

TO Stefan Jansen van Vuuren

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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.

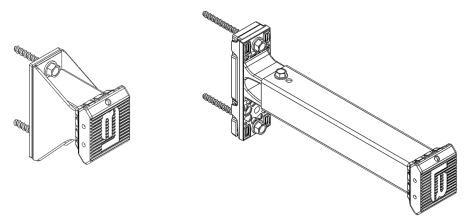


Figure 1.1: Isometric view of Hitch Class 1 Clip (left) and Hitch Class 2/3 Clip (right)

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.

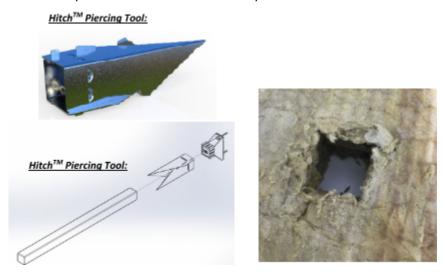


Figure 1.3: Hitch Piercing Tool

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.

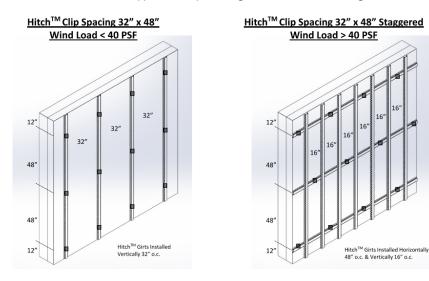


Figure 1.4: Clip arrangement configuration

### 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	• 2.5" • 1"			
Class 2	psi concrete  • 16-gauge Steel Stud  • 18-gauge Steel Stud  • Wood stud spf  • CMU	• 16" • 10" • 6" • 3"	32" horizontally, 48" vertically		
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 Exterio	or Insulation	
				Fact	ored / Ultir	nate Wind I	Load
	Backup Wall:	Fasteners:	eg	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	ead to	147 lbf	100 lbf	80 lbf	8 lbf	
	20MPa / 3,000 PSI Concrete	Two Hilti KH-EZ 1/4" x 3 1/2" (48.8mm Embedment)	Facto e Dear	147 lbf	100 lbf	80 lbf	8 lbf
Class	18 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill	EF	147 lbf	100 lbf	80 lbf	8 lbf
ū	16 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill	]	147 lbf	100 lbf	80 lbf	8 lbf
	Wood Stud SPF	Three #14 x 2 1/2" Lag wood screws/GRK	Max / u	147 lbf	100 lbf	80 lbf	8 lbf
	CMU Backup Wall	Two Hilti KH-EZ 1/4" x 3 1/2"	Σ `	147 lbf	100 lbf	80 lbf	8 lbf

2.5" of Exterior Insulation						
Factored / Ultimate Wind Load						
215 lbf	535 lbf	640 lbf				
122 lbf	81 lbf	69 lbf	5 lbf			
122 lbf	81 lbf	69 lbf	5 lbf			
122 lbf	81 lbf	30 lbf	5 lbf			
122 lbf	81 lbf	69 lbf	5 lbf			
122 lbf	81 lbf	69 lbf	5 lbf			
122 lbf	81 lbf	69 lbf	5 lbf			
	Fact 215 lbf 122 lbf 122 lbf 122 lbf 122 lbf 122 lbf 122 lbf	Factored / Ultin 215 lbf 375 lbf 122 lbf 81 lbf	Factored / Ultimate Wind 215 lbf 375 lbf 535 lbf 122 lbf 81 lbf 69 lbf 122 lbf 81 lbf 69 lbf 122 lbf 81 lbf 30 lbf 122 lbf 81 lbf 69 lbf 122 lbf 81 lbf 69 lbf 122 lbf 81 lbf 69 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

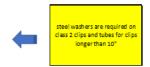
3" of Exterior Insulation
Factored / Ultimate Wind Load

