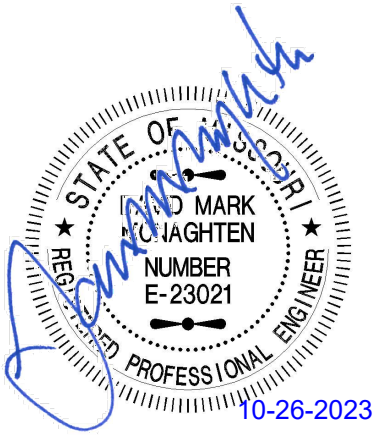
PMA | Engineering

STRUCTURAL DESIGN CALCULATIONS
For

Lee's Summit Commerce Center
Building #2
Storage Rack Anchorage

Lee's Summit, Missouri

October 26, 2023



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Professional Engineering Corporation
Missouri State Certificate of Authority #001400

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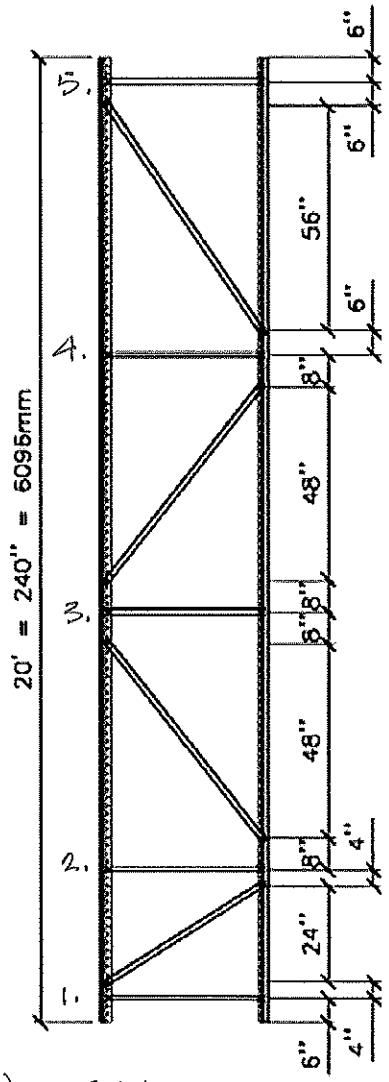
Project LEES SUMMIT RACK ANCHORAGE Sheet of

DESIGN ANCHORAGE FOR RACK SYSTEM.

- ☐ HEIGHT AND RACK LAYOUT OF SYSTEM SHOWN AT RIGHT.
- ☐ LENGTH OF EACH SECTION = 96"
- ☐ CAPACITY OF EACH 96" BEAM = 5370 lb.
  ∴ EACH RACK LEVEL CAN SUPPORT (2)(5370) = 10740 lb.
- ☐ CAPACITY OF EACH COLUMN = 15300 lb.
  FOUR COLUMN CAPACITY = (4)(15300) = 61200
  IF EVENLY DISTRIBUTED TO 5 LEVELS = $\frac{61200}{5}$ = 12,240 lb / LEVEL.

∴ BEAM CAPACITY CONTROLS = 10740 lb / RACK



DETERMINE SEISMIC LOADS TO RACK.

AT EACH LEVEL V = 0.027 (10740) = 289.98 lb.

FOR OVERTURNING:

SEISMIC: 67% OF RATED LOAD CAPACITY AT EACH LEVEL. = (0.67)(289.98) = 194 lb

DISTRIBUTE SEISMIC LOAD TO EA. LEVEL:

LEVEL	h_x	W_x	$h_x W_x$	$\frac{h_x W_x}{\Sigma h_x W_x}$	F_x
5	19.5'	194	3783	0.40	388 lb
4	14.75'	194	2862	0.31	301
3	9.42'	194	1827	0.20	194
2	4.08'	194	791	0.08	77
1	0.5'	194	82	0.01	10
		970	9345	1.0	970 ✓

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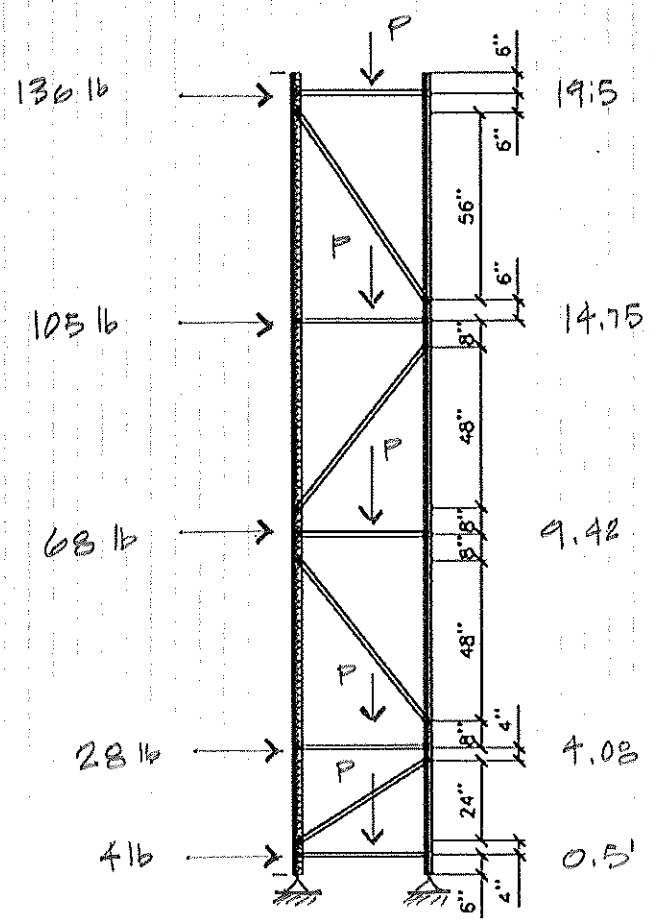
Project LEE'S SUMMIT RACKING Sheet of



P = 3251 lb
(SEE BELOW)

APPLY SEISMIC LOADS TO FRAME

EACH FRAME TAKES 1/2 OF GRAVITY AND LATERAL.

GRAVITY LOAD AT EACH LEVEL: $(0.85 + 0.14 \times 0.107)(0.7)(1/2)(10740)$

$= 3251$ lb

SEISMIC LOADS = $0.7\ (1/2)\ F_x$

CHECK OVERTURNING:

$M_R = (5)(3251)(1.5') = 24\,382$ lb·ft

$M_O = (136)(19.5) + (105)(14.75) + (68)(9.42) + (28)(4.08) + (4)(0.5)$

$= 2652 + 1549 + 640 + 114 + 2 = 4957$ lb·ft

FACTOR OF SAFETY: $\frac{24\,382}{4957} = 4.9 > 1.5$ ok.

