STRUCTURAL CALCULATIONS (SHOP DRAWING)

PROJECT: 5900 SW 114TH TERRACE
PINECREST, FL 33156

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CARLOS LOPEZ REYES, P.E. ASSUMES RESPONSIBILITY FOR BOTH MANUAL AND COMPUTER-GENERATED CALCULATIONS

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CHAPTER # 1: GLASS RAILING AT STAIR

1 SCOPE OF WORK

THIS DOCUMENT INCLUDES THE CALCULATION FOR THE FALLOWING SYSTEMS:

- INTERIOR GLASS RAILING.

2 DESIGN CRITERIA

FLORIDA BUILDING CODE 2023 EDITION

200 LBS CONCENTRATED LOAD ACTING ANY DIRECTION

50 LBS/FT DISTRIBUTED LOAD ACTING ANY DIRECTION

3 GLASS BALUSTRADE GUARD RAIL

Glass Light Height	h=	44 in
Railing Guard Height	H=	42 in
Concentrated Load	P=	200 lbs
Distributed Load	q=	50 plf

3.1 Glass Bending Strenght.

Glass Thickness t= 0.5625 in

$S_x = 12*t^2/6 = 2*t^2 =$ 0.633 in^3/ft.

$F_{b\ live} = 24000/4 =$ 6,000 psi

$F_{b\ wind} = 10,600 =$ 10,600 psi - Per ASTM E1300

$M_{alllive} = F_{b\ live} \times S =$ 316.5 ft-lbs

$M_{allwind} = F_{b\ wind} \times S =$ 559.2 ft-lbs

1) Concentrated Load 200 lbs

The worst case is with the load at end of panel top corner with no top rail. The Load will be initially resisted by a strip.

b1 = 8*t = 4.5 in

At 2" from top

Max moment M_{max1} = 200*2 = 400 in-lbs

Bending Stress $f_{bx1} = (M_{max1}/S_x)/(b1/12)$ = 1,685.1 psi > $F_{b\ live}$ = 6,000 psi OK.

At bottom of panel

The shear will transfer along the glass 45 degree angle to spread across the panel.

b2 = b1 + h = 48.5 in

Max moment M_{max2} = 200*h = 8,800 in-lbs

Bending Stress $f_{bx2} = (M_{max2}/S_x)/(b2/12)$ = 3,439.7 psi > $F_{b\ live}$ = 6,000 psi OK.

2) Uniformly Distributed Load 50 lbs/ft

Max moment M_{max3} = 50*h = 2,200 in-lbs

Bending Stress $f_{bx3} = M_{max3}/S_x$ = 3,475.5 psi > $F_{b\ live}$ = 6,000 psi OK.

3.2 Deflection.

E= $1.04*10^7$ psi

t= 0.5625 in

Deflection $\Delta = P*h^3/(3*E*(b2/12)*t^3)$ = 0.75 in (200 lbs load min width) OK

Deflection $\Delta = u*h^3/(3*E*t^3)$ = 0.77 in (50 plf load) OK

ASTM E-2358 limits deflection to h/12 (3.5" for 42" guard height). For comfort level it is recommended to limit the deflection to 1" for 42" guard height.

3.3 Check Connection.

Connect with standoff to concrete using 3/8" x 3-3/4" concrete anchor hilti kbtz bolt with min. embedment of 3" into 3,000 psi concrete.

Reactions are calculated using summation of forces and summation of moments:

V=D+L

Where D = glass dead load plus cap rail or other attachments to the glass.

L = greater of 200# or 50plf* B

Where B= 41.125” = 3.43ft

L_1=200#

L_2=50plf*3.43ft=171.5#

L=Max(L_1,L_2)=200#

Vertical load share per standoff:

V_s=D/2 standoffs.

D= 6.83*(3.43’*4.42’) = 104#

V_s=D/2 = 104/2 = 52#

Assumes vertical load is supported on any 2 standoffs to allow for construction tolerances, glass expansion and contraction and other factors that may cause uneven vertical loading on the standoffs.

Moment on standoffs from vertical force:

$M_v = V_s*k$

Where k = distance from centerline of glass to face of support attachment, typically 2” for standard fitting.