				Fact	ored / Ultin	nate Wind I	Load
	Backup Wall:	Fasteners:	d/ ad	215 lbf	375 lbf	535 lbf	640 lbf
2	20MPa / 3,000 PSI Concrete	Two Hilti HIT-HY 200 3/8" x 4 1/2" Embedment	를 의 [		223 lbf	160 lbf	6 lbf
	20MPa / 3,000 PSI Concrete	Two Hilti KH-EZ 1/4" x 3 1/2" (48.8mm Embedment)	act	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	ate	250 lbf	185 lbf	75 lbf	6 lbf
	Wood Stud SPF	Three #14 x 2 1/2" Lag wood screws/GRK	ti xi	250 lbf	201 lbf	83 lbf	6 lbf
	CMU Backup Wall	Two Hilti KH-EZ 1/4" x 3 1/2"	돌	250 lbf	201 lbf	83 lbf	6 lbf

6" of Exterior Insulation							
Fact	Factored / Ultimate Wind Load						
215 lbf	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							
Fact	ored / Ultir	nate 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				

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		



### 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

				Fact	ored / Ultin	nate Wind I	Load
	Backup Wall:	Fasteners:	paq/	215 lbf	375 lbf	535 lbf	640 lbf
m	20MPa / 3,000 PSI Concrete	Two Hilti HIT-HY 200 3/8" x 4 1/2" Embedment	Hilti HIT-HY 200 3/8" x 4 1/2" Embedment		220 lbf	160 lbf	40 lbf
	20MPa / 3,000 PSI Concrete	Two Hilti KH-EZ 1/4" x 3 1/2" (48.8mm Embedment)	∣ਦੋੜ	260 lbf	187 lbf	130 lbf	32 lbf
1 8	18 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill	n Fa	71 lbf	49 lbf	20 lbf	NR
8	16 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill	ate	140 lbf	100 lbf	39 lbf	4 lbf
	Wood Stud SPF	Three #14 x 2 1/2" Lag wood screws/GRK	Maxir Ultim	150 lbf	108 lbf	44 lbf	5 lbf
	CMU Backup Wall	Two Hilti KH-EZ 1/4" x 3 1/2"	žŠ	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 bf	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 1500 psi

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,

Max Jafari, MBA, P.Eng NFRC Certified Simulator mjafari@rdh.com 778 370 6923 RDH Building Science Inc.

**David Vadocz** | P.Eng. Reviewed by

encl.

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

### LIMITS OF COMMISSION

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# Appendix A Class 1 Analysis



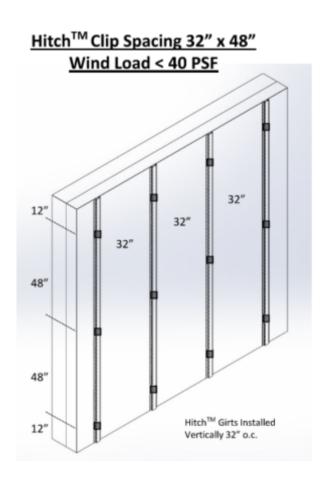
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Max Jafari P.Eng. 2022-02-01

Project: Longboard Clip Class 1

Project#: 25403.000

### LONGBOARD HITCH CLIPS (for loads less than 40psf)



# Class 1 Clips for 2.5" insulation:

Factored Dead load Factored Wind load

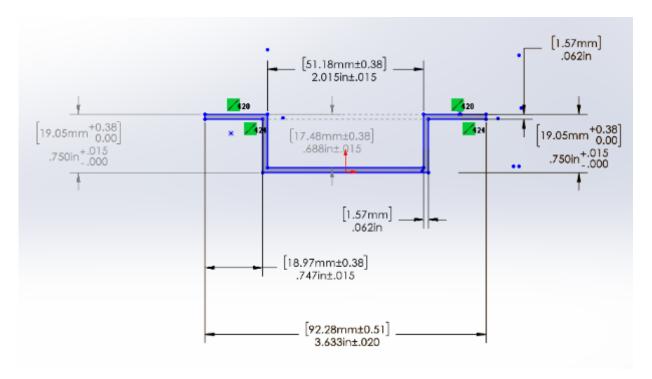
$$D_L := 4 \ psf \cdot 1.25 = 0.239 \ kPa$$
  
 $W_l := 18 \ psf \cdot 1.4 = 1.207 \ kPa$ 

**Tributary Width** 

$$b_w \coloneqq \frac{32 \ \textit{in} + 32 \ \textit{in}}{2} = 812.8 \ \textit{mm}$$