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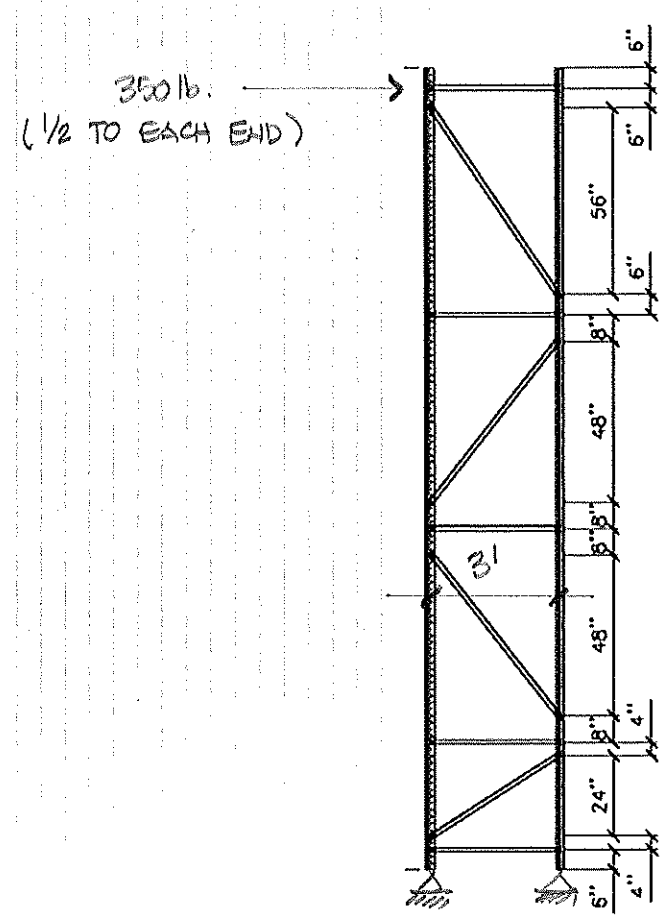
Project LEE'S SUMMIT STORAGE Sheet of



RACK HEIGHT TO DEPTH RATIO = $\frac{20}{3}$ = 6.67' > 6 ∴ APPLY 350 lb LOAD AT TOP RACK.

CONSERVATIVELY ASSUME RACK WEIGHT IS NEGLIGIBLE.

M_O = (350 lb)(½)(20') = 3500 lb·ft

UPLIFT FORCE = $\frac{3500\ lb}{3}$ = 1167 lb

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Project LEE'S SUMMIT RACKING Sheet of

DESIGN ANCHORAGE FOR RACKING:

FOR SEISMIC LOADING:

NO UPLIFT

SHEAR = 970 lb / 4 LEGS = 242.5 lb EA. LEG.

(USE 242.5 x 1.4 FOR ANCHOR EVAL.).

FOR OVERTURNING CHECK.

UPLIFT = 1167 lb EA. LEG.

SHEAR = 350 lb / 4 LEGS = 87.5 lb.

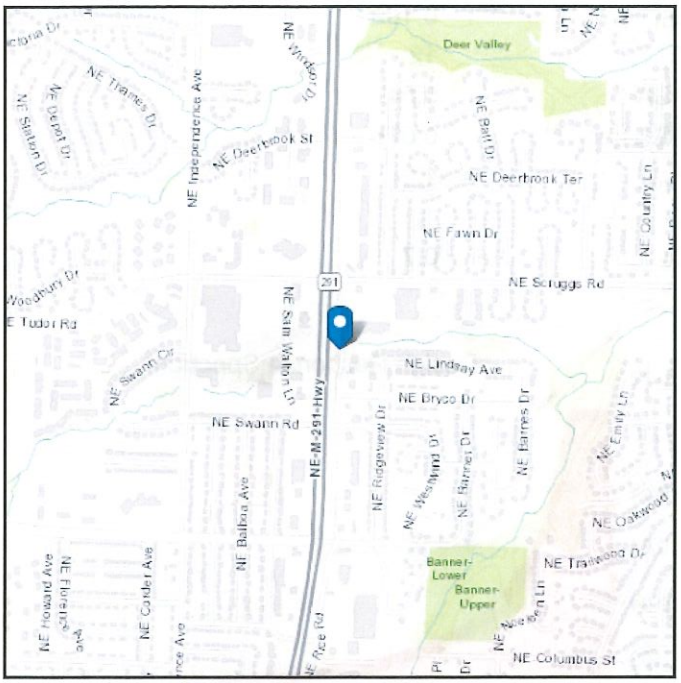
SEE HILTI PROFE OUTPUT.

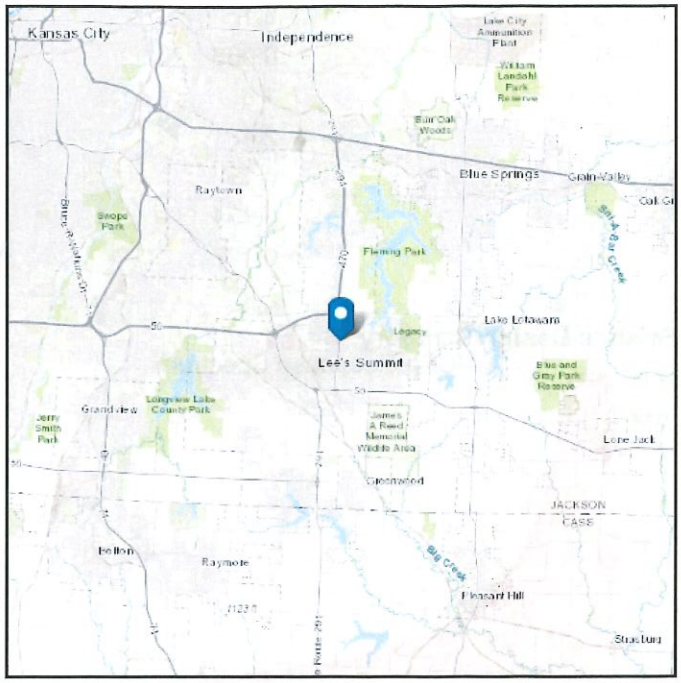
BASE PL ACCOMMODATES (2) 1/2" ϕ ANCHORS W/ 3.88" SPACING.

ASCE 7 Hazards Report

Address:
64086
Lees Summit, Missouri

Standard:	ASCE/SEI 7-16	**Latitude:**	38.929646
Risk Category:	II	**Longitude:**	-94.359493
Soil Class:	D - Default (see Section 11.4.3)	**Elevation:**	964.9234990402807 ft (NAVD 88)





Seismic

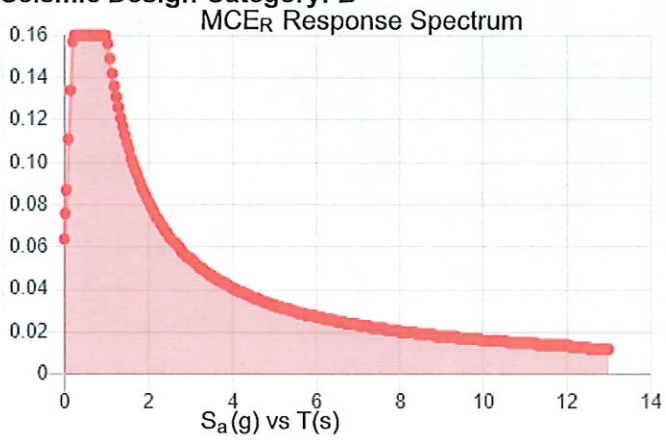
D - Default (see Section 11.4.3)

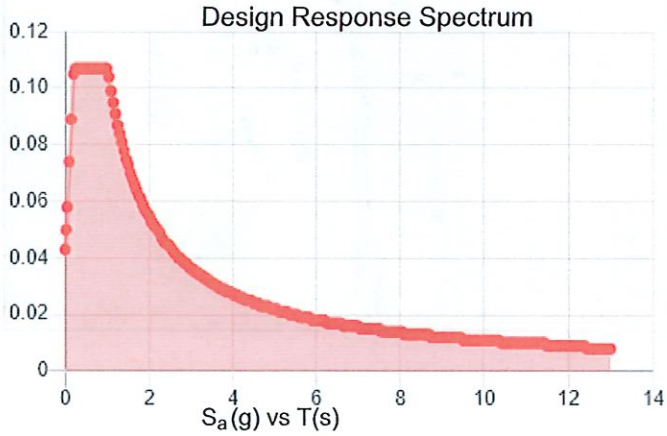
Site Soil Class:

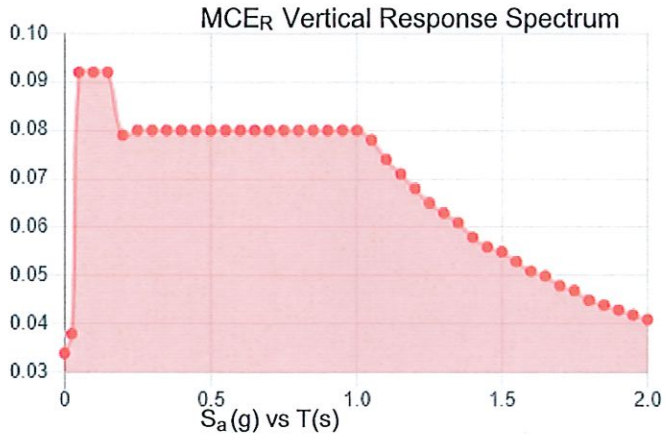
Results:

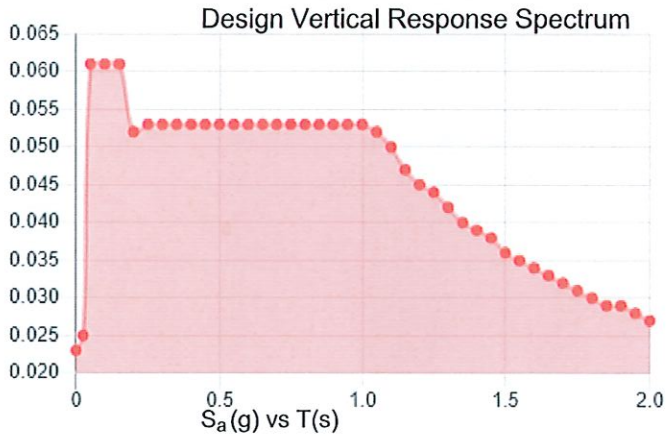
S_S :	0.1	S_{D1} :	0.109
S_1 :	0.068	T_L :	12
F_a :	1.6	PGA :	0.047
F_v :	2.4	PGA_M :	0.076
S_{MS} :	0.16	F_{PGA} :	1.6
S_{M1} :	0.164	I_e :	1
S_{DS} :	0.107	C_v :	0.7

Seismic Design Category: B









Data Accessed: **Thu Oct 26 2023**

Date Source:

USGS Seismic Design Maps based on ASCE/SEI 7-16 and ASCE/SEI 7-16 Table 1.5-2. Additional data for site-specific ground motion procedures in accordance with ASCE/SEI 7-16 Ch. 21 are available from USGS.

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PMA Engineering

ENGINEER:	DMM	**DATE:**	10/26/2023	**PAGE:**	1
CHECKED:		**DATE:**			
PROJECT:	Lee's Summit Rack Anchorage			**SHEET:**	1 OF 1

Seismic Base Shear for Buildings & Nonbuildings, Equivalent Lateral Force Procedure: ASCE 7-16

Input Data:					**Code Reference:**
Risk Category:			II		Table 1.5-1
Seismic Importance Factor, I_e:			1.00		Table 1.5-2
Site Soil Class:	*Soils report NOT provided (Sect 11.4.4)*		D (Default)		Table 20.3-1
Short Period Spectral Acceleration, S_s:			0.100		Figure 22-1
1 sec. Period Spectral Acceleration, S_1:			0.068		Figure 22-2
Site Coefficient, F_a:	*NOT Isolated or Damped Structure (Section 11.4.8 Item 1)*		1.60		Table 11.4-1
	Exceptions of Section 11.4.8 were NOT evaluated.			**OKAY.**	
Site Coefficient, F_v:			2.40		Table 11.4-2
Response Modification Coefficient, R:	*Nonbuilding Structures Similar to Buildings Ch 12*		4		Table 12.2-1
System Type:	*A-18. Light-frame (cold-formed steel) wall systems using flat strap bracing*				
Detailing Requirements:	*Sect. 14.1*				
	Exceptions of Sect 15.4.1 Item 2 are NOT applicable.			**OKAY.**	
Approx Building Period Parameter, C_T:	*All Other Structural Systems*		0.02		Table 12.8-2
Approx Building Period Parameter, x:			0.75		Table 12.8-2
Long Period Transition Period, T_L (sec):			12		Figure 22-14
Building Height Above "Base", h_n (ft):	Ht Restriction per Table 12.2-1:	NL	20 ft.	**OKAY.**	

Calculated Data:					**Code Reference:**
Short Period, Specral Response, $S_{MS} = Fa*S_S$			0.160		Eqn. 11.4-1
1 sec. Period, Spectral Response, $S_{M1}=F_v*S_1$			0.163		Eqn. 11.4-2
Short Period, Design Response, $S_{DS} = 2/3*S_{MS}$	*Requirements of Section 12.8.1.3 were NOT evaluated.*		0.107		Eqn. 11.4-3
1 sec. Period, Design Response, $S_{D1} = 2/3*S_{M1}$			0.109		Eqn. 11.4-4
SDC, Design Short Period (S_{DS}):	*Req's for SDS eval only were NOT evaluated (Section 11.6)*		A		Table 11.6-1
SDC, Design 1 sec Period (S_{D1}):			B	<---- CONTROLS	Table 11.6-2
SDC, 1 sec Period (S_1):			N/A		Sect. 11.6
SDC, 1 sec Period & Short Period (S_1 & S_s):			N/A		Sect. 11.4.2
Seismic Design Category:			**B**		
Velocity Domain Period, Ts = SD1/(SDS) (sec)			1.020		Sect. 11.3
Approximate Fundamental Period, $T_a = C_T*h_n^x$ (sec)			0.19		Eqn. 12.8-7
Seismic Response Coeff, CS = (SDS)/(R/Ie)			0.027	<---- CONTROLS	Eqn. 12.8-2
CS = 0.3*(SDS)*Ie	for Rigid Nonbuilding Structures w/ Ta < 0.06 (sec)		N/A		Eqn. 15.4-5
CS,MAX = SD1/((R/Ie)*Ta)	for $T_a \le T_L$		0.144		Eqn. 12.8-3
CS,MAX = SD1*TL/((R/Ie)*Ta²)	for $T_a > T_L$		N/A		Eqn. 12.8-4
CS,MIN = 0.044*(SDS)*Ie > 0.01			0.010		Eqn. 12.8-5
CS,MIN = 0.5*S1/(R/Ie)	for $S_1 \ge 0.6$		N/A		Eqn. 12.8-6
Seismic Base Shear:		**V =**	**0.027 W**		Eqn. 12.8-1

Company:	PMA Engineering	Page:	1
Address:	6717 Shawn Miss Pkwy	Specifier:	David McNaghten
Phone I Fax:	9138311262 |	E-Mail:	dmcnaghten@pmaengineering.com
Design:	Concrete - Oct 26, 2023	Date:	10/26/2023
Fastening point:			

Specifier's comments:

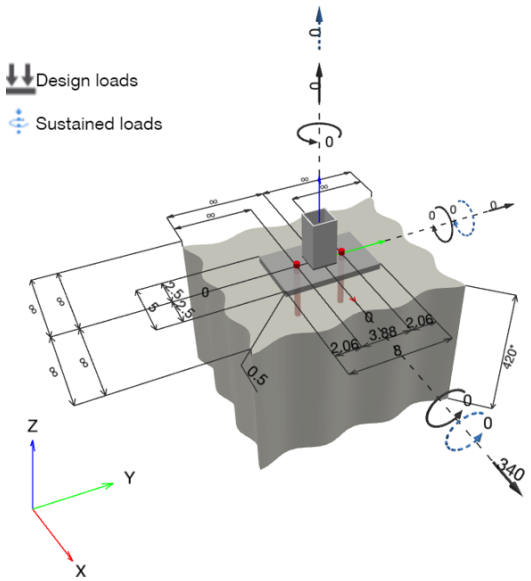
1 Anchor Design

1.1 Input data

Anchor type and diameter:	**KWIK-X 1/2 (4 1/4) hnom2**
Item number:	418076 KH-EZ 1/2"x5" (element) / 2362252 KHC 1/2" LARGE (capsule)
Effective embedment depth:	$h_{ef,opti}$ = 4.250 in. ($h_{ef,limit}$ = 5.500 in.), h_{nom} = 4.250 in.
Material:	Carbon Steel
Evaluation Service Report:	ESR-5065
Issued I Valid:	1/1/2023 | 12/1/2023
Proof:	Design Method ACI 318-19 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate[CBFEM]:	l_x x l_y x t = 5.000 in. x 8.000 in. x 0.500 in.;
Profile:	Square HSS (AISC), HSS2X2X.125; (L x W x T) = 2.000 in. x 2.000 in. x 0.125 in.
Base material:	cracked concrete, 2500, f_c' = 2,500 psi; h = 420.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: not present, shear: not present; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar

[CBFEM] - The anchor calculation is based on a component-based Finite Element Method (CBFEM)

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



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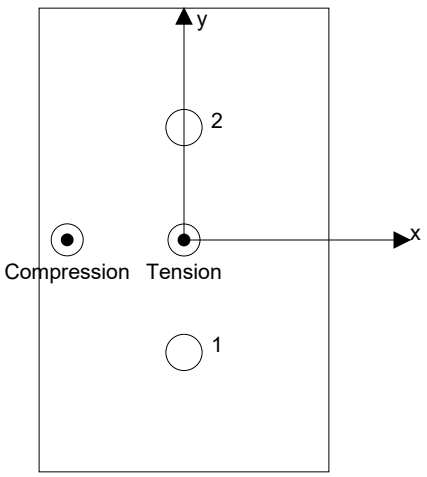
Phone I Fax:	9138311262 |	E-Mail:	dmcnaghten@pmaengineering.com
Design:	Concrete - Oct 26, 2023	Date:	10/26/2023
Fastening point:			

1.1.1 Design results

Case	Description	Forces [lb] / Moments [in.lb]	Seismic	Max. Util. Anchor [%]
1	Combination 1	N = 0; V_x = 340; V_y = 0; M_x = 0; M_y = 0; M_z = 0;	no	4

1.2 Load case/Resulting anchor forces



Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	2	170	170	-0
2	2	170	170	0

resulting tension force in (x/y)=(0.000/0.000): 4 [lb]
resulting compression force in (x/y)=(-2.015/0.003): 4 [lb]

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

1.3 Tension load

	Load N_{ua} [lb]	Capacity ϕ N_n [lb]	Utilization $\beta_N = N_{ua}/\phi$ N_n	Status
Steel Strength*	2	11,777	1	OK
Bond Strength**	4	10,558	1	OK
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	4	6,313	1	OK

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

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Design:	Concrete - Oct 26, 2023	Date:	10/26/2023
Fastening point:			

1.3.1 Steel Strength

N_{sa} = ESR value	refer to ICC-ES ESR-5065
$\phi\ N_{sa} \geq N_{ua}$	ACI 318-19 Table 17.5.2

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.16	112,540

Calculations

N_{sa} [lb]
18,119

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
18,119	0.650	11,777	2

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Fastening point:			

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)

$\psi_{cp,Na} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{c_{Na}}{c_{ac}}\right) \leq 1.0$ 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]
2,126	0.500	4.250	∞	1.000	1,901

$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	c_{ac} [in.]	λ_a
0.000	0.001	6.724	1.000

Calculations

c_{Na} [in.]	A_{Na} [in.^{2}]	A_{Na0} [in.^{2}]	$\psi_{ed,Na}$
6.919	245.20	191.50	1.000

$\psi_{ec1,Na}$	$\psi_{ec2,Na}$	$\psi_{cp,Na}$	N_{ba} [lb]
1.000	1.000	1.000	12,688

Results

N_{ag} [lb]	ϕ_{bond}	ϕN_{ag} [lb]	N_{ua} [lb]
16,243	0.650	10,558	4

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Fastening point:			

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)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ 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.]	$\psi_{c,N}$
4.250	0.000	0.001	∞	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
6.724	17	1.000	2,500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
212.04	162.57	1.000	1.000	1.000	1.000	7,447

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
9,712	0.650	6,313	4

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Design:	Concrete - Oct 26, 2023	Date:	10/26/2023
Fastening point:			

1.4 Shear load

	Load V_{ua} [lb]	Capacity ϕ V_n [lb]	Utilization $\beta_V = V_{ua}/\phi$ V_n	Status
Steel Strength*	170	5,547	4	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	340	13,599	3	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

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

1.4.1 Steel Strength

V_{sa} = ESR value refer to ICC-ES ESR-5065
ϕ $V_{steel} \geq V_{ua}$ ACI 318-19 Table 17.5.2

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
0.16	112,540

Calculations

V_{sa} [lb]
9,245

Results

V_{sa} [lb]	ϕ_{steel}	ϕ V_{sa} [lb]	V_{ua} [lb]
9,245	0.600	5,547	170

Company:	PMA Engineering	Page:	7
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Fastening point:			

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)

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

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

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

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	4.250	0.000	0.000	∞

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	6.724	17	1.000	2,500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
212.04	162.57	1.000	1.000	1.000	1.000	7,447

Results

V_{cpg} [lb]	$\phi_{concrete}$	ϕV_{cpg} [lb]	V_{ua} [lb]
19,428	0.700	13,599	340

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

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.001	0.031	5/3	1	OK

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

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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."

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1.7 Installation data

Profile: Square HSS (AISC), HSS2X2X.125; (L x W x T) = 2.000 in. x 2.000 in. x 0.125 in.

Hole diameter in the fixture: d_f = 0.625 in.

Plate thickness (input): 0.500 in.

Drilling method: Hammer drilled

Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: KWIK-X 1/2 (4 1/4) hnom2

Item number: 418076 KH-EZ 1/2"x5" (element) / 2362252 KHC 1/2" LARGE (capsule)

Maximum installation torque: -

Hole diameter in the base material: 0.500 in.

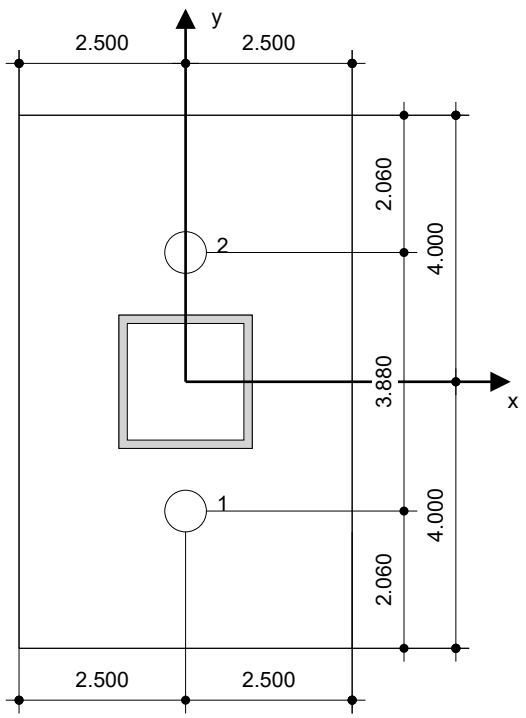
Hole depth in the base material: 5.250 in.

