ALEXANDER HADDAD

PROFESSIONAL ENGINEER.

JOB ADDRESS: 2028 PALISADES
LOS ANGELES, CA

DATE:9/03/2023

Design/ verification of guard rail connection.

Rail height: 42" Max, above platform.
Post: 1.5"X1.5"X 1/8", Schedule 40 (*Where applicable)*
Shoe connection: Weld &/ or ESR - 3269
Baseplate, or angle thickness: 1/2"

APPLICALBEL CODES: CBC 2022 & AISC 7-16 (Based on 50 plf. uniform lateral @ top of rail, or 200 lbs. lateral point load @ top of rail @ 4 ft O.C.)
AISC 15TH EDITION:
STEEL TUBE INSTITUTE OF NORTH AMERICA (*where applicable)*
NDS MANUAL (*Where applicable)*

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BASE SHOE WELDED CONNECTION FOR GLASS GUARD RAIL DESIGN (*Welded to ½" metal angle*)

BASE SHOE IS CONTINUOUS.

P = 200 LBS. *Lateral point load, or 50 pounds uniform along top rail.*

M_{AX} = 200 LBS X 42" = 8,400 in-lbs.

CHECK loading to lag bolts (Couple 4" apart):
Machine bolts welded to back of 6X3.5 X ½ angle, FY = 36 KSI.
T = C = 8,400 in-lb./ 4.0" = 2,100 lbs.
Tensile per bolt = 2.10 Kips
Assume A307, ALL THREAD machine bolts. Tensile = 9.90/2.0 = 4.95 KIPS > 2.1 KIPS. OK

CHECK FILLET WELDS: (3/4" machine bolts side mounted/ weld to 6"x3.5"x1/2" angle)

Theta = 90^0 Based on ¼" fillet.

A_W = 0.707 (1/4) = 0.1678 in-lbs.

SO: F_W = 0.60 (70 ksi) (1.5) = 63 ksi
R_n = (63 ksi) (0.1768 in) = 11.41 k/in
(11.14 k/in)/ 2 = 5.56 k/in, allowable
PARAMETER OF 3/4" BOLT = 2X3.14.15X.75/2.0 = 2.356 inches x 5.56^k = 13.099 x.50 = 6.55 kips > 2.1 kips

BASE SHOE WELDED TO SUPPORTING METAL ANGLE (Option 1)

Weld both sides ¼" fillet, 3" pass both sides of base shoe at 12 inches intervals.

1.5 K/IN X3" pass X2 = 9 KIPS. OK. (Force perpendicular to weld)

====→ PARRALLEL TO AXIS = 0.707 X70X0.30X .025 = 3.71 K/IN
====→ PERPENDICULAR TO THE AXIS = 5.56 K/IN. *OK*

Allowable load to angle, based on 3" fillet weld both sides @ 12" intervals.
*See page 13/20 of the report for illustration purpose. See detail provided.

Base shoe attached per ESR-3269 (Option 2)

Per SR-3269, use provided ½" thread anchors, ASTM F837 Alloy Group 1 with minimum tensile strength 67.5 KSI, described in Section 4.2.3.3.1.
*See page 13/20 of the report for illustration purpose.

Table 7-2
Available Tensile Strength of Bolts, kips

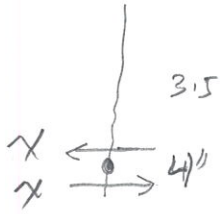
Nominal Bolt Diameter, d, in.			5/8		3/4		7/8		1	
Nominal Bolt Area, in.^{2}			0.307		0.442		0.601		0.785	
Designation	F_{nt}/Ω (ksi)	ϕF_{nt} (ksi)	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Group A	45.0	67.5	13.8	20.7	19.9	29.8	27.1	40.6	35.3	53.0
Group B	56.5	84.8	17.3	26.0	25.0	37.4	34.0	51.0	44.4	66.6
Group C	75.0	113	–	–	–	–	–	–	58.9	88.4
A307	22.5	33.8	6.90	10.4	9.94	14.9	13.5	20.3	17.7	26.5

Nominal Bolt Diameter, d, in.			1 1/8		1 1/4		1 3/8		1 1/2	
Nominal Bolt Area, in.^{2}			0.994		1.23		1.48		1.77	
Designation	F_{nt}/Ω (ksi)	ϕF_{nt} (ksi)	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n
	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Group A	45.0	67.5	44.7	67.1	55.2	82.8	66.8	100	79.5	119
Group B	56.5	84.8	56.2	84.2	69.3	104	83.9	126	99.8	150
Group C	75.0	113	74.6	112	92.0	138	–	–	–	–
A307	22.5	33.8	22.4	33.5	27.6	41.4	33.4	50.1	39.8	59.6

ASD	LRFD
$\Omega = 2.00$	$\phi = 0.75$

– Indicates that this grade is unavailable in the given diameter.
Group A includes ASTM F3125 Grades A325 and F1852 bolts.
Group B includes ASTM F3125 Grades A490 and F2280 bolts.
Group C includes ASTM F3043 and ASTM F3111.

