

CAEP

Submittal Documents

Seismic Analysis of the Boiler SF 2000



March 29, 2019

*For:
WEIL-McLAIN*

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Summary

The scope of this report is the seismic qualification, based on the structural analysis, of the boiler model SF 2000, 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 contingency 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 | 02/23/2018 | First Issue | Sam Salissen |
| B | 03/31/2019 | The model is updated | 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 boiler, model SF 2000, 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 $F_{EXX} = 70 \text{ksi} > 54 \text{ksi}$ for base material) based on ASME allowable stress in welds under shear and tension is $0.3 * \text{tensile strength} = 21000 \text{psi}$. 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.

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 Number | Input | Gross Output | Net Rating | Combustion Efficiency | Thermal Efficiency | Boiler Water Content | Vent/Air Pipe Size | Stack/vent flow rate | Boiler weight (pounds) | | |
|---------------------|---------------|---------------|---------------|-----------------------|--------------------|----------------------|--------------------|----------------------|------------------------|---------------------------|-----------------|
| | Btuh (Note 1) | Btuh (Note 1) | Btuh (Note 2) | % (Note 3) | % (Note 4) | Gallons | Inches (Note 5) | scfm (Note 6) | Dry weight (no water) | Operating weight (filled) | Shipping weight |
| SF1000 | 1,000,000 | 958,000 | 833,000 | 96.1 | 95.8 | 13 | 6, 8 or 10 | 279 | 865 | 975 | 1,130 |
| SF1500 | 1,500,000 | 1,437,000 | 1,250,000 | 95.9 | 95.8 | 19 | 8 or 10 | 418 | 1,050 | 1,210 | 1,310 |
| SF2000 | 2,000,000 | 1,906,000 | 1,657,000 | 95.8 | 95.3 | 25 | 8 or 10 | 558 | 1,250 | 1,460 | 1,510 |

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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SEISMIC CALCULATION WORKSHEET

JOB NAME: SA-SF-2000
CUSTOMER: WEIL-McLAIN
DATE: 2/23/2019 PRP BY: CAE PIPING JOB#

BUILDING CODE: IBC-2012 / 2015
SEISMIC DESIGN: S_{ds} = 2 BLDG. ELEVATION: h = 40 ft /EQUIP. LOCATION: z = 40 ft
I_s = 1 R_p = 2.5
a_s = 1 Ω₀ = 2.0
** Assume worst case location.

ANCHORAGE TO CONCRETE: [X] 40 ft. RF [] 0 ft. GF


LOAD COMBINATION: LRFD (0.9 DL + 1.00 E)

EQUIPMENT TAG: SLIM FIT 2000

EQUIPMENT Information: W_p = max operating weight = 1460 lbs.

APPLIED SEISMIC FORCE/ CALCULATIONS:
 $F_p / W_p = (0.4 \times a_p \times S_{ds} \times (1 + (2 \times (z / h)) / (R_p / I_p))) / 0.96 = 0.96$
 $F_p / W_p = 0.96g$; F_{p,max} / 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_{ps} = Applied Lateral Seismic Force = 1.0 x 0.96g x W_p = 1402 lbs. *WORST CASE
 F_{pv} = Vertical component of seismic force = 1.0 x 0.2 x S_{ds} x W_p = 584 lbs. *WORST CASE
 F_v = Vertical total load = F_{pv} - 0.9*W_p = -730 lbs.

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



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SEISMIC CALCULATION WORKSHEET

JOB NAME: SA-SF-2000
CUSTOMER: WEIL-McLAIN
DATE: 2/23/2019 PRP BY: CAE PIPING JOB#

BUILDING CODE: IBC-2012 / 2015
SEISMIC DESIGN: S_{ds} = 2 BLDG. ELEVATION: h = 40 ft /EQUIP. LOCATION: z = 40 ft
I_s = 1 R_p = 2.5
a_s = 1 Ω₀ = 2.0
** Assume worst case location.

