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Design:	RFI #143: BNT: L2 Roof, Connection to Column- Pos	Date:	1/12/2024
Fastening point:			

Specifier's comments:

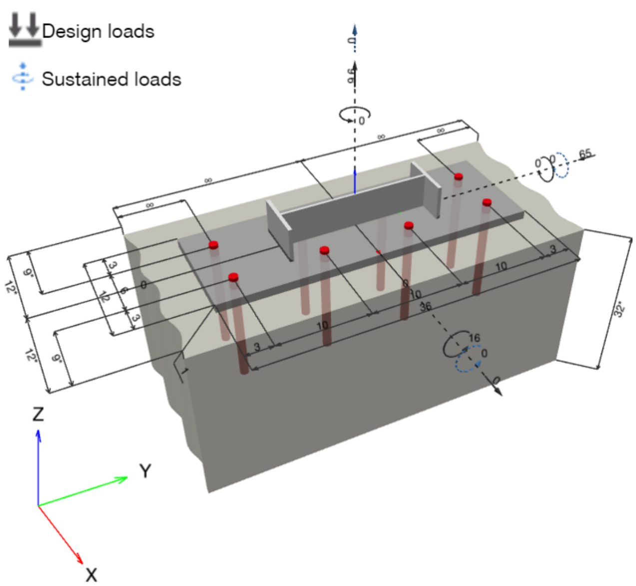
1 Anchor Design

1.1 Input data

Anchor type and diameter:	**HIT-HY 200 V3 + HAS-V-36 (ASTM F1554 Gr.36) 1**
Item number:	not available (element) / 2334276 HIT-HY 200-R V3 (adhesive)
Effective embedment depth:	$h_{ef,act}$ = 12.000 in. ($h_{ef,limit}$ = - in.)
Material:	ASTM F1554 Grade 36
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 = 1.000 in.
Anchor plate^{CBFEM} :	l_x x l_y x t = 12.000 in. x 36.000 in. x 1.000 in.;
Profile:	W shape (AISC), W18X35; (L x W x T x FT) = 17.700 in. x 6.000 in. x 0.300 in. x 0.425 in.
Base material:	uncracked concrete, 8000, f_c' = 8,000 psi; h = 32.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: present, shear: present; no supplemental splitting reinforcement present
	edge reinforcement: none or < No. 4 bar

^{CBFEM} - The anchor calculation is based on a component-based Finite Element Method (CBFEM)

Geometry [in.] & Loading [kip, ft.kip]



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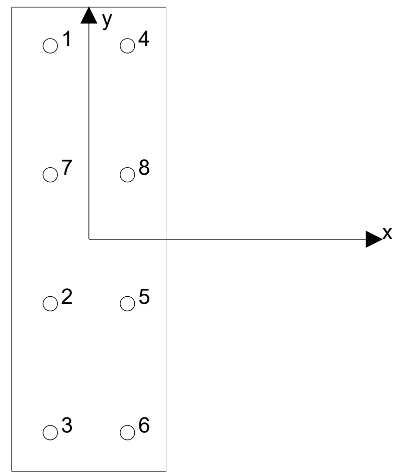
1.1.1 Design results

Case	Description	Forces [kip] / Moments [ft.kip]	Seismic	Max. Util. Anchor [%]
1	Combination 1	N = 9.600; V_x = 0.000; V_y = -65.000; M_x = 16.00000; M_y = 0.00000; M_z = 0.00000;	no	160

1.2 Load case/Resulting anchor forces



Anchor reactions [kip]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	3.600	7.972	0.014	-7.971
2	0.869	8.257	-0.050	-8.256
3	0.214	8.084	-0.024	-8.084
4	3.599	7.971	-0.015	-7.971
5	0.869	8.256	0.050	-8.256
6	0.216	8.084	0.024	-8.084
7	6.365	8.188	0.027	-8.188
8	6.367	8.188	-0.027	-8.188

resulting tension force in (x/y)=(0.000/0.000): 0.000 [kip]
resulting compression force in (x/y)=(0.000/0.000): 0.000 [kip]

Anchor forces are calculated based on a component-based Finite Element Method (CBFEM)

1.3 Tension load

	Load N_{ua} [kip]	Capacity ϕ N_n [kip]	Utilization $\beta_N = N_{ua}/\phi$ N_n	Status
Steel Strength*	6.367	26.348	25	OK
Bond Strength**	22.098	39.244	57	OK
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	22.098	40.192	55	OK

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

1.3.1 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]
0.61	58,000

Calculations

N_{sa} [kip]
35.130

Results

N_{sa} [kip]	ϕ_{steel}	$\phi\ N_{sa}$ [kip]	N_{ua} [kip]
35.130	0.750	26.348	6.367

1.3.2 Bond Strength

$N_{ag} = \left(\frac{A_{Na}}{A_{Na0}}\right) \psi_{ec1,Na}\ \psi_{ec2,Na}\ \psi_{ed,Na}\ \psi_{cp,Na}\ N_{ba}$ ACI 318-19 Eq. (17.6.5.1b)

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

A_{Na} see ACI 318-19, Section 17.6.5.1, Fig. R 17.6.5.1(b)

$A_{Na0} = (2\ c_{Na})^2$ ACI 318-19 Eq. (17.6.5.1.2a)

$c_{Na} = 10\ d_a \sqrt{\frac{\tau_{uncr}}{1100}}$ ACI 318-19 Eq. (17.6.5.1.2b)

