RICE
ENGINEERING
105 School Creek Trail | Luxemburg, WI 54217
(P) 920.617.1042 | (F) 920.617.1100

01/24/2024

STAR System International Ltd.
7465 Conway Avenue
Burnaby, BC V5E 2P7

Project: STAR System Aluminum Railing

To Whom It May Concern:

I would like to take this opportunity to introduce myself and our firm. My name is Joseph Bauer and I have fifteen years of experience in the design of railings. Our firm, Rice Engineering, is located northeast of Green Bay, Wisconsin, in the village of Luxemburg. Rice Engineering is licensed in all (50) U.S. States, Puerto Rico, Guam, and ten provinces of Canada. We have over 25 years of experience in the curtain wall and building envelope industry. Our fifty structural engineers and drafters provide structural calculations and shop drawings to installers and manufactures in the design of:

- Curtain walls, windows, storefront and blast design
- Composite and metal panel cladding
- Sunshades, canopies and awnings
- Louvers, fans, vents and hatches
- Stairs, platforms, mezzanines, railings and guardrails
- Glass walls, channel glass, glass stairs and floors
- Roof mounted equipment
- Florida product approvals and Miami Dade NOA's

Rice Engineering has more than 18 years of experience in railing engineering and anchorage design. Our Railing Engineering Group provides structural analysis and calculations for glass, aluminum, stainless steel, and steel railings with various infills and anchorage into all types of building structure. Each design considers live loads, wind loads, and infill loads based on IBC specifications and local building codes.

Our Midwest location allows us to provide our services at a competitive rate. We understand there are many options for engineering services. Therefore, we focus on working with our customers to provide cost effective solutions that meet their needs, in a timely manner. Our typical turn time is one to three weeks for engineering. If the project you are working on requires project specific calculations, please contact us and we can provide you with a quote.

Sincerely,

Joseph Bauer, P.E. (FL, GA, ID, KY, MA, MI, NY, OK, WI)
Manager – Railings Engineering Group

Cc: File

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STAR System International Ltd.
7465 Conway Avenue
Burnaby, BC V5E 2P7

RE: STAR System Aluminum Railing - IBC 2021

January 24, 2023

To whom it may concern:

Rice Engineering is pleased to submit this report and calculations which summarizes our analysis of the STAR Aluminum Railing System.

The calculations performed are for the STAR System “Classic Style” Picket Rail based on each members die drawing and assembly drawing which was provided to Rice Engineering previously by East & West Alum Craft. These drawings can be found at the end of the report.

Our conclusions for this report are based on design loads provided by the International Building Code 2021 (IBC 2021). The analysis provided meets the appropriate allowable stress design methods set forth by the Aluminum Association’s “Aluminum Design Manual”. The posts, post reinforcement, and base plates are designed solely by utilizing the test data as set forth per IBC 2021.

For the purposes of this report, a surface mount condition has been considered for two different substrate types: F’c= 4,000 psi normal weight cracked concrete and Southern Pine wood blocking (SG = 0.55 minimum). There is also an option for S-P-F wood blocking (SG = 0.42 minimum). The calculations are limited to the anchors embedment depth / penetration, spacing and edge distance dimensions as shown in the report. Also included are calculations for a surface core mounted condition. If the field conditions for the rail system installation are not as provided in this report, please contact East & West Alum Craft for custom anchorage design calculations. If using a core mounted condition, please contact the Engineer of Record on the project to verify concrete breakout is OK.

Since there are infinite layout possibilities for guardrails, the calculations provided with this report are limited to straight run guardrail systems with consideration for 1-span and 2+ span layouts. For guardrail layouts that include U-shapes, L-shapes or other custom layouts, please contact East & West Alum Craft for project specific guardrail calculations.

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Conclusions for STAR System Commercial Guards:

1. It is assumed that the commercial guardrails are a maximum height of 42”
2. Per the IBC 2021, a minimum design concentrated load of 200 LB applied in any direction at the top of the guard is required. Separately, a 50 PLF design uniform load in any direction is required at the top of the guard. Finally, a 50 LB lateral load applied over 1 ft^2 of the picket infill is required
3. Based on the above criteria from #2, the maximum post spacing for commercial applications for rail systems with 6061-T6 posts and 2” tall 6061-T6 I beam reinforcement are:

1-Span Guard (2 posts):	**6’-5” maximum**
2-Span or greater:	**4’-0” maximum**

4. See calculation sheets A4 through A6 for the appropriate standard concrete anchorage, wood anchorage and core mounted layout requirements for commercial applications.

Attachments:

The following sheets are the final calculations and STAR System layout and appropriate die drawings for the IBC 2021 analysis.

The structural calculations contained within this report are not intended to be submitted as project specific structural calculations. Rice Engineering assumes no liability for use of calculations. If project specific calculations are required, please contact Rice Engineering, 920-617-1042. The analysis within this report provides an acceptable engineered design for the STAR System to resist the specified loading, as well as the requirements outlined in IBC 2015.

If there are any questions regarding this submittal, please contact STAR System International Ltd..

Sincerely,

Joseph Bauer

RICE ENGINEERING
105 School Creek Trail | Luxemburg, WI 54217
(P) 920.617.1042 | (F) 920.617.1100

Star System - IBC 2021
Railing Calculations

Project Location:
USA
REI Project # R23-08-261

Prepared for:
STAR System International Ltd. - Burnaby, BC
01/24/2024

Design Criteria:

1. Railing live loads per **Building Code (IBC 2021)**:
   Guardrails
   - 50 plf uniform load in any direction on handrails and top rails of guards
   - 200 pound concentrated load in any direction on handrails and top rails of guards
   - 50 lb concentrated load over 1 ft^2 of infill area
   - Concentrated load and uniform loads need not be assumed to act concurrently
2. Metal railing deflections per ICC-ES AC273 and IBC.
3. Aluminum members designed per AA, "Aluminum Design Manual".
4. Member sizes, grade, alloy and strengths shall be as recommended in the calculation package.
5. Stainless steel screws (ASTM A193) & bolts (ASTM F593) to be **condition "CW", 300 Series, group 1 or 2, Fy= 65 ksi.**
6. All other fasteners shall be the size and strength as is recommended in the calculation package.
7. Aluminum welds to be **5356 filler alloy unless otherwise noted.**
8. Concrete strength is assumed to be **F'c= 4,000 psi, normal weight, cracked.**
9. Cement or epoxy based grout shall be a minimum **F'c= 6,000 psi, non-metallic, non-shrink.**
10. Concrete anchors shall be as recommended in the calculation package. Installer is responsible for maintaining the fastener spacing, edge distance, end distance, embedment depth and minimum substrate thickness that is recommended in the calculation package.
11. Concrete anchors shall be installed per manufacturer's recommended installation procedures, including recommended ambient temperatures for chemical/adhesive anchors.
12. **Concrete slabs and curbs, structural steel, masonry units, wood blocking, and all other anchorage substrates designed by others.**
13. Shim dis-similar metals. Maximum recommended shim height for guardrails is 1/2", full bearing shims.
14. Design of material separation to prevent reaction between dissimilar materials **not designed by Rice Engineering Inc.**
15. Wood substrates are assumed to be **Southern Pine or Equal, SG=0.55 minimum or S-P-F or Equal, SG = 0.42 minimum.**
16. Any and all 3rd party testing is not part of this submittal and is included for reference purposes only.

Disclaimer:

This Certification is limited to the structural design of structural components of this handrail or divider system.
It does NOT include responsibility for:

- Structural design of misc. hardware (latches, hinges, etc.).
- Structural design of concrete slabs and other masonry units
- Structural design of wood blocking or wood framing
- Structural design of all other anchorage substrates
- Glass breakage due to airborne debris or foreign objects
- The manufacture, assembly, or installation of the system.
- Quantities of materials or dimensional accuracy of drawings

The structural calculations contained within this report are not intended to be submitted as project specific structural calculations. Rice Engineering assumes no liability for use of calculations. If project specific calculations are required, please contact Rice Engineering, 920-617-1042. The analysis within this report provides an acceptable engineered design for the STAR Picket Rail System to resist the specified loading, as well as the requirements outlined in IBC 2021.

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Star System - IBC 2021
Railing Calculations

Project Location:
USA
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Prepared for:
STAR System International Ltd. - Burnaby, BC
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Page:	Description:	Date:	Revision:
IBC	IBC Analysis	1/10/24	
A1	Top Rail	1/10/24	
A2-A2A	Post Analysis	1/10/24	
A2.1	Post Analysis	1/10/24	
A3-A3.1	Picket Infill	1/10/24	
A4	Anchorage to Concrete	1/10/24	
A5	Anchorage to Wood	1/10/24	
A5A-A5C	Lag Screws	1/10/24	
A5.1	Lag Screws	1/10/24	
A6	Anchorage to Grout	1/10/24	
S1-S2	Section Properties	1/10/24	
	System Drawings		
	Appendix A – Concrete Anchor Data		
	Appendix B – 3rd Party Testing (Not part of this submittal)		

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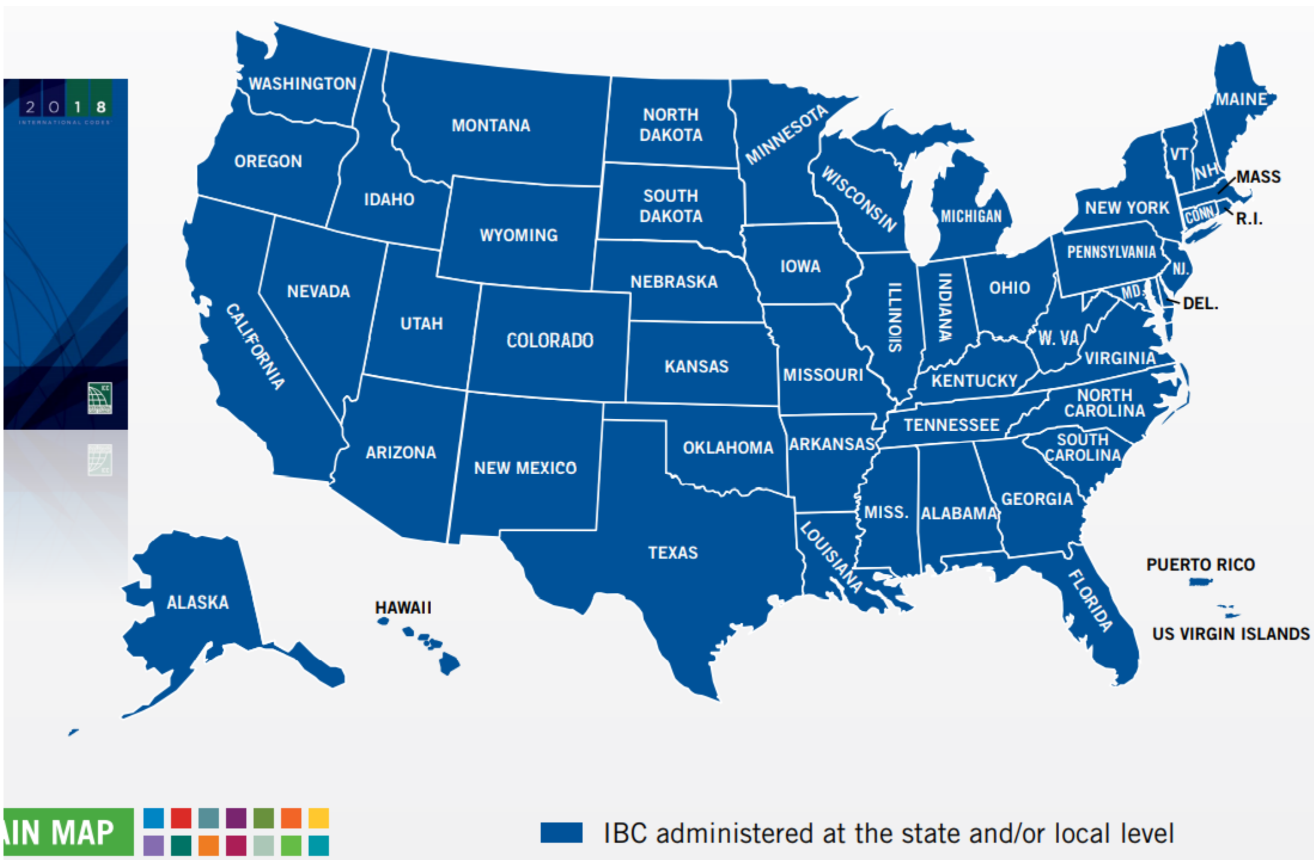


International Building Code 2021 Analysis

50 plf uniform load in any direction on top rail

200# concentrated load in any direction on top rail

50# concentrated load applied to 1 square foot of infill

Extruded Railing and Post

IBC Rail Analysis (1-Span)	Detail Ref.	Sheet No: A1

Input Variables:

$F_H := 50$ PLF Load Case 1 (Uniform Load)

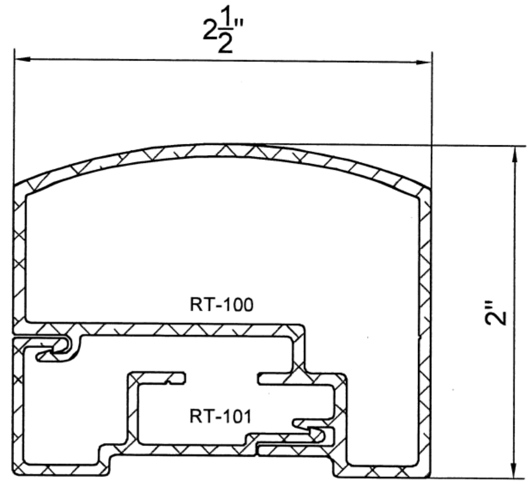
$F_V := 50$ PLF Vertical uniform load (Simultaneous)

$P := 200$ lb Load Case 2 (Point Load)

$L_{bp} := 3$ in Unbraced Length of Post

$L_w := 0$ in Max Bottom Rail Weld Length

$L := 77$ in ***6'-5" MAX RAIL SPAN***



2 1/2" x 2" Top Rail RT-100/101

Number of Railing Spans:

- [x] 1 span *(Worst Case Check for Railing)*
- [ ] 2 span
- [ ] 3 or more spans

Top Rail Section:

Top Rail

Insert Channel:

Channel

Railing Temper:

- [ ] 6063-T5
- [x] 6005-T5 or equal
- [ ] Open Section
- [x] Closed Section

Channel Temper:

- [ ] 6063-T5
- [x] 6005-T5 or equal

Calculations: *All Calculations Below This Line Are Automatic*

Railing Properties		*Channel Properties*	
$I_{xr} = 0.320$	in^4	$I_{xch} = 0.009$	in^4
$I_{yr} = 0.500$	in^4	$I_{ych} = 0.054$	in^4
$S_{xr} = 0.260$	in^3	$S_{xch} = 0.017$	in^3
$S_{yr} = 0.350$	in^3	$S_{ych} = 0.078$	in^3
$J_r = 0.400$	in^4	$J_{ch} = 0.001$	in^4
$E_r = 10100000$	psi	$E_{ch} = 10100000$	psi
$d_r = 2.50$	in	$d_{ch} = 1.38$	in

$I_{xtotr} := I_{xr} + I_{xch}$ $I_{xtotr} = 0.329$ in^4

$I_{ytotr} := I_{yr} + I_{ych}$ $I_{ytotr} = 0.554$ in^4

Computational Factors

$K_1 := (8 \cdot q1) + (8 \cdot q2) + (9.5 \cdot q3)$ $K_1 = 8$

$K_2 := (4 \cdot q1) + (5 \cdot q2) + (5 \cdot q3)$ $K_2 = 4$

$K_3 := (48 \cdot q1) + (66 \cdot q2) + (87 \cdot q3)$ $K_3 = 48$

Railing Analysis:

$L_{br} := L - 2 \quad W_h := \frac{F_H}{12} \quad W_v := \frac{F_V}{12}$

IBC Rail Analysis (1-Span)	Detail Ref.	Sheet No: A1 A

Case 1 Uniform Load:

$\Delta_{yr1} := \frac{5 \cdot W_h \cdot L^4}{384 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr1} = 0.341$ in Modeled as a simple span

$\Delta_{xr1} := \frac{5 \cdot W_v \cdot L^4}{384 \cdot E_r \cdot I_{xtotr}}$ $\Delta_{xr1} = 0.57$ in

$\Delta_{allr} := \frac{L}{96}$ $\Delta_{allr} = 0.8$ in Per ASTM Specification E985 / ICC AC273

$M_{yrmax} := \frac{W_h \cdot L^2}{K_1}$ $M_{yrmax} = 3088$ in·lb

$M_{xrmax} := \frac{W_v \cdot L^2}{K_1}$ $M_{xrmax} = 3088$ in·lb

$r_{yr} := \frac{1}{1.7} \cdot \sqrt{\frac{I_{xr} \cdot d_r}{S_{yr}} \left[-.5 + \sqrt{1.25 + .152 \cdot \frac{J_r}{I_{xr}} \cdot \left(\frac{L_{br}}{d_r} \right)^2} \right]}$

$T6_r = 1 \quad Sc_r = 1$

$T5_r = 0 \quad So_r = 0$

$S_{RO1} := \frac{L_{br}}{\sqrt{r_{yr}}} \quad S_{RC1} := \frac{2 \cdot L_{br} \cdot S_{yr}}{\sqrt{I_{xr} \cdot J_r}}$

$f_{bry1} := \frac{M_{yrmax} \cdot I_{yr}}{S_{yr} \cdot I_{ytotr}}$ $f_{bry1} = 7963$ psi

$f_{brx1} := \frac{M_{xrmax} \cdot I_{xr}}{S_{xr} \cdot I_{xtotr}}$ $f_{brx1} = 11552$ psi

$F_{brx} := 12500 \cdot T5_r + 19500 T6_r$

Case 2 - Point Load:

$M_{prmax} := \frac{P \cdot L}{K_2}$ $M_{prmax} = 3850$ in·lb

$\Delta_{yr2} := \frac{P \cdot L^3}{K_3 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr2} = 0.34$ in

$f_{bry2} := \frac{M_{prmax} \cdot I_{yr}}{S_{yr} \cdot I_{ytotr}}$ $f_{bry2} = 9928$ psi

$\Delta_{xr2} := \frac{P \cdot L^3}{K_3 \cdot E_r \cdot I_{xtotr}}$ $\Delta_{xr2} = 0.572$ in

$f_{brx2} := \frac{M_{prmax} \cdot I_{xr}}{S_{xr} \cdot I_{xtotr}}$ $f_{brx2} = 14403$ psi

$F_{bry} = 19500$ psi $F_{brx} = 19500$ psi

Calculation Results:

$Int_{r1} := \max\left[\left[\left(\frac{f_{brx1}}{F_{brx}} \right) + \left(\frac{f_{bry1}}{F_{bry}} \right) \right] \cdot S, \max\left(\frac{f_{bry1}}{F_{bry}}, \frac{f_{brx1}}{F_{brx}} \right) \right]$ $Int_{r1} = 0.59$

$Int_{r2} := \max\left(\frac{f_{bry2}}{F_{bry}}, \frac{f_{brx2}}{F_{brx}} \right)$ $Int_{r2} = 0.74$

$RAILS := \begin{cases} \text{"OK"} & \text{if } \frac{\max(\Delta_{yr1}, \Delta_{xr1}, \Delta_{yr2}, \Delta_{xr2})}{\Delta_{allr}} \le 1 \wedge Int_{r1} \le 1 \wedge Int_{r2} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$

RAILS = "OK"

Inputs:

$b := 2$	in		
$t := 0.125$	in		
$d := 2$	in		
$L := 48$	in	Post Tributary Width	
$h := 42$	in	Railing Height	
$L_b := 3$	in	Bottom Rail Height	
$L_w := 2$	in	Max Bottom Rail Weld Length	

Post Analysis	Detail Ref.	Sheet No: A2

Post Material:

6061-T6 Aluminum

$b_1 := b - 2t = 1.75$ in

$d_1 := d - 2t = 1.75$ in

Post Properties:

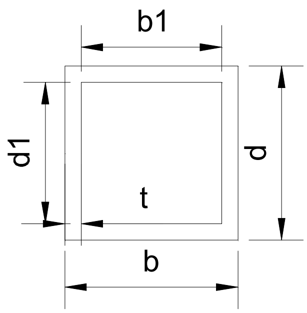
$A := b \cdot d - b_1 \cdot d_1 = 0.938$ in^2

$I_x := 0.0833\left(b \cdot d^3 - b_1 \cdot d_1^3\right) = 0.552$ in^3

$S_x := \left(b \cdot d^3 - b_1 \cdot d_1^3\right) \cdot (6d)^{-1} = 0.55$ in^3

$Z_x := 0.25 \cdot b \cdot d^2 - 0.25 b_1 \cdot d_1^2 = 0.66$ in^3

$J := 2 \cdot t \cdot b^2 \cdot d^2 \cdot (b + d)^{-1} = 1.0000$



Railing Loading:

$W_h := 50$	plf	Horizontal Uniform Load
$W_v := 0$	plf	Simultaneous Vertical Load
$P := 200$	lb	Concentrated Load

Use 2" x 2" x 1/8" Wall Tube
(6061-T6 or better)
with reinforcement as shown below

Post Construction:

☑ Welded within 1" of Maximum Moment

☑ Bottom rail welded to post

Calculations:

All Calculations Below This Line Are Automatic

$$E_p := \begin{cases} 10000000 & \text{if } M1 < 7 \\ 29000000 & \text{otherwise} \end{cases} = 10000000$$

$w_h := \frac{W_h}{12} = 4.17$ pli $\quad w_v := \frac{W_v}{12} = 0$ pli

Allowable Stress Coefficients:

$X1 = 10.2$	$X5 = 10.2$	$X9 = 9.1$	$X13 = 58$	$X17 = 16$
$X2 = 0.08$	$X6 = 0.08$	$X10 = 28.2$	$X14 = 346$	$X18 = 0.07$
$X3 = 6943$	$X7 = 6943$	$X11 = 12$	$X15 = 11.8$	$X19 = 123$
$X4 = 23599$	$X8 = 23599$	$X12 = 0.11$	$X16 = 64.2$	$X20 = 982$

Material Properties:

$F_{ty} = 15000$	psi
$F_{cy} = 15000$	psi
$F_{tu} = 24000$	psi
$F_{tyw} = 15000$	psi
$F_{cyw} = 15000$	psi
$F_{tuw} = 24000$	psi
$F_{ySTL} = 0$	psi

2" Min. Length - I Stub Properties - 6061-T6

$I_{st} := 0.347$	in^4	$L_{st} := 2$	in
$S_{st} := 0.401$	in^3	$E_{st} := 10000000$	psi
$F_{bst} = 9091$	psi		

Note: Separate Dissimilar Metals

$S_r := \frac{2 \cdot L_b \cdot S_x}{C_b \sqrt{I_y \cdot J}} = 2.67 \qquad C_b = 1.67$

[F.3.1] $$F_{bAL} := \begin{cases} \left[\left(X1 - X2\sqrt{S_r}\right) \cdot 1000\right] & \text{if } S_r \le X3 \\ \frac{X4}{S_r} & \text{otherwise} \end{cases} = 10066 \text{ psi}$$

[F.8.1.1]
[F.8.1.2] $$F_{bAL2} := \min\left(\min\left(\frac{F_{ty}}{1.65}, \frac{F_{tu}}{1.95}\right), \min\left(\frac{1.30 \cdot F_{ty}}{1.65}, \frac{1.42 \cdot F_{tu}}{1.95}\right)\right) = 9091 \text{ psi}$$

