

# Submittal Documents

Seismic Analysis of the Boiler SVF 725/850



MAY 31, 2022

No. 39128

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 SVF 725/850, 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 2018, ASCE 7-22 and AISC 14<sup>th</sup> standards for the seismic zone 4, as the 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 the seismic lugs meets the design requirements of IBC 2018, ASCE 7-22 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
А	05/31/2022	First Issue	Sam Salissen

# **Table of Contents**

1	Intr	oduction	. 6
	1.1	Scope	. 6
2	Ass	umptions and open issues	6
3	Req	uirements and Prerequisites	. 7
	3.1	Stress criteria	7
	3.2	Loads	. 7
4	FE :	model	10
	4.1	The extent of the model	10
	4.2	Material data	10
5	Stre	ss Analyses	11
	5.1	Analysis of assembly: Load Case 1	11
	5.2	Analysis of assembly: Load Case 2	12
	5.3	Analysis of assembly: Load Case 3	13
	5.4	Anchor Bolts	14
	5.5	Results Evaluation	14
6	Con	clusion	14
7	Ref	erences	15

# **APPENDICES**

APPENDIX 1- Drawing with COG markup

APPENDIX 2- Anchor Bolt Calculation Report

# 1 Introduction

# 1.1 Scope

The scope of this report is the seismic qualification, based on the structural analysis, of the boiler, model SVF 725/850, under the seismic loads (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 2018, ASCE 7-22 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 the allowable stresses of the structural members, based on (AISC), is less than the allowable stress in the welds. 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 2018 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 & ASCE 7-22 for the steel parts and LRFD for the anchorage calculations.

# 3.2 Loads

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

850-Sheet Metal Asy.SLDA	SM			
				Option
Override Mass Prope	rties	Recalculate	1	
Include hidden bodies/	components			
Show weld bead mass				
Report coordinate values i	relative to:	- default		
Mass properties of 850-Sh Configuration: Default Coordinate system: d		1		
* Includes the mass prope	rties of one o	r more hidden co	mponent	s/bodies
Mass = 674.97 pounds				
Volume = 4243.92 cubic ir	thes			
Surface area = 44573.43 s	quare inches			
Center of mass: ( inches ) X = 0.45 Y = 29.85 Z = -15.61				
Principal axes of inertia ar		oments of inertia	(pound	s * squar
Taken at the center of ma lx = (0.01, 1.00, -0.01 ly = (0.10, 0.01, 0.99 lz = (1.00, -0.01, -0.10	) Px = 771 ) Py = 138	189.82 3350.05 4734.59		
Moments of inertia: ( pou Taken at the center of ma			coordin	
Lxx = 154571.09	Lxy = 42	8.56	Lxz = 1	612.67
Lyx = 428.56 Lzx = 1612.67	Lyy = 77 Lzy = -70		Lyz = - Lzz = 1	767.46 38501.79
Moments of inertia: ( pou Taken at the output coord				
Ixx = 920330.24 Iyx = 9417.74	lxy = 94 lyy = 24		Ixz = -3 Iyz = -3	087.31
lzx = -3087.31	lzy = -31			39999.87
<				
Help	Print		Convit	Clipboa

Three load cases are considered in this report, the analyses are based on the worst load combinations specified in ASCE 7-22. 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