$\frac{200}{1000} \times 3.5 = 0.7$ K-FT $= 0.7 \times 12 = 8.4^{K-11}$ → $0.7^{K\cdot ft}$



BOLTS (COUPLE) SPACED @ 4"

$(2x)4" = 8.4^{K-11}$

$8x = 8.4$

$x = \frac{8.4}{8} = 1.05^{K} < 9.94^{K}$ OK

Table 7-1
Available Shear Strength of Bolts, kips

Nominal Bolt Diameter, d, in.					5/8		3/4		7/8		1	
Nominal Bolt Area, in.^{2}					0.307		0.442		0.601		0.785	
Designation	Thread Cond.	F_{nv}/Ω (ksi)	ϕF_{nv} (ksi)	Loading	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n
		ASD	LRFD		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Group A	N	27.0	40.5	S	8.29	12.4	11.9	17.9	16.2	24.3	21.2	31.8
				D	16.6	24.9	23.9	35.8	32.5	48.7	42.4	63.6
	X	34.0	51.0	S	10.4	15.7	15.0	22.5	20.4	30.7	26.7	40.0
				D	20.9	31.3	30.1	45.1	40.9	61.3	53.4	80.1
Group B	N	34.0	51.0	S	10.4	15.7	15.0	22.5	20.4	30.7	26.7	40.0
				D	20.9	31.3	30.1	45.1	40.9	61.3	53.4	80.1
	X	42.0	63.0	S	12.9	19.3	18.6	27.8	25.2	37.9	33.0	49.5
				D	25.8	38.7	37.1	55.7	50.5	75.7	65.9	98.9
Group C	N	45.0	67.5	S	–	–	–	–	–	–	35.3	53.0
				D	–	–	–	–	–	–	70.7	106
	X	56.5	84.8	S	–	–	–	–	–	–	44.4	66.6
				D	–	–	–	–	–	–	88.7	133
A307	Not applicable	13.5	20.3	S	4.14	6.23	5.97	8.97	8.11	12.2	10.6	15.9
				D	8.29	12.5	11.9	17.9	16.2	24.4	21.2	31.9

Nominal Bolt Diameter, d, in.					1 1/8		1 1/4		1 3/8		1 1/2	
Nominal Bolt Area, in.^{2}					0.994		1.23		1.48		1.77	
Designation	Thread Cond.	F_{nv}/Ω (ksi)	ϕF_{nv} (ksi)	Loading	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n	r_n/Ω	ϕr_n
		ASD	LRFD		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
Group A	N	27.0	40.5	S	26.8	40.3	33.2	49.8	40.0	59.9	47.8	71.7
				D	53.7	80.5	66.4	99.6	79.9	120	95.6	143
	X	34.0	51.0	S	33.8	50.7	41.8	62.7	50.3	75.5	60.2	90.3
				D	67.6	101	83.6	125	101	151	120	181
Group B	N	34.0	51.0	S	33.8	50.7	41.8	62.7	50.3	75.5	60.2	90.3
				D	67.6	101	83.6	125	101	151	120	181
	X	42.0	63.0	S	41.7	62.6	51.7	77.5	62.2	93.2	74.3	112
				D	83.5	125	103	155	124	186	149	223
Group C	N	45.0	67.5	S	44.7	67.1	55.4	83.0	–	–	–	–
				D	89.5	134	111	166	–	–	–	–
	X	56.5	84.8	S	56.2	84.3	69.5	104	–	–	–	–
				D	112	169	139	209	–	–	–	–
A307	Not applicable	13.5	20.3	S	13.4	20.2	16.6	25.0	20.0	30.0	23.9	35.9
				D	26.8	40.4	33.2	49.9	40.0	60.1	47.8	71.9

ASD	LRFD
$\Omega = 2.00$	$\phi = 0.75$

– Indicates that this grade is unavailable in the given diameter.
For end loaded connections greater than 38 in., see *AISC Specification* Table J3.2 footnote b.
Group A includes ASTM F3125 Grades A325 and F1852 bolts.
Group B includes ASTM F3125 Grades A490 and F2280 bolts.
Group C includes ASTM F3043 and ASTM F3111.
Thread condition "N" indicates that threads are included in the shear plane.
Thread condition "X" indicates that threads are excluded from the shear plane.
S = single shear D = double shear

SHEAR FORCE DUE TO LIVE LOAD IS MINIMAL < 11.94 K

X2 BOLTS

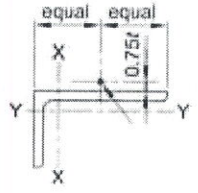
5.97 X 2 = 11.94 K

Table 4-12 (continued)

Available Strength in Axial Compression, kips

Eccentrically Loaded Single Angles

F_y = 36 ksi



L6

Shape		L6×4×				L6×3½×					
		3/8 c,t		5/16 c,t		1/2		3/8 c,t		5/16 c,t	
lb/ft		12.3		10.3		15.3		11.7		9.80	
Design		P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD	P_n/Ω_c ASD	$\phi_c P_n$ LRFD
Effective length, L_c (ft), with respect to least radius of gyration, r_z	0	59.9	90.0	55.7	83.7	47.7	71.6	44.1	66.3	41.5	62.5
	1	58.9	88.7	55.8	83.8	46.9	70.6	43.3	65.2	40.8	61.3
	2	56.2	84.8	53.2	80.3	44.7	67.5	41.1	62.1	38.5	58.1
	3	51.9	78.6	48.7	73.9	41.4	62.6	37.8	57.3	35.2	53.3
	4	46.6	70.9	43.4	66.1	37.3	56.6	33.9	51.5	31.2	47.5
	5	41.0	62.6	37.8	57.8	33.0	50.3	29.7	45.4	27.1	41.5
	6	35.6	54.6	32.5	50.0	28.8	44.1	25.7	39.4	23.3	35.8
	7	30.6	47.2	27.8	42.9	24.9	38.3	21.9	33.7	19.9	30.7
	8	26.2	40.4	23.8	36.8	21.5	33.0	18.6	28.7	17.0	26.2
	9	22.3	34.5	20.3	31.5	18.3	28.2	15.7	24.3	14.2	22.0
	10	19.1	29.5	17.2	26.8	15.8	24.3	13.4	20.7	12.1	18.7
	11	16.4	25.3	14.7	22.9	13.7	21.1	11.6	17.9	10.4	16.0
	12	14.2	22.0	12.7	19.7	12.0	18.5	10.1	15.6	9.04	13.9
	13	12.4	19.3	11.1	17.2						
	14	11.0	17.0	9.83	15.2						
Properties											
A_g, in.^{2}		3.61		3.03		4.50		3.44		2.89	
r_z, in.		0.870		0.874		0.756		0.763		0.767	