[F.8.2.1] $S_{rf} := b_1 \cdot t^{-1} = 14$

[B.5.4.2] $$F_{bAL3} := \begin{cases} X9 \cdot 1000 & \text{if } S_{rf} < X10 \\ \text{otherwise} & \begin{cases} \left(X11 - X12 \cdot S_{rf}\right) \cdot 1000 & \text{if } S_{rf} \le X13 \\ \frac{X14}{S_{rf}} \cdot 1000 & \text{otherwise} \end{cases} \end{cases} = 9100 \text{ psi}$$

[F.8.2.2] $S_{rw} := d_1 \cdot t^{-1} = 14$

[B.5.5.1] $$F_{bAL4} := \begin{cases} X15 \cdot 1000 & \text{if } S_{rw} < X16 \\ \text{otherwise} & \begin{cases} \left(X17 - X18 \cdot S_{rw}\right) \cdot 1000 & \text{if } S_{rf} \le X19 \\ \frac{X20}{S_{rw}} \cdot 1000 & \text{otherwise} \end{cases} \end{cases} = 11800 \text{ psi}$$

$F_{bSTL} := \frac{F_{ySTL}}{1.67} = 0$ psi

$F_b := \max\left(\min\left(F_{bAL}, F_{bAL2}, F_{bAL3}, F_{bAL4}\right), F_{bSTL}\right) = 9091$ psi

$\Delta_{xp1} := \frac{w_h \cdot L \cdot \left(h - L_{st}\right)^3}{3 \cdot E_p \cdot I_x} = 0.77$ in

$\Delta_{xp2} := \frac{P \cdot 0.85 \cdot \left(h - L_{st}\right)^3}{3 \cdot E_p \cdot I_x} = 0.66$ in

$\Delta_{tot} := \frac{w_h \cdot L \cdot \left(h - L_{st}\right)^3}{3 \cdot E_p \cdot I_x} + \frac{w_h \cdot L \cdot \left[h - \left(h - L_{st}\right)\right]^3}{3 \cdot \left[\left(E_p \cdot I_x\right) + \left(E_{st} \cdot I_{st}\right)\right]} = 0.77$ in

$\Delta_{allp} := \frac{2 \cdot h}{60} = 1.4$ in Per IBC

Case 1 - Uniform Load:

$M_{xpmax} := (w_h \cdot L \cdot h) + w_v \cdot L \cdot \Delta_{tot}$ $M_{xpmax} = 8400$ lb·in

$M_{xpmax2} := w_h \cdot L \cdot (h - L_{st}) + w_v \cdot L \cdot \Delta_{xp1}$ $M_{xpmax2} = 8000$ lb·in

Case 2 - Point Load:

$M_{xpmax3} := (P \cdot h \cdot 0.85)$ $M_{xpmax3} = 7140$ lb·in

$M_{xpmax4} := P \cdot (h - L_{st}) \cdot 0.85$ $M_{xpmax4} = 6800$ lb·in

Max Post Stress Above Reinforcement:

$$f_{bpx} := \begin{cases} \frac{\max(M_{xpmax2}, M_{xpmax4})}{Z_x} & \text{if } M1 \geq 7 \\ \frac{\max(M_{xpmax2}, M_{xpmax4})}{S_x} & \text{otherwise} \end{cases}$$

$f_{bpx} = 14499$ psi

$F_{bpx} = 19500$ psi

Max Post/Stub Combined Stress @ Bottom Rail Weld:

(Run Reinforcement Past Bottom Rail)

$h_{br} := h - L_b$ $h_{br} = 39$ in

$M_{b1} := w_h \cdot L \cdot h_{br} + w_v \cdot L \cdot \frac{w_h \cdot L \cdot h_{br}^3}{3 \cdot E_p \cdot I_x}$ $M_{b1} = 7800$ in·lb

$M_{b2} := P \cdot 0.85 \cdot h_{br}$ $M_{b2} = 6630$ in·lb

$f_{bbr} := \max(M_{b1}, M_{b2}) \cdot \frac{I_x \cdot E_p}{(I_x \cdot E_p + I_{st} \cdot E_{st}) \cdot S_x}$ $f_{bbr} = 8677$ psi

$F_{bw} := \min\left(\frac{F_{tyw}}{1.65}, \frac{F_{tuw}}{1.95}\right)$ $F_{bw} = 9091$ psi

$A_w := (L_w + 2) \cdot (2) \cdot t \cdot C2$ $A_w = 1.000$ in^2

$F_{bbr} := \max\left[F_{bSTL}, \max\left[F_{bpx} - \frac{A_w}{A} \cdot (F_{bpx} - F_{bw}), F_{bw}\right]\right]$ $F_{bbr} = 9091$ psi

Max Post/Stub Combined Stress:

$$f_{bpx2} := \begin{cases} \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_x \cdot E_p}{(I_x \cdot E_p + I_{st} \cdot E_{st}) \cdot Z_x} & \text{if } M1 \geq 7 \\ \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_x \cdot E_p}{(I_x \cdot E_p + I_{st} \cdot E_{st}) \cdot S_x} & \text{otherwise} \end{cases}$$

$f_{bpx2} = 9345$ psi

$F_b = 9091$ psi

3% Over
OK Per Testing
See Sheet A2.1

Max Stub Stress:

$f_{bst} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{st} \cdot E_{st}}{(I_x \cdot E_p + I_{st} \cdot E_{st}) \cdot S_{st}}$

$f_{bst} = 8090$ psi

$F_{bst} = 9091$ psi

Calculation Results:

$Int_{p1} := \max\left(\frac{f_{bpx}}{F_{bpx}}, \frac{f_{bpx2}}{F_b \cdot 1.03}, \frac{f_{bst}}{F_{bst}}, \frac{f_{bbr}}{F_{bbr}}\right)$ $Int_{p1} = 1$

$$POSTS := \begin{cases} \text{"OK"} & \text{if } Int_{p1} \leq 1 \wedge \frac{\max(\Delta_{xp1}, \Delta_{xp2}, \Delta_{tot})}{\Delta_{allp}} \leq 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$$

POSTS = "OK"

Reactions for Anchorage (ASD):

$R := \max(P \cdot 0.85, w_h \cdot L) = 200$ lb

$M := \max(M_{xpmax}, M_{xpmax3}) = 8400$ in·lb

$M_p = 5156$ in·lb

$M_{st} = 3244$ in·lb

Inputs:

ADM Testing

Post Analysis	Detail Ref.	Sheet No: A2.1

$$a \equiv \begin{pmatrix} 534 \\ 521 \\ 556 \\ 583 \\ 568 \\ 584 \\ 538 \\ 573 \\ 475 \\ 480 \\ 499 \\ 572 \\ 489 \\ 538 \\ 514 \end{pmatrix} \text{ lb}$$

Method 2:

$\beta_o := 3.5$ target reliablility index

Rt_i strength of ith test

$Rt := a$

$\alpha := 0.2$

$e := 2.72$

$M_m := 1.00$ mean value of material factor

$F_m := 1.0$ mean value of fabrication factor

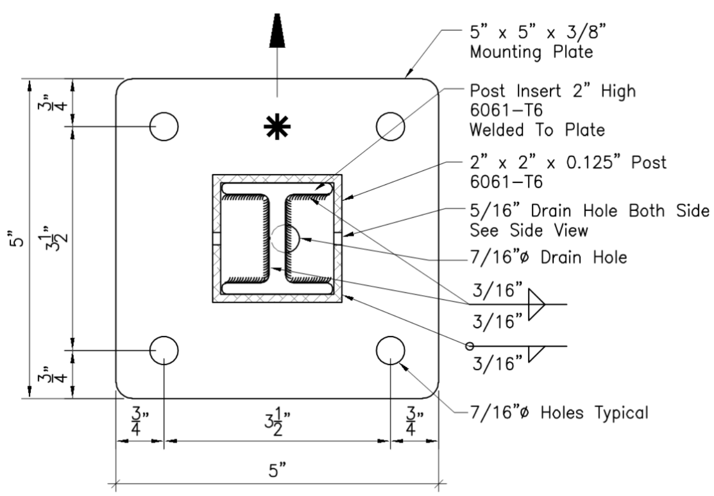
$V_M := 0.06$ coefficient of variation of material factor

$V_F := 0.15$ coefficient of variation of fabrication factor

$n := rows(a) = 15$ number of tests

Calculations:

All Calculations Below This Line Are Automatic



$$C_n := \frac{n^2 - 1}{n^2 - 3n} = 1.24$$ correction factor

$$R_{tm} := mean(a) = 534.93$$ mean strength of all tests

$$V_P := \sqrt{\frac{\left[\sum_{i=0}^{n-1}\left(\frac{Rt_i}{R_{tm}}\right)^2\right] - \frac{\left[\sum_{i=0}^{n-1}\left(\frac{Rt_i}{R_{tm}}\right)\right]^2}{n}}{n-1}} = 0.07$$

coefficient of variation of the ratio of the observed failure loads divided by the average value of all observed failure loads

$V_Q := 0.21$ coefficient of variation of the loads

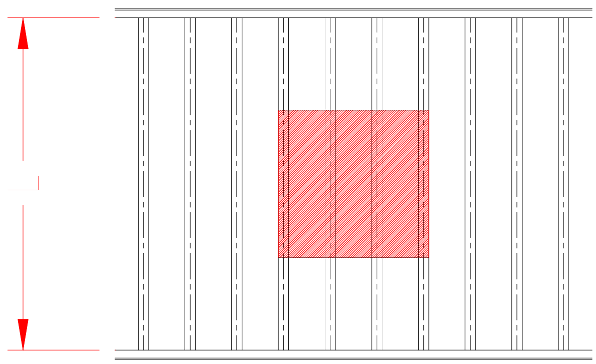
$$\Omega := \max\left[\left[\frac{1.05\alpha + 1}{M_m \cdot F_m \cdot (\alpha + 1)}\right] \cdot e^{\beta_o \cdot \sqrt{V_M^2 + V_F^2 + C_n \cdot V_P^2 + V_Q^2}}, 1.95\right] = 2.65$$

Safety Factor

$$Allowable2 := \frac{R_{tm}}{\Omega} = 202 \text{ lb}$$

$$M_{all2} := Allowable2 \cdot 42 = 8467 \text{ in} \cdot \text{lb}$$

Use 2" x 2" x 1/8" Wall Post (6061-T6)
with 2" Tall Aluminum Reinforcement (6061-T6)
(Loaded the Strong Way)
Test Report By Others - See Appendix A



Picket Infill	Detail Ref.	Sheet No: A3

Picket Dimensions:

$b := 0.625$ in (Picket Size)

$d := b$

$t := 0.05$ in (Wall thickness)

$L := 37.5$ in (Picket Length)

$L_r := 75$ in (Rail Length)

$Load := 50$ psf over 1 ft^2

$Trib := 4.5$ in (Picket Spacing - o.c.)

- [x] 6063-T5
- [ ] 6063-T6
- [ ] 6005-T5 or 6005A-T61
- [ ] 6061-T6

---

all calculations below this line are automatic

Check Pickets:

$B := 12$ in

$A := \frac{L - B}{2}$ $C := A$

$A = 12.75$ in

$C = 12.75$ in

$w := \frac{Load \cdot Trib}{144}$ $w = 1.56$ pli

$\Delta act := \frac{(w \cdot B) \cdot L^3}{48 \cdot E \cdot I_x}$ $\Delta act = 0.319$ in

$\Delta all := \frac{L}{60}$ $\Delta all = 0.625$ in

$R1 := \frac{w \cdot B}{2 \cdot L} \cdot (2C + B)$ $R1 = 9.4$ lb

$M := R1 \cdot \left(A + \frac{R1}{2w}\right)$ $M = 147.7$ lb·in

$S_r := \frac{2 \cdot L S_x}{\sqrt{J \cdot I_x}}$ $S_r = 196.7$

$f_{bx} := \frac{M}{S_x}$

$$PICKET := \begin{cases} \text{"OK"} & \text{if } \frac{f_{bx}}{F_{bx}} \le 1 \wedge \frac{\Delta act}{\Delta all} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$$

$f_{bx} = 7227$ psi

$F_{bx} = 9518$ psi

PICKET = "OK"

$d_1 := d - 2t$ $b_1 := b - 2t$ $E := 10.1 \cdot 10^6$ psi

$I_x := \frac{(b \cdot d^3) - (b_1 \cdot d_1^3)}{12}$ $I_x = 0.01$ in^4

$S_x := \frac{(b \cdot d^3) - (b_1 \cdot d_1^3)}{6d}$ $S_x = 0.02$ in^3

$J := \frac{4 \cdot (b - t)^4 \cdot t}{4 \cdot (b - t)}$ $J = 0.01$ in^4

Check Intermediate or Bottom Rails:

Input: $I_{x1} := 0.04$ in^4

$I_{x2} := 0.03$ in^4 $S_{y2} := 0.04$ in^3

$w_1 := \frac{Load}{12}$ $w_1 = 4.17$ $\frac{lb}{in}$

$b_{10} := 12 = 12$ in

$a := \frac{L_r - b_{10}}{(2)} = 31.5$ in

$c := a = 31.5$ in

$M_2 := \frac{w_1 \cdot b_{10}}{8 \cdot L_r^2} \cdot (2 \cdot c + b_{10}) \left[4 \cdot a \cdot L_r + b_{10} \cdot (2c + b_{10})\right]$

$f_{b2} := \frac{M_2 \cdot I_{x1}}{S_{y2} \cdot (I_{x1} + I_{x2})}$ $f_{b2} = 12321$ psi

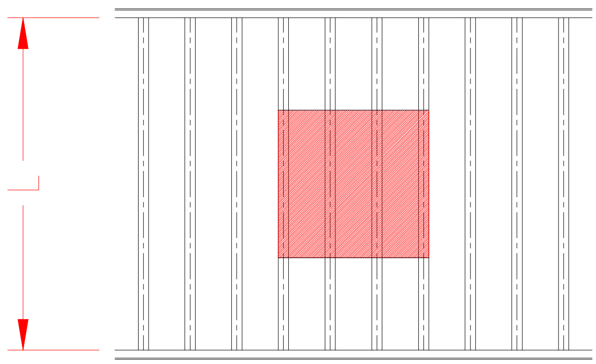
$\Delta_r := \frac{Load \cdot L_r^3}{48 \cdot E \cdot (I_{x1} + I_{x2})} = 0.62$ in $\Delta rall := \frac{L_r}{120} = 0.63$ in

$$RAIL := \begin{cases} \text{"OK"} & \text{if } \frac{f_{b2}}{19500} \le 1 \wedge \frac{\Delta_r}{\Delta rall} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$$

RAIL = "OK"

Use 5/8" x 5/8" x 0.050" Wall Picket
(6063-T5 or better)

Use Bottom Rail, As Shown
(6005-T5 or 6005A-T61)



Picket Infill	Detail Ref.	Sheet No: A3.1

Picket Dimensions:

$b := 0.625$ in (Picket Size)

$d := b$

$t := 0.05$ in (Wall thickness)

$L := 37.5$ in (Picket Length)

$L_r := 75$ in (Rail Length)

$Load := 50$ psf over 1 ft^2

$Trib := 3.94$ in (Picket Spacing - o.c.)

☑ 6063-T5
☐ 6063-T6
☐ 6005-T5 or 6005A-T61
☐ 6061-T6

---

all calculations below this line are automatic

Check Pickets:

$B := 12$ in

$A := \frac{L - B}{2}$ $C := A$

$A = 12.75$ in

$C = 12.75$ in

$w := \frac{Load \cdot Trib}{144}$ $w = 1.37$ pli

$\Delta_{act} := \frac{(w \cdot B) \cdot L^3}{48 \cdot E \cdot I_x}$ $\Delta_{act} = 0.28$ in

$\Delta_{all} := \frac{L}{60}$ $\Delta_{all} = 0.625$ in

$R1 := \frac{w \cdot B}{2 \cdot L} \cdot (2C + B)$ $R1 = 8.2$ lb

$M := R1 \cdot \left(A + \frac{R1}{2w}\right)$ $M = 129.3$ lb·in

$S_r := \frac{2 \cdot L \cdot S_x}{\sqrt{J \cdot I_x}}$ $S_r = 196.7$

$f_{bx} := \frac{M}{S_x}$

$PICKET := \begin{cases} \text{"OK"} & \text{if } \frac{f_{bx}}{F_{bx}} \le 1 \wedge \frac{\Delta_{act}}{\Delta_{all}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$

$f_{bx} = 6327$ psi

$F_{bx} = 9518$ psi

PICKET = "OK"

$d_1 := d - 2t$ $b_1 := b - 2t$ $E := 10.1 \cdot 10^6$ psi

$I_x := \frac{(b \cdot d^3) - (b_1 \cdot d_1^3)}{12}$ $I_x = 0.01$ in^4

$S_x := \frac{(b \cdot d^3) - (b_1 \cdot d_1^3)}{6d}$ $S_x = 0.02$ in^3

$J := \frac{4 \cdot (b - t)^4 \cdot t}{4 \cdot (b - t)}$ $J = 0.01$ in^4

Check Intermediate or Bottom Rails:

Input: $I_{x1} := 0.04$ in^4

$I_{x2} := 0.03$ in^4 $S_{y2} := 0.04$ in^3

$w_1 := \frac{Load}{12}$ $w_1 = 4.17$ $\frac{lb}{in}$

$b_{10} := 12 = 12$ in

$a := \frac{L_r - b_{10}}{(2)} = 31.5$ in

$c := a = 31.5$ in

$M_2 := \frac{w_1 \cdot b_{10}}{8 \cdot L_r^2} \cdot (2 \cdot c + b_{10}) \left[4 \cdot a \cdot L_r + b_{10} \cdot (2c + b_{10})\right]$

$f_{b2} := \frac{M_2 \cdot I_{x1}}{S_{y2} \cdot (I_{x1} + I_{x2})}$ $f_{b2} = 12321$ psi

$\Delta_r := \frac{Load \cdot L_r^3}{48 \cdot E \cdot (I_{x1} + I_{x2})} = 0.62$ in $\Delta_{rall} := \frac{L_r}{120} = 0.63$ in

$RAIL := \begin{cases} \text{"OK"} & \text{if } \frac{f_{b2}}{19500} \le 1 \wedge \frac{\Delta_r}{\Delta_{rall}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$

RAIL = "OK"

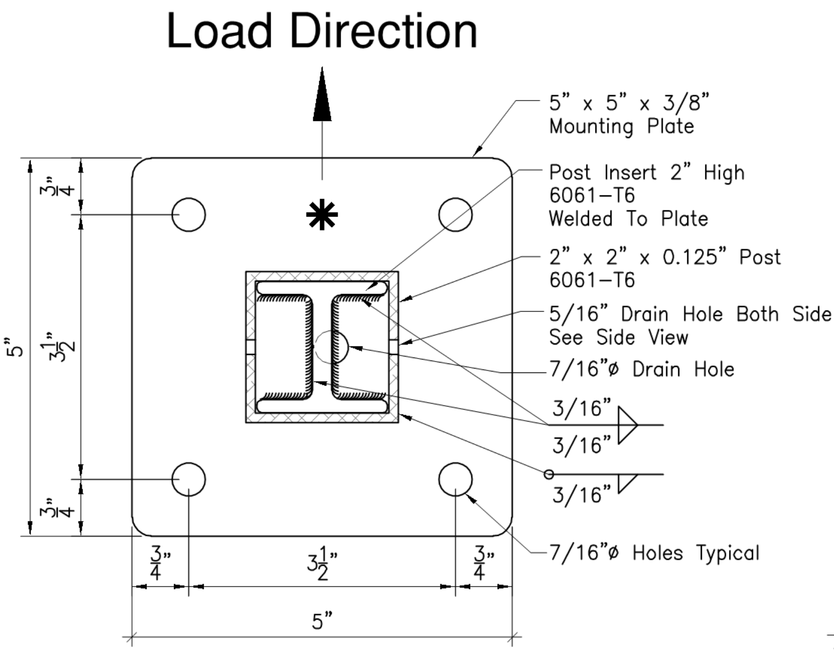
Use 5/8" x 5/8" x 0.050" Wall Picket
(6063-T5 or better)

Use Bottom Rail, As Shown
(6005-T5 or 6005A-T61)

IBC Anchorage to Concrete	Detail Ref.	Sheet No: A4

$R_{max} := 202$ lb $b := 2$ in (post width)

$M_{max} := 8467$ in·lb $d := 2$ in (post depth)



Chk Post Weld to Base Plate:

<u>Use 3/16" fillet weld all around</u>
5356 filler alloy
OK Per Testing

Chk I-Beam Weld to Base Plate:

<u>Use 3/16" Fillet Welds</u>
5356 filler alloy - All Around - Inside of I-Beam
OK Per Testing

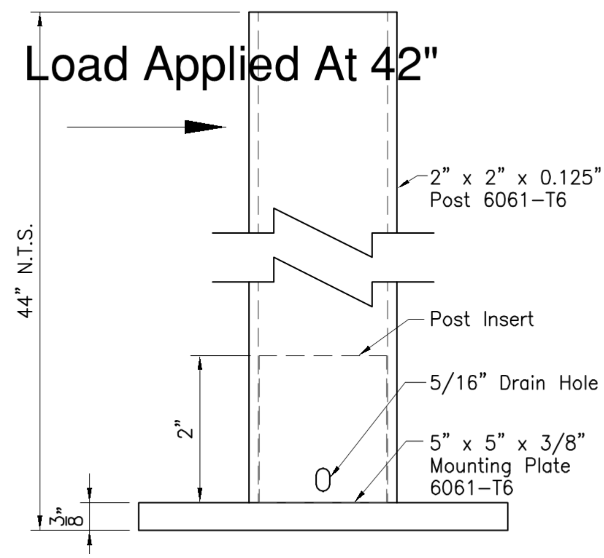
Chk Base Plate:

<u>Use 3/8" x 5" x 5" Plate</u>
6061-T6 alloy
OK Per Testing

Chk Anchor Bolts:

$V_b := R_{max} \cdot 1.6$ $V_b = 323$ lb

$M_b := M_{max} \cdot 1.6$ $M_b = 13547$ in·lb



*****SEE CONCRETE ANCHOR MANUFACTURER DATA*****

<u>Use (4) 3/8" Dia. SS Hilti HIT-Z-R Rods</u>
<u>with HIT-HY 200 Adhesive</u>
300 Series Stainless Steel

Embedment: 2-3/4" Min.
Edge Distance: 3-1/4"
2nd Edge Distance: 3-1/4"
Spacing: 3-1/2"
Min. Slab Thickness: 5"
Concrete Strength: f'c= 4,000 psi, Normal Wt., Cracked

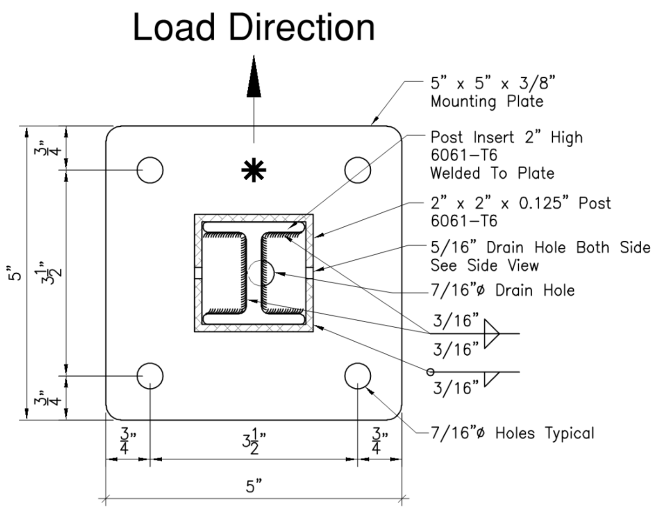
*****Install per Manufacturer's instructions*****