	JOB NAME:						HEET									
CAEP	SVF 850			BUILDING	G CODE											
				IBC-2018												
				SEISMIC	DESIGN	BLD	G, ELEVA	TION								
14271 Jeffery Rd.,	CUSTOME	ER:		S as =	2	<u>/E0</u>	UIP. LOCA	TION								
Irvine, CA 90032	WEIL-McL	.AIN		1 <sub>p</sub> =	1		h	=	40 fi							
PH (949) 923 9073 FX (949) 264 7184				a <sub>p</sub> =	1		**z	=	40 fi	X	40 ft. RF		_			
www.caepiping.com	DATE:	PRP. BY.:	CAE PIPING JOB #:	R <sub>p</sub> =	2.5	** A	ssume wors	st					LOAD	COMBINATION		
"CALL US - TO SET THINGS RIGHT"	5/29/2022			Ω₀ =	2.0	G	ase location.						LRFD	-1		
				1	ap	, R <sub>p</sub> , Ω <sub>o</sub> per AS	CE 7-10		ļ				(		0.9 DL +	- <mark>1.20</mark> E )
EQUIPMENT TAG: SVF 850											01t.GF					
											or below gro	und				
			APPLIED SEISMIC	ORCE/ CA	LCULATION	S:						ANCHO	RAGE TO C	ONCRETE		SHT. NUMBER:
EQUIPMENT Information:			$F_{\rho}$ / $W_{\rho}$ =	(0.4 x	a <sub>p X</sub> S	es X (		1 + (	2 X ( 2	( <i>h</i> )))	$I = (R_{\rho} - )$	/ I <sub>p</sub> )	= 0.96			1 OF 1
W_P = max. operating weight	= 510 lbs.		$F_{\rho} \neq W_{\rho} = 0.9$	16g ; F <sub>é</sub>	o,eein   Wg	=	0.3	× S	ies × Ip	= 0.60	;F <sub>p,max</sub> )	W <sub>p</sub> =	1.6	х	S <sub>ds</sub> × I <sub>p</sub>	= 3.20
			$F_{\rho h}$ = Applied Later	al Seismic F	orce	= 1.2		x (	0.96g x	W,		=	588 lbs.		*WORS	ST CASE
			$F_{\rho v} = Vertical comp$	onent of seis	smic force	=	1.0	x C	).2 x S <sub>e</sub>	ς × Wρ		=	204 lbs.		*WORS	ST CASE
			F , = Vertical total I	ad = I	F <sub>₽V</sub> 9*VVp	=	-255 lbs.									

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

	JOB NAME	1		SEISMIC	CALCULA	TION WORKSH	EET									
CAEP	SVF 850			<b>BUILDIN</b>	<u>G CODE</u>											
				IBC-2018	IBC-2018											
				SEISMIC	DESIGN	BLDC	G, ELEVAT	TION								
14271 Jeffery Rd.,	CUSTOME	R:		S <sub>ets</sub> =	2	/EQU	JIP. LOCA	TION								
Irvine, CA 90032	WEIL-McL	AIN		I <sub>P</sub> =	1		h	=	40 fl							
PH (949) 923 9073 FX (949) 264 7184				a <sub>p</sub> =	1		**z	=	40 fl	X	40 ft. RF					
www.caepiping.com	DATE:	PRP. BY.:	CAE PIPING JOB#:	R <sub>p</sub> =	2.5	** As:	sume wors	st					LOAD	COMBINATION		
"CALL US - TO SET THINGS RIGHT"	5/29/2022			Ω₀ =	2.0	cas	se location.						LRFD	-2		
				1		a <sub>p</sub> , R <sub>p</sub> , Ω <sub>o</sub> per ASC	E 7-10						(		1 DL +	120 E )
EQUIPMENT TAG: SVF 850											0ft.GF					
											or below grou	ind				
			APPLIED SEISMIC	FORCE/ CA	LCULATIO	NS:						ANCH	ORAGE TO C	ONCRETE		SHT. NUMBER:
EQUIPMENT Information:			$F_{\rho}$ / $W_{\rho}$ =	(0.4 x	a <sub>p</sub> x	\$ <sub>₫5</sub> X (		1 + (	2 × ( <b>z</b>	/ /)))	/ ( R <sub>p</sub> /	I <sub>p</sub>	) = 0.96			1 OF 1
<b>W</b> <sub>P</sub> = max, operating weight	= 510 lbs.		$F_{\rho} \neq W_{\rho} = 0.9$	96g ; F	o,min   Wp	=	0.3	x	S <sub>ds</sub> × I <sub>p</sub>	= 0.60	;F <sub>p,max</sub> )	W <sub>p</sub>	= 1.6	х	S <sub>ets</sub> × I <sub>p</sub>	= 3.20
			$F_{\rho h}$ = Applied Later	al Seismic I	Force	= 1.2		х	0.96g x 🖡	V,			= <mark>588 lbs.</mark>		*WOR8	ST CASE
			$F_{\rho\nu}$ = Vertical comp	ponent of sei	smic force	=	1.0	x	0.2 × S <sub>ds</sub>	× W <sub>p</sub>			= <mark>204 lbs.</mark>		*WOR8	ST CASE
			F , = Vertical total l	oad =	F <sub>ρν</sub> - Wip	=	-306 lbs.									