Minimum thickness of the base material: 6.500 in.

1/2 (4 1/4) hnom2 Hilti KH-EZ Carbon steel screw anchor with Hilti KHC

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• No accessory required	• SIW 6-A22 Impact Screw Driver



Coordinates Anchor [in.]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.000	-1.940	-	-	-	-
2	0.000	1.940	-	-	-	-

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular l_x x l_y x t = 5.000 in x 8.000 in x 0.500 in Calculation: CBFEM Material: ASTM A36; F_y = 36,000 psi; ε_{lim} = 5.00%
Anchor type and size:	KWIK-X 1/2 (4 1/4) hnom2, h_{ef} = 4.250 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 = 0.500 in
Profile:	HSS2X2X.125; (L x W x T x FT) = 2.000 in x 2.000 in x 0.125 in x - 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:	Cracked concrete; 2500; $f_{c,cyl}$ = 2,500 psi; h = 420.000 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	2,784	0.00	529	0.00	1	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	2 lb	2 lb
Anchor 2	2 lb	2 lb

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

Part	Load combination	Material	f_y [psi]	ε_{lim} [%]	σ_{Ed} [psi]	ε_{Pl} [%]	Status
Plate	Combination 1	ASTM A36	36,000	5.00	529	0.00	OK
Profile	Combination 1	ASTM A500 Gr.B Rect	46,000	5.00	2,784	0.00	OK
Profile	Combination 1	ASTM A500 Gr.B	46,000	5.00	2,783	0.00	OK

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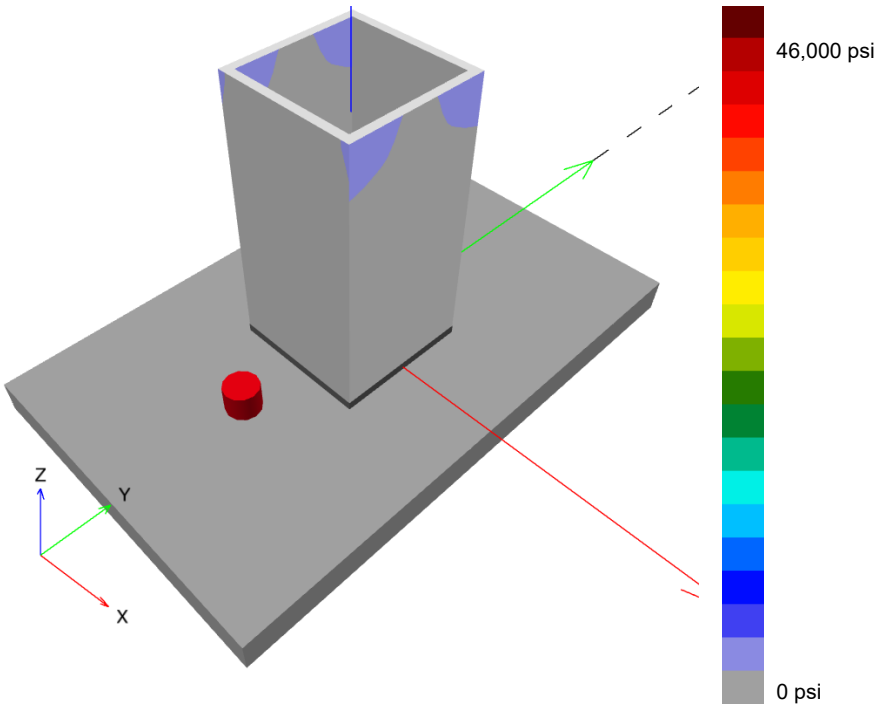
Part	Load combination	Material	f_y [psi]	ε_{lim} [%]	σ_{Ed} [psi]	ε_{Pl} [%]	Status
Profile	Combination 1	ASTM A500 Gr.B Rect	46,000	5.00	2,139	0.00	OK
Profile	Combination 1	ASTM A500 Gr.B Rect	46,000	5.00	2,139	0.00	OK

2.4.1.1 Equivalent stress

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



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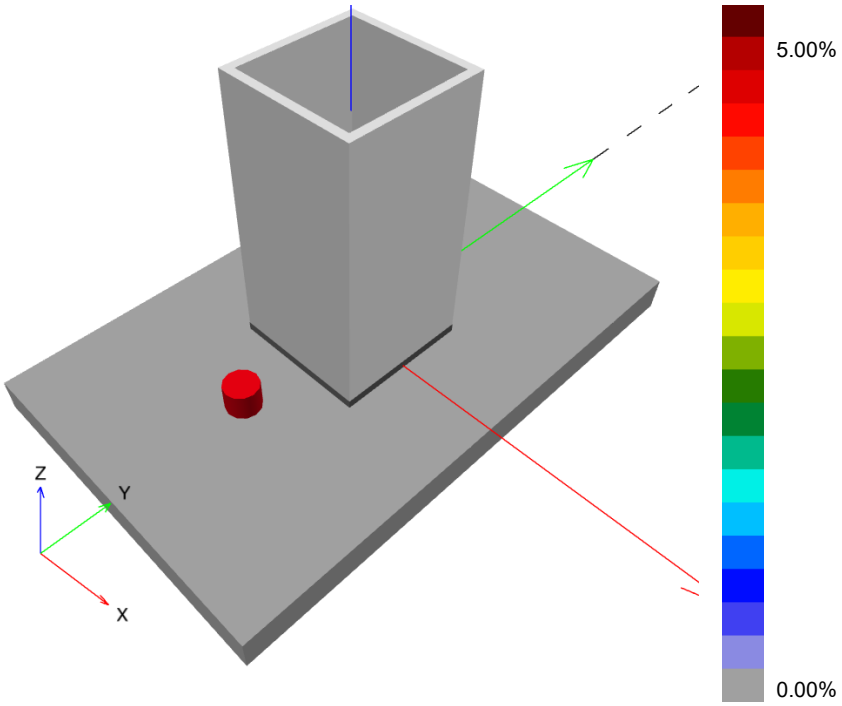
2.4.1.2 Plastic strain

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)

$\Phi R_n = 0.75\, R_n$

$V \leq \Phi R_n$

Variables

	l_c [in]	t [in]	F_u [psi]	d [in]	R_n [lb]
Anchor 1	2.188	0.500	58,000	0.500	34,800
Anchor 2	2.188	0.500	58,000	0.500	34,800

Results

	V [lb]	ΦR_n [lb]	Utilization [%]	Status
Anchor 1	170	26,100	1	OK
Anchor 2	170	26,100	1	OK