OR

<u>Use (4) 3/8" Dia. SS Hilti Kwik Bolt TZ2 Anchors</u>
300 Series Stainless Steel

Embedment: 3" Min.
Edge Distance: 3-1/4"
2nd Edge Distance: 3-1/4"
Spacing: 3-1/2"
Min. Slab Thickness: 5"
Concrete Strength: f'c= 4,000 psi, Normal Wt., Cracked

*****Install per Manufacturer's instructions*****



IBC Anchorage to Wood	Detail Ref.	Sheet No: A5

$R_{max} := 202$ lb $b := 2$ in (post width)

$M_{max} := 8467$ in·lb $d := 2$ in (post depth)

Chk Post Weld to Base Plate:

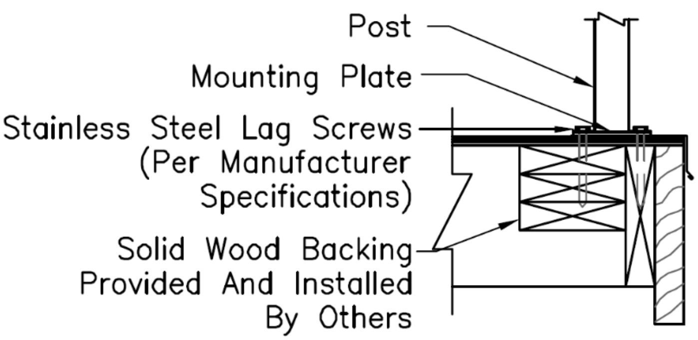
Use 3/16" fillet weld all around
5356 filler alloy
OK Per Testing

Chk I-Beam Weld to Base Plate:

Use 3/16" Fillet Welds
5356 filler alloy - All Around - Inside of I-Beam
OK Per Testing

Chk Base Plate:

Use 3/8" x 5" x 5" Plate
6061-T6 alloy
OK Per Testing



see Sheet A5B for Wet Conditions - Southern Pine

Use (4) 3/8" Dia. SS Lag Screws
300 Series Stainless Steel

Penetration: 4-1/4" Min.
Thread Engagement: 3-3/16" min.
Edge Distance: 1-1/2"
End Distance: 2-5/8"
Spacing: as shown
Assume S.G. = 0.55 (So. Pine)

Install per NDS Guidelines
Wood Blocking Designed By Others
Moisture Content > or = to 19%

Chk Anchor Bolts:

$V_b := \frac{R_{max}}{2}$ $V_b = 101$ lb

$T_b := \frac{M_{max}}{4.25 \cdot 0.85 \cdot 2}$ $T_b = 1172$ lb

Sheet A5A for Dry Conditions - Southern Pine

Use (4) 3/8" Dia. SS Lag Screws
300 Series Stainless Steel

Penetration: 3" Min.
Thread Engagement: 2-9/16" min.
Edge Distance: 1-1/2"
End Distance: 2-5/8"
Spacing: as shown
Assume S.G. = 0.55 (So. Pine)

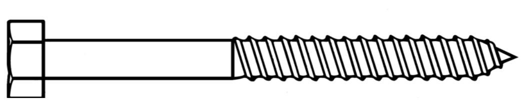
Install per NDS Guidelines
Wood Blocking Designed By Others
Moisture Content < 19%

Sheet A5C for Dry Conditions - SPF

Use (4) 3/8" Dia. SS Lag Screws
300 Series Stainless Steel

Penetration: 4-5/16" Min.
Thread Engagement: 3-1/4" min.
Edge Distance: 1-1/2"
End Distance: 2-5/8"
Spacing: as shown
Assume S.G. = 0.42 (S-P-F)

Install per NDS Guidelines
Wood Blocking Designed By Others
Moisture Content < 19%



RICE ENGINEERING
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Fax: (920) 617-1100
www.rice-inc.com

Project Description: **Star System - IBC 2021**

Job No:	R23-08-261		
Engineer:	JDB	Sheet No:	A5
Date:	1/10/2024	Rev:	
Chk By:		Date:	

Dowel Type Fastener Capacity

Lag Screws	Detail Ref.	Sheet No: A5A

$V_{pos} := 101 \cdot lbf$ $V_{neg} := 101 \cdot lbf$

$T_{pos} := 1172 \cdot lbf$ $T_{neg} := 1172 \cdot lbf$

3/8 in Lag Screw SS

$l_m := 4.5$ thickness of main member, in.

$l_s := 0.375$ thickness of side member, in

6061-T6 Hole

$F_{yb} = 65000$ bending yield strength, psi.

$D = 0.375$ unthreaded shank diameter of screw, in.

$D_r = 0.27$ root diameter of screw

$F_{es} = 43000$ bearing strength, psi

Mixed Maple Southern Pine

$p := 3$ penetration, in

$t_{shim} := 0.75$ thickness of shim, in

$C_D := 1.6$ load duration factor, 10.3.2

$C_M := 1.0$ wet service factor, 10.3.3

$C_t := 1.0$ temperature factor, 10.3.4

$C_g := 1.0$ group action factor, 10.3.6

$C_\Delta := 1.0$ geometry factor, 11.5.1

$C_{eg} := 1.0$ end grain factor, 11.5.2

$C_{di} := 1.0$ diaphragm factor, 11.5.3

$\theta := 90$ angle of load to grain, degree

Calculations

$K_\theta := 1 + 0.25 \cdot \frac{\theta}{90} = 1.25$ $R_e := \frac{F_{em}}{F_{es}} = 0.1$ $R_t := \frac{l_m}{l_s} = 12$

$$k_1 := \frac{\sqrt{R_e + 2 \cdot R_e^2 \cdot (1 + R_t + R_t^2) + R_t^2 \cdot R_e^3} - R_e \cdot (1 + R_t)}{1 + R_e} = 0.48$$

$$k_2 := -1 + \sqrt{2 \cdot (1 + R_e) + \frac{2 \cdot F_{yb} \cdot (1 + 2 \cdot R_e) \cdot D_r^2}{3 \cdot F_{em} \cdot l_m^2}} = 0.5$$

$$k_3 := -1 + \sqrt{\frac{2 \cdot (1 + R_e)}{R_e} + \frac{2 \cdot F_{yb} \cdot (2 + R_e) \cdot D_r^2}{3 \cdot F_{em} \cdot l_s^2}}$$

$$K_D := \begin{cases} 2.2 & \text{if } D_r \le 0.17 \\ \text{otherwise} & \begin{cases} 10 \cdot D_r + 0.5 & \text{if } 0.17 < D_r \le 0.25 \\ 0 & \text{otherwise} \end{cases} \end{cases} = 0$$

$$R_{d1} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 4.0 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \quad \text{otherwise} \end{cases} = 5$$

$$R_{d2} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 3.6 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \quad \text{otherwise} \end{cases} = 4.5$$

$$R_{d3} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 3.2 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \quad \text{otherwise} \end{cases} = 4$$

$Z_{Im} := \frac{D_r \cdot l_m \cdot F_{em}}{R_{d1}} = 998.45$ $Z_{Is} := \frac{D_r \cdot l_s \cdot F_{es}}{R_{d1}} = 854.63$ $Z_{II} := \frac{k_1 \cdot D_r \cdot l_s \cdot F_{es}}{R_{d2}} = 454.32$ $Z_{IIIm} := \frac{k_2 \cdot D_r \cdot l_m \cdot F_{em}}{(1 + 2R_e) \cdot R_{d3}} = 518.01$

$Z_{IIIs} := \frac{k_3 \cdot D_r \cdot l_s \cdot F_{em}}{(2 + R_e) \cdot R_{d3}} = 236.93$ $Z_{IV} := \frac{D_r^2}{R_{d3}} \cdot \sqrt{\frac{2 \cdot F_{em} \cdot F_{yb}}{3 \cdot (1 + R_e)}} = 225.73$

$Z_1 := \min(Z_{Im}, Z_{Is}, Z_{II}, Z_{IIIm}, Z_{IIIs}, Z_{IV}) = 225.73$

$W_1 = 351.84$

$R_{pos} := \sqrt{T_{pos}^2 + V_{pos}^2} = 1176.34 \text{ lbf}$ $R_{neg} := \sqrt{T_{neg}^2 + V_{neg}^2} = 1176.34 \text{ lbf}$

$\alpha_{pos} := \text{atan}(T_{pos} \cdot V_{pos}^{-1}) = 85.07 \cdot deg$ $\alpha_{neg} := \text{atan}(T_{neg} \cdot V_{neg}^{-1}) = 85.07 \cdot deg$

Results

$Z' := Z_1 \cdot C_D \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot lbf = 361.17 \text{ lbf}$ **Allowable Shear**

$W' := W_1 \cdot C_D \cdot C_M \cdot C_t \cdot C_{eg} \cdot p_{ten} \cdot lbf = 1442.53 \text{ lbf}$ **Allowable Tension**

$$Z_{\alpha pos} := \frac{W' \cdot Z'}{W' \cdot (\cos(\alpha_{pos}))^2 + Z' \cdot (\sin(\alpha_{pos}))^2} = 1411.38 \text{ lbf} \qquad Int_{pos} := \frac{R_{pos}}{Z_{\alpha pos}} = 0.83$$

$$Z_{\alpha neg} := \frac{W' \cdot Z'}{W' \cdot (\cos(\alpha_{neg}))^2 + Z' \cdot (\sin(\alpha_{neg}))^2} = 1411.38 \text{ lbf} \qquad Int_{neg} := \frac{R_{neg}}{Z_{\alpha neg}} = 0.83$$

Fastener = "3/8 in Lag Screw SS"
Predrill = "Predrill Holes at 60% - 75% D"
Penetration = "Verify Blocking Thickness"
Material = "Mixed Maple Southern Pine"

$G = 0.55$

$p_{ten} = 2.56$

Dowel Type Fastener Capacity

Lag Screws	Detail Ref.	Sheet No: A5B

$V_{pos} := 101 \cdot lbf$ $V_{neg} := 101 \cdot lbf$

$T_{pos} := 1172 \cdot lbf$ $T_{neg} := 1172 \cdot lbf$

3/8 in Lag Screw SS

$l_m := 4.5$ thickness of main member, in.

$l_s := 0.375$ thickness of side member, in

6061-T6 Hole

$F_{yb} = 65000$ bending yield strength, psi.

$D = 0.375$ unthreaded shank diameter of screw, in.

$D_r = 0.27$ root diameter of screw

$F_{es} = 43000$ bearing strength, psi

Mixed Maple Southern Pine

$p := 4.25$ penetration, in

$t_{shim} := 0.75$ thickness of shim, in

$C_D := 1.6$ load duration factor, 10.3.2

$C_M := 0.7$ wet service factor, 10.3.3

$C_t := 1.0$ temperature factor, 10.3.4

$C_g := 1.0$ group action factor, 10.3.6

$C_\Delta := 1.0$ geometry factor, 11.5.1

$C_{eg} := 1.0$ end grain factor, 11.5.2

$C_{di} := 1.0$ diaphragm factor, 11.5.3

$\theta := 90$ angle of load to grain, degree

Calculations

$K_\theta := 1 + 0.25 \cdot \frac{\theta}{90} = 1.25$ $R_e := \frac{F_{em}}{F_{es}} = 0.1$ $R_t := \frac{l_m}{l_s} = 12$

$$k_1 := \frac{\sqrt{R_e + 2 \cdot R_e^2 \cdot (1 + R_t + R_t^2) + R_t^2 \cdot R_e^3} - R_e \cdot (1 + R_t)}{1 + R_e} = 0.48$$

$$k_2 := -1 + \sqrt{2 \cdot (1 + R_e) + \frac{2 \cdot F_{yb} \cdot (1 + 2 \cdot R_e) \cdot D_r^2}{3 \cdot F_{em} \cdot l_m^2}} = 0.5$$

$$k_3 := -1 + \sqrt{\frac{2 \cdot (1 + R_e)}{R_e} + \frac{2 \cdot F_{yb} \cdot (2 + R_e) \cdot D_r^2}{3 \cdot F_{em} \cdot l_s^2}}$$

$$K_D := \begin{cases} 2.2 & \text{if } D_r \le 0.17 \\ \text{otherwise} & \begin{cases} 10 \cdot D_r + 0.5 & \text{if } 0.17 < D_r \le 0.25 \\ 0 & \text{otherwise} \end{cases} \end{cases} = 0$$

$$R_{d1} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 4.0 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \text{ otherwise} \end{cases} = 5$$

$$R_{d2} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 3.6 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \text{ otherwise} \end{cases} = 4.5$$

$$R_{d3} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 3.2 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \text{ otherwise} \end{cases} = 4$$

$Z_{lm} := \frac{D_r \cdot l_m \cdot F_{em}}{R_{d1}} = 998.45$ $Z_{ls} := \frac{D_r \cdot l_s \cdot F_{es}}{R_{d1}} = 854.63$ $Z_{II} := \frac{k_1 \cdot D_r \cdot l_s \cdot F_{es}}{R_{d2}} = 454.32$ $Z_{IIIm} := \frac{k_2 \cdot D_r \cdot l_m \cdot F_{em}}{(1 + 2R_e) \cdot R_{d3}} = 518.01$

$Z_{IIIs} := \frac{k_3 \cdot D_r \cdot l_s \cdot F_{em}}{(2 + R_e) \cdot R_{d3}} = 236.93$ $Z_{IV} := \frac{D_r^2}{R_{d3}} \cdot \sqrt{\frac{2 \cdot F_{em} \cdot F_{yb}}{3 \cdot (1 + R_e)}} = 225.73$

$Z_1 := \min(Z_{lm}, Z_{ls}, Z_{II}, Z_{IIIm}, Z_{IIIs}, Z_{IV}) = 225.73$

$W_1 = 351.84$

$R_{pos} := \sqrt{T_{pos}^2 + V_{pos}^2} = 1176.34 \text{ lbf}$ $R_{neg} := \sqrt{T_{neg}^2 + V_{neg}^2} = 1176.34 \text{ lbf}$

$\alpha_{pos} := \operatorname{atan}(T_{pos} \cdot V_{pos}^{-1}) = 85.07 \cdot deg$ $\alpha_{neg} := \operatorname{atan}(T_{neg} \cdot V_{neg}^{-1}) = 85.07 \cdot deg$

Results

$Z' := Z_1 \cdot C_D \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot lbf = 252.82 \text{ lbf}$ **Allowable Shear**

$W' := W_1 \cdot C_D \cdot C_M \cdot C_t \cdot C_{eg} \cdot p_{ten} \cdot lbf = 1256.05 \text{ lbf}$ **Allowable Tension**

$$Z_{\alpha pos} := \frac{W' \cdot Z'}{W' \cdot (\cos(\alpha_{pos}))^2 + Z' \cdot (\sin(\alpha_{pos}))^2} = 1220.35 \text{ lbf}$$ $Int_{pos} := \frac{R_{pos}}{Z_{\alpha pos}} = 0.96$

$$Z_{\alpha neg} := \frac{W' \cdot Z'}{W' \cdot (\cos(\alpha_{neg}))^2 + Z' \cdot (\sin(\alpha_{neg}))^2} = 1220.35 \text{ lbf}$$ $Int_{neg} := \frac{R_{neg}}{Z_{\alpha neg}} = 0.96$

Fastener = "3/8 in Lag Screw SS"
Predrill = "Predrill Holes at 60% - 75% D"
Penetration = "Verify Blocking Thickness"
Material = "Mixed Maple Southern Pine"

$G = 0.55$

$p_{ten} = 3.19$

Dowel Type Fastener Capacity

Lag Screws	Detail Ref.	Sheet No: A5C

$V_{pos} := 101 \cdot lbf$ $\quad V_{neg} := 101 \cdot lbf$

$T_{pos} := 1172 \cdot lbf$ $\quad T_{neg} := 1172 \cdot lbf$

3/8 in Lag Screw SS

$l_m := 4.5$ thickness of main member, in.

$l_s := 0.375$ thickness of side member, in

6061-T6 Hole

$F_{yb} = 65000$ bending yield strength, psi.

$D = 0.375$ unthreaded shank diameter of screw, in.

$D_r = 0.27$ root diameter of screw

$F_{es} = 43000$ bearing strength, psi

Spruce Pine-Fir

$p := 4.3125$ penetration, in

$t_{shim} := 0.75$ thickness of shim, in

$C_D := 1.6$ load duration factor, 10.3.2

$C_M := 1.0$ wet service factor, 10.3.3

$C_t := 1.0$ temperature factor, 10.3.4

$C_g := 1.0$ group action factor, 10.3.6

$C_\Delta := 1.0$ geometry factor, 11.5.1

$C_{eg} := 1.0$ end grain factor, 11.5.2

$C_{di} := 1.0$ diaphragm factor, 11.5.3

$\theta := 90$ angle of load to grain, degree

Calculations

$K_\theta := 1 + 0.25 \cdot \frac{\theta}{90} = 1.25 \quad R_e := \frac{F_{em}}{F_{es}} = 0.07 \quad R_t := \frac{l_m}{l_s} = 12$

$$K_D := \begin{cases} 2.2 & \text{if } D_r \le 0.17 \\ \text{otherwise} & \begin{cases} 10 \cdot D_r + 0.5 & \text{if } 0.17 < D_r \le 0.25 \\ 0 & \text{otherwise} \end{cases} \end{cases} = 0$$

$$k_1 := \frac{\sqrt{R_e + 2 \cdot R_e^2 \cdot \left(1 + R_t + R_t^2\right) + R_t^2 \cdot R_e^3} - R_e \cdot (1 + R_t)}{1 + R_e} = 0.33$$

$$R_{d1} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 4.0 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \text{ otherwise} \end{cases} = 5$$

$$k_2 := -1 + \sqrt{2 \cdot (1 + R_e) + \frac{2 \cdot F_{yb} \cdot (1 + 2 \cdot R_e) \cdot D_r^2}{3 \cdot F_{em} \cdot l_m^2}} = 0.48$$

$$R_{d2} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 3.6 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \text{ otherwise} \end{cases} = 4.5$$

$$k_3 := -1 + \sqrt{\frac{2 \cdot (1 + R_e)}{R_e} + \frac{2 \cdot F_{yb} \cdot (2 + R_e) \cdot D_r^2}{3 \cdot F_{em} \cdot l_s^2}}$$

$$R_{d3} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 3.2 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \text{ otherwise} \end{cases} = 4$$

$Z_{Im} := \frac{D_r \cdot l_m \cdot F_{em}}{R_{d1}} = 675.33 \quad Z_{Is} := \frac{D_r \cdot l_s \cdot F_{es}}{R_{d1}} = 854.63 \quad Z_{II} := \frac{k_1 \cdot D_r \cdot l_s \cdot F_{es}}{R_{d2}} = 316.97 \quad Z_{IIIm} := \frac{k_2 \cdot D_r \cdot l_m \cdot F_{em}}{(1 + 2R_e) \cdot R_{d3}} = 358.38$

$Z_{IIIs} := \frac{k_3 \cdot D_r \cdot l_s \cdot F_{em}}{(2 + R_e) \cdot R_{d3}} = 202.26 \quad Z_{IV} := \frac{D_r^2}{R_{d3}} \cdot \sqrt{\frac{2 \cdot F_{em} \cdot F_{yb}}{3 \cdot (1 + R_e)}} = 188.37$

$Z_1 := \min(Z_{Im}, Z_{Is}, Z_{II}, Z_{IIIm}, Z_{IIIs}, Z_{IV}) = 188.37$

$W_1 = 234.78$

$R_{pos} := \sqrt{T_{pos}^2 + V_{pos}^2} = 1176.34 \text{ lbf} \quad R_{neg} := \sqrt{T_{neg}^2 + V_{neg}^2} = 1176.34 \text{ lbf}$

$\alpha_{pos} := \text{atan}\left(T_{pos} \cdot V_{pos}^{-1}\right) = 85.07 \cdot \text{deg} \quad \alpha_{neg} := \text{atan}\left(T_{neg} \cdot V_{neg}^{-1}\right) = 85.07 \cdot \text{deg}$

Results

$Z' := Z_1 \cdot C_D \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot lbf = 301.39 \text{ lbf}$ **Allowable Shear**

$W' := W_1 \cdot C_D \cdot C_M \cdot C_t \cdot C_{eg} \cdot p_{ten} \cdot lbf = 1209.14 \text{ lbf}$ **Allowable Tension**

Fastener = "3/8 in Lag Screw SS"
Predrill = "Predrill Holes at 40% - 70% D"
Penetration = "Verify Blocking Thickness"
Material = "Spruce Pine-Fir"

$$Z_{\alpha pos} := \frac{W' \cdot Z'}{W' \cdot (\cos(\alpha_{pos}))^2 + Z' \cdot (\sin(\alpha_{pos}))^2} = 1182.88 \text{ lbf} \quad Int_{pos} := \frac{R_{pos}}{Z_{\alpha pos}} = 0.99$$

$$Z_{\alpha neg} := \frac{W' \cdot Z'}{W' \cdot (\cos(\alpha_{neg}))^2 + Z' \cdot (\sin(\alpha_{neg}))^2} = 1182.88 \text{ lbf} \quad Int_{neg} := \frac{R_{neg}}{Z_{\alpha neg}} = 0.99$$

$G = 0.42$

$p_{ten} = 3.22$

Dowel Type Fastener Capacity (NDS 2012)

Lag Screws	Detail Ref.	Sheet No: A5.1

$V_{pos} := 101 \cdot lbf$ $V_{neg} := 101 \cdot lbf$

$T_{pos} := 1172 \cdot lbf$ $T_{neg} := 1172 \cdot lbf$

3/8 in Lag Screw SS

$l_m := 4.5$ thickness of main member, in.

$l_s := 0.375$ thickness of side member, in

6061-T6 Hole

$F_{yb} = 65000$ bending yield strength, psi.

$D = 0.375$ unthreaded shank diameter of screw, in.