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

	JOB NAME		SEISMIC	CALCULA	TION WORKS	HEET											
CAEP	SVF 850			BUILDING	<u>G CODE</u>												
				IBC-2018													
							G, ELEVA	TION									
14271 Jeffery Rd.,	14271 Jeffery Rd., CUSTOMER;						QUIP. LOCA	TION									
Irvine, CA 90032	1 <sub>p</sub> =	1		h	=	40 fl											
PH (949) 923 9073 FX (949) 264 7184				a, =	1		**z	=	40 fl	X	40 ft. RF						
www.caepiping.com DATE: PRP. BY.: CAE PIPING JOB#:					2.5	** A	ssume wor:	st					LOAD	COMBINATION			
"CALL US - TO SET THINGS RIGHT"	5/29/2022			Ω <sub>0</sub> =	2.0	c	ase location						LRFD	-3			
				1	6	a <sub>p</sub> , R <sub>p,</sub> Ω <sub>e</sub> per AS	CE 7-10		1				(		0.9 DL →	2.00	Ε)
EQUIPMENT TAG: SVF 850											01L GF						
											or below gro	und					
			APPLIED SEISMIC F	ORCE/ CA	LCULATIO	NS:						ANCHO	RAGE TO C	ONCRETE		SHT. N	UMBER:
EQUIPMENT Information:			$F_{\rho}$ / $W_{\rho}$ = 1	0.4 x	a, x	)× zu R		1 + (	2 × ( z	/ / )))	/ ( R <sub>p</sub> - 1	iρ)	= 0.96			1	0F 1
$W_P = \max$ operating weight	16g ; F <sub>6</sub>	min   Wp	=	0.3	х	S <sub>ds</sub> × Ip	= 0.60	;F <sub>p,max</sub> /	W <sub>p</sub> =	1.6	х	S <sub>ds</sub> × I <sub>p</sub>	= 3.1	20			
	Fph = Applied Later	al Seismic F	orce	= 2.0		х	0.96g x <b>W</b>	ρ		=	980 lbs.		*WOR	ST CAS	E		
$F_{\rho\nu}$ = Vertical co					smic force	=	1.0	х	0.2 x S <sub>ds</sub>	× W <sub>p</sub>		=	204 lbs.		*WOR	ST CAS	E
			$F_{v}$ = Vertical total le	bad = I	F <sub>ρt</sub> 9*Wp	=	-255 lbs.										

The seismic load and acceleration and the weight 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 #		eismic Force [lbf]	Vertical Seismic Force FPV [lbf]	Total vertical Force FV [lbf]	Horizontal Seismic Acceleration [g]				
	FZ	FX			AY	AX-AZ			
1	588	0	204	-255	0.5	1.152			
2	588	0	204	-306	0.6	1.152			
3	980	0	204	-255	0.5	1.92			

# 4 FE model

# 4.1 The extent of the model

A FE model is built based on the SoildWorks model provided by WM. The loads bearing parts , corresponding to the load path from the COG to the base plates, are included in the FE- model. Flexible joints and contact elements are used to assemble the parts, simulating the bolts and welds, see Fig. 2.



Figure 2- FE model of the boiler and joint/contact definitions

# 4.2 Material data

The material properties used in the construction of the boiler is governed under the internationally recognized ANSI, ASTM standards for the solid shapes and the AWS standards for welding wire. The specific alloys of steel bar, tube, plate, round and channel used in the construction include **S235JR** Carbon Steel and listed below.

