Edward C. Robison, PE, SE

02 January 2013

Architectural Metal Works
ATTN: Sean Wentworth
1483 67th ST
Emeryville, CA 94608

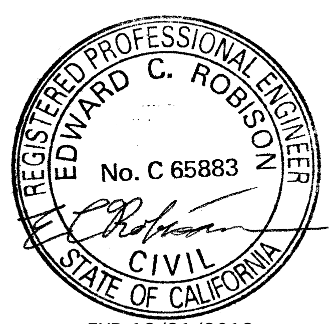
SUBJ: 501 CORTE MADERA AVE, CORTE MADERA, CA 94925
BALCONY GUARD BASE PLATE MOUNTS

The guards for the subject project were designed and approved using posts embedded 3 inches into the concrete deck. It is proposed to revise the mounting method to using 5" square base plates attached to the deck using post installed expansion anchors.

The revised anchorage is designed for 200# concentrated load on the top rail. This is based on an effective post spacing of under 4' on center as the tributary rail length to any single post will be effectively under 4' so the distributed load cases won't control.

Base plate shall be 5"x5" x ⅜" fabricated from aluminum 6061-T6 plate.
Base plate shall be attached to the post bars using two ⅜" ASTM F 879 (or equivalent strength) stainless steel countersunk screws into each bar (four total per post)
Anchorage to the slab shall use ⅜" diameter Hilti Kwik-Bolt 3.
Minimum slab edge distance (center line of anchors to edge of slab is 2.8"

Edward Robison, P.E.



EXP 12/31/2013
Signed 01/02/2013

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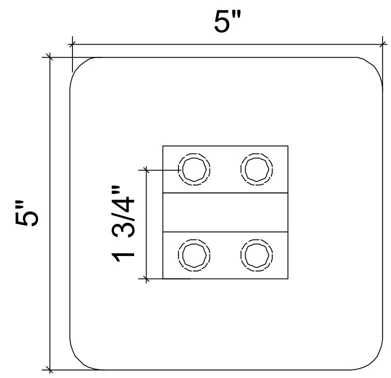

Connection to base plate
Tension load on screws:
T = 200#*42"/(2*1.75") = 2,400# each
Failure modes → screw tension
→ screw shear
→ screw withdrawal
Base plate to post screws are 304 Stainless steel ASTM F879-98 Stainless Steel Countersunk Head Cap Screw

For screw withdrawal
See ADM 5.4

$W = 2.3 \bullet e \bullet d \bullet \pi \bullet F_{sy}$
Screw into tapped hole.
e = full thread engagement = 1"
d = max root diameter = 0.248" (¼" screw)
minor = 0.185"

$F_{sy} = 20$ ksi

$W = 2/3 \bullet 1" \bullet 0.248" \bullet \pi \bullet 20^{ksi}$
$W = 10.39^{k}$
$W' = \frac{10.39}{3.0}$ Safety factor $= 3.46^{k}$

Screw tension → From ASTM F 879 Table 3
For ¼" screw: T_n = 2,420#; T_s = 0.75*2,420/1.6 = 1,134#
For 5/16" screw: T_n = 3,980#; T_s = 0.75*3,980/1.6 = 1,866#
For 3/8" screw: T_n = 5,890#; T_s = 0.75*5,890/1.6 = 2,761# ≥ 2,400# Use ⅜" screws.

Requires ⅜" screws-

Base plate bending stress
$F_t = 24 \text{ ksi} \rightarrow S_{min} = \frac{5" \bullet 3/8^2}{6} = 0.117 \text{ in}^3$

Base plate allowable moment - 6061-T6 aluminum plate
$M_a = 28\text{ksi}*0.117\text{in}^3 = 3{,}276"\#$

Moment arm from centerline of post screws to edge of anchorage = 0.920"
Maximum allowable anchor tension load:
$T_{aanchor}$ = 3,276"#/(2*0.920) = 1,780# each

Maximum allowable moment on post based on base plate bending:
Mmax = 1,780#*2anchors*3.75" = 13,350"# ≥ 8,400"# Base plate okay at ⅜" thick.

