STRUCTURAL ENGINEERING CALCULATIONS

FOR

CRASH CHAMPIONS
451 SE OLDHAM PARKWAY
LEE'S SUMMIT, MISSOURI

PREPARED BY

MICHAEL J. FALBE, P.E.

OF

BOB D. CAMPBELL & COMPANY, INC.
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FOR

ROSE DESIGN GROUP, INC.
P.O. BOX 100
OLATHE, KS 66051

OCTOBER 22, 2021

STATE OF MISSOURI
MICHAEL
JOHN FALBE
NUMBER
E-24014
10.22.2021
REGISTERED PROFESSIONAL ENGINEER

BOB D. CAMPBELL & CO.
Structural Engineers Since 1957
4338 Belleview Ave. 816.531.4144
Kansas City, MO 64111 www.bdc-engrs.com

Project:	Crash Champions
Project No.:	RCI2112
Location:	Lee's Summit, MO
By:	MJF
Date:	10/22/2021

Structural Design Criteria

Building Code:
International Building Code (IBC 2018)

Concrete:	ACI 318-14
Steel:	AISC 360-16
Wood:	NDS 2018
Connections:	ASCE 7-16

ANSI as approved in 2016

Basic Load Combinations (ASCE7)

Allowable Stress Design (ASD)
1.) D
2.) D + L
3.) D + (Lr or S or R)
4.) D + 0.75L + 0.75(Lr or S of R)
5.) D + (0.6W or 0.7E)
6a.) D + 0.75L + 0.75(0.6W) + 0.75(lR or S or R)
6b.) D + 0.75L + 0.75(0.7E) + 0.75S
7.) 0.6D + 0.6W
8.) 0.6D + 0.7E

Strength Design (LRFD)
1.) 1.4D
2.) 1.2D + 1.6L + 0.5(Lr or S or R)
3.) 1.2D + 1.6(Lr or S or R) + (L or 0.5W)
4.) 1.2D + 1.0W + L + 0.5(Lr or S or R)
5.) 1.2D + 1.0E + L + 0.2S
6.) 0.9D + 1.0W
7.) 0.9D+ 1.0E

Structural Design Loads

Live Loads:
Roof 20 psf

Geotechnical Information

Spread footings, grade beams, and retaining walls are designed to bear on engineered fill or undisturbed soil capable of safely sustaining 2,000psf

Materials

Steel:	Beams & Columns:	ASTM A992, Grade 50
	Miscellaneous steel:	ASTM A36
	Tubes & Pipes:	ASTM A500, Grade B

Concrete:
3500 psi (footings, grade beams)
4000 psi (interior flatwork)
4500 psi w/ 6% +/- 1% air entrainment (exterior flatwork)

Reinf. Steel: ASTM A615 or A706 Grade 60 steel

Wood:	Joists, beams, & trusses	No. 2 DF-L or SP
	LVL Members	Fb=2,600psf, E=1,900ksi
	PSL Members	Fb=2,900psf, E=2,000ksi

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Wind Loads

International Building Code 2018 / ASCE7-16 *Spreadsheet password = bdc*

ASCE 7-16:

Chapter 26 - General Requirements

Occupancy Risk Category	II		Table 1.5-2
Basic Wind Speed, V	109	mph	Figure 26.5-1A, B, C
Wind Directionality Factor, Kd	0.85		Table 26.6-1
Exposure Category	C		Section 26.7.3
Topographic Factor, Kzt	1.00		Section 26.8.2
Gust Effect Factor, G	0.85		Section 26.11.1
Enclosure Classification	Enclosed		Section 26.12
Internal Pressure Coefficient, Gcpi (Case 1)	0.18		Table 26.13-1
Internal Pressure Coefficient, Gcpi (Case 2)	-0.18		Table 26.13-1

Chapter 27 - Wind Loads on Buildings - MWFRS (Directional Procedure)

Windward Wall - Case 1 (Positive Internal Pressure)					
z (ft)	Kz p. 205	Velocity Pressure, qz qz = 0.00256KzKztKdV^2	Cp p. 207	Design Wind Pressure p = qGCp - qi(Gcpi)	Design Wind Pressure Windward + Leeward
0-15	0.85	21.98	0.8	10.57 psf	**25.27 psf**
16-20	0.90	23.27	0.8	11.45 psf	**26.15 psf**
21-25	0.94	24.30	0.8	12.15 psf	**26.85 psf**
26-30	0.98	25.34	0.8	12.85 psf	**27.56 psf**
31-40	1.04	26.89	0.8	13.91 psf	**28.61 psf**
41-50	1.09	28.18	0.8	14.79 psf	**29.49 psf**
51-60	1.13	29.21	0.8	15.49 psf	**30.19 psf**
61-70	1.17	30.25	0.8	16.19 psf	**30.90 psf**
71-80	1.21	31.28	0.8	16.90 psf	**31.60 psf**
81-90	1.24	32.06	0.8	17.42 psf	**32.13 psf**
91-100	1.26	32.57	0.8	17.78 psf	**32.48 psf**

Leeward Wall - Case 1 (Positive Internal Pressure)				
Mean Roof Height h (ft)	Kz p. 205	Velocity Pressure, qz qz = 0.00256KzKztKdV^2	Cp p. 264	Design Wind Pressure p = qGCp - qi(Gcpi)
25	0.94	24.30	-0.5	-14.70 psf

Side Wall - Case 1 (Positive Internal Pressure)				
Mean Roof Height h (ft)	Kz p. 205	Velocity Pressure, qz qz = 0.00256KzKztKdV^2	Cp p. 264	Design Wind Pressure p = qGCp - qi(Gcpi)
25	0.94	24.30	-0.7	-18.83 psf

Windward Wall - Case 2 (Negative Internal Pressure)					
z (ft)	Kz p. 205	Velocity Pressure, qz qz = 0.00256KzKztKdV^2	Cp p. 207	Design Wind Pressure p = qGCp - qi(Gcpi)	Design Wind Pressure Windward + Leeward
0-15	0.85	21.98	0.8	19.32 psf	**25.27 psf**
16-20	0.90	23.27	0.8	20.20 psf	**26.15 psf**
21-25	0.94	24.30	0.8	20.90 psf	**26.85 psf**
26-30	0.98	25.34	0.8	21.60 psf	**27.56 psf**
31-40	1.04	26.89	0.8	22.66 psf	**28.61 psf**
41-50	1.09	28.18	0.8	23.54 psf	**29.49 psf**
51-60	1.13	29.21	0.8	24.24 psf	**30.19 psf**
61-70	1.17	30.25	0.8	24.94 psf	**30.90 psf**
71-80	1.21	31.28	0.8	25.65 psf	**31.60 psf**
81-90	1.24	32.06	0.8	26.17 psf	**32.13 psf**
91-100	1.26	32.57	0.8	26.53 psf	**32.48 psf**

Leeward Wall - Case 2 (Negative Internal Pressure)				
Mean Roof Height h (ft)	Kz p. 205	Velocity Pressure, qz qz = 0.00256KzKztKdV^2	Cp p. 264	Design Wind Pressure p = qGCp - qi(Gcpi)
25	0.94	24.30	-0.5	-5.95 psf
Side Wall - Case 1 (Negative Internal Pressure)				
Mean Roof Height h (ft)	Kz p. 205	Velocity Pressure, qz qz = 0.00256KzKztKdV^2	Cp p. 264	Design Wind Pressure p = qGCp - qi(Gcpi)
25	0.94	24.30	-0.7	-10.09 psf

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Earthquake Loads

International Building Code 2018 / ASCE7-16 *Spreadsheet password = bdc*

			(ASCE 7-16)
Occupancy Risk Category	II		*(Table 1.5-1)*
Ss	10.0	%g	*(Figure 22-1)*
S1	6.9	%g	*(Figure 22-2)*
Site Class (per soil report or assume D	D		*(Table 20.3-1)*
Site Coefficient, Fa	1.3		*(Table 11.4-1)*
Site Coefficient, Fv	1.5		*(Table 11.4-2)*
Importance Factor,	1.0		*(Table 1.5-1)*

11.4.3 Site coefficients and adjusted maximum considered earthquake response acceleration parameter

for short periods, Sms = Fa*Ss	0.130	*(Equation 11.4-1)*
at 1-second period, Sm1 = Fv*S1	0.103	*(Equation 11.4-2)*

11.4.4 Design spectral response acceleration parameters

Sds = (2/3)*Sms	0.087	
Sd1 = (2/3)*Sm1	0.069	
Seismic Design Category	B	*(Tables 11.6-1 and 11.6-2)*