Legend
input result check





Girt width

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

Dead Load on the Girts

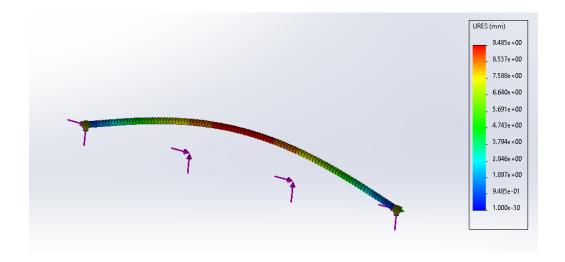
Wind Load on the Girts

$$G_w \coloneqq 2 \; in$$

$$G_w \coloneqq 2 \; \textbf{in}$$
 
$$sw_2 \coloneqq W_l \cdot b_w = 5.6 \; \frac{\textbf{lbf}}{\textbf{in}}$$

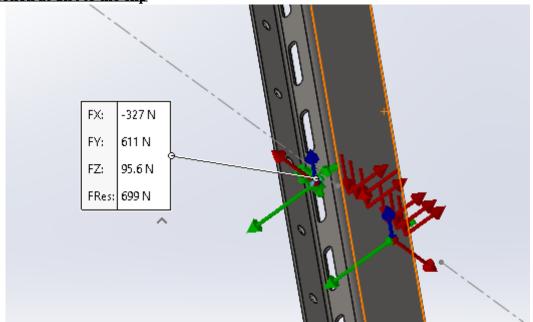
$$D_{lG}\!\coloneqq\!\frac{D_L\!\cdot\!b_w}{G_w}\!=\!0.556~\textit{psi}$$

$$W_{lG} \coloneqq \frac{W_l \cdot b_w}{G_w} = 2.8 \; extbf{\textit{psi}}$$





Connection at Girt to the clip



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

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

Safety factor  $\phi := 4.3$ 

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

 $\overrightarrow{Check\left(\left[\,\boldsymbol{V}_{r}\!>\!\boldsymbol{V}_{f}\,\right]\right)}\!=\!\left[\,\text{"OK"}\,\right]$ 

## Class 1 clips with 2.5" insulation:

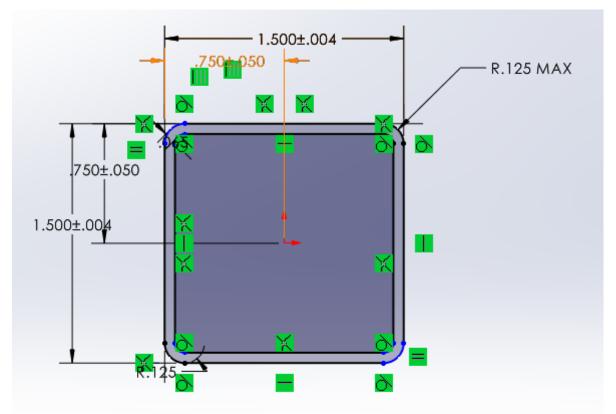
Frame width b := 32 in = 0.813 m

span l := 48 in

RDH Building Science Inc.





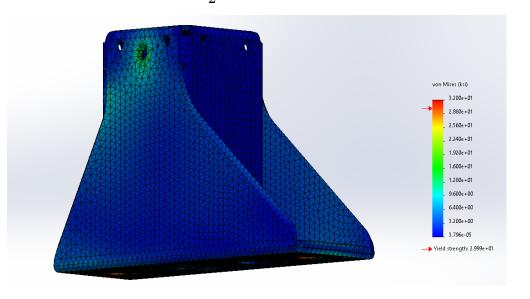


Tube width Tube length

Dead Load on the Tube

Wind Load on the Tube

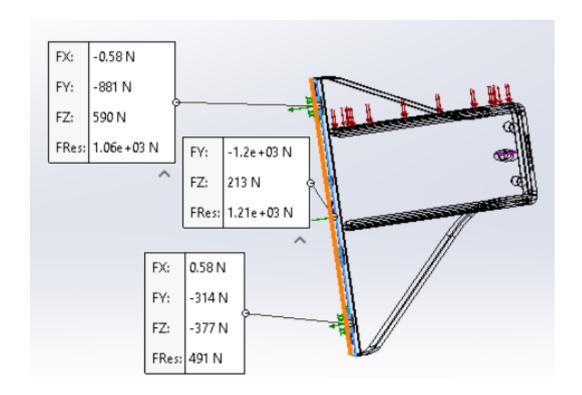
$$\begin{split} T_w &\coloneqq 1.5 \, \textit{in} \\ T_l &\coloneqq 2.5 \, \textit{in} \\ D_{lG} &\coloneqq \frac{D_L \cdot b \cdot l}{T_w \cdot T_l} = 14.222 \, \textit{psi} \\ W_{lG} &\coloneqq \frac{W_l \cdot b \cdot l}{2} = 134.4 \, \textit{lbf} \end{split}$$



