CAEP

Submittal Documents

Seismic Analysis of the Boiler SF 750

June 24, 2019

For:
WEIL-McLAIN

Prepared By:
Sam Salissen, ME,PE, Ph.D.

CAE Piping ● 14271 Jeffrey Rd., Irvine, CA 92620 ● Tel: (800) 948-1460

Summary

The scope of this report is the seismic qualification, based on the structural analysis, of the Slim Fit boiler model 750, under the seismic loads for the seismic zone 4 in the United States. The analyses are limited to the load path from the COG of the assembly to the floor and the interior parts of the boiler are not within the scope of this work.

The qualification is in accordance with the seismic design requirements of IBC 2015, ASCE 7-10 and AISC 14th edition for the seismic zone 4, for non-structural components and based on the seismic parameters used in this report.

The structural analyses carried out on the base frame assembly and based on the safety factors reported in section **5.4**, the design requirements of AISC, is met in all the analyses performed in this report.

It is concluded that the design of the main frame and seismic stands meets the design requirements of IBC 2015, ASCE 7-10 and ASME BPVC and AISC standards. This conclusion is contingence to the accuracy of the SolidWorks model and other input data provided by WEIL-McLAIN (WM) and used to build the FE models and set up the analyses (material, COG,...) appended in Appendix 1.

Revision History

Rev	Date	Scope of the revision	Created by
A	06/24/2019	First Issue	Sam Salissen

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1 Introduction

1.1 Scope

The scope of this report is the seismic qualification, based on the structural analysis, of the Slim Fit boiler model 750, under the seismic loads for the seismic zone 4 in the states. The analyses are limited to the load path from the COG of the assembly to the floor and the interior parts of the boiler are not within the scope of this work. The qualification is in accordance with the design requirements of IBC 2015, ASCE 7-10 and AISC.

2 Assumptions and open issues

In this chapter, assumptions and open issues are presented in two categories. The definition of each is presented below.

Open issues- Is defined as issues that must be solved, otherwise the analysis cannot be completed.

Key assumption- Is defined as assumptions that may have noticeable impact on the analysis results.

2.1 Open Issues

- No open issues exist.

2.2 Key Assumptions

No fabrication drawing of the parts and assembly were provided and the analyses are based on the SolidWorks model that is provided by WM and no responsibility of the accuracy of the model with respect to the actual assembly will be taken by the author of this report.

- The weight and the location of the center of the gravity of the boiler assembly are estimated and provided by WM, Appendix 1.
- It is assumed that the material of the base frame and the top plate are S235JR.
- It is assumed that the welds have at least the same strength as the base material (Weld strength FEXX=70ksi>54ksi for base material) based on ASME allowable stress in welds under shear and tension is 0.3 *tensile strength =21000psi. In this case it is lower than the allowable stress of the in the members (AISC). So, no weld analysis will be performed in this work.
- It is assumed that no load will be transferred from the connecting piping system to the boiler during a seismic event, flex joint will be needed at the connection points.

3 Requirements and Prerequisites

3.1 Stress criteria

The seismic loads are calculated based on the IBC 2015 code. The detail of the used parameters and the calculations are as follows. Seismic analyses are performed (using FEM) based on ASD approach of the AISC 14 edition & ASCE 7-10 for the steel parts and LRFD for the anchorage calculations.

3.2 Loads

The following inputs are used for the weight of the boilers.

Boiler Model	Shipping weight	Operating weight	Water content	Water flow rate per boiler		Vent/air pipe size — Provide a separate vent for each boiler	Electrical service required
	Pounds per boiler	Pounds per boiler	Gallons per boiler	GPM @ 30°F rise	GPM @ 40°F rise		Amps per boiler
		Note 2				Note 3	Note 4
SF-550	505	476	5.5	34	26	6" or 8"	25 (boiler) 15 (Boiler Circulator)
SF-750	550	529	6.5	47	35	6" or 8"	25 (boiler) 15 (Boiler Circulator)

Three load cases are considered in this report, the analyses are based on the worst load combinations specified in ASCE 7-10. The following parameters are used in calculation of the seismic loads as follows:

1- Load case 1: Used for the analyses of the steel parts

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CUSTOMER: **WEIL-McLAIN**

DATE:	PRP. BY.:	CAE PIPING JOB #:
6/24/2019		

SEISMIC CALCULATION WORKSHEET

BUILDING CODE: **IBC-2012 / 2015**

SEISMIC DESIGN

S_{ds} = 2
I_p = 1
a_p = 1
R_p = 2.5
Ω_o = 2.0

a_p, R_p, Ω_o per ASCE 7-10

BLDG. ELEVATION / EQUIP. LOCATION

h = 40 fl
$^{**}z$ = 40 fl
** Assume worst case location.