12.8 Equivalent Lateral Force Procedure

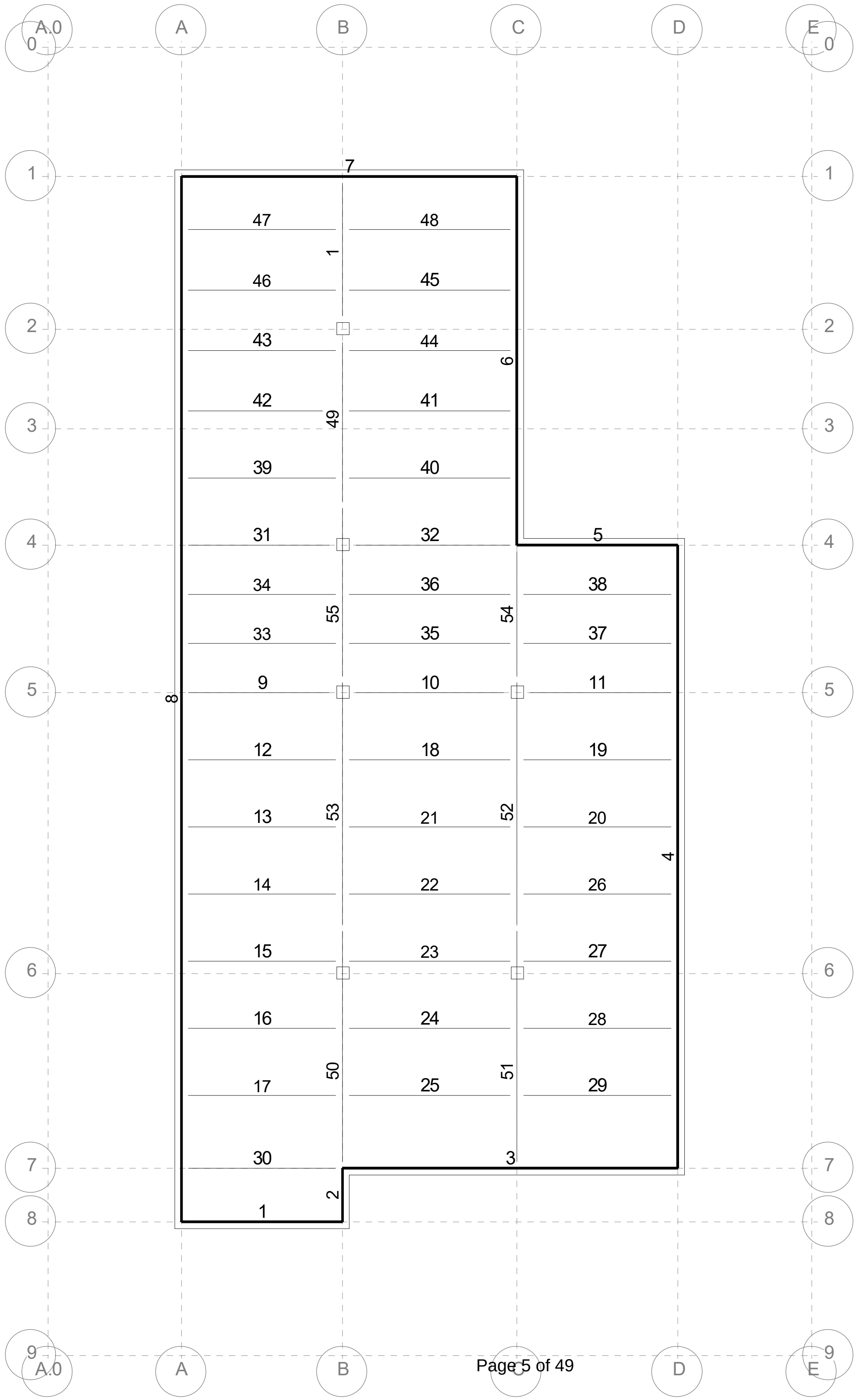
Seismic Force Resisting System	Oridinary Precast Concrete Shear Walls	
Response Modification Factor, R	3.0	*(Table 12.2-1)*
Cs = Sds/(R/I)	0.029	
Seismic Base Shear, V = CsW	**0.029 W**	*(12.8-1)*
W = Effective seismic weight per Section 12.7.2		

Floor Map

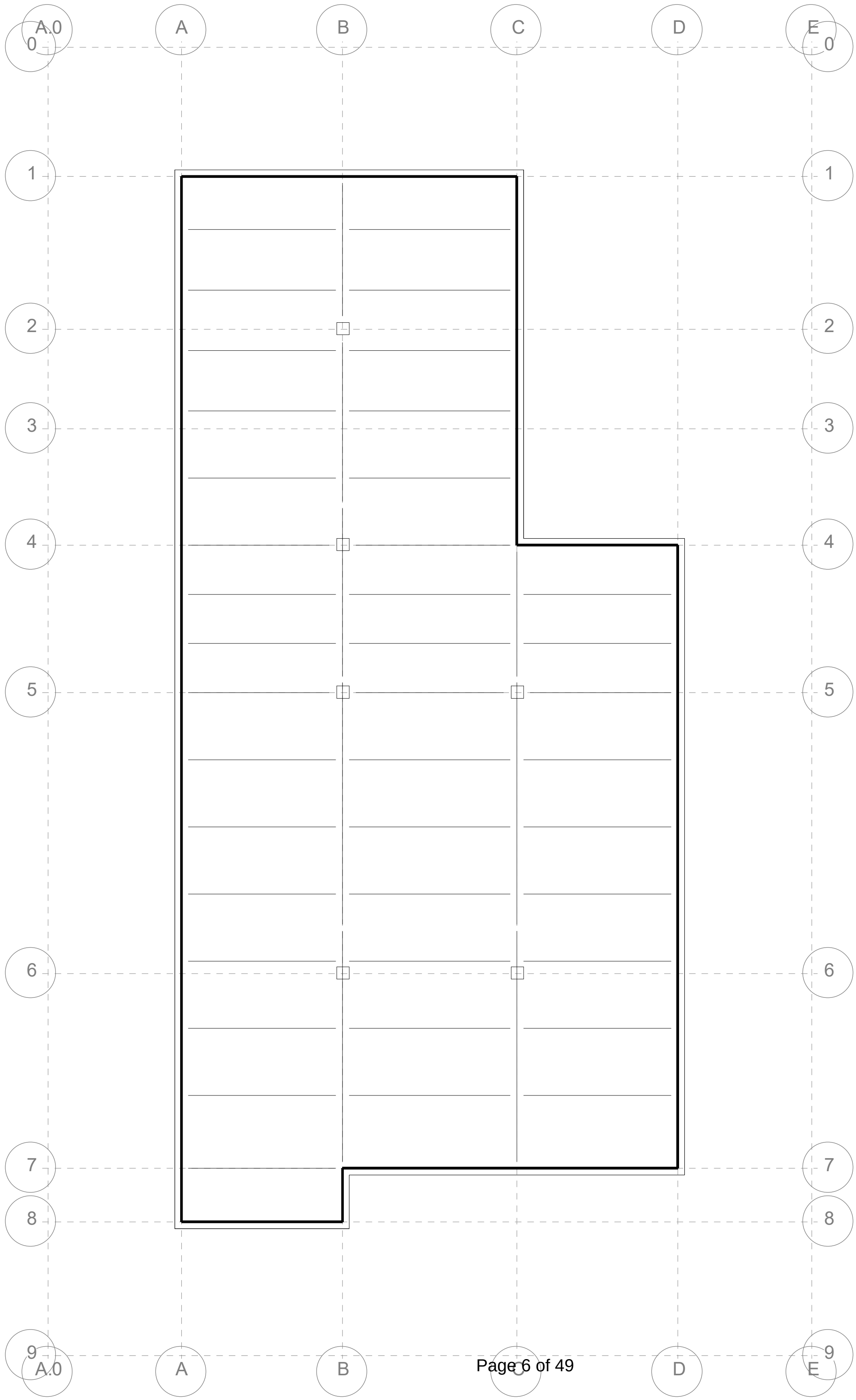
RAM Steel 17.02.01.23
DataBase: RCI2112
Building Code: IBC