$\psi_{ec,Na} = \left(\frac{1}{1 + \frac{e_N'}{c_{Na}}}\right) \leq 1.0$ ACI 318-19 Eq. (17.6.5.3.1)

$\psi_{ed,Na} = 0.7 + 0.3 \left(\frac{c_{a,min}}{c_{Na}}\right) \leq 1.0$ ACI 318-19 Eq. (17.6.5.4.1b)

$\psi_{cp,Na} = MAX\left(\frac{c_{a,min}}{c_{ac}}, \frac{c_{Na}}{c_{ac}}\right) \leq 1.0$ ACI 318-19 Eq. (17.6.5.5.1b)

$N_{ba} = \lambda_a \cdot \tau_{k,c} \cdot \pi \cdot d_a \cdot h_{ef}$ ACI 318-19 Eq. (17.6.5.2.1)

Variables

$\tau_{k,c,uncr}$ [psi]	d_a [in.]	h_{ef} [in.]	$c_{a,min}$ [in.]	$\alpha_{overhead}$	$\tau_{k,c}$ [psi]
2,494	1.000	12.000	9.000	1.000	2,494

$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	c_{ac} [in.]	λ_a
0.000	7.082	22.346	1.000

Calculations

c_{Na} [in.]	A_{Na} [in.^{2}]	A_{Na0} [in.^{2}]	$\psi_{ed,Na}$
14.989	1,439.47	898.68	0.880

$\psi_{ec1,Na}$	$\psi_{ec2,Na}$	$\psi_{cp,Na}$	N_{ba} [kip]
1.000	0.679	0.671	94.015

Results

N_{ag} [kip]	ϕ_{bond}	$\phi\ N_{ag}$ [kip]	N_{ua} [kip]
60.376	0.650	39.244	22.098

1.3.3 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)

$\psi_{cp,N} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ 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.]	$\psi_{c,N}$
12.000	0.000	7.082	9.000	1.000

c_{ac} [in.]	k_c	λ_a	f_c' [psi]
22.346	24	1.000	8,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [kip]
1,584.00	1,296.00	1.000	0.718	0.850	0.806	89.234

Results

N_{cbg} [kip]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [kip]	N_{ua} [kip]
53.589	0.750	40.192	22.098

1.4 Shear load

	Load V_{ua} [kip]	Capacity ϕ V_n [kip]	Utilization $\beta_V = V_{ua}/\phi$ V_n	Status
Steel Strength*	8.257	13.702	61	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	65.000	104.541	63	OK
Concrete edge failure in direction x+**	65.000	48.164	135	not recommended

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

1.4.1 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]
0.61	58,000

Calculations

V_{sa} [kip]
21.080

Results

V_{sa} [kip]	ϕ_{steel}	ϕ V_{sa} [kip]	V_{ua} [kip]
21.080	0.650	13.702	8.257

1.4.2 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)

$\psi_{ed,N} = 0.7 + 0.3\left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ 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

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	12.000	0.000	0.000	9.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f_c' [psi]
1.000	22.346	24	1.000	8,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [kip]
1,584.00	1,296.00	1.000	1.000	0.850	0.806	89.234

Results

V_{cpg} [kip]	$\phi_{concrete}$	$\phi\ V_{cpg}$ [kip]	V_{ua} [kip]
149.345	0.700	104.541	65.000

1.4.3 Concrete edge failure in direction x+

OPPOSITE SIGN TO AISC DESIGN GUIDE

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$ 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)

$V_b = 9\ \lambda_a\ \sqrt{f_c'}\ c_{a1}^{1.5}$ ACI 318-19 Eq. (17.7.2.2.1b)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
9.000	-	0.004	1.400	32.000

l_e [in.]	λ_a	d_a [in.]	f_c' [psi]	$\psi_{parallel,V}$
8.000	1.000	1.000	8,000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [kip]
769.50	364.50	1.000	1.000	1.000	21.735

Results

V_{cbg} [kip]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [kip]	V_{ua} [kip]
64.218	0.750	48.164	65.000

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

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.563	1.350	1.000	160	not recommended

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

1.6 Warnings

- The anchor design methods in PROFIS Engineering require rigid anchor plates as per current regulations (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 base 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.
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2021, ETAG 001/Annex C, EOTA TR029 etc.). This means that the anchor plate should be sufficiently rigid to prevent load re-distribution to the anchors due to elastic/plastic displacements. The user accepts that the anchor plate is considered close to rigid by engineering judgment."

1.7 Installation data

Anchor type and diameter: HIT-HY 200 V3 + HAS-V-36 (ASTM F1554 Gr.36) 1

Profile: W shape (AISC), W18X35; (L x W x T x FT) = 17.700 in. x 6.000 in. x 0.300 in. x 0.425 in.

Item number: not available (element) / 2334276 HIT-HY 200-R V3 (adhesive)

Hole diameter in the fixture: d_f = 1.125 in.

Maximum installation torque: 0.15000 ft.kip

Plate thickness (input): 1.000 in.

Hole diameter in the base material: 1.125 in.

Hole depth in the base material: 12.000 in.

Drilling method: Hammer drilled

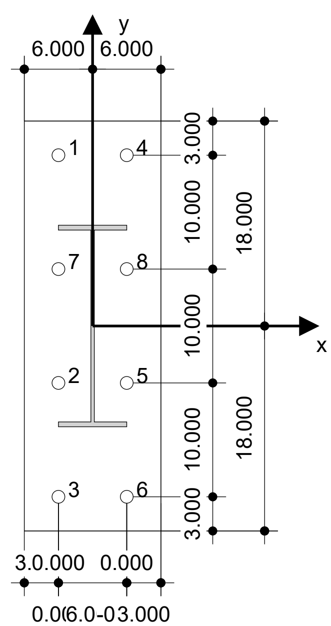
Minimum thickness of the base material: 14.250 in.