[X] 40 ft. RF
[ ]
[ ] 0 ft. GF or below ground

LOAD COMBINATION
LRFD
(1.2 DL + 1.00 E)

EQUIPMENT TAG: SLIM FIT 2000

EQUIPMENT Information:

W_P = max. operating weight = 600 lbs.

APPLIED SEISMIC FORCE/ CALCULATIONS:

ANCHORAGE TO CONCRETE

SHT. NUMBER: 1 OF 1

F_p / W_p = (0.4 x a_p x S_{ds} x (1 + (2 x (z / h))) / (R_p / I_p) = 0.96

F_p / W_p = 0.96g ; $F_{p,min} / W_p$ = 0.3 x S_{ds} x I_p = 0.60 ; $F_{p,max} / W_p$ = 1.6 x S_{ds} x I_p = 3.20

F_{ph} = Applied Lateral Seismic Force = 1.0 x 0.96g x W_p .... = 576 lbs. *WORST CASE

F_{pv} = Vertical component of seismic force = 1.0 x 0.2 x S_{ds} x W_p .... = 240 lbs. *WORST CASE

F_v = Vertical total load = F_{pv} - .9*Wp = -300 lbs.

2- Load case 2: Used for the analyses of the steel parts

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6/24/2019		

SEISMIC CALCULATION WORKSHEET
BUILDING CODE: IBC-2012 / 2015

SEISMIC DESIGN		BLDG. ELEVATION / EQUIP. LOCATION	
S_{ds} =	2	h =	40 ft
I_p =	1	**z =	40 ft
a_p =	1		
R_p =	2.5	** Assume worst case location.	
Ω_o =	2.0		

a_p, R_p, Ω_o per ASCE 7-10

X 40 ft. RF
0 ft. GF
or below ground

LOAD COMBINATION: LRFD
(0.9 DL + 1.00 E)

EQUIPMENT TAG: SLIM FIT 2000

EQUIPMENT Information:
W_p = max. operating weight = 600 lbs.

APPLIED SEISMIC FORCE/ CALCULATIONS: ANCHORAGE TO CONCRETE — SHT. NUMBER: 1 OF 1

F_p / W_p = (0.4 x a_p x S_{ds} x (1 + (2 x (z / h))) / (R_p / I_p)) = 0.96
F_p / W_p = 0.96g ; $F_{p,min}$ / W_p = 0.3 x S_{ds} x I_p = 0.60 ; $F_{p,max}$ / W_p = 1.6 x S_{ds} x I_p = 3.20
F_{ph} = Applied Lateral Seismic Force = 1.0 x 0.96g x W_p = 576 lbs. *WORST CASE
F_{pv} = Vertical component of seismic force = 1.0 x 0.2 x S_{ds} x W_p = 240 lbs. *WORST CASE
F_v = Vertical total load = F_{pv} - .9*Wp = -300 lbs.

3- Load case 3: Used in the analyses of the anchorage

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WEIL-McLAIN		
DATE:	PRP. BY.:	CAE PIPING JOB #:
6/24/2019		

SEISMIC CALCULATION WORKSHEET
BUILDING CODE: IBC-2012 / 2015

SEISMIC DESIGN		BLDG. ELEVATION / EQUIP. LOCATION	
S_{ds} =	2	h =	40 ft
I_p =	1	**z =	40 ft
a_p =	1		
R_p =	2.5	** Assume worst case location.	
Ω_o =	2.0		

a_p, R_p, Ω_o per ASCE 7-10

X 40 ft. RF
0 ft. GF
or below ground

LOAD COMBINATION: LRFD 2013
(0.9 DL + 2.50 E)

EQUIPMENT TAG: SLIM FIT 2000

EQUIPMENT Information:
W_p = max. operating weight = 600 lbs.

APPLIED SEISMIC FORCE/ CALCULATIONS: ANCHORAGE TO CONCRETE — SHT. NUMBER: 1 OF 1

F_p / W_p = (0.4 x a_p x S_{ds} x (1 + (2 x (z / h))) / (R_p / I_p)) = 0.96
F_p / W_p = 0.96g ; $F_{p,min}$ / W_p = 0.3 x S_{ds} x I_p = 0.60 ; $F_{p,max}$ / W_p = 1.6 x S_{ds} x I_p = 3.20
F_{ph} = Applied Lateral Seismic Force = 2.5 x 0.96g x W_p = 1440 lbs. *WORST CASE
F_{pv} = Vertical component of seismic force = 1.0 x 0.2 x S_{ds} x W_p = 240 lbs. *WORST CASE
F_v = Vertical total load = F_{pv} - .9*Wp = -300 lbs.

The seismic (& dead weights) loads are applied at the location of the center of the gravity of boiler's assembly, using rigid elements, see Fig. 1.