10/22/21 13:31:53
Steel Code: AISC 360-16 ASD

Floor Type: Roof **Beam Numbers**



Floor Type: Roof

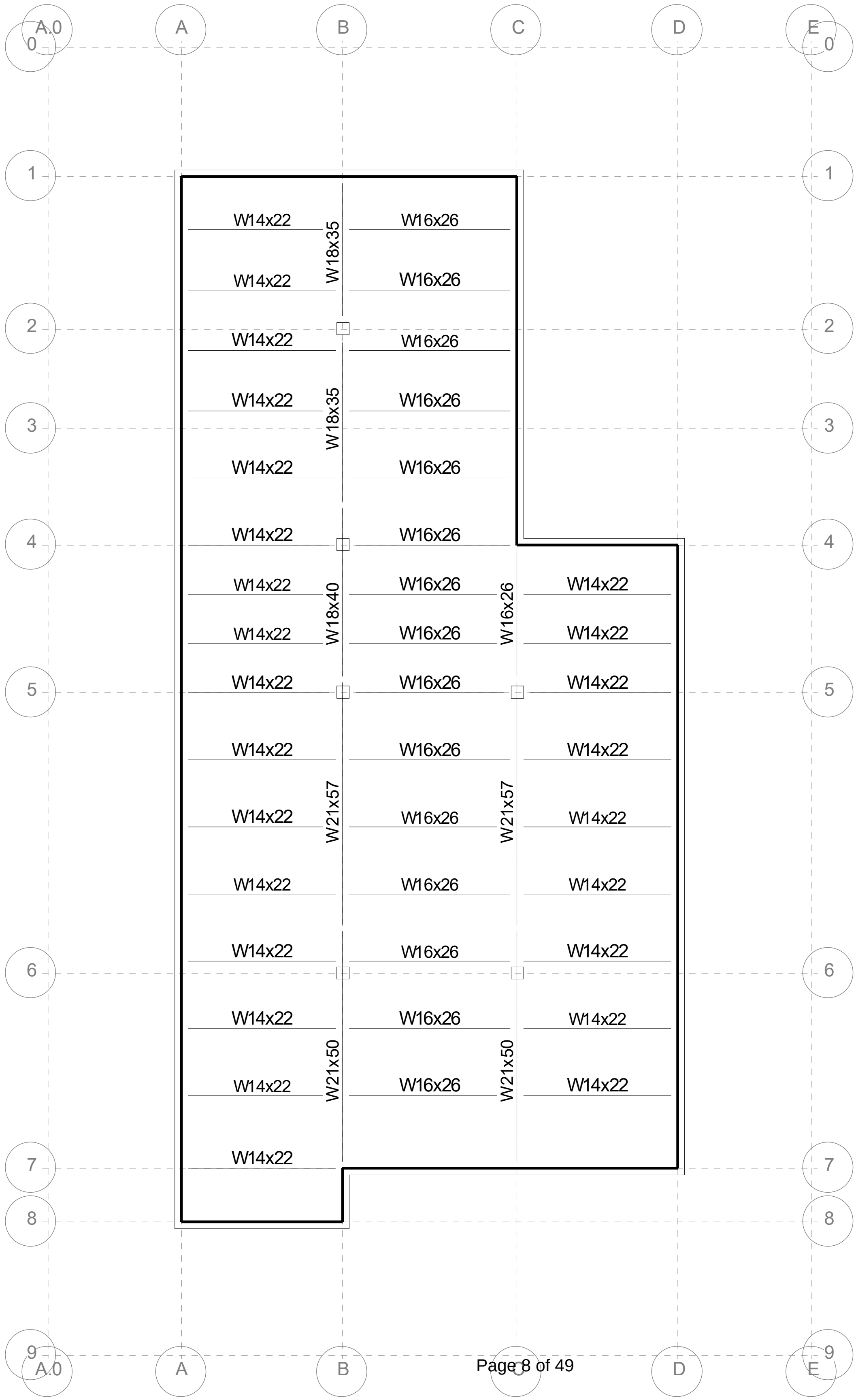


Surface Loads

	Label	DL psf	CDL psf	LL psf	Reduction Type	PLL psf	CLL psf	Mass DL psf
	Roof	20.0	0.0	20.0	Roof	0.0	0.0	0.0

Floor Map

Floor Type: Roof **Beam Designs**



STEEL BEAM DESIGN SUMMARY:

Demand/Capacity Limits for: Strength: 1.000 Deflection: 1.000

Floor Type: Roof

Bm #	Length ft	+Ma kip-ft	-Ma kip-ft	Mn/Ω kip-ft	Fy ksi	Beam Size	Studs
1	22.67	67.7	0.0	132.3	50.0	W18X35 u	
9	24.00	26.6	0.0	82.8	50.0	W14X22 u	
10	26.00	31.5	0.0	110.3	50.0	W16X26 u	
11	24.00	26.6	0.0	82.8	50.0	W14X22 u	
12	24.00	30.4	0.0	82.8	50.0	W14X22 u	
13	24.00	30.4	0.0	82.8	50.0	W14X22 u	
14	24.00	30.4	0.0	82.8	50.0	W14X22 u	
15	24.00	30.4	0.0	82.8	50.0	W14X22 u	
16	24.00	30.4	0.0	82.8	50.0	W14X22 u	
17	24.00	31.6	0.0	82.8	50.0	W14X22 u	
18	26.00	36.0	0.0	110.3	50.0	W16X26 u	
19	24.00	30.4	0.0	82.8	50.0	W14X22 u	
20	24.00	30.4	0.0	82.8	50.0	W14X22 u	
21	26.00	36.0	0.0	110.3	50.0	W16X26 u	
22	26.00	36.0	0.0	110.3	50.0	W16X26 u	
23	26.00	36.0	0.0	110.3	50.0	W16X26 u	
24	26.00	36.0	0.0	110.3	50.0	W16X26 u	
25	26.00	37.4	0.0	110.3	50.0	W16X26 u	
26	24.00	30.4	0.0	82.8	50.0	W14X22 u	
27	24.00	30.4	0.0	82.8	50.0	W14X22 u	
28	24.00	30.4	0.0	82.8	50.0	W14X22 u	
29	24.00	31.6	0.0	82.8	50.0	W14X22 u	
30	24.00	28.7	0.0	82.8	50.0	W14X22 u	
31	24.00	26.6	0.0	82.8	50.0	W14X22 u	
32	26.00	31.5	0.0	110.3	50.0	W16X26 u	
33	24.00	22.7	0.0	82.8	50.0	W14X22 u	
34	24.00	22.7	0.0	82.8	50.0	W14X22 u	
35	26.00	27.0	0.0	110.3	50.0	W16X26 u	
36	26.00	27.0	0.0	110.3	50.0	W16X26 u	
37	24.00	22.7	0.0	82.8	50.0	W14X22 u	
38	24.00	22.7	0.0	82.8	50.0	W14X22 u	
39	24.00	30.4	0.0	82.8	50.0	W14X22 u	
40	26.00	36.0	0.0	110.3	50.0	W16X26 u	
41	26.00	34.3	0.0	110.3	50.0	W16X26 u	
42	24.00	29.0	0.0	82.8	50.0	W14X22 u	
43	24.00	27.5	0.0	82.8	50.0	W14X22 u	
44	26.00	32.6	0.0	110.3	50.0	W16X26 u	
45	26.00	32.6	0.0	110.3	50.0	W16X26 u	
46	24.00	27.5	0.0	82.8	50.0	W14X22 u	

Beam Summary

Bm #	Length	+Ma	-Ma	Mn/Ω	Fy	Beam Size	Studs
47	24.00	25.8	0.0	82.8	50.0	W14X22 u	
48	26.00	30.7	0.0	110.3	50.0	W16X26 u	
49	26.67	108.3	0.0	140.8	50.0	W18X35 u	
50	29.00	83.7	-140.1	253.3	50.0	W21X50 u	
	6.33	0.0	-140.1				
51	29.00	83.9	-139.0	252.9	50.0	W21X50 u	
	6.33	0.0	-139.0				
52	35.50	177.3	-13.2	273.5	50.0	W21X57 u	
	1.50	0.0	-13.2				
53	35.50	179.9	-10.1	272.1	50.0	W21X57 u	
	1.50	0.0	-10.1				
54	20.50	55.2	0.0	92.9	50.0	W16X26 u	
55	20.50	38.4	-83.3	193.3	50.0	W18X40 u	
	5.50	0.0	-83.3				

* after Size denotes beam failed stress/capacity criteria.
# after Size denotes beam failed deflection criteria.
u after Size denotes this size has been assigned by the User.

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Address:		Specifier:	
Phone I Fax:	|	E-Mail:	
Design:	Concrete - Oct 22, 2021	Date:	10/22/2021
Fastening point:			

Specifier's comments:

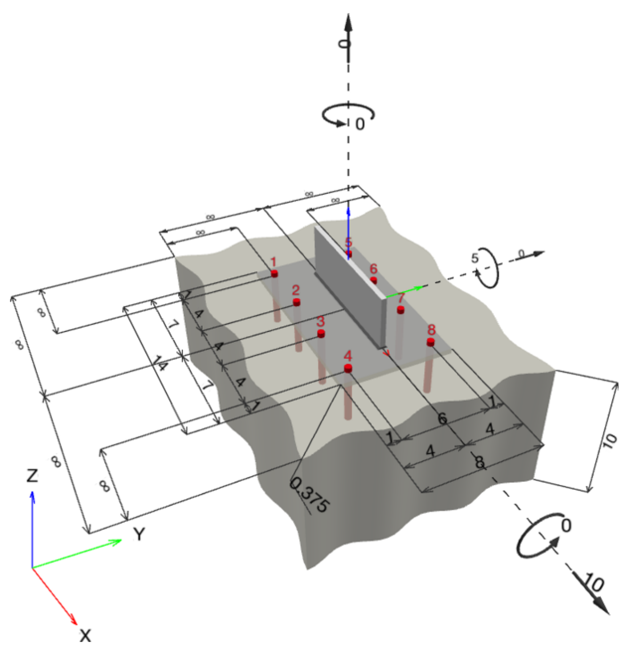
1 Anchor Design

1.1 Input data

Anchor type and diameter:	**AWS D1.1 GR. B 1/2**
Item number:	not available
Effective embedment depth:	h_{ef} = 4.000 in.
Material:	
Evaluation Service Report:	Hilti Technical Data
Issued I Valid:	- | -
Proof:	Design Method ACI 318-11 / CIP
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.375 in.
Anchor plate^{CBFEM} :	l_x x l_y x t = 14.000 in. x 8.000 in. x 0.375 in.;
Profile:	Rectangular plates and bars (AISC), 10 - 3/8; (L x W x T) = 10.000 in. x 0.375 in.
Base material:	cracked concrete, 5000, f_c' = 5,000 psi; h = 10.000 in.
Reinforcement:	tension: condition B, shear: condition B;
	edge reinforcement: none or < No. 4 bar