$D_r = 0.27$ root diameter of screw

$F_{es} = 43000$ bearing strength, psi

Mixed Maple Southern Pine

$p := 4.5$ penetration, in

$t_{shim} := 0.75$ thickness of shim, in

$C_D := 1.6$ load duration factor, 10.3.2

$C_M := 0.7$ wet service factor, 10.3.3

$C_t := 1.0$ temperature factor, 10.3.4

$C_g := 1.0$ group action factor, 10.3.6

$C_\Delta := 1.0$ geometry factor, 11.5.1

$C_{eg} := 1.0$ end grain factor, 11.5.2

$C_{di} := 1.0$ diaphragm factor, 11.5.3

$\theta := 90$ angle of load to grain, degree

Calculations

$K_\theta := 1 + 0.25 \cdot \frac{\theta}{90} = 1.25$ $R_e := \frac{F_{em}}{F_{es}} = 0.1$ $R_t := \frac{l_m}{l_s} = 12$

$$k_1 := \frac{\sqrt{R_e + 2 \cdot R_e^2 \cdot \left(1 + R_t + R_t^2\right) + R_t^2 \cdot R_e^3} - R_e \cdot \left(1 + R_t\right)}{1 + R_e} = 0.48$$

$$k_2 := -1 + \sqrt{2 \cdot \left(1 + R_e\right) + \frac{2 \cdot F_{yb} \cdot \left(1 + 2 \cdot R_e\right) \cdot D_r^2}{3 \cdot F_{em} \cdot l_m^2}} = 0.5$$

$$k_3 := -1 + \sqrt{\frac{2 \cdot \left(1 + R_e\right)}{R_e} + \frac{2 \cdot F_{yb} \cdot \left(2 + R_e\right) \cdot D_r^2}{3 \cdot F_{em} \cdot l_s^2}}$$

$$K_D := \begin{cases} 2.2 & \text{if } D_r \le 0.17 \\ \text{otherwise} & \begin{cases} 10 \cdot D_r + 0.5 & \text{if } 0.17 < D_r \le 0.25 \\ 0 & \text{otherwise} \end{cases} \end{cases} = 0$$

$$R_{d1} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 4.0 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \text{ otherwise} \end{cases} = 5$$

$$R_{d2} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 3.6 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \text{ otherwise} \end{cases} = 4.5$$

$$R_{d3} := \begin{cases} K_D & \text{if } D_r \le 0.25 \\ 3.2 \cdot K_\theta & \text{if } 0.25 < D_r \le 1 \text{ otherwise} \end{cases} = 4$$

$Z_{Im} := \frac{D_r \cdot l_m \cdot F_{em}}{R_{d1}} = 998.45$ $Z_{Is} := \frac{D_r \cdot l_s \cdot F_{es}}{R_{d1}} = 854.63$ $Z_{II} := \frac{k_1 \cdot D_r \cdot l_s \cdot F_{es}}{R_{d2}} = 454.32$ $Z_{IIIm} := \frac{k_2 \cdot D_r \cdot l_m \cdot F_{em}}{\left(1 + 2R_e\right) \cdot R_{d3}} = 518.01$

$Z_{IIIs} := \frac{k_3 \cdot D_r \cdot l_s \cdot F_{em}}{\left(2 + R_e\right) \cdot R_{d3}} = 236.93$ $Z_{IV} := \frac{D_r^2}{R_{d3}} \cdot \sqrt{\frac{2 \cdot F_{em} \cdot F_{yb}}{3 \cdot \left(1 + R_e\right)}} = 225.73$

$Z_1 := \min\left(Z_{Im}, Z_{Is}, Z_{II}, Z_{IIIm}, Z_{IIIs}, Z_{IV}\right) = 225.73$

$W_1 = 351.84$

$R_{pos} := \sqrt{T_{pos}^2 + V_{pos}^2} = 1176.34 \text{ lbf}$ $R_{neg} := \sqrt{T_{neg}^2 + V_{neg}^2} = 1176.34 \text{ lbf}$

$\alpha_{pos} := \operatorname{atan}\left(T_{pos} \cdot V_{pos}^{-1}\right) = 85.07 \cdot deg$ $\alpha_{neg} := \operatorname{atan}\left(T_{neg} \cdot V_{neg}^{-1}\right) = 85.07 \cdot deg$

Results

$Z' := Z_1 \cdot C_D \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot lbf = 252.82 \text{ lbf}$ **Allowable Shear**

$W' := W_1 \cdot C_D \cdot C_M \cdot C_t \cdot C_{eg} \cdot p_{ten} \cdot lbf = 1305.31 \text{ lbf}$ **Allowable Tension**

Fastener = "3/8 in Lag Screw SS"
Predrill = "Predrill Holes at 60% - 75% D"
Penetration = "Verify Blocking Thickness"
Material = "Mixed Maple Southern Pine"

$$Z_{\alpha pos} := \frac{W' \cdot Z'}{W' \cdot \left(\cos\left(\alpha_{pos}\right)\right)^2 + Z' \cdot \left(\sin\left(\alpha_{pos}\right)\right)^2} = 1266.44 \text{ lbf}$$ $Int_{pos} := \frac{R_{pos}}{Z_{\alpha pos}} = 0.93$

$$Z_{\alpha neg} := \frac{W' \cdot Z'}{W' \cdot \left(\cos\left(\alpha_{neg}\right)\right)^2 + Z' \cdot \left(\sin\left(\alpha_{neg}\right)\right)^2} = 1266.44 \text{ lbf}$$ $Int_{neg} := \frac{R_{neg}}{Z_{\alpha neg}} = 0.93$

$G = 0.55$

$p_{ten} = 3.31$

IBC Anchorage to Grout	Detail Ref.	Sheet No: A6

Chk Conc. Grout:

$R_{LL} := 202$ lb $R_{WL} := 0$ lb $\phi := 0.65$

$M_{LL} := 8467$ lb·in $M_{WL} := 0$ lb·in $f'_{c1} := 6000$ psi *Grout Strength*

$f'_{c2} := 4000$ psi *Conc. Strength*

$R_{max} := \max\left(R_{LL}\cdot 1.6, R_{WL}\cdot 0.6^{-1}\right) = 323$ lb

$M_{max} := \max\left(M_{LL}\cdot 1.6, M_{WL}\cdot 0.6^{-1}\right) = 13547$ lb·in

$C_{a1} := 5in$ (edge dist. from CL bolt to edge DIRECTION OF LOAD)

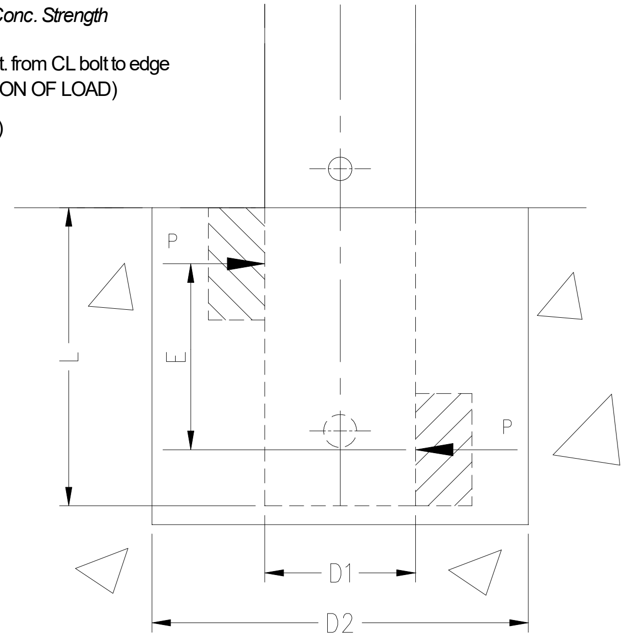
$L_1 := 4$ in

$D_1 := 2$ in *(Post Width)*

$D_2 := 4$ in *(Grout Pocket Width)*

$C_{a2} := 5in$ (end dist.)

$c_1 := \frac{L_1}{2}$



Assume Whitney stress block for bearing distribution:

$$\beta_1 := \begin{cases} \max\left(\left(\begin{matrix} 0.85 - .05\cdot\frac{f'_{c1} - 4000}{1000} \\ 0.65 \end{matrix}\right)\right) & \text{if } f'_{c1} \ge 4000 \\ 0.85 & \text{otherwise} \end{cases} \qquad \beta_1 = 0.75$$

$a_1 := \beta_1 \cdot c_1 = 1.5$ in

$A_1 := a_1 \cdot D_1$ $A_1 = 3$ in *(Bearing Area)*

$E_1 := L_1 - a_1$ $E_1 = 2.5$ in *(Load Eccentricity)*

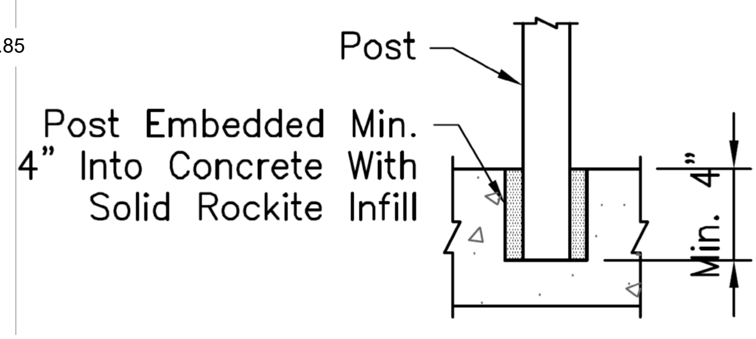
$P_1 := \frac{M_{max}}{E_1} + \frac{R_{max}}{2}$ $P_1 = 5580$ lb *(Bearing Load)*

$\phi F_{p1} := \phi \cdot 0.85 \cdot A_1 \cdot f'_{c1}$ $\phi F_{p1} = 9945$ lb *(Allowable Bearing Load)*

$I_1 := \frac{P_1}{\phi F_{p1}}$ $\boxed{I_1 = 0.56}$

Chk Concrete (for reference only):

$$\beta_2 := \begin{cases} \max\left(\left(\begin{matrix} 0.85 - .05\cdot\frac{f'_{c2} - 4000}{1000} \\ 0.65 \end{matrix}\right)\right) & \text{if } f'_{c2} \ge 4000 \\ 0.85 & \text{otherwise} \end{cases} \qquad \beta_2 = 0.85$$



$a_2 := \beta_2 \cdot c_1$ $a_2 = 1.7$ in

$A_2 := a_2 \cdot D_2$ $A_2 = 6.8$ in *(Bearing Area)*

$E_2 := L_1 - a_2$ $E_2 = 2.3$ in *(Load Eccentricity)*

$P_2 := \frac{M_{max}}{E_2} + \frac{R_{max}}{2}$ $P_2 = 6052$ lb *(Bearing Load)*

$\phi F_{p2} := \phi \cdot 0.85 \cdot A_2 \cdot f'_{c2}$ $\phi F_{p2} = 15028$ lb *(Allowable Bearing Load)*

$I_2 := \frac{P_2}{\phi F_{p2}}$ $\boxed{I_2 = 0.4}$

Note: Recommend Rockite for interior use and Kwixset for exterior (or interior) use.

Chk Breakout (for reference only):

Assumptions:

ConcreteReinf = "No Reinforcement"

ConcreteZone = "Cracked Concrete"

Concrete = "Condition B"

SiesmicCondition = "D, E, or F (Moderate to High Seismic Risk)"

$\boxed{\phi V_n := V_n \cdot \phi_v \cdot \alpha = 2847 \text{ lbf}}$ > $\boxed{V_{ua} = 6052 \text{ lbf}}$ (D.7.2)

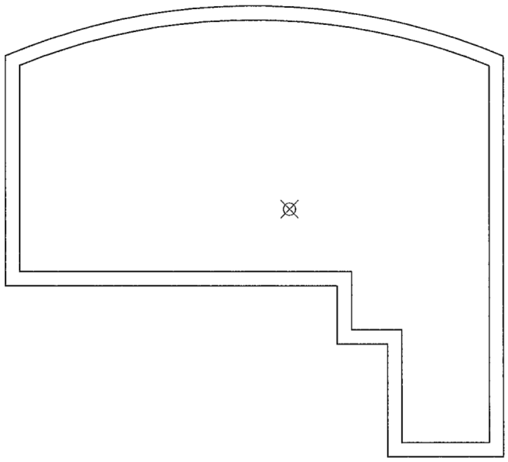
Use 6,000 psi, Cement or Epoxy Based Grout
Non-Shrink & Non-Metallic
4" Min. Post Embedment in Grout

-Design of bearing on concrete by others
-Design of concrete breakout and point loads by others. ***E.O.R. to check concrete breakout***

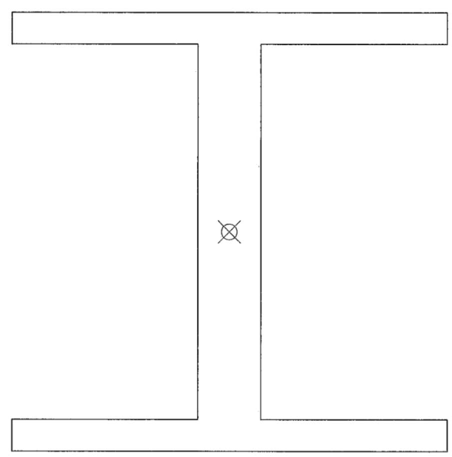
-Recommend bituminus paint or other inert coating to isolate aluminum from grout on the outside and inside walls of the post

ANCHORS = "REINFORCEMENT OR ADDITIONAL CHANGES REQUIRED; EOR TO CHECK CONCRETE BREAKOUT"

Section Properties	Detail Ref.	Sheet No: S1

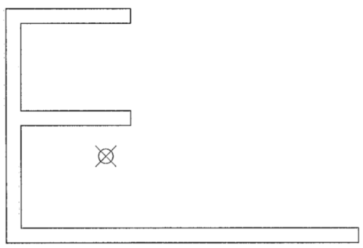


Area:	0.6249 sq in
Perimeter:	17.6024 in
Bounding box:	X: -1.4272 -- 1.0728 in
	Y: -1.2347 -- 1.0153 in
Centroid:	X: 0.0000 in
	Y: 0.0000 in
Moments of inertia:	X: 0.3194 in4
	Y: 0.4956 in4
Section Modulus:	X: 0.259 in3
	Y: 0.347 in3
Torsional Constant:	J: 0.4 in4

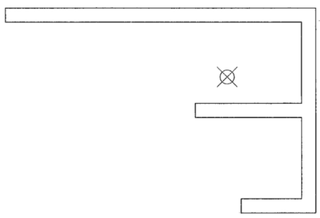


Area:	0.8025 sq in
Perimeter:	9.8800 in
Bounding box:	X: -0.8650 -- 0.8650 in
	Y: -0.8650 -- 0.8650 in
Centroid:	X: 0.0000 in
	Y: 0.0000 in
Moments of inertia:	X: 0.3466 in4
	Y: 0.1098 in4
Radii of gyration:	X: 0.6572 in
	Y: 0.3699 in
Section Modulus:	X: 0.401 in3
	Y: 0.127 in3

Section Properties	Detail Ref.	Sheet No: S2



Area: 0.2125 sq in
Perimeter: 6.8720 in
Bounding box: X: -0.4247 -- 1.0753 in
Y: -0.3698 -- 0.6302 in
Centroid: X: 0.0000 in
Y: 0.0000 in
Moments of inertia: X: 0.0281 in4
Y: 0.0389 in4
Section Modulus: X: 0.045 in3
Y: 0.036 in3



Area: 0.1864 sq in
Perimeter: 6.0440 in
Bounding box: X: -0.9791 -- 0.3909 in
Y: -0.6086 -- 0.3084 in
Centroid: X: 0.0000 in
Y: 0.0000 in
Moments of inertia: X: 0.0180 in4
Y: 0.0295 in4
Section Modulus: X: 0.03 in3
Y: 0.03 in3

APPENDIX A: CONCRETE ANCHORS

Company:		Page:	1
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	A4- IBC Adhesive	Date:	1/11/2024
Fastening point:			

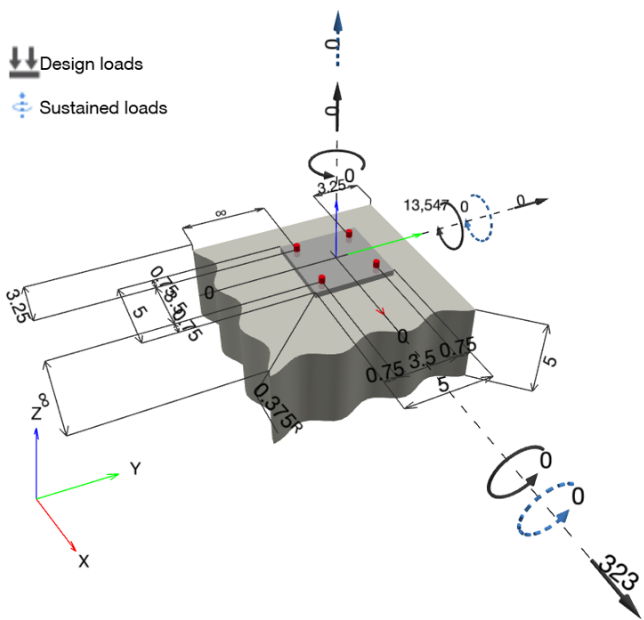
Specifier's comments:

1 Input data

Anchor type and diameter:	**HIT-HY 200 V3 + HIT-Z-R 3/8**
Item number:	2018451 HIT-Z-R 3/8" x 4 3/8" (element) / 2334276 HIT-HY 200-R V3 (adhesive)
Effective embedment depth:	$h_{ef,opti}$ = 2.690 in. ($h_{ef,limit}$ = 2.750 in.)
Material:	A4
Evaluation Service Report:	ESR-4868
Issued I Valid:	11/1/2022 | 11/1/2024
Proof:	Design Method ACI 318-19 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.375 in.
Anchor plate[R] :	l_x x l_y x t = 5.000 in. x 5.000 in. x 0.375 in.; (Recommended plate thickness: not calculated)
Profile:	no profile
Base material:	cracked concrete, 4000, f_c' = 4,000 psi; h = 5.000 in., Temp. short/long: 130/110 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: not present, shear: not present; no supplemental splitting reinforcement present
	edge reinforcement: none or < No. 4 bar

[R] - The anchor calculation is based on a rigid anchor plate assumption.

Geometry [in.] & Loading [lb, in.lb]



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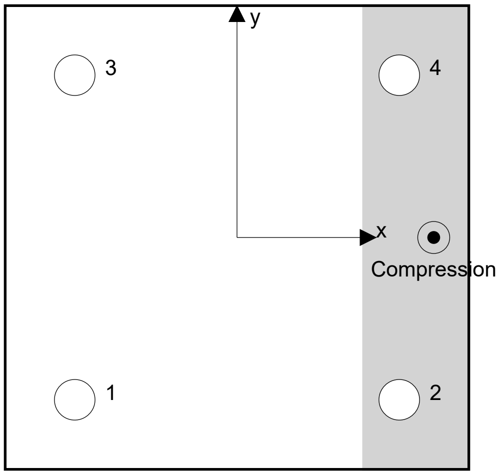
Company:		Page:	2
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	A4- IBC Adhesive	Date:	1/11/2024
Fastening point:			

1.1 Design results

Case	Description	Forces [lb] / Moments [in.lb]	Seismic	Max. Util. Anchor [%]
1	Combination 1	N = 0; V_x = 323; V_y = 0; M_x = 0; M_y = 13,547; M_z = 0;	no	100

2 Load case/Resulting anchor forces



Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	1,749	81	81	0
2	0	81	81	0
3	1,749	81	81	0
4	0	81	81	0

max. concrete compressive strain: 0.28 [‰]
max. concrete compressive stress: 1,233 [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(4.622/2.500): 3,499 [lb]

Anchor forces are calculated based on the assumption of a rigid anchor plate.

3 Tension load

	Load N_{ua} [lb]	Capacity ϕ N_n [lb]	Utilization $\beta_N = N_{ua}/\phi$ N_n	Status
Steel Strength*	1,749	4,749	37	OK
Pullout Strength*	1,749	5,169	34	OK
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	3,499	3,503	100	OK

* highest loaded anchor **anchor group (anchors in tension)

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3.1 Steel Strength

N_{sa} = ESR value   refer to ICC-ES ESR-4868
$\phi\ N_{sa} \geq N_{ua}$ ACI 318-19 Table 17.5.2

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.08	94,200

Calculations

N_{sa} [lb]
7,306

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
7,306	0.650	4,749	1,749

3.2 Pullout Strength

$N_{pn} = N_p\ \lambda_a$ refer to ICC-ES ESR-4868
$\phi\ N_{pn} \geq N_{ua}$ ACI 318-19 Table 17.5.2

Variables

λ_a	N_p [lb]
1.000	7,952

Calculations

N_{pn} [lb]
7,952

Results

N_{pn} [lb]	$\phi_{concrete}$	$\phi\ N_{pn}$ [lb]	N_{ua} [lb]
7,952	0.650	5,169	1,749

3.3 Concrete Breakout Failure

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b$	ACI 318-19 Eq. (17.6.2.1b)
$\phi\ N_{cbg} \geq N_{ua}$	ACI 318-19 Table 17.5.2
A_{Nc} see ACI 318-19, Section 17.6.2.1, Fig. R 17.6.2.1(b)	
$A_{Nc0} = 9\ h_{ef}^2$	ACI 318-19 Eq. (17.6.2.1.4)
$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e_N'}{3\ h_{ef}}}\right) \leq 1.0$	ACI 318-19 Eq. (17.6.2.3.1)
$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$	ACI 318-19 Eq. (17.6.2.4.1b)
$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$	ACI 318-19 Eq. (17.6.2.6.1b)
$N_b = k_c\ \lambda_a\ \sqrt{f_c'}\ h_{ef}^{1.5}$	ACI 318-19 Eq. (17.6.2.2.1)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
2.690	0.000	0.000	3.250	1.000

c_{ac} [in.]	k_c	λ_a	f_c' [psi]
6.678	17	1.000	4,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
78.57	65.12	1.000	1.000	0.942	1.000	4,743

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
5,389	0.650	3,503	3,499

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4 Shear load

	Load V_{ua} [lb]	Capacity ϕ V_n [lb]	Utilization $\beta_V = V_{ua}/\phi$ V_n	Status
Steel Strength*	81	2,630	4	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	323	11,169	3	OK
Concrete edge failure in direction y+**	323	3,932	9	OK

* highest loaded anchor **anchor group (relevant anchors)

4.1 Steel Strength

V_{sa} = ESR value refer to ICC-ES ESR-4868

ϕ $V_{steel} \geq V_{ua}$ ACI 318-19 Table 17.5.2

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
0.08	94,200

Calculations

V_{sa} [lb]
4,384

Results

V_{sa} [lb]	ϕ_{steel}	ϕ V_{sa} [lb]	V_{ua} [lb]
4,384	0.600	2,630	81

4.2 Pryout Strength (Concrete Breakout Strength controls)

$V_{cpg} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}} \right) \psi_{ec,N} \; \psi_{ed,N} \; \psi_{c,N} \; \psi_{cp,N} \; N_b \right]$ ACI 318-19 Eq. (17.7.3.1b)

$\phi \; V_{cpg} \geq V_{ua}$ ACI 318-19 Table 17.5.2

A_{Nc} see ACI 318-19, Section 17.6.2.1, Fig. R 17.6.2.1(b)

$A_{Nc0} = 9 \; h_{ef}^2$ ACI 318-19 Eq. (17.6.2.1.4)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2 \, e_N'}{3 \, h_{ef}}} \right) \leq 1.0$ ACI 318-19 Eq. (17.6.2.3.1)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}} \right) \leq 1.0$ ACI 318-19 Eq. (17.6.2.4.1b)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}} \right) \leq 1.0$ ACI 318-19 Eq. (17.6.2.6.1b)

$N_b = k_c \; \lambda_a \; \sqrt{f_c'} \; h_{ef}^{1.5}$ ACI 318-19 Eq. (17.6.2.2.1)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	2.690	0.000	0.000	3.250

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f_c' [psi]
1.000	6.678	17	1.000	4,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
116.31	65.12	1.000	1.000	0.942	1.000	4,743

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi \; V_{cpg}$ [lb]	V_{ua} [lb]
15,956	0.700	11,169	323

4.3 Concrete edge failure in direction y+

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$	ACI 318-19 Eq. (17.7.2.1b)
$\phi\ V_{cbg} \geq V_{ua}$	ACI 318-19 Table 17.5.2
A_{Vc} see ACI 318-19, Section 17.7.2.1, Fig. R 17.7.2.1(b)	
$A_{Vc0} = 4.5\ c_{a1}^2$	ACI 318-19 Eq. (17.7.2.1.3)
$\psi_{ec,V} = \left(\frac{1}{1 + \frac{e_V'}{1.5c_{a1}}}\right) \leq 1.0$	ACI 318-19 Eq. (17.7.2.3.1)
$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$	ACI 318-19 Eq. (17.7.2.4.1b)
$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$	ACI 318-19 Eq. (17.7.2.6.1)
$V_b = \left(7\left(\frac{l_e}{d_a}\right)^{0.2}\sqrt{d_a}\right)\lambda_a \sqrt{f_c'}\ c_{a1}^{1.5}$	ACI 318-19 Eq. (17.7.2.2.1a)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
3.250	3.250	0.000	1.000	5.000

l_e [in.]	λ_a	d_a [in.]	f_c' [psi]	$\psi_{parallel,V}$
2.690	1.000	0.375	4,000	2.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
56.67	47.53	1.000	1.000	1.000	2,356

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
5,617	0.700	3,932	323

5 Combined tension and shear loads, per ACI 318-19 section 17.8

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.999	0.082	1.000	91	OK

$\beta_{NV} = (\beta_N + \beta_V) / 1.2 <= 1$

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6 Warnings

- The anchor design methods in PROFIS Engineering require rigid anchor plates per current regulations (AS 5216:2021, ETAG 001/Annex C, EOTA TR029 etc.). This means load re-distribution on the anchors due to elastic deformations of the anchor plate are not considered - the anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Engineering calculates the minimum required anchor plate thickness with CBFEM to limit the stress of the anchor plate based on the assumptions explained above. The proof if the rigid anchor plate assumption is valid is not carried out by PROFIS Engineering. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- Condition A applies where the potential concrete failure surfaces are crossed by supplementary reinforcement proportioned to tie the potential concrete failure prism into the structural member. Condition B applies where such supplementary reinforcement is not provided, or where pullout or pryout strength governs.
- Design Strengths of adhesive anchor systems are influenced by the cleaning method. Refer to the INSTRUCTIONS FOR USE given in the Evaluation Service Report for cleaning and installation instructions.
- For additional information about ACI 318 strength design provisions, please go to https://submittals.us.hilti.com/PROFISAnchorDesignGuide/
- Installation of Hilti adhesive anchor systems shall be performed by personnel trained to install Hilti adhesive anchors. Reference ACI 318-19, Section 26.7.