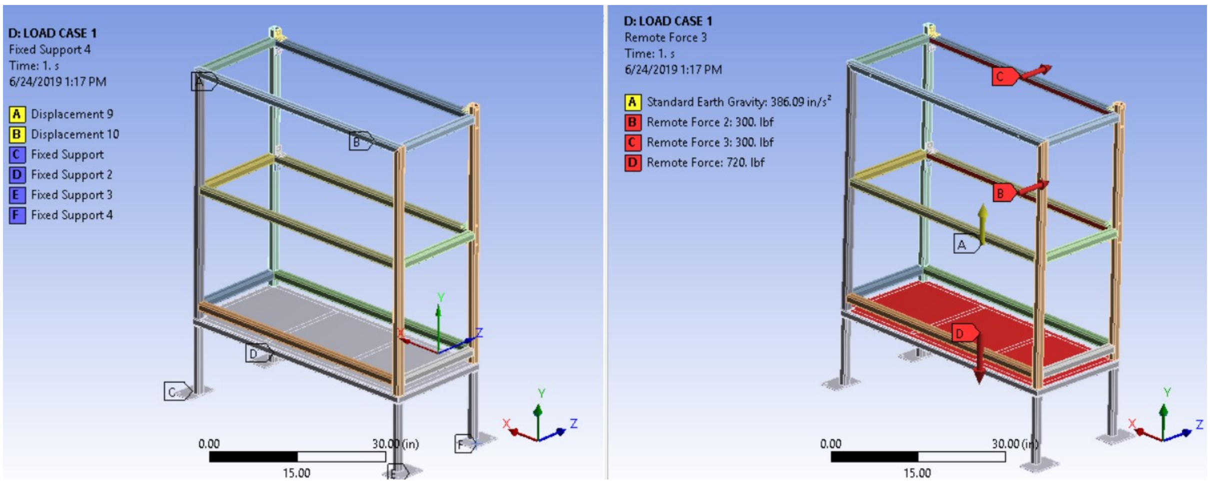


Figure **1**- Loads acting on the boiler structure

5.3.1 Bolts

Hilti KBZ anchor bolts, 3/8" (2 3/4" embedment), are used to anchor the base plates to the floor and the side tue to the wall. The maximum reaction loads at the location of the joints are extracted from the FE-analyses (load case 3 above). The detail of the anchor bolt calcs are provided in Appendix 3. The minimum concrete thickness of 5" and PSI rating of 3.000 psi are considered in the analyses).

Table-3: Reaction loads in the base plate

Reaction forces [lbf]			Reaction moments [lbf-ft]		
FX	FY	FZ	MX	MY	MZ
40	75	180	135	15	20

Table-4: Reaction loads in the side anchor bolts

Reaction forces [lbf]		
FX	FY	FZ
5	40	596

3/8" grade 5 steel bolts are needed for jointing the angles to the longitudinal tubes in front of the frame. The maximum reaction loads on these bolts are listed in the following.

Table-5: Reaction loads in the bolts of angles holding the longitudinal tubes

Reaction forces [lbf]		
FX	FY	FZ
190	5	25

5.4 Results Evaluation

Minimum required strength specified in ASCE is obtained in the analyses of the supporting frame assembly carried out in sections 5.1 to 5.4. The stresses reported in section 5 are the local stresses and the average stress through the thickness of the members are much lower and that can be shown by stress linearization through the thickness. However, since even the maximum local peak stresses don't exceed the allowable values, the stress linearization work is skipped here.

6 Conclusion

Seismic analysis of the boiler, model SF 750, is carried out in this report and based on the safety factors reported in section **5.4**, minimum required strength factor is obtained in all the analyses performed in this report.

It is concluded that the design of the structure of the boiler SF-1000 meets the design requirements of AISC, ASCE7-10 and IBC 2012 standards.