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

1 Hilti HAS Carbon steel threaded rod with Hilti HIT-HY 200 V3 Safe Set System

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• Compressed air with required accessories to blow from the bottom of the hole • Proper diameter wire brush	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor [in.]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-3.000	15.000	9.000	15.000	-	-
2	-3.000	-5.000	9.000	15.000	-	-
3	-3.000	-15.000	9.000	15.000	-	-
4	3.000	15.000	15.000	9.000	-	-

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
5	3.000	-5.000	15.000	9.000	-	-
6	3.000	-15.000	15.000	9.000	-	-
7	-3.000	5.000	9.000	15.000	-	-
8	3.000	5.000	15.000	9.000	-	-

2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular l_x x l_y x t = 12.000 in x 36.000 in x 1.000 in Calculation: CBFEM Material: ASTM A36; F_y = 36,000 psi; ε_{lim} = 5.00%
Anchor type and size:	HIT-HY 200 V3 + HAS-V-36 (ASTM F1554 Gr.36) 1, h_{ef} = 12.000 in
Anchor stiffness:	The anchor is modeled considering stiffness values determined from load displacement curves tested in an independent laboratory. Please note that no simple replacement of the anchor is possible as the anchor stiffness has a major impact on the load distribution results.
Design method:	AISC and LRFD-based design using component-based FEM
Stand-off installation:	e_b = 0.000 in (No stand-off); t = 1.000 in
Profile:	W18X35; (L x W x T x FT) = 17.700 in x 6.000 in x 0.300 in x 0.425 in Material: ASTM A500 Gr.B Rect; F_y = 46,000 psi; ε_{lim} = 5.00% Eccentricity x: 0.000 in Eccentricity y: 0.000 in
Base material:	Uncracked concrete; 8000; $f_{c,cyl}$ = 8,000 psi; h = 32.000 in
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: E70xx
Mesh size:	Number of elements on edge: 8 Min. size of element: 0.394 in Max. size of element: 1.969 in

2.2 Summary

	Description	Profile		Anchor plate			Concrete [%]
		σ_{Ed} [psi]	ε_{Pl} [%]	σ_{Ed} [psi]	ε_{Pl} [%]	Hole bearing [%]	
1	Combination 1	30,919	0.00	11,313	0.00	8	1

2.3 Anchor plate classification

Results below are displayed for the decisive load combinations: Combination 1

Anchor tension forces	Equivalent rigid anchor plate (CBFEM)	Component-based Finite Element Method (CBFEM) anchor plate design
Anchor 1	3.445 kip	3.600 kip
Anchor 2	0.539 kip	0.869 kip
Anchor 3	0.000 kip	0.214 kip
Anchor 4	3.445 kip	3.599 kip
Anchor 5	0.539 kip	0.869 kip
Anchor 6	0.000 kip	0.216 kip
Anchor 7	3.064 kip	6.365 kip
Anchor 8	3.064 kip	6.367 kip

User accepted to consider the selected anchor plate as rigid by his/her engineering judgement. This means the anchor design guidelines can be applied.

2.4 Profile/Stiffeners/Plate

Profile and stiffeners are verified at the level of the steel to concrete connection. The connection design does not replace the steel design for critical cross sections, which should be performed outside of PROFIS Engineering.

2.4.1 Equivalent stress and plastic strain

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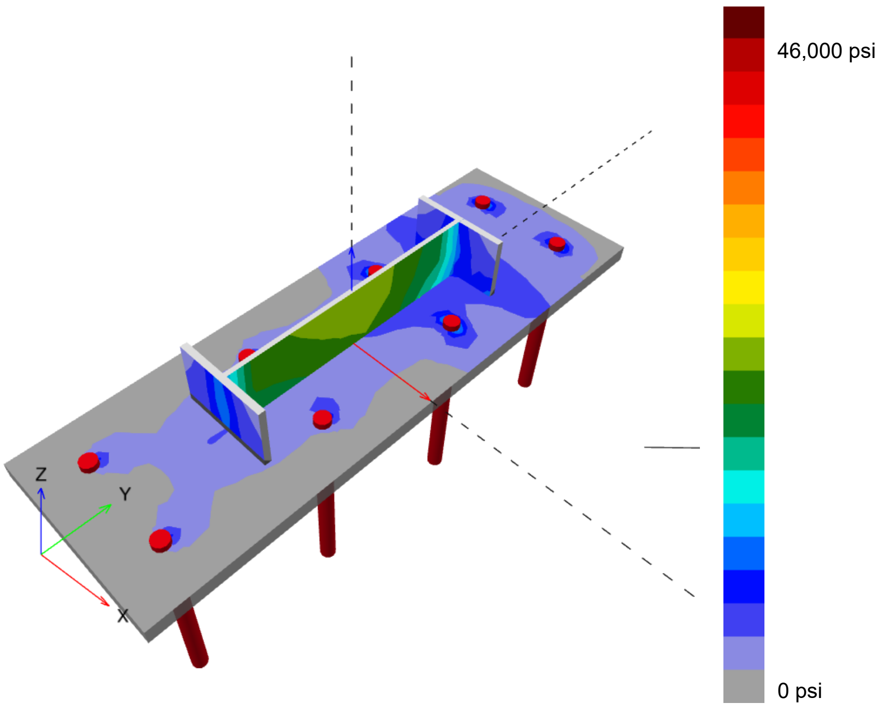
Part	Load combination	Material	f_y [psi]	ε_{lim} [%]	σ_{Ed} [psi]	ε_{Pl} [%]	Status
Plate	Combination 1	ASTM A36	36,000	5.00	11,313	0.00	OK
Profile	Combination 1	ASTM A500 Gr.B Rect	46,000	5.00	30,542	0.00	OK
Profile	Combination 1	ASTM A500 Gr.B Rect	46,000	5.00	28,672	0.00	OK
Profile	Combination 1	ASTM A500 Gr.B Rect	46,000	5.00	30,919	0.00	OK