Legend input result check



### Connection at Class 1 clip base to the Substrate:



Force in connection from solid-works  $V_f = .590 \ kN = 132.637 \ lbf$ ;

 $T_f = 1.2 \ kN = 269.771 \ lbf$ 



### Fasteners into wood substrate:

Try #12x2 1/2" wood screw

Allowable Lateral Resistance:  $V_r = 182 \ lbf$ 

Number of Screws:  $n_{Fe} \coloneqq 1$ Number of Rows of Scews:  $n_R \coloneqq 1$ 

 $K' \coloneqq 1.0$   $T'_{rw} \coloneqq 31 \frac{N}{mm}$   $J_E \coloneqq 1.0$ Modification Factors:

Allowable Withdrawl Resistance:

Length of Penetration:  $L_p \coloneqq 2.5 \ \boldsymbol{in}$ 

Withdrawal Resistance:

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

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

### 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:  $Emb \coloneqq 2 in$ 

Withdrawal Resistance:

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

$$Check \coloneqq \mathbf{if} \left( T_r \! > \! T_f, \text{``Good''}, \text{``FAIL''} \right) \! = \text{``Good''}$$

Legend input result check



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### 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

 $n \coloneqq 1$ 

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

### 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  $T_r \coloneqq 150 \; \textit{lbf} \cdot n = 1.334 \; \textit{kN}$  Shear resistance  $V_r \coloneqq 207 \; \textit{lbf} \cdot n = 1.842 \; \textit{kN}$ 

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

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

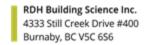
				-	l" of Extend	r insulation	)
				Fact	ored / Ultin	nate Wind I	Load
	Backup Wall:	Fasteners:	pa	215 lbf	375 lbf	535 lbf	640 lbf
	20MPa / 3,000 PSI Concrete	Two Hilti HIT-HY 200 3/8" x 4 1/2" Embedment	ton	147 lbf	100 lbf	80 lbf	8 lbf
	20MPa / 3,000 PSI Concrete	Two Hilti KH-EZ 1/4" x 3 1/2" (48.8mm Embedment)		147 lbf	100 lbf	80 lbf	8 lbf
ass	18 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill	E at a	147 lbf	100 lbf	80 lbf	8 lbf
믕	16 Gauge Steel Stud	Three ITW Teks 1/4"-14 x 2 1/2" Self Drill	ᄩᆤᄀ	147 lbf	100 lbf	80 lbf	8 lbf
	Wood Stud SPF	Three #14 x 2 1/2" Lag wood screws/GRK	ž 5	147 lbf	100 lbf	80 lbf	8 lbf
	CMU Backup Wall	Two Hilti KH-EZ 1/4" x 3 1/2"	Σ ``	147 lbf	100 lbf	80 lbf	8 lbf

2.5" of Exterior Insulation												
Factored / Ultimate Wind Load												
215 lbf	375 lbf	535 lbf	640 lbf									
122 lbf	81 lbf	69 lbf	5 lbf									
122 lbf	81 lbf	69 lbf	5 lbf									
122 lbf	81 lbf	30 lbf	5 lbf									
122 lbf	81 lbf	69 lbf	5 lbf									
122 lbf	81 lbf	69 lbf	5 lbf									
122 lbf	81 lbf	69 lbf	5 lbf									

Legend
<a href="mailto:line">input result</a> check

# Appendix B Class 2 and 3 Analysis





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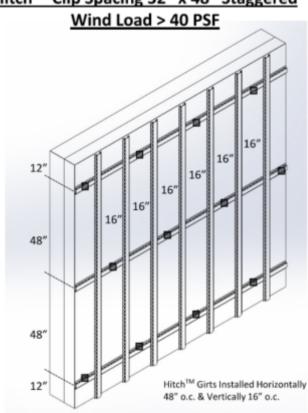
Max Jafari P.Eng. 2022-02-01

