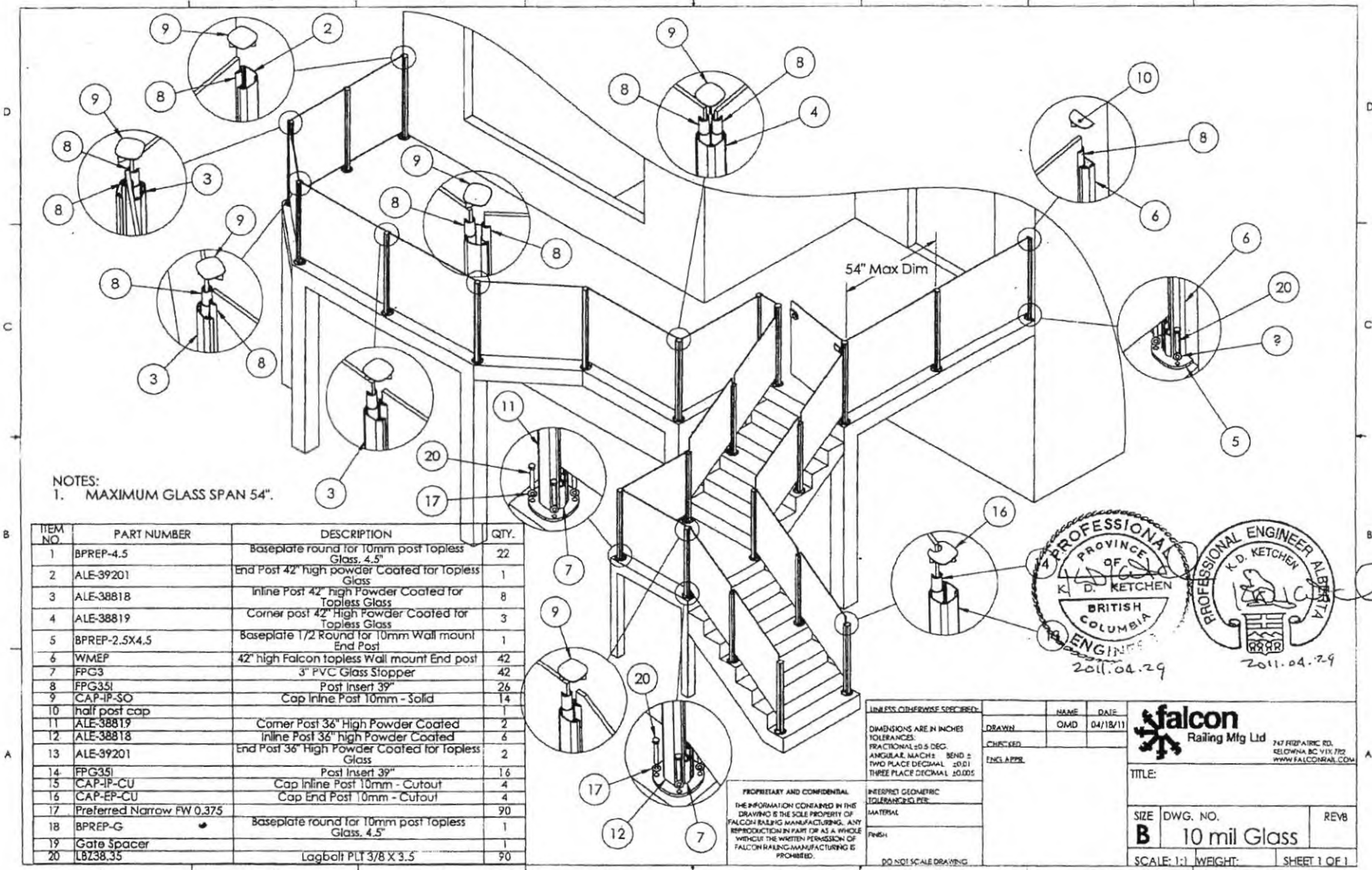

NOTES:
1. MAXIMUM GLASS SPAN 54".