2.4.1.1 Equivalent stress

Results below are displayed for the decisive load combination: 1 - Combination 1



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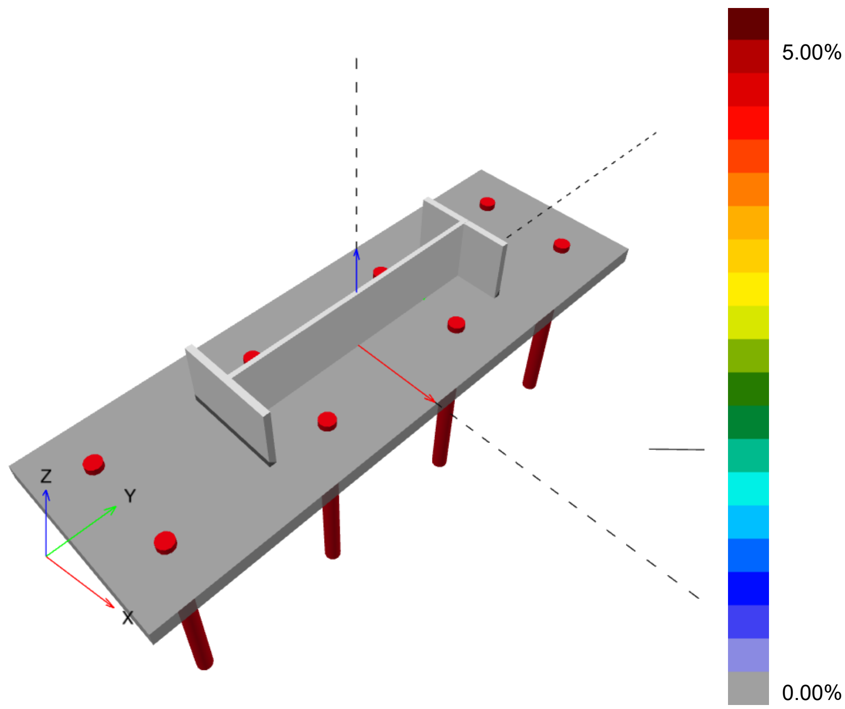
2.4.1.2 Plastic strain

Results below are displayed for the decisive load combination: 1 - Combination 1



2.4.2 Plate hole bearing resistance, AISC 360-16 Section J3

Decisive load combination: 1 - Combination 1

Equations

R_n = $\min(1.2\ l_c\ t\ F_u\ ,\ 2.4\ d\ t\ F_u)$ (AISC 360-16 J3-6a, c)

ΦR_n = $0.75\ R_n$

$V \leq \Phi R_n$

Variables

	l_c [in]	t [in]	F_u [psi]	d [in]	R_n [kip]
Anchor 1	2.438	1.000	58,000	1.000	139.200
Anchor 2	8.875	1.000	58,000	1.000	139.200
Anchor 3	8.875	1.000	58,000	1.000	139.200
Anchor 4	2.438	1.000	58,000	1.000	139.200
Anchor 5	8.875	1.000	58,000	1.000	139.200
Anchor 6	8.875	1.000	58,000	1.000	139.200
Anchor 7	8.875	1.000	58,000	1.000	139.200
Anchor 8	8.875	1.000	58,000	1.000	139.200