ASD	LRFD
Ω_c = 1.67	ϕ_c = 0.90

[a] Shape is slender for compression with F_y = 36 ksi; tabulated values have been adjusted accordingly.
[f] Shape exceeds compact limit for flexure with F_y = 36 ksi.
Note: Heavy line indicates L_c/r_z equal to or greater than 200.

PER SEGMENT OF GLASS

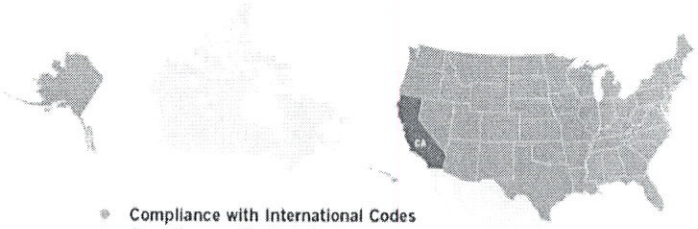
- MOMENT GENERATED BY RAIL = 8.4 K-in
- LOAD IS SET @ 3" MAX FROM CENTER OF GRAVITY

8.4 K-in / 3.0" = 2.8 K ACTING ON ANGLE ↓

0.66 Fy (41.4/1.67) = 16.36 K

OK → 16.36 > 2.8 K

ICC EVALUATION SERVICE®



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ICC-ES Evaluation Report
ESR-3269

Reissued November 2021

Revised March 2022

This report is subject to renewal November 2022.

DIVISION: 05 00 00—METALS
Section: 05 52 00—Metal Railings
Section: 05 73 13—Glazed Decorative Metal Railings

DIVISION: 08 00 00—OPENINGS
Section: 08 81 00—Glass Glazing
Section: 08 88 00—Special Function Glazing

DIVISION: 32 00 00—EXTERIOR IMPROVEMENTS
Section: 32 35 00—Screening Devices

REPORT HOLDER:

C.R. LAURENCE COMPANY, INC.

EVALUATION SUBJECT:

GRS™ GLASS BALUSTRADE GUARD SYSTEM FOR MONOLITHIC TEMPERED GLASS APPLICATIONS

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2018, 2015, 2012, 2009 and 2006 *International Building Code®* (IBC)
- 2018, 2015, 2012, 2009 and 2006 *International Residential Code®* (IRC)
- 2013 *Abu Dhabi International Building Code* (ADIBC)†

†The ADIBC is based on the 2009 IBC. 2009 IBC code sections referenced in this report are the same sections in the ADIBC.

Properties evaluated:

- Structural
- Durability

2.0 USES

The GRS Glass Rail System structural glass balustrades described in this report are intended for interior and exterior weather-exposed applications, and are suitable for use in most natural environments. The GRS system may be used for residential, commercial and industrial applications for guards along balconies, porches, mezzanines, stairs and similar locations except where vehicle impact resistance is required. The system is compatible with all construction types.

3.0 DESCRIPTION

3.1 General:

The GRS Glass Rail System utilizes an extruded aluminum base shoe, complying with 6063-T52, to anchor and support single fully tempered structural glass balustrades ($^1/_2$-inch [12.7 mm], $^5/_8$-inch [15.9 mm], or $^3/_4$-inch [19.1 mm], depending on use) which support the selected top rail and/or handrail [various profiles are made of stainless steel complying with 304 or 316 (in some cases, the top rails are required to have higher yield strengths than specified in 304 or 316 which are verified through mill certifications for the stainless steel sheets), brass complying with C26000, or aluminum complying with 6063-T6] to construct building guards. A complete GRS specification requires identification of the top rail (cap rail) profile and material; glass thickness with the maximum and minimum light widths; glazing system (either wet or a specific dry glazing method); base shoe; and anchorage to the supporting structure. When a handrail is used, the handrail profile, mounting bracket, and mounting bracket spacing must be specified. A complete installation requires either a top rail or a handrail. The base shoe may be installed with non-structural cladding of any compatible material bonded to it with adhesive. Figure 1 shows the typical guard elevation with the components. The complete GRS specifications must be noted on plans submitted to the code official for approval.

The profiles, section properties and strengths of the various base shoes are detailed in Section 4.2.3 of this report.

The profiles, section properties and strengths of the various top rails are detailed in Section 4.2.4.

The profiles, section properties and strengths of the various handrails are detailed in Section 4.2.7.

