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Company:		Page:	1
Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	Concrete - Apr 5, 2023	Date:	4/5/2023
Fastening point:			

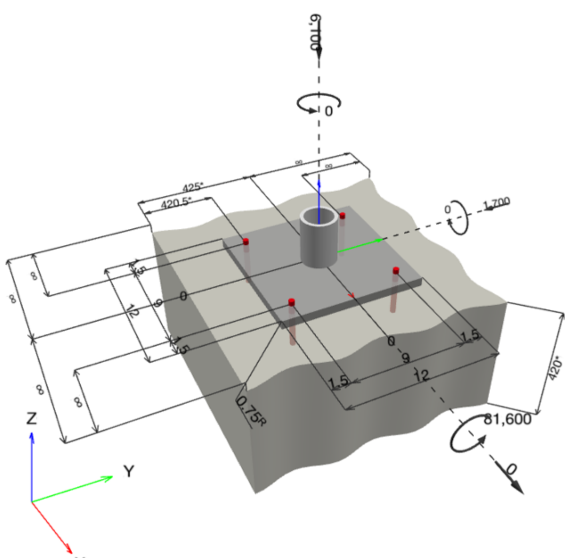
Specifier's comments:

1 Input data

Anchor type and diameter:	**HSL-3-R M12**
Item number:	2159983 HSL-3-R M12 25/-/-
Effective embedment depth:	$h_{ef,act}$ = 3.150 in.
Material:	A4
Evaluation Service Report:	ESR-1545
Issued I Valid:	3/1/2022 | 3/1/2024
Proof:	Design Method ACI 318-19 / Mech
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.750 in.
Anchor plate[R] :	l_x x l_y x t = 12.000 in. x 12.000 in. x 0.750 in.;
Profile:	Round HSS (AISC), HSS3X.300; (L x W x T) = 3.000 in. x 3.000 in. x 0.300 in.
Base material:	cracked concrete, 4000, f_c' = 4,000 psi; h = 420.000 in.
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: present, shear: present; no supplemental splitting reinforcement present
	edge reinforcement: > No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (17.10.5.3 (a))
	Shear load: yes (17.10.6.3 (a))

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

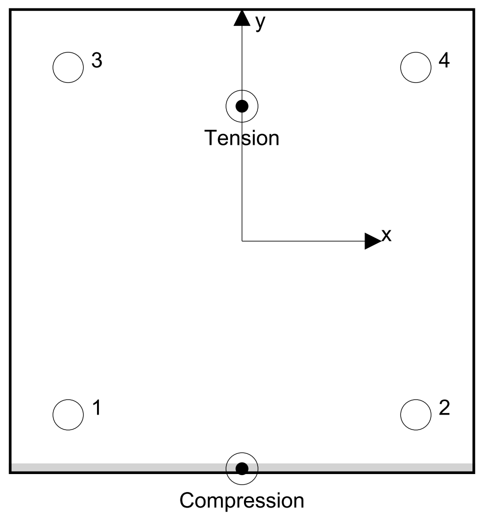
Geometry [in.] & Loading [lb, in.lb]



1.1 Design results

Case	Description	Forces [lb] / Moments [in.lb]	Seismic	Max. Util. Anchor [%]
1	Combination 1	$N = -6{,}100$; $V_x = 0$; $V_y = -1{,}700$; $M_x = 81{,}600$; $M_y = 0$; $M_z = 0$;	yes	27

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	271	425	0	-425
2	271	425	0	-425
3	2,158	425	0	-425
4	2,158	425	0	-425

max. concrete compressive strain:	0.01 [‰]
max. concrete compressive stress:	4,420 [psi]
resulting tension force in (x/y)=(0.000/3.495):	4,858 [lb]
resulting compression force in (x/y)=(0.000/-5.897):	10,958 [lb]

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

3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	2,158	15,919	14	not recommended
Pullout Strength*	2,158	8,474	26	not recommended[A]
Concrete Breakout Failure**	4,858	18,589	27	not recommended[A]

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

[A] When 17.10.5.3 (a) is selected for seismic design, the design steel strength must be the governing design strength having the highest utilization.

