Stand Alone Glass Balustrade (with Base Shoe)	Detail Ref.	Sheet No:
	A42-0091	2

Inputs:

$WL := 5$ psf (wind load)

$P := 200$ lb (point load)

$W_h := 4.17$ pli (horizontal uniform load)

$W_v := 0$ pli (vertical uniform load)

$h := 38$ in (height of rail)

$w := 36$ in (minimum glass lite width)*

$t := 0.469$ in (glass equivalent thickness)

$F_g := 6000$ psi (glass allowable bending stress)

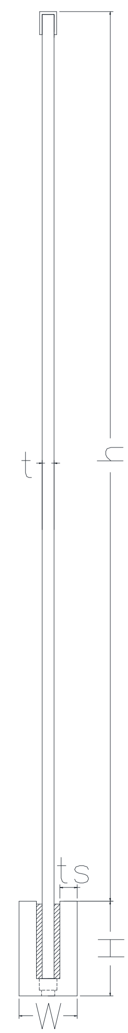
$F_{gw} := 6000$ psi (glass allowable bending stress WL)

$E_g := 10400000$ psi glass modulus of elasticty

$S := 12$ in (fastener spacing)

<u>Use 1/2" Glass, Fully Tempered</u>
with polished edges
*Minimum Glass Lite Width: 3'-0" **

**Note: narrower widths may be equivalent to the minimum glass width, if a top channel or handrail is present to transfer the live loads to the adjacent lites.*



Calculations:

$$I_{g1} := \frac{\min(h,w)\cdot t^3}{12} = 0.309 \quad in^4 \qquad S_{g1} := \frac{\min(h,w)\cdot t^2}{6} = 1.320 \quad in^3$$

$$I_{g2} := \frac{S\cdot t^3}{12} = 0.103 \quad in^4 \qquad S_{g2} := \frac{S\cdot t^2}{6} = 0.440 \quad in^3$$

Point Load:

$M_{g1} := P\cdot h$ $\quad M_{g1} = 7600$ in·lb

$f_{g1} := \frac{M_{g1}}{S_{g1}}$ $\quad f_{g1} = 5759$ psi

$\Delta_{g1} := \frac{P\cdot h^3}{3\cdot E_g\cdot I_{g1}}$ $\quad \Delta_{g1} = 1.137$ in

<u>NOTE:</u> Under full design load, the rail will deflect about 1-3/16", this is acceptable per ASTM E2358 deflection limits. Customer please verify the deflection is acceptable.

Uniform Load:

$\Delta_{g2} := \frac{(W_h\cdot S)\cdot h^3}{3\cdot E_g\cdot I_{g2}}$ $\quad \Delta_{g2} = 0.853$ in

$M_{g2} := (W_h\cdot S)\cdot h + W_v\cdot S\cdot \Delta_{g2} = 1902$ in·lb

$f_{g2} := \frac{M_{g2}}{S_{g2}}$ $\quad f_{g2} = 4322$ psi

Wind Load:

$W_{WL} := \frac{WL\cdot S}{144}$ $\quad W_{WL} = 0.42$ pli

$M_{g3} := \frac{W_{WL}\cdot h^2}{2}$ $\quad M_{g3} = 301$ in·lb

$\Delta_{g3} := \frac{W_{WL}\cdot h^4}{8\cdot E_g\cdot I_{g2}}$ $\quad \Delta_{g3} = 0.101$ in

$f_{g3} := \frac{M_{g3}}{S_{g2}}$ $\quad f_{g3} = 684$ psi

$\Delta_{all} := \frac{h}{24} + \frac{w}{96}$ $\quad \Delta_{all} = 1.96$ in

Reactions from Point Load:

$V_p := P$ $\quad \boxed{V_p = 200}$ lb

$M_p := M_{g1}$ $\quad \boxed{M_p = 7600}$ in·lb

Reactions from Wind or Uniform Load:

$V_w := \max\left(W_{WL}\cdot h, \frac{M_{g2}}{h}\right)$ $\quad \boxed{V_w = 50}$ lb

$M_w := \max(M_{g2}, M_{g3})$ $\quad \boxed{M_w = 1902}$ in·lb

$$GLASS := \begin{cases} \text{"OK"} & \text{if } \frac{\max(f_{g1}, f_{g2})}{F_g} \le 1 \wedge \frac{f_{g3}}{F_{gw}} \le 1 \wedge \frac{\max(\Delta_{g1}, \Delta_{g2}, \Delta_{g3})}{\Delta_{all}} \le 1 \\ \text{"FAILS"} & \text{otherwise} \end{cases}$$