Fastening meets the design criteria!

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7 Installation data

Profile: no profile

Hole diameter in the fixture (pre-setting) : d_f = 0.438 in.

Hole diameter in the fixture (through fastening) : d_f = 0.500 in.

Plate thickness (input): 0.375 in.

Recommended plate thickness: not calculated

Drilling method: Hammer drilled

Cleaning: Compressed air cleaning of the drilled hole according to instructions for use is required

Anchor type and diameter: HIT-HY 200 V3 + HIT-Z-R 3/8

Item number: 2018451 HIT-Z-R 3/8" x 4 3/8" (element) / 2334276 HIT-HY 200-R V3 (adhesive)

Maximum installation torque: 354 in.lb

Hole diameter in the base material: 0.438 in.

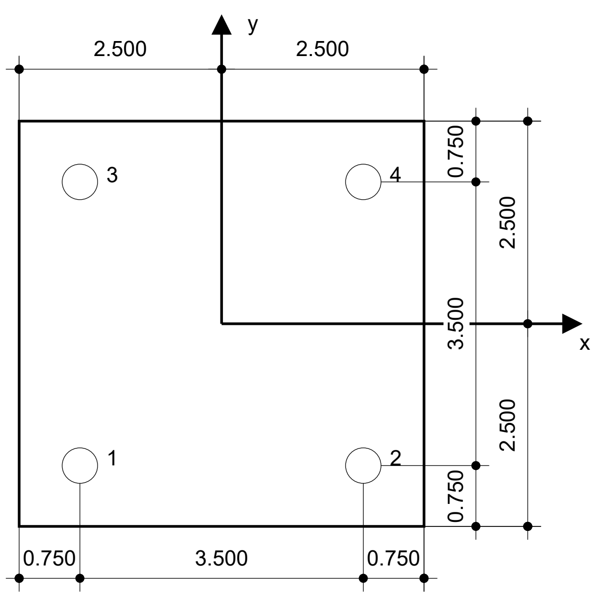
Hole depth in the base material: 3.690 in.

Minimum thickness of the base material: 4.940 in.

3/8 Hilti HIT-Z Stainless steel non-cleaning bonded expansion anchor with Hilti HIT-HY 200 V3 Safe Set System

7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• -	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor [in.]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-1.750	-1.750	3.250	-	-	6.750
2	1.750	-1.750	6.750	-	-	6.750
3	-1.750	1.750	3.250	-	-	3.250
4	1.750	1.750	6.750	-	-	3.250

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8 Remarks; Your Cooperation Duties

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- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

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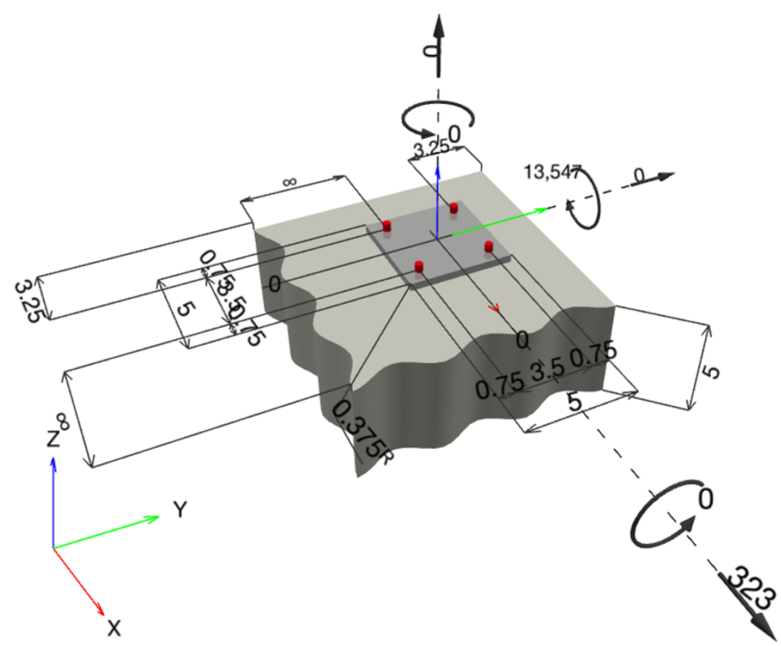
Specifier's comments:

1 Input data

Anchor type and diameter:	**Kwik Bolt TZ2 - SS 304 3/8 (2 1/2) hnom3**
Item number:	2210245 KB-TZ2 3/8x5 SS304
Effective embedment depth:	$h_{ef,act}$ = 2.500 in., h_{nom} = 3.000 in.
Material:	AISI 304
Evaluation Service Report:	ESR-4266
Issued I Valid:	12/17/2021 | 12/1/2023
Proof:	Design Method ACI 318-19 / Mech
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.375 in.
Anchor plate[R] :	l_x x l_y x t = 5.000 in. x 5.000 in. x 0.375 in.; (Recommended plate thickness: not calculated)
Profile:	no profile
Base material:	cracked concrete, 4000, f_c' = 4,000 psi; h = 5.000 in.
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: not present, shear: not present; no supplemental splitting reinforcement present
	edge reinforcement: none or < No. 4 bar

[R] - The anchor calculation is based on a rigid anchor plate assumption.

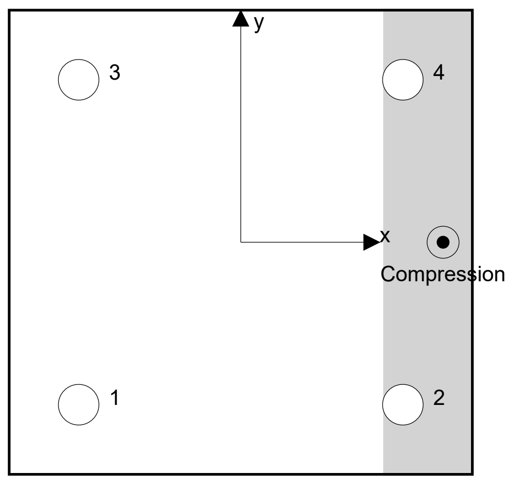
Geometry [in.] & Loading [lb, in.lb]



1.1 Design results

Case	Description	Forces [lb] / Moments [in.lb]	Seismic	Max. Util. Anchor [%]
1	Combination 1	$N = 0; V_x = 323; V_y = 0;$ $M_x = 0; M_y = 13,547; M_z = 0;$	no	100

2 Load case/Resulting anchor forces



Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	1,722	81	81	0
2	0	81	81	0
3	1,722	81	81	0
4	0	81	81	0

max. concrete compressive strain: 0.33 [‰]
max. concrete compressive stress: 1,453 [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(4.684/2.500): 3,444 [lb]

Anchor forces are calculated based on the assumption of a rigid anchor plate.

3 Tension load

	Load N_{ua} [lb]	Capacity ϕ N_n [lb]	Utilization $\beta_N = N_{ua}/\phi$ N_n	Status
Steel Strength*	1,722	4,637	38	OK
Pullout Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	3,444	3,465	100	OK

* highest loaded anchor **anchor group (anchors in tension)

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3.1 Steel Strength

N_{sa} = ESR value   refer to ICC-ES ESR-4266

$\phi\ N_{sa} \geq N_{ua}$ ACI 318-19 Table 17.5.2

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.05	120,104

Calculations

N_{sa} [lb]
6,182

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
6,182	0.750	4,637	1,722

3.2 Concrete Breakout Failure

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b$ — ACI 318-19 Eq. (17.6.2.1b)

$\phi\ N_{cbg} \geq N_{ua}$ — ACI 318-19 Table 17.5.2

A_{Nc} see ACI 318-19, Section 17.6.2.1, Fig. R 17.6.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ — ACI 318-19 Eq. (17.6.2.1.4)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e'_N}{3\ h_{ef}}}\right) \leq 1.0$ — ACI 318-19 Eq. (17.6.2.3.1)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ — ACI 318-19 Eq. (17.6.2.4.1b)

$\psi_{cp,N} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ — ACI 318-19 Eq. (17.6.2.6.1b)

$N_b = k_c\ \lambda_a\ \sqrt{f'_c}\ h_{ef}^{1.5}$ — ACI 318-19 Eq. (17.6.2.2.1)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
2.500	0.000	0.000	3.250	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
4.000	17	1.000	4,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
73.50	56.25	1.000	1.000	0.960	1.000	4,250

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
5,331	0.650	3,465	3,444

4 Shear load

	Load V_{ua} [lb]	Capacity ϕ V_n [lb]	Utilization $\beta_V = V_{ua}/\phi$ V_n	Status
Steel Strength*	81	3,177	3	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	323	11,196	3	OK
Concrete edge failure in direction y+**	323	3,875	9	OK

* highest loaded anchor **anchor group (relevant anchors)

4.1 Steel Strength

V_{sa} = ESR value refer to ICC-ES ESR-4266

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-19 Table 17.5.2

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
0.05	120,104

Calculations

V_{sa} [lb]
4,887

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
4,887	0.650	3,177	81

4.2 Pryout Strength

$V_{cpg} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}} \right) \psi_{ec,N} \; \psi_{ed,N} \; \psi_{c,N} \; \psi_{cp,N} \; N_b \right]$	ACI 318-19 Eq. (17.7.3.1b)
$\phi \; V_{cpg} \geq V_{ua}$	ACI 318-19 Table 17.5.2
A_{Nc} see ACI 318-19, Section 17.6.2.1, Fig. R 17.6.2.1(b)	
$A_{Nc0} = 9 \, h_{ef}^2$	ACI 318-19 Eq. (17.6.2.1.4)
$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2 \, e'_N}{3 \, h_{ef}}} \right) \leq 1.0$	ACI 318-19 Eq. (17.6.2.3.1)
$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}} \right) \leq 1.0$	ACI 318-19 Eq. (17.6.2.4.1b)
$\psi_{cp,N} = \text{MAX} \left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}} \right) \leq 1.0$	ACI 318-19 Eq. (17.6.2.6.1b)
$N_b = k_c \; \lambda_a \; \sqrt{f'_c} \; h_{ef}^{1.5}$	ACI 318-19 Eq. (17.6.2.2.1)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	2.500	0.000	0.000	3.250

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	4.000	17	1.000	4,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
110.25	56.25	1.000	1.000	0.960	1.000	4,250

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi \; V_{cpg}$ [lb]	V_{ua} [lb]
15,994	0.700	11,196	323

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4.3 Concrete edge failure in direction y+

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ ACI 318-19 Eq. (17.7.2.1b)

$\phi\ V_{cbg} \geq V_{ua}$ ACI 318-19 Table 17.5.2

A_{Vc} see ACI 318-19, Section 17.7.2.1, Fig. R 17.7.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ ACI 318-19 Eq. (17.7.2.1.3)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{e_V'}{1.5c_{a1}}}\right) \leq 1.0$ ACI 318-19 Eq. (17.7.2.3.1)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ ACI 318-19 Eq. (17.7.2.4.1b)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ ACI 318-19 Eq. (17.7.2.6.1)

$V_b = \left(7 \left(\frac{l_e}{d_a}\right)^{0.2} \sqrt{d_a}\right) \lambda_a \sqrt{f_c'}\ c_{a1}^{1.5}$ ACI 318-19 Eq. (17.7.2.2.1a)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
3.250	3.250	0.000	1.000	5.000

l_e [in.]	λ_a	d_a [in.]	f_c' [psi]	$\psi_{parallel,V}$
2.500	1.000	0.375	4,000	2.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
56.67	47.53	1.000	1.000	1.000	2,321

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
5,536	0.700	3,875	323

5 Combined tension and shear loads, per ACI 318-19 section 17.8

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.994	0.083	1.000	90	OK

$\beta_{NV} = (\beta_N + \beta_V) / 1.2 <= 1$

Company:		Page:	8
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	A4- IBC KBTZ	Date:	1/11/2024
Fastening point:			

6 Warnings

- The anchor design methods in PROFIS Engineering require rigid anchor plates per current regulations (AS 5216:2021, ETAG 001/Annex C, EOTA TR029 etc.). This means load re-distribution on the anchors due to elastic deformations of the anchor plate are not considered - the anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Engineering calculates the minimum required anchor plate thickness with CBFEM to limit the stress of the anchor plate based on the assumptions explained above. The proof if the rigid anchor plate assumption is valid is not carried out by PROFIS Engineering. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- Condition A applies where the potential concrete failure surfaces are crossed by supplementary reinforcement proportioned to tie the potential concrete failure prism into the structural member. Condition B applies where such supplementary reinforcement is not provided, or where pullout or pryout strength governs.
- Refer to the manufacturer's product literature for cleaning and installation instructions.
- For additional information about ACI 318 strength design provisions, please go to https://submittals.us.hilti.com/PROFISAnchorDesignGuide/
- Hilti post-installed anchors shall be installed in accordance with the Hilti Manufacturer's Printed Installation Instructions (MPII). Reference ACI 318-19, Section 26.7.

Fastening meets the design criteria!

Company:		Page:	9
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	A4- IBC KBTZ	Date:	1/11/2024
Fastening point:			

7 Installation data

Profile: no profile

Hole diameter in the fixture: d_f = 0.438 in.

Plate thickness (input): 0.375 in.

Recommended plate thickness: not calculated

Drilling method: Hammer drilled

Cleaning: Manual cleaning of the drilled hole according to instructions for use is required.

Anchor type and diameter: Kwik Bolt TZ2 - SS 304 3/8 (2 1/2) hnom3

Item number: 2210245 KB-TZ2 3/8x5 SS304

Maximum installation torque: 361 in.lb

Hole diameter in the base material: 0.375 in.

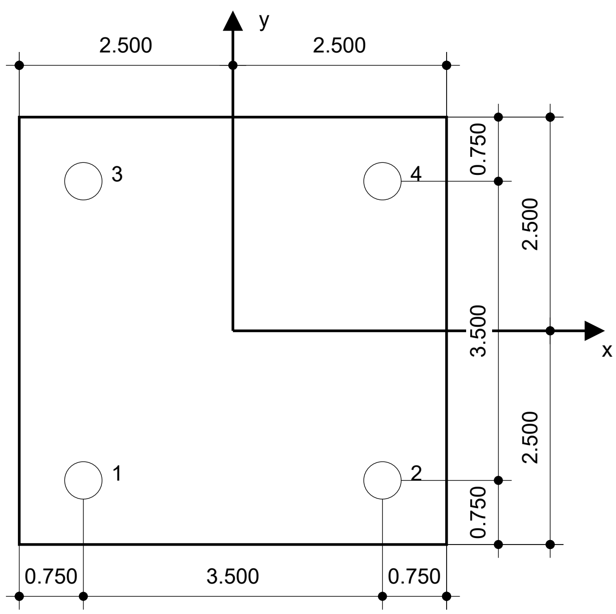
Hole depth in the base material: 3.250 in.

Minimum thickness of the base material: 5.000 in.

Hilti KB-TZ2 stud anchor with 3 in embedment, 3/8 (2 1/2) hnom3, Stainless steel, installation per ESR-4266

7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• Manual blow-out pump	• Torque controlled cordless impact tool • Torque wrench • Hammer



Coordinates Anchor [in.]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-1.750	-1.750	3.250	-	-	6.750
2	1.750	-1.750	6.750	-	-	6.750
3	-1.750	1.750	3.250	-	-	3.250
4	1.750	1.750	6.750	-	-	3.250

8 Remarks; Your Cooperation Duties

- Any and all information and data contained in the Software concern solely the use of Hilti products and are based on the principles, formulas and security regulations in accordance with Hilti's technical directions and operating, mounting and assembly instructions, etc., that must be strictly complied with by the user. All figures contained therein are average figures, and therefore use-specific tests are to be conducted prior to using the relevant Hilti product. The results of the calculations carried out by means of the Software are based essentially on the data you put in. Therefore, you bear the sole responsibility for the absence of errors, the completeness and the relevance of the data to be put in by you. Moreover, you bear sole responsibility for having the results of the calculation checked and cleared by an expert, particularly with regard to compliance with applicable norms and permits, prior to using them for your specific facility. The Software serves only as an aid to interpret norms and permits without any guarantee as to the absence of errors, the correctness and the relevance of the results or suitability for a specific application.
- You must take all necessary and reasonable steps to prevent or limit damage caused by the Software. In particular, you must arrange for the regular backup of programs and data and, if applicable, carry out the updates of the Software offered by Hilti on a regular basis. If you do not use the AutoUpdate function of the Software, you must ensure that you are using the current and thus up-to-date version of the Software in each case by carrying out manual updates via the Hilti Website. Hilti will not be liable for consequences, such as the recovery of lost or damaged data or programs, arising from a culpable breach of duty by you.

APPENDIX B: 3RD PARTY TESTING

(NOTE RICE ENGINEERING DID NOT PERFORM THE TESTING. THIS IS INCLUDED FOR REFERENCE PURPOSES ONLY AND IS NOT CONSIDERED PART OF THE SIGNED/SEALED SUBMITTAL.

Aluminum Post Strength
Performance Test Report

Rendered To:
STAR Systems International, LLC.

Report No.:
QCT19-5620.01

Test Date(s):
November 22, 2019

Report Date:
December 11, 2019

QUAST CONSULTING AND TESTING, INC.
Exterior Façade/Fenestration Consulting Testing
1055 Indianhead Drive • Mosinee, WI 54455-0241 • Phone: 715-693-TEST (8378) • Fax: 715-693-0689
www.qct-usa.com

ALUMINUM POST STRENGTH PERFORMANCE TEST REPORT

Rendered to:

STAR Systems International, LLC
7465 Conway Avenue
Burnaby, B.C. Canada, V5E 2P7

Report No.: QCT19-5620.01
Test Dates: 11/22/2019
Report Date: 11/25/2019
Test Report Retention Date: 11/22/2021

Project Summary:

Quast Consulting and Testing, Inc. was contracted by STAR Systems International, LLC to perform strength testing on aluminum posts. The posts were supplied by STAR Systems International, LLC. and tested at Quast Consulting and Testing Laboratory located in Mosinee, WI. Test specimen description and results are reported herein.

Test Specimen: (See Appendix A)

The aluminum mounting plate was 5" x 5" x 3/8" thick with four bolt holes spaced 3/4" from edges. A 2" tall 1-3/4" x 1-3/4" aluminum I-section with 1/4" web and 5/32" flanges was welded to the center of the mounting plate. A 2" x 2" x 1/8" thick aluminum post was fit over the I-Section and welded to the mounting plate on all sides. The post was bolted to a rigid steel W-section using 1/2-13 x 2-1/4" long A307 steel bolts.

Test Procedure: (See Photo #1)

In order to facilitate loading, a steel collar was fitted over the post with its horizontal centerline positioned 42" from the bottom of the mounting plate. Load was applied to the collar horizontally and parallel to the web of the aluminum I-section insert. Load was measured using a load cell. Horizontal deflection at the point of load application was measured using a string potentiometer. A data acquisition program was used to generate load vs deflection data for each test. Peak load and pulling rate were tabulated as results. See Appendix B for Load vs Deflection graphs of all tests.

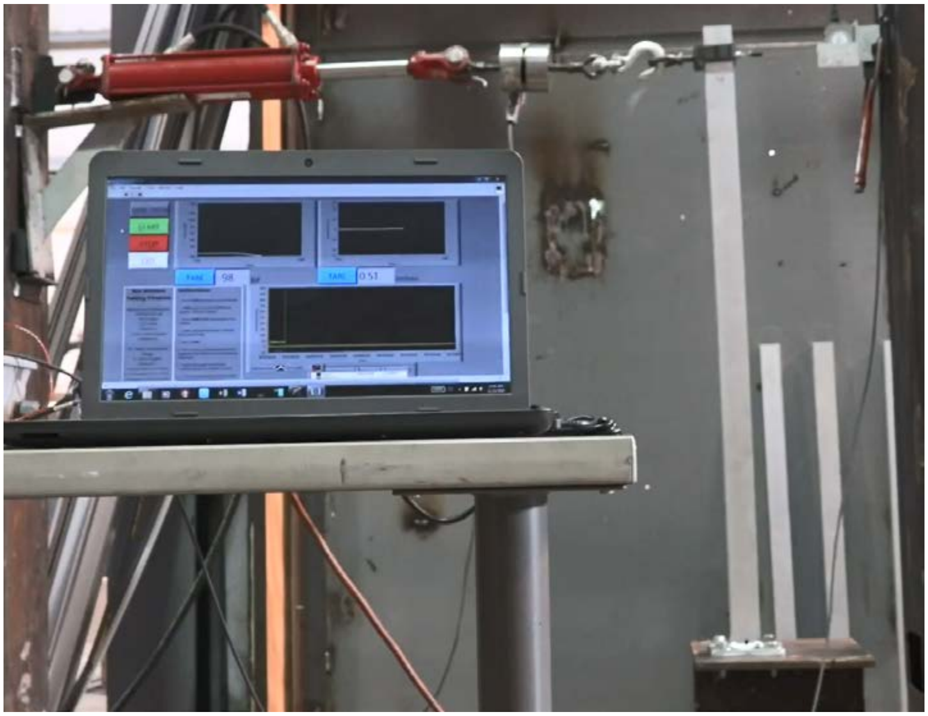


Photo #1: Test Setup

Test Results: (See Appendix C for photos of failed posts)

Post #	Peak Force (lbf)	Pulling Rate (in/min)	Failure Location
1	534	1.2	weld-post
2	521	0.8	weld-post
3	556	1.2	weld-post
4	583	0.7	weld-post and post
5	568	1.5	weld-post and throat
6	584	2.5	post
7	538	2.5	weld-post and post
8	573	2.3	weld-post and post
9	475	3.1	weld-post
10	480	2.3	weld-post and post
11	499	2.5	weld-post
12	572	2.7	throat
13	489	3.2	weld-post and throat
14	538	3.4	weld-post and throat
15	514	3.6	weld-post
Average	**535**	**2.2**	
Standard Deviation	**37.6**		

Drawing Reference: The test specimen drawings have been reviewed by Quast Consulting and Testing, Inc. and are representative of the test specimen reported herein.