ANCHORAGE TO CONCRETE: [X] 40 ft. RF [] 0 ft. GF

LOAD COMBINATION: LRFD (1.2 DL + 1.00 E)

EQUIPMENT TAG: SLIM FIT 2000

EQUIPMENT Information: W_p = max operating weight = 1460 lbs.

APPLIED SEISMIC FORCE/ CALCULATIONS:
 $F_p / W_p = (0.4 \times a_p \times S_{ds} \times (1 + (2 \times (z / h)) / (R_p / I_p))) / 0.96 = 0.96$
 $F_p / W_p = 0.96g$; F_{p,max} / 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_{ps} = Applied Lateral Seismic Force = 1.0 x 0.96g x W_p = 1402 lbs. *WORST CASE
 F_{pv} = Vertical component of seismic force = 1.0 x 0.2 x S_{ds} x W_p = 584 lbs. *WORST CASE
 F_v = Vertical total load = F_{pv} - 1.2*W_p = -1168 lbs.

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

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EQUIPMENT TAG: SLIM FIT 2000

SEISMIC CALCULATION WORKSHEET

JOB NAME: SA-SF-2000

BUILDING CODE: IBC-2012 / 2016

SEISMIC DESIGN: $S_{ds} = 2$
 $I_p = 1$
 $a_p = 1$
 $R_p = 2.5$
 $\Omega_0 = 2.0$

BLDG. ELEVATION: h = 40 ft
/EQUIP. LOCATION: **z = 40 ft

** Assume worst case location

a_p, R_p, Ω_0 per ASCE 7-10

ANCHORAGE TO CONCRETE

40 ft. RF

0 ft. GF

or below ground

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

SHT. NUMBER: 1 OF 1

EQUIPMENT Information:
 W_p = max. operating weight = 1460 lbs.

APPLIED SEISMIC FORCE/ CALCULATIONS:

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

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

F_{ph} = Applied Lateral Seismic Force = 2.5 x 0.96g x W_p = 3504 lbs. *WORST CASE

F_{pv} = Vertical component of seismic force = 1.0 x 0.2 x $S_{ds} \times W_p$ = 584 lbs. *WORST CASE

F_v = Vertical total load = $F_{pv} - G'W_p$ = -730 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.

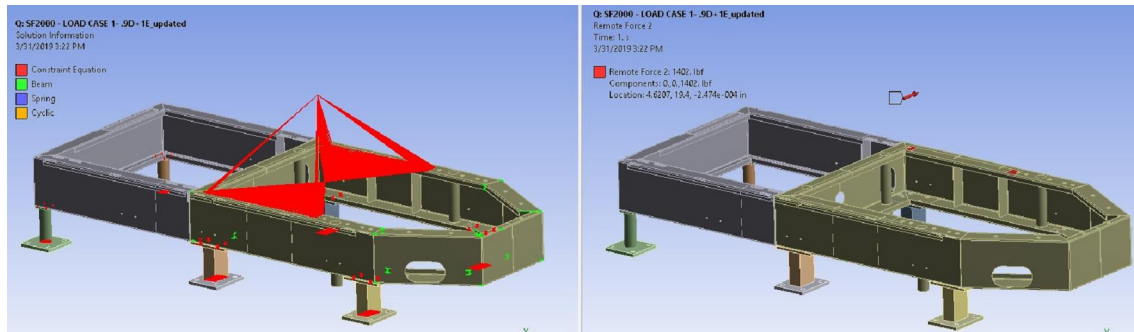


Figure 1- Loads acting on the boiler structure

Table 1- Load Summary

| load Case # | Horizontal Seismic Force FP [lbf] | | Vertical Seismic Force FPV [lbf] | Total vertical Force FV [lbf] |
|-------------|-----------------------------------|----|----------------------------------|-------------------------------|
| | FZ | FX | | |
| 1 | 1402 | 0 | 584 | -605 |
| 2 | 1402 | 0 | 584 | -968 |
| 3 | 3504 | 0 | 584 | -605 |

5.3.1 Anchor Bolts

Hilti KBZ anchor bolts, 3/8" (2 3/4" embedment), are used to anchor the base plates to the floor. 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, Fig. 11

| Reaction forces [lbf] | | | Reaction moments [lbf-ft] | | |
|--------------------------|------|------|------------------------------|----|----|
| FX | FY | FZ | MX | MY | MZ |
| 22 | 1087 | 1195 | 640 | 46 | 67 |

5.4 Results Evaluation

Minimum required strength specified in ASCE (LRFD design approach) is obtained in the analyses of the assembly carried out in sections 5.1 to 5.4, (minimum safety factor of 1 for LRFD load). 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 2000, 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-2000 meets the design requirements of AISC, ASCE7-10 and IBC 2012 standards.