3.1 Steel Strength

N_{sa} = ESR value refer to ICC-ES ESR-1545
$\phi\ N_{sa} \geq N_{ua}$ ACI 318-19 Table 17.5.2

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.13	101,500

Calculations

N_{sa} [lb]
13,266

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
13,266	1.200	15,919	2,158

3.2 Pullout Strength

$N_{pn,f'_c} = N_{p,2500}\ \lambda_a\ (f_c'/2500)^{0.5}$ refer to ICC-ES ESR-1545
$\phi\ N_{pn,f'_c} \geq N_{ua}$ ACI 318-19 Table 17.5.2

Variables

f'_c [psi]	λ_a	$N_{p,2500}$ [lb]
4,000	1.000	6,699

Calculations

$(f_c'/2500)^{0.5}$
1.265

Results

N_{pn,f'_c} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi\ N_{pn,f'_c}$ [lb]	N_{ua} [lb]
8,474	1.000	1.000	8,474	2,158

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)

$\psi_{cp,N} = MAX\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ 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.]	$\psi_{c,N}$
3.150	0.000	3.495	420.500	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
8.625	24	1.000	4,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
340.40	89.30	1.000	0.575	1.000	1.000	8,484

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
18,589	1.000	1.000	18,589	4,858

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4 Shear load

	Load V_{ua} [lb]	Capacity $\phi\ V_n$ [lb]	Utilization $\beta_V = V_{ua}/\phi\ V_n$	Status
Steel Strength*	425	4,603	10	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	1,700	45,278	4	OK
Concrete edge failure in direction y-**	1,700	2,732,990	1	OK

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

4.1 Steel Strength

$V_{sa,eq}$ = ESR value refer to ICC-ES ESR-1545

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

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]	$\alpha_{V,seis}$
0.13	101,500	0.387

Calculations

$V_{sa,eq}$ [lb]
7,082

Results

$V_{sa,eq}$ [lb]	ϕ_{steel}	$\phi_{nonductile}$	$\phi\ V_{sa,eq}$ [lb]	V_{ua} [lb]
7,082	0.650	1.000	4,603	425

4.2 Pryout Strength

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

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

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

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

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

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

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

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

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	3.150	0.000	0.000	420.500

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	8.625	24	1.000	4,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
340.40	89.30	1.000	1.000	1.000	1.000	8,484

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi \; V_{cpg}$ [lb]	V_{ua} [lb]
64,682	0.700	1.000	1.000	45,278	1,700

4.3 Concrete edge failure in direction y-

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

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

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

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

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

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

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

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

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
420.500	-	0.000	1.200	420.000

l_e [in.]	λ_a	d_a [in.]	f_c' [psi]	$\psi_{parallel,V}$
1.420	1.000	0.710	4,000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
533,610.00	795,691.13	1.000	1.000	1.225	3,694,980

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi_{seismic}$	$\phi_{nonductile}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
3,643,986	0.750	1.000	1.000	2,732,990	1,700

