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Making Buildings Better™

TO **Stefan Jansen van Vuuren**
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Longboard Architectural Products.
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R-25403.000
Longboard Hitch System Development | Structural Review
DATE May 4, 2022

REGARDING **Longboard Hitch Cladding Attachment System Structural Review**

Dear Mr. van Vuuren,

As requested by Longboard Architectural Products (LB), RDH Building Science Inc. (RDH) is pleased to provide you with this report for structural assessment of the Hitch Cladding Attachment System. This report summarizes the capacity of the Hitch Clips for a variety of spacing arrangements and hitch length, as well as the capacity of individual clip components for different wind load scenarios.

1 System Description

The Hitch Clip system utilizes intermittent stainless-steel clips with thermal break shims to support exterior insulation and cladding. The system will be able to support up to 16" of exterior insulation and cladding outboard of the substrate.

The Hitch cladding attachment clip consists of three variations, Class 1, Class 2 and Class 3, as shown in Figure 1.1. Class 1 style is used for low levels of exterior insulation (1" to 2.5") and is made of a stainless-steel clip with polyamide thermal breaks. Class 2 and 3 styles are used for higher levels of exterior insulation (3"+) and are made of aluminum clip base, stainless steel square tube and polyamide thermal breaks.

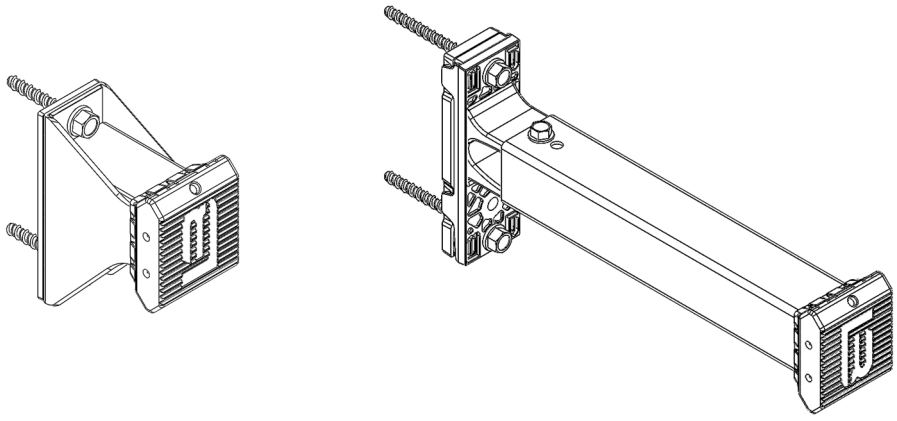


Figure 1.1: Isometric view of Hitch Class 1 Clip (left) and Hitch Class 2/3 Clip (right)

The Class 2 and 3 styles are differentiated by their aluminum clip base, as shown in Figure 1.2. The Class 3 style is intended to be used on walls with more than 6" of exterior insulation.

Figure 1.2: Side view of aluminum clip base class 2 (left) and class 3 (right)

The installation tool for the 2 and 3 system, shown in Figure 1.3, punctures through the mineral wool insulation, and allows the excess insulation to be saved and inserted into the Hitch tube to help maintain insulation continuity.

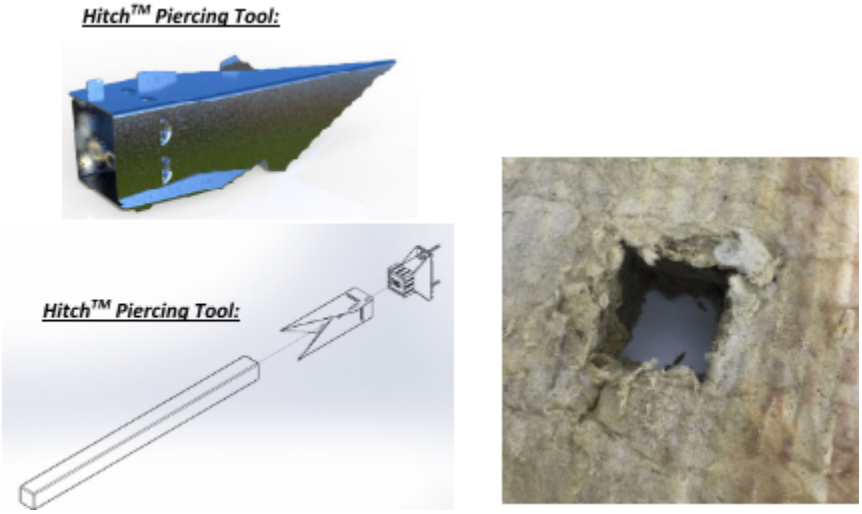


Figure 1.3: Hitch Piercing Tool

For this thermal analysis, a steel stud backup wall system was used with Class 1, 2 and 3. Hitch clips were evaluated for two types of clip arrangements shown in Figure 4.

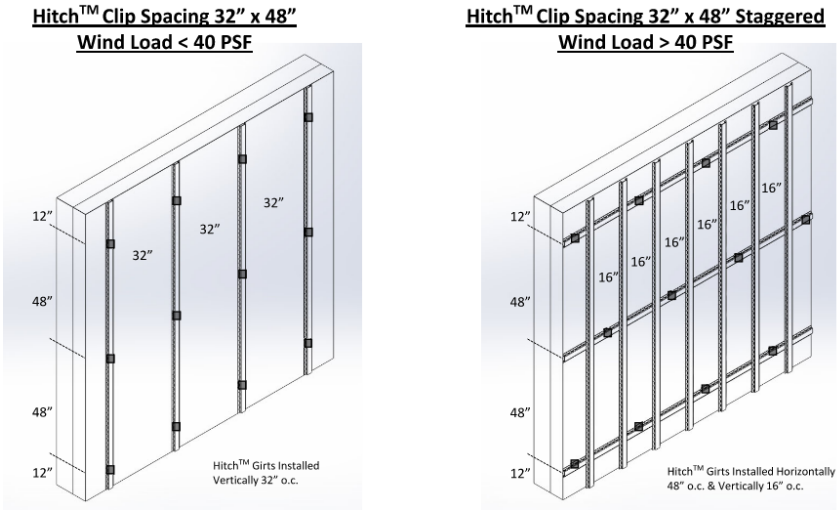


Figure 1.4: Clip arrangement configuration

1.1 Evaluated Scenarios

The following scenarios, shown in Table 1.1, were evaluated for the various Hitch system components to determine the structural capacity.

Table 1.1 Thermal Analysis Evaluated Scenarios

System Type	Backup Wall	Exterior Mineral Wool Insulation Thickness	Component Spacing
Class 1	• 20 Mpa/3000 psi concrete • 16-gauge Steel Stud • 18-gauge Steel Stud • Wood stud spf • CMU	• 2.5” • 1”	32” horizontally, 48” vertically
Class 2		• 16” • 10” • 6” • 3”	
Class 3		• 16” • 10” • 6”	

2 Methodology

2.1 Evaluation Assumptions

The Hitch System assemblies for this report were evaluated using FEA analysis.

This method allows for the analysis of complex 3D geometries, such as point connections, complex clip shapes and exterior crossing substructure components, to provide a more comprehensive assessment of the impact of the loads.

The calculations, including resistances and section properties, were completed in accordance with, where applicable:

- Engineering Design in Wood
- Canadian Institute of Steel Construction, Tenth Edition
- American Architectural Manufacturers Association 1991
- CSA A23.3-14 Design of concrete structures
- CSA S157-05 Strength design in aluminum

2.2 Software

FEA analysis was performed using SOLIDWORKS Simulation Professional. SOLIDWORKS is a three-dimensional multi-physics finite element analysis software tool that can be used to analyze complex 3D geometries.

2.3 Calculations

The specified loads applied to the hitch clips were determined as prescribed by the Canadian building codes applicable to a cladding system. There were three different types of loading used to determine the minimum system requirements:

- Wind load
- Dead load
- Seismic load

In this report, the following structural components were evaluated:

Class 1:

- Base Thermal Break & Shim Plate (PA6 33% Glass -0.125")
- Class 1 Clip (304 Stainless Steel Tube -16ga wall)
- Washer Plate (304 Stainless Steel -0.09")
- Fasteners #14 (Supplied by Others)
- Thermal Sleeve (Extruded PA66 25% Glass)
- Head Thermal Break Cap (Injection Molded PA6 33% Glass)
- Self-Tapping Fasteners #10 (Stainless Steel)

Class 2 and Class 3:

- Two-piece Thermal Break (Injection Molded PA6 33% Glass)
- Class 2/3 Clip Base (Extruded 6005A T61 Aluminum Alloy)
- Fasteners #14 (Supplied by Others)
- 1 ½" Square Slotted Tube (304 Stainless Steel Tube -16ga wall)
- Self-Drilling Fasteners ¼" (Stainless Steel)
- Thermal Sleeve (Extruded PA66 25% Glass)
- Head Thermal Break Cap (Injection Molded PA6 33% Glass)
- Self-Tapping Fasteners #10 (Stainless Steel)
- 304 Stainless Steel washers- (Steel washers are required on class 2 clips and tubes longer than 10" and class 3 clips and their tubes longer than 7")

3 Structural Results

All loads in these tables are factored load and need to be adjusted for specific project.