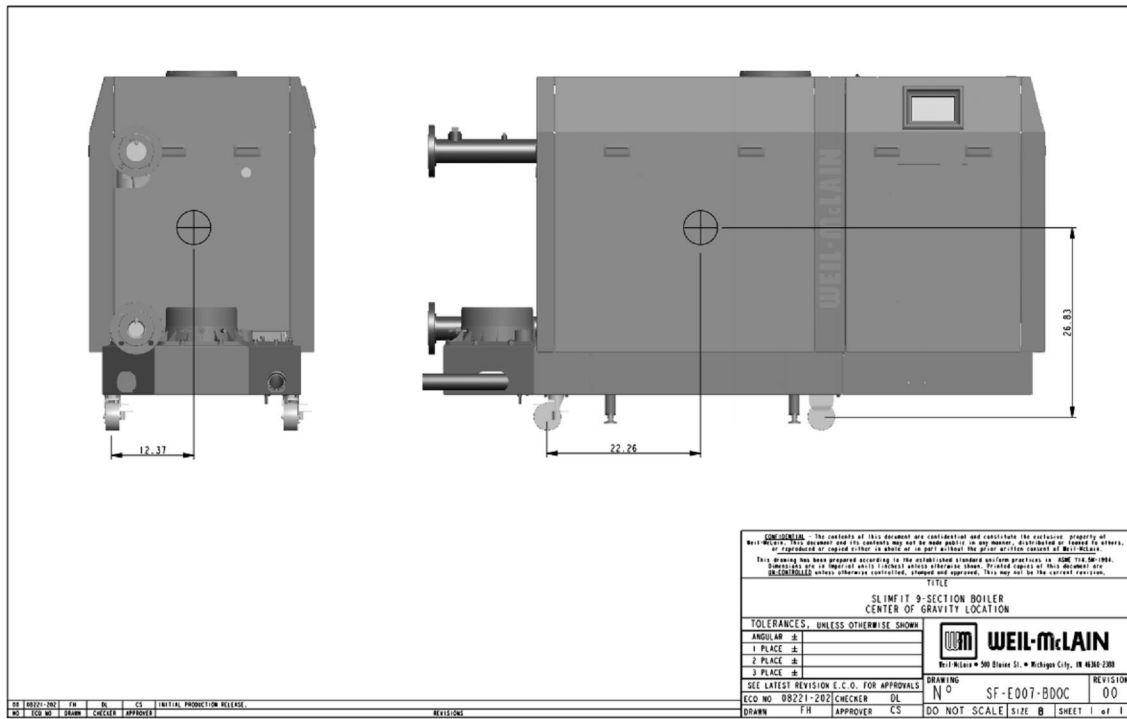
7 References

[1]- IBC 2012.

[2]- AISC 14th Edition.

[3]- ASCE 7-10.

APPENDIX 1- Drawing with COG markup



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Appendix 2- Anchor Bolt Calculation