^{CBFEM} - The anchor calculation is based on a component-based Finite Element Method (CBFEM)

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



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1.1.1 Design results

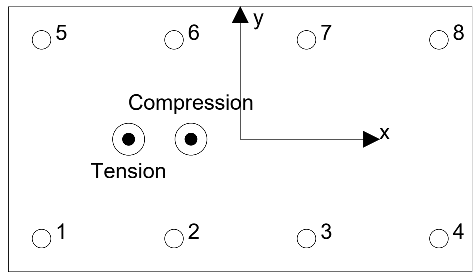
Case	Description	Forces [kip] / Moments [ft.kip]	Seismic	Max. Util. Anchor [%]
1	Combination 1	$N = 0.000$; $V_x = 10.000$; $V_y = 0.000$; $M_x = 0.00000$; $M_y = 5.00000$; $M_z = 0.00000$;	no	72

1.2 Load case/Resulting anchor forces

Anchor reactions [kip]

Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	3.134	1.241	1.241	0.030
2	2.617	1.248	1.248	0.011
3	0.625	1.255	1.255	0.006
4	0.138	1.256	1.256	-0.014
5	3.132	1.241	1.241	-0.030
6	2.617	1.248	1.248	-0.011
7	0.625	1.255	1.255	-0.006
8	0.138	1.256	1.256	0.014



resulting tension force in (x/y)=(-3.371/-0.000): 13.025 [kip]
resulting compression force in (x/y)=(-1.488/0.002): 14.998 [kip]

Anchor forces are calculated based on a component-based Finite Element Method (CBFEM)

1.3 Tension load

	Load N_{ua} [kip]	Capacity ϕ N_n [kip]	Utilization $\beta_N = N_{ua}/\phi$ N_n	Status
Steel Strength*	3.134	9.555	33	OK
Pullout Strength*	3.134	16.492	20	OK
Concrete Breakout Failure**	13.025	18.253	72	OK
Concrete Side-Face Blowout, direction **	N/A	N/A	N/A	N/A

* highest loaded anchor **anchor group (anchors in tension)

1.3.1 Steel Strength

$N_{sa} = A_{se,N}\, f_{uta}$ ACI 318-11 Eq. (D-2)

$\phi\ N_{sa} \geq N_{ua}$ ACI 318-11 Table D.4.1.1

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.20	65,000

Calculations

N_{sa} [kip]
12.740

Results

N_{sa} [kip]	ϕ_{steel}	$\phi\ N_{sa}$ [kip]	N_{ua} [kip]
12.740	0.750	9.555	3.134

1.3.2 Pullout Strength

$N_{pN} = \psi_{c,p}\, N_p$ ACI 318-11 Eq. (D-13)

$N_p = 8\, A_{brg}\, f'_c$ ACI 318-11 Eq. (D-14)

$\phi\ N_{pN} \geq N_{ua}$ ACI 318-11 Table D.4.1.1

Variables

$\psi_{c,p}$	A_{brg} [in.^{2}]	λ_a	f'_c [psi]
1.000	0.59	1.000	5,000

Calculations

N_p [kip]
23.560

Results

N_{pn} [kip]	$\phi_{concrete}$	$\phi\ N_{pn}$ [kip]	N_{ua} [kip]
23.560	0.700	16.492	3.134

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1.3.3 Concrete Breakout Failure

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b$	ACI 318-11 Eq. (D-4)
$\phi\ N_{cbg} \geq N_{ua}$	ACI 318-11 Table D.4.1.1
$A_{Nc0} = 9\ h_{ef}^2$	ACI 318-11 Eq. (D-5)
$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e_N^{'}}{3\ h_{ef}}}\right) \leq 1.0$	ACI 318-11 Eq. (D-8)
$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}}\right) \leq 1.0$	ACI 318-11 Eq. (D-10)
$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}}\right) \leq 1.0$	ACI 318-11 Eq. (D-12)
$N_b = k_c\ \lambda_a\ \sqrt{f_c^{'}}\ h_{ef}^{1.5}$	ACI 318-11 Eq. (D-6)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
4.000	3.371	0.000	∞	1.000

c_{ac} [in.]	k_c	λ_a	$f_c^{'}$ [psi]
-	24	1.000	5,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [kip]
432.00	144.00	0.640	1.000	1.000	1.000	13.576

Results

N_{cbg} [kip]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [kip]	N_{ua} [kip]
26.075	0.700	18.253	13.025

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Design:	Concrete - Oct 22, 2021	Date:	10/22/2021
Fastening point:			

1.4 Shear load

	Load V_{ua} [kip]	Capacity ϕ V_n [kip]	Utilization $\beta_V = V_{ua}/\phi$ V_n	Status
Steel Strength*	1.256	8.281	16	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength**	10.000	57.021	18	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

* highest loaded anchor   **anchor group (relevant anchors)

1.4.1 Steel Strength

$V_{sa} = A_{se,V}\, f_{uta}$ ACI 318-11 Eq. (D-28)

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]
0.20	65,000

Calculations

V_{sa} [kip]
12.740

Results

V_{sa} [kip]	ϕ_{steel}	$\phi\ V_{sa}$ [kip]	V_{ua} [kip]
12.740	0.650	8.281	1.256

1.4.2 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 318-11 Eq. (D-41)

$\phi \; V_{cpg} \geq V_{ua}$ ACI 318-11 Table D.4.1.1

A_{Nc} see ACI 318-11, Part D.5.2.1, Fig. RD.5.2.1(b)

$A_{Nc0} = 9 \; h_{ef}^2$ ACI 318-11 Eq. (D-5)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2 \, e_N'}{3 \, h_{ef}}} \right) \leq 1.0$ ACI 318-11 Eq. (D-8)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}} \right) \leq 1.0$ ACI 318-11 Eq. (D-10)

$\psi_{cp,N} = \mathrm{MAX} \left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}} \right) \leq 1.0$ ACI 318-11 Eq. (D-12)

$N_b = k_c \; \lambda_a \; \sqrt{f_c'} \; h_{ef}^{1.5}$ ACI 318-11 Eq. (D-6)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	4.000	0.000	0.000	∞

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f_c' [psi]
1.000	∞	24	1.000	5,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [kip]
432.00	144.00	1.000	1.000	1.000	1.000	13.576

Results

V_{cpg} [kip]	$\phi_{concrete}$	$\phi \; V_{cpg}$ [kip]	V_{ua} [kip]
81.459	0.700	57.021	10.000

1.5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
0.714	0.175	5/3	63	OK

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

1.6 Warnings

- The anchor design methods in PROFIS Engineering require rigid anchor plates as 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 Engineering calculates the minimum required anchor plate thickness with CBFEM 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 Engineering. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- Condition A applies where the potential concrete failure surfaces are crossed by supplementary reinforcement proportioned to tie the potential concrete failure prism into the structural member. Condition B applies where such supplementary reinforcement is not provided, or where pullout or pryout strength governs.
- For additional information about ACI 318 strength design provisions, please go to https://submittals.us.hilti.com/PROFISAnchorDesignGuide/
- The anchor design methods in PROFIS Engineering require rigid anchor plates, as per current regulations (AS 5216:2018, ETAG 001/Annex C, EOTA TR029 etc.). This means that the anchor plate should be sufficiently rigid to prevent load re-distribution to the anchors due to elastic/plastic displacements. The user accepts that the anchor plate is considered close to rigid by engineering judgment."

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Phone I Fax:	|	E-Mail:	
Design:	Concrete - Oct 22, 2021	Date:	10/22/2021
Fastening point:			

1.7 Installation data

Profile: Rectangular plates and bars (AISC), 10 - 3/8; (L x W x T) = 10.000 in. x 0.375 in.

Hole diameter in the fixture: d_f = 0.562 in.

Plate thickness (input): 0.375 in.