2.5 Concrete

Decisive load combination: 1 - Combination 1

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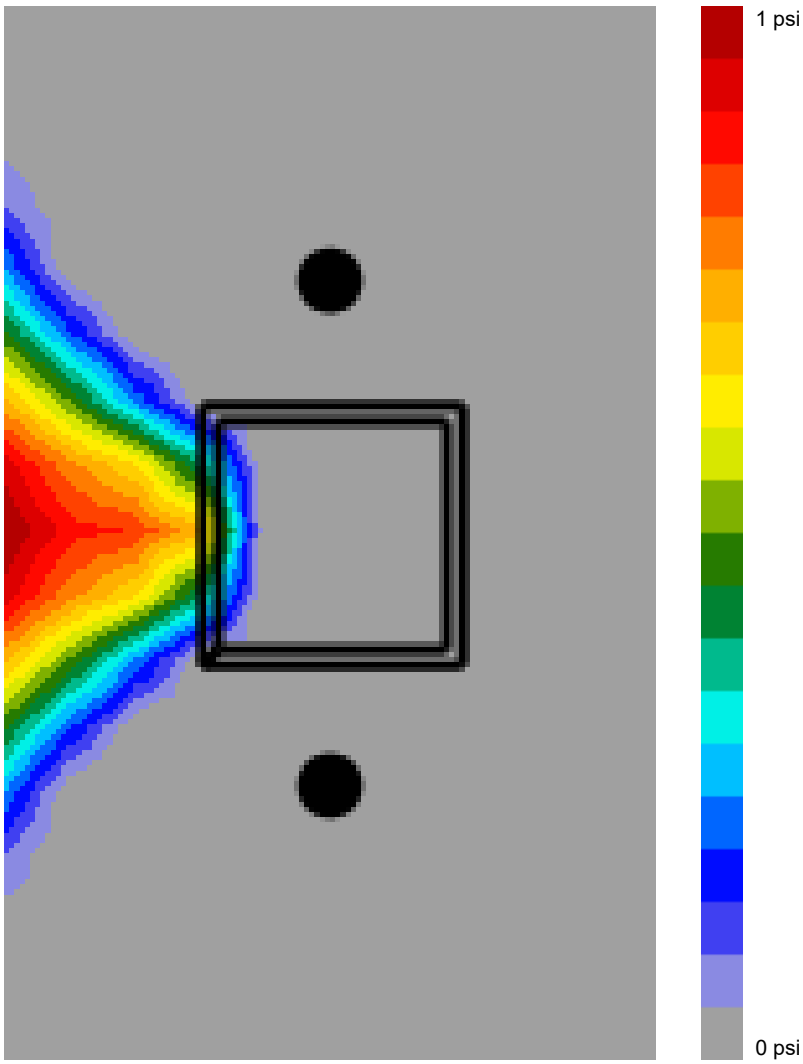
2.5.1 Compression in concrete under the anchor plate



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

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Equations

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

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

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

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

Variables

N [lb]	f_c' [psi]	Φ	A_1 [in²]	A_2 [in²]
4	2,500	0.65	8.38	526,416.23

Results

Load combination	F_p [psi]	σ [psi]	Utilization [%]	Status
Combination 1	2,762	0	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	4%	OK
Anchor plate	Combination 1	2%	OK
Concrete	Combination 1	1%	OK
Profile	Combination 1	7%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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

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Specifier's comments:

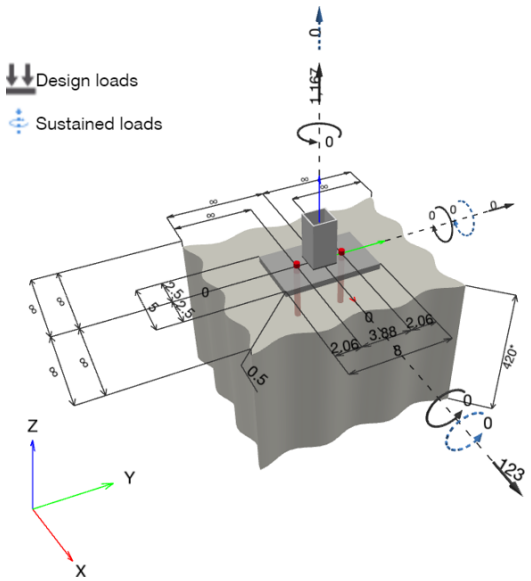
1 Anchor Design

1.1 Input data

Anchor type and diameter:	**KWIK-X 1/2 (4 1/4) hnom2**
Item number:	418076 KH-EZ 1/2"x5" (element) / 2362252 KHC 1/2" LARGE (capsule)
Effective embedment depth:	$h_{ef,opti}$ = 4.250 in. ($h_{ef,limit}$ = 5.500 in.), h_{nom} = 4.250 in.
Material:	Carbon Steel
Evaluation Service Report:	ESR-5065
Issued I Valid:	1/1/2023 | 12/1/2023
Proof:	Design Method ACI 318-19 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate[CBFEM]:	l_x x l_y x t = 5.000 in. x 8.000 in. x 0.500 in.;
Profile:	Square HSS (AISC), HSS2X2X.125; (L x W x T) = 2.000 in. x 2.000 in. x 0.125 in.
Base material:	cracked concrete, 2500, f_c' = 2,500 psi; h = 420.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: not present, shear: not present; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar

[CBFEM] - The anchor calculation is based on a component-based Finite Element Method (CBFEM)

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



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1.1.1 Design results

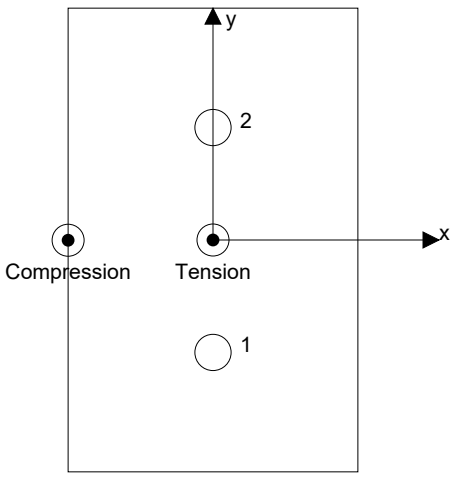
Case	Description	Forces [lb] / Moments [in.lb]	Seismic	Max. Util. Anchor [%]
1	Combination 1	N = 1,167; V_x = 123; V_y = 0; M_x = 0; M_y = 0; M_z = 0;	no	19

1.2 Load case/Resulting anchor forces

Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	584	62	62	3
2	584	62	61	-3



resulting tension force in (x/y)=(0.000/-0.000): 1,168 [lb]
resulting compression force in (x/y)=(-2.500/-0.004): 4 [lb]

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

1.3 Tension load

	Load N_{ua} [lb]	Capacity ϕ N_n [lb]	Utilization $\beta_N = N_{ua}/\phi$ N_n	Status
Steel Strength*	584	11,777	5	OK
Bond Strength**	1,168	10,560	12	OK
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Failure**	1,168	6,314	19	OK

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

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1.3.1 Steel Strength

N_{sa} = ESR value	refer to ICC-ES ESR-5065
$\phi\ N_{sa} \geq N_{ua}$	ACI 318-19 Table 17.5.2

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.16	112,540

Calculations

N_{sa} [lb]
18,119

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
18,119	0.650	11,777	584

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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)

$\psi_{cp,Na} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{c_{Na}}{c_{ac}}\right) \leq 1.0$ 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]
2,126	0.500	4.250	∞	1.000	1,901

$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	c_{ac} [in.]	λ_a
0.000	0.000	6.724	1.000

Calculations

c_{Na} [in.]	A_{Na} [in.^{2}]	A_{Na0} [in.^{2}]	$\psi_{ed,Na}$
6.919	245.20	191.50	1.000

$\psi_{ec1,Na}$	$\psi_{ec2,Na}$	$\psi_{cp,Na}$	N_{ba} [lb]
1.000	1.000	1.000	12,688

Results

N_{ag} [lb]	ϕ_{bond}	ϕN_{ag} [lb]	N_{ua} [lb]
16,246	0.650	10,560	1,168

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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)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ 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.]	$\psi_{c,N}$
4.250	0.000	0.000	∞	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
6.724	17	1.000	2,500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
212.04	162.57	1.000	1.000	1.000	1.000	7,447

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
9,714	0.650	6,314	1,168

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1.4 Shear load

	Load V_{ua} [lb]	Capacity ϕ V_n [lb]	Utilization $\beta_V = V_{ua}/\phi$ V_n	Status
Steel Strength*	62	5,547	2	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	123	13,598	1	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

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

1.4.1 Steel Strength

V_{sa} = ESR value refer to ICC-ES ESR-5065
ϕ $V_{steel} \geq V_{ua}$ ACI 318-19 Table 17.5.2

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
0.16	112,540

Calculations

V_{sa} [lb]
9,245

Results

V_{sa} [lb]	ϕ_{steel}	ϕ V_{sa} [lb]	V_{ua} [lb]
9,245	0.600	5,547	62

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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)

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

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

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

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	4.250	0.000	0.000	∞

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	6.724	17	1.000	2,500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
212.04	162.57	1.000	1.000	1.000	1.000	7,447

Results

V_{cpg} [lb]	$\phi_{concrete}$	ϕV_{cpg} [lb]	V_{ua} [lb]
19,426	0.700	13,598	123

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

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.185	0.011	5/3	7	OK

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

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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."