BASE PLATE MOUNTED TO CONCRETE - Expansion Bolt Alternative:
Base plate mounted to concrete with Hilti Kwik Bolt 3 in accordance with ESR-2302 wedge anchor 3/8"x3" concrete anchors with 2" effective embedment (2.625" nominal). Minimum conditions used for the calculations:
$f'_c \geq 3{,}000$ psi
Edge distance ≥ 2.8"

See attached Hilti Profis Design report.

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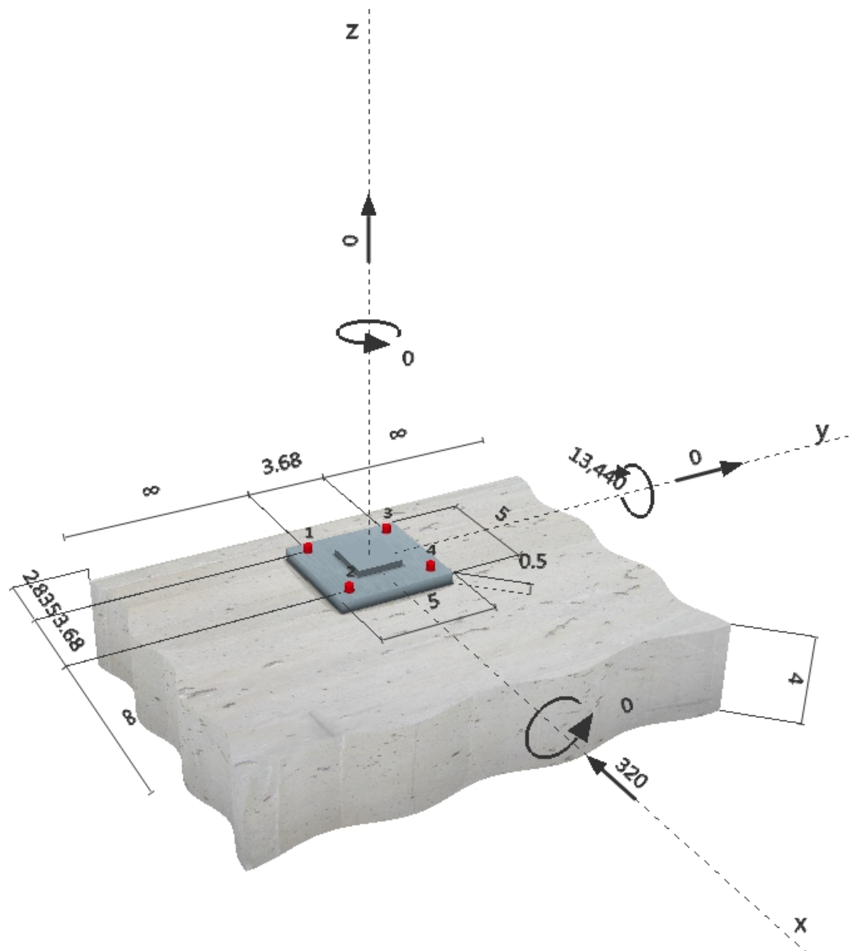
E-Mail:	elrobison@narrows.com		

Specifier's comments: Guard Base Plate Mounts

1 Input data

Anchor type and diameter:	**Kwik Bolt 3 - SS 3/8 (2)**
Effective embedment depth:	h_{ef} = 2.000 in., h_{nom} = 2.625 in.
Material:	AISI 304
Evaluation Service Report::	ESR 2302
Issued I Valid:	6/1/2012 | 12/1/2013
Proof:	design method ACI 318 / AC193
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 5.000 in. x 5.000 in. x 0.500 in.; (Recommended plate thickness: not calculated)
Profile:	Rectangular plates and bars (AISC); (L x W x T) = 2.125 in. x 2.000 in. x 0.000 in.
Base material:	uncracked concrete, 3000, f_c' = 3000 psi; h = 4.000 in.
Reinforcement:	tension: condition A, shear: condition A; no supplemental splitting reinforcement present
	edge reinforcement: > No. 4 bar
Seismic loads (cat. C, D, E, or F)	no