Anchor type and diameter: AWS D1.1 GR. B 1/2

Item number: not available

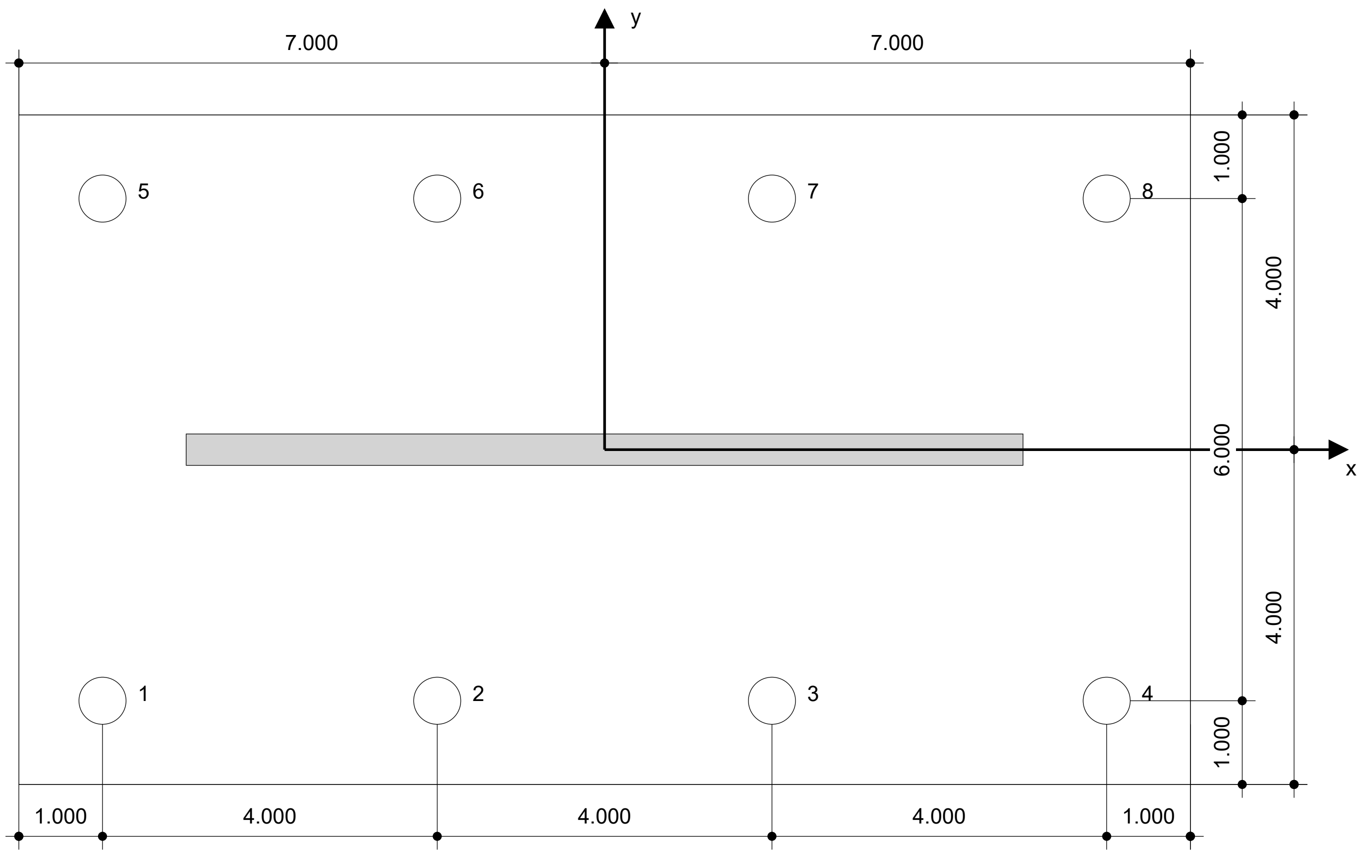
Maximum installation torque: -

Hole diameter in the base material: - in.

Hole depth in the base material: 4.000 in.

Minimum thickness of the base material: 4.813 in.

Hilti AWS welded headed stud anchor with 4 in embedment, 1/2, Steel galvanized, installation per instruction for use



Coordinates Anchor [in.]

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-6.000	-3.000	-	-	-	-
2	-2.000	-3.000	-	-	-	-
3	2.000	-3.000	-	-	-	-
4	6.000	-3.000	-	-	-	-

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
5	-6.000	3.000	-	-	-	-
6	-2.000	3.000	-	-	-	-
7	2.000	3.000	-	-	-	-
8	6.000	3.000	-	-	-	-

2 Anchor plate design

2.1 Input data

Anchor plate:	Shape: Rectangular l_x x l_y x t = 14.000 in x 8.000 in x 0.375 in Calculation: CBFEM Material: ASTM A36; F_y = 36,000 psi; ε_{lim} = 5.00%
Anchor type and size:	AWS D1.1 GR. B 1/2, h_{ef} = 4.000 in
Anchor stiffness:	The anchor is modeled considering stiffness values determined from load displacement curves tested in an independent laboratory. Please note that no simple replacement of the anchor is possible as the anchor stiffness has a major impact on the load distribution results.
Design method:	AISC and LRFD-based design using component-based FEM
Stand-off installation:	e_b = 0.000 in (No stand-off); t = 0.375 in
Profile:	10 - 3/8; (L x W x T x FT) = 10.000 in x 0.375 in x - x - Material: ASTM A500 Gr.B Rect; F_y = 46,000 psi; ε_{lim} = 5.00% Eccentricity x: 0.000 in Eccentricity y: 0.000 in
Base material:	Cracked concrete; 5000; $f_{c,cyl}$ = 5,000 psi; h = 10.000 in
Welds (profile to anchor plate):	Type of redistribution: Plastic Material: E70xx
Mesh size:	Number of elements on edge: 8 Min. size of element: 0.394 in Max. size of element: 1.969 in

2.2 Summary

	Description	Profile		Anchor plate			Welds [%]	Concrete [%]
		σ_{Ed} [psi]	ε_{Pl} [%]	σ_{Ed} [psi]	ε_{Pl} [%]	Hole bearing [%]		
1	Combination 1	16,665	0.00	36,006	0.02	9	76	7

2.3 Anchor plate classification

Results below are displayed for the decisive load combinations: Combination 1

Anchor tension forces	Equivalent rigid anchor plate (CBFEM)	Component-based Finite Element Method (CBFEM) anchor plate design
Anchor 1	1.877 kip	3.134 kip
Anchor 2	1.014 kip	2.617 kip
Anchor 3	0.151 kip	0.625 kip
Anchor 4	-0.000 kip	0.138 kip
Anchor 5	1.877 kip	3.132 kip
Anchor 6	1.014 kip	2.617 kip
Anchor 7	0.151 kip	0.625 kip
Anchor 8	-0.000 kip	0.138 kip

User accepted to consider the selected anchor plate as rigid by his/her engineering judgement. This means the anchor design guidelines can be applied.

2.4 Profile/Stiffeners/Plate

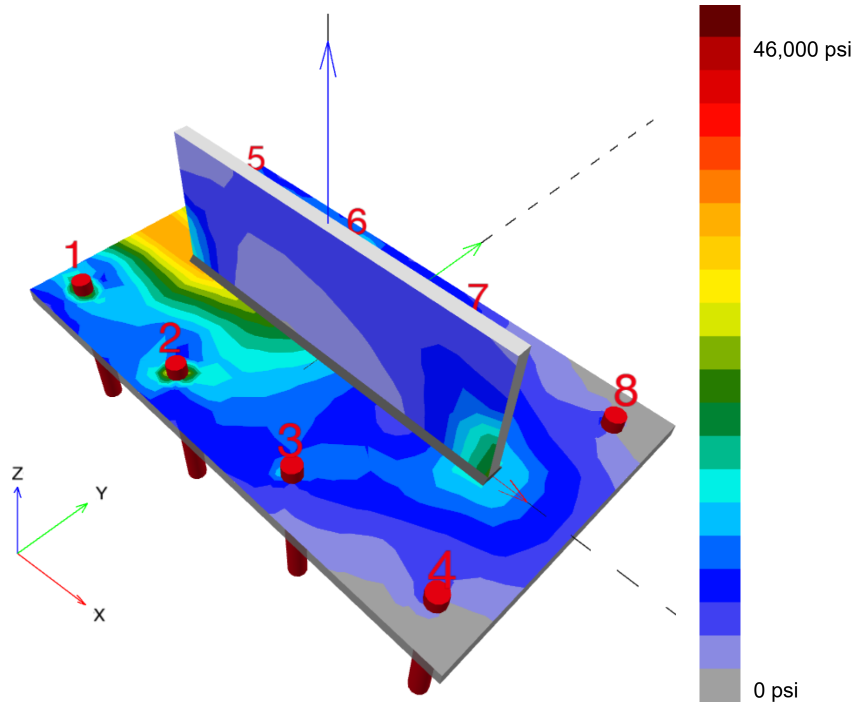
Profile and stiffeners are verified at the level of the steel to concrete connection. The connection design does not replace the steel design for critical cross sections, which should be performed outside of PROFIS Engineering.