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	BPREP-4.5	Baseplate round for 10mm post Topless Glass, 4.5"	22
2	ALE-39201	End Post 42" high powder Coated for Topless Glass	1
3	ALE-38818	Inline Post 42" high Powder Coated for Topless Glass	8
4	ALE-38819	Corner post 42" High Powder Coated for Topless Glass	3
5	BPREP-2.5X4.5	Baseplate 1/2 Round for 10mm Wall mount End Post	1
6	WMEP	42" high Falcon topless Wall mount End post	42
7	FPG3	3" PVC Glass Stopper	42
8	FPG35I	Post Insert 39"	26
9	CAP-IP-SO	Cap Inline Post 10mm - Solid	14
10	half post cap		1
11	ALE-38819	Corner Post 36" High Powder Coated	2
12	ALE-38818	Inline Post 36" high Powder Coated	6
13	ALE-39201	End Post 36" High Powder Coated for Topless Glass	2
14	FPG35I	Post Insert 39"	16
15	CAP-IP-CU	Cap Inline Post 10mm - Cutout	4
16	CAP-EP-CU	Cap End Post 10mm - Cutout	4
17	Preferred Narrow FW 0.375		90
18	BPREP-G	Baseplate round for 10mm post Topless Glass, 4.5"	1
19	Gate Spacer		1
20	LBZ38.35	Lagbolt PLT 3/8 X 3.5	90

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA K. D. KETCHEN
2011.04.29

PROFESSIONAL ENGINEER ALBERTA K.D. KETCHEN
2011.04.29

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±0.5 DEG.
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±0.01
THREE PLACE DECIMAL ±0.005
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	OMD	04/18/11
CHECKED		
ENG APPR.		

falcon Railing Mfg Ltd
747 FRITZ A1BIC RD, KELOWNA BC V1X 7P2
WWW.FALCONRAIL.COM

TITLE:

SIZE	DWG. NO.	REV
B	10 mil Glass	B

SCALE: 1:1 WEIGHT: SHEET 1 OF 1

7/5/2012
1:00 PM

TEST REPORT

REPORT NUMBER: 100320369COQ-002A
ORIGINAL ISSUE DATE: May 10, 2011
REVISION DATE: May 16, 2011

EVALUATION CENTER

INTERTEK TESTING SERVICES NA LTD.
1500 BRIGANTINE DRIVE
COQUITLAM, BC V3K 7C1

RENDERED TO

FALCON RAILING AND SUPERDECK INC.
747 FITZPATRICK ROAD
KELOWNA, BC V1X 5E2
CANADA

PRODUCT EVALUATED: Aluminum Topless Glass Railing System
EVALUATION PROPERTY: Load Requirements

Report of Falcon Railing and Superdeck Inc. Aluminum Topless Glass Railing System for compliance with the applicable requirements of Section 1607.7.1 *Handrails and Guards* of the 2009 International Building Code (IBC)

1 Table of Contents

APPENDIX A: Test Data (3 pages)

Intertek

Test:	**IBC Loads on Guards** Test #1		Project: G100320369
Date:	27-Jan-11		Eng/Tech: Chris Chang
Client:	Falcon Railing and Superdeck Inc.		Reviewer: Riccardo DeSantis
Product:	**Aluminum Topless 10 mm Glass Panel Railing System**		
Installation:	**Top Mount**		
Post Spacing:	4.50 ft	1.37 m	
Height of Guard:	42 in	1070 mm	
Opening in Guard:	1.625 in	41 mm	
Method:	2009 International Building Code (IBC) Section 1607.7.1 Handrails and Guards Section 1713 Test Safe Load		
Safety Factor:	2.5 4.0 For structural glass		
Equipment:	Artech 5K load cell (Intertek ID# SN138768, cal due August 20, 2011) Vaisala Indicator (Intertek ID# V2920010, cal due November 2, 2011)		
Time/Temp/RH:	11:00AM / 14.4°C / 52.9%		

Test	Design Load (Inward/ Outward) (lbf)	Factored Load	Calculated Moment (lbf-ft)	Equivalent Quarter-Point Load (lbf)	Required Proof Load (lbf)	Pass/Fail	Ultimate Load (lbf)
Individual Elements / Components (1ft²)	50	200	-	-	200	**PASS**	
Horizontal Uniform Load (per ft)	50	125	316	281	563	**PASS**	
Top of Post Horizontal Concentrated Load	200	500	-	-	500	**PASS**	**565.16**