The glass must be Kind FT fully tempered glass conforming to the requirements of ANSI Z97.1-14, ASTM C1048 and CPSC 16 CFR 1201. The fully tempered glass must have an average Modulus of Rupture $F_r \geq 24{,}000$ psi. Glass type, condition, class, form, quality and finish as defined in ASTM C1036 must meet these standards and the modulus of rupture.

3.2 Durability:

The materials incorporated in the system described in this report are inherently corrosion-resistant. The material type specified must be appropriate for the environment of the

installation. Information verifying the durability must be submitted to the code official, when requested.

4.0 DESIGN AND INSTALLATION

4.1 General:

Installation of the GRS glass balustrade guards must comply with the manufacturer's published instructions, this report and IBC Sections 1015, 1607.8.1, and 2407 (2012 IBC Sections 1013, 1607.8.1, and 2407; 2009 and 2006 IBC Sections 1013, 1607.7.1, and 2407) or IRC Section R312, whichever is applicable. Handrails/grab rails must comply with IBC Sections 1011.11 and 1014 (2012 IBC Sections 1012 and 1009.15, 2009 IBC Sections 1012 and 1009.12, and 2006 IBC Sections 1012 and 1009.10) or IRC Sections R311.7.8 and R311.8.3 (2009 IRC Sections R311.7.7 and R311.8.3, and 2006 IRC Sections R3115.6 and R311.6.3), whichever is applicable. The manufacturer's published installation instructions, called "GRS Glass Railing Dry Glaze Taper-Loc System for Tempered Glass Applications (AVD3919-2/11)," must be available at the jobsite at all times during installation. In the event of a conflict between this report and the manufacturer's instructions, this report governs.

4.2 Design:

4.2.1 Loading: The applicable project-specific loads must be identified. Minimum required loads are one of the following:

- 50 plf (0.73 kN/m) on the top rail in any direction
- 200 lbs (0.89 kN) on the top rail in any direction, and 50 lbs (0.22 kN) on one square foot at any location perpendicular to the glass balustrade
- The wind load on the full area of glass, in psf

Wind load must be determined by a qualified individual based on the project-specific conditions, taking into account the balustrade location on the structure. For installations in compliance with the IRC Section R312, the 50 plf (0.73 kN/m) top rail load is not applicable.

4.2.2 Glass:

4.2.2.1 General: Sandblasted glass must have a $^3/_4$-inch nominal thickness, with the allowable loads based on a $^1/_2$-inch (12.7 mm) thickness, as noted in the tables of this report.

Minimum spacing between glass panels is $^1/_4$ inch (6.4 mm) for $^1/_2$-inch- and $^5/_8$-inch-thick (12.7 and 15.9 mm) glass panels, and $^1/_2$ inch (12.7 mm) for $^3/_4$-inch-thick (19.1 mm) glass panels.

Holes and notches must not be located within the first third of the balustrade height from the base shoe. Holes and notches must conform to ASTM C1048.

4.2.2.2 Live Loads: The allowable live load glass panel stress is equal to the modulus of rupture divided by a safety factor of 4 [24,000/4 = 6,000 psi (41.3 MPa)].

4.2.2.3 Wind Loads: Table 1 provides the allowable wind loads. This is based on an allowable wind load stress of 9600 psi. 8,400 "#/3" = 2,800 < 6,000 OK

4.2.3 Base Shoes:

The appropriate base shoe must be selected based on glass thickness, installation method and loading. Figure 2 shows the base shoe options. Tables 2a through 2g provide the allowable wind loads for the base shoes, glass thickness and anchorages. The base shoe must be installed in accordance with the manufacturer's published installation instructions and this report. The end anchor must be installed no less than $1^1/_2$ inches nor more than 12 inches from the end of the base shoes to the centerline of the anchor. A minimum of two anchors are required for any base shoe section. PROVIDED ½" METAL ANGLE

4.2.3.1 Steel Substrate: The base shoe is attached to a structural steel member with a minimum thickness of $^1/_4$ inch (6.4 mm) using $^1/_2$-13 by $^3/_4$-inch long, ASTM F-837 Alloy Group 1 (condition AF with a minimum tensile strength of 67.5 ksi), stainless steel, socket head cap screws installed into tapped holes. When installation is in a through-bolt condition, the cap screw length must be increased to a length sufficient to permit proper installation with full engagement of the nut. When installation is to weld blocks, drainage blocks or solid shims more than 2 inches (51 mm) long by the full base shoe width at each anchor, no reduction in allowable wind loads is required.

4.2.3.1.1 Surface-mounted to Steel: The allowable wind loads must be as shown in Table 2a. Guard height (Hg) is measured from the bottom of base shoe to the top of the guard. An appropriate top rail or grab rail must be used.

4.2.3.1.2 Fascia-mounted to Steel: The allowable wind loads must be as shown in Table 2b (heights from top of base shoe to top of guard).

4.2.3.2 Concrete Substrate: The base shoe is attached to a concrete member with a minimum thickness of 5 inches and minimum compression strength of 3,000 psi (20.6 MPa), and in an uncracked condition. The attachment is made using either a $^3/_8$-inch-diameter-by-4-inch screw-in Hilti HUS-EZ (KH-EZ) anchor in accordance with ESR-3027, or a Hilti HSL-3 M8 x $3^3/_4$-inch (95 mm) anchor in accordance with ESR-1545. Minimum spacing between anchors is 6 inches (152 mm). For 12-inch-on-center (305 mm) anchor spacing, anchor locations may be moved to avoid reinforcement, provided the same number of anchors is provided and no two anchors are closer than 6 inches (152 mm) center-to-center.