Project: Longboard Clip Class 2&3

Project#: 25403.000

### LONGBOARD HITCH CLIPS (for loads higher than 40psf)

# Hitch<sup>™</sup> Clip Spacing 32" x 48" Staggered



# Class 2& 3 Clips for 15" insulation:

Factored Dead load

$$D_l = 12 \ psf \cdot 1.25 = 0.718 \ kPa$$
  
 $W_l = 75 \ psf \cdot 1.4 = 5.027 \ kPa$ 

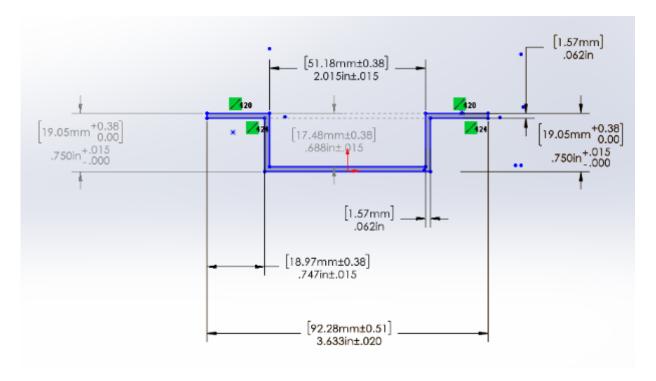
Factored Wind load

**Tributary Width** 

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

Legend
input result check





Girt width

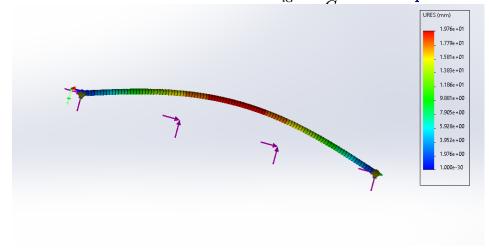
$$G_w \coloneqq 2$$
 in

Dead Load on the Girts

$$D_{lG} \coloneqq \frac{D_l \cdot b_w}{G_w} = 0.833 \ \textit{psi}$$

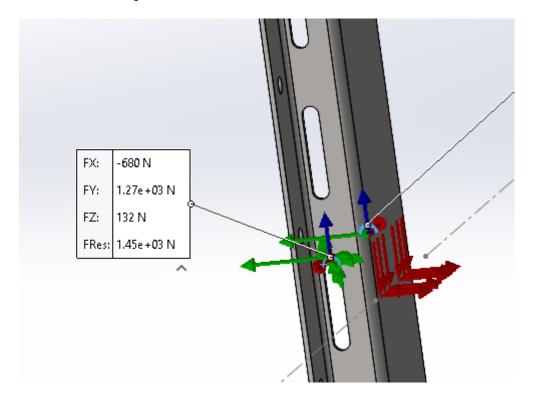
Wind Load on the Girts

$$W_{lG} = \frac{W_l \cdot b_w}{G} = 5.833 \ \textit{psi}$$





### **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  $V_r = \frac{1500 \ \textit{lbf}}{\phi} = 348.837 \ \textit{lbf}$ 

 $\overrightarrow{Check\left(\left\lceil V_r > V_f \right\rceil\right)} = \left[\text{"OK"}\right]$ 

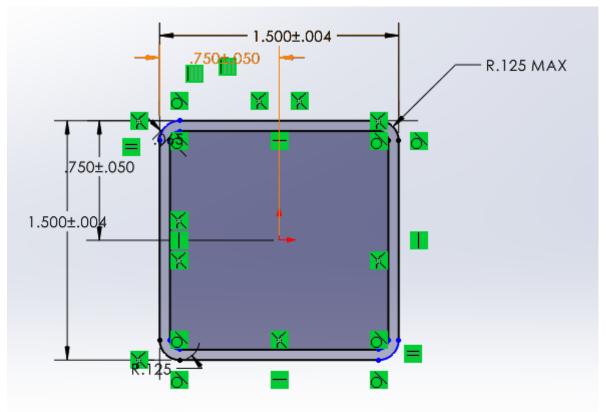
### Connection at the Square Tube to Clip Base:

Frame width b := 32 in = 0.813 m

span l = 48 in

Legend
<a href="mailto:line">input result</a> check





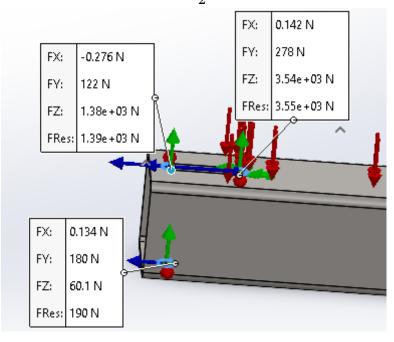
Tube width
Tube length

Dead Load on the Tube

Wind Load on the Tube

$$\begin{split} T_w &\coloneqq 1.5 \, \textbf{\textit{in}} \\ T_l &\coloneqq 13.889 \, \textbf{\textit{in}} \\ D_{lG} &\coloneqq \frac{D_l \boldsymbol{\cdot} \boldsymbol{b} \boldsymbol{\cdot} \boldsymbol{l}}{T_w \boldsymbol{\cdot} T_l} = 7.68 \, \, \textbf{\textit{psi}} \end{split}$$

$$W_{lG} = \frac{\overset{\circ}{W_l} \cdot \overset{\circ}{b} \cdot l}{2} = 560 \ \textit{lbf}$$



Legend input result check



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

### **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]

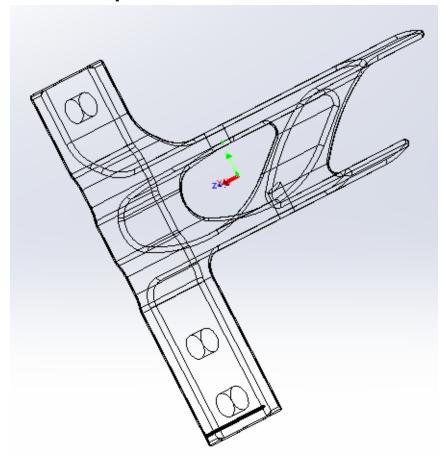
Safety factor  $\phi \coloneqq 3$ strength resistance factor  $\varphi \coloneqq 0.5$ 

Shear resistance  $V'_r \coloneqq 646 \ \textit{lbf} = 2.874 \ \textit{kN}$ 

 $V_r := V'_r \cdot \phi \cdot \varphi = 969 \ lbf$ 

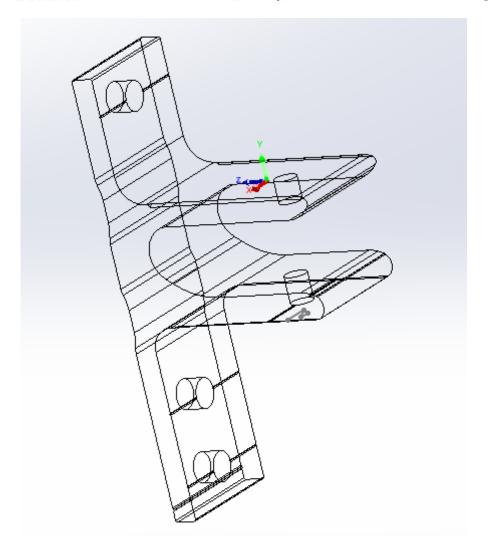
$$\overrightarrow{Check\left(\left[\left.V_{r}\!>\!V_{f}\right]\right)}\!=\!\left[\text{"OK"}\right]$$

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



Legend
<a href="mailto:line">input result</a> check





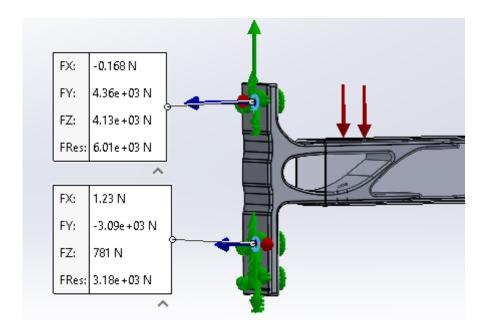
Frame width b := 32 in = 0.813 m

span l = 48 in

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

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





Force in connection from solid-works  $V_f\!\coloneqq\!4.36~$   $\pmb{kN}\!=\!980.167~$   $\pmb{lbf}$ ;  $T_f\!\coloneqq\!4.13~$   $\pmb{kN}\!=\!928.461~$   $\pmb{lbf}$ 