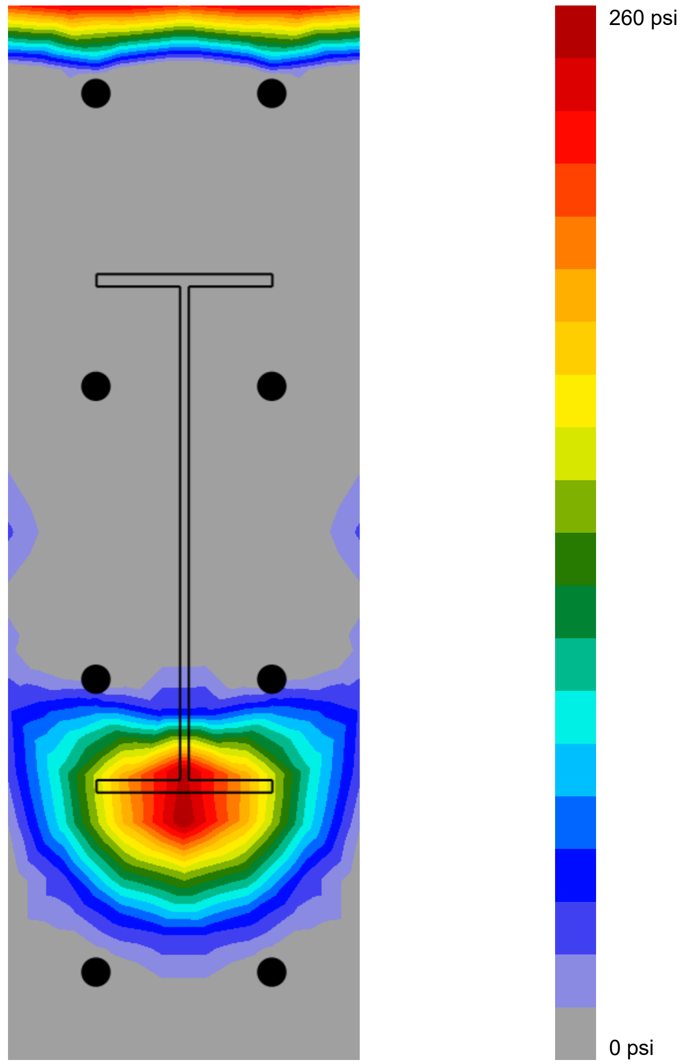
Results

	V [kip]	ΦR_n [kip]	Utilization [%]	Status
Anchor 1	7.972	104.400	8	OK
Anchor 2	8.256	104.400	8	OK
Anchor 3	8.084	104.400	8	OK
Anchor 4	7.972	104.400	8	OK
Anchor 5	8.256	104.400	8	OK
Anchor 6	8.084	104.400	8	OK
Anchor 7	8.188	104.400	8	OK
Anchor 8	8.188	104.400	8	OK

2.5 Concrete

Decisive load combination: 1 - Combination 1

2.5.1 Compression in concrete under the anchor plate



2.5.2 Concrete block compressive strength resistance check, AISC 360-16 Section J8

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Equations

$$F_p = \Phi\, f_{p,max}$$

$$f_{p,max} = 0.85\, f_c' \sqrt{\left(\frac{A_2}{A_1}\right)} \leq 1.7\, f_c;\quad \sqrt{\left(\frac{A_2}{A_1}\right)} \leq 2$$

$$\sigma = \frac{N}{A_1}$$

$$\text{Utilization} = \frac{\sigma}{F_p}$$

Variables

N [kip]	f_c' [psi]	Φ	A_1 [in²]	A_2 [in²]
12.933	8,000	0.65	186.24	1,037.52

Results

Load combination	F_p [psi]	σ [psi]	Utilization [%]	Status
Combination 1	8,840	69	1	OK

2.6 Symbol explanation

A_1	Loaded area of concrete
A_2	Supporting area
d	Nominal diameter of the bolt
ε_{lim}	Limit plastic strain
ε_{Pl}	Plastic strain from CBFEM results
f_c	Concrete compressive strength
f_c'	Concrete compressive strength
F_u	Specified minimum tensile strength of the connected material
F_p	Concrete block design bearing strength
$f_{p,max}$	Concrete block design bearing strength maximum
f_y	Yield strength
l_c	Clear distance, in the direction of the force, between the edge of the hole and the edge of the adjacent hole or edge of the material
N	Resulting compression force
σ	Average stress in concrete
σ_{Ed}	Equivalent stress
Φ	Resistance factor
ΦR_n	Factored resistance
t	Thickness of the anchor plate
V	Resultant of shear forces Vy, Vz in bolt.

2.7 Warnings

- By using the CBFEM calculation functionality of PROFIS Engineering you may act outside the applicable design codes and your specified anchor plate may not behave rigid. Please, validate the results with a professional designer and/or structural engineer to ensure suitability and adequacy for your specific jurisdiction and project requirements.
- The anchor is modeled considering stiffness values determined from load displacement curves tested in an independent laboratory. Please note that no simple replacement of the anchor is possible as the anchor stiffness has a major impact on the load distribution results.

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3 Summary of results

Design of the anchor plate, anchors, welds and other elements are based on CBFEM (component based finite element method) and AISC.

	Load combination	Max. utilization	Status
Anchors	Combination 1	**160%**	NOT OK
Anchor plate	Combination 1	32%	OK
Concrete	Combination 1	1%	OK
Profile	Combination 1	68%	OK

Fastening does not meet the design criteria!

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Design:	Copy - RFI #143: BNT: L2 Roof, Connection to Colu	Date:	1/12/2024
Fastening point:			

Specifier's comments:

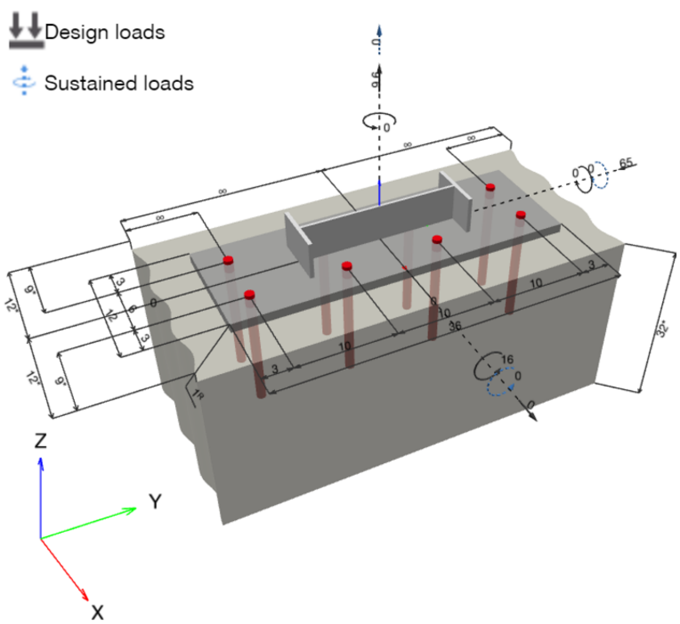
1 Input data

Anchor type and diameter:	**HIT-HY 200 V3 + HAS-V-36 (ASTM F1554 Gr.36) 1**
Item number:	not available (element) / 2334276 HIT-HY 200-R V3 (adhesive)
Effective embedment depth:	$h_{ef,act}$ = 12.000 in. ($h_{ef,limit}$ = - in.)
Material:	ASTM F1554 Grade 36
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 = 1.000 in.
Anchor plate^R :	l_x x l_y x t = 12.000 in. x 36.000 in. x 1.000 in.;
Profile:	W shape (AISC), W18X35; (L x W x T x FT) = 17.700 in. x 6.000 in. x 0.300 in. x 0.425 in.
Base material:	uncracked concrete, 8000, f_c' = 8,000 psi; h = 32.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: present, shear: 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.

RAN WITH AISC DESIGN GUIDE

Geometry [in.] & Loading [kip, ft.kip]



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1.1 Design results

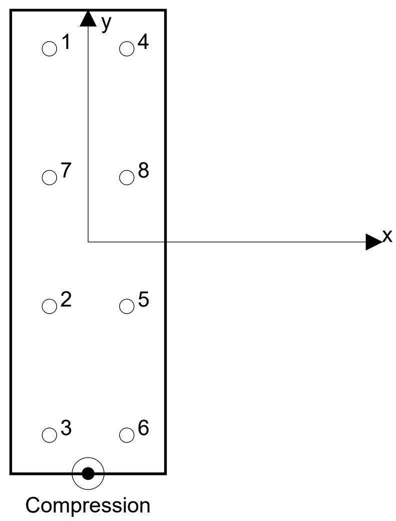
Case	Description	Forces [kip] / Moments [ft.kip]	Seismic	Max. Util. Anchor [%]
1	Combination 1	N = 9.600; V_x = 0.000; V_y = -65.000; M_x = 16.00000; M_y = 0.00000; M_z = 0.00000;	no	71

2 Load case/Resulting anchor forces

Anchor reactions [kip]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	3.354	8.125	0.000	-8.125
2	1.318	8.125	0.000	-8.125
3	0.301	8.125	0.000	-8.125
4	3.354	8.125	0.000	-8.125
5	1.318	8.125	0.000	-8.125
6	0.301	8.125	0.000	-8.125
7	2.336	8.125	0.000	-8.125
8	2.336	8.125	0.000	-8.125



max. concrete compressive strain: 0.00 [‰]
max. concrete compressive stress: 8,840 [psi]
resulting tension force in (x/y)=(0.000/0.000): 0.000 [kip]
resulting compression force in (x/y)=(6.000/0.021): 5.018 [kip]

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

3 Tension load

	Load N_{ua} [kip]	Capacity ϕ N_n [kip]	Utilization $\beta_N = N_{ua}/\phi$ N_n	Status
Steel Strength*	3.354	26.348	13	OK
Bond Strength**	14.618	39.458	38	OK
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	14.618	40.384	37	OK

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

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]
0.61	58,000

Calculations

N_{sa} [kip]
35.130

Results

N_{sa} [kip]	ϕ_{steel}	$\phi\ N_{sa}$ [kip]	N_{ua} [kip]
35.130	0.750	26.348	3.354

3.2 Bond Strength

$N_{ag} = \left(\frac{A_{Na}}{A_{Na0}}\right) \psi_{ec1,Na}\ \psi_{ec2,Na}\ \psi_{ed,Na}\ \psi_{cp,Na}\ N_{ba}$	ACI 318-19 Eq. (17.6.5.1b)
$\phi\ N_{ag} \geq N_{ua}$	ACI 318-19 Table 17.5.2
A_{Na} see ACI 318-19, Section 17.6.5.1, Fig. R 17.6.5.1(b)	
$A_{Na0} = (2\ c_{Na})^2$	ACI 318-19 Eq. (17.6.5.1.2a)
$c_{Na} = 10\ d_a \sqrt{\frac{\tau_{uncr}}{1100}}$	ACI 318-19 Eq. (17.6.5.1.2b)
$\psi_{ec,Na} = \left(\frac{1}{1 + \frac{e_N'}{c_{Na}}}\right) \leq 1.0$	ACI 318-19 Eq. (17.6.5.3.1)
$\psi_{ed,Na} = 0.7 + 0.3 \left(\frac{c_{a,min}}{c_{Na}}\right) \leq 1.0$	ACI 318-19 Eq. (17.6.5.4.1b)
$\psi_{cp,Na} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{c_{Na}}{c_{ac}}\right) \leq 1.0$	ACI 318-19 Eq. (17.6.5.5.1b)
$N_{ba} = \lambda_a \cdot \tau_{k,c} \cdot \pi \cdot d_a \cdot h_{ef}$	ACI 318-19 Eq. (17.6.5.2.1)

Variables

$\tau_{k,c,uncr}$ [psi]	d_a [in.]	h_{ef} [in.]	$c_{a,min}$ [in.]	$\alpha_{overhead}$	$\tau_{k,c}$ [psi]
2,494	1.000	12.000	9.000	1.000	2,494

$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	c_{ac} [in.]	λ_a
0.000	6.963	22.346	1.000

Calculations

c_{Na} [in.]	A_{Na} [in.^{2}]	A_{Na0} [in.^{2}]	$\psi_{ed,Na}$
14.989	1,439.47	898.68	0.880