4.2.3.2.1 Concrete Strength: The allowable wind load (W^1) for concrete strengths between 3000 psi (20.6 MPa) and 5,000 psi (34.4 MPa) may be adjusted by applying the adjustment factor in the following equation:

$c_w = \sqrt{(f'_c/3000)}$

$W' = c_w * W$

where W is allowable wind load from the tables

f'_c = specified concrete compressive strength, in psi

4.2.3.2.2 Sand-lightweight Concrete: When installation is into sand-lightweight concrete, the allowable wind loads from the tables in this report must be reduced by a factor of 0.6.

4.2.3.2.3 Adjusted Wind Load: For a 42-inch (1067 mm) guard height, the allowable wind load from the tables in this report must be greater than 26 psf (1.25 kN/m^2) in order for the guard anchorage to be able to support the 50 plf (0.73 kN/m) live load. When typical anchor spacing is 12 inches (305 mm) on center, additional anchors may be added to the base shoe (for 10-foot (304 mm) base shoes or shorter lengths) as follows to provide a 26 psf (1.25 kN/m^2) allowable wind load and a 50 plf (0.73 kN/m) top rail live load:

- 26.0 psf ≥ W' > 23.6 psf, add one anchor
- 23.6 psf ≥ W'> 21.7 psf, add two anchors
- psf ≥ W' > 20.0 psf, add three anchors

For **SI:** 1 psf = 0.0479 kN/m^2

Added anchors must be distributed to divide the base shoe into approximately equal segments.

4.2.3.2.4 Surface-mounted: When edge distance is equal to or greater than 3.75 inches (95 mm) (concrete edge parallel to the anchor and to the centerline of the anchor), the allowable wind loads must be as provided in Table 2c for the guard height (Hg) from bottom of the base shoe. For edge distances less than 3.75 inches (95 mm), required for the full anchor strength, the allowable wind load must be as provided in Table 2d. Linear interpolation between Tables 2c and 2d is permitted for edge distances from 1.75 inches to 3.75 inches.

4.2.3.2.4.1 When installation is to drainage blocks or solid shims, 2 inches long by the full base shoe width at each anchor, the allowable wind loads must be as provided in Table 2e.

4.2.3.2.5 Fascia-mounted: When fascia-mounted to a slab edge, beam, wall or similar item, the minimum concrete thickness must be 6 inches (152 mm). The top and bottom of the base shoe must not extend past the concrete edge. The allowable wind load must be as determined using Table 2f, where guard height is total height above the top of the base shoe. Applicable adjustment factors from Sections 4.2.3.2.1 and 4.2.3.2.2 must be applied. Minimum wind loads must be verified in accordance with Section 4.2.3.2.3

4.2.3.2.5.1 Fascia-mounted over Drainage Blocks: When installation is with aluminum drainage blocks 2 inches (51 mm) wide by 4 inches (102 mm) deep at each anchor, the allowable wind load must be reduced by multiplying by 0.95 as shown in the following equation:

$W' = 0.95W$

4.2.3.3 Wood Substrate: Wood must have a moisture content under 19 percent at the time of fabrication and be a species and grade with specific gravity $G \geq 0.49$. For exterior locations all base shoes and fasteners must be stainless steel (304 or 316). Fasteners must be tightened so that the base shoe is in tight contact with the supporting wood.

4.2.3.3.1 Surface-mounted: All base shoes are similar and interchangeable.

4.2.3.3.1.1 Wet service (Moisture content of wood may exceed 19% at any extended period of time):

Direct surface mounting of the base shoes to wood in wet service locations is prohibited. The base shoe must be attached to steel or aluminum brackets or continuous angles which are directly attached to the wood structure.

Refer to Figure 3 for the aluminum bracket. Refer to Figure 4 for the steel bracket. The allowable wind loads using the steel or aluminum brackets are:

36-inch guard height, W = 46.7 psf (2.24 kN/m^2)

42-inch guard height, W = 34.3 psf (1.64 kN/m^2)

The continuous angles must be L5x5x$^5/_{16}$ inch and comply with ASTM A36 with a G90 galvanization or 6063 T5 aluminum.

The base shoe must be connected to the steel angle with $^1/_2$ inch (12.7 mm) diameter by $^3/_4$ inch (19.1 mm) long ASTM F837 Alloy Group 1 (condition AF with a minimum tensile strength of 67.5 ksi) stainless steel socket head cap screws into tapped holes spaced 12 inches o.c. (305 mm).

The attachment of the continuous angle to the wood substrate must be with minimum No. 14x3-inch (76 mm) stainless steel wood screws spaced 3 inches on center along each leg.

Allowable wind load using the continuous angles is:

42-inch guard height, W = 68.8 psf (3.289 kN/m^2)

4.2.3.3.1.2 Dry service (Moisture content of wood ≤ 19% at all times):

Dry service conditions include interior and exterior locations where the wood is adequately protected so that the moisture content remains at or below 19% at all times.

Base shoes are surface mounted directly to wood with a specific gravity $G \geq 0.49$ and a compressive strength perpendicular to the grain ≥ 625 psi (4.1 MPa).

The base shoe must be anchored with $^3/_8$-inch (9.5 mm) diameter by 5-inch (127 mm) long lag screws.

The B5L base shoe must not be used for surface mounting to wood when guard height exceeds 24 inches (610 mm).

Lag screw length must be increased as needed to obtain a minimum of 3$^1/_2$" embedment into the solid wood when subfloor thickness exceeds $^3/_4$ inch.