2.4.1 Equivalent stress and plastic strain

Part	Load combination	Material	f_y [psi]	ε_{lim} [%]	σ_{Ed} [psi]	ε_{Pl} [%]	Status
Plate	Combination 1	ASTM A36	36,000	5.00	36,006	0.02	OK
Profile	Combination 1	ASTM A500 Gr.B Rect	46,000	5.00	16,665	0.00	OK

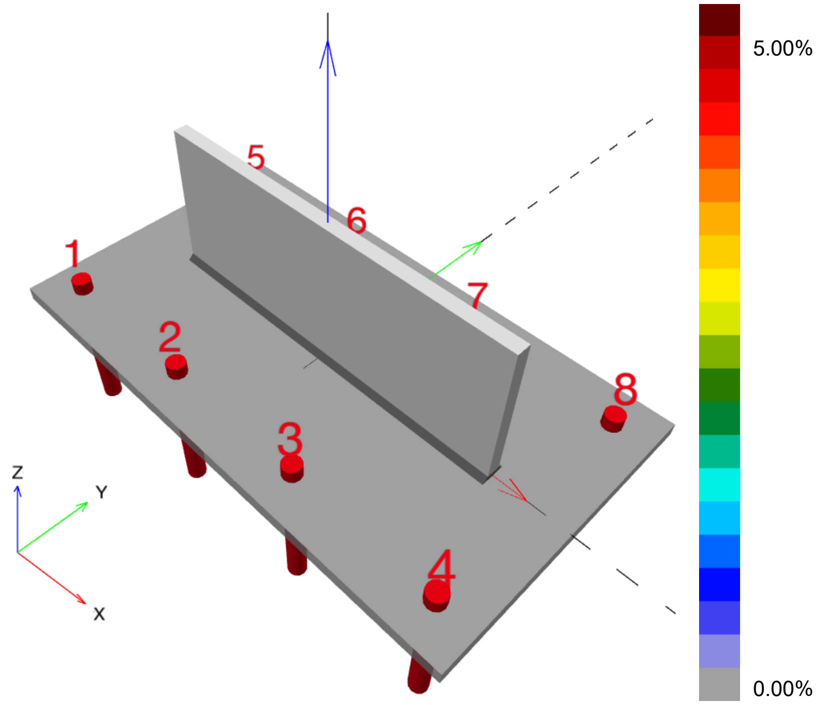
2.4.1.1 Equivalent stress

Results below are displayed for the decisive load combination: 1 - Combination 1



2.4.1.2 Plastic strain

Results below are displayed for the decisive load combination: 1 - Combination 1



2.4.2 Plate hole bearing resistance, AISC 360-16 Section J3

Decisive load combination: 1 - Combination 1

Equations

R_n	=	$\min(1.2\ l_c\ t\ F_u\ ,\ 2.4\ d\ t\ F_u)$ (AISC 360-16 J3-6a, c)
ΦR_n	=	$0.75\ R_n$
V	$\leq$	ΦR_n

Variables

	l_c [in]	t [in]	F_u [psi]	d [in]	R_n [kip]
Anchor 1	0.719	0.375	58,000	0.500	18.777
Anchor 2	3.438	0.375	58,000	0.500	26.114
Anchor 3	3.438	0.375	58,000	0.500	26.114
Anchor 4	3.438	0.375	58,000	0.500	26.114
Anchor 5	0.719	0.375	58,000	0.500	18.777
Anchor 6	3.438	0.375	58,000	0.500	26.114
Anchor 7	3.438	0.375	58,000	0.500	26.114
Anchor 8	3.438	0.375	58,000	0.500	26.114

Results

	V [kip]	ΦR_n [kip]	Utilization [%]	Status
Anchor 1	1.241	14.083	9	OK
Anchor 2	1.248	19.585	7	OK
Anchor 3	1.255	19.585	7	OK
Anchor 4	1.257	19.585	7	OK
Anchor 5	1.241	14.083	9	OK
Anchor 6	1.248	19.585	7	OK
Anchor 7	1.255	19.585	7	OK
Anchor 8	1.257	19.585	7	OK

2.5 Welds

Profiles are modeled without taking the corner radius into account. Special rules for welding (e.g. for cold-formed profiles ...) are not taken into account by the software.

2.5.1 Anchor plate to profile

Decisive load combination: 1 - Combination 1

Equations

$$F_{nw} = 0.6\, F_{EXX}\, (1.0 + 0.5 \sin^{1.5} \Theta)$$

$$\Phi R_n = \Phi\, F_{nw}\, A_w$$

$$\text{Utilization} = \frac{F_n}{\Phi\, R_n}$$

Variables

Edge	X_u	T_h [in]	L_s [in]	L [in]	L_c [in]	F_{EXX} [psi]	Θ [°]	A_w [in²]
Member 1-bfl 1	E70xx	◢0.188◣	0.265	9.978	0.907	70,000	44.6	0.17
Member 1-bfl	E70xx	◢0.188◣	0.265	9.978	0.907	70,000	44.7	0.17

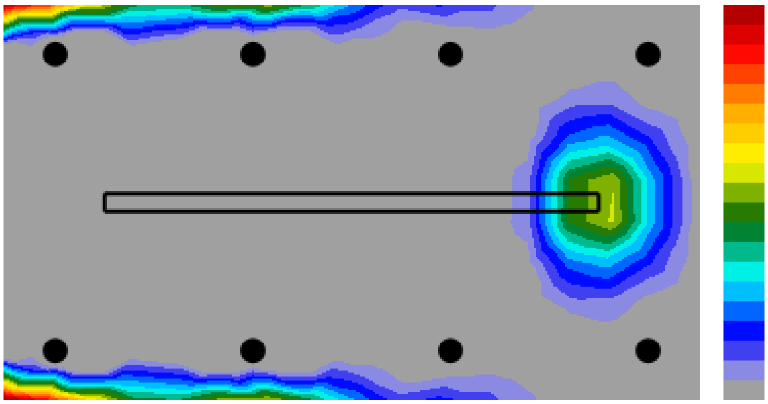
Results

Edge	F_n [kip]	ΦR_n [kip]	Utilization [%]	Status
Member 1-bfl 1	5.204	6.935	76	OK
Member 1-bfl	5.204	6.936	76	OK

2.6 Concrete

Decisive load combination: 1 - Combination 1

2.6.1 Compression in concrete under the anchor plate



2.6.2 Concrete block compressive strength resistance check, AISC 360-16 Section J8

Equations

$$F_p = \Phi f_{p,max}$$

$$f_{p,max} = 0.85 f_c' \sqrt{\left(\frac{A_2}{A_1}\right)} \leq 1.7 f_c; \quad \sqrt{\left(\frac{A_2}{A_1}\right)} \leq 2$$

$$\sigma = \frac{N}{A_1}$$

$$\text{Utilization} = \frac{\sigma}{F_p}$$

Variables

N [kip]	f_c' [psi]	Φ	A_1 [in²]	A_2 [in²]
14.998	5,000	0.65	43.51	2,302.71

Results

Load combination	F_p [psi]	σ [psi]	Utilization [%]	Status
Combination 1	5,525	345	7	OK

2.7 Symbol explanation

A_1	Loaded area of concrete
A_2	Supporting area
A_w	Effective area of weld critical element
d	Nominal diameter of the bolt
ε_{lim}	Limit plastic strain
ε_{Pl}	Plastic strain from CBFEM results
f_c	Concrete compressive strength
f_c'	Concrete compressive strength
F_{EXX}	Electrode classification number, i.e. minimum specified tensile strength
F_u	Specified minimum tensile strength of the connected material
F_n	Force in weld critical element
F_{nw}	Nominal stress of the weld material
F_p	Concrete block design bearing strength
$f_{p,max}$	Concrete block design bearing strength maximum
f_y	Yield strength
l_c	Clear distance, in the direction of the force, between the edge of the hole and the edge of the adjacent hole or edge of the material
L	Length of weld
L_c	Length of weld critical element
L_s	Leg size of weld
N	Resulting compression force
σ	Average stress in concrete
σ_{Ed}	Equivalent stress
Φ	Resistance factor
ΦR_n	Factored resistance
R_n	Resistance
t	Thickness of the anchor plate
Θ	Angle of loading measured from the weld longitudinal axis
T_h	Throat thickness of weld
V	Resultant of shear forces Vy, Vz in bolt.
X_u	Filler metal tensile strength

2.8 Warnings

- By using the CBFEM calculation functionality of PROFIS Engineering you may act outside the applicable design codes and your specified anchor plate may not behave rigid. Please, validate the results with a professional designer and/or structural engineer to ensure suitability and adequacy for your specific jurisdiction and project requirements.
- The anchor is modeled considering stiffness values determined from load displacement curves tested in an independent laboratory. Please note that no simple replacement of the anchor is possible as the anchor stiffness has a major impact on the load distribution results.

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Design:	Concrete - Oct 22, 2021	Date:	10/22/2021
Fastening point:			

3 Summary of results

Design of the anchor plate, anchors, welds and other elements are based on CBFEM (component based finite element method) and AISC.

	Load combination	Max. utilization	Status
Anchors	Combination 1	72%	OK
Anchor plate	Combination 1	100%	OK
Welds	Combination 1	76%	OK
Concrete	Combination 1	7%	OK
Profile	Combination 1	37%	OK

Fastening meets the design criteria!