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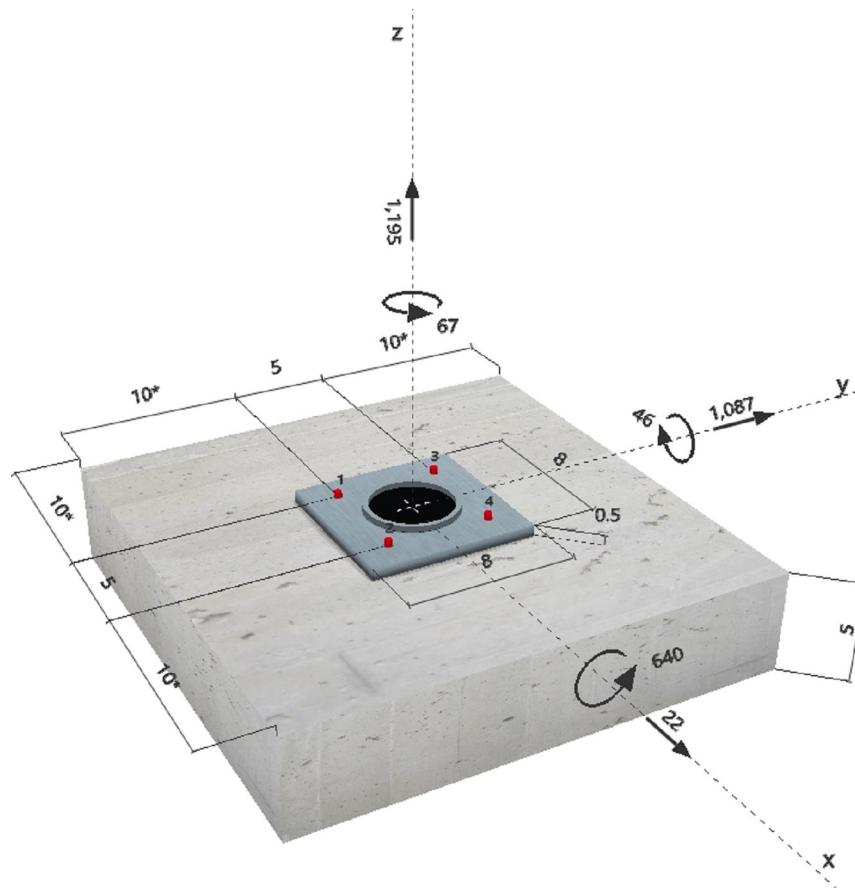
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1
 ANCHOR SF2000
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Specifier's comments:
1 Input data

| | |
|------------------------------------|---|
| 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 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); $t = 0.500$ in. |
| Anchor plate: | $l_x \times l_y \times t = 8.000$ in. x 8.000 in. x 0.500 in.; (Recommended plate thickness: not calculated) |
| Profile: | Round HSS, Steel pipe (AISC); $(L \times W \times T) = 4.500$ in. x 4.500 in. x 0.237 in. |
| Base material: | cracked concrete, 3000, $f'_c = 3000$ psi; $h = 5.000$ in. |
| Installation: | hammer drilled hole, Installation condition: Dry |
| Reinforcement: | tension: condition B, shear: condition B; no supplemental splitting reinforcement present |
| Seismic loads (cat. C, D, E, or F) | edge reinforcement: none or < No. 4 bar Tension load: yes (17.2.3.4.3 (d)) Shear load: yes (17.2.3.5.3 (c)) |


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


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2 Load case/Resulting anchor forces

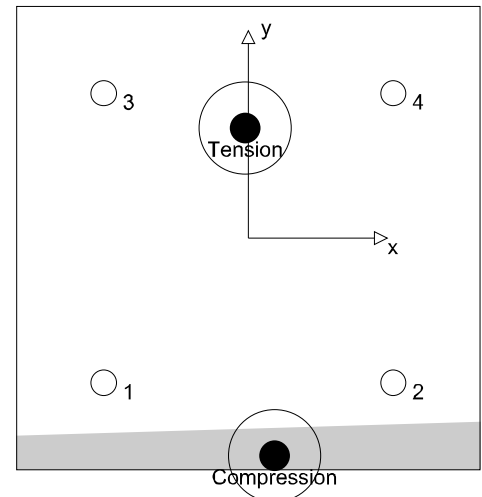
Load case: Design loads

Anchor reactions [lb]