Class 1:

Clip Class & Insulation Thickness	Wind Load	Max Allowable Dead Load PSF for Tube- Limit States Design Canada	Max Allowable Dead Load PSF for Clip Base - Limit States Design Canada
Class 1 @ 2.5"	8 PSF	14PSF	N/A
Class 1 @ 2.5"	18 PSF	10PSF	N/A
Class 1 @ 2.5"	50 PSF	5PSF	N/A
Class 1 @ 1"	8 PSF	15PSF	N/A

Class 1 @ 1"	18 PSF	12PSF	N/A
Class 1 @ 1"	50 PSF	6PSF	N/A

				1" of Exterior Insulation				2.5" of Exterior Insulation			
				Factored / Ultimate Wind Load				Factored / Ultimate Wind Load			
Class 1	Backup Wall:	Fasteners:	Maximum Factored / Ultimate Dead Load	215 lbf	375 lbf	535 lbf	640 lbf	215 lbf	375 lbf	535 lbf	640 lbf
	20MPa / 3,000 PSI Concrete	Two Hilti HIT-HY 200 3/8" x 4 1/2" Embedment		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	69 lbf	5 lbf
	20MPa / 3,000 PSI Concrete	Two Hilti KH-EZ 1/4" x 3 1/2" (48.8mm Embedment)		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	69 lbf	5 lbf
	18 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	30 lbf	5 lbf
	16 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	69 lbf	5 lbf
	Wood Stud SPF	Three #14 x 2 1/2" Lag wood screws/GRK		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	69 lbf	5 lbf
	CMU Backup Wall	Two Hilti KH-EZ 1/4" x 3 1/2"		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	69 lbf	5 lbf

Class 2:

Clip Class & Insulation Thickness	Wind Load	Max Allowable Dead Load PSF for Tube- Limit States Design Canada	Max Allowable Dead Load PSF for Clip Base - Limit States Design Canada
Class 2 @ 15"	8 PSF	13PSF	3PSF
Class 2 @ 15"	25 PSF	10PSF	2.5PSF
Class 2 @ 15"	50 PSF	5PSF	NR
Class 2 @ 10"	8 PSF	19PSF	4.5PSF
Class 2 @ 10"	25 PSF	17PSF	4PSF
Class 2 @ 10"	50 PSF	13PSF	0.1PSF
Class 2 @ 6"	8 PSF	34PSF	7.5PSF
Class 2 @ 6"	25 PSF	32PSF	6.5PSF
Class 2 @ 6"	50 PSF	30PSF	0.1PSF
Class 2 @ 3"	8 PSF	68PSF	15PSF
Class 2 @ 3"	25 PSF	67PSF	13PSF
Class 2 @ 3"	50 PSF	66PSF	0.15PSF

				3" of Exterior Insulation			
				Factored / Ultimate Wind Load			
Class 2	Backup Wall:	Fasteners:	Maximum Factored / Ultimate Dead Load	215 lbf	375 lbf	535 lbf	640 lbf
	20MPa / 3,000 PSI Concrete	Two Hilti HIT-HY 200 3/8" x 4 1/2" Embedment		250 lbf	223 lbf	160 lbf	6 lbf
	20MPa / 3,000 PSI Concrete	Two Hilti KH-EZ 1/4" x 3 1/2" (48.8mm Embedment)		250 lbf	223 lbf	160 lbf	6 lbf
	18 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill		140 lbf	95 lbf	36 lbf	6 lbf
	16 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill		250 lbf	185 lbf	75 lbf	6 lbf
	Wood Stud SPF	Three #14 x 2 1/2" Lag wood screws/GRK		250 lbf	201 lbf	83 lbf	6 lbf
	CMU Backup Wall	Two Hilti KH-EZ 1/4" x 3 1/2"		250 lbf	201 lbf	83 lbf	6 lbf

6" of Exterior Insulation

Factored / Ultimate Wind Load			
215 lbf	375 lbf	535 lbf	640 lbf
115 lbf	97 lbf	85 lbf	4 lbf
115 lbf	97 lbf	85 lbf	4 lbf
60 lbf	40 lbf	16 lbf	NR
115 lbf	90 lbf	35 lbf	4 lbf
115 lbf	97 lbf	41 lbf	4 lbf
115 lbf	97 lbf	41 lbf	4 lbf

11" of Exterior Insulation

Factored / Ultimate Wind Load			
215 lbf	375 lbf	535 lbf	640 lbf
80 lbf	76 lbf	60 lbf	3 lbf
80 lbf	76 lbf	60 lbf	3 lbf
31 lbf	23 lbf	9 lbf	NR
80 lbf	50 lbf	22 lbf	3 lbf
80 lbf	58 lbf	27 lbf	3 lbf
80 lbf	58 lbf	27 lbf	3 lbf

16" of Exterior Insulation

Factored / Ultimate Wind Load			
215 lbf	375 lbf	535 lbf	640 lbf
47 lbf	52lbf	48 lbf	NR
47 lbf	52lbf	48 lbf	NR
23 lbf	17 lbf	6 lbf	NR
47 lbf	37 lbf	20 lbf	NR
46 lbf	43 lbf	25 lbf	NR
46 lbf	43 lbf	25 lbf	NR

steel washers are required on class 2 clips and tubes for clips longer than 10"

Class 3:

Clip Class & Insulation Thickness	Wind Load	Max Allowable Dead Load PSF for Tube- Limit States Design Canada	Max Allowable Dead Load PSF for Clip Base - Limit States Design Canada
Class 3 @ 15"	8 PSF	13PSF	9.5PSF
Class 3 @ 15"	25 PSF	10PSF	8PSF
Class 3 @ 15"	50 PSF	5PSF	1PSF
Class 3 @ 10"	8PSF	19PSF	12PSF
Class 3 @ 10"	25 PSF	17PSF	11PSF
Class 3 @ 10"	50 PSF	13PSF	1.5PSF
Class 3 @ 6"	8 PSF	34PSF	13PSF
Class 3 @ 6"	25 PSF	32PSF	12PSF
Class 3 @ 6"	50 PSF	30PSF	2PSF

6" of Exterior Insulation

				Factored / Ultimate Wind Load			
Class 3	Backup Wall:	Fasteners:	Maximum Factored / Ultimate Dead Load	215 lbf	375 lbf	535 lbf	640 lbf
	20MPa / 3,000 PSI Concrete	Two Hilti HIT-HY 200 3/8" x 4 1/2" Embedment		315lbf	220 lbf	160 lbf	40 lbf
	20MPa / 3,000 PSI Concrete	Two Hilti KH-EZ 1/4" x 3 1/2" (48.8mm Embedment)		260 lbf	187 lbf	130 lbf	32 lbf
	18 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill		71 lbf	49 lbf	20 lbf	NR
	16 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill		140 lbf	100 lbf	39 lbf	4 lbf
	Wood Stud SPF	Three #14 x 2 1/2" Lag wood screws/GRK		150 lbf	108 lbf	44 lbf	5 lbf
	CMU Backup Wall	Two Hilti KH-EZ 1/4" x 3 1/2"		150 lbf	108 lbf	44 lbf	5 lbf

11" of Exterior Insulation

Factored / Ultimate Wind Load			
215 lbf	375 lbf	535 lbf	640 lbf
280 lbf	185 lbf	140 lbf	31 lbf
233 lbf	155 lbf	115 lbf	26 lbf
40 lbf	28 lbf	11 lbf	NR
78 lbf	52 lbf	20 lbf	3 lbf
84 lbf	59 lbf	22 lbf	3 lbf
84 lbf	59 lbf	22 lbf	3 lbf

16" of Exterior Insulation

Factored / Ultimate Wind Load			
215 lbf	375 lbf	535 lbf	640 lbf
195 lbf	158 lbf	115 lbf	26 lbf
170 lbf	131 lbf	92 lbf	20 lbf
28 lbf	21 lbf	7 lbf	NR
50 lbf	39 lbf	15 lbf	NR
54 lbf	41 lbf	16 lbf	NR
54 lbf	41 lbf	16 lbf	NR

steel washers are required on class 3 clips and tubes for clips longer than 7"

** Assumptions:

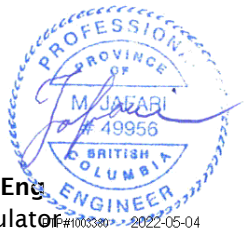
Clip base material is "Alumimum alloy 6005A-T61"
Concrete substrate to be 20MPa compressive strength or better
Minimum of 2" edge distance will be maintained
Untracked concrete for chemical anchors
Concrete masonry units are fully grouted with minimum masonry prism strength of 1500psi
CMU fasteners are installed as per HILTI instructions and min edge distances
NR: Not recommended

4 Conclusion

RDH performed FEA simulations of the Hitch cladding attachment clip to determine the max dead and wind load capacity of the system. Based on the FEA simulation results, the Hitch cladding attachment clip have different capacity base on the class and substrate materials. The actual capacity for each project needs to be determined according to the class, substrates, climatic and seismic information, and applicable codes and standards.