$\boxed{GLASS = \text{"OK"}}$

Stand Alone Glass Balustrade (with Base Shoe)	Detail Ref.	Sheet No:
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Inputs:

$N := 4$ (Number of Fasteners Effective at Ends)

$t_s := 0.75$ in (Wall Thickness of Shoe)

$H := 4.118$ in (Height of Base)

$W := 2.5$ in (Width of Base)

$w = 36$ in (Minimum Glass Lite Width)

$C_f := 0.85$ (Crushing Factor Required)

Outputs: (From Previous Sheet)

$V_p = 200$ lb (Shear From Point Load)

$M_p = 7600$ in·lb (Moment From Point Load)

$V_w = 50$ lb (Shear From Wind/Uniform Load)

$M_w = 1902$ in·lb (Moment From Wind/Uniform Load)

$S = 12$ in (Fastener Spacing)

$h = 38$ in (Height From Top of Rail to Top of Base)

Calculations:

$M_{tot1} := M_p + V_p \cdot H$ $M_{tot1} = 8424$ in·lb

$M_{tot2} := M_w + V_w \cdot H$ $M_{tot2} = 2108$ in·lb

Anchors to Concrete:

$M_1 := \frac{M_{tot1}}{N} \cdot 1.6 \cdot (3)$ $M_1 = 10108$ in·lb

$V_1 := \frac{V_p}{N} \cdot 1.6 \cdot (3)$ $V_1 = 240$ lb

$M_2 := M_{tot2} \cdot 1.6 \cdot (3)$ $M_2 = 10116$ in·lb

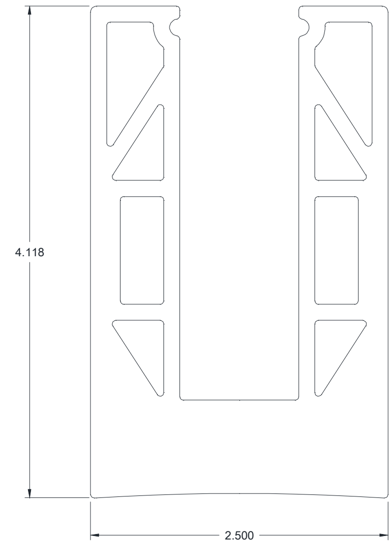
$V_2 := V_w \cdot 1.6 \cdot (3)$ $V_2 = 240$ lb

*****SEE HILTI PROFIS OR POWERS PDA DATA*****

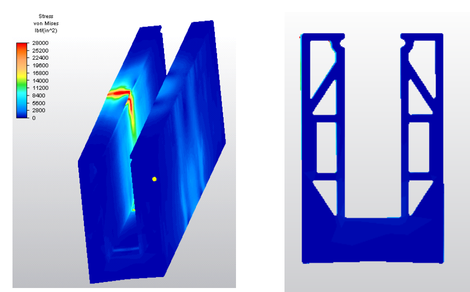
Use 1/2" Dia. SS Hilti Kwik Bolt TZ or Equal
300 Series Stainless Steel

Embedment: 3-5/8" Min.
Edge Distance: 4"
2nd Edge Distance: 4"
Spacing: 12"
Min. Slab Thickness: 8"
Concrete Strength: f'c= 4,000 psi, Cracked Concrete

*****Install per Manufacturer's instructions*****



Base Shoe Analysis:



Use Extruded Aluminum Base Shoe As Shown
6005-T5 Alloy Minimum

Anchors to Steel:

$T_1 := \frac{M_{tot1}}{N \cdot W \cdot 0.5 \cdot C_f}$ $T_1 = 1982$ lb

$V_3 := \frac{V_p}{N}$ $V_3 = 50$ lb

$T_2 := \frac{M_{tot2}}{W \cdot 0.5 \cdot C_f}$ $T_2 = 1984$ lb

$V_4 := V_w$ $V_4 = 50$ lb

$T_{all} := 5676$ $T_{all} = 5676$ lb

$V_{all} := 2984$ $V_{all} = 2984$ lb

$I := \left(\frac{\max(V_3, V_4)}{V_{all}}\right)^2 + \left(\frac{\max(T_1, T_2)}{T_{all}}\right)^2$ $I = 0.12$ < 1.0

Use 1/2-13 S.S. Cap Screws @ 12" O.C.
(300 Series S.S., Cond. CW, Fy = 65 ksi)