4.2.3.3.1.2.1 One- and Two-family Dwellings and IRC Applications [(200 pounds (0.89 kN) Top Rail Live Load Only)]: When installed in private residences, the anchors must be installed at 12 inches (305 mm) on center or less. For a 36-inch (914 mm) guard height, the minimum number of anchors is four; and for a 42-inch (1067 mm) guard height, the minimum number of anchors is five.

4.2.3.3.1.2.2 Other Locations [(50 plf (0.73 kN/m) Top Rail Live Load)]: When installed in applications where the 50 plf (0.73 kN/m) live load is applicable in accordance with IBC Section 1607.8.1 (2009 and 2006 IBC Section 1607.7.1), the anchors must be installed at 6 inches (152 mm) on center or less. The minimum number of anchors in any guard segment is five.

USING 3/4" M.B.

4.2.3.3.2 Fascia-mounted: The base shoes must be attached with $^1/_2$-inch-by-4-inch (12.7 mm by 102 mm) lag screws installed directly to the structural wood member. The top of the base shoe must be flush with or below the top of the beam corner radius and the beam must extend below the bottom of the base shoe. The allowable wind load must be as determined in accordance with Table 2G. Linear interpolation for other heights or anchor spacing is allowable.

4.2.4 Top Rails: A top rail is required for a code- compliant guard installation, except as noted in Figure 1. The term "cap rail" denotes the same thing as "top rail" and the two may be used interchangeably. The top rail is installed in accordance with the details provided in the manufacturer's installation details referenced in Section 4.1 of this report.

4.2.4.1 Support: The top rail must be installed so as to remain in place in the event of the failure of any one glass light. This requires the use of a minimum of three glass lights or a combination of other top rail supports and glass lights totaling three, minimum. Figure 5 illustrates the top rail support conditions. The top rail end condition (Figure 6) must be checked to verify that the rail will remain in place in the event of failure of the end glass light. End support must be designed when required for a code-compliant installation. The stabilizing end cap shown in Figure 14 is an acceptable method of end support.

4.2.4.2 Top Rail Profiles: The top rail profiles are shown in Figure 7. The maximum middle and end spans of the top rail profiles supported by glass only are given in Table 3.

4.2.4.3 Stainless Steel End Post: Where the end glass panel width exceeds the maximum end top rail span in Table 3, the top rail must be supported at the end by a post or the wall. A stainless steel post inserted in the base shoe and top rail may be used, as shown in Figure 6. The post minimum width for a maximum glass height of

where: $(3.5 \times 200)/2.5 = 280 < 352$ FT-LB

H = glass height above supports, in feet

$M_{gmax}/2.5$ = 352 ft-lb for 1/2-inch fully tempered glass

566.4 ft-lb for 5/8-inch fully tempered glass

827.2 ft-lb for 3/4-inch fully tempered glass

For **SI:** 1 ft – 1 lbf = 1.356 N-m

5.6 When installed where exposed to moisture, the base shoe anchors must be of a material intended for the use and identified by the manufacturer as acceptable for exterior applications. When installed in a corrosive environment, such as one where there is exposure to salt water or pool water, the anchors must be 316 stainless steel.

5.7 All metals in contact with aluminum must be either an alloy approved for direct aluminum contact, or isolated from the aluminum by an approved coating.

5.8 The GRS systems described in this report must not be used in Wind-Borne Debris Regions.

5.9 The GRS™ Glass Balustrade Guard System and the proper top rail or handrail must be installed in accordance with the manufacturer's instructions, this report, Sections 1014, 1015, and 2407 of the IBC (Sections 1012, 1013, and 2407 of the 2012, 2009 and 2006 IBC) or Sections R311.7.8 and R312 of the IRC, whichever is applicable.

5.10 All glass must be fully tempered, fabricated, and inspected in accordance with ASTM C1048, and the glass fabricator must provide certification of compliance with ASTM C1058 for fully tempered glass. Glass must be procured directly from a qualified glass fabricator and is not produced or supplied by C.R. Laurence Co., Inc.

5.11 The CRL GRS™ and Taper-Loc® components, except for the glass, are supplied by C.R. Laurence Co., Inc., in Los Angeles, California.

6.0 EVIDENCE SUBMITTED

6.1 Data in accordance with the ICC-ES Acceptance Criteria for Glass Railing and Balustrade Systems (AC439) dated April 2019.

6.2 Manufacturer's published installation instructions.

7.0 IDENTIFICATION

7.1 The CRL GRS™ and Taper-Loc® guard system components described in this report are identified by a stamp on the packaging bearing the manufacturer's name (C.R. Laurence Co., Inc., sometimes abbreviated as CRL); product description and/or part number; and the ICC-ES evaluation report number (ESR-3269).