S235JR Carbon Steel: E=2.9E+7 psi, S<sub>Y</sub>=34,000 psi

# 5 Stress Analyses

# 5.1 Analysis of assembly: Load Case 1

In this load case, the lateral seismic load and acceleration, calculated in Section 3.2, is applied in the direction of X-Axis(lateral), as shown in Fig. 3. All dimensions, loads and stresses are in inch, lbf and psi, respectively.



Fig. 3 – Loading case 1- Loading and boundary conditions

Maximum peak stress (Bending+ membrane+ stress concentration stresses) and shear stress of 31,657psi and 17,492psi are computed in the FE analysis, Fig.4, which meets the requirements of AISC. The peak stresses in the parts, Fig.4, are local stresses and the linearized stresses through the thickness of the part at the location where the highest stress is occurred, is much less than the values reported here.



Fig. 4 – Maximum peak and shear stresses in load case 1

# 5.2 Analysis of assembly: Load Case 2

In this load case, the lateral seismic load and acceleration, calculated in Section 3.2, is applied in the direction of X-Axis (lateral), as shown in Fig. 5. All dimensions, loads and stresses are in inch, lbf and psi, respectively.



Fig. 5 - Load case 2- Loading and boundary conditions

Maximum peak stress (Bending+ membrane+ stress concentration stresses) and shear stress of 33,535psi and 18,006psi are computed in the FE analysis Fig.6, which meets the requirements of AISC. The peak stresses in the parts, Fig. 6, are local stresses and the linearized stresses through the thickness of the part at the location where the highest stress is occurred, is much less than the values reported here.



Fig. 6 – Maximum peak and shear stresses in load case 2

# 5.3 Analysis of assembly: Load Case 3

In this load case, the lateral seismic load, calculated in Section 3.2, is applied in the direction of X-Axis, as shown in Fig. 8. All dimensions, loads and stresses are in inch, lbf and psi, respectively.



Fig. 8 – Load case 3- Loading and boundary conditions

The maximum reaction loads at the base plates are extracted from the analyses and shown in Figure 10. These loads are used in the analysis of the anchor bolts.



Fig. 10 - Maximum reaction force in the base plates

#### 5.4 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 anchor bolts are extracted from the FE-analyses (load case 3). 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).

Reaction forces [lbf]									
FX	FY	FZ							
325	150	350							

Table-3: Reaction loads in the base plate, Fig. 10

#### 5.5 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 SVF 725/850, 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 SVF 725/850 meets the design requirements of AISC, ASCE7-10 and IBC 2018 standards.

# 7 References

- [1]- IBC 2012.
- [2]- AISC 14<sup>th</sup> Edition.
- [3]- ASCE 7-10.

# APPENDIX 1- Drawing with COG markup





2 Roce Declind + XX 3 Roce Declind + XXX EX LIST Refloce C. FOR APPROVALS EX LIST Refloce C. C RORAPPROVALS EX LIST Refloce C. APPROVALS		m practices in ASVE Y143M-1994. Dimensions are in imperial units (inches) unless otherwise controlled, stamped and approved. The may not be the current solution.
Angular 1.X* Proce Decimal ± XX 2 Proce Decimal ± XXX 3 Proce Decimal ± XXX 3 Proce Decimal ± XXX 2 Roce Decimal ± XXXX 2 Roce		VF 850
SEE LATEST REVISION E.C.U. FOR APPROVALS	Angular ± X° 1 Place Decimal ± X 2 Place Decimal ± XX	
ECO NO ECO-XXXX OHECKER XXX NO. XXXXXXXXDOC X		 VVVVVVVVV0000 VVV