4 Remarks; Your Cooperation Duties

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

RAM Structural System
Bentley

RAM Steel 17.02.01.23
DataBase: RCI2112 10/22/21 13:38:19
Building Code: IBC Steel Code: AISC360-16 LRFD

DEMAND/CAPACITY LIMIT FOR STRENGTH : 1.000

Column Line B-6

Level	Pu	Mux	Muy	LC	Interaction Eq.	Angle	Fy	Size
Roof	65.4	0.0	0.0	1	0.61 Eq Axial	0.0	46	HSS6X6X1/4

Column Line B-5

Level	Pu	Mux	Muy	LC	Interaction Eq.	Angle	Fy	Size
Roof	43.9	0.0	0.0	1	0.41 Eq Axial	0.0	46	HSS6X6X1/4

Column Line B-4

Level	Pu	Mux	Muy	LC	Interaction Eq.	Angle	Fy	Size
Roof	50.6	0.0	0.0	1	0.47 Eq Axial	0.0	46	HSS6X6X1/4

Column Line B-2

Level	Pu	Mux	Muy	LC	Interaction Eq.	Angle	Fy	Size
Roof	29.9	0.0	7.1	6	0.44 Eq H1-1a	0.0	46	HSS6X6X1/4

Column Line C-6

Level	Pu	Mux	Muy	LC	Interaction Eq.	Angle	Fy	Size
Roof	65.2	0.0	0.0	1	0.61 Eq Axial	0.0	46	HSS6X6X1/4

Column Line C-5

Level	Pu	Mux	Muy	LC	Interaction Eq.	Angle	Fy	Size
Roof	46.5	0.0	0.0	1	0.44 Eq Axial	0.0	46	HSS6X6X1/4

Base Plate Design Summary

RAM Structural System
Bentley

RAM Steel 17.02.01.23
DataBase: RCI2112
Building Code: IBC

10/22/21 13:39:20
Steel Code: AISC360-16 LRFD

BASE PLATES:

Design Code: AISC360-16 LRFD

Plate Fy (ksi)	36.000
Minimum Dimension From Face of Column to Edge of Plate (in)	3.000
Minimum Dimension From Side of Column to Edge of Plate (in)	3.000
Increment of Plate Dimensions (in)	0.250
Increment of Plate Thickness (in)	0.125
Minimum Footing Dimension Parallel to Web (ft)	10.00
Minimum Footing Dimension Perpendicular to Web (ft)	10.00
Keep Base Plate Square:	Y

Column Line	**Column Size**	**Fy (ksi)**	**N (in)**	**B (in)**	**tp (in)**
B-6	HSS6X6X1/4	36	12.00	12.00	0.625
B-5	HSS6X6X1/4	36	12.00	12.00	0.500
B-4	HSS6X6X1/4	36	12.00	12.00	0.500
B-2	HSS6X6X1/4	36	12.00	12.00	0.500
C-6	HSS6X6X1/4	36	12.00	12.00	0.625
C-5	HSS6X6X1/4	36	12.00	12.00	0.500

Use 3/4" thickness for all base plates

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Structural Engineers Since 1957
4338 Belleview Ave. 816.531.4144
Kansas City, MO 64111 www.bdc-engrs.com

Project:	Crash Champions
Project No.:	RCI2112
Location:	Lee's Summit, MO
By:	MJF
Date:	10/22/2021

Spread Footing 4.0

This spreadsheet calculates the allowable load capacity of a square spread footing. *password=bdc*

Given:

Width of Square Footing	4	**ft**
Thickness of Footing	36	**in.**
Rebar Size	#5	
Area of Rebar	0.31	**sq. in.**
Quantity of bottom steel in each direction	5	
f'c Compressive Strength of Concrete (psi)	3500	**psi**
fy Yield Stress of Reinforcing Steel (ksi)	60	**ksi**
Allowable Soil Bearing Pressure	2	**ksf**

1. Calculate Maximum Allowable Total Load

Maximum Allowable Load = (area of footing x allowable soil bearing pressure) - (weight of footing + weght of displaced soil)

Area of Footing	16	sf
Density of concrete	150	pcf
Density of soil	120	pcf
Weight of footing	7.20	kips
Weight of displaced soil	5.76	kips
Maximum Allowable Load	**30.6**	**kips**

2. Check Thickness For Two-Way Shear

The critical perimeter is at d/2 from the face of the column.

davg (t - 3"cover - 1")	32	in.
Dimension of square column or loaded area	12	in.
bo Length of Critical Shear Perimeter	176	in.
ϕVc = 0.75*4*((f'c)^1/2)*bo*d	999.6	kips
Load Factor	1.8	
Max. Allowable Load = ϕVc / Load Factor	**555.3**	kips

Controlling Allowable Load =	**30.6**	kips
Maximum Applied Load =	22.8	kips
Check	OK	

4. Check Reinforcement

The critical section for moment is at the face of the column.

Mu = q x (tributary area) x (moment arm)	9.0	k*ft
b	48	in.
d	32	in.
As	1.55	sq. in.
C=0.85f'cba	143	a
T=Asfy	93	kips
a	0.65	in.
ϕMn = 0.9*Asfy(d-a/2)	**220.93**	k*ft

Reinforcement OK?	**OK**

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Project:	Crash Champions
Project No.:	RCI2112
Location:	Lee's Summit, MO
By:	MJF
Date:	10/22/2021

Spread Footing 5.0

This spreadsheet calculates the allowable load capacity of a square spread footing. *password=bdc*

Given:

Width of Square Footing	5	**ft**
Thickness of Footing	18	**in.**
Rebar Size	#4	
Area of Rebar	0.2	**sq. in.**
Quantity of bottom steel in each direction	10	
f'c Compressive Strength of Concrete (psi)	3500	**psi**
fy Yield Stress of Reinforcing Steel (ksi)	60	**ksi**
Allowable Soil Bearing Pressure	2	**ksf**

1. Calculate Maximum Allowable Total Load

Maximum Allowable Load = (area of footing x allowable soil bearing pressure) - (weight of footing + weght of displaced soil)

Area of Footing	25	sf
Density of concrete	150	pcf
Density of soil	120	pcf
Weight of footing	5.63	kips
Weight of displaced soil	4.50	kips
Maximum Allowable Load	**48.9**	**kips**

2. Check Thickness For Two-Way Shear

The critical perimeter is at d/2 from the face of the column.

davg (t - 3"cover - 1")	14	in.
Dimension of square column or loaded area	12	in.
bo Length of Critical Shear Perimeter	104	in.
ϕVc = 0.75*4*((f'c)^1/2)*bo*d	258.4	kips
Load Factor	1.8	
Max. Allowable Load = ϕVc / Load Factor	**143.6**	kips

Controlling Allowable Load =	**48.9**	kips
Maximum Applied Load =	46.5	kips
Check	OK	

4. Check Reinforcement

The critical section for moment is at the face of the column.

Mu = q x (tributary area) x (moment arm)	20.0	k*ft
b	60	in.
d	14	in.
As	2.00	sq. in.
C=0.85f'cba	179	a
T=Asfy	120	kips
a	0.67	in.
ϕMn = 0.9*Asfy(d-a/2)	**122.97**	k*ft

Reinforcement OK?	**OK**

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Kansas City, MO 64111 www.bdc-engrs.com

Project:	Crash Champions
Project No.:	RCI2112
Location:	Lee's Summit, MO
By:	MJF
Date:	10/22/2021

Spread Footing 6.0

This spreadsheet calculates the allowable load capacity of a square spread footing. *password=bdc*

Given:

Width of Square Footing	6	**ft**
Thickness of Footing	20	**in.**
Rebar Size	#4	
Area of Rebar	0.2	**sq. in.**
Quantity of bottom steel in each direction	12	
f'c Compressive Strength of Concrete (psi)	3500	**psi**
fy Yield Stress of Reinforcing Steel (ksi)	60	**ksi**
Allowable Soil Bearing Pressure	2	**ksf**

1. Calculate Maximum Allowable Total Load

Maximum Allowable Load = (area of footing x allowable soil bearing pressure) - (weight of footing + weght of displaced soil)

Area of Footing	36	sf
Density of concrete	150	pcf
Density of soil	120	pcf
Weight of footing	9.00	kips
Weight of displaced soil	7.20	kips
Maximum Allowable Load	**70.2**	**kips**

2. Check Thickness For Two-Way Shear

The critical perimeter is at d/2 from the face of the column.

davg (t - 3"cover - 1")	16	in.
Dimension of square column or loaded area	12	in.
bo Length of Critical Shear Perimeter	112	in.
ϕVc = 0.75*4*((f'c)^1/2)*bo*d	318.0	kips
Load Factor	1.8	
Max. Allowable Load = ϕVc / Load Factor	**176.7**	kips

Controlling Allowable Load =	**70.2**	kips
Maximum Applied Load =	65.4	kips
Check	OK	

4. Check Reinforcement

The critical section for moment is at the face of the column.

