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Guardrail Calculations

For

Drawing 1056

Fabricators:

High Point JS Welding
Architectural Metal Fabricators, LLC
418 Route 206
Montague, New Jersey 07827
Tel: (973) 293-8330
Fax: (973) 293-8331

Drawing: 1056
Date: 11/05/2014

Drawings Reviewed:
SHT-1: Guardrail Calculation, Railing Layout Plan

STATE OF NEW YORK
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LICENSED PROFESSIONAL ENGINEER

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Guard and Railing Code Requirements

Per 2010 Building Code of New York State:

All handrail and guardrail systems shall be designed to resist a single concentrated load of 200 lb load applied in any direction at any point on the handrail or top rail and to transfer this load through the supports to the structure to produce the maximum load effect on the element being considered. Further, all handrail and guardrail systems shall be designed to resist a 50 lb/ft uniform load applied in any direction along the handrail or top rail. The greatest load combination shall govern.

Intermediate rails (all those except the handrail), and panel fillers shall be designed to withstand a horizontally applied normal load of 50 lb on an area not to exceed 12 in. by 12 in. including openings and space between rails and located so as to produce the maximum load effects. Reactions due to this loading are not required to be superimposed with the loads specified in either preceding paragraph.

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Guardrail Calculations – SHT-1

Typical Aluminum Picket Type Guardrail Detail

Post and rail section properties:

Pipe1 ½Ø Schedule 40, OD = 1.90", tw = 0.145"

S = 0.326 in^3, I = 0.310 in^4, L = 60", H = 42"

Aluminum Alloy 6061-T6 (Unwelded)

Fb = 27.6 ksi, Fy = 38 ksi, E = 10,100 ksi

Rail Maximum Load, w = 50 plf

M = w l^2 / 12 = 50 plf x $5'^2$ / 12 = 104.17 lb-ft = 1,250 lb-in

Smin = M / Fb = 1,250 lb-in / 27,600 psi = 0.045 in^3

S = 0.326 in^3 > Smin = 0.045 in^3 OK

Rail Stiffness, K_R = E I_R / L = 10,100,000 psi x 0.31 in^4 / 60"

K_R = 52,183.33

Post Stiffness, KP = E I_P / H = 10,100,000 psi x 0.31 in^4 / 42"

K_P = 74,547.62

Stiffness Ratio, R = K_R / K_P = 52,183.33 / 74,547.62 = 0.70

Load Proportion Factor, P_F = 0.82 (Graph)

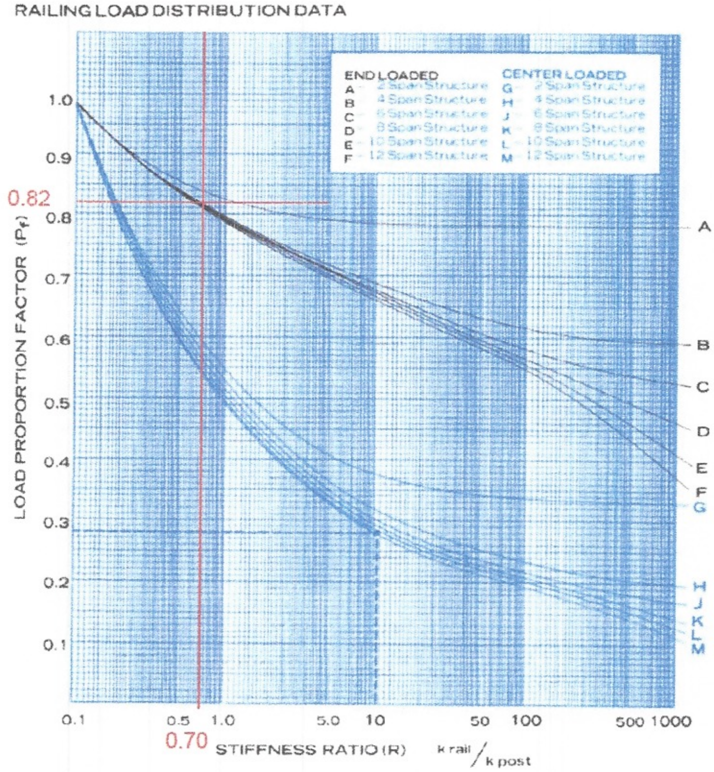
Post Maximum Load, P = w l = 50 plf x 5' = 250 lb x 0.82 = 205 lb

M = P L / 2 = 205 lb x 42" / 2 = 4,305 lb-in

Smin = M / Fb = 4,305 lb-in / 27,600 psi = 0.156 in^3

S = 0.326 in^3 > Smin = 0.156 in^3 OK

RAILING LOAD DISTRIBUTION DATA



The stiffness of a rail or post is

$k = \frac{E \times I}{h}$ for the post

$k = \frac{E \times I}{L}$ for the rail

Stiffness ratio is determined as

$R = \frac{k\,rail}{k\,post}$

The stiffness ratio (R) is then plotted on the chart at left to obtain Load Proportion Factor (P_f).