COG WITH WATER BODY





COG WITHOUT WATER BODY

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B	DE		н	1	J	K	L	M	N	0	P Q	R	S T U	V W	X Y
1	ТГ	Cover Plate Assembly	1										Aass Properties		- 0
		3305 2223	1	1020	0.28	14.9							lass Properties		- 0
	2	330100225	1	1020	0.28	2.98							850-Sheet Metal Asy.SLDA	CM	
		570318102	1	1020	0.28	0.55									Options
		330100227	1	1020	0.28	3.039									Options
		590318010	1			0.01									
		460005712	1			0.04							Override Mass Prope	ties Recalculat	*
	1	591419201	1			0.02									
		590300034 COPY	1	1020		0.02	29.6						Include hidden bodies		
		511390494	1			0.17							Create Center of Mass f	eature	
1	0	590300057	1			0.001							Show weld bead mass		
1	1	511330495	1	1020		0.13							Report coordinate values r	alathus to:	
	2	590300088 RO	1			0.03									
	3	590318183	1	1		0.38							Mass properties of 850-Sh Configuration: Default	eet Metal Asy	
	4	590318195	1			0.13							Configuration: Default Coordinate system: d	efault	
1	s	591000077	1			7.2									
		510312372	-	1		-							<ul> <li>Includes the mass prope</li> </ul>	ties of one or more hidden	components/bodies.
		560907843											Mass = 537.84 pounds		
-	3	HM_500	1			13.61									
-	ь	Silencer	1			1.09							Volume = 2272.09 cubic in	ches	
	2	560907551 RHD	-										Surface area = 43687.18 st	uare inches	
-		560907551 pipe RH0	1	pc	0.28	0.15									
-		511246296 RHD	1	Brass	0.31	0.63							Center of mass: (inches) X = 0.56		
-		511246296_RH0	1	Brass		0.6							Y = 27.54		
		560907850	1	DC		0.99							Z = -15.06		
		591125926	1			13.7							Principal axes of inertia an	d principal moments of iner	tia: ( pounds * square
		560907857	1			1.55						-	Taken at the center of mar	8.	
-		2640000317 R0	1			4.5	58,63						Ix = (0.02, 1.00, 0.05) Iy = (0.09, -0.06, 0.99)	Px = 72086.78 Px = 121053.67	
-		2681000050 (blower)	1			13.47							Iz = (1.00, -0.01, -0.09	Pz = 136490.26	
		4464(261	1			0.02									
	0	48301012	2			0.06							Moments of inertia: ( pour Taken at the center of mar	ids " square inches ) is and aligned with the outp	ut coordinate system
- 1	1	1003600744	1			0.66							Lxx = 136342.59	Lxy = 1124.07	Lxz = 1446.91
	2	1003500112	1			3.33							Lyx = 1124.07 Lyx = 1446.91	Lyy = 72247.08 Lzy = 2597.67	Lyz = 2597.67 Lzz = 121041.04
	3	2701000147	1			1.86							LLX = 1440.91	Leg = 239/10/	LLL = 121041.04
		4452k341	2	-		0.04						-	Moments of inertia: ( pour	ids * square inches)	
	5	990300022	1	-		0.04							Taken at the output coord lxx = 666166.74	inate system. by = 9417.71	bz = -3087.30
	6	590300022 590318041	1			0.02							lyx = 9417.71	by = 194334.59	lyz = -220407.61
	7	590318042	2	-		0.001						-	Izx = -3087.30	lzy = -220407.61	lzz = 529114.94
	8	gas_valve_v4730c_RH0	1	-		2.339									
		gas_varve_v4/30c_kH0 HX850 11152021	1			283.31	283.31					-			,
	++-	INV030_TTT320CT	+ <u> </u>	-		200.01	200.01						Help	Print	Copy to Clipboard
-	++-		-				371.54								
-+	++-		-	-			0.36	Unassigned part Wt (cad model Dry vrt-dry from Fab Part)							
-+	++-		-	-			137.14	Unassigned part Wt (Cad model Dry vrt-dry from Fab Part) vvater body							
-+	++-		+	-				Cummulative Fab Parts + Water Bodies							
		1	1	1	1	1	505.04	cummulauve nau naris + mater bodies							

Appendix 2- Anchor Bolt Calculation

# Profis Anchor 2.7.1

SVF 825

5/29/2022

#### www.hilti.us

Company: Specifier: Address: Phone I Fax: E-Mail:

#### Specifier's comments:

I

#### 1 Input data

Anchor type and diameter:	Kwik Bolt TZ - CS 3/8 (2 3/4)
Effective embedment depth:	h <sub>ef,act</sub> = 2.750 in., h <sub>nom</sub> = 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, 3000, f <sub>c</sub> ' = 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
	edge reinforcement: none or < No. 4 bar
Seismic loads (cat. C, D, E, or F)	Tension load: yes (17.2.3.4.3 (d))
	Shear load: yes (17.2.3.5.3 (c))

Page:

Date:

Project:

Sub-Project I Pos. No.:

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



Input data and results must be checked for agreement with the existing conditions and for plausibility! PROFIS Anchor ( c ) 2003-2009 Hilti AG, FL-9494 Schaan Hilti is a registered Trademark of Hilti AG, Schaan

# **Profis Anchor 2.7.1**

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Company: Specifier: Address: Phone I Fax: E-Mail:

Page: Project: Sub-Project I Pos. No.: Date:

SVF 825

5/29/2022

2

#### 2 Load case/Resulting anchor forces

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Load case: Design loads

#### Anchor reactions [lb]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	150	460	325	325
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 <sub>ua</sub> [lb]	Capacity 🖕 N <sub>n</sub> [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	150	4875	4	OK
Pullout Strength*	150	1685	9	OK
Concrete Breakout Strength**	150	977	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
φNs	<sub>a</sub> ≥ N <sub>ua</sub>	ACI 318-14 Table 17.3.1.1

#### Variables

A <sub>se,N</sub> [in. <sup>2</sup> ]	f <sub>uta</sub> [psi]
0.05	125000

#### Calculations

N<sub>sa</sub> [lb] 6500

## Results

N <sub>sa</sub> [lb]	∲ steel	∲ nonductile	φ N <sub>sa</sub> [lb]	N <sub>ua</sub> [lb]
6500	0.750	1.000	4875	150



Company:	
Specifier:	
Address:	
Phone I Fax:	
E-Mail:	

	FIULS ALC
Page:	3
Project:	SVF 825
Sub-Project I Pos. No	).:
Date:	5/29/2022

#### 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

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#### Variables

ŕ <sub>c</sub> [psi]	λa	N <sub>p,2500</sub> [lb]
3000	1.000	3155
Calculations		

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

#### Results

N <sub>pn,f</sub> [lb]	∲ concrete	∮ seismic	$\phi$ nonductile	φ N <sub>pn,fc</sub> [lb]	N <sub>ua</sub> [lb]	
3456	0.650	0.750	1.000	1685	150	_

#### 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)
$\phi N_{cb} \ge N_{ua}$	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)
$\psi_{\text{ec,N}} = \left(\frac{1}{1 + \frac{2 e_N}{3 h_{\text{ef}}}}\right) \le 1.0$	ACI 318-14 Eq. (17.4.2.4)
$\psi_{ed,N} = 0.7 + 0.3 \left( \frac{c_{a,min}}{1.5h_{ef}} \right) \le 1.0$	ACI 318-14 Eq. (17.4.2.5b)
$\begin{split} \psi_{\text{cp,N}} &= \text{MAX} \left( \frac{c_{\text{a,min}}}{c_{\text{ac}}}, \frac{1.5h_{\text{ef}}}{c_{\text{ac}}} \right) \leq 1.0 \\ N_{\text{b}} &= k_{\text{c}} \lambda_{\text{a}} \sqrt{t_{\text{c}}^{\text{c}} h_{\text{ef}}^{1.5}} \end{split}$	ACI 318-14 Eq. (17.4.2.7b)
$N_{\rm b} = K_{\rm c} \lambda_{\rm a} \sqrt{f_{\rm c}} h_{\rm ef}^{1.5}$	ACI 318-14 Eq. (17.4.2.2a)

#### Variables

h <sub>ef</sub> [in.]	e <sub>c1,N</sub> [in.]	e <sub>c2,N</sub> [in.]	c <sub>a,min</sub> [in.]	Ψ c,N
1.667	0.000	0.000	2.500	1.000
c <sub>ac</sub> [in.]	k <sub>c</sub>	λa	ŕ <sub>c</sub> [psi]	
4.125	17	1.000	3000	