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

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.261	0.092	5/3	13	OK

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

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.
- Refer to the manufacturer's product literature for cleaning and installation instructions.
- For additional information about ACI 318 strength design provisions, please go to https://submittals.us.hilti.com/PROFISAnchorDesignGuide/
- "An anchor design approach for structures assigned to Seismic Design Category C, D, E or F is given in ACI 318-19, Chapter 17, Section 17.10.5.3 (a) that requires the governing design strength of an anchor or group of anchors be limited by ductile steel failure. If this is NOT the case, the connection design (tension) shall satisfy the provisions of Section 17.10.5.3 (b), Section 17.10.5.3 (c), or Section 17.10.5.3 (d). The connection design (shear) shall satisfy the provisions of Section 17.10.6.3 (a), Section 17.10.6.3 (b), or Section 17.10.6.3 (c)."
- Section 17.10.5.3 (b) / Section 17.10.6.3 (a) require the attachment the anchors are connecting to the structure be designed to undergo ductile yielding at a load level corresponding to anchor forces no greater than the controlling design strength. Section 17.10.5.3 (c) / Section 17.10.6.3 (b) waive the ductility requirements and require the anchors to be designed for the maximum tension / shear that can be transmitted to the anchors by a non-yielding attachment. Section 17.10.5.3 (d) / Section 17.10.6.3 (c) waive the ductility requirements and require the design strength of the anchors to equal or exceed the maximum tension / shear obtained from design load combinations that include E, with E increased by ω_0.
- Hilti post-installed anchors shall be installed in accordance with the Hilti Manufacturer's Printed Installation Instructions (MPII). Reference ACI 318-19, Section 26.7.

Fastening does not meet 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	4,420 [psi]	4,420 [psi]	100	OK
Tension Interface	1,483.63 [in.lb/in.]	4,556.25 [in.lb/in.]	33	OK
Uniaxial Moment (Strong Axis)	1,275.45 [in.lb/in.]	4,556.25 [in.lb/in.]	28	OK
Uniaxial Moment (Weak Axis)	4,290.96 [in.lb/in.]	4,556.25 [in.lb/in.]	95	OK

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

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

Variables

B [in.]	N [in.]	L [in.]	W [in.]
12.000	12.000	850.000	850.000

f_c' [psi]	ϕ	P_u [lb]	M_u [in.lb]
4,000	0.650	6,100	0

Calculations

A_1 [in.^{2}]	A_2 [in.^{2}]
144.00	722,500.00

Results

f_{pu} [psi]	$f_{pu(max)}$ [psi]
4,420	4,420

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

$$A_1 = B \cdot N$$
$$A_2 = L \cdot W$$
$$f_{pu(max)} = \phi \left(0.85 f'_c \sqrt{\frac{A_2}{A_1}}\right), \sqrt{\frac{A_2}{A_1}} \leq 2$$
$$m = \frac{N-0.8d}{2}$$
$$n = \frac{B-0.8b_f}{2}$$
$$M_{pl1} = C_r \cdot \frac{x}{b_{eff}}$$
$$\phi M_n = \phi \cdot F_y \cdot \frac{t_p^2}{4}$$
$$M_{pl1} \leq \phi M_n$$

Variables

B [in.]	N [in.]	L [in.]	W [in.]	d [in.]	b_f [in.]
12.000	12.000	850.000	850.000	3.000	3.000

F_y [psi]	ϕ	t_p [in.]	P_u [lb]	M_u [in.lb]
36,000	0.900	0.750	6,100	81,600

Calculations

A_1 [in.^{2}]	A_2 [in.^{2}]	$f_{pu(max)}$ [psi]	m [in.]	n [in.]
144.00	722,500.00	4,420	4.800	4.800

f_{pu} [psi]	C_r [lb]	x [in.]	b_{eff} [in.]	M_{pl1} [in.lb/in.]
4,420	10,958	1.397	12.000	1,275.45

Results

M_n [in.lb/in.]	ϕ	ϕM_n [in.lb/in.]	M_{pl1} [in.lb/in.]
5,062.49	0.900	4,556.25	1,275.45

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

$A_1 = B \cdot N$

$A_2 = L \cdot W$

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

$m = \frac{N-0.8d}{2}$

$n = \frac{B-0.8b_f}{2}$

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

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

$M_{pl2} \leq \phi M_n$

Variables

B [in.]	N [in.]	L [in.]	W [in.]	d [in.]	b_f [in.]
12.000	12.000	850.000	850.000	3.000	3.000