Tension force: (+Tension, -Compression)

| Anchor | Tension force | Shear force | Shear force x | Shear force y |
|--------|---------------|-------------|---------------|---------------|
| 1 | 142 | 236 | 46 | 232 |
| 2 | 117 | 315 | 46 | 312 |
| 3 | 959 | 234 | -35 | 232 |
| 4 | 934 | 314 | -35 | 312 |

max. concrete compressive strain: 0.09 [%]
 max. concrete compressive stress: 391 [psi]
 resulting tension force in (x/y)=(-0.057/1.899): 2151 [lb]
 resulting compression force in (x/y)=(0.449/-3.759): 956 [lb]



3 Tension load

| | Load N_{ua} [lb] | Capacity ϕN_n [lb] | Utilization $\beta_N = N_{ua}/\phi N_n$ | Status |
|------------------------------|--------------------|--------------------------|---|--------|
| Steel Strength* | 959 | 4875 | 20 | OK |
| Pullout Strength* | 959 | 1685 | 57 | OK |
| Concrete Breakout Strength** | 2151 | 3606 | 60 | 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} | $\phi_{nonductile}$ | ϕN_{sa} [lb] | N_{ua} [lb] |
|---------------|----------------|---------------------|--------------------|---------------|
| 6500 | 0.750 | 1.000 | 4875 | 959 |

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3.2 Pullout Strength

$$N_{pn,f_c} = N_{p,2500} \lambda_a \sqrt{\frac{f_c}{2500}} \quad \text{refer to ICC-ES ESR-1917}$$

$$\phi N_{pn,f_c} \geq N_{ua} \quad \text{ACI 318-14 Table 17.3.1.1}$$

Variables

| f_c [psi] | λ_a | $N_{p,2500}$ [lb] |
|-------------|-------------|-------------------|
| 3000 | 1.000 | 3155 |

Calculations

$$\frac{\sqrt{\frac{f_c}{2500}}}{1.095}$$

Results

| N_{pn,f_c} [lb] | $\phi_{concrete}$ | $\phi_{seismic}$ | $\phi_{nonductile}$ | $\phi N_{pn,f_c}$ [lb] | N_{ua} [lb] |
|-------------------|-------------------|------------------|---------------------|------------------------|---------------|
| 3456 | 0.650 | 0.750 | 1.000 | 1685 | 959 |

3.3 Concrete Breakout Strength

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

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

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

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

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

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

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

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

Variables

| h_{ef} [in.] | $e_{c1,N}$ [in.] | $e_{c2,N}$ [in.] | $c_{a,min}$ [in.] | $\psi_{c,N}$ |
|----------------|------------------|------------------|-------------------|--------------|
| 2.750 | 0.057 | 1.899 | 10.000 | 1.000 |
| c_{ac} [in.] | k_c | λ_a | f_c [psi] | |
| 4.125 | 17 | 1.000 | 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] |
|------------------------------|-------------------------------|----------------|----------------|---------------|---------------|------------|
| 175.56 | 68.06 | 0.986 | 0.685 | 1.000 | 1.000 | 4246 |

Results

| N_{cbg} [lb] | $\phi_{concrete}$ | $\phi_{seismic}$ | $\phi_{nonductile}$ | ϕN_{cbg} [lb] | N_{ua} [lb] |
|----------------|-------------------|------------------|---------------------|---------------------|---------------|
| 7398 | 0.650 | 0.750 | 1.000 | 3606 | 2151 |

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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* | 315 | 1466 | 22 | OK |
| Steel failure (with lever arm)* | N/A | N/A | N/A | N/A |
| Pryout Strength** | 1087 | 12956 | 9 | OK |
| Concrete edge failure in direction y+** | 1091 | 3592 | 31 | OK |

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

4.1 Steel Strength

$V_{sa,eq}$ = ESR value refer to ICC-ES ESR-1917
 $\phi V_{steel} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

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

Calculations

$$\frac{V_{sa,eq} [\text{lb}]}{2255}$$

Results

| $V_{sa,eq}$ [lb] | ϕ_{steel} | $\phi_{nonductile}$ | ϕV_{sa} [lb] | V_{ua} [lb] |
|------------------|----------------|---------------------|--------------------|---------------|
| 2255 | 0.650 | 1.000 | 1466 | 315 |