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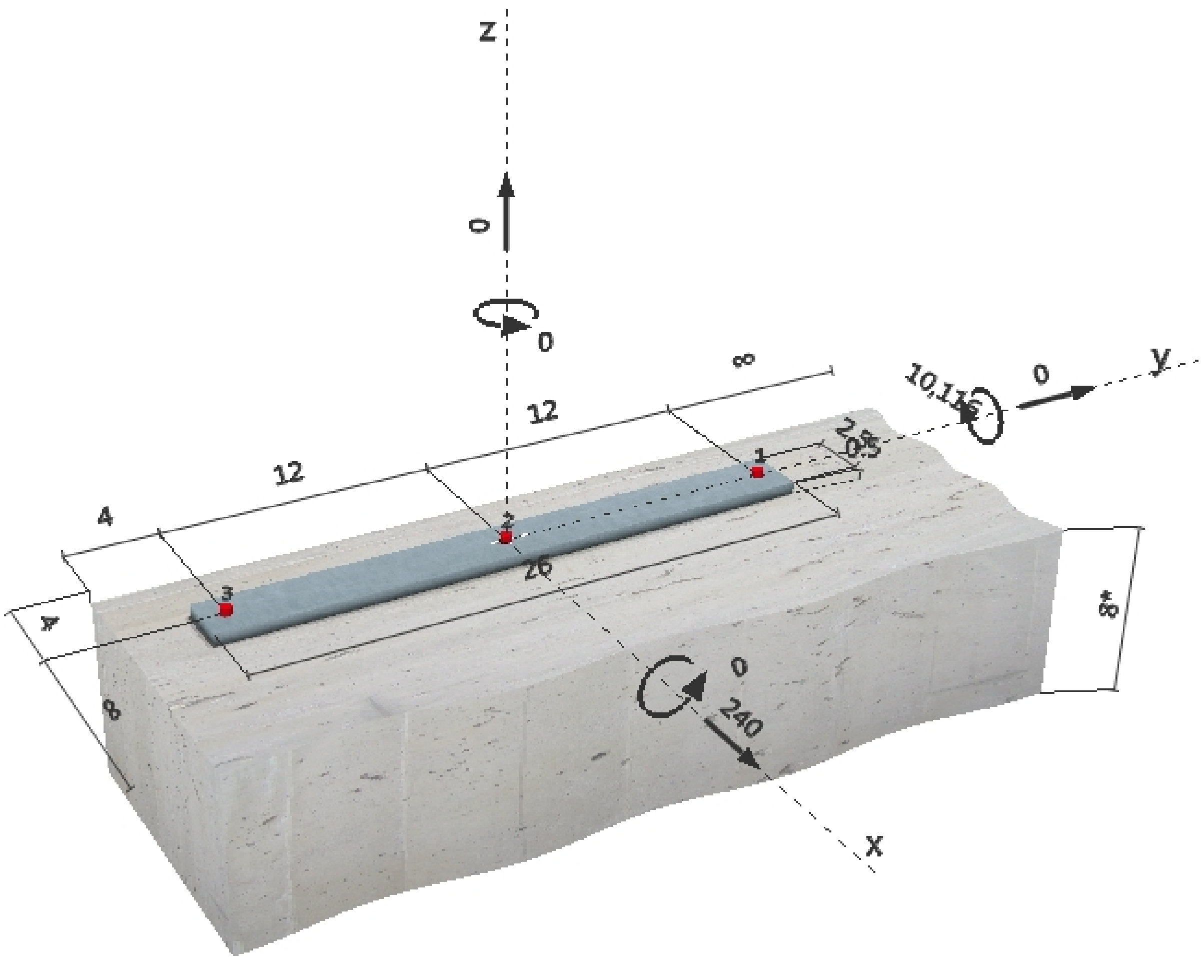
Specifier's comments:

1 Input data

Anchor type and diameter:	**Kwik Bolt TZ - SS 316 1/2 (3 1/4)**
Effective embedment depth:	h_{ef} = 3.250 in., h_{nom} = 3.625 in.
Material:	AISI 316
Evaluation Service Report:	ESR-1917
Issued I Valid:	6/1/2016 | 5/1/2017
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 = 2.500 in. x 26.000 in. x 0.500 in.; (Recommended plate thickness: not calculated
Profile:	no profile
Base material:	cracked concrete, 4000, f_c' = 4000 psi; h = 8.000 in.
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present
	edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	no