List of Official Observers:

Name:	Company:
Brian Sasman	Quast Consulting and Testing, Inc.
Arlen Fisher	Quast Consulting and Testing, Inc.
Norm Plumb	STAR Systems International, LLC.
Paul Zen	East West Alum Craft Ltd
Tony Dente	East West Alum Craft Ltd

Electronic records of data sheets, drawings, correspondence, this report, or other pertinent project documentation will be retained for a period of 10 years from the test completion date. Physical respresentative samples of the test specimen will be retained for a period of 2 years from the test completion date. At the end of this retention period, such material shall be discarded without notice and the service life of this report will expire.

Results obtained are tested values and were secured by using the designated test methods. This report does not constitute certification of this product nor an opinion or endorsement by this laboratory. It is the exclusive property of the client so named herein and relates only to the specimens tested. This report may not be reproduced, except in full, without the written approval of Quast Consulting and Testing, Inc.

QUAST CONSULTING & TESTING, INC.

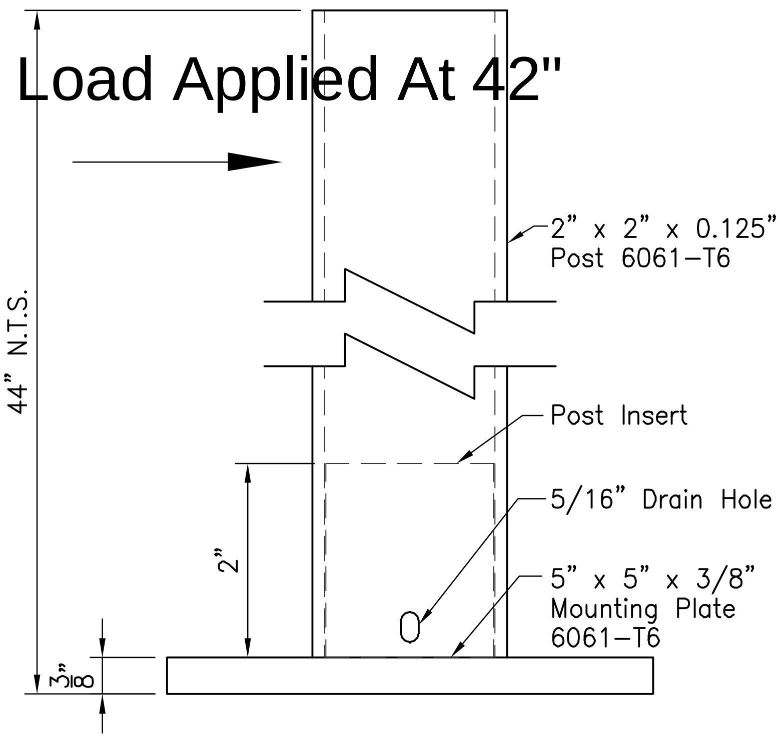
Arlen Fisher, P.E.
Project Manager

QUAST CONSULTING & TESTING, INC.

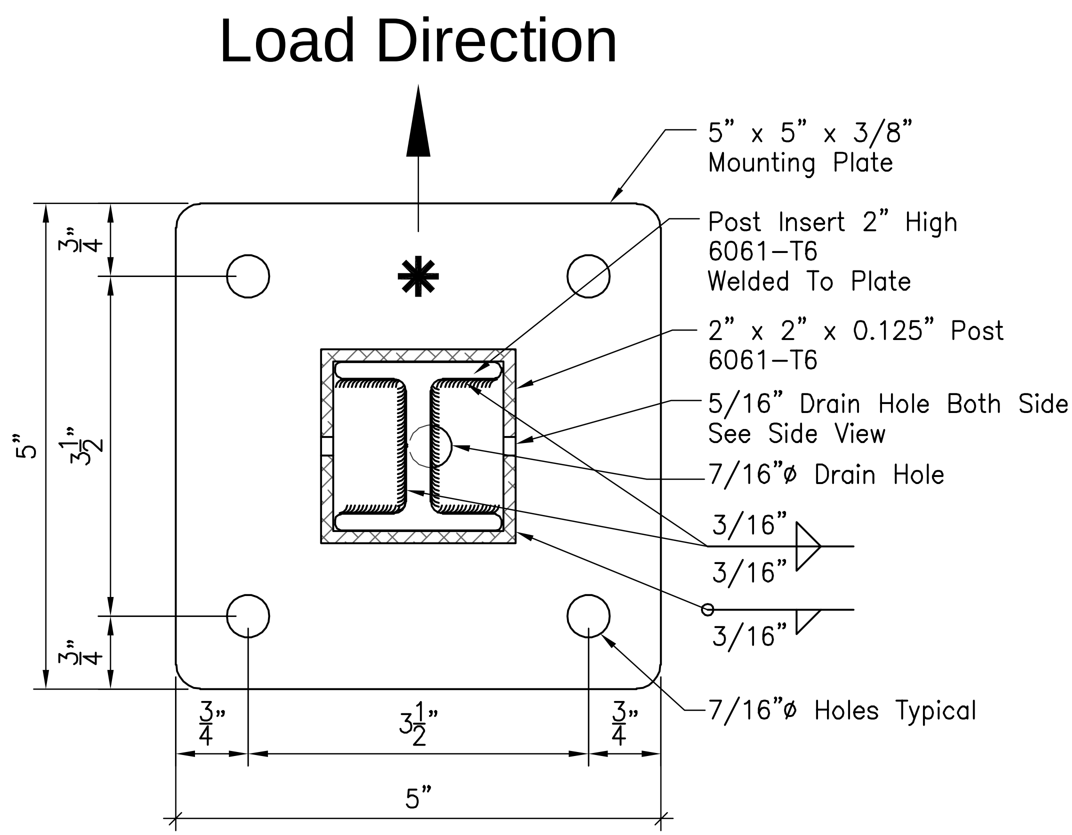
Brian M. Sasman, P.E.
Reviewer

Attachments: This report is complete only when all attachments listed are included.

- Appendix A: As-Built Drawings (1 Page)
- Appendix B: Load vs Deflection Graphs (8 Pages)
- Appendix C: Photos of Failed Posts (8 Pages)



Side View



Mounting Plate Detail

Quantity x15

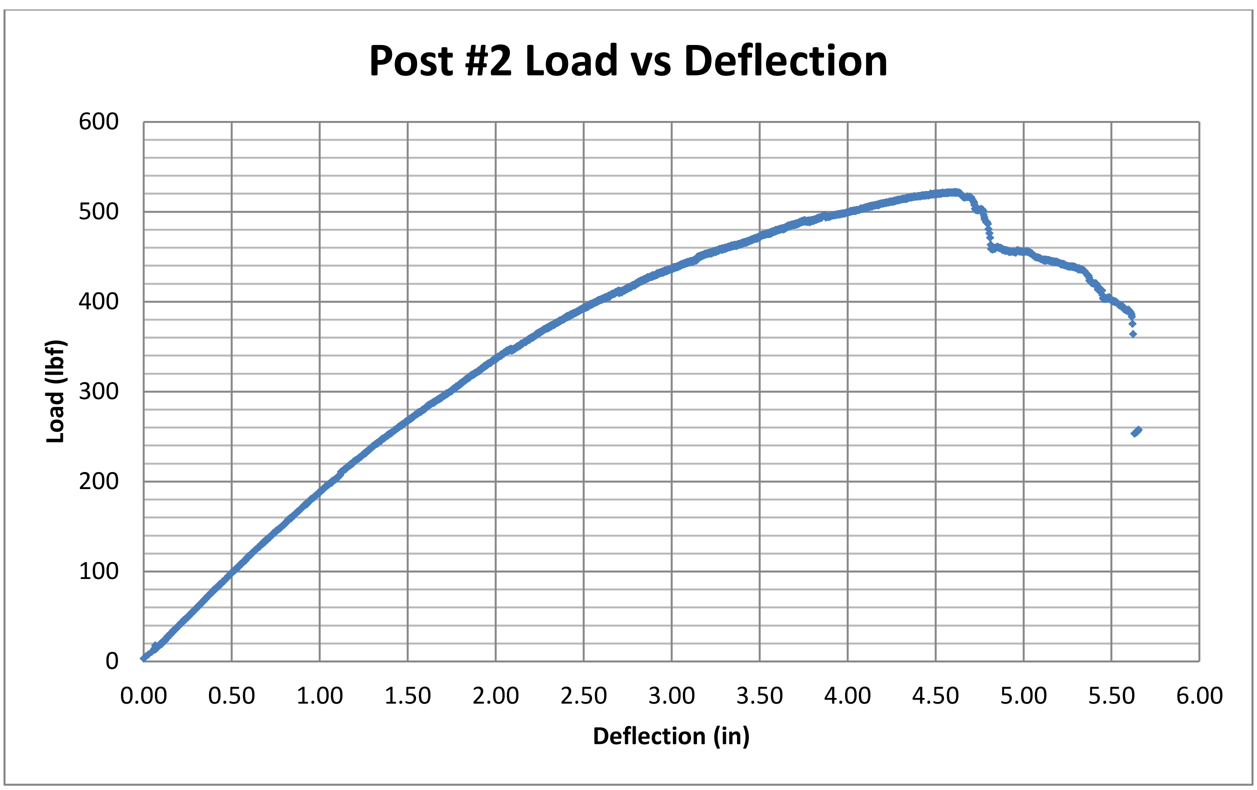
Project: Post Testing	Drawing No.	Scale: 6"=1'-0"	Seal
	Drawn By: KK	Date: Nov. 14, 2019	
Title: 2" Post 5x5 Mounting Plate Detail	Alloy: 6061-T6	Post No.: #1 > #15	

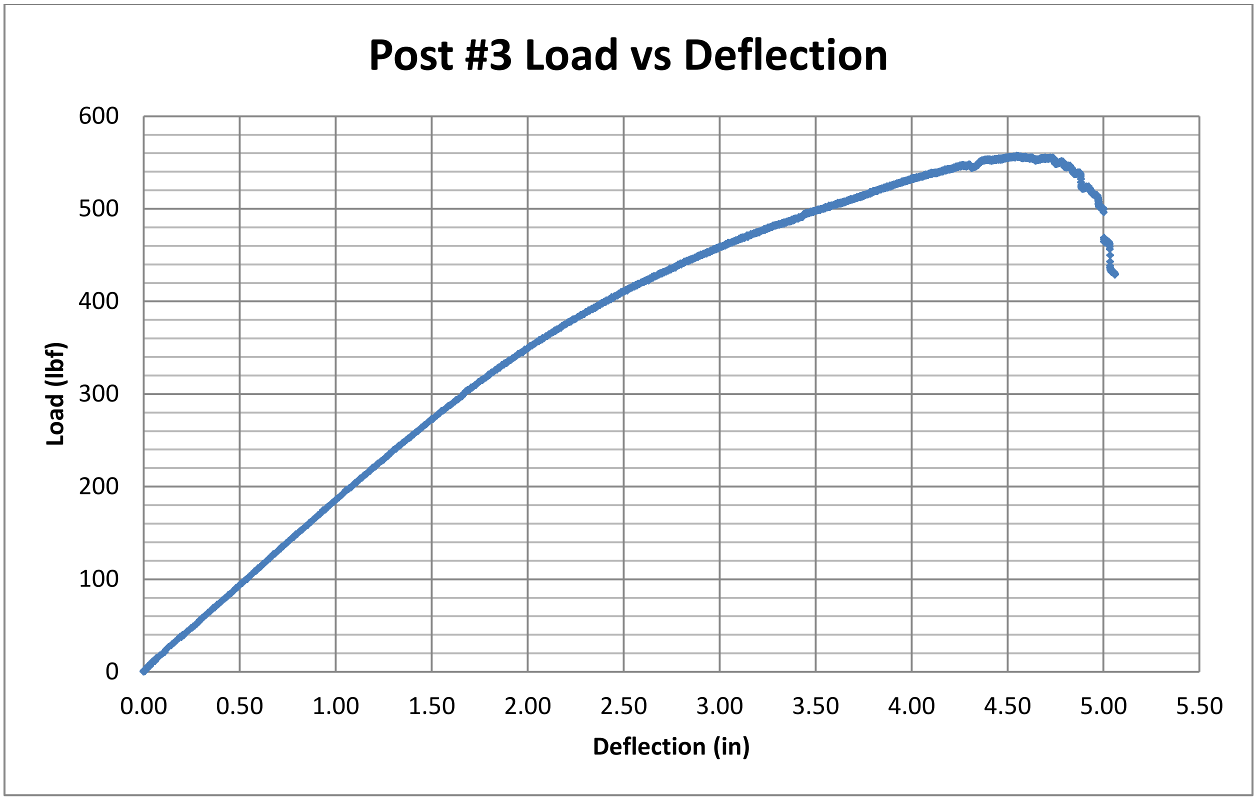
EAST & WEST ALUM CRAFT LTD.
Phone: 604-438-6261 Fax: 604-438-4021

File: East West\S.T.A.R\Post Testing\Post Testing Nov 14 2019.Dwg

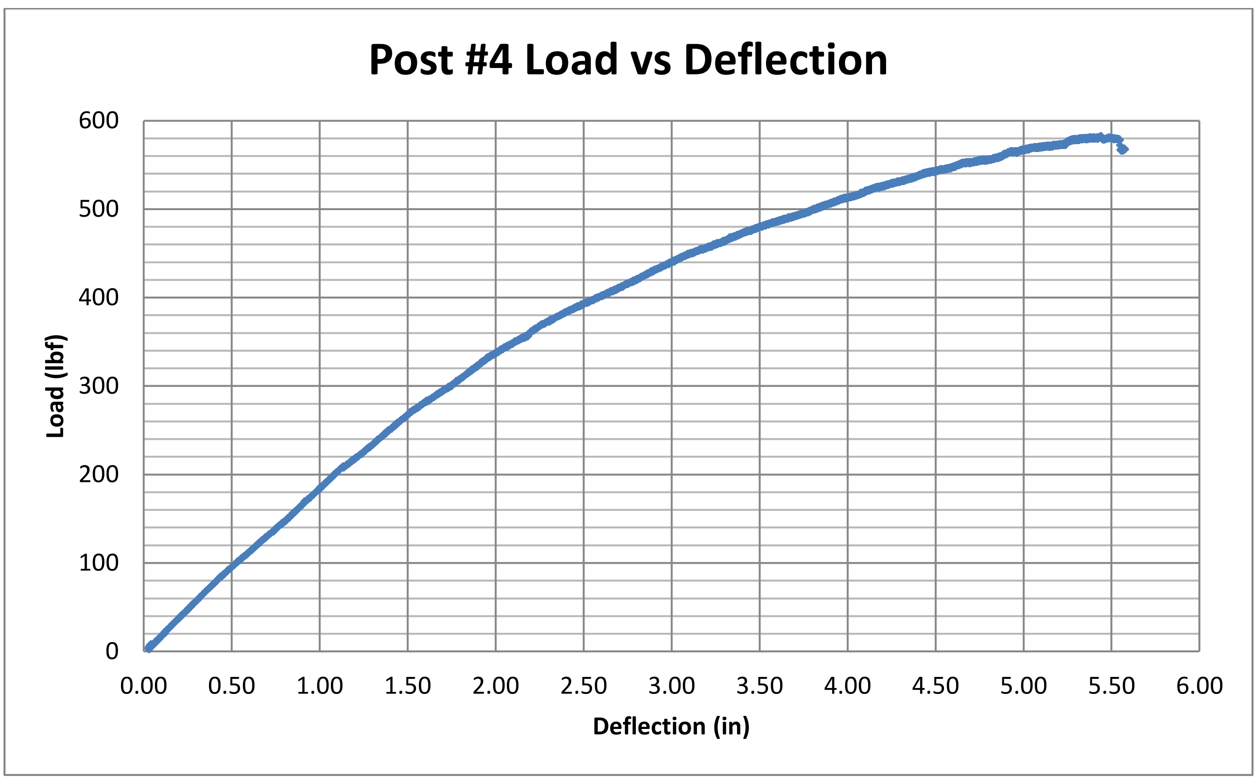
Appendix B


Post #1 Load vs Deflection
Load (lbf)
600
500
400
300
200
100
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
Deflection (in)

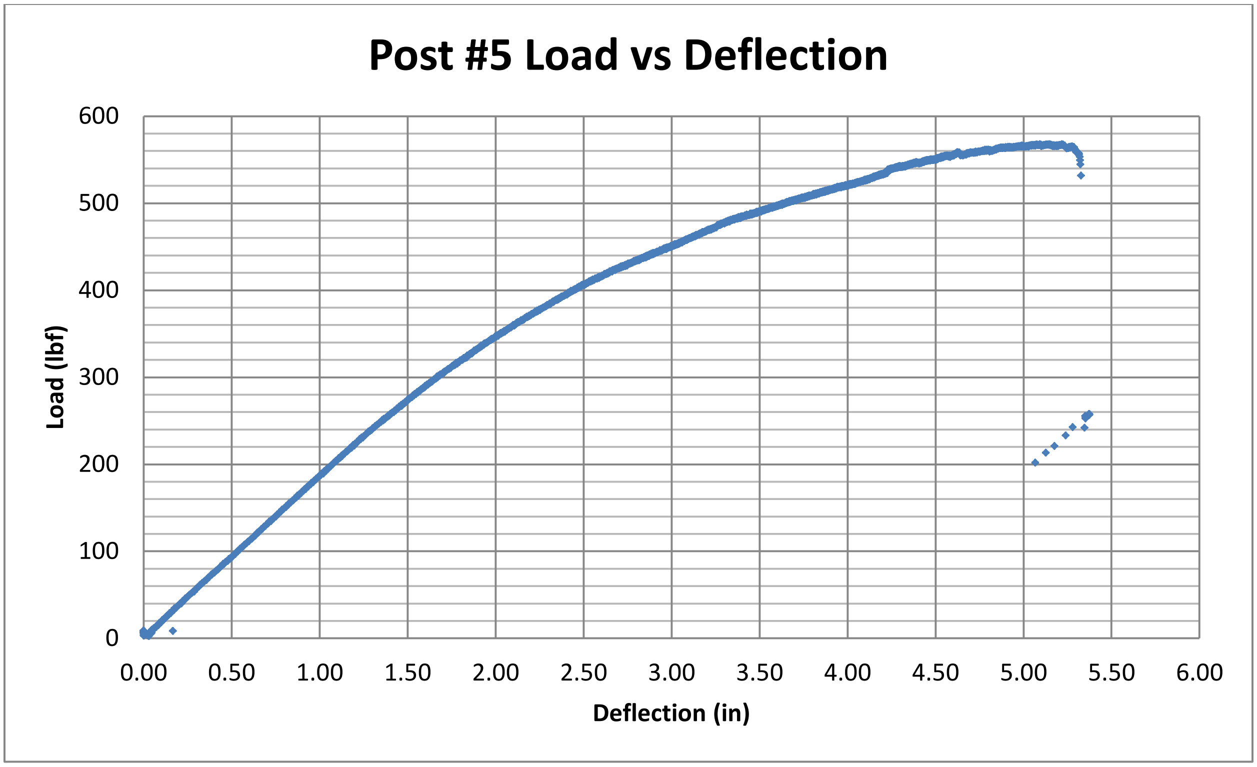

Post #2 Load vs Deflection
Load (lbf)
600
500
400
300
200
100
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
Deflection (in)

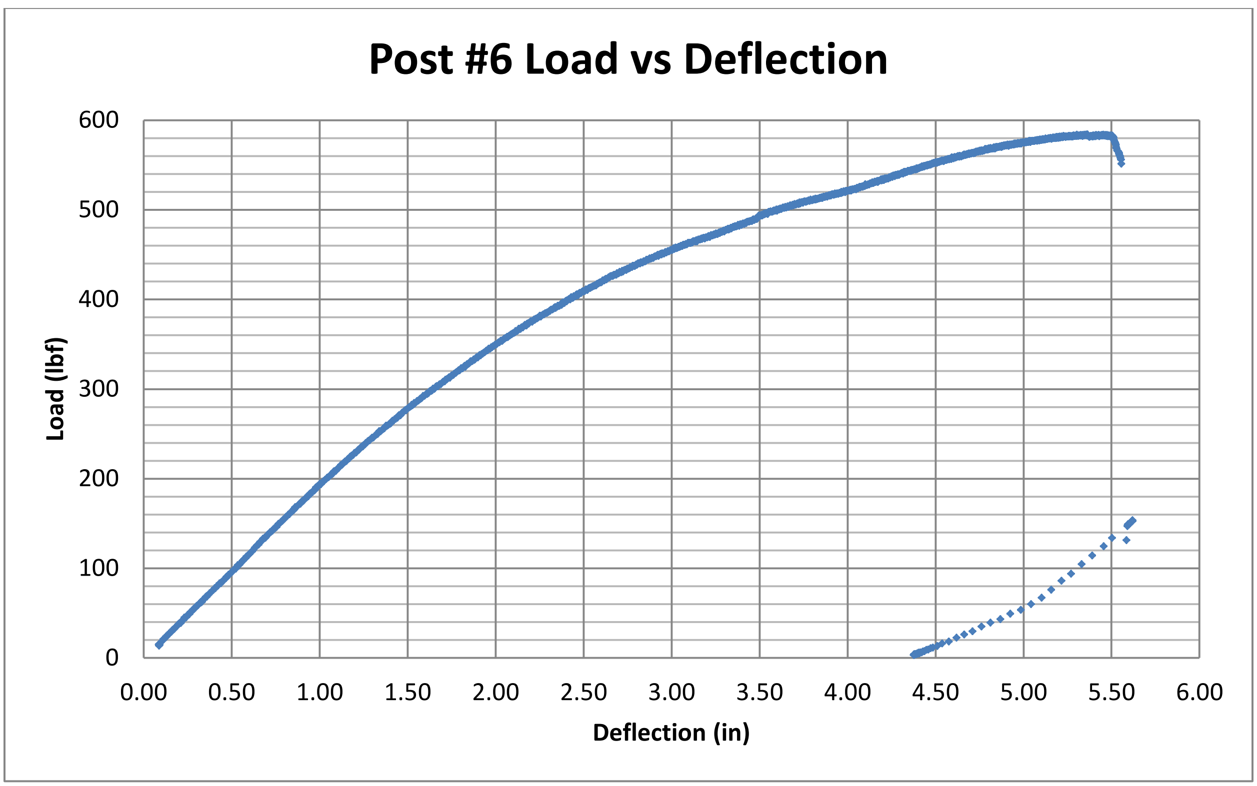


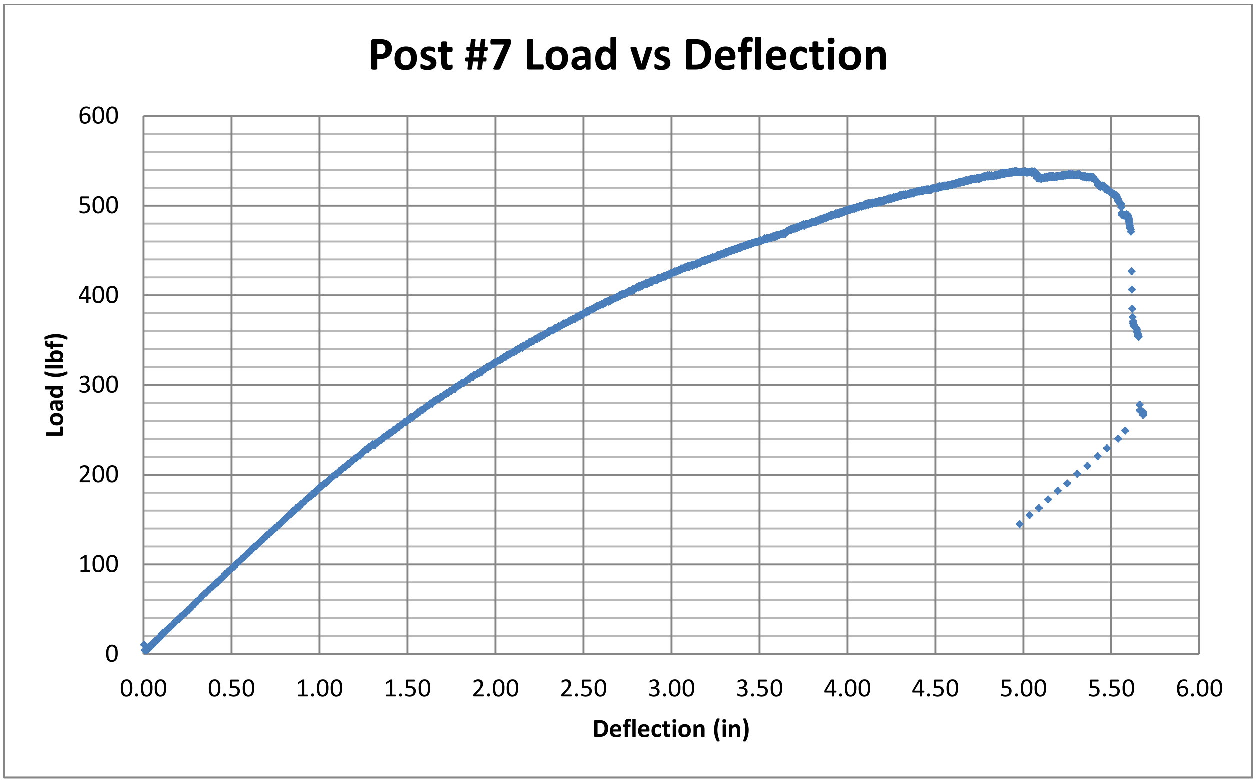
Post #3 Load vs Deflection
Load (lbf)
Deflection (in)
0
100
200
300
400
500
600
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50

