING AND CONNECTIONS.

7.a) POST ANCHORAGE TO CONCRETE



Concrete Strength: $fc := 3000 \cdot psi$

Minimum Embedment: $emb := 4 \cdot in$

Hole Diameter: $hd := 2 \cdot in$

Post Heigth: $hp := 42 \cdot in$

Horizontal or Vertical Load: $P := 200 \cdot lb$

Minimum Edge Distance: $dedge := 4 \cdot in$

a) Concrete Breakout (Tension)

$ANo := 9 \cdot emb^2$ $\quad ANo = 144 \cdot in^2$

$AN := 3 \cdot emb \cdot (1.5 \cdot emb + dedge)$ $\quad AN = 120 \cdot in^2$

$ANfinal := \min(ANo, AN)$ $\quad ANfinal = 120 \cdot in^2$

$\psi 2 := \text{if}\left(dedge < 1.5 \cdot emb, 0.7 + 0.3 \cdot \dfrac{dedge}{1.5 \cdot emb}, 1\right)$ $\quad \psi 2 = 0.9$

$\psi 3 := 1.4$

$Nb := 17 lb^{.5} \cdot in^{-0.5} \cdot \sqrt{fc} \cdot emb^{1.5}$ $\quad Nb = 7449.03\ lb$

$$Ncb := \frac{ANfinal}{ANo} \cdot \psi 2 \cdot \psi 3 \cdot Nb \qquad \boxed{Ncb = 7821.48\,lb}$$

$Pu := 1.6 \cdot P$ $\quad Pu = 320\,lb$ $\quad \phi := 0.75$ $\quad \phi Ncb := \phi \cdot Ncb$

$\phi Ncb = 5866\,lb$

$Control := if(Pu > \phi \cdot Ncb, \text{"NOT O.K."}, \text{"O.K."})$ $\quad \boxed{Control = \text{"O.K."}}$

b) Pullout Strength of Anchor in Tension

Weld Size $\quad t := \frac{1}{8} \cdot in$ $\quad fc := 3000 \cdot psi$

$b := 2 \cdot in$ $\quad$ Effective Weld Size $\quad teff := 0.707 \cdot t$ $\quad teff = 0.09 \cdot in$

$Abrg := 4 \cdot b \cdot teff$ $\quad Abrg = 0.71 \cdot in^2$ $\quad \psi 4 := 1.4$

$Npn := \psi 4 \cdot Abrg \cdot 8 \cdot fc$ $\quad Npn = 23755.2\,lb$

$Control := if(Pu > \phi \cdot Npn, \text{"NOT O.K."}, \text{"O.K."})$ $\quad \boxed{Control = \text{"O.K."}}$

b) Concrete Breakout (Shear) $\quad$ Bolt Diameter: $\quad do := 2.0 \cdot in$

$AVo := 4.5 \cdot dedge^2$ $\quad AVo = 72 \cdot in^2$

$AV := AVo$ $\quad AV = 72 \cdot in^2$

Assume Depth of Support > 1.5dedge

$\psi 6 := 1$ $\quad \psi 7 := 1.4$

$lo := \min(emb, 8 \cdot do)$ $\quad lo = 4 \cdot in$

$$Vb := 7 \cdot lb^{0.5} \cdot in^{-1} \cdot \left[\left(\frac{lo}{do}\right)^{0.2} \cdot \sqrt{do} \cdot \sqrt{fc} \cdot dedge^{1.5}\right] \qquad Vb = 4982.76\,lb$$

$$Vcb := \frac{AV}{AVo} \cdot \psi 6 \cdot \psi 7 \cdot Vb \qquad \boxed{Vcb = 6975.86\,lb}$$

$Vu := 1.6 \cdot P$ $\quad Vu = 320\,lb$ $\quad \phi := 0.75$

$Control := if(Vu > \phi \cdot Vcb, \text{"NOT O.K."}, \text{"O.K."})$ $\quad \boxed{Control = \text{"O.K."}}$

USE 3" HOLE DIAMETER. 4" MIN. EDGE DISTANCE AND 4" MIN. EMB.
USE 1/8" WELD SIZE AROUND BOTTOM END OF POST.

7.b) POST - BOTTOM RAILING CONNECTION

Try 1/8" Weld Aluminum Filler Alloy 5356 $Fw := 7000 \cdot psi$

Effective Width = $\frac{1}{8} \cdot 0.707in = 0.09 \cdot in$

Area of Welding $Aw := \left(2 \cdot \frac{7}{8} \cdot in + 1.75 \cdot in\right) \cdot 0.088 \cdot in$ $Aw = 0.308 \cdot in^2$

Allowable Shear $Vallow := Aw \cdot Fw$ $Vallow = 2156 lb$ > 200 lb **O.K.**

USE 1/8" WELD SIZE ALUMINUM FILLER ALLOY 5356