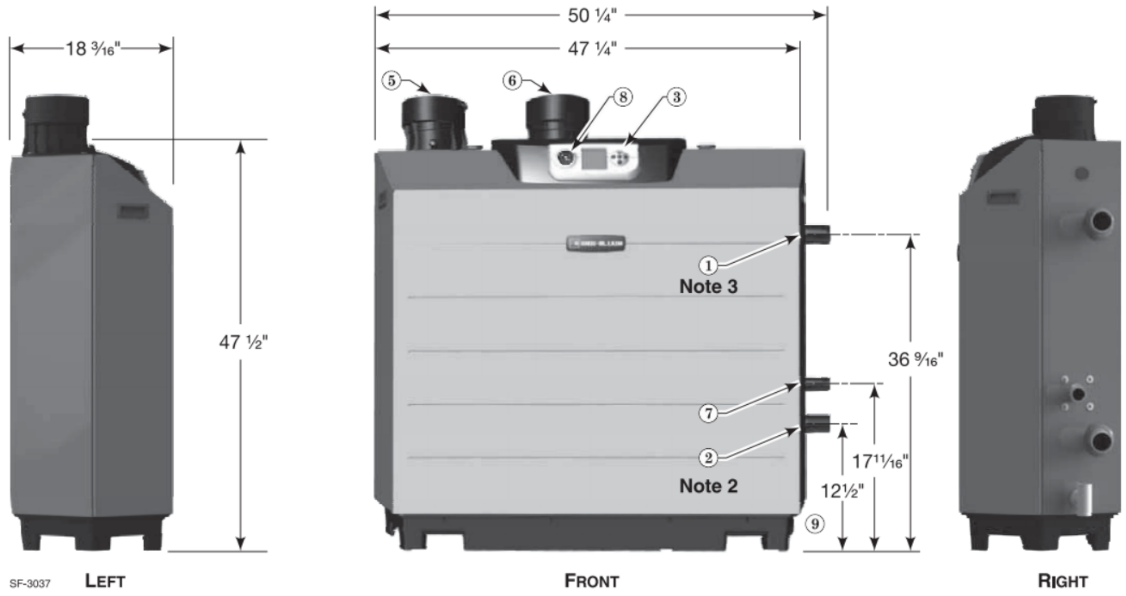
7 *References*

[1]- IBC 2012.

[2]- AISC 14th Edition.

[3]- ASCE 7-10.

APPENDIX ***1-*** Overall dimensions of boiler



Appendix ***2***- Anchor Bolt Calculation

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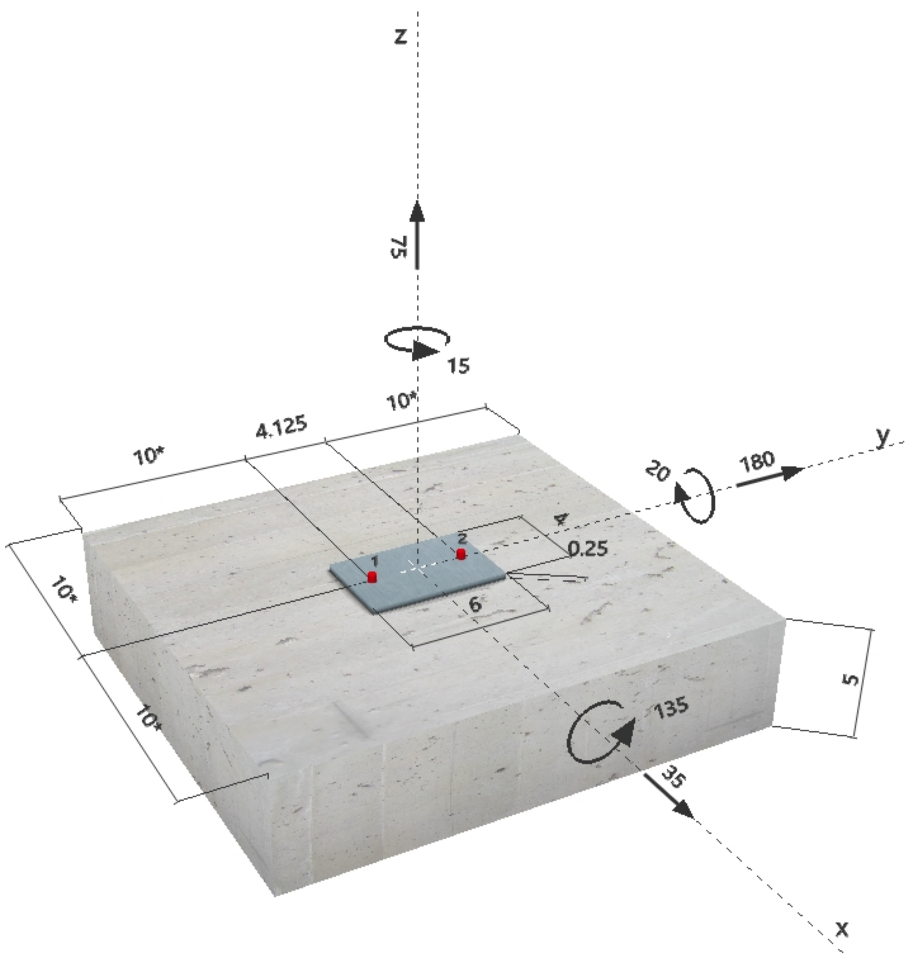
Specifier's comments:

1 Input data

Anchor type and diameter:	**Kwik Bolt TZ - CS 3/8 (2 3/4)**
Effective embedment depth:	$h_{ef,act}$ = 2.750 in., h_{nom} = 3.063 in.
Material:	Carbon Steel
Evaluation Service Report:	ESR-1917
Issued I Valid:	6/1/2016 | 5/1/2017
Proof:	Design method ACI 318-14 / Mech.
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.250 in.
Anchor plate:	l_x x l_y x t = 4.000 in. x 6.000 in. x 0.250 in.; (Recommended plate thickness: not calculated
Profile:	no profile
Base material:	cracked concrete, 2500, f_c' = 2500 psi; h = 5.000 in.
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar

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



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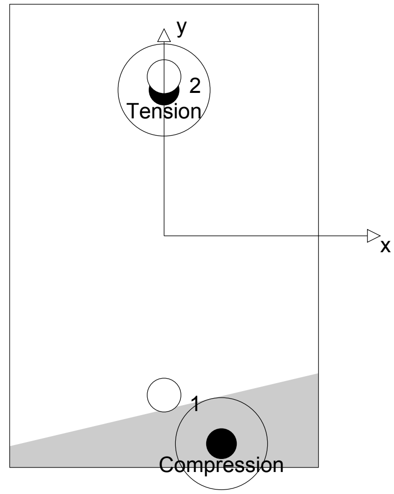
2 Load case/Resulting anchor forces



Load case: Design loads

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

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	17	109	61	90
2	381	94	-26	90

max. concrete compressive strain: 0.07 [‰]
max. concrete compressive stress: 311 [psi]
resulting tension force in (x/y)=(0.000/1.889): 398 [lb]
resulting compression force in (x/y)=(0.744/-2.692): 323 [lb]

3 Tension load

	Load N_{ua} [lb]	Capacity ϕ N_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	381	4875	8	OK
Pullout Strength*	381	2051	19	OK
Concrete Breakout Strength**	398	2592	16	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 318-14 Table 17.3.1.1

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.05	125000

Calculations

N_{sa} [lb]
6500

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
6500	0.750	4875	381

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3.2 Pullout Strength

$N_{pn,f'_c} = N_{p,2500}\ \lambda_a \sqrt{\frac{f'_c}{2500}}$ refer to ICC-ES ESR-1917

$\phi\ N_{pn,f'_c} \geq N_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

f'_c [psi]	λ_a	$N_{p,2500}$ [lb]
2500	1.000	3155

Calculations

$\sqrt{\frac{f'_c}{2500}}$
1.000

Results

N_{pn,f'_c} [lb]	$\phi_{concrete}$	$\phi\ N_{pn,f'_c}$ [lb]	N_{ua} [lb]
3155	0.650	2051	381

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 318-14 Eq. (17.4.2.1b)

$\phi\ N_{cbg} \geq N_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Nc} see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-14 Eq. (17.4.2.1c)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e'_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.4)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.5b)

$\psi_{cp,N} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.7b)

$N_b = k_c\ \lambda_a \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-14 Eq. (17.4.2.2a)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
2.750	0.000	1.889	10.000	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
4.125	17	1.000	2500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
102.09	68.06	1.000	0.686	1.000	1.000	3876

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
3988	0.650	2592	398

4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	109	2337	5	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength*	109	4070	3	OK
Concrete edge failure in direction y+**	190	2720	7	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 318-14 Table 17.3.1.1

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
0.05	125000

Calculations

V_{sa} [lb]
3595

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
3595	0.650	2337	109

4.2 Pryout Strength

$V_{cp} = k_{cp}\left[\left(\frac{A_{Nc}}{A_{Nc0}}\right)\psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b\right]$ ACI 318-14 Eq. (17.5.3.1a)

$\phi\ V_{cp} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Nc} see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-14 Eq. (17.4.2.1c)

$\psi_{ec,N} = \left(\frac{1}{1+\frac{2\ e_N'}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.4)

$\psi_{ed,N} = 0.7 + 0.3\left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.5b)

$\psi_{cp,N} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.7b)

$N_b = k_c\ \lambda_a \sqrt{f_c'}\ h_{ef}^{1.5}$ ACI 318-14 Eq. (17.4.2.2a)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	2.750	0.000	0.000	10.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f_c' [psi]
1.000	4.125	17	1.000	2500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
51.05	68.06	1.000	1.000	1.000	1.000	3876

Results

V_{cp} [lb]	$\phi_{concrete}$	$\phi\ V_{cp}$ [lb]	V_{ua} [lb]
5814	0.700	4070	109

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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 318-14 Eq. (17.5.2.1b)

$\phi\ V_{cbg} \geq V_{ua}$ — ACI 318-14 Table 17.3.1.1

A_{Vc} see ACI 318-14, Section 17.5.2.1, Fig. R 17.5.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ — ACI 318-14 Eq. (17.5.2.1c)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V'}{3c_{a1}}}\right) \leq 1.0$ — ACI 318-14 Eq. (17.5.2.5)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ — ACI 318-14 Eq. (17.5.2.6b)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ — ACI 318-14 Eq. (17.5.2.8)