Mode of Failure: 2 fasteners connecting base to post broke at the tension side

Intertek

Test:	**IBC Loads on Guards** Test #2		Project: G100320369
Date:	27-Jan-11		Eng/Tech: Chris Chang
Client:	Falcon Railing and Superdeck Inc.		Reviewer: Riccardo DeSantis
Product:	**Aluminum Topless 10 mm Glass Panel Railing System**		
Installation:	**Top Mount**		
Post Spacing:	4.50 ft	1.37 m	
Height of Guard:	42 in	1070 mm	
Opening in Guard:	1.625 in	41 mm	
Method:	2009 International Building Code (IBC)		
	Section 1607.7.1 Handrails and Guards		
	Section 1713 Test Safe Load		
Safety Factor:	2.5		
	4.0 For structural glass		
Equipment:	Artech 5K load cell (Intertek ID# SN138768, cal due August 20, 2011)		
	Vaisala Indicator (Intertek ID# V2920010, cal due November 2, 2011)		
Time/Temp/RH:	1:00PM / 14.1°C / 53.2%		

Test	Design Load (Inward/ Outward) (lbf)	Factored Load	Calculated Moment (lbf-ft)	Equivalent Quarter-Point Load (lbf)	Required Proof Load (lbf)	Pass/Fail	Ultimate Load (lbf)
Individual Elements / Components (1ft²)	50	200	-	-	200	**PASS**	
Horizontal Uniform Load (per ft)	50	125	316	281	563	**PASS**	
Top of Post Horizontal Concentrated Load	200	500	-	-	500	**PASS**	**642.07**

Mode of Failure: 2 fasteners connecting base to post broke at the tension side

Intertek

Test:	**IBC Loads on Guards** Test #3		Project: G100320369
Date:	27-Jan-11		Eng/Tech: Chris Chang
Client:	Falcon Railing and Superdeck Inc.		Reviewer: Riccardo DeSantis
Product:	**Aluminum Topless 10 mm Glass Panel Railing System**		
Installation:	**Top Mount**		
Post Spacing:	4.50 ft	1.37 m	
Height of Guard:	42 in	1070 mm	
Opening in Guard:	1.625 in	41 mm	
Method:	2009 International Building Code (IBC) Section 1607.7.1 Handrails and Guards Section 1713 Test Safe Load		
Safety Factor:	2.5 4.0 For structural glass		
Equipment:	Artech 5K load cell (Intertek ID# SN138768, cal due August 20, 2011) Vaisala Indicator (Intertek ID# V2920010, cal due November 2, 2011)		
Time/Temp/RH:	1:15PM / 14.2°C / 53.2%		

Test	Design Load (Inward/ Outward) (lbf)	Factored Load	Calculated Moment (lbf-ft)	Equivalent Quarter-Point Load (lbf)	Required Proof Load (lbf)	Pass/Fail	Ultimate Load (lbf)
Individual Elements / Components (1ft²)	50	200	-	-	200	**PASS**	
Horizontal Uniform Load (per ft)	50	125	316	281	563	**PASS[1]**	
Top of Post Horizontal Concentrated Load	200	500	-	-	500	**PASS[2]**	**574.70**

Note [1]: Glass dislodged from post at 437.36lbs; system was restrained horizontally using straps to continue test.

Note [2]: Straps were left on for Top of Post Horizontal Concentrated Load.

Mode of Failure: 2 fasteners connecting base to post broke at the tension side

REVISION SUMMARY

DATE	SECTION		SUMMARY	INTERTEK INITIALS	
				TECHNICIAN	REVIEWER
May 16, 2011	All	Throughout	Changed "*Falcon Railing and Superdeck Ltd.*" to "*Falcon Railing and Superdeck Inc.*"		

2 Introduction

Intertek Testing Services NA Ltd. (Intertek) has conducted a test program for Falcon Railing and Superdeck Inc. on aluminum guardrail systems. The evaluation was carried out to determine whether the railing systems would resist the loads specified in Section 1607.7.1 *Handrails and Guards* of the 2009 International Building Code (IBC). This evaluation was conducted in the month of January 2011.

3 Test Samples

3.1. SAMPLE SELECTION

The client submitted three (3) aluminum railing systems to the Evaluation Center on January 26, 2011. Samples were not independently selected for testing.