7.2 The report holder's contact information is the following:

C.R. LAURENCE COMPANY, INC.
ARCHITECTURAL RAILING DIVISION
2503 EAST VERNON AVENUE
LOS ANGELES, CALIFORNIA 90058
(800) 421-6144
www.crlaurence.com
www.crl-arch.com

TABLE 1—GLASS PANELS STRENGTH INTERIOR

GLASS PANEL THICKNESS (in.)	MINIMUM GLASS PANEL THICKNESS (in.)	MINIMUM GLASS PANEL WIDTH[2] (in,)	GUARD HEIGHT (Hg)[1], (in.)	GLASS HEIGHT ABOVE TOP OF BASE SHOE (in.)	ALLOWABLE WIND PRESSURE (psf)	LIVE LOAD[3] 50 PLF MAXIMUM HEIGHT ABOVE TOP OF BASE SHOE (in.) BASED ON:	
						STRESS	1" DEFLECTION
1/2	0.469	2'-6"	36	32	71.1	52.75	40.08
		2'-10.5"	42	38	52.2		
5/8	0.595	1'-7"	36	32	114.4	84.0	50.84
		1'-10"	42	38	84.1		
3/4	0.719	1'-0"	36	32	167.1	124	64.44
		1'-3"	42	38	122.8		

For **SI:** 1 inch = 25.4 mm; 1 foot = 305 mm; 1 psf = 0.0479 kN/m^2.

[1]The allowable wind loads may be adjusted for other panel heights by:

$$W' = \frac{W_{42} * 42^2}{H_g^2}$$

where H_g = total guard height measured from bottom of base shoe to top of top rail in inches.
W_{42} = Allowable load at 42-inch guard height.

[2]Minimum glass panel width is defined as the minimum width of glass required to support the 200 pound concentrated live load acting horizontally. The minimum glass light width is 6 inches when top rail is continuous across a total glass width of 1.5 times the minimum width or attached to additional supports at rail ends. Where the top rail is continuous, multiple adjacent glass lights may be added together to provide the total length.[3]Other loads listed in Section 4.2.1 must be considered.

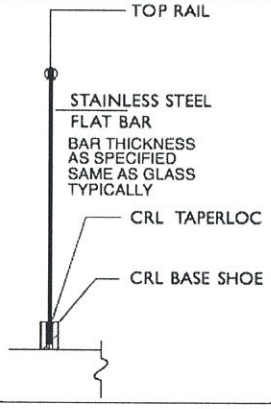
TABLE 2A—SURFACE-MOUNTED SHOE

Surface mounted to steel with 1/2-inch cap screws @ 12 inches on center[1]:			
Total guard height (Hg) from bottom of base shoe			
1/2-inch cap screw to steel Base Shoe	36-inch Height Allowable wind load	42-inch Height Allowable wind load	Live Load[2] 50 plf Max. Height
8B, B5G, B5S, B5T	75.3 psf	* 55.3 psf > 50	89 in.
B5L	67.7 psf	49.8 psf	80 in.
B6S	78.9 psf	58.0 psf	93 in.
B7S	82.8 psf	60.9 psf	98 in.
Surface mounted to steel with 1/2-inch cap screws @ 6 inches on center:			
1/2-inch cap screw to steel Base Shoe	36-inch Height Allowable wind load	42-inch Height Allowable wind load	Live Load[2] 50 plf Max. Height
8B, B5G, B5S, B5T	150.0 psf	110.2 psf	178 in.
B5L	134.5 psf	98.8 psf	160 in.
B6S	157.2 psf	115.5 psf	186 in.
B7S	165.1 psf	121.3 psf	196 in.

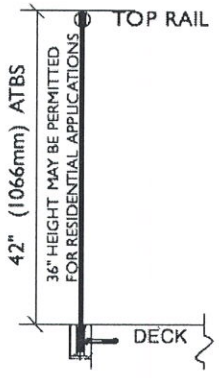
For **SI:** 1 inch = 25.4 mm; 1 psf = 0.0479 kN/m^2.

[1]Allowable wind load may be limited by glass strength. See Table 1 in this report.
[2]Other loads listed in Section 4.2.1 must be considered.