M_v = 52*2 = 104#-in

For horizontal loading, moment about upper standoffs:

M_L = 50plf*B*h or 200#*h

M_L = 200*40.1875 = 8037.5 /3-in

$M_T = M_L + M_v$

M_T = 8037.5 + 104 = 8141.5 #-in

Glass standoffs resist loading by forming a couple (tension and compression reactions)

Two pairs of standoffs per panel

Calculate R_1 by ΣM about R_u

$\Sigma M = M_T+(a-c)^* R_1 = 0$

$R_1 = M_T/(a-c)$

Typically a-c = 4” minimum

R_1 = 8141.5/4 = 2035.375 #

Load share to individual standoff:

$R_{s1} = R_1 /n$ where n = number of standoff pairs, 2 or 3. In this project is 2 pairs

R_{s1} = 2035.375/2 = 1017.69 #

$R_u = R_1+F$ where F = either wind force or live load depending on which produced the greatest moment.

R_u= 2035.375+200 = 2235.375#

$R_{su} = R_u /n$.

R_{su} = 2235.375/2 = 1117.69#

Standoff anchors – 3/8" stainless steel threaded rod to standoff and 3/8" rod to steel support.

Tensile area of 3/8" threaded rod (UNC) = 0.0775 in^2

Rod strength = (0.6*75ksi) * 0.0775 in^2 = 3,487#

Check thread strength into standoff – minimum thread embed = 3/8"

Internal thread stripping area = 0.828 in^2 for 3/8 – 16 threads

Allowable load on threads = $0.58*A_{sn}*t*F_{tu}/3$ = 0.58*0.828*(3/8)*45ksi/3 = 2,700#

Allowable shear strength = 0.3*75 ksi*0.0775 in^2 = 1,744#

Determine tension and shear on mounting stud:

From Σ forces:

Vertical loads will increase tension force in mounting stud:

D= 6.83*(3.43'*4.42') = 104# < 1744# OK

$T = T_M$+V*2"/1"

T= 2235.375+104*2"/1" =2443.375# < 2700# OK

Check Interaction of shear and tension. Check combined tension and shear on anchors:

T/2,700 + D/1,744 < 1.2

2443.375/2700 + 104/1744 = 0.965 < 1.2 OK

CHAPTER # 2: GLASS RAILING AL BALCONY

1 SCOPE OF WORK

THIS DOCUMENT INCLUDES THE CALCULATION FOR THE FALLOWING SYSTEMS:

- EXTERIOR RAILING AS DESIGNED AND MANUFACTURED BY ALUVETRO SRL.

2 DESIGN CRITERIA

FLORIDA BUILDING CODE 2023 EDITION

200 LBS CONCENTRATED LOAD ACTING ANY DIRECTION

50 LBS/FT DISTRIBUTED LOAD ACTING ANY DIRECTION

50 PSF WIND LOAD

3 GLASS BALUSTRADE GUARD RAIL

Glass Light Height	h=	34 3/16 in
Railing Guard Height	H=	36 in
Concentrated Load	P=	200 lbs
Distributed Load	q=	50 plf
Wind Load	Pd=	50 psf

3.1 Glass Bending Strenght.

Glass Thickness t= 0.81 in

$S_x = 12*t^2/6 = 2*t^2 =$ 1.3122 in^3/ft.

$F_{b\ live} = 24000/4 =$ 6,000 psi

$F_{b\ wind} = 10{,}600 =$ 10,600 psi - Per ASTM E1300

$M_{alllive} = F_{b\ live} \times S =$ 381.04 ft-lbs

$M_{allwind} = F_{b\ wind} \times S =$ 673.17 ft-lbs

1) Concentrated Load 200 lbs

The worst case is with the load at end of panel top corner with no top rail. The Load will be initially resisted by a strip.

$b1 = 8*t =$ 6.48 in

At 2” from top

Max moment $M_{max1} = 200*2 =$ 400 in-lbs

Bending Stress $f_{bx1} = (M_{max1}/S_x)/(b1/12) =$ 564.5 psi > $F_{b\ live}$ = 6,000 psi OK.

At bottom of panel

The shear will transfer along the glass 45 degree angle to spread across the panel.

$b2 = b1 + h =$ 40.67 in

Max moment $M_{max2} = 200*h =$ 6,837 in-lbs

Bending Stress $f_{bx2} = (M_{max2}/S_x)/(b2/12) =$ 1,537.5 psi > $F_{b\ live}$ = 6,000 psi OK.