$\psi_{ec1,Na}$	$\psi_{ec2,Na}$	$\psi_{cp,Na}$	N_{ba} [kip]
1.000	0.683	0.671	94.015

Results

N_{ag} [kip]	ϕ_{bond}	$\phi\ N_{ag}$ [kip]	N_{ua} [kip]
60.704	0.650	39.458	14.618

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.]	$\psi_{c,N}$
12.000	0.000	6.963	9.000	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
22.346	24	1.000	8,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [kip]
1,584.00	1,296.00	1.000	0.721	0.850	0.806	89.234

Results

N_{cbg} [kip]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [kip]	N_{ua} [kip]
53.845	0.750	40.384	14.618

4 Shear load

	Load V_{ua} [kip]	Capacity ϕ V_n [kip]	Utilization $\beta_V = V_{ua}/\phi$ V_n	Status
Steel Strength*	8.125	13.702	60	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	65.000	104.542	63	OK
Concrete edge failure in direction x-**	65.000	96.357	68	OK

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

4.1 Steel Strength

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

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
0.61	58,000

Calculations

V_{sa} [kip]
21.080

Results

V_{sa} [kip]	ϕ_{steel}	$\phi\ V_{sa}$ [kip]	V_{ua} [kip]
21.080	0.650	13.702	8.125

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)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ 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

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	12.000	0.000	0.000	9.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	22.346	24	1.000	8,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [kip]
1,584.00	1,296.00	1.000	1.000	0.850	0.806	89.234

Results

V_{cpg} [kip]	$\phi_{concrete}$	$\phi\ V_{cpg}$ [kip]	V_{ua} [kip]
149.346	0.700	104.542	65.000

4.3 Concrete edge failure in direction x-

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$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\ \psi_{ed,V}\ \psi_{c,V}\ \psi_{h,V}\ \psi_{parallel,V}\ V_b$	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)
$V_b = 9\ \lambda_a\ \sqrt{f_c'}\ c_{a1}^{1.5}$	ACI 318-19 Eq. (17.7.2.2.1b)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
9.000	-	0.000	1.400	32.000

l_e [in.]	λ_a	d_a [in.]	f_c' [psi]	$\psi_{parallel,V}$
8.000	1.000	1.000	8,000	2.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [kip]
769.50	364.50	1.000	1.000	1.000	21.735

Results

V_{cbg} [kip]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [kip]	V_{ua} [kip]
128.475	0.750	96.357	65.000

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

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.370	0.675	5/3	71	OK

$\beta_{NV} = \beta_N^{\zeta} + \beta_V^{\zeta} <= 1$

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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!
- User is responsible for evaluating the hole bearing capacity in case of shear forces.
- 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!

7 Anchor plate and concrete bearing stress check

	Load	Capacity	Utilization [%]	Status
Concentric Compression	N/A	N/A	N/A	N/A
Concrete bearing	8,840 [psi]	8,840 [psi]	100	OK
Tension Interface	5,012.02 [in.lb/in.]	8,099.99 [in.lb/in.]	62	OK
Uniaxial Moment (Strong Axis)	1,244.77 [in.lb/in.]	8,099.99 [in.lb/in.]	16	OK
Uniaxial Moment (Weak Axis)	1,495.77 [in.lb/in.]	8,099.99 [in.lb/in.]	19	OK

7.1 Concrete bearing check (per AISC DG1, section 3.1.1)

$A_1 = B \cdot N$

$A_2 = L \cdot W$

$f_{pu(max)} = \phi \left(0.85f'_c \sqrt{\frac{A_2}{A_1}}\right), \sqrt{\frac{A_2}{A_1}} \leq 2$

$f_{pu} = f_{pu(max)}$

Variables

B [in.]	N [in.]	L [in.]	W [in.]
12.000	36.000	72.000	24.000

f_c' [psi]	ϕ	P_u [kip]	M_u [ft.kip]
8,000	0.650	9.600	0.00000

Calculations

A_1 [in.^{2}]	A_2 [in.^{2}]
432.00	1,728.00

Results

f_{pu} [psi]	$f_{pu(max)}$ [psi]
8,840	8,840

7.2 Plate bending (Strong Axis), Compression (per AISC DG1, sections 3.3 and AISC's Engineering Journal, Volume 51, No. 4)

$A_1 = B \cdot N$

$A_2 = L \cdot W$

$f_{pu(max)} = \phi \left(0.85f'_c \sqrt{\frac{A_2}{A_1}}\right), \sqrt{\frac{A_2}{A_1}} \leq 2$

$m = \frac{N-0.95d}{2}$

$n = \frac{B-0.80b_f}{2}$

$M_{pl1} = C_r \cdot \frac{x}{b_{eff}}$

$\phi M_n = \phi \cdot F_y \cdot \frac{t_p^2}{4}$

$M_{pl1} \leq \phi M_n$

Variables

B [in.]	N [in.]	L [in.]	W [in.]	d [in.]	b_f [in.]
12.000	36.000	72.000	24.000	17.700	6.000

F_y [psi]	ϕ	t_p [in.]	P_u [kip]	M_u [ft.kip]
36,000	0.900	1.000	9.600	16.00000

Calculations

A_1 [in.^{2}]	A_2 [in.^{2}]	$f_{pu(max)}$ [psi]	m [in.]	n [in.]
432.00	1,728.00	8,840	9.593	3.600

f_{pu} [psi]	C_r [kip]	x [in.]	b_{eff} [in.]	M_{pl1} [in.lb/in.]
8,840	5.019	2.976	12.000	1,244.77