We trust this report meets your needs at this time. Please do not hesitate to contact us with any questions you might have.

Yours truly,



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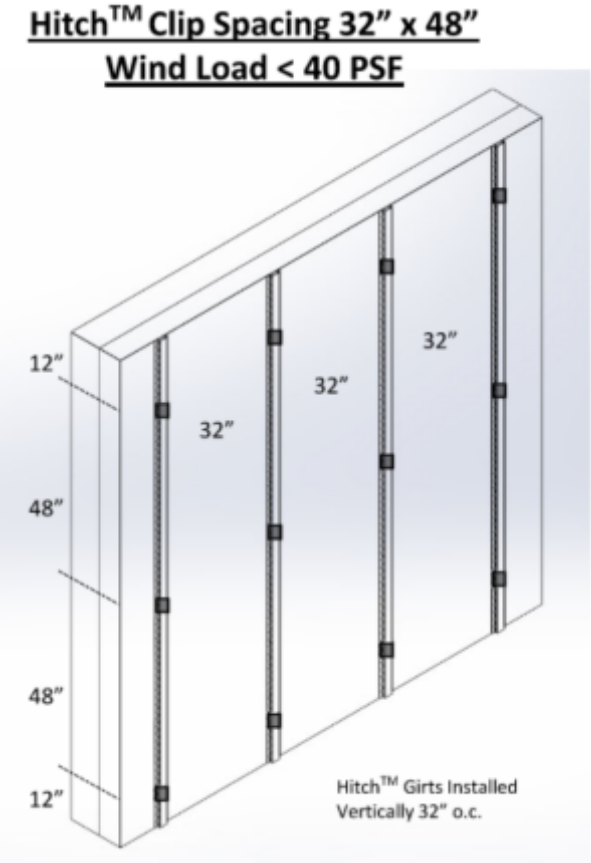
Appendix A: Class 1 Analysis
Appendix B: Class 2 and 3 Analysis

Appendix A

Class 1 Analysis

Max Jafari P.Eng. Project: Longboard Clip Class 1 Project#: 25403.000
2022-02-01

LONGBOARD HITCH CLIPS (for loads less than 40psf)



Class 1 Clips for 2.5" insulation:

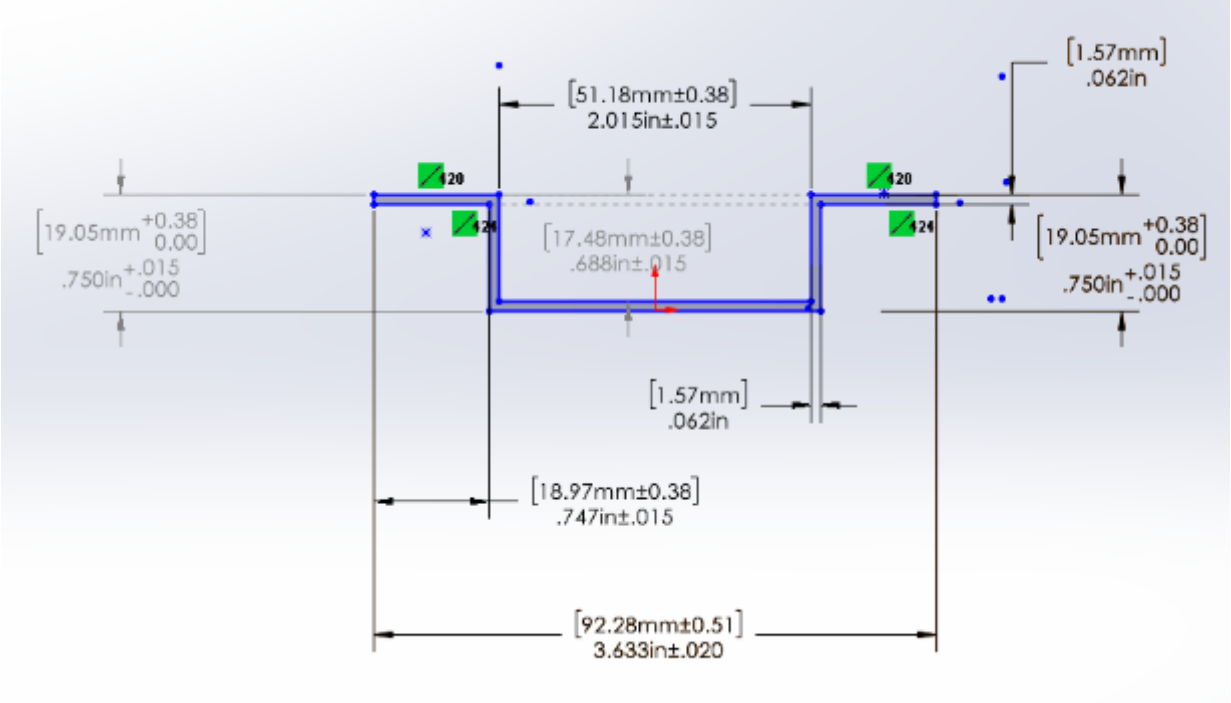
Factored Dead load $D_L := 4\ psf \cdot 1.25 = 0.239\ kPa$

Factored Wind load $W_l := 18\ psf \cdot 1.4 = 1.207\ kPa$

Tributary Width $b_w := \frac{32\ in + 32\ in}{2} = 812.8\ mm$

Legend
input *result* *check*

Class1 Clips.mcdx
Developed by __MJ___, _Feb __ 2022
Checked by __DV___, __Feb__ 2022