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



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2 Load case/Resulting anchor forces

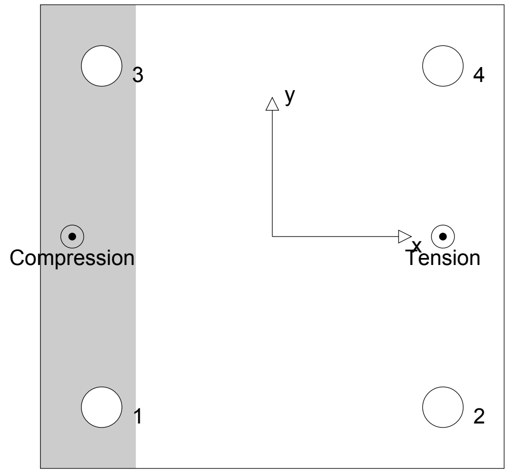
Load case: Design loads

Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	80	-80	0
2	1681	80	-80	0
3	0	80	-80	0
4	1681	80	-80	0

max. concrete compressive strain: 0.30 [‰]
max. concrete compressive stress: 1307 [psi]
resulting tension force in (x/y)=(1.840/0.000): 3363 [lb]
resulting compression force in (x/y)=(-2.157/0.000): 3363 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	1681	5175	33	OK
Pullout Strength*	1681	2111	80	OK
Concrete Breakout Strength**	3363	4499	75	OK

* anchor having the highest loading **anchor group (anchors in tension)

3.1 Steel Strength

N_{sa} = ESR value refer to ICC-ES ESR 2302

$\phi N_{steel} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

Variables

n	$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
1	0.06	115000

Calculations

N_{sa} [lb]
6900

Results

N_{sa} [lb]	ϕ_{steel}	ϕN_{sa} [lb]	N_{ua} [lb]
6900	0.750	5175	1681

3.2 Pullout Strength

$N_{pn,f'_c} = N_{p,2500}\sqrt{\frac{f'_c}{2500}}$ refer to ICC-ES ESR 2302

$\phi N_{pn,f'_c} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

Variables

f'_c [psi]	$N_{p,2500}$ [lb]
3000	2965

Calculations

$\sqrt{\frac{f'_c}{2500}}$
1.095

Results

N_{pn,f'_c} [lb]	$\phi_{concrete}$	$\phi N_{pn,f'_c}$ [lb]	N_{ua} [lb]
3248	0.650	2111	1681

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3.3 Concrete Breakout Strength

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b$ ACI 318-08 Eq. (D-5)

$\phi\ N_{cbg} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

A_{Nc} see ACI 318-08, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-08 Eq. (D-6)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e'_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-08 Eq. (D-9)

$\psi_{ed,N} = 0.7 + 0.3\left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-08 Eq. (D-11)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-08 Eq. (D-13)

$N_b = k_c\ \lambda\ \sqrt{f'_c}\ h_{ef}^{1,5}$ ACI 318-08 Eq. (D-7)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
2.000	0.000	0.000	6.515	1.000

c_{ac} [in.]	k_c	λ	f'_c [psi]
4.375	24	1	3000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
58.08	36.00	1.000	1.000	1.000	1.000	3718

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
5998	0.750	4499	3363

4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	80	3237	3	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	320	4491	8	OK
Concrete edge failure in direction x-**	320	2285	15	OK

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

V_{sa} = ESR value refer to ICC-ES ESR 2302

$\phi\, V_{steel} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

Variables

n	$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
1	0.06	115000

Calculations

V_{sa} [lb]
4980

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\, V_{sa}$ [lb]	V_{ua} [lb]
4980	0.650	3237	80

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 318-08 Eq. (D-31)