4.2 Pryout Strength

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

$$\phi V_{cpG} \geq V_{ua} \quad \text{ACI 318-14 Table 17.3.1.1}$$

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

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

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

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

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

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

Variables

$$\frac{k_{cp}}{2} \quad \frac{h_{ef} [\text{in.}]}{2.750} \quad \frac{e_{c1,N} [\text{in.}]}{0.739} \quad \frac{e_{c2,N} [\text{in.}]}{0.015} \quad \frac{c_{a,min} [\text{in.}]}{10.000}$$

$$\frac{\psi_{c,N}}{1.000} \quad \frac{c_{ac} [\text{in.}]}{4.125} \quad \frac{k_c}{17} \quad \frac{\lambda_a}{1.000} \quad \frac{f_c [\text{psi}]}{3000}$$

Calculations

| A_{Nc} [in. ²] | A_{Nc0} [in. ²] | $\psi_{ec1,N}$ | $\psi_{ec2,N}$ | $\psi_{ed,N}$ | $\psi_{cp,N}$ | N_b [lb] |
|------------------------------|-------------------------------|----------------|----------------|---------------|---------------|------------|
| 175.56 | 68.06 | 0.848 | 0.996 | 1.000 | 1.000 | 4246 |

Results

| V_{cpG} [lb] | $\phi_{concrete}$ | $\phi_{seismic}$ | $\phi_{nonductile}$ | ϕV_{cpG} [lb] | V_{ua} [lb] |
|----------------|-------------------|------------------|---------------------|---------------------|---------------|
| 18509 | 0.700 | 1.000 | 1.000 | 12956 | 1087 |

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4.3 Concrete edge failure in direction y+

$$V_{cbg} = \left(\frac{A_{Vc}}{A_{Vc0}} \right) \psi_{ec,V} \psi_{ed,V} \psi_{c,V} \psi_{h,V} \psi_{parallel,V} V_b \quad \text{ACI 318-14 Eq. (17.5.2.1b)}$$

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

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

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

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

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

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

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

Variables

| c_{a1} [in.] | c_{a2} [in.] | e_{cV} [in.] | $\psi_{c,V}$ | h_a [in.] |
|----------------|----------------|----------------|--------------|---------------------|
| 6.667 | 10.000 | 0.369 | 1.000 | 5.000 |
| l_e [in.] | λ_a | d_a [in.] | f_c [psi] | $\psi_{parallel,V}$ |
| 2.750 | 1.000 | 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] |
|------------------------------|-------------------------------|---------------|---------------|--------------|------------|
| 125.00 | 200.00 | 0.964 | 1.000 | 1.414 | 6020 |

Results

| V_{cbg} [lb] | $\phi_{concrete}$ | $\phi_{seismic}$ | $\phi_{nonductile}$ | ϕV_{cbg} [lb] | V_{ua} [lb] |
|----------------|-------------------|------------------|---------------------|---------------------|---------------|
| 5132 | 0.700 | 1.000 | 1.000 | 3592 | 1091 |

5 Combined tension and shear loads

| β_N | β_V | ζ | Utilization β_{NV} [%] | Status |
|-----------|-----------|---------|------------------------------|--------|
| 0.597 | 0.304 | 5/3 | 56 | OK |

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

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!
- An anchor design approach for structures assigned to Seismic Design Category C, D, E or F is given in ACI 318-14, Chapter 17, Section 17.2.3.4.3 (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 17.2.3.4.3 (b), Section 17.2.3.4.3 (c), or Section 17.2.3.4.3 (d). The connection design (shear) shall satisfy the provisions of Section 17.2.3.5.3 (a), Section 17.2.3.5.3 (b), or Section 17.2.3.5.3 (c).
-
- 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.



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Profis Anchor 2.7.1

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Fastening meets the design criteria!