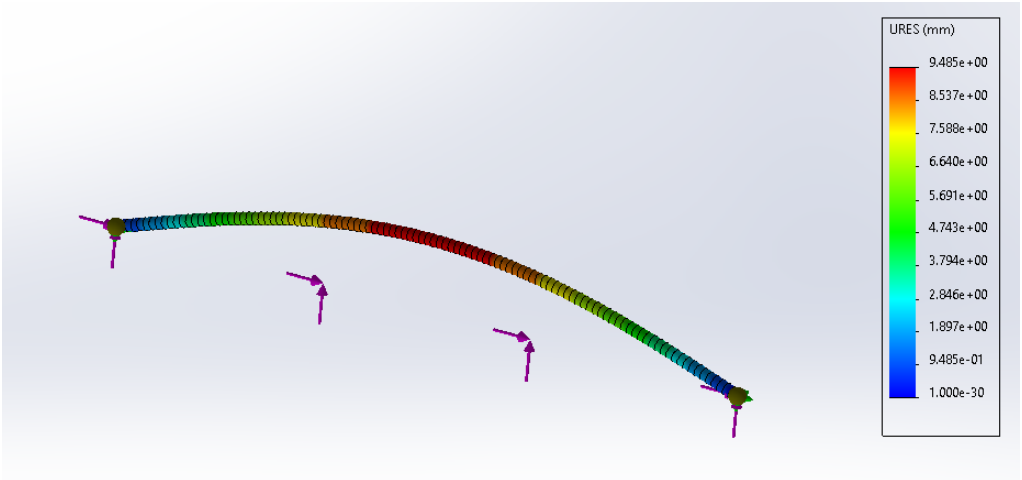
Girt width $G_w := 2\ in$

$sw_1 := D_L \cdot b_w = 1.111\ \frac{lbf}{in}$

$sw_2 := W_l \cdot b_w = 5.6\ \frac{lbf}{in}$

Dead Load on the Girts $D_{lG} := \frac{D_L \cdot b_w}{G_w} = 0.556\ psi$

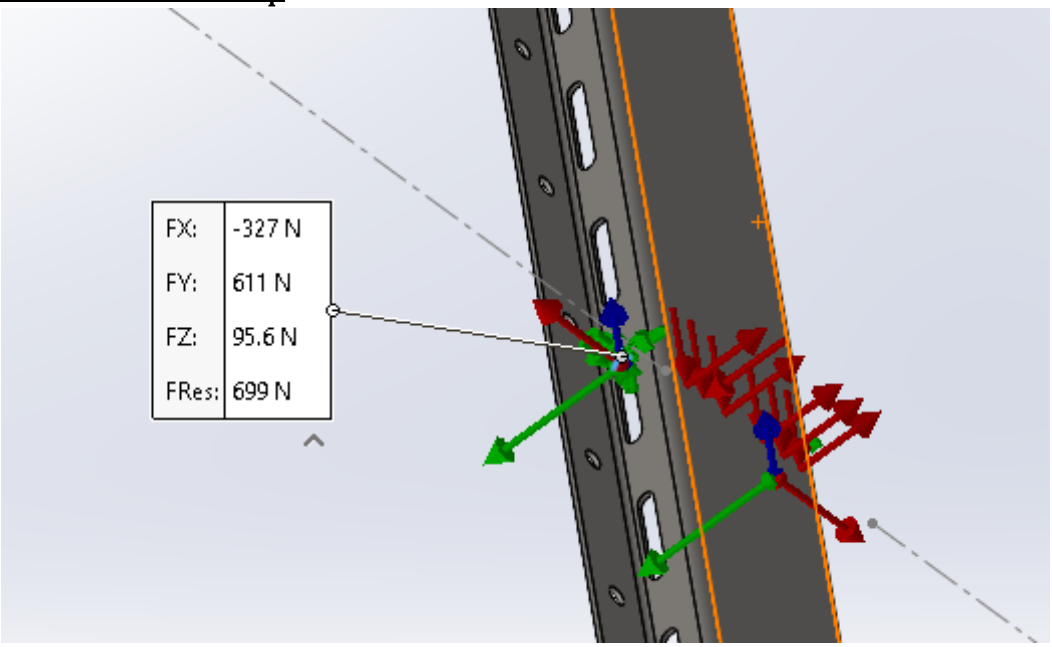
Wind Load on the Girts $W_{lG} := \frac{W_l \cdot b_w}{G_w} = 2.8\ psi$



Legend
input *result* *check*

Class1 Clips.mcdx
Developed by __MJ___, _Feb __ 2022
Checked by __DV___, __Feb__ 2022

Connection at Girt to the clip



Force in connection from solid-works $V_f := \sqrt{(95.6)^2 + (611)^2}\ \boldsymbol{N} = 139.029\ \boldsymbol{lbf}$;

From ITW construction products data sheet #10-24 teks screws

Safety factor $\phi := 4.3$

Shear resistance $V_r := \frac{1500\ \boldsymbol{lbf}}{\phi} = 348.837\ \boldsymbol{lbf}$

$\overrightarrow{Check\left(\left[V_r > V_f\right]\right)} = [\text{“OK”}]$

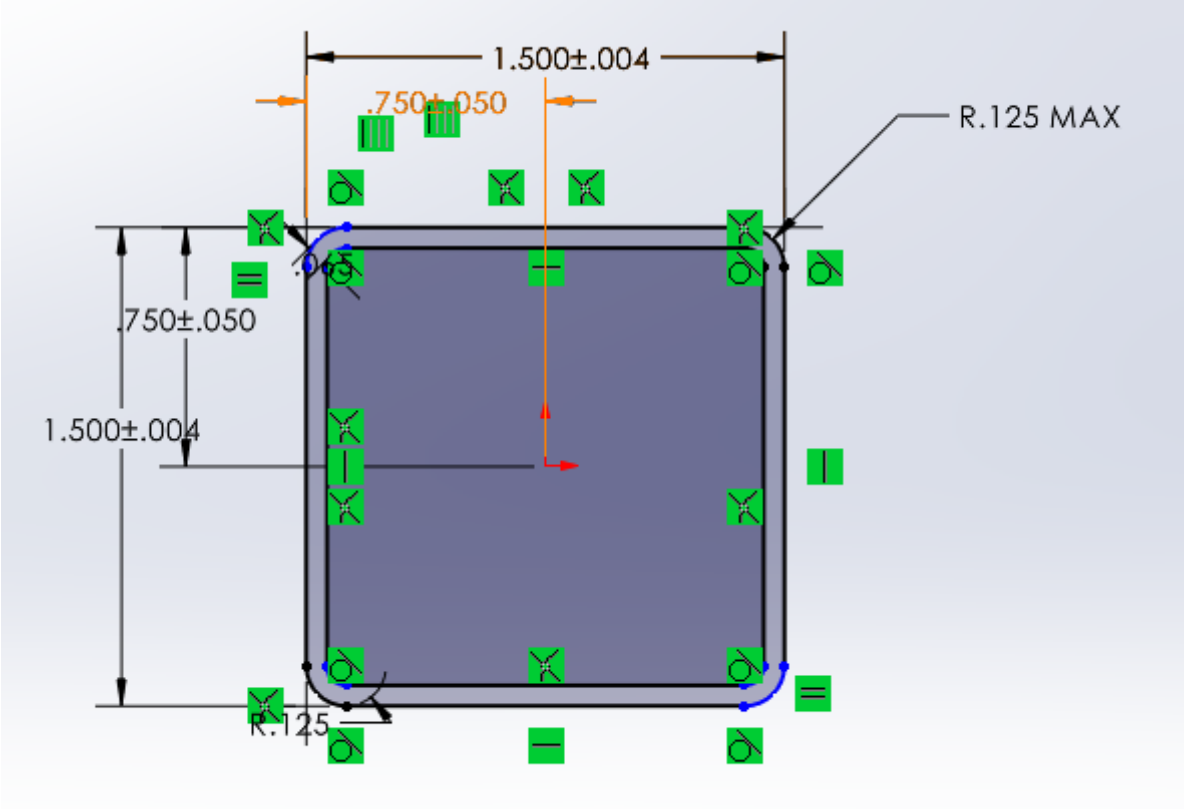
Class 1 clips with 2.5" insulation:

Frame width $b := 32\ \boldsymbol{in} = 0.813\ \boldsymbol{m}$

span $l := 48\ \boldsymbol{in}$

Legend
input *result* *check*

Class1 Clips.mcdx
Developed by __MJ___, _Feb __ 2022
Checked by __DV___, __Feb__ 2022

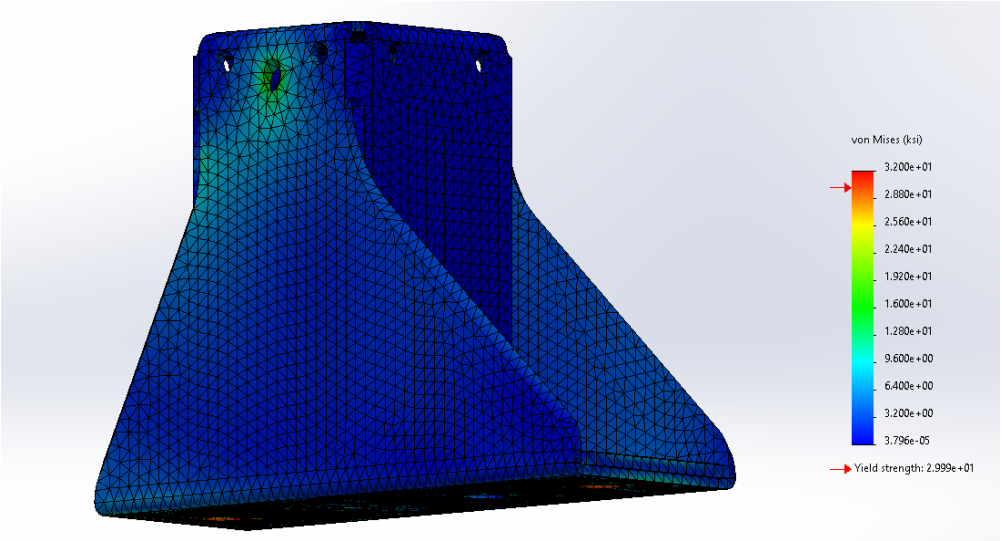


Tube width $T_w := 1.5\ in$

Tube length $T_l := 2.5\ in$

Dead Load on the Tube $D_{lG} := \frac{D_L \cdot b \cdot l}{T_w \cdot T_l} = 14.222\ psi$