ZERO WIND/INTERNAL



SURFACE MOUNTED BASE SHOE



FASCIA MOUNTED BASE SHOE

OPTION

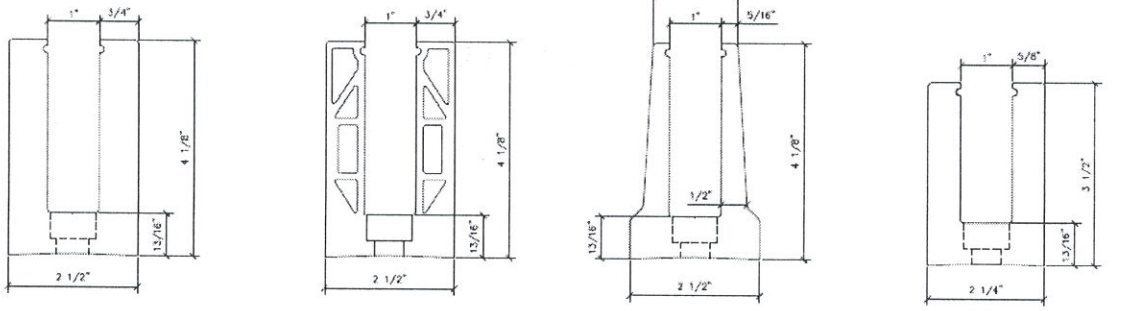
TABLE 2B—FASCIA-MOUNTED SHOE CALCS FOR 3/4" SIDE MOUNT

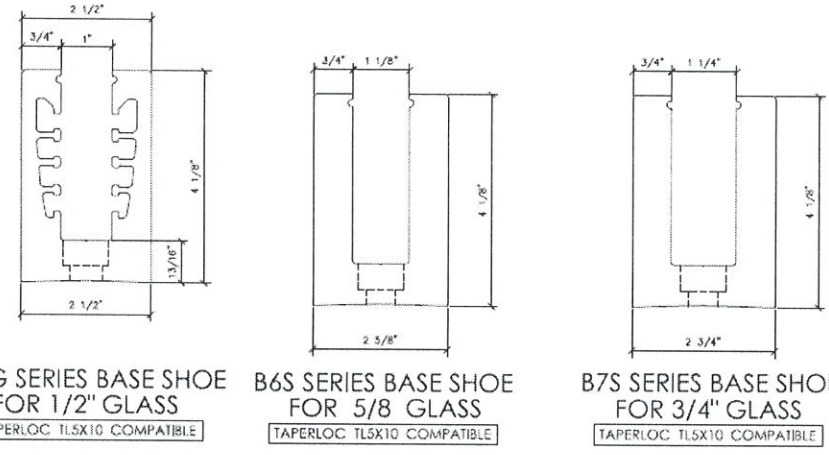
Fascia mounted to steel with 1/2-inch cap screws @ 12 inches on center[1]:			
Total Guard Height above top of base shoe			
1/2-inch cap screw to steel Base Shoe	36-inch Height Allowable wind load	42-inch Height Allowable wind load	Live Load[2] 50 plf Max. Height
8B, B5G, B5S	68.7 psf	51.2 psf	87 in.
B5L	47.5 psf	35.3 psf	58 in.
B6S	68.7 psf	51.2 psf	87 in.
B7S	68.7 psf	51.2 psf	87 in.
Fascia mounted to steel with 1/2-inch cap screws @ 6 inches on center:			
1/2-inch cap screw to steel Base Shoe	36-inch Height Allowable wind load	42-inch Height Allowable wind load	Live Load[2] 50 plf Max. Height
8B, B5G, B5S	138.2 psf	103.0 psf	178 in.
B5L	95.6 psf	71.2 psf	121 in.
B6S	138.2 psf	103.0 psf	178 in.
B7S	138.2 psf	103.0 psf	178 in.

For **SI:** 1 inch = 25.4 mm; 1 psf = 0.0479 kN/m^2.

[1]Allowable wind load may be limited by glass strength. See Table 1 in this report.
[2]Other loads listed in Section 4.2.1 must be considered.

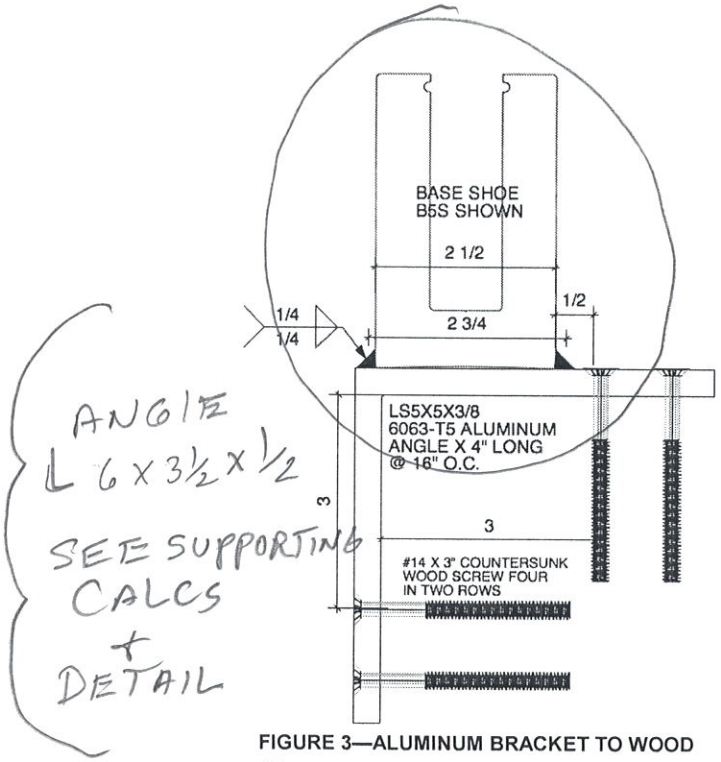
ZERO / INTERIOR INSTALLATION





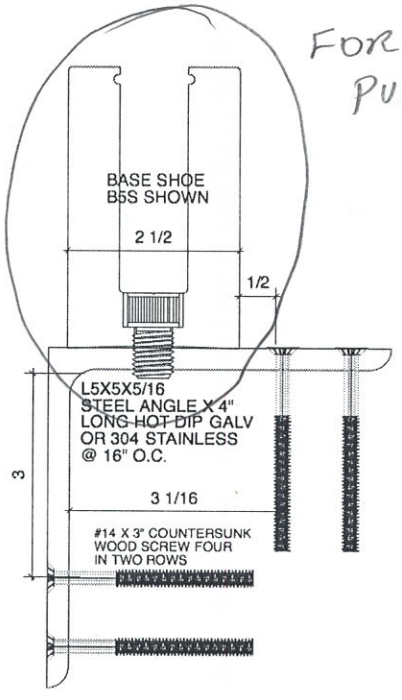
For **SI:** 1 inch = 25.4 mm.

FIGURE 2—BASE SHOES



ANGLE
L 6 X 3½ X ½
SEE SUPPORTING CALCS + DETAIL

FIGURE 3—ALUMINUM BRACKET TO WOOD
(Dimensions are in inches; 1 inch = 25.4 mm)



FOR ILLUSTRATION PURPOSE

FIGURE 4—STEEL BRACKET TO WOOD
(Dimensions are in inches; 1 inch = 25.4 mm)