$\phi\, V_{cpg} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

A_{Nc} see ACI 318-08, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9\, h_{ef}^2$ ACI 318-08 Eq. (D-6)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\, e_N'}{3\, h_{ef}}} \right) \leq 1.0$ ACI 318-08 Eq. (D-9)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}} \right) \leq 1.0$ ACI 318-08 Eq. (D-11)

$\psi_{cp,N} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}} \right) \leq 1.0$ ACI 318-08 Eq. (D-13)

$N_b = k_c\, \lambda\, \sqrt{f_c'}\, h_{ef}^{1.5}$ ACI 318-08 Eq. (D-7)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
1	2.000	0.000	0.000	2.835

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ	f_c' [psi]
1.000	4.375	24	1	3000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
92.11	36.00	1.000	1.000	0.984	0.686	3718

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi\, V_{cpg}$ [lb]	V_{ua} [lb]
6415	0.700	4491	320

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4.3 Concrete edge failure in direction x-

$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ec,V}\, \psi_{ed,V}\, \psi_{c,V}\, \psi_{h,V}\, \psi_{parallel,V}\, V_b$ ACI 318-08 Eq. (D-22)

$\phi\, V_{cbg} \geq V_{ua}$ ACI 318-08 Eq. (D-2)

A_{Vc} see ACI 318-08, Part D.6.2.1, Fig. RD.6.2.1(b)

$A_{Vc0} = 4.5\, c_{a1}^2$ ACI 318-08 Eq. (D-23)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e'_V}{3c_{a1}}}\right) \leq 1.0$ ACI 318-08 Eq. (D-26)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ ACI 318-08 Eq. (D-28)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ ACI 318-08 Eq. (D-29)

$V_b = \left(7 \left(\frac{l_e}{d_a}\right)^{0.2} \sqrt{d_a}\right) \lambda \sqrt{f'_c}\, c_{a1}^{1.5}$ ACI 318-08 Eq. (D-24)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
2.835	-	0.000	1.400	4.000

l_e [in.]	λ	d_a [in.]	f'_c [psi]	$\psi_{parallel,V}$
2.000	1	0.375	3000	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
48.74	36.17	1.000	1.000	1.031	1566

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\, V_{cbg}$ [lb]	V_{ua} [lb]
3047	0.750	2285	320

5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.796	0.140	5/3	73	OK

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

6 Warnings

- To avoid failure of the anchor plate the required thickness can be calculated in PROFIS Anchor. Load re-distributions 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 loading!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Refer to the manufacturer's product literature for cleaning and installation instructions.
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI318 or the relevant standard!

Fastening meets the design criteria!