F_y [psi]	ϕ	t_p [in.]	P_u [lb]	M_u [in.lb]
36,000	0.900	0.750	6,100	81,600

Calculations

A_1 [in.^{2}]	A_2 [in.^{2}]	$f_{pu(max)}$ [psi]	m [in.]	n [in.]
144.00	722,500.00	4,420	4.800	4.800

f_{pu} [psi]	C_r [lb]	x [in.]	b_{eff} [in.]	M_{pl2} [in.lb/in.]
4,420	4,383	4.800	4.903	4,290.96

Results

M_n [in.lb/in.]	ϕ	ϕ M_n [in.lb/in.]	M_{pl2} [in.lb/in.]
5,062.49	0.900	4,556.25	4,290.96

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

$$m = \frac{N-0.8d}{2}$$

$$n = \frac{B-0.8b_f}{2}$$

$$M_{pl} = \frac{T_u \cdot x}{b_{eff}}$$

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

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

Variables

B [in.]	N [in.]	d [in.]	b_f [in.]	F_y [psi]
12.000	12.000	3.000	3.000	36,000

ϕ	t_p [in.]	P_u [lb]	M_u [in.lb]
0.900	0.750	6,100	81,600

Calculations

m [in.]	n [in.]
4.800	4.800

T_u [lb]	x [in.]	b_{eff} [in.]
2,158	3.300	4.800

Results

M_n [in.lb/in.]	ϕ	ϕM_n [in.lb/in.]	M_{pl} [in.lb/in.]
5,062.49	0.900	4,556.25	1,483.63

8 Installation data

Profile: Round HSS (AISC), HSS3X.300; (L x W x T) = 3.000 in. x 3.000 in. x 0.300 in.

Hole diameter in the fixture: d_f = 0.787 in.

Plate thickness (input): 0.750 in.

Drilling method: Hammer drilled

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

Anchor type and diameter: HSL-3-R M12

Item number: 2159983 HSL-3-R M12 25/-/-

Maximum installation torque: 708 in.lb

Hole diameter in the base material: 0.709 in.

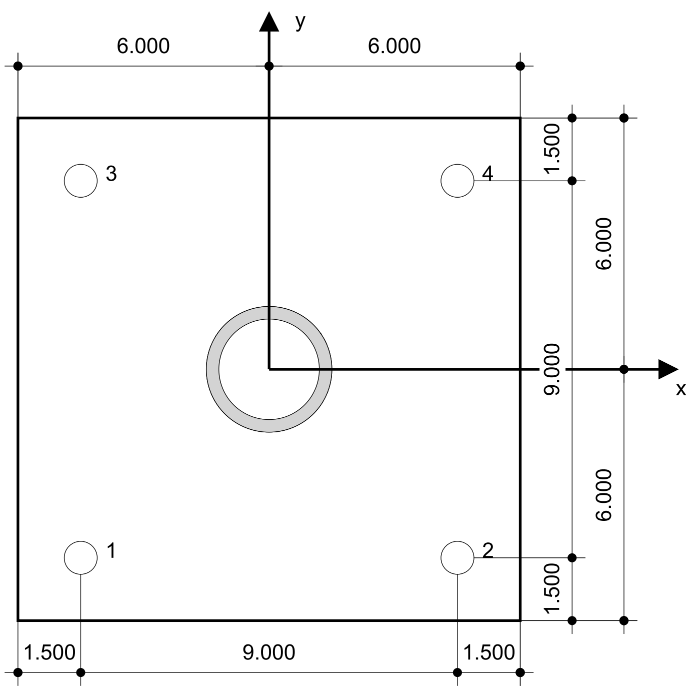
Hole depth in the base material: 4.134 in.

Minimum thickness of the base material: 6.250 in.

Hilti HSL-3 expansion anchor with 3.149606 in embedment, M12, Stainless steel, installation per ESR-1545

8.1 Recommended accessories

Drilling	Cleaning	Setting
• -	• -	• -



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-4.500	-4.500	-	-	420.500	-
2	4.500	-4.500	-	-	420.500	-
3	-4.500	4.500	-	-	429.500	-
4	4.500	4.500	-	-	429.500	-

9 Remarks; Your Cooperation Duties

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