When the load proportion factor has been determined, it is multiplied by the total load to determine the load one post must sustain.

This graph has been determined by computer analysis and confirmed by laboratory test.

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Ornamental Aluminum Picket Guardrail Type #1

Post section and equivalent rail properties:
TS1 ½x1 ½x¼, $S = 0.4514\ in^3$, $I = 0.3385\ in^4$, L = 53.5", H = 39"
Aluminum Alloy 6061-T6 (Unwelded)
Fb = 27.6 ksi, Fy = 38 ksi, E = 10,100 ksi

Ornamental Rail #HP1001 section properties:
Manufacturer to provide exact properties
Rail Maximum Load, w = 50 plf

$M = w\ l^2 / 12 = 50\ plf \times 5'^2 / 12 = 104.17\ lb\text{-}ft = 1{,}250\ lb\text{-}in$

$Smin = M / Fb = 1{,}250\ lb\text{-}in / 27{,}600\ psi = 0.045\ in^3$

Rail Stiffness, $K_R = E\ I_R / L = 10{,}100{,}000\ psi \times 0.3385\ in^4 / 60"$

$K_R = 56{,}980.83$

Post Stiffness, $K_P = E\ I_P / H = 10{,}100{,}000\ psi \times 0.3385\ in^4 / 42"$

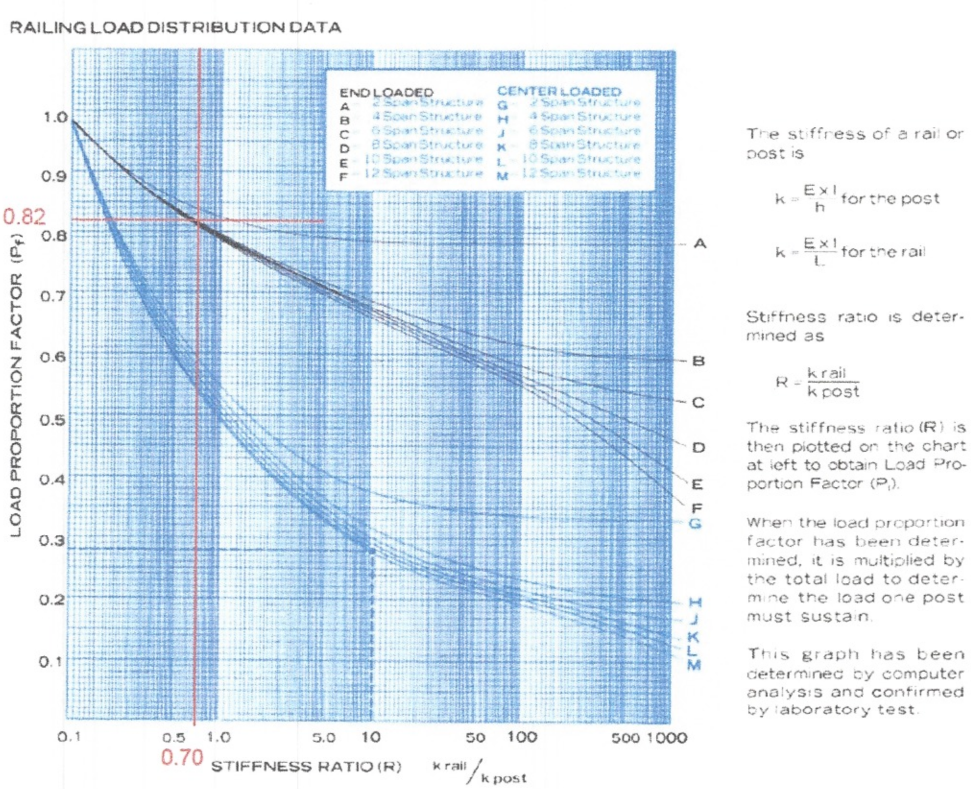
$K_P = 81{,}401.19$

Stiffness Ratio, $R = K_R / K_P = 56{,}980.33 / 81{,}401.19 = 0.70$

Load Proportion Factor, PF = 0.82 (Graph)

Post Maximum Load, P = 250 lb x 0.82 = 205 lb
M = P L / 2 = 205 lb x 42" / 2 = 4305 lb-in
Bending stress, fb = M / S = 4305 lb-in / $0.4514\ in^3$ = 9537 psi