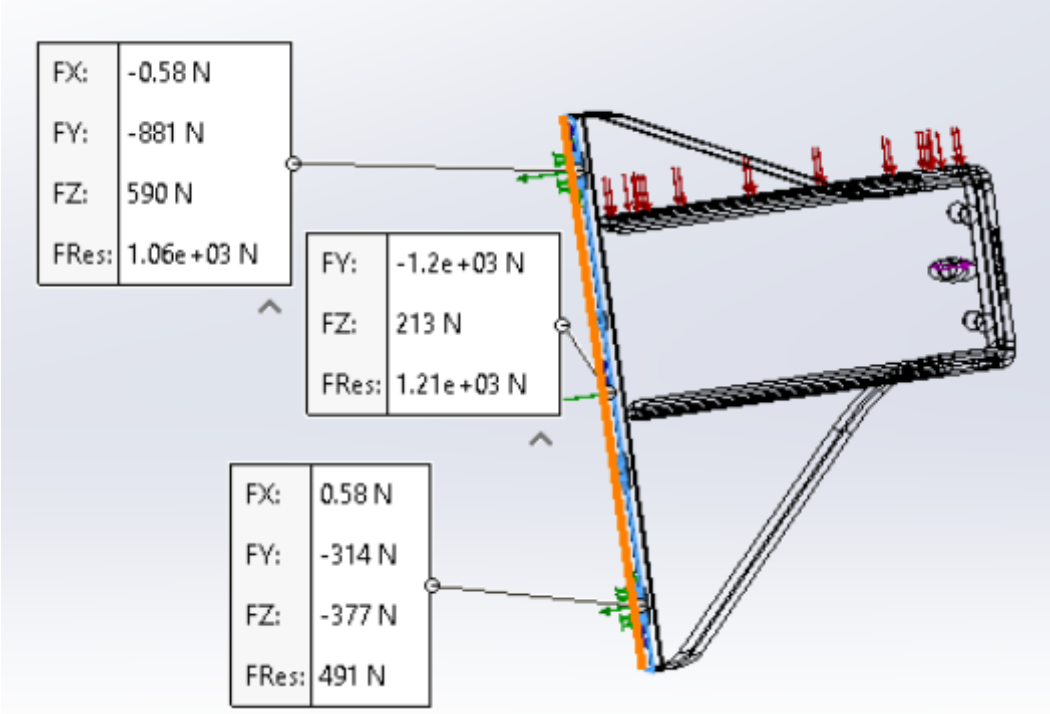
Wind Load on the Tube $W_{lG} := \frac{W_l \cdot b \cdot l}{2} = 134.4\ lbf$



Legend
input *result* *check*

Class1 Clips.mcdx
Developed by __MJ___, _Feb __ 2022
Checked by __DV___, __Feb__ 2022

Connection at Class 1 clip base to the Substrate:



Force in connection from solid-works

$V_f := .590\ \boldsymbol{kN} = 132.637\ \boldsymbol{lbf}$;

$T_f := 1.2\ \boldsymbol{kN} = 269.771\ \boldsymbol{lbf}$

Fasteners into wood substrate:

Try #12x2 1/2" wood screw

Allowable Lateral Resistance: $V_r := 182\ lbf$
Number of Screws: $n_{Fe} := 1$
Number of Rows of Scews: $n_R := 1$
Modification Factors: $K' := 1.0$ $J_E := 1.0$
Allowable Withdrawl Resistance: $T'_{rw} := 31\ \frac{N}{mm}$

Length of Penetration: $L_p := 2.5\ in$

Withdrawal Resistance:

$T_{rw} := T'_{rw} \cdot L_p \cdot n_{Fe} \cdot K' \cdot J_E = 1.969\ kN$

$\overrightarrow{Check\left(\begin{bmatrix} V_r > V_f \\ T_{rw} > T_f \end{bmatrix}\right)} = \begin{bmatrix} \text{“OK”} \\ \text{“OK”} \end{bmatrix}$

Fasteners into concrete substrate:

Assumptions:
- Concrete substrate to be 20MPa compressive strength or better
- Minimum of 2" edge distance will be maintained

Try 1/4"Ø x 2.5" Tapcons

Effective Embedment: $Emb := 2\ in$

Withdrawal Resistance:

$T_r := 595\ lbf = 2.647\ kN$

$Check := \text{if}\left(T_r > T_f, \text{“Good”}, \text{“FAIL”}\right) = \text{“Good”}$

Legend
input *result* *check*

Shear Resistance:

$$V_r := 417\ lbf = 1.855\ kN$$

$$\overrightarrow{\left(\begin{bmatrix} V_r > V_f \\ T_r > T_f \end{bmatrix}\right)} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

interaction

$n := 1$

$$I := \left(\frac{V_f}{V_r}\right)^n + \left(\frac{T_f}{T_r}\right)^n = 0.771 \qquad \overrightarrow{\left(\begin{bmatrix} I < 1 \\ I < 1.1 \\ I > 1.1 \end{bmatrix}\right)} = \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix}$$

Fasteners into steel stud substrate:

- Fastener will have UNC threads in load region of the shank
- All minimum edge distances will be maintained
- Fastener to be SAE Grade 5 Steel - UNC Thread

Try (2)#12-14 x 1.5" Self Tapping Screw on the top of clip base instead of one(shown on the drawings)
[ITW Tek screw data sheets]

Number of screws on the top of clip base $n := 2$

Withdrawal resistance $T_r := 150\ lbf \cdot n = 1.334\ kN$
Shear resistance $V_r := 207\ lbf \cdot n = 1.842\ kN$

$$\overrightarrow{\left(\begin{bmatrix} V_r > V_f \\ T_r > T_f \end{bmatrix}\right)} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

Connection at Class 1 clip base to the Substrate (Summary):

				1" of Exterior Insulation				2.5" of Exterior Insulation			
				Factored / Ultimate Wind Load				Factored / Ultimate Wind Load			
	Backup Wall:	Fasteners:	Maximum Factored / Ultimate Dead Load	215 lbf	375 lbf	535 lbf	640 lbf	215 lbf	375 lbf	535 lbf	640 lbf
Class 1	20MPa / 3,000 PSI Concrete	Two Hilti HIT-HY 200 3/8" x 4 1/2" Embedment		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	69 lbf	5 lbf
	20MPa / 3,000 PSI Concrete	Two Hilti KH-EZ 1/4" x 3 1/2" (48.8mm Embedment)		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	69 lbf	5 lbf
	18 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	30 lbf	5 lbf
	16 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	69 lbf	5 lbf
	Wood Stud SPF	Three #14 x 2 1/2" Lag wood screws/GRK		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	69 lbf	5 lbf
	CMU Backup Wall	Two Hilti KH-EZ 1/4" x 3 1/2"		147 lbf	100 lbf	80 lbf	8 lbf	122 lbf	81 lbf	69 lbf	5 lbf

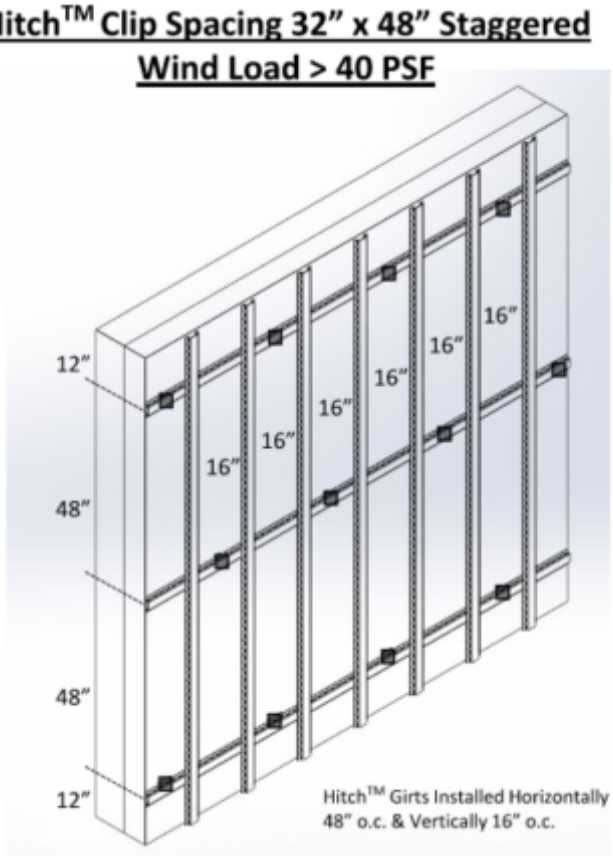
Legend
input *result* *check*

Appendix B

Class 2 and 3 Analysis

Max Jafari P.Eng. Project: Longboard Clip Class 2&3 Project#: 25403.000
2022-02-01

LONGBOARD HITCH CLIPS (for loads higher than 40psf)



Class 2& 3 Clips for 15" insulation:

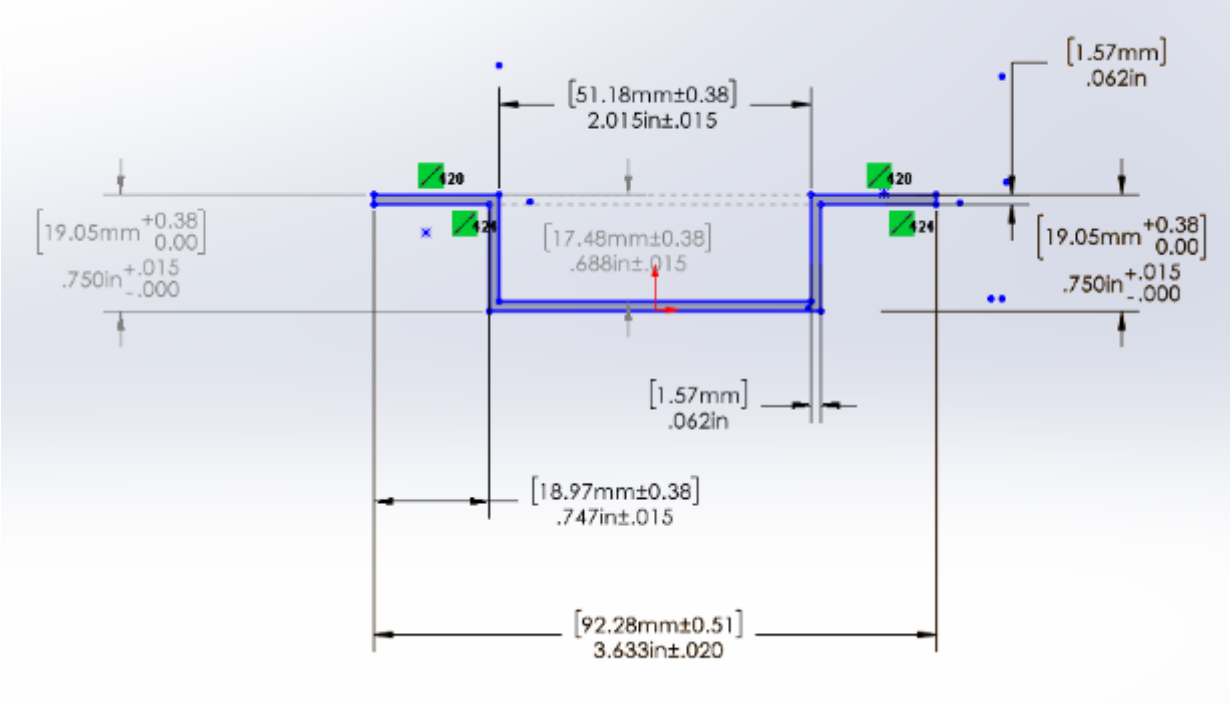
Factored Dead load $D_l := 12\ psf \cdot 1.25 = 0.718\ kPa$

Factored Wind load $W_l := 75\ psf \cdot 1.4 = 5.027\ kPa$

Tributary Width $b_w := \frac{16\ in + 16\ in}{2} = 406.4\ mm$

Legend
input *result* *check*

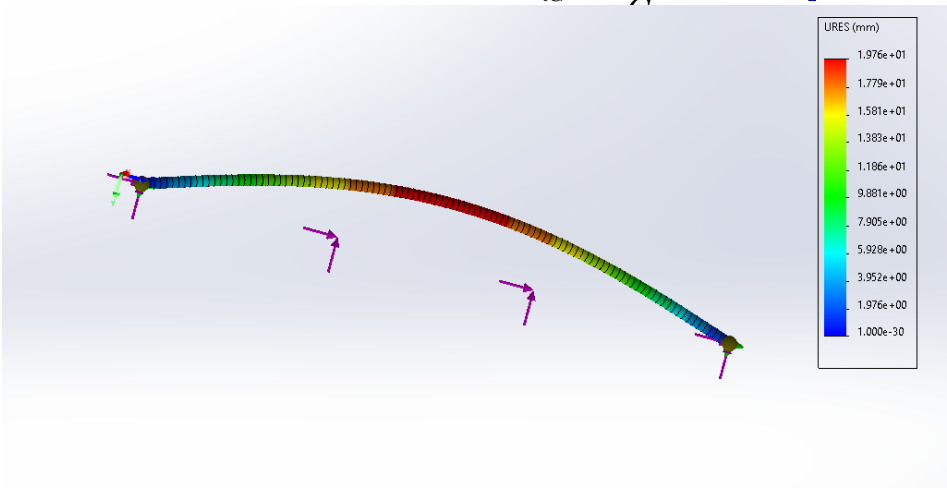
Classes 2&3 Clips.mcdx
Developed by __MJ___, _Feb__ 2022
Checked by __DV___, __Feb__ 2022



Girt width $G_w := 2\ in$

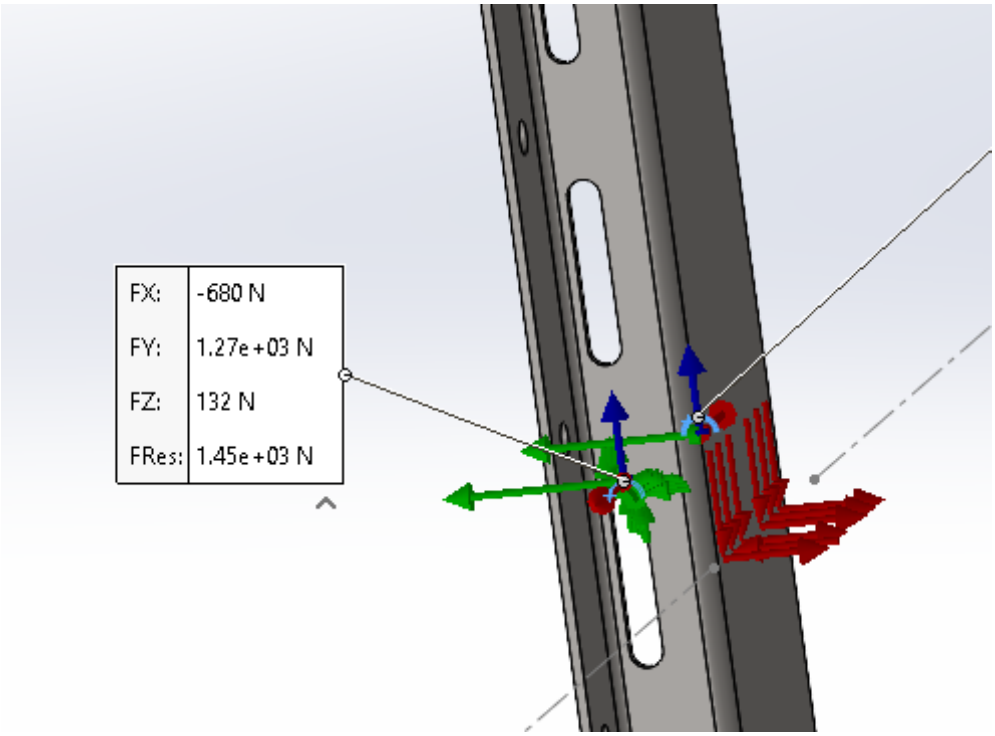
Dead Load on the Girts $D_{lG} := \frac{D_l \cdot b_w}{G_w} = 0.833\ psi$

Wind Load on the Girts $W_{lG} := \frac{W_l \cdot b_w}{G_w} = 5.833\ psi$



Legend
input *result* *check*

Connection at Girt to the Square Tube:



Force in connection from solid-works $V_f := \sqrt{(132)^2 + (1270)^2}\ N = 287.045\ lbf$;