3.2. SAMPLE AND ASSEMBLY DESCRIPTION

The samples were identified as the following:

Table 1. Railing Configurations

Railing	Post	Post Spacing	Mounting Plate	Rails	Panel Insert
Glass Panel - Top Mount	2-1/2" x 2-1/2"	54"	4-1/2" x 4-1/2" x 3/8"	No Top Rail	10 mm Glass

Note: Post to sub-structure fastener evaluation is beyond the scope of this report. 3/8 in. Grade 5 bolts were used to install the specimen for testing.

4 Testing and Evaluation Methods

The test specimen was loaded at a rate to achieve the specified loads between 10 seconds and 5 minutes. The specified test loads were held for one minute before the load was released. As per the 2009 IBC, the following tests were conducted:

4.1. 2009 IBC: SECTION 1607.7.1 HANDRAILS AND GUARDS

1) Handrails and guards shall be designed to resist a load of 50 pounds per linear foot (plf) (0.73 kN/m) applied in any direction at the top.

2) Handrails and guards shall be able to resist a single concentrated load of 200 pounds (0.89 kN), applied in any direction at any point along the top.

3) Intermediate rails, balusters and panel fillers shall be designed to withstand a horizontally applied normal load of 50 pounds (0.22 kN) on an area equal to 1 square foot (0.093 m^2).

Notes:
1. A live load factor of 2.5 is applicable to the above loads. A live load factor of 4.0 is applicable for glass in-fill.

4.2. IN-FILL LOAD TEST

A load of 200 lbs was applied to the glass panel using a 1 square foot block normal to the in-fill. After release of the load, the system was evaluated for failure, any evidence of disengagements of any component and/or visible cracking from any component.

4.3. UNIFORM LOAD TEST

The guardrail system was subjected to a maximum equivalent uniform load of 125 plf applied horizontally at the top of the railing system; the load was applied directly to the glass panel as there was no top rail. The load was applied using quarter point loading. After release of the load, the system was evaluated for failure, any evidence of disengagements and/or visible cracking from any component.

4.4. CONCENTRATED LOAD TEST

The guardrail system was subjected to a horizontal concentrated load of 500 lbs at the top of post to verify the glass to post connection capacity .

5 Testing and Evaluation Results

5.1. RESULTS AND OBSERVATIONS

The product test results are shown in Table 1 below and a full set of test data is located in Appendix A.

Table 1. Test Results

System Description	Test	Compliance
Aluminum Topless Glass Panel Railing System – Top Mount	In-fill load	Pass
	Uniform Load	Pass
	Concentrated Top of Post	Pass

6 Conclusion

The Falcon Railing and Superdeck Inc. aluminum railing systems identified in this test report have complied with the requirements of Section 1607.7.1 *Handrails and Guards* of the 2009 International Building Code. The product test results are presented in Section 5 of this report.

INTERTEK TESTING SERVICES NA LTD.

Reported by: _____
Chris Chang, EIT
Test Engineer – Construction Products

Reviewed by: _____
Riccardo DeSantis
Lab Supervisor / Test Technician – Building Products

ROV CONSULTING INC
STRUCTURAL ENGINEERS

REPORT

Date	Tuesday, 2016-May-17	Project	4605
To	Falcon Railing & Superdeck Kelowna, British Columbia Canada 747 Fitzpatrick Rd.	C/O	Glass Guardrails 250 765 2248 dono@falconrail.com
From	Bahareh Reza		bahar@rovconsulting.ca

Delivered Via: Email

Re Structural Review of Glass Guard with **10 mm glass**

1 Introduction

The purpose of this report is investigating the structural performance of the 10mm *glass guard with the top rail and post* proposed by Falcon Railing & Super deck.

2 Load and Design Requirements

The guard has been designed based on the load requirements according to Part 4 BC Building Code 2012 (Table 1) and the wind load pressure of Kelowna, BC. The glass panels have been designed according to the CAN/CGSB-12.20-M89, Structural Design of Glasses for Buildings. The recommended maximum *factored resistance* for fully tempered flat glass plates loaded normal to the surface and subjected to live loads with 1-minute load duration is 100 MPa away from edges and 80 MPa for clean cut edges.