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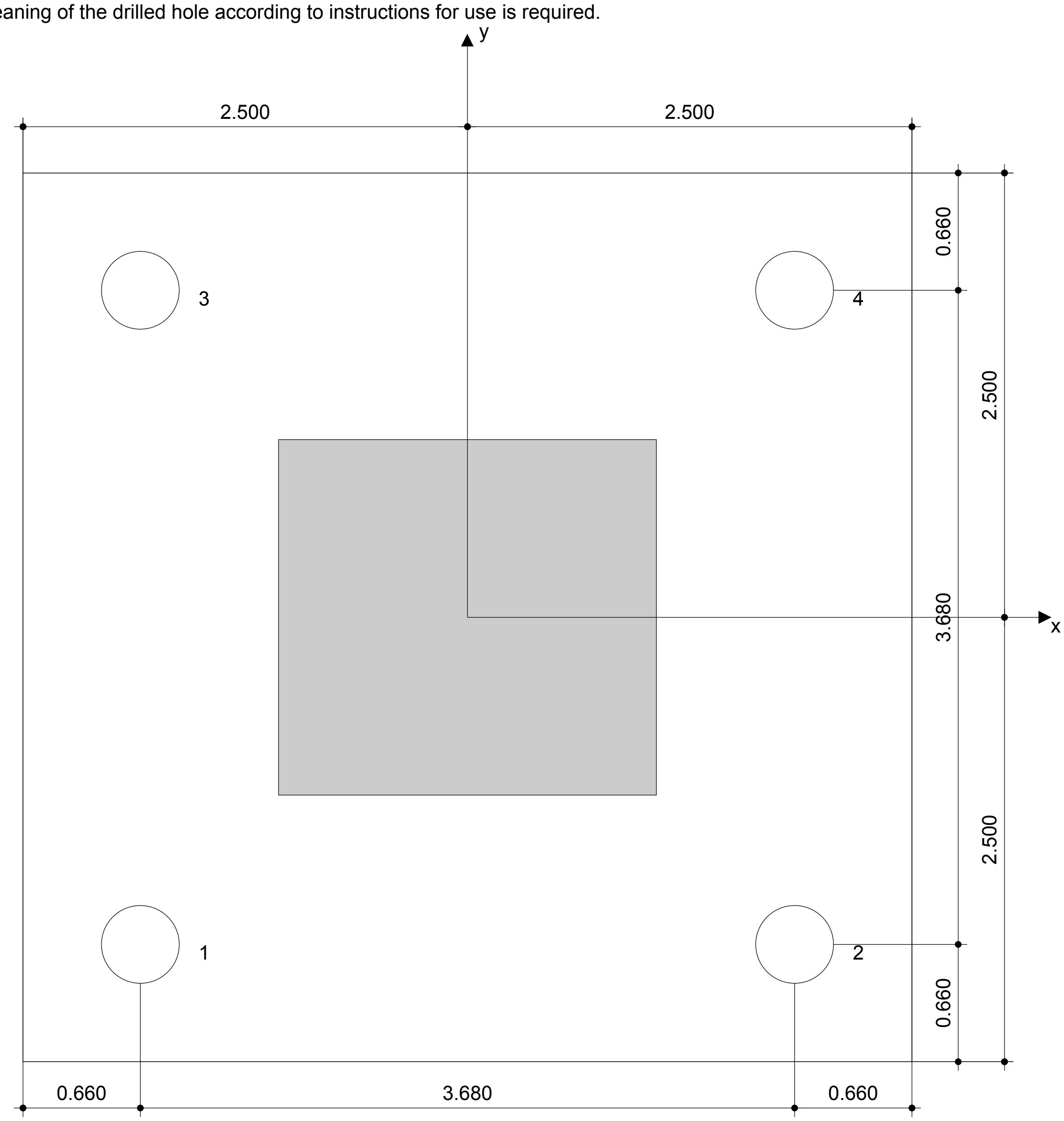
7 Installation data

Anchor plate, steel: -
Profile: Rectangular plates and bars (AISC); 2.125 x 2.000 x 0.000 in.
Hole diameter in the fixture: d_f = 0.438 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Cleaning: Manual cleaning of the drilled hole according to instructions for use is required.

Anchor type and diameter: Kwik Bolt 3 - SS, 3/8 (2)
Installation torque: 240.000 in.lb
Hole diameter in the base material: 0.375 in.
Hole depth in the base material: 2.625 in.
Minimum thickness of the base material: 4.000 in.



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-1.840	-1.840	2.835	-	-	-
2	1.840	-1.840	6.515	-	-	-
3	-1.840	1.840	2.835	-	-	-
4	1.840	1.840	6.515	-	-	-

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8 Remarks; Your Cooperation Duties

- Any and all information and data contained in the Software concern solely the use of Hilti products and are based on the principles, formulas and security regulations in accordance with Hilti's technical directions and operating, mounting and assembly instructions, etc., that must be strictly complied with by the user. All figures contained therein are average figures, and therefore use-specific tests are to be conducted prior to using the relevant Hilti product. The results of the calculations carried out by means of the Software are based essentially on the data you put in. Therefore, you bear the sole responsibility for the absence of errors, the completeness and the relevance of the data to be put in by you. Moreover, you bear sole responsibility for having the results of the calculation checked and cleared by an expert, particularly with regard to compliance with applicable norms and permits, prior to using them for your specific facility. The Software serves only as an aid to interpret norms and permits without any guarantee as to the absence of errors, the correctness and the relevance of the results or suitability for a specific application.
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