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1.7 Installation data

Profile: Square HSS (AISC), HSS2X2X.125; (L x W x T) = 2.000 in. x 2.000 in. x 0.125 in.

Hole diameter in the fixture: d_f = 0.625 in.

Plate thickness (input): 0.500 in.

Drilling method: Hammer drilled

Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: KWIK-X 1/2 (4 1/4) hnom2

Item number: 418076 KH-EZ 1/2"x5" (element) / 2362252 KHC 1/2" LARGE (capsule)

Maximum installation torque: -

Hole diameter in the base material: 0.500 in.

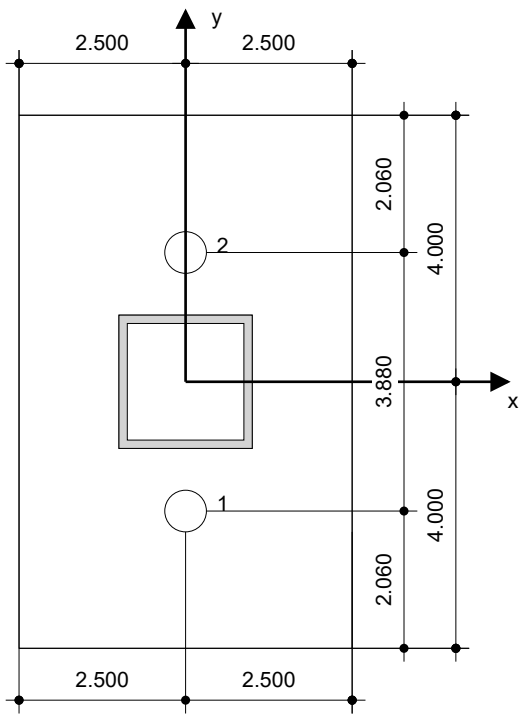
Hole depth in the base material: 5.250 in.

Minimum thickness of the base material: 6.500 in.

1/2 (4 1/4) hnom2 Hilti KH-EZ Carbon steel screw anchor with Hilti KHC

1.7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• No accessory required	• SIW 6-A22 Impact Screw Driver



Coordinates Anchor [in.]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.000	-1.940	-	-	-	-
2	0.000	1.940	-	-	-	-

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2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular l_x x l_y x t = 5.000 in x 8.000 in x 0.500 in Calculation: CBFEM Material: ASTM A36; F_y = 36,000 psi; ε_{lim} = 5.00%
Anchor type and size:	KWIK-X 1/2 (4 1/4) hnom2, h_{ef} = 4.250 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 = 0.500 in
Profile:	HSS2X2X.125; (L x W x T x FT) = 2.000 in x 2.000 in x 0.125 in x - 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:	Cracked concrete; 2500; $f_{c,cyl}$ = 2,500 psi; h = 420.000 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	4,204	0.00	2,452	0.00	1	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	584 lb	584 lb
Anchor 2	584 lb	584 lb

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

Part	Load combination	Material	f_y [psi]	ε_{lim} [%]	σ_{Ed} [psi]	ε_{Pl} [%]	Status
Plate	Combination 1	ASTM A36	36,000	5.00	2,452	0.00	OK
Profile	Combination 1	ASTM A500 Gr.B Rect	46,000	5.00	3,920	0.00	OK
Profile	Combination 1	ASTM A500 Gr.B	46,000	5.00	4,204	0.00	OK

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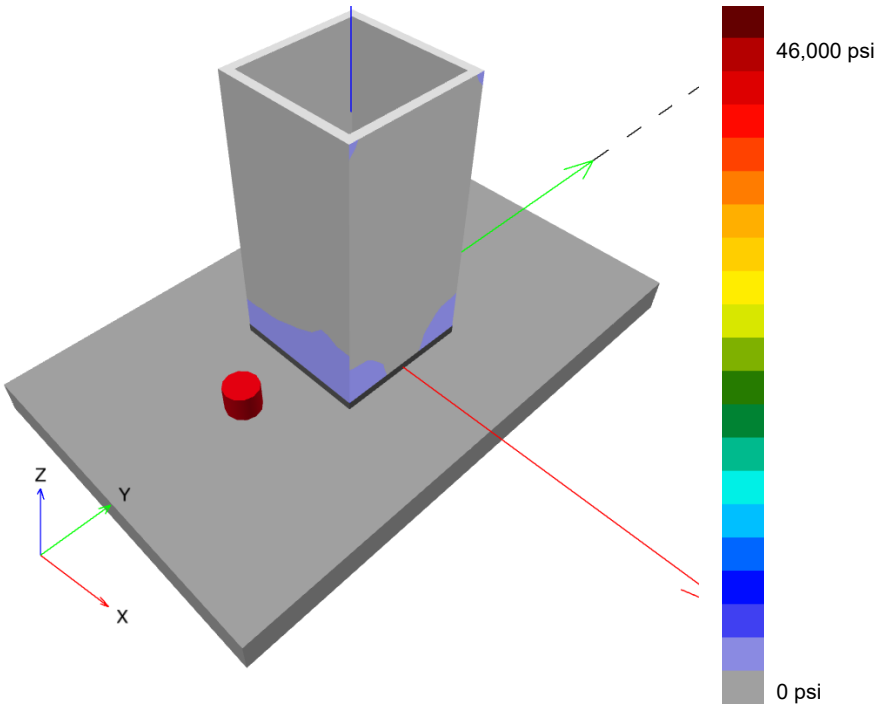
Part	Load combination	Material	f_y [psi]	ε_{lim} [%]	σ_{Ed} [psi]	ε_{Pl} [%]	Status
Profile	Combination 1	ASTM A500 Gr.B Rect	46,000	5.00	3,997	0.00	OK
Profile	Combination 1	ASTM A500 Gr.B Rect	46,000	5.00	3,997	0.00	OK

2.4.1.1 Equivalent stress

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



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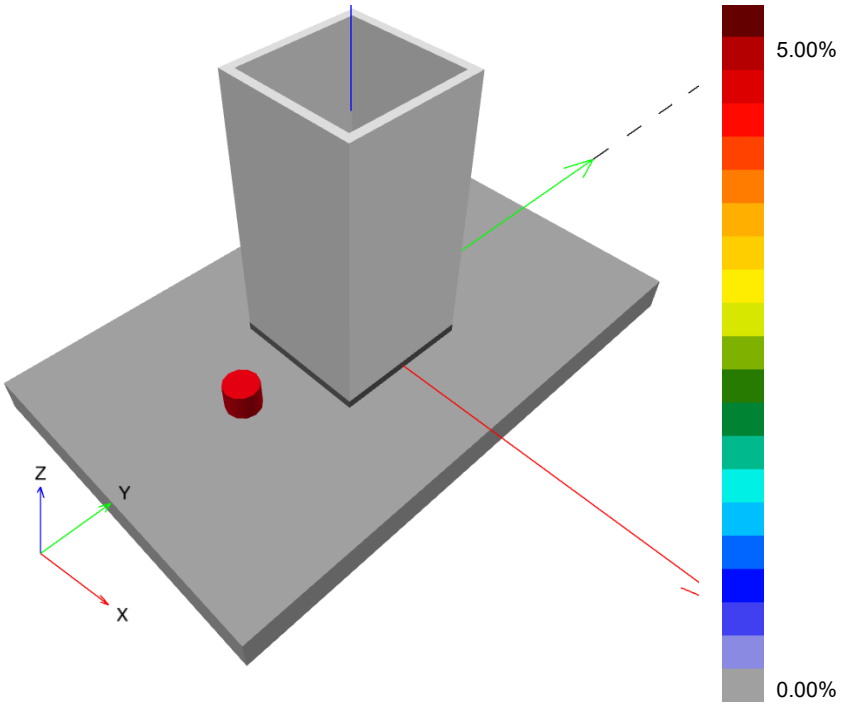
Fastening point:			