Table 1 Loads for guard according to Part 4 BC Building Code 2012

Table 4.1.5.14. Loads for Guard			
Location of Guard	**Minimum Design Loads**		
	Horizontal Load Applied Inward or Outward at any Point at the minimum Required height of the guard	Horizontal Load Applied Inward or Outward on Elements within the Guard, Including Solid Panels and Pickets	Evenly distributed Vertical Load Applied at the Top of the Guard
All Guards	0.75 KN/m or Concentrated Load of 1.0 KN Applied at any Point	0.5 KN applied over a maximum width of 100 mm and a height of 100 mm	1.5 KN/m

In order to investigate the performance of the proposed glass guardrail it has been analysed based on the assumption that the aluminum posts are placed at maximum 47 inch O.C. and they have a total

height of minimum 32 inch face mount (29 in thru deck) or 30-inch top mount. Additionally, it was assumed that the glass height is maximum 39 inch and placed 3 inch above the deck level, which gives a total height of 42-inch guard thru deck (Figure 1). The result of the analysis has been summarized in Section 4.

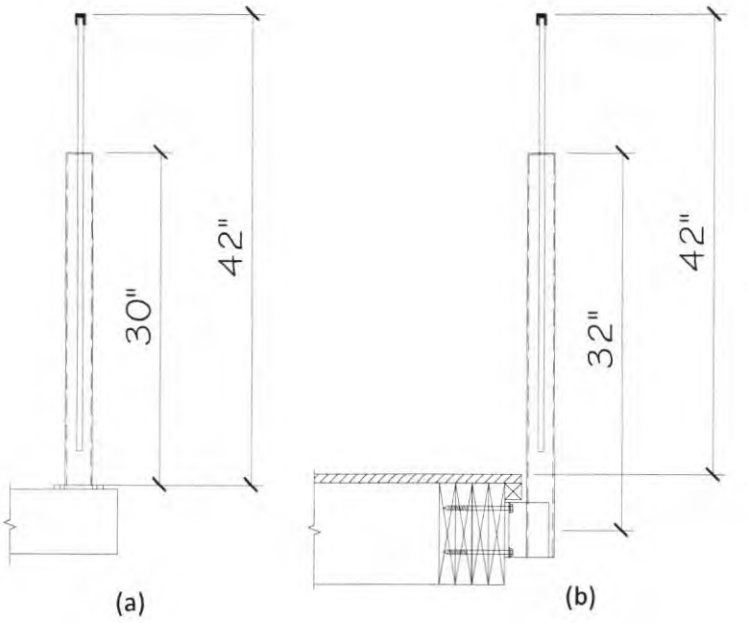

Figure 1 (a) Top-mount guardrail (b) Face-mount guardrail

3 Specifications of the Glass Guard Top Rail and Posts

Figure 2 indicates the section detail for the lower channel gasket that proposed for the glass guard top cap by Falcon Railing & Superdeck. The proposed top rail will be extruded from 6005 A T5 alloy which has an ultimate tensile strength 38 ksi and yield strength 35 ksi. As it is shown in the Figure 2, ROV suggested to increase the depth of the channel by 1/16 inch (adding 1.59 mm which gives a total web thickness of 11.11 mm) in order to avoid bending and/or buckling failure of the glass guard top rail.

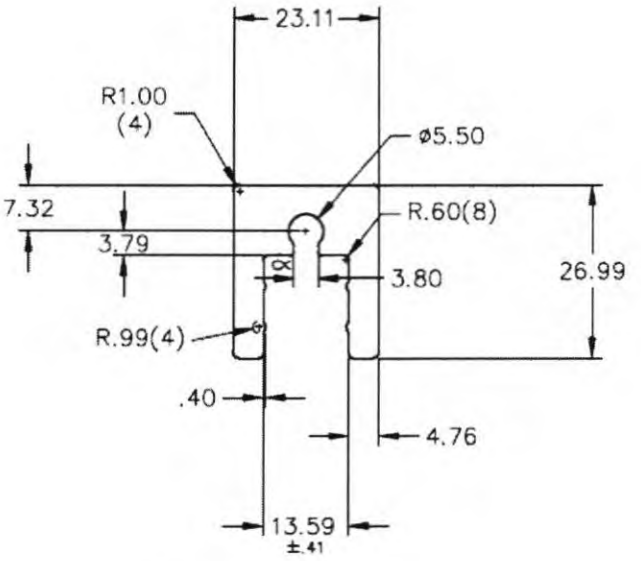

Figure 2 Glass Guard Top Rail Dimension

Figure 3 indicates the aluminum posts that has been proposed for the 10 mm glass guard by Falcon Railing & Superdeck. The guards' posts material has been assumed to be aluminium 6061-T6 or 6005A-T5 (minimum Yield Strength 35 ksi).