### Fasteners into wood substrate:

Try 1/2"Ø x 3" lag screw

Allowable Lateral Resistance:  $V_r = 998 \ lbf$ 

Number of Screws:  $n_{Fe} \coloneqq 1$ Number of Rows of Scews:  $n_R \coloneqq 1$ 

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:

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

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

### 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:

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

$$Check \coloneqq \mathbf{if} \left( T_r \! > \! T_f, \text{``Good''}, \text{``FAIL''} \right) \! = \text{``Good''}$$

Shear Resistance:

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

Legend input result check



$$\overrightarrow{\left(\!\left[\!\!\begin{array}{c} V_r \!>\! V_f \\ T_r \!>\! T_f \end{array}\!\!\right]} \!=\! \left[\!\!\begin{array}{c} 1 \\ 1 \end{array}\!\!\right]$$

### interaction

$$n \coloneqq 1$$

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

$$\overrightarrow{\begin{bmatrix} I < 1 \\ I < 1.1 \\ I > 1.1 \end{bmatrix}} = \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix}$$

### <u>Fasteners into steel stud substrate:</u>

- 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)

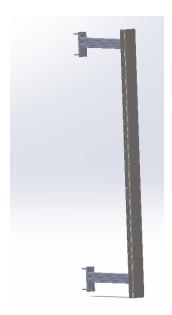
[ITW Tek screw data sheets]