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 [lb]
Anchor 1	2.190	0.500	58,000	0.500	34,800
Anchor 2	2.190	0.500	58,000	0.500	34,800

Results

	V [lb]	ΦR_n [lb]	Utilization [%]	Status
Anchor 1	62	26,100	1	OK
Anchor 2	61	26,100	1	OK

2.5 Concrete

Decisive load combination: 1 - Combination 1

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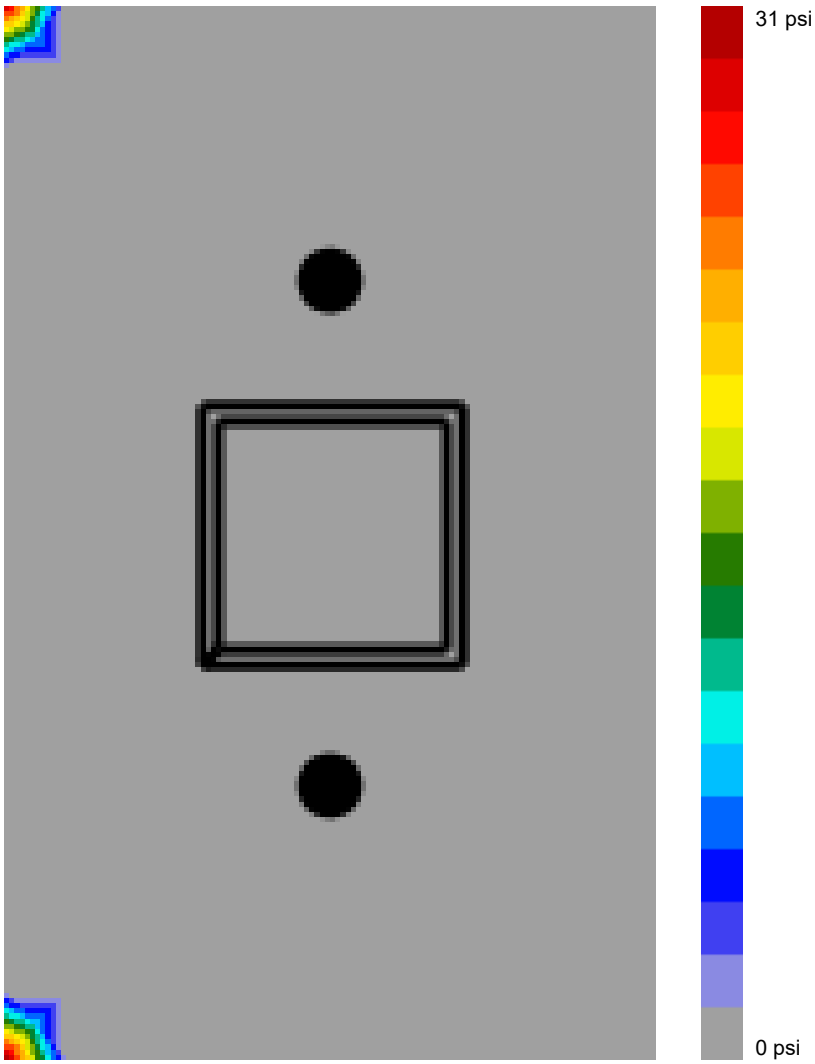
2.5.1 Compression in concrete under the anchor plate



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

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Equations

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

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

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

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

Variables

N [lb]	f_c' [psi]	Φ	A_1 [in²]	A_2 [in²]
4	2,500	0.65	0.50	534,782.11

Results

Load combination	F_p [psi]	σ [psi]	Utilization [%]	Status
Combination 1	2,762	8	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	19%	OK
Anchor plate	Combination 1	7%	OK
Concrete	Combination 1	1%	OK
Profile	Combination 1	10%	OK

Fastening meets the design criteria!

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4 Remarks; Your Cooperation Duties

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Kansas City, MO 64129
(816) 444-6500

Invoice

Date	Invoice #
2/22/2021	15681

PAID 02/22/2021

Bill To	Ship To
Midwest Distribution 10 N.E. Skyline Dr. Lee's Summit MO. 64086	Midwest Distribution 10 N.E. Skyline Dr. Lee's Summit MO. 64086 Steve 816-246-2149

P.O. Number	Terms	Rep	Ship	Via
		ST	2/22/2021	

Qty	Item	Description	Price Each	Amount
8	NEupright48"x144"	Teardrop upright 48"x144" Green NEW (15,300#)	105.00	840.00T
30	NEBeams96"x4"	Teardrop Beams 96" x 4" NEW (5,370#)	32.50	975.00T
1	Delivery	Delivery customer asked for discount	75.00	75.00

X

Seller makes no representation, warranties or covenants with respect to the property being sold, whether expressed, implied, or otherwise; and transfers all property being sold as is, where is, with all faults and no warranty on merchantability or fitness by seller. Buyer waives any rights it has by statute or otherwise with respect to the property being sold and agrees to indemnify seller against claims made by its officers, agents, employees or transferees. CREDIT CARD PAYMENTS WILL BE CHARGED A 3.5% PROCESSING FEE.

Subtotal	$1,890.00
Sales Tax (8.6%)	$156.09
Total	$2,046.09
Payments/Credits	-$2,046.09
Balance Due	$0.00

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Bill To	Ship To
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P.O. Number	Terms	Rep	Ship	Via
		AC	6/16/2021	

Qty	Item	Description	Price Each	Amount
42	U303036-144	36" x 144" Tear Drop Upright-NEW BLUE in stock (15,300#)	109.00	4,578.00T
144	NEBeams96"x4.5"	Teardrop Beams 96" x 4.5" (5500#) lb NEW in stock	44.00	6,336.00T
144	WD3646WW	36"x46" Step Wire Deck, 2500 lb capacity each NEW in stock (2,500#)	19.00	2,736.00T
		Delivery week of July 6		

X

Subtotal	$13,650.00
Sales Tax (5.6%)	$764.40
Total	$14,414.40
Payments/Credits	$14,414.40
Balance Due	$0.00

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P.O. Number	Terms	Rep	Ship	Via
		TR	10/20/2023	Certified Tow

Qty	Item	Description	Price Each	Amount
8	U303048-240	48" x 240" Tear Drop Upright-NEW BLUE	334.00	2,672.00T
12	U303036-240	36" x 240" Tear Drop Upright-NEW BLUE	278.00	3,336.00T
46	NEupright36"x240"	36" x 240" Tear Drop Upright- GREEN	278.00	12,788.00T
2	Delivery	Delivery	150.00	300.00

X

Subtotal	$19,096.00
Sales Tax (5.6%)	$1,052.58
Total	$20,148.58
Payments/Credits	$0.00
Balance Due	$20,148.58

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Thank you for your business!!
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