#### Calculations

A <sub>Nc</sub> [in. <sup>2</sup> ]	A <sub>Nc0</sub> [in. <sup>2</sup> ]	Ψ ec1,N	$\Psi$ ec2,N	$\Psi$ ed,N	Ψ cp,N	N <sub>b</sub> [lb]
25.00	25.00	1.000	1.000	1.000	1.000	2003
Results						
N <sub>cb</sub> [lb]	∮ concrete	φ seismic	$\phi$ nonductile	φ N <sub>cb</sub> [lb]	N <sub>ua</sub> [lb]	
2003	0.650	0.750	1.000	977	150	



# www.hilti.usProfis Anchor 2.7.1Company:Page:4Specifier:Project:SVF 825Address:Sub-Project I Pos. No.:Phone I Fax:Phone I Fax:IDate:5/29/2022E-Mail:Sub-Project I Pos. No.:SUPProject I Pos. No.:

#### 4 Shear load

	Load V <sub>ua</sub> [lb]	Capacity <sub>o</sub> V <sub>n</sub> [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	460	1466	32	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	460	2805	17	OK
Concrete edge failure in direction x+**	460	581	80	OK

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

#### 4.1 Steel Strength

V <sub>sa,eq</sub> = ESR value	refer to ICC-ES ESR-1917
$\phi V_{\text{steel}} \ge V_{\text{ua}}$	ACI 318-14 Table 17.3.1.1

#### Variables

A <sub>se,V</sub> [in. <sup>2</sup> ]	f <sub>uta</sub> [psi]
0.05	125000

#### Calculations

#### Results

V <sub>sa,eq</sub> [lb]	∮ steel	$\phi$ nonductile	φ V <sub>sa</sub> [lb]	V <sub>ua</sub> [lb]
2255	0.650	1.000	1466	460

#### 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)
∳ V <sub>cp</sub> ≥ V <sub>ua</sub> A <sub>Nc</sub> see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)	ACI 318-14 Table 17.3.1.1
$A_{\rm Nc0} = 9 h_{\rm ef}^2$	ACI 318-14 Eq. (17.4.2.1c)
$\Psi_{\text{ec,N}} = \left(\frac{1}{1 + \frac{2 e_{N}}{3 h_{\text{ef}}}}\right) \le 1.0$	ACI 318-14 Eq. (17.4.2.4)
$\psi_{\text{ed,N}} = 0.7 + 0.3 \left( \frac{c_{a,\min}}{1.5h_{\text{ef}}} \right) \le 1.0$	ACI 318-14 Eq. (17.4.2.5b)
$\psi_{\text{cp,N}} = \text{MAX}\left(\frac{c_{a,\min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \le 1.0$	ACI 318-14 Eq. (17.4.2.7b)
$N_{\rm b} = k_{\rm c} \lambda_{\rm a} \sqrt{f_{\rm c}} h_{\rm ef}^{1.5}$	ACI 318-14 Eq. (17.4.2.2a)

#### Variables

k	h <sub>ef</sub> [in.]	e <sub>c1,N</sub> [in.]	e <sub>c2,N</sub> [in.]	c <sub>a,min</sub> [in.]		
2	1.667	0.000	0.000	2.500		
Ψ c,N	c <sub>ac</sub> [in.]	k <sub>c</sub>	λa	f <sub>c</sub> [psi]		
1.000	4.125	17	1.000	3000		
Calculations						
A <sub>Nc</sub> [in. <sup>2</sup> ]	A <sub>Nc0</sub> [in. <sup>2</sup> ]	Ψ ec1,N	Ψ ec2,N	$\psi_{\text{ed,N}}$	Ψ cp,N	N <sub>b</sub> [lb]
25.00	25.00	1.000	1.000	1.000	1.000	2003
Results						

V <sub>cp</sub> [lb]	φ <sub>concrete</sub>	∮ seismic	∮ nonductile	φ V <sub>cp</sub> [lb]	V <sub>ua</sub> [lb]
4007	0.700	1.000	1.000	2805	460



Company:	
Specifier:	
Address:	
Phone I Fax:	
E-Mail:	