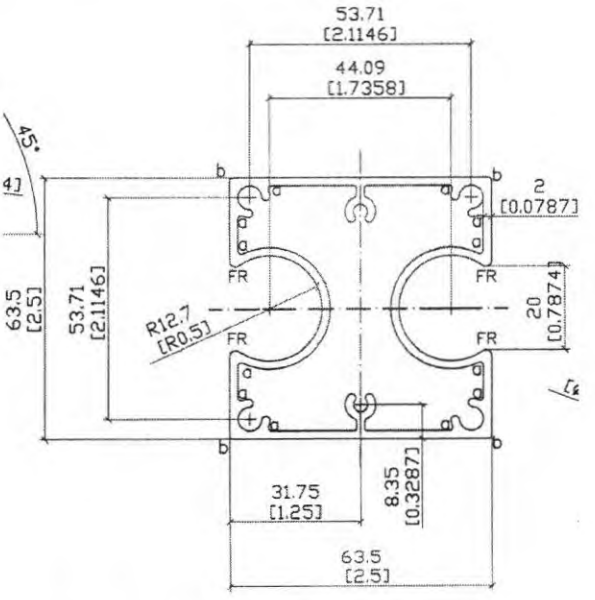

Figure 3 Typical Post Section for 10 mm glass guardrail

4 Analysis Result

4.1 Members' Stress

- The maximum stress on the aluminium top cap (with detail shown in Figure 2) is **30 ksi** under the bending. The governing load combination is LC1 (1.25 Dead + 1.5 Horizontal Point Live Load) where a glass light fails and the 1 KN horizontal load imposed on the middle of the top rail with failed glass. The maximum unbraced length where the proposed aluminium top cap can perform safely is 47 inch. This is especially important where there is a cantilever glass at the corner, which gives the maximum acceptable width 47" for the glass panel at the corner (e.g. 42" post distance plus 5" cantilever). The maximum stress on the aluminium top cap reaches to **31 ksi** if the 47" width glass light at the corner fails.
- The maximum stress on the aluminium posts is **16 ksi** under the bending. The governing load combination is LC2 (1.25 Dead + 1.5 Horizontal Linear Live Load).
- The maximum stress of 70 Mpa in the 10 mm tempered glass occurs at the top corner of the glass panel right below the top cap where we assumed the glass besides this edge has been failed. The governing load combination is LC2 (1.25 Dead + 1.5 Horizontal Linear Live Load) where a glass light fails and the 0.75 KN.m horizontal load imposed on top rail.
- The maximum stress on the aluminum top rail occurs in the top-mount guard system, while the maximum stress on the aluminum post and 10 mm tempered glass occurs in the face-mount guard system.

4.2 Deflection

- The maximum member deflection of **33 mm** occurred on top of the glass guardrail where the horizontal point load applies which is less than 40 mm allowable deflection for glass guard rail. The deflection has been calculated under the un-factored loads where non of the glasses failed.
- The maximum deflection of **17 mm** occurs in the aluminium post under the horizontal point load.

4.3 Force at the corner of the guard rail

In order to check the screw capacity in the guard corner (Figure 4), the glass guard rail has been analysed where the one of the glass lights at the corner fails. The maximum forces that need to be bear at the corner of the top rail are as below:

F_Z = 357 lb

F_Y = 351 lb

Fastener 1/4-20 x 2" HWH Tek/4 (Figure 5)

Allowable Tensile Stress = 949 x 3 x o.5 = 1423.5 lb > 357 O.K.

Allowable shear stress = 921 x 3 x 0.5 = 1381.5 lb > 351 O.K.