<u>Bending stress ratio = 9537 psi / 27.6 ksi = 0.345 ≤ 1.0 OK</u>



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Ornamental Aluminum Picket Guardrail Type #2

Post section and equivalent rail properties:
TS2x2x1/8, S = 0.552 in^3, I = 0.552 in^4, L = 60", H = 42"
Aluminum Alloy 6061-T6 (Unwelded)
Fb = 27.6 ksi, Fy = 38 ksi, E = 10,100 ksi

Ornamental Rail #HP1001 section properties:
Manufacturer to provide exact properties
Rail Maximum Load, w = 50 plf

$M = w\,l^2 / 12 = 50 \text{ plf} \times 5'^2 / 12 = 104.17 \text{ lb-ft} = 1{,}250 \text{ lb-in}$

$S_{min} = M / Fb = 1{,}250 \text{ lb-in} / 27{,}600 \text{ psi} = 0.045 \text{ in}^3$

Rail Stiffness, $K_R = E\,I_R / L = 10{,}100{,}000 \text{ psi} \times 0.552 \text{ in}^4 / 60"$

$K_R = 92{,}920$

Post Stiffness, $K_P = E\,I_P / H = 10{,}100{,}000 \text{ psi} \times 0.552 \text{ in}^4 / 42"$

$K_P = 132{,}742.86$

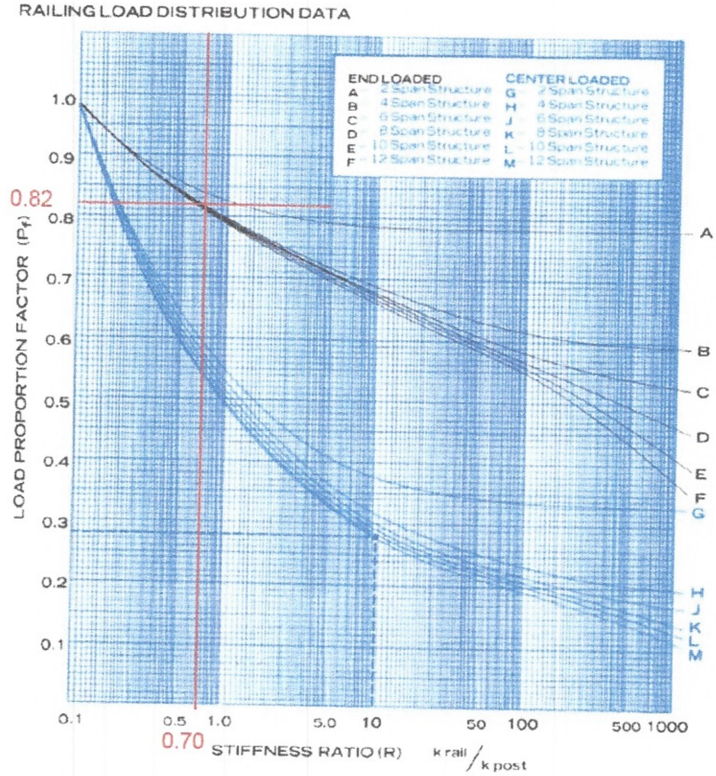
Stiffness Ratio, $R = K_R / K_P = 92{,}920 / 132{,}742.86 = 0.70$

Load Proportion Factor, PF = 0.82 (Graph)

Post Maximum Load, P = 250 lb x 0.82 = 205 lb
M = P L / 2 = 205 lb x 42" / 2 = 4305 lb-in
Bending stress, fb = M / S = 4305 lb-in / 0.552 in^3 = 7799 psi

<u>Bending stress ratio = 7799 psi / 27.6 ksi = 0.283 $\leq$ 1.0 OK</u>

RAILING LOAD DISTRIBUTION DATA



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Guardrail Type #2 Base Plate

M = 4305 lb-in
Base Plate properties:
PL5x5x3/8, S = 5" x 0.375"^{2} / 6 = 0.117 in^3, Aluminum Alloy 6061-T3
Fb = 27.6 ksi, Fy = 38 ksi, E = 10,100 ksi

Square, Stiffened / Unstiffened Base Plate, Any Rod Material - Rev. F /G

Assumptions:
1) Rod groups at corners. Total # rods divisible by 4. Maximum total # of rods = 48 (12 per Corner).
2) Rod Spacing = Straight Center-to-Center distance between any (2) adjacent rods (same corner)
3) Clear space between bottom of leveling nut and top of concrete **not** exceeding (1)*(Rod Diameter)