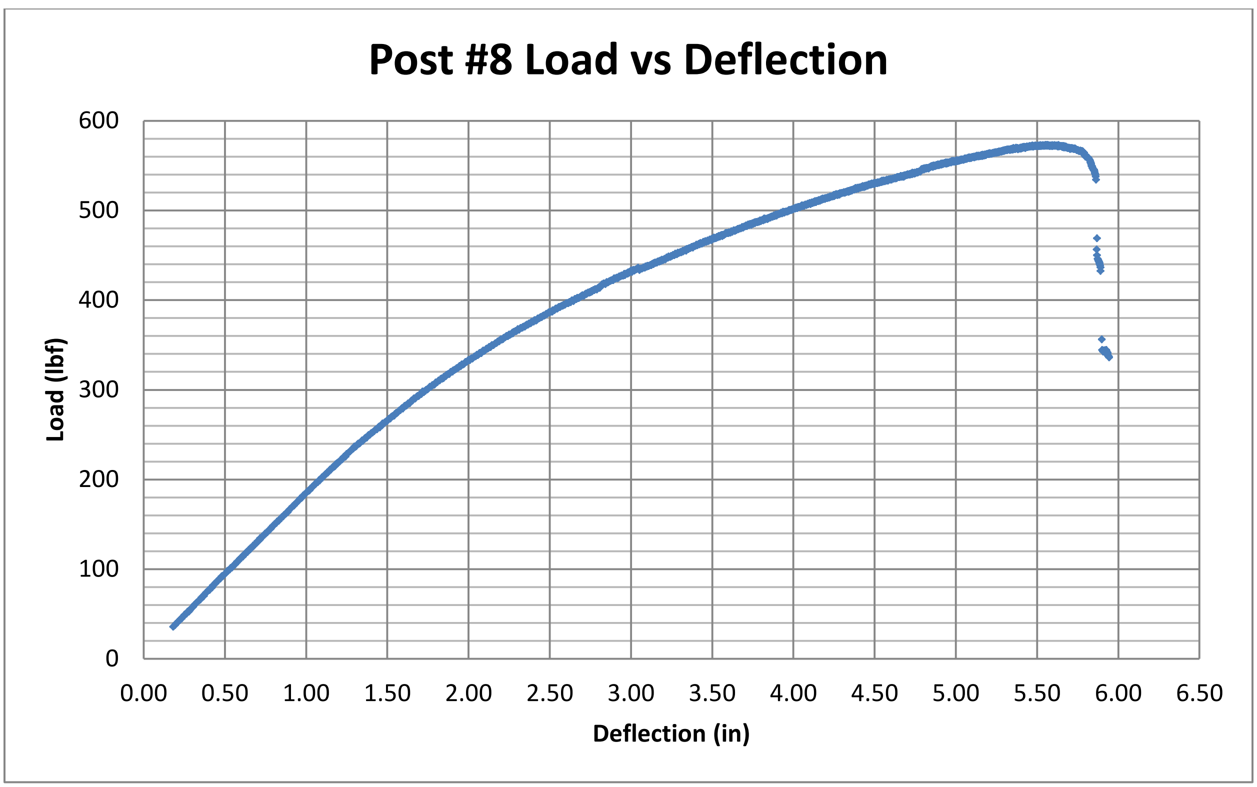


Post #4 Load vs Deflection
Load (lbf)
Deflection (in)
0
100
200
300
400
500
600
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00

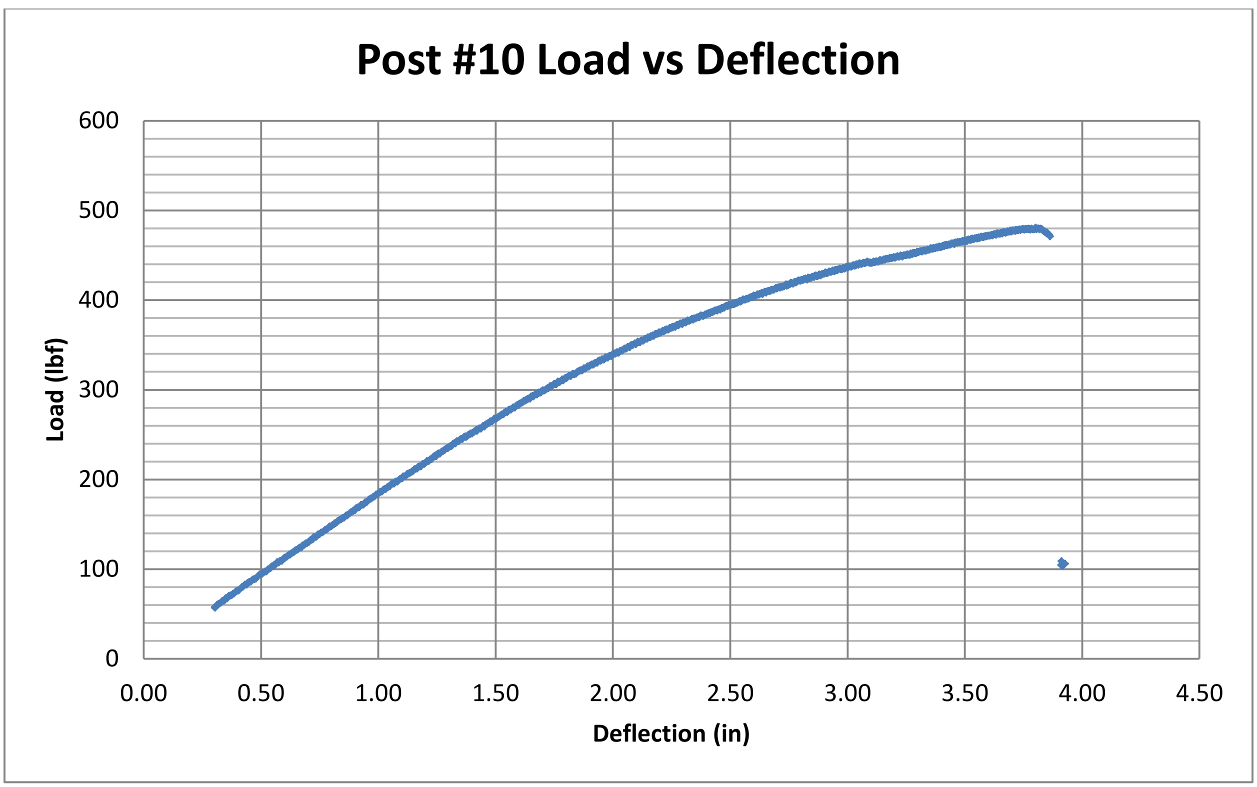

Post #5 Load vs Deflection
600
500
400
300
200
100
0
Load (lbf)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
Deflection (in)

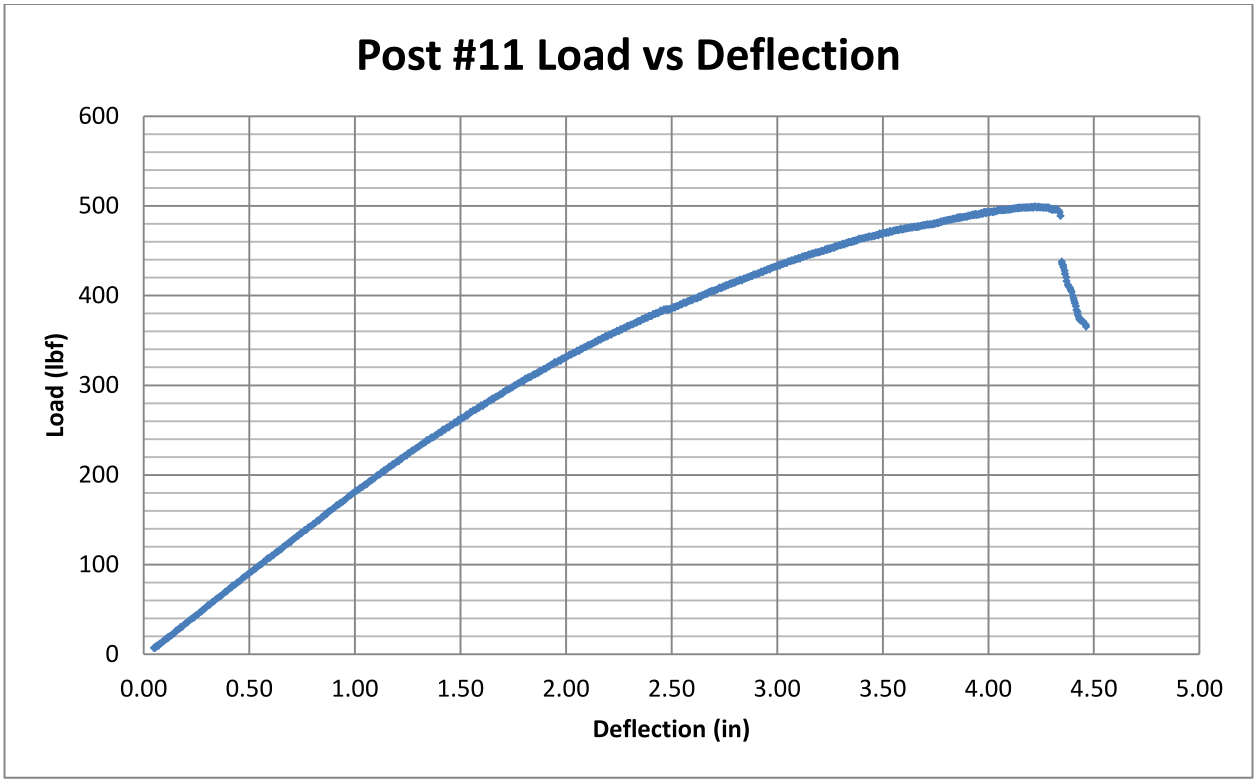

Post #6 Load vs Deflection
600
500
400
300
200
100
0
Load (lbf)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
Deflection (in)

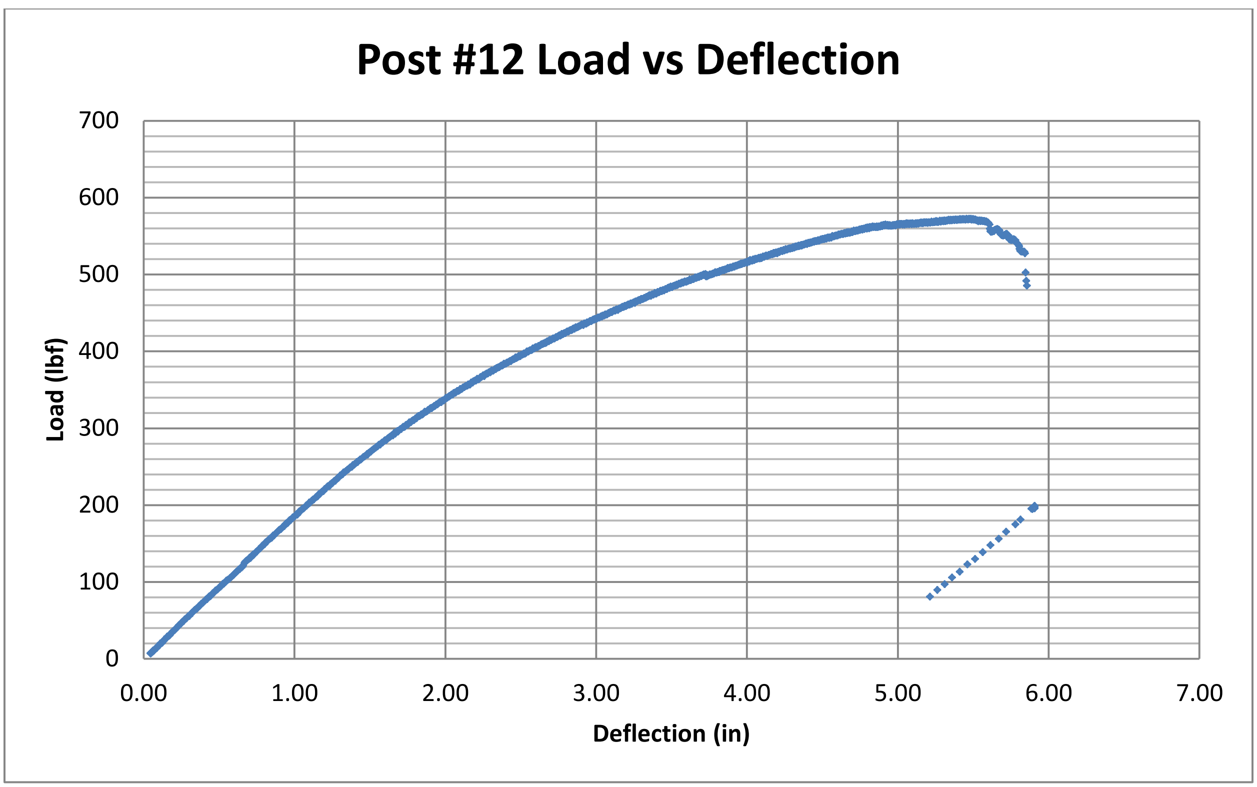

Post #7 Load vs Deflection
Load (lbf)
600
500
400
300
200
100
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
Deflection (in)

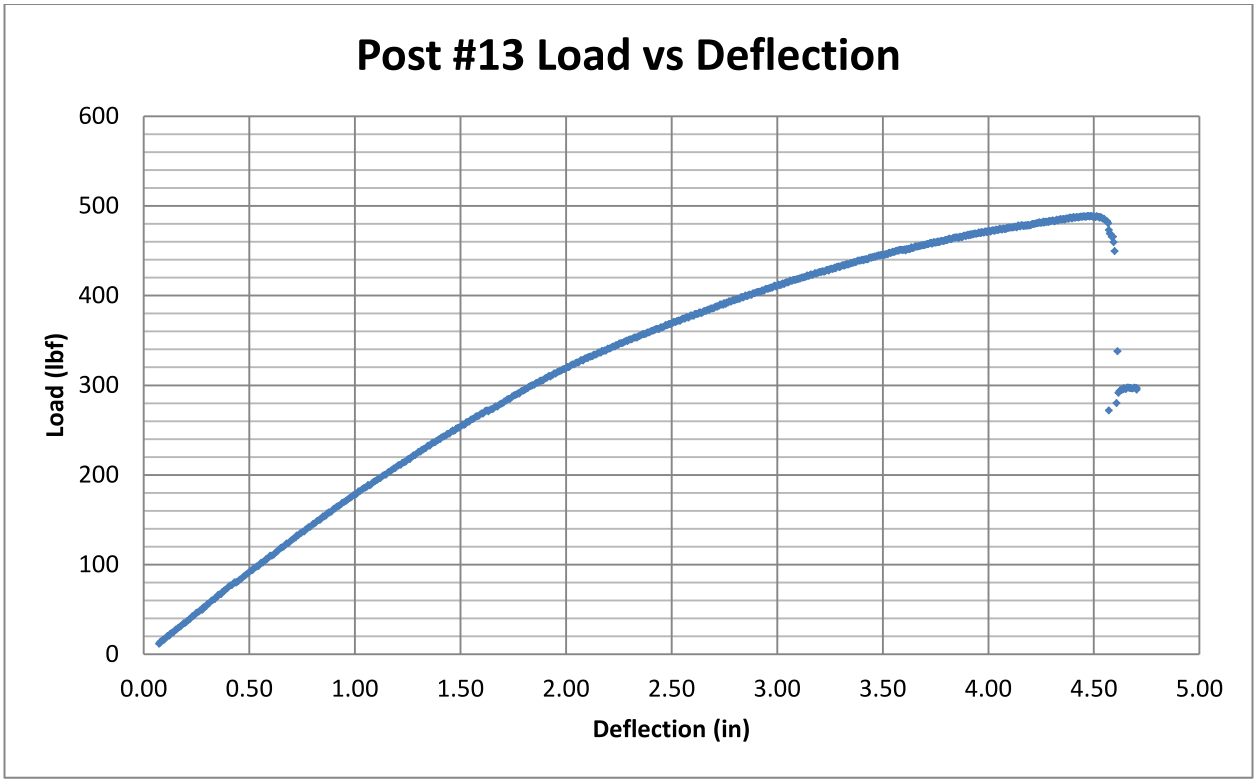

Post #8 Load vs Deflection
Load (lbf)
600
500
400
300
200
100
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
Deflection (in)

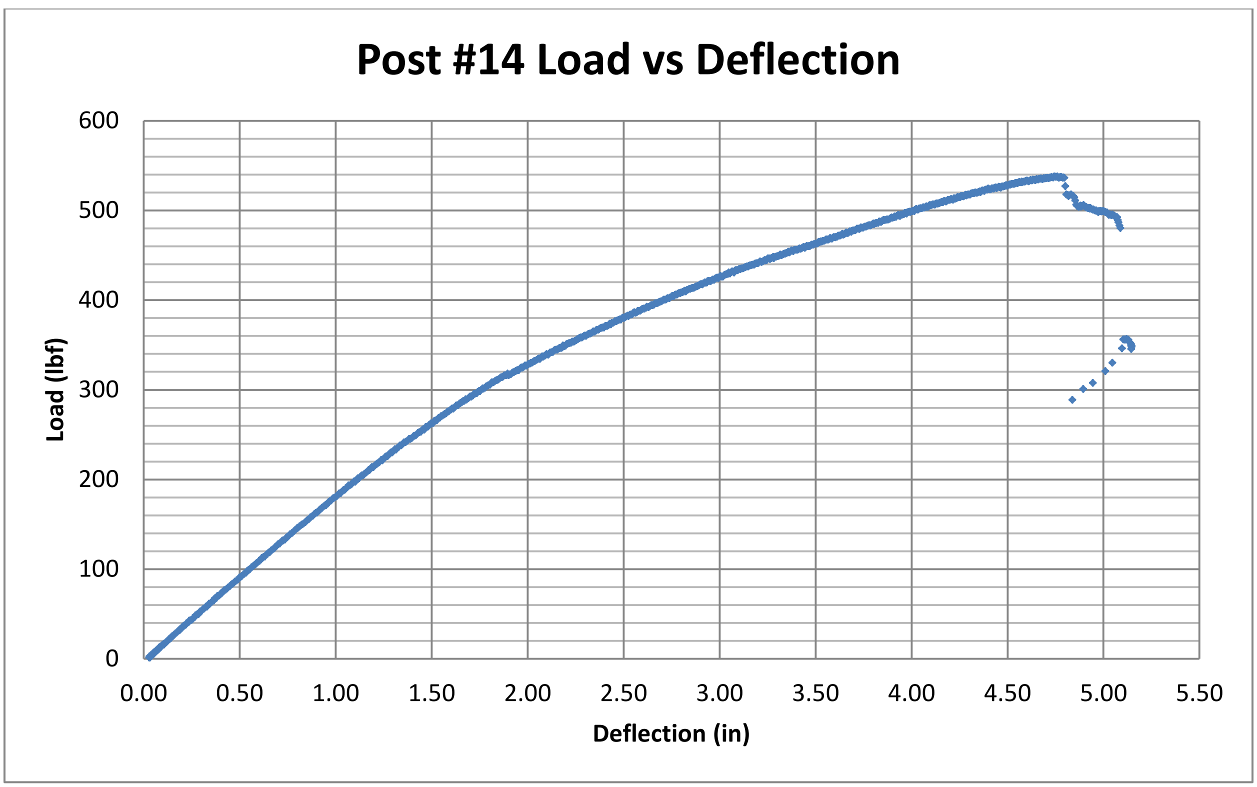

Post #9 Load vs Deflection
600
500
400
300
200
100
0
Load (lbf)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
Deflection (in)