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



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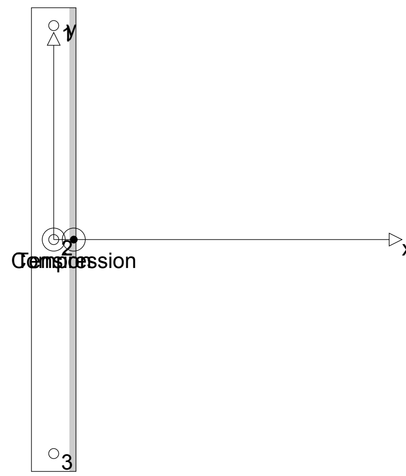
2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	2993	80	80	0
2	2993	80	80	0
3	2993	80	80	0

max. concrete compressive strain: 0.43 [‰]
max. concrete compressive stress: 1867 [psi]
resulting tension force in (x/y)=(0.000/0.000): 8978 [lb]
resulting compression force in (x/y)=(1.127/0.000): 8978 [lb]



3 Tension load

	Load N_{ua} [lb]	Capacity ϕ N_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	2993	8665	35	OK
Pullout Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	8978	10263	88	OK

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

3.1 Steel Strength

N_{sa} = ESR value   refer to ICC-ES ESR-1917
$\phi\ N_{sa} \geq N_{ua}$ ACI 318-08 Eq. (D-1)

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.10	115000

Calculations

N_{sa} [lb]
11554

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
11554	0.750	8665	2993

3.2 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.]	$\psi_{c,N}$
3.250	0.000	0.000	4.000	1.000

c_{ac} [in.]	k_c	λ	f'_c [psi]
6.000	17	1	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
251.83	95.06	1.000	1.000	0.946	1.000	6299

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
15789	0.650	10263	8978

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4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	80	4472	2	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	240	22105	2	OK
Concrete edge failure in direction y-**	240	4248	6	OK

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

4.1 Steel Strength

V_{sa} = ESR value   refer to ICC-ES ESR-1917

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

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
0.10	115000

Calculations

V_{sa} [lb]
6880

Results

V_{sa} [lb]	ϕ_{steel}	ϕV_{sa} [lb]	V_{ua} [lb]
6880	0.650	4472	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.]
2	3.250	0.000	0.000	4.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ	f'_c [psi]
1.000	6.000	17	1	4000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
251.83	95.06	1.000	1.000	0.946	1.000	6299

Results

V_{cpg} [lb]	$\phi_{concrete}$	ϕV_{cpg} [lb]	V_{ua} [lb]
31578	0.700	22105	240

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 318-08 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.]
4.000	4.000	0.000	1.000	8.000

l_e [in.]	λ	d_a [in.]	f_c' [psi]	$\psi_{parallel,V}$
3.250	1.000	0.500	4000	2.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
60.00	72.00	1.000	1.000	1.000	3642

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
6069	0.700	4248	240

5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.875	0.056	1.000	78	OK

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

6 Warnings

- The anchor design methods in PROFIS Anchor require rigid anchor plates 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 Anchor calculates the minimum required anchor plate thickness with FEM 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 Anchor. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- 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 ACI 318 or the relevant standard!

Fastening meets the design criteria!

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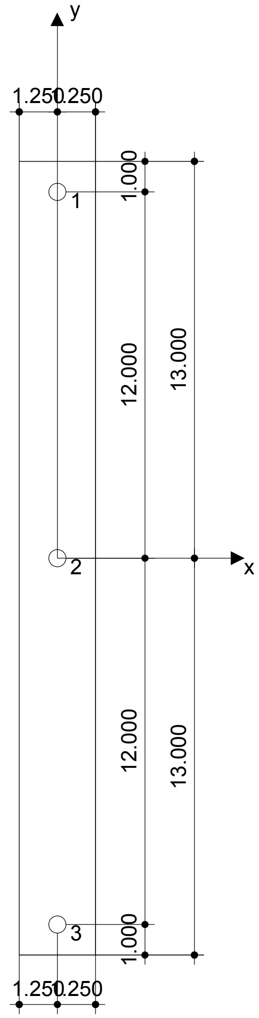
7 Installation data

Anchor plate, steel: -
Profile: no profile
Hole diameter in the fixture: d_f = 0.563 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Drilling method: Hammer drilled
Cleaning: Manual cleaning of the drilled hole according to instructions for use is required.

Anchor type and diameter: Kwik Bolt TZ - SS 316 1/2 (3 1/4)
Installation torque: 480.001 in.lb
Hole diameter in the base material: 0.500 in.
Hole depth in the base material: 4.000 in.
Minimum thickness of the base material: 8.000 in.

7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• Manual blow-out pump	• Torque controlled cordless impact tool (Hilti Safeset System) • Torque wrench • Hammer



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.000	12.000	4.000	-	28.000	-
2	0.000	0.000	4.000	-	16.000	-
3	0.000	-12.000	4.000	-	4.000	-

8 Remarks; Your Cooperation Duties

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