From ITW construction products data sheet #10-24 teks screws

Safety factor $\phi := 4.3$

Shear resistance $V_r := \frac{1500\ lbf}{\phi} = 348.837\ lbf$

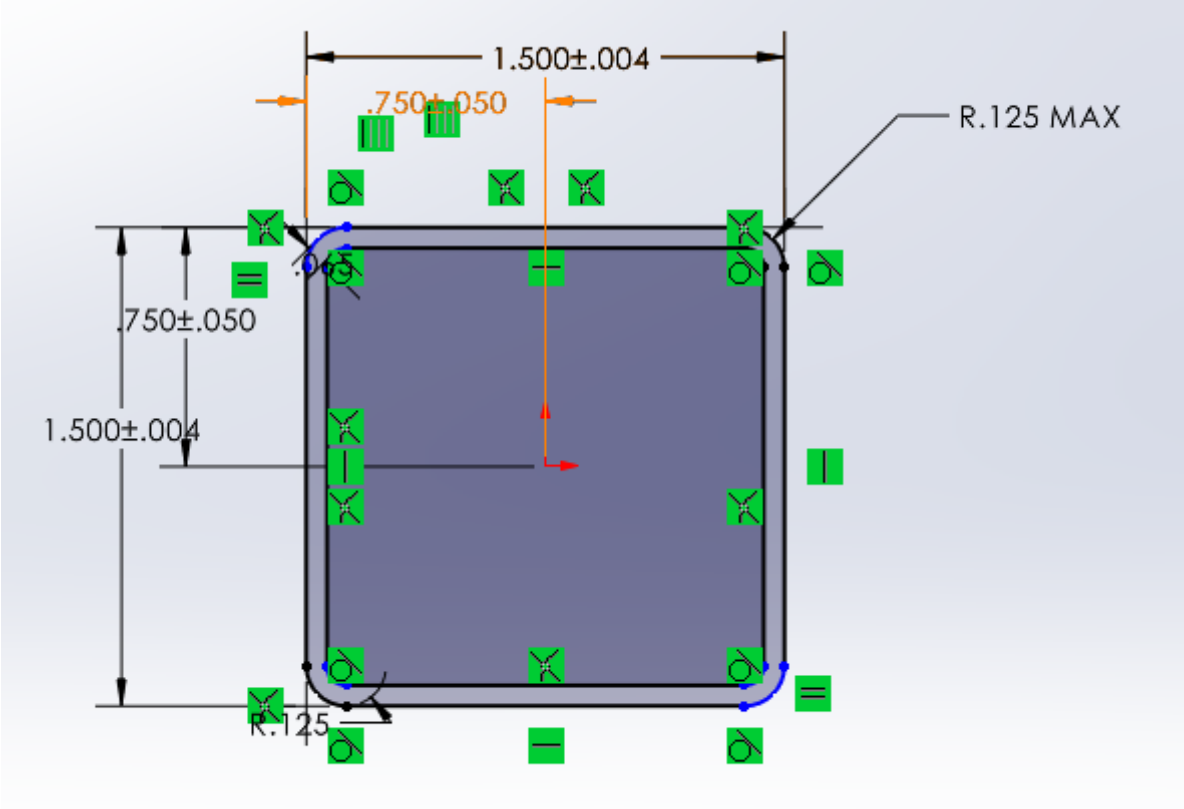
$\overrightarrow{Check\left(\left[V_r > V_f\right]\right)} = [\text{“OK”}]$

Connection at the Square Tube to Clip Base :

Frame width $b := 32\ in = 0.813\ m$

span $l := 48\ in$

Legend
input *result* *check*

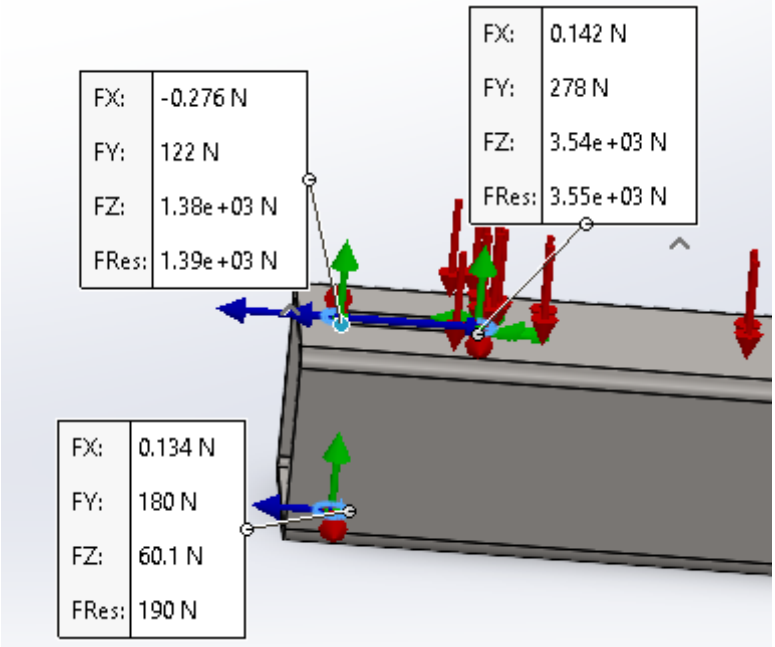


Tube width $T_w := 1.5\ in$

Tube length $T_l := 13.889\ in$

Dead Load on the Tube $D_{lG} := \frac{D_l \cdot b \cdot l}{T_w \cdot T_l} = 7.68\ psi$

Wind Load on the Tube $W_{lG} := \frac{W_l \cdot b \cdot l}{2} = 560\ lbf$



Legend
input *result* *check*

Classes 2&3 Clips.mcdx
Developed by __MJ___, _Feb__ 2022
Checked by __DV___, __Feb__ 2022

Force in connection from solid-works $V_f := 3.54\ kN = 795.824\ lbf$;

Assumptions:

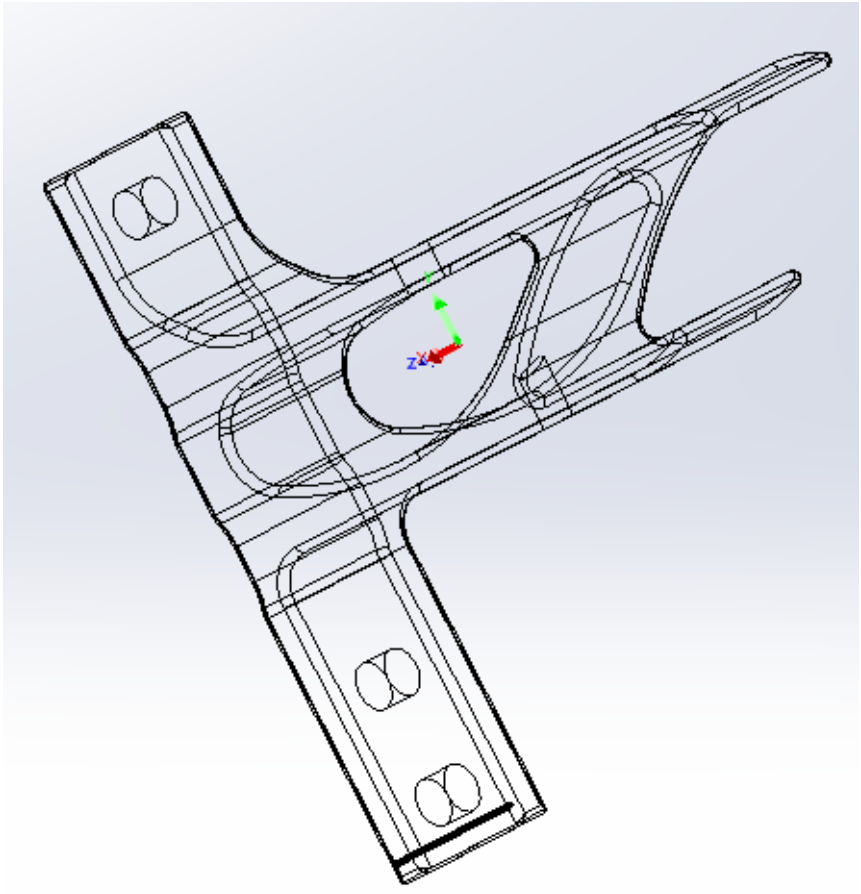
- Fastener will have UNC threads in load region of the shank
- All minimum edge distances will be maintained
- Fastener to be SAE Grade 5 Steel - UNC Thread

Try (2)1/4"Ø-20 x 1" Self Tapping Screw on the top instead of one(shown on the drawings)
[Table 20.3 - AAMA TIR-A9-14]

Safety factor	$\phi := 3$
strength resistance factor	$\varphi := 0.5$
Shear resistance	$V'_r := 646\ lbf = 2.874\ kN$
	$V_r := V'_r \cdot \phi \cdot \varphi = 969\ lbf$