2) Uniformly Distributed Load 50 lbs/ft

Max moment $M_{max3} = 50*h =$ 1,709.4 in-lbs

Bending Stress $f_{bx3} = M_{max3}/S_x =$ 1,303 > $F_{b\ live}$ = 6,000 psi OK.

3) Wind Load Pd = 50 psf

UDL = Pdx12/12 = 50 lbs/ft

Max moment $M_{max4} = 0.55xUDLxh^2/12 =$ 2,678.5 in-lbs

Bending Stress $f_{bx4} = M_{max4}/S_x =$ 2,041.2 psi > $F_{b\ live}$ = 10,600 psi OK.

3.2 Deflection.

E= $1.04*10^7$ psi

t= 0.81 in

Deflection $\Delta = P*h^3/(3*E*(b2/12)*t^3) =$ 0.14 in (200 lbs load min width) OK

Deflection $\Delta = u*h^3/(3*E*t^3) =$ 0.12 in (50 plf load) OK

Deflection $\Delta = Pd/12*h^4/(8*E*t^3) =$ 0.13 in (50 psf wind load) OK

ASTM E-2358 limits deflection to h/12 (3.5” for 42” guard height). For comfort level it is recommended to limit the deflection to 1” for 42” guard height.

3.3 Check Connection.

Connect Base Shoe to concrete using 3/8” diameter wedge bolt with min. embedment of 3_1/2” into 3,000 psi concrete at 4.9” o.c.

Allowable Tension/Pullout $T_{a\ nom}$= 2,035 lbs

Load adjustment factor for spacing f_{AN} = 0.86

Then the reduced Allowable Tension/Pullout Ta =$T_{a\ nom}$*f_{AN} = 1,750 lbs

Allowable Shear $V_{a\ nom}$= 1,735 lbs

Load adjustment factor for spacing f_{AN} = 0.67

Then the reduced Allowable Shear Va =$V_{a\ nom}$*f_{AN} = 1,162 lbs

Anchors spacing As = 4.9 in

Resistant arm of anchor d= 1.25 in

1) Concentrated Load 200 lbs

Max moment M_{max1} = 200*h = 6,837.5 in-lbs

End reaction at base shoe R1 = 200 lbs.

b3 = b1 +H = 42.67 in

Number of anchors in minimum width b3 of 200 lbs N1 = b3/As = 8.71

Max pull out/ tension of the anchor

T1 = (M_{max1}/d)/N1 = (6,837.5/1.25)/8.71= 628.01 lbs

Shear of the anchor

V1 = R1/N1 = 200/8.71= 22.96 lbs

Combined Tension / Pullout and Shear

T1/Ta + V1/Va = (628.01/1,750)+(22.96/1,162) = 0.339 < 1.0 OK.

2) Uniformly Distributed Load 50 lbs/ft

Max moment M_{max2} = 50*H = 1,800 in-lbs

End reaction at base shoe R2 = 158.3 lbs.

Number of anchors in unit width of 50 lbs/ft N2 = 12/As = 2.45

Max pull out/ tension of the anchor

T2 = (M_{max2}/d)/N2 = (1,80/1.25)/2.45= 587.76 lbs

Shear of the anchor

V2 = R2/N2 = 158.3/2.45 = 64.61 lbs

Combined Tension / Pullout and Shear

T2/Ta + V2/Va = (587.76/1,750)+(64.61/1,162) = 0.391 < 1.0 OK.

3) Wind Load Pd = 50 psf

UDL = Pdx12/12 = 50 lbs/ft

Max moment M_{max3} = 1/2*UDL*H^2/12 = 2,700 in-lbs

End reaction at base shoe R3 = UDL*H = 150 lbs.

Number of anchors in unit width of 50 lbs/ft N3 = 12/As = 2.45

Max pull out/ tension of the anchor

T3 = (M_{max3}/d)/N3 = (2,700/1.25)/2.45= 881.63 lbs

Shear of the anchor

V3 = R3/N3 = 150/2.45 = 61.22 lbs

Combined Pullout / Tension and Shear

T3/Ta + V3/Va = (881.63/1,750)+(61.22/1,162) = 0.556 < 1.0 OK.