$V_b = \left(7 \left(\frac{l_e}{d_a}\right)^{0.2} \sqrt{d_a}\right) \lambda_a \sqrt{f_c'}\ c_{a1}^{1.5}$ — ACI 318-14 Eq. (17.5.2.2a)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
6.667	10.000	0.000	1.000	5.000

l_e [in.]	λ_a	d_a [in.]	f_c' [psi]	$\psi_{parallel,V}$
2.750	1.000	0.375	2500	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
100.00	200.00	1.000	1.000	1.414	5495

Results

V_{cbg} [lb]	$\phi_{concrete}$	$\phi\ V_{cbg}$ [lb]	V_{ua} [lb]
3886	0.700	2720	190

5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.186	0.070	5/3	8	OK

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

6 Warnings

- 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! 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!
- Hilti post-installed anchors shall be installed in accordance with the Hilti Manufacturer's Printed Installation Instructions (MPII). Reference ACI 318-14, Section 17.8.1.

Fastening meets the design criteria!

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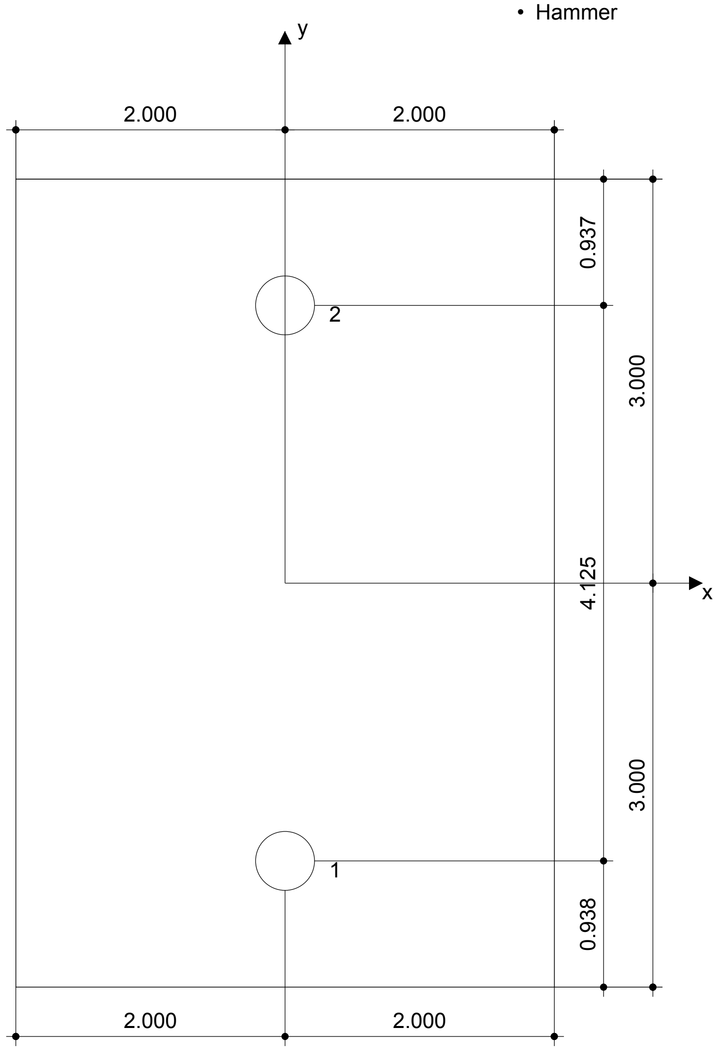
7 Installation data

Anchor plate, steel: -
Profile: no profile
Hole diameter in the fixture: d_f = 0.438 in.
Plate thickness (input): 0.250 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 - CS 3/8 (2 3/4)
Installation torque: 25.000 ft.lb
Hole diameter in the base material: 0.375 in.
Hole depth in the base material: 3.375 in.
Minimum thickness of the base material: 5.000 in.

7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer	• Manual blow-out pump	• Torque wrench
• Properly sized drill bit		• Hammer



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.000	-2.063	10.000	10.000	10.000	14.125
2	0.000	2.063	10.000	10.000	14.125	10.000

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8 Remarks; Your Cooperation Duties