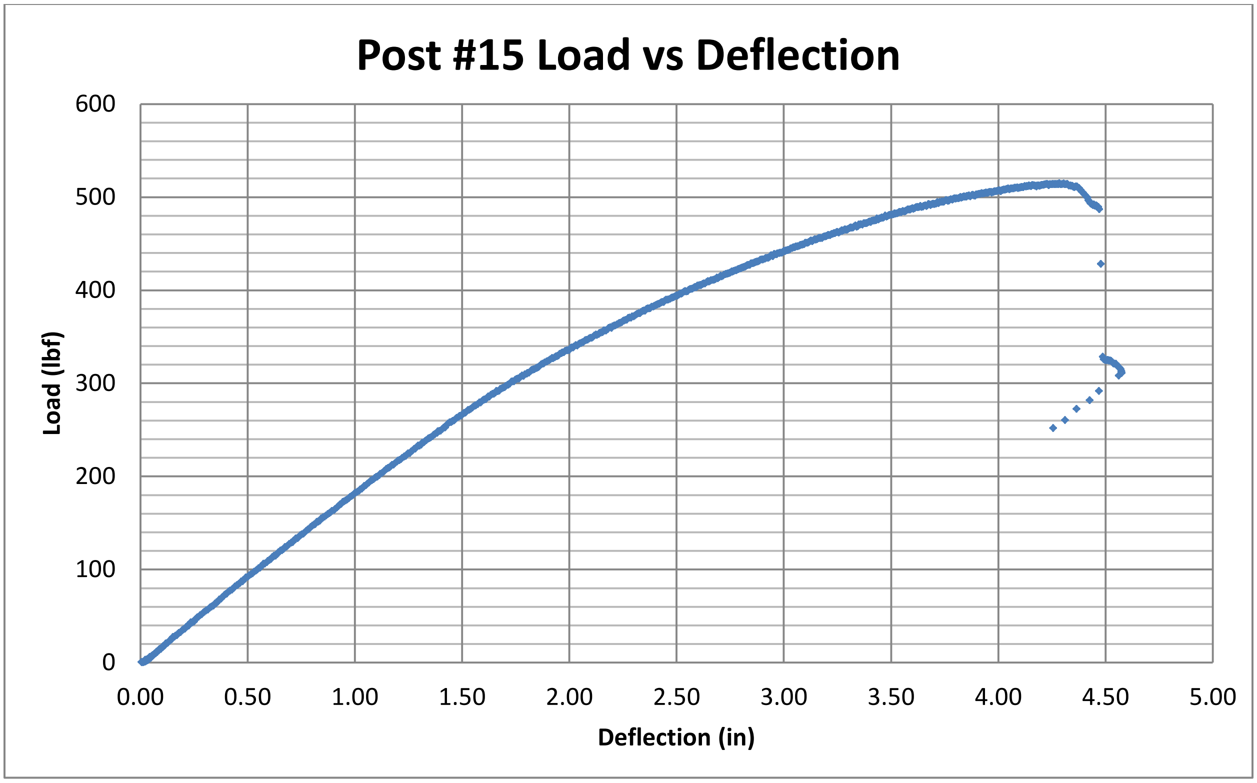

Post #10 Load vs Deflection
600
500
400
300
200
100
0
Load (lbf)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
Deflection (in)


Post #11 Load vs Deflection
600
500
400
300
200
100
0
Load (lbf)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Deflection (in)

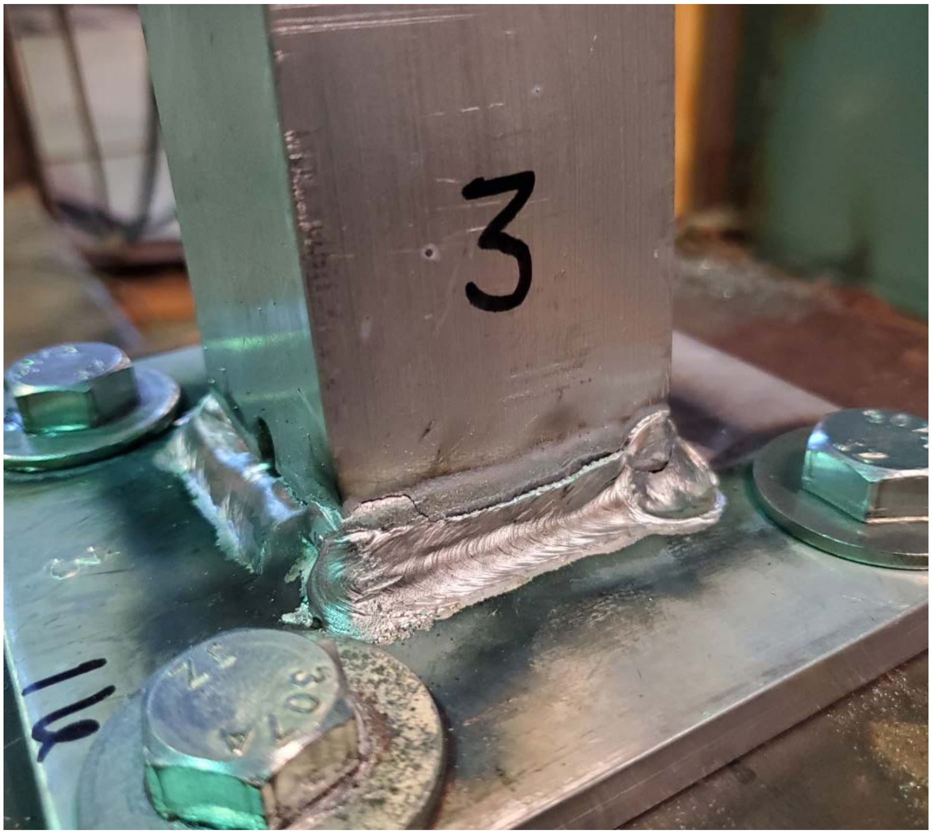

Post #12 Load vs Deflection
700
600
500
400
300
200
100
0
Load (lbf)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
Deflection (in)


Post #13 Load vs Deflection
Load (lbf)
600
500
400
300
200
100
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Deflection (in)


Post #14 Load vs Deflection
Load (lbf)
600
500
400
300
200
100
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
Deflection (in)


Post #15 Load vs Deflection
Load (lbf)
600
500
400
300
200
100
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Deflection (in)

Appendix C
(number printed on post is opposite of pulling direction)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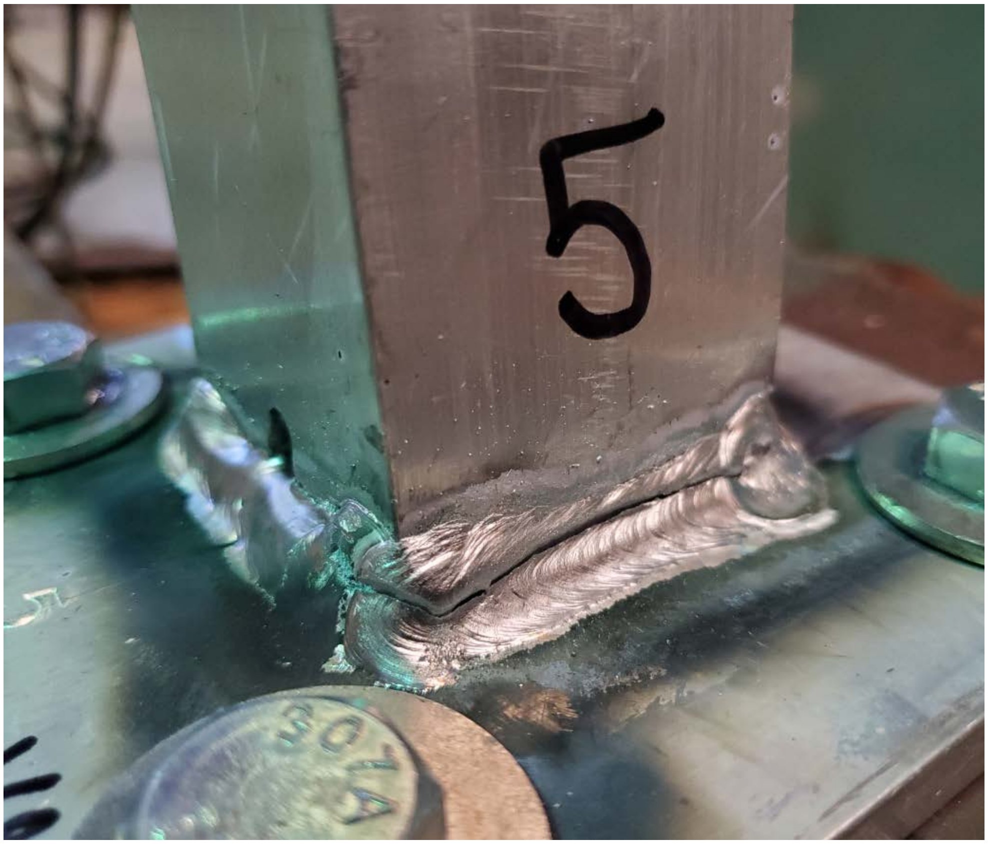
4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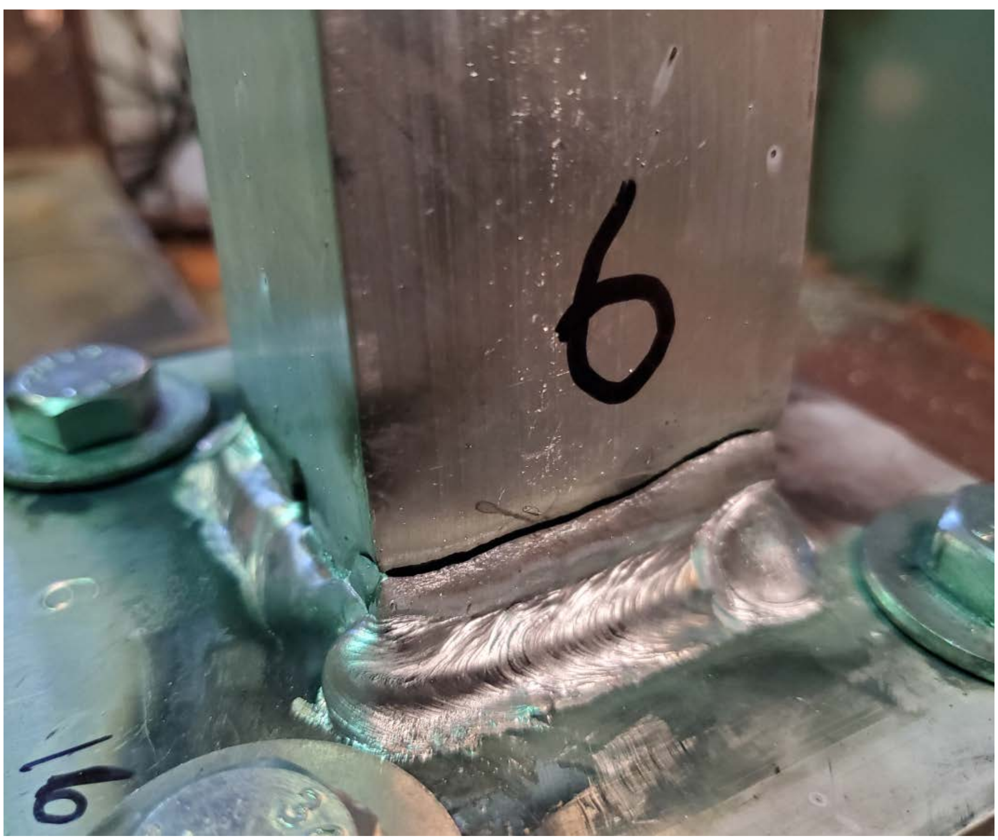
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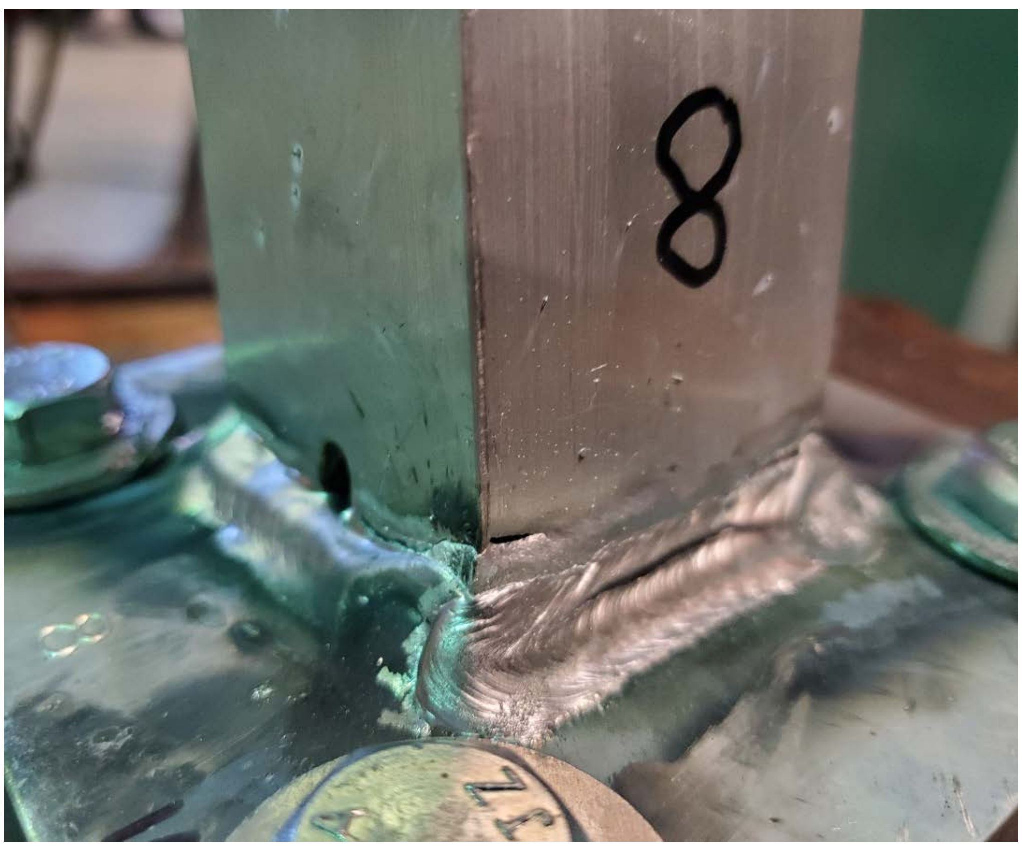
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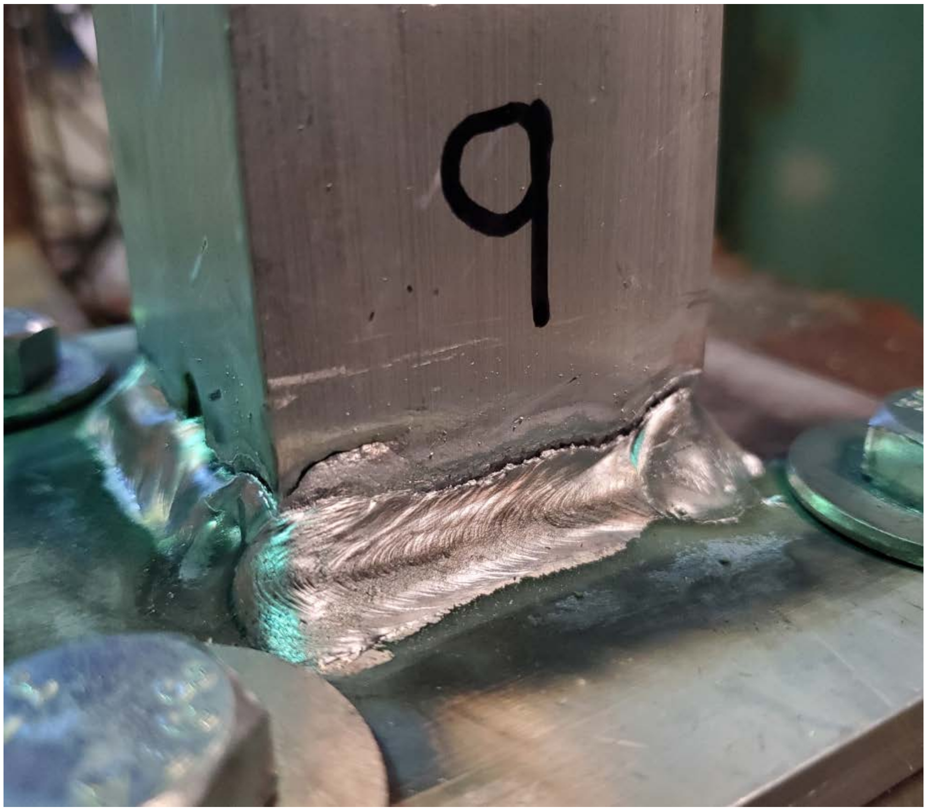
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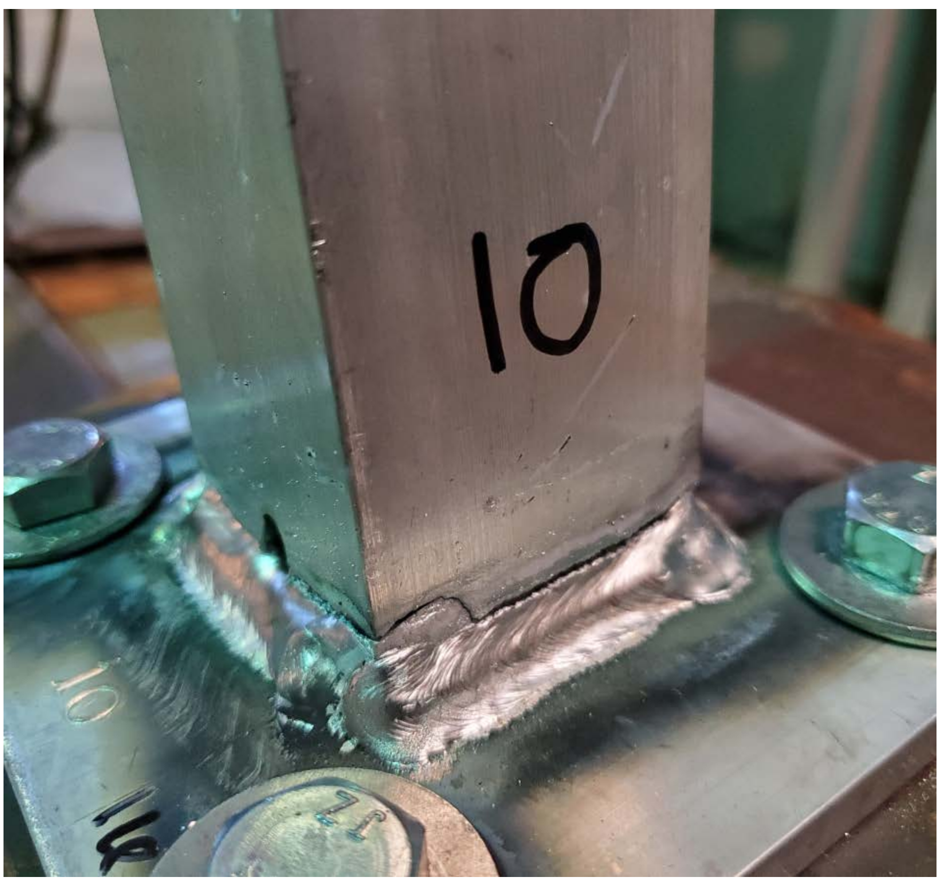
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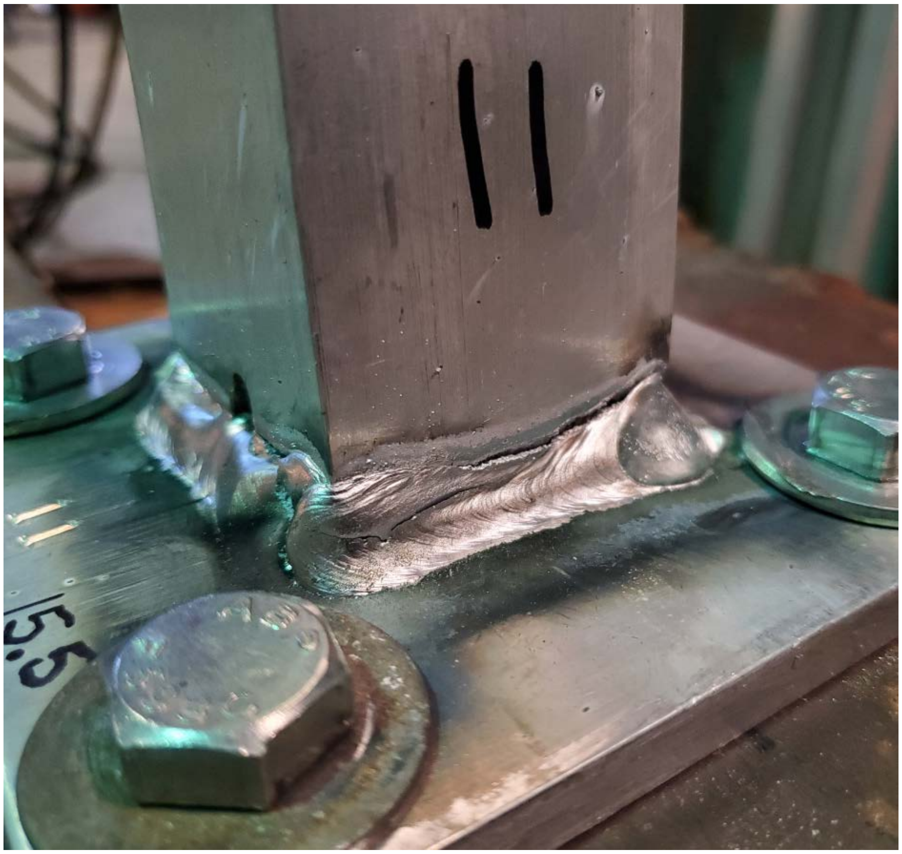
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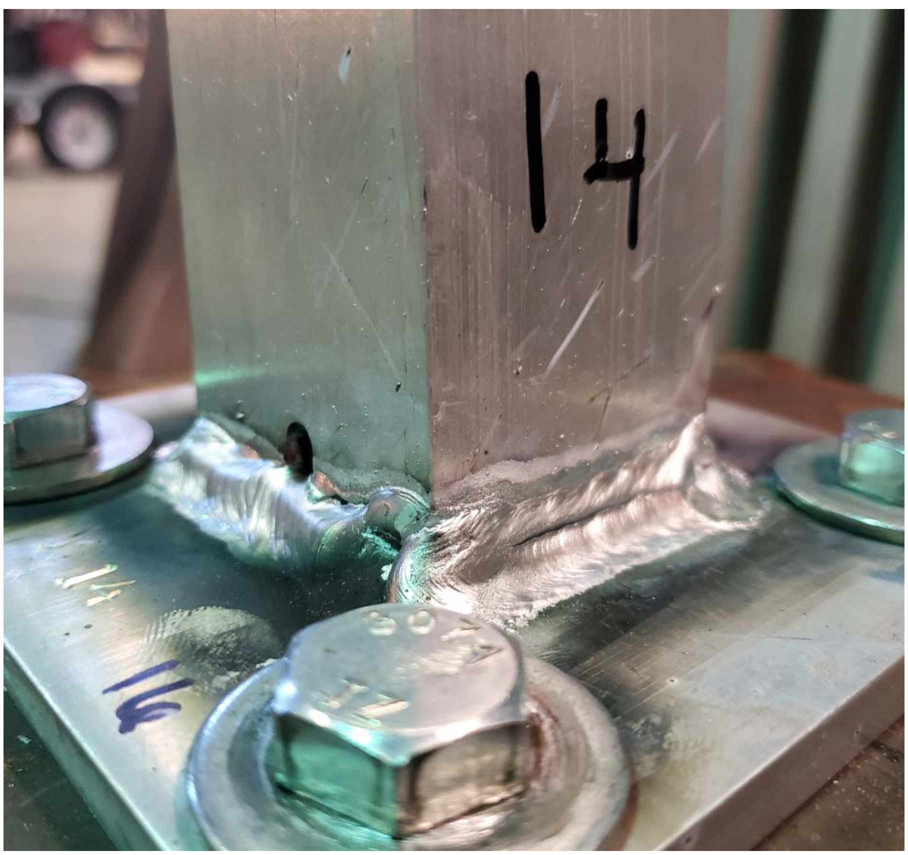
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