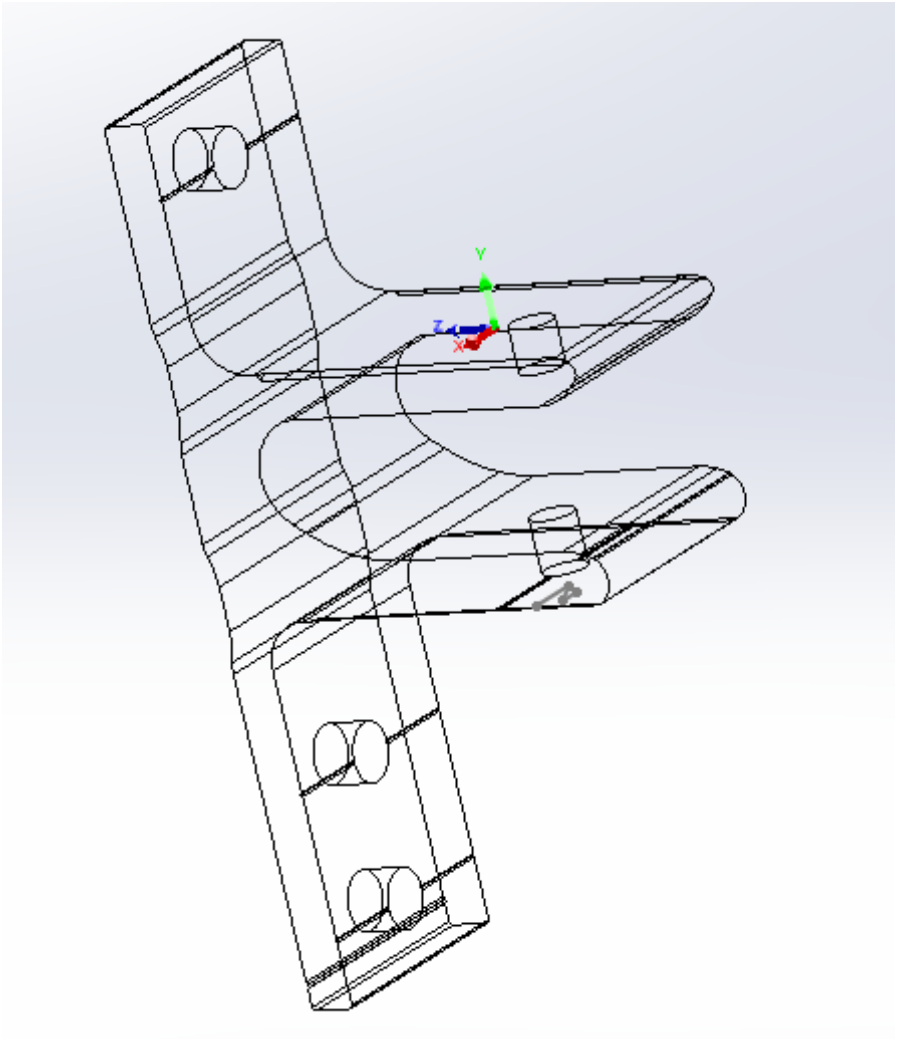
$\overrightarrow{Check\left(\left[V_r > V_f\right]\right)} = \left[\text{“OK”}\right]$

Connection at Class 2 and 3 clip base to the Substrate:



Legend
input *result* *check*

Classes 2&3 Clips.mcdx
Developed by __MJ___, _Feb__ 2022
Checked by __DV___, __Feb__ 2022



Frame width $b := 32\ in = 0.813\ m$

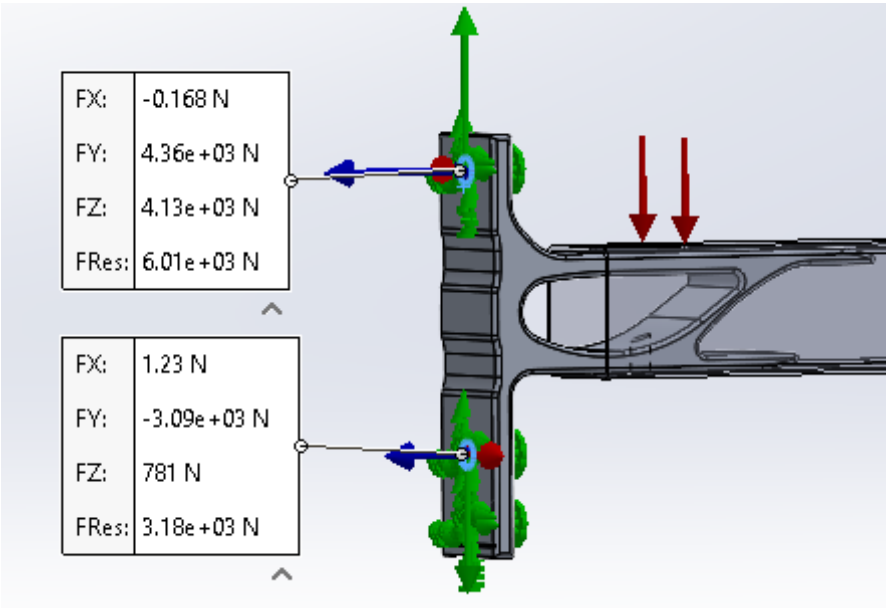
span $l := 48\ in$

Dead Load on the Tube $D_{lG} := \frac{D_l \cdot b \cdot l}{T_w \cdot T_l} = 7.68\ psi$

Wind Load on the Tube $W_{lG} := \frac{W_l \cdot b \cdot l}{2} = 560\ lbf$

Legend
input *result* *check*

Classes 2&3 Clips.mcdx
Developed by __MJ___, _Feb__ 2022
Checked by __DV___, __Feb__ 2022



Force in connection from solid-works $V_f := 4.36\ \boldsymbol{kN} = 980.167\ \boldsymbol{lbf}$;
$T_f := 4.13\ \boldsymbol{kN} = 928.461\ \boldsymbol{lbf}$

Fasteners into wood substrate:

Try 1/2"Ø x 3" lag screw
Allowable Lateral Resistance: $V_r := 998\ lbf$
Number of Screws: $n_{Fe} := 1$
Number of Rows of Scews: $n_R := 1$
Modification Factors: $K' := 1.0$ $J_E := 1.0$

Allowable Withdrawl Resistance: $T'_{rw} := 61\ \frac{N}{mm}$

Length of Penetration: $L_p := 4\ in$

Withdrawal Resistance:

$T_{rw} := T'_{rw} \cdot L_p \cdot n_{Fe} \cdot K' \cdot J_E = 6.198\ kN$

$\overrightarrow{Check\left(\begin{bmatrix} V_r > V_f \\ T_{rw} > T_f \end{bmatrix}\right)} = \begin{bmatrix} \text{“OK”} \\ \text{“OK”} \end{bmatrix}$

Fasteners into concrete substrate:

Assumptions:
- Concrete substrate to be 20MPa compressive strength or better
- Minimum of 2" edge distance will be maintained

Try Hilti 3/8"Ø KH-EZ
[Hilti North American Product Tech Guide, Volume 2: Anchor Fastening, Edition 17]

Effective Embedment: $Emb := 2.5\ in$

Withdrawal Resistance:

$T_r := 1660\ lbf = 7.384\ kN$

$Check := \text{if}\left(T_r > T_f, \text{“Good”}, \text{“FAIL”}\right) = \text{“Good”}$

Shear Resistance:

$V_r := 3320\ lbf = 14.768\ kN$

Legend
input *result* *check*

$$\overrightarrow{\left(\begin{bmatrix} V_r > V_f \\ T_r > T_f \end{bmatrix}\right)} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

interaction

$n := 1$

$$I := \left(\frac{V_f}{V_r}\right)^n + \left(\frac{T_f}{T_r}\right)^n = 0.855 \qquad \overrightarrow{\left(\begin{bmatrix} I < 1 \\ I < 1.1 \\ I > 1.1 \end{bmatrix}\right)} = \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix}$$

Fasteners into steel stud substrate:

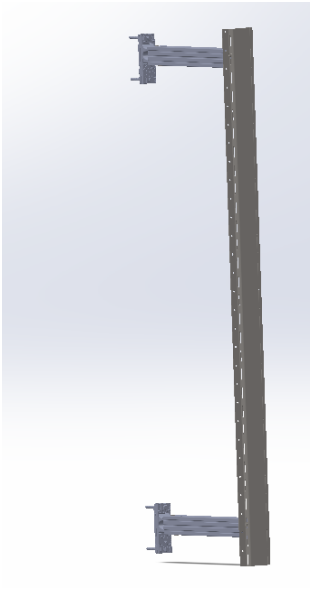
- Fastener will have UNC threads in load region of the shank
- All minimum edge distances will be maintained
- Fastener to be SAE Grade 5 Steel - UNC Thread

Try (4)#12-14 x 1.5" Self Tapping Screw on the top of clip base instead of one(shown on the drawings)
[ITW Tek screw data sheets]

Number of screws on the top of clip base $n := 4$

Withdrawal resistance $T_r := 242\ lbf \cdot n = 4.306\ kN$
Shear resistance $V_r := 316\ lbf \cdot n = 5.623\ kN$

$$\overrightarrow{\left(\begin{bmatrix} V_r > V_f \\ T_r > T_f \end{bmatrix}\right)} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$



Connection at Class 2 and 3 clip base to the Substrate (Summary):