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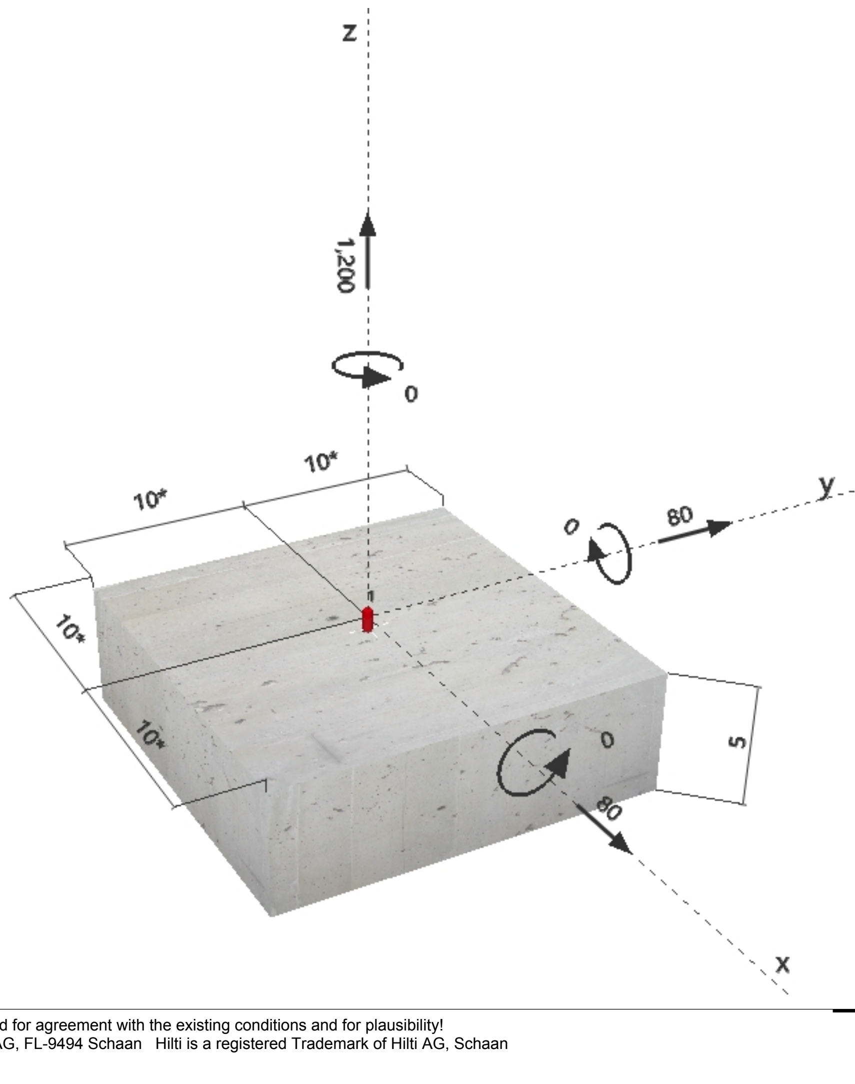
Specifier's comments:

1 Input data

Anchor type and diameter:	**Kwik Bolt TZ - CS 3/8 (2 3/4)**
Effective embedment depth:	$h_{ef,act}$ = 2.750 in., h_{nom} = 3.063 in.
Material:	Carbon Steel
Evaluation Service Report:	ESR-1917
Issued I Valid:	6/1/2016 | 5/1/2017
Proof:	Design method ACI 318-14 / Mech.
Stand-off installation:	- (Recommended plate thickness: not calculated)
Profile:	no profile
Base material:	cracked concrete, 2500, f_c' = 2500 psi; h = 5.000 in.
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present
	edge reinforcement: none or < No. 4 bar

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	1200	113	80	80

max. concrete compressive strain: - [‰]
max. concrete compressive stress: - [psi]
resulting tension force in (x/y)=(0.000/0.000): 0 [lb]
resulting compression force in (x/y)=(0.000/0.000): 0 [lb]

3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	1200	4875	25	OK
Pullout Strength*	1200	2051	59	OK
Concrete Breakout Strength**	1200	2520	48	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 318-14 Table 17.3.1.1

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.05	125000

Calculations

N_{sa} [lb]
6500

Results

N_{sa} [lb]	ϕ_{steel}	ϕN_{sa} [lb]	N_{ua} [lb]
6500	0.750	4875	1200

3.2 Pullout Strength

$N_{pn,f'_c} = N_{p,2500}\ \lambda_a \sqrt{\frac{f'_c}{2500}}$ refer to ICC-ES ESR-1917

$\phi\ N_{pn,f'_c} \geq N_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

f'_c [psi]	λ_a	$N_{p,2500}$ [lb]
2500	1.000	3155

Calculations

$\sqrt{\frac{f'_c}{2500}}$
1.000

Results

N_{pn,f'_c} [lb]	$\phi_{concrete}$	$\phi\ N_{pn,f'_c}$ [lb]	N_{ua} [lb]
3155	0.650	2051	1200

3.3 Concrete Breakout Strength

$N_{cb} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b$ ACI 318-14 Eq. (17.4.2.1a)

$\phi\ N_{cb} \geq N_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Nc} see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-14 Eq. (17.4.2.1c)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e'_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.4)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.5b)

$\psi_{cp,N} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.7b)