Shear-tensile stress Combination = 357/1423.5 + 351/1381.5 = 0.51 <1 ✓✓

Minimum edge distance = 1/2 in ✓✓

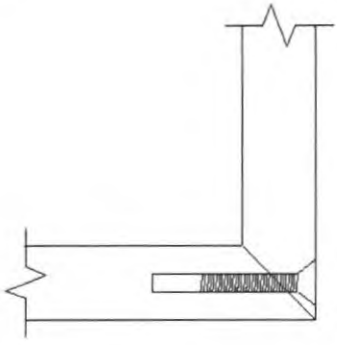

Figure 4 Fastener ¼ - 20 HWH Tek at the guard corners

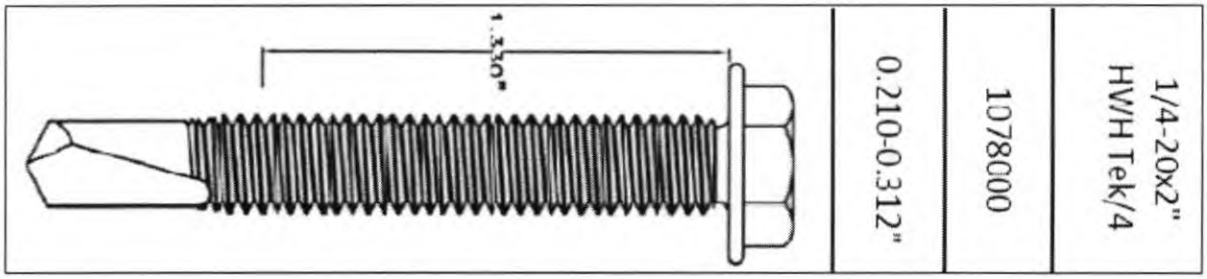

Figure 5 – Fastener ¼ - 20 x 2" HWH Tek/4

4.4 Maximum reaction to design post mount connection

4.4.1 face mount connection

Maximum moment for design of the connection is 1.5 kN.m. Based on the geometry of the connection it requires 3/8" 4.5"x 4.5" aluminum baseplate with 4-3/8" (6") lag screw @ 3" O.C. For the connection to the SPF washers are required.

- ➔ Withdrawal force per each row T = 1.5 KN.m / 76 E-3 m = 20 KN
- ➔ Withdrawal force per each bolt= 20/2 = 10 KN

Withdrawal Resistance: $P_{rw} = \Phi * Y_w * L_t * n_F * J_E$ =11.9 kN > 10 KN ✓✓

4.4.2 Top mount connection

Maximum moment for design of the connection is 1.4 kN.m. Based on the geometry of the connection it requires 3/8" 4.5"x 4.5" aluminum baseplate with 4- KWIK HUS-EZ (KH-EZ) 3/8" (3 ¼") @ 3" O.C. The minimum acceptable concrete depth for this connection is 6 inch or 150 mm.

5 Conclusion

The structural performance of the 10 mm glass guard top rail posts proposed by Falcon Railing & Super deck has been analysed. The result of this analysis has been summarized in Table 2. The guard has been analyzed based on the load requirements according to Part 4 BC Building Code 2012 and the CAN/CGSB-12.20-M89, Structural Design of Glasses for Buildings. This study shows that, the glass guard rail can perform safely based on the geometry that was assumed (the aluminum posts were placed at maximum 47 inch O.C. and they had a total height of minimum 32-inch face-mount (minimum 26.2" thru deck) and/or 30-inch thru the deck, and the glass guard had a maximum total height of 42 in thru deck). Based on the geometry of the connection it requires 3/8" 4.5"x 4.5" aluminum baseplate at the base, with 4-3/8" (6") lag screw for the face mount connection to SPF or 4- KWIK HUS-EZ (KH-EZ) 3/8" (3 ¼") for the top mount connection to the concrete deck with minimum of 6" concrete thickness.

Table 2 – Analysis Result of Aluminum glass guard

Type	Top Cap	Post	Minimum Post Height	Maximum Total Height	Maximum Panel Width	Base Plate	Connection
Face Mount	Lower Channel Gasket (Fig. 2)	2.5"x2.5"x2mm Tube (Fig 3)	32" (29" Thru Deck)	42" Thru Deck	47"	3/8"-4.5"x4.5"	4-3/8" (6") lag screw @ 3" O.C.
Top Mount	Lower Channel Gasket (Fig. 2)	2.5"x2.5"x2mm Tube (Fig 3)	30" Thru Deck	42" Thru Deck	47"	3/8"-4.5"x4.5"	- KWIK HUS-EZ (KH-EZ) 3/8" (3 ¼") @ 3" O.C.

Sincerely,

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
M. YAZDINEZHAD
38222
2016-05-17

Mahdi Yazdinezhad, P.Eng., MASc
Structural Engineer