Results

M_n [in.lb/in.]	ϕ	ϕM_n [in.lb/in.]	M_{pl1} [in.lb/in.]
8,999.99	0.900	8,099.99	1,244.77

7.3 Plate bending (Weak Axis), Compression (per AISC DG1, sections 3.3 and AISC's Engineering Journal, Volume 51, No. 4)

$A_1 = B \cdot N$

$A_2 = L \cdot W$

$f_{pu(max)} = \phi \left(0.85f'_c \sqrt{\frac{A_2}{A_1}}\right), \sqrt{\frac{A_2}{A_1}} \leq 2$

$m = \frac{N-0.95d}{2}$

$n = \frac{B-0.80b_f}{2}$

$M_{pl2} = C_r \cdot \frac{x}{b_{eff}}$

$\phi M_n = \phi \cdot F_y \cdot \frac{t_p^2}{4}$

$M_{pl2} \leq \phi M_n$

Variables

B [in.]	N [in.]	L [in.]	W [in.]	d [in.]	b_f [in.]
12.000	36.000	72.000	24.000	17.700	6.000

F_y [psi]	ϕ	t_p [in.]	P_u [kip]	M_u [ft.kip]
36,000	0.900	1.000	9.600	16.00000

Calculations

A_1 [in.^{2}]	A_2 [in.^{2}]	$f_{pu(max)}$ [psi]	m [in.]	n [in.]
432.00	1,728.00	8,840	9.593	3.600

f_{pu} [psi]	C_r [kip]	x [in.]	b_{eff} [in.]	M_{pl2} [in.lb/in.]
8,840	1.506	3.600	3.624	1,495.77

Results

M_n [in.lb/in.]	ϕ	ϕM_n [in.lb/in.]	M_{pl2} [in.lb/in.]
8,999.99	0.900	8,099.99	1,495.77

7.4 Plate bending, tension (per AISC DG1, sections 3.2, 3.3)

$$m = \frac{N-0.95d}{2}$$

$$n = \frac{B-0.80b_f}{2}$$

$$M_{pl} = \frac{T_{u1} \cdot x_1}{b_{eff1}} + \frac{T_{u2} \cdot x_2}{b_{eff2}}$$

$$\phi M_n = \phi \cdot F_y \cdot \frac{t_p^2}{4}$$

$$M_{pl} \leq \phi M_n$$

Variables

B [in.]	N [in.]	d [in.]	b_f [in.]	F_y [psi]
12.000	36.000	17.700	6.000	36,000

ϕ	t_p [in.]	P_u [kip]	M_u [ft.kip]
0.900	1.000	9.600	16.00000

Calculations

m [in.]	n [in.]
9.593	3.600

T_{u1} [kip]	x_1 [in.]	b_{eff1} [in.]
2.336	3.407	6.000

T_{u2} [kip]	x_2 [in.]	b_{eff2} [in.]
3.354	6.592	6.000

Results

M_n [in.lb/in.]	ϕ	ϕM_n [in.lb/in.]	M_{pl} [in.lb/in.]
8,999.99	0.900	8,099.99	5,012.02

8 Installation data

Profile: W shape (AISC), W18X35; (L x W x T x FT) = 17.700 in. x 6.000 in. x 0.300 in. x 0.425 in.

Hole diameter in the fixture: d_f = 1.125 in.

Plate thickness (input): 1.000 in.

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 + HAS-V-36 (ASTM F1554 Gr.36) 1

Item number: not available (element) / 2334276 HIT-HY 200-R V3 (adhesive)

Maximum installation torque: 0.15000 ft.kip

Hole diameter in the base material: 1.125 in.

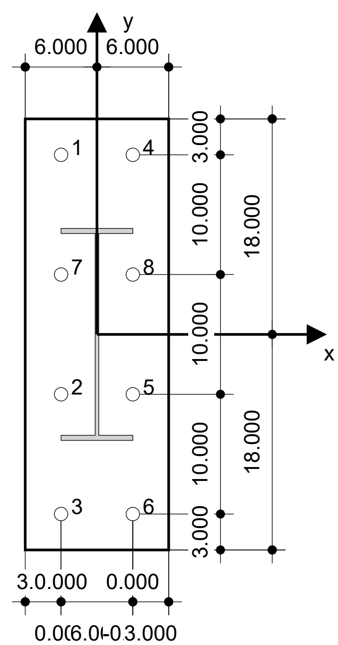
Hole depth in the base material: 12.000 in.

Minimum thickness of the base material: 14.250 in.

1 Hilti HAS Carbon steel threaded rod with Hilti HIT-HY 200 V3 Safe Set System

8.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• Compressed air with required accessories to blow from the bottom of the hole • Proper diameter wire brush	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-3.000	15.000	9.000	15.000	-	-
2	-3.000	-5.000	9.000	15.000	-	-
3	-3.000	-15.000	9.000	15.000	-	-
4	3.000	15.000	15.000	9.000	-	-
5	3.000	-5.000	15.000	9.000	-	-
6	3.000	-15.000	15.000	9.000	-	-
7	-3.000	5.000	9.000	15.000	-	-
8	3.000	5.000	15.000	9.000	-	-

9 Remarks; Your Cooperation Duties

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Company:		Page:	18
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	RFI #143: BNT: L2 Roof, Connection to Column- Pos	Date:	1/12/2024
Fastening point:			

4 Remarks; Your Cooperation Duties

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