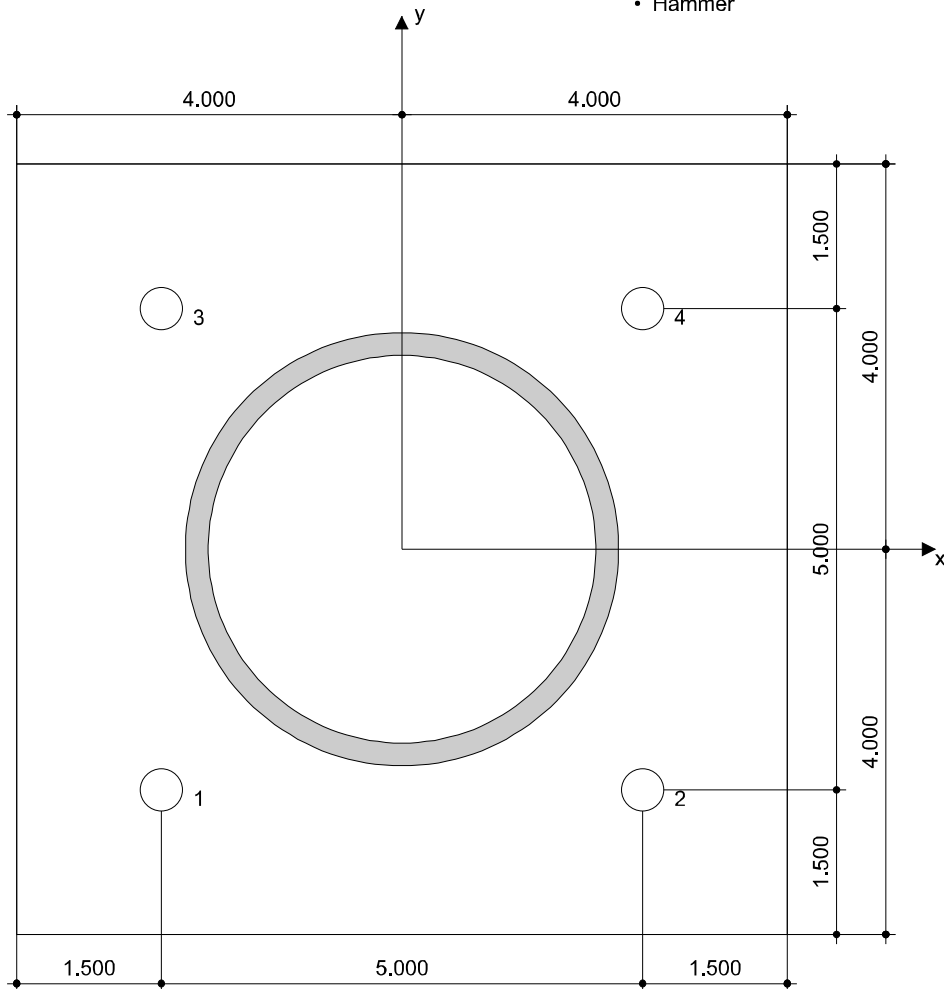
7 Installation data

Anchor plate, steel: -
 Profile: Round HSS, Steel pipe (AISC); 4.500 x 4.500 x 0.237 in.
 Hole diameter in the fixture: $d_f = 0.438$ 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 - 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 |
|--|--|---|
| <ul style="list-style-type: none"> • Suitable Rotary Hammer • Properly sized drill bit | <ul style="list-style-type: none"> • Manual blow-out pump | <ul style="list-style-type: none"> • Torque wrench • Hammer |



Coordinates Anchor in.

| Anchor | x | y | C _{-x} | C _{+x} | C _{-y} | C _{+y} |
|--------|--------|--------|-----------------|-----------------|-----------------|-----------------|
| 1 | -2.500 | -2.500 | 10.000 | 15.000 | 10.000 | 15.000 |
| 2 | 2.500 | -2.500 | 15.000 | 10.000 | 10.000 | 15.000 |
| 3 | -2.500 | 2.500 | 10.000 | 15.000 | 15.000 | 10.000 |
| 4 | 2.500 | 2.500 | 15.000 | 10.000 | 15.000 | 10.000 |



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8 Remarks; Your Cooperation Duties

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