Site Data

BU#:	*Type #2 Base Plate*
Site Name:	
App #:	

Base Reactions

TIA Revision:	G	
Factored Moment, Mu:	0.35875	ft-kips
Factored Axial, Pu:	0.25	kips
Factored Shear, Vu:	0.25	kips

Anchor Rod Data

Eta Factor, η	0.7	TIA G (Fig. 4-4)
Qty:	4	
Diam:	0.5	in
Rod Material:	Other	
Yield, Fy:	36	ksi
Strength, Fu:	58	ksi
Bolt Circle:	5	in

Anchor Rod Results

TIA G --> Max Rod (Cu+ Vu/η):	1.0 Kips
Axial Design Strength, Φ*Fu*Anet:	6.6 Kips
Anchor Rod Stress Ratio:	15.4% **Pass**

Plate Data

W=Side:	5	in
Thick:	0.375	in
Grade:	27.6	ksi
Clip Distance:	0	in

Base Plate Results — Flexural Check

Base Plate Stress:	8.6 ksi
PL Design Bending Strength, Φ*Fy:	24.8 ksi
Base Plate Stress Ratio:	34.6% **Pass**

PL Ref. Data

Yield Line (in):	4.58
Max PL Length:	5.07

Stiffener Data (Welding at both sides)

Configuration:	Unstiffened	
Weld Type:		**
Groove Depth:		in **
Groove Angle:		degrees
Fillet H. Weld:		<-- Disregard
Fillet V. Weld:		in
Width:		in
Height:		in
Thick:		in
Notch:		in
Grade:		ksi
Weld str.:		ksi
Clear Space between Stiffeners at B.C.		in

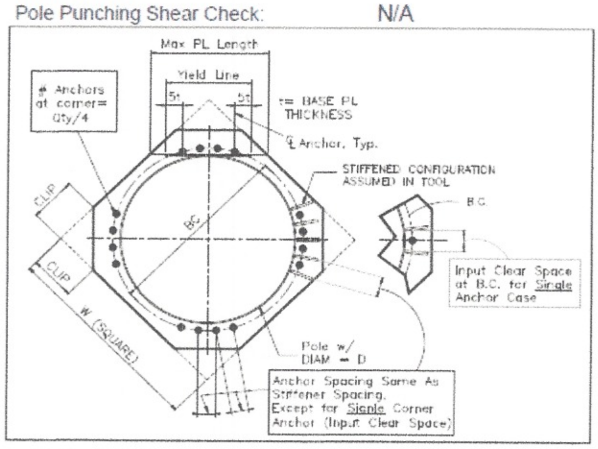
N/A - Unstiffened

Stiffener Results

Horizontal Weld :	N/A
Vertical Weld:	N/A
Plate Flex+Shear, fb/Fb+(fv/Fv)^2:	N/A
Plate Tension+Shear, ft/Ft+(fv/Fv)^2:	N/A
Plate Comp. (AISC Bracket):	N/A

Pole Results

Pole Punching Shear Check:	N/A



Pole Data

Diam:	2	in
Thick:	0.125	in
Grade:	27.6	ksi
# of Sides:	4	"0" IF Round

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¾"Ø Schedule 40 Round Aluminum Baluster design

Section properties:
S = 0.071 in^3, Span = 34.2"
Three balusters cover 12" x 12" lateral force area
M = P l / 4 = 50 lb x 34.2" / 4 = 428 lb-in
Smin = M / Fb = 0.428 kip-in / 27.6 ksi = 0.0155 in^3
<u>S = (3) 0.071 in^3 = 0.213 in^3 > Smin = 0.0155 in^3, OK</u>

¾"x¾"x0.062" Square Aluminum Baluster Type #1 design

Section properties:
S = 0.036 in^3, Span = 37.13"
Three balusters cover 12" x 12" lateral force area
M = P l / 4 = 50 lb x 37.13" / 4 = 464 lb-in
Smin = M / Fb = 0.464 kip-in / 27.6 ksi = 0.0168 in^3
<u>S = (3) 0.036 in^3 = 0.108 in^3 > Smin = 0.0168 in^3, OK</u>

¾"x¾"x0.062" Square Aluminum Baluster Type #2 design

Section properties:
S = 0.036 in^3, Span = 35.5"
Three balusters cover 12" x 12" lateral force area
M = P l / 4 = 50 lb x 35.5" / 4 = 444 lb-in
Smin = M / Fb = 0.444 kip-in / 27.6 ksi = 0.0161 in^3
<u>S = (3) 0.036 in^3 = 0.108 in^3 > Smin = 0.0161 in^3, OK</u>

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