$N_b = k_c\ \lambda_a \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-14 Eq. (17.4.2.2a)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
2.750	0.000	0.000	10.000	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
4.125	17	1.000	2500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
68.06	68.06	1.000	1.000	1.000	1.000	3876

Results

N_{cb} [lb]	$\phi_{concrete}$	$\phi\ N_{cb}$ [lb]	N_{ua} [lb]
3876	0.650	2520	1200

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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*	113	2337	5	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	113	5427	3	OK
Concrete edge failure in direction x+**	113	2720	5	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 318-14 Table 17.3.1.1

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
0.05	125000

Calculations

V_{sa} [lb]
3595

Results

V_{sa} [lb]	ϕ_{steel}	ϕV_{sa} [lb]	V_{ua} [lb]
3595	0.650	2337	113

4.2 Pryout Strength

$$V_{cp} = k_{cp} \left[\left(\frac{A_{Nc}}{A_{Nc0}} \right) \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b \right]$$ ACI 318-14 Eq. (17.5.3.1a)

$\phi V_{cp} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Nc} see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)

$A_{Nc0} = 9\, h_{ef}^2$ ACI 318-14 Eq. (17.4.2.1c)

$$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\, e'_N}{3\, h_{ef}}} \right) \leq 1.0$$ ACI 318-14 Eq. (17.4.2.4)

$$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}} \right) \leq 1.0$$ ACI 318-14 Eq. (17.4.2.5b)

$$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}} \right) \leq 1.0$$ ACI 318-14 Eq. (17.4.2.7b)

$N_b = k_c\, \lambda_a \sqrt{f'_c}\, h_{ef}^{1.5}$ ACI 318-14 Eq. (17.4.2.2a)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	2.750	0.000	0.000	10.000

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	4.125	17	1.000	2500

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
68.06	68.06	1.000	1.000	1.000	1.000	3876

Results

V_{cp} [lb]	$\phi_{concrete}$	ϕV_{cp} [lb]	V_{ua} [lb]
7753	0.700	5427	113

4.3 Concrete edge failure in direction x+

$V_{cb} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ed,V}\, \psi_{c,V}\, \psi_{h,V}\, \psi_{parallel,V}\, V_b$ — ACI 318-14 Eq. (17.5.2.1a)

$\phi\ V_{cb} \geq V_{ua}$ — ACI 318-14 Table 17.3.1.1

A_{Vc} see ACI 318-14, Section 17.5.2.1, Fig. R 17.5.2.1(b)

$A_{Vc0} = 4.5\ c_{a1}^2$ — ACI 318-14 Eq. (17.5.2.1c)

$\psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_V'}{3c_{a1}}}\right) \leq 1.0$ — ACI 318-14 Eq. (17.5.2.5)

$\psi_{ed,V} = 0.7 + 0.3\left(\frac{c_{a2}}{1.5c_{a1}}\right) \leq 1.0$ — ACI 318-14 Eq. (17.5.2.6b)

$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \geq 1.0$ — ACI 318-14 Eq. (17.5.2.8)

$V_b = \left(7 \left(\frac{l_e}{d_a}\right)^{0.2} \sqrt{d_a}\right) \lambda_a \sqrt{f_c'}\ c_{a1}^{1.5}$ — ACI 318-14 Eq. (17.5.2.2a)

Variables

c_{a1} [in.]	c_{a2} [in.]	e_{cV} [in.]	$\psi_{c,V}$	h_a [in.]
6.667	10.000	0.000	1.000	5.000

l_e [in.]	λ_a	d_a [in.]	f_c' [psi]	$\psi_{parallel,V}$
2.750	1.000	0.375	2500	1.000

Calculations

A_{Vc} [in.^{2}]	A_{Vc0} [in.^{2}]	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{h,V}$	V_b [lb]
100.00	200.00	1.000	1.000	1.414	5495

Results

V_{cb} [lb]	$\phi_{concrete}$	$\phi\ V_{cb}$ [lb]	V_{ua} [lb]
3886	0.700	2720	113

5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.585	0.048	5/3	42	OK

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

6 Warnings

- 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! 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!
- Hilti post-installed anchors shall be installed in accordance with the Hilti Manufacturer's Printed Installation Instructions (MPII). Reference ACI 318-14, Section 17.8.1.

Fastening meets the design criteria!

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7 Installation data

Anchor plate, steel: -
Profile: -
Hole diameter in the fixture: -
Plate thickness (input): -
Recommended plate thickness: -
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 - CS 3/8 (2 3/4)
Installation torque: 300.000 in.lb
Hole diameter in the base material: 0.375 in.
Hole depth in the base material: 3.375 in.
Minimum thickness of the base material: 5.000 in.

7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer	• Manual blow-out pump	• Torque wrench
• Properly sized drill bit		• Hammer

Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	0.000	0.000	10.000	10.000	10.000	10.000

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