Page:	5
Project:	SVF 825
Sub-Project I Pos. No.:	
Date:	5/29/2022

#### 4.3 Concrete edge failure in direction x+

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$V_{cb} = \left(\frac{A_{Vc}}{A_{Vc0}}\right) \psi_{ed,V} \psi_{c,V} \psi_{h,V} \psi_{parallel,V} V_{b}$	ACI 318-14 Eq. (17.5.2.1a)
$\phi V_{cb} \ge V_{ua}$	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)
	ACI 310-14 Eq. (17.5.2.10)
$\Psi_{ec,V} = \left(\frac{1}{1 + \frac{2e_v}{3c_{a1}}}\right) \le 1.0$	ACI 318-14 Eq. (17.5.2.5)
$\Psi_{\text{ed},V} = 0.7 + 0.3 \left( \frac{c_{a2}}{1.5 c_{a1}} \right) \le 1.0$	ACI 318-14 Eq. (17.5.2.6b)
$\psi_{h,V} = \sqrt{\frac{1.5c_{a1}}{h_a}} \ge 1.0$	ACI 318-14 Eq. (17.5.2.8)
$V_{b} = \left(7 \left(\frac{I_{e}}{d_{a}}\right)^{0.2} \sqrt{d_{a}}\right) \lambda_{a} \sqrt{f_{c}} c_{a1}^{1.5}$	ACI 318-14 Eq. (17.5.2.2a)

Variables

c <sub>a1</sub> [in.]	c <sub>a2</sub> [in.]	e <sub>cV</sub> [in.]	Ψ c,V	h <sub>a</sub> [in.]
2.500	2.500	0.000	1.000	5.000
l <sub>e</sub> [in.]	λа	d <sub>a</sub> [in.]	ť <sub>c</sub> [psi]	$\Psi$ parallel,V
2.750	1.000	0.375	3000	1.000

Calculations

A <sub>Vc</sub> [in. <sup>2</sup> ]	A <sub>Vc0</sub> [in. <sup>2</sup> ]	$\Psi$ ec,V	$\psi_{\text{ed,V}}$	$\psi_{h,V}$	V <sub>b</sub> [lb]
18.75	28.13	1.000	0.900	1.000	1382
Results					
V <sub>cb</sub> [lb]	∲ concrete	φ seismic	$\phi$ nonductile	φ V <sub>cb</sub> [lb]	V <sub>ua</sub> [lb]
829	0.700	1.000	1.000	581	460

#### 5 Combined tension and shear loads

β <sub>N</sub>	βv	ζ	Utilization β <sub>N,V</sub> [%]	Status	
0.154	0.792	5/3	73	OK	

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

#### **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.



Company: Specifier: Address: Phone I Fax: E-Mail:

I

Page: Project: Sub-Project I Pos. No.: Date:

6 SVF 825 5/29/2022

# Fastening meets the design criteria!



Company:Page:7Specifier:Project:SVF 825Address:Sub-Project I Pos. No.:Phone I Fax:Phone I Fax:|Date:5/29/2022E-Mail:Sub-Project I Pos. No.:Sub-Project I Pos. No.:

#### 7 Installation data

 Anchor plate, steel: Anchor type and diameter: Kwik Bolt TZ - CS 3/8 (2 3/4)

 Profile: Installation torque: 25.000 ft.lb

 Hole diameter in the fixture: Hole diameter in the base material: 0.375 in.

 Plate thickness (input): Hole depth in the base material: 3.375 in.

 Recommended plate thickness: Minimum thickness of the base material: 5.000 in.

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

#### 7.1 Recommended accessories

Dr	illing				С	leaning		Setting
Suitable Rotary Hammer			•	<ul> <li>Manual blow-out pump</li> </ul>		Torque wrench		
•	Properly siz	ed drill b	it				Hammer	
Coordinates Anchor in.								
	Anchor	x	У	C <sub>-x</sub>	C+x	C <sub>-y</sub>	C+y	
	1	0.000	0.000	2,500	2,500	2,500	2,500	

#### 8 Remarks; Your Cooperation Duties

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