Number of screws on the top of clip base

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

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





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

						G" of Exteris	rintulatio	1		1" of Extent	or in sullet is	in .		10	5" of Exteri	or intulatio	п		
					Fact	tored / Ultir	nate Wind	Load	Fact	to red / Ultin	nate Wind	Load		Facto	ared/Util	na te Wind			
Г		Backup Walt	Fast eners:	> 0	2151M	3751M	535 M	640 lbf	2151bf	375 IM	535 M	G40 lb f	21	215 IM	37 5 I M	53.5 IM	6401M		
		OMPs / 3,000 PS Concrete	Two Hilb HIT-HY 200 3/8" x 4 1/2 "Embedment	2 8	1.151bf	97 bf	85 lbf	4.64	80 br	76 br	60 lbf	3.66	4	47 EF	528b f	48 64	NR		steel washers are required on
- 1	m F	OMPs / 3,000 PS Concrete	Two Hilbi KH-EZ 1/4" x 31/2" (49.9mm Embedment)	1 2 2	1.151bf	97 bf	85 156	4 64	SD bf	76 bf	E0 1FL	3.04	- 4	47 EF	528b f	48 FA	NR	4	class 2 dips and tubes for dips
	i I	IS Gauge Steel Stud	Three ITW Tels 1/6"-16 x 21/2" Self Drill	5 8	60 br	40 br	16 lbf	NR	31 bf	23 bf	9 bf	NR	2	23 bf	17 br	SIBE	NR		longer than 10"
	o	IS Gauge Steel Stud	Three ITW Tels 1/6"-16 x 21/2" Self Drill	2 8	1.151bf	90 bf	35 (6)	4.64	80 bf	50 br	22 lbf	3.64	4	47 Er	37 br	20 BF	NR	-	
	- [	Wood Stud SPF	Three #1 4 x 2 1/2" lag wood strews/GRK	op a	1.151bf	97 bf	41.156	4.64	50 bf	58 bf	27 lbf	3.04	- 4	46 EF	43 EF	75 bf	NR		
		OMU Backup Wall	Two Hitti KH-EZ 1/4" x 3 1 /2"	3.5	1.151bf	97 bf	41.166	4.64	SO by	58 br	27 lbf	3.66	4	46 br	43 EF	25 M	NR		
						G" of Exterio				I" of Extent			_			or insulatio			
					Fact	tored / Ultir	nate Wind	Load	Fact	tored / Ultin	nate Wind	Load		Facto	med/Util	na te Wind	Load	I	
г	_	Backup Walt	Fast ones:	2.0					Fact		nate Wind		21		med/Util		Load		
Γ			East eners: Tw 01littl HIT-HY 20.0 3/8" x 4 1/2 "E mbed ment	/pase [cond	2 15 IM 31 Sty	3751M 220 br	sas tor 160 tor	GAO Ib f	2 15 lbf 2 10 lbf	a751M 185 br	sas Mind sas Mi 140 br	G40 bf	19	Facto 215 IM 195 Ibr	3751M 1581M	S3SIM 11SIbr	G401bf 25 bf		steel washers are required on
Γ		20 MPa / 3,000 PS Concrete 20 MPa / 3,000 PS Concrete	Two Hilb HIT-HY 2003/8" x 4 1/2" Embedment Two Hilb KH-EZ 1/4" x 3 1 /2" (48.8mm Embedment)	actored/ adtood	2 15 lbf 2 15 lbf 2 15 lbf 2 50 lbf	3751M 220 M 187 M	535 lbf 160 lbf 130 lbf	G40 bf 401bf 321bf	2151M 2101M 2001M 2331M	375 lbf 185 bf 185 bf	sas ter 140 ter 115 ter	G40 bf 311bf 251bf	13	Facto 215 IM 1951br 1701br	37 5 lbf 15 fl lbf	5351bf 1151bf 92 bf	6401M 25 br 20 br	_	class 3 dips and tubes for dips
	210	20 MPa / 3,000 PS Concrete 20 MPa / 3,000 PS Concrete 18 Gauge Steel Stud	Two HIR HIT-HY 200 3/8" x 4 1/2 "Embed ment Two HIR NH-CZ 1/6" x 3 1/2" (48.8mm Embedment) Three HTW Tels 1/6"-14 x 2 1/2" Self Orli	n Factored / Dead Load	2 15 IM 31 Sty	3751M 220 br	sas tor 160 tor	GAO Ib f	2 15 lbf 2 10 lbf	375 lbf 185 br 185 br 28 br	140 br 115 br 111 br	S40 bf 31 br 25 br	15 17 2	Facto 215 lbf 195 lbf 170 lbf 28 lbf	3751M 1581M	53 Sibr 53 Sibr 115 br 52 br 71br	G401bf 26 bf 20 bf NR	<b>—</b>	
	Gastã	OMPa / 3,000 PS Concrete OMPa / 3,000 PS Concrete IS Gauge Steel Stud IS Gauge Steel Stud	Two HIRE HIT-HY 200 3/8" x 4 1/2 "Embed ment Two HIRE NI-CZ 1/8" x 3 1/2" (46.8 mm Embed ment) Three HTM Tels 1 /6"-14 x 2 1/2" Self Drill Three HTM Tels 1 /6"-14 x 2 1/2" Self Drill	varn Factored /	2 15 lbf 2 15 lbf 2 15 lbf 2 50 lbf	3751M 220 M 187 M	535 lbf 160 lbf 130 lbf	GIO BY 401bY 321bY NR 4 bY	2 15 lbf 2 15 lbf 2 15 lbf 2 15 lbf 40 lbf 78 lbf	275 lbf 185 lbf 185 lbf 195 lbf 28 lbf 52 lbf	140 br 115 br 11 lbr 20 lbr	G40 lbf 311bf 261bf NR 3 lbf	13 13 2 5	Facto 215 lbf 195 lbf 170 lbf 29 lbf 50 lbf	37 5164 15 8167 13 1167 21 67 39 67	53 S IM 115 Ibr 92 br 71br 15 br	G401M G401M 26 bf 20 bf NR NR	<b>—</b>	class 3 dips and tubes for dips
	Gans 3	20 MPa / 3,000 PS Concrete 20 MPa / 3,000 PS Concrete 18 Gauge Steel Stud	Two HIR HIT-HY 200 3/8" x 4 1/2 "Embed ment Two HIR NH-CZ 1/6" x 3 1/2" (48.8mm Embedment) Three HTW Tels 1/6"-14 x 2 1/2" Self Orli	sofrnum Factored /	2151M 315M 2601M 71 M	275 lbf 275 lbf 220 br 187 br 49 br	100 br 100 br 20 br	G40 bf 401bf 321bf NR	21516f 21016f 20016f 20016f 40 67	375 lbf 185 br 185 br 28 br	140 br 115 br 111 br	S40 bf 31 br 25 br	13 2 5 5	Facto 215 lbf 195 lbf 170 lbf 28 lbf	3751bf 1581bf 1311bf 21 bf	53 S lbf 115 lbf 92 lbf 71bf	G401bf 26 bf 20 bf NR	<b>←</b>	class 3 dips and tubes for dips