Mu = q x (tributary area) x (moment arm)	37.5	k*ft
b	72	in.
d	16	in.
As	2.40	sq. in.
C=0.85f'cba	214	a
T=Asfy	144	kips
a	0.67	in.
ϕMn = 0.9*Asfy(d-a/2)	**169.17**	k*ft

Reinforcement OK?	**OK**

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Kansas City, MO 64111 www.bdc-engrs.com

Project:	Crash Champions
Project No.:	RCI2112
Location:	Lee's Summit, MO
By:	MJF
Date:	10/22/2021

Continuous Footing

This spreadsheet calculates the required width of a continuous footing

Given:

Allowable soil bearing capacity (psf)	**2000**

Design Summary

Total Load (plf)	3292
Required width (ft)	1.65
Width of footing (ft)	**1.83**
Depth of footing (ft)	**3**
Bearing Pressure (psf)	1799

Calculate Roof Load

	Load (psf)	Trib. Width (ft.)	Load (plf)
Roof Dead Load	**25**	**12**	300
Roof Live load	**25**	**12**	300
Roof Total Load			**600**

Calculate Floor Load

	Load (psf)	Trib. Width (ft.)	Load (plf)
Floor Dead Load	**0**	**0**	0
Floor Live load	**0**	**0**	0
Floor Total Load			**0**

Calculate Wall Load

Material	Load (psf)	Height (ft.)	Load (plf)
4" face brick	**0**	**0**	0
8" masonry	**0**	**0**	0
12" masonry	**0**	**0**	0
stud wall w/ sheathing	**0**	**0**	0
10" precast	**125**	**20**	2500
WIND LOAD	***0***	***0***	***0***
Wall Total Load			**2500**

Calculate Self Load of Footing

Width of footing (ft)	1.83
Depth of footing (ft)	3
Density (pcf)	150
G.B. Total Load (plf)	**824**

Calculate Load of Soil Displaced by Footing

Width of footing (ft)	1.83
Depth of footing (ft)	3
Density (pcf)	115
Didplaced Soil Total Load (plf)	**631**

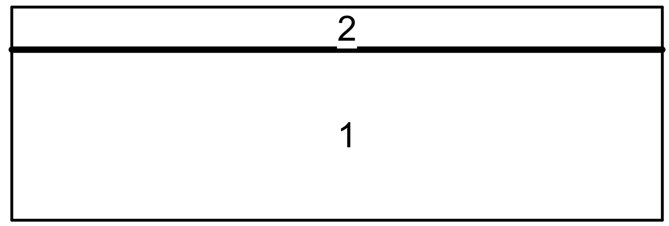
Load Summary

Roof Total Load	600
Floor Total Load	0
Wall Total Load	2500
Footing Total Load (plf)	824
Displaced Soil Total Load (plf)	-631
Total Load	**3292**

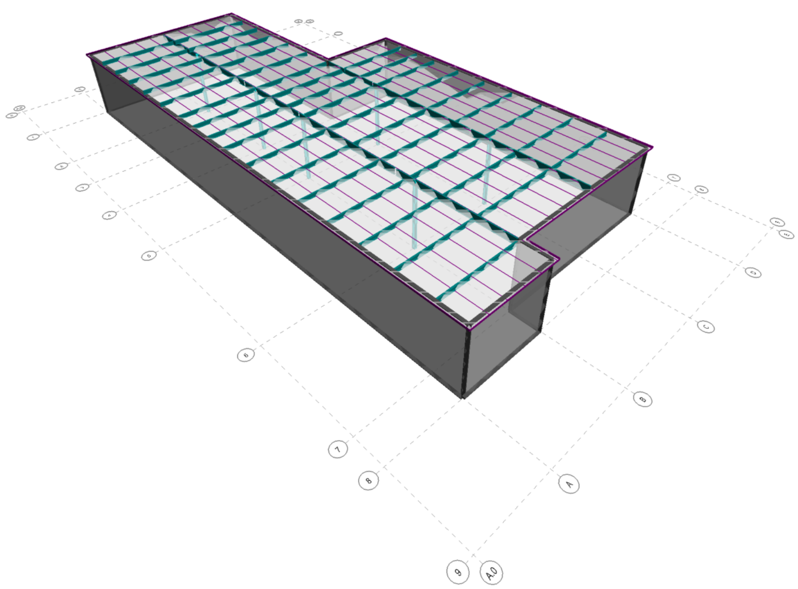
Profile X-Axis

Roof - Diaph #1

Base

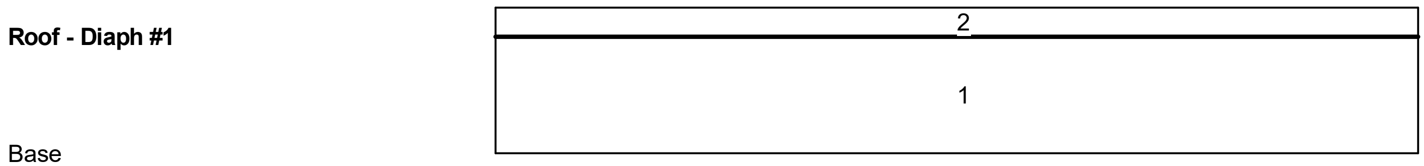


Zone	Start (ft)	End (ft)	Height (ft)	
1	19.0000	95.0000	20.0000	
2	19.0000	95.0000	5.0000	Parapet

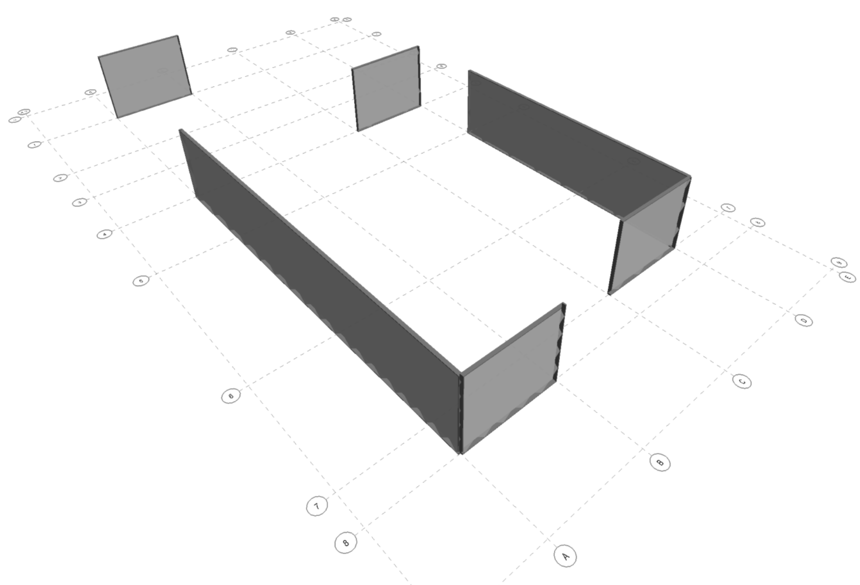


Exposure Boundaries

Profile Y-Axis



Zone	Start (ft)	End (ft)	Height (ft)	
1	19.0000	176.6670	20.0000	
2	19.0000	176.6670	5.0000	Parapet



CRITERIA:

Rigid End Zones:		Ignore Effects	
Member Force Output:		At Face of Joint	
P-Delta:	Yes	Scale Factor:	1.00
Ground Level:	Base		

Mesh Criteria :

Max. Distance Between Nodes on Mesh Line (ft) : 4.00
Merge Node Tolerance (in) : 0.0100
Geometry Tolerance (in) : 0.0050

Walls Out-of-plane Stiffness Not Included in Analysis.
Sign considered for Dynamic Load Case Results.
Rigid Links Included at Fixed Beam-to-Wall Locations
Eigenvalue Analysis : Eigen Vectors (Subspace Iteration)

DIAPHRAGM DATA:

Story	Diaph #	Diaph Type
Roof	1	Rigid

Disconnect Internal Nodes of Beams: Yes
Disconnect Nodes outside Slab Boundary: Yes

STORY MASS DATA:

Includes Self Mass of:

Beams
Columns (Half mass of columns above and below)
Walls (Half mass of walls above and below)
Slabs/Deck

Calculated Values:

Story	Diaph #	Weight kips	Mass k-s2/ft	MMI ft-k-s2	Xm ft	Ym ft	EccX ft	EccY ft
Roof	1	609.73	18.94	69713	53.27	95.72	3.80	7.88

Story	Diaph #	Combine
Roof	1	None

WIND EXPOSURE DATA:

Calculated Values:

Story	Diaph #	Building Extents (ft)				Expose	Parapet
		Min X	Max X	Min Y	Max Y		ft
Roof	1	19.00	95.00	19.00	176.67	Full	5.00

STORY GRAVITY LOADS DATA:

Includes Weight of:

Beams
Columns
Walls
Slabs/Deck

Live Load Reduction (Calculated)

Reducible :	0.00 %
Storage :	0.00 %
Roof :	0.00 %

Calculated Values:

Story	Diaph #	Dead kips	Xc ft	Yc ft	Live kips	Xc ft	Yc ft
Roof	1	1390.30	53.25	95.54	0.00	0.00	0.00

Story	Diaph #	Roof kips	Xc ft	Yc ft	Combine
Roof	1	205.33	53.16	94.16	None

RAM Structural System
RAM Frame 17.02.01.23
Bentley DataBase: RCI2112 10/22/21 14:06:05

LOAD CASE: Wind

ASCE 7-16
Exposure: C
Basic Wind Speed (mph): 109.0
Apply Directionality Factor, Kd = 0.85
Use Topography Factor, Kzt: 1.00
Ground Elevation Factor, Ke: 1.00
Use Calculated Frequency for X-Dir.
Use Calculated Frequency for Y-Dir.
Gust Factor for Rigid Structures, G: Use Calculated G for X-Dir.
Gust Factor for Rigid Structures, G: Use Calculated G for Y-Dir.
Damping Ratio for Flexible Structures= 0.01
Mean Roof Height in X-Dir. (ft): Top Story Height + Parapet = 25.00
Mean Roof Height in Y-Dir. (ft): Top Story Height + Parapet = 25.00
Ground Level for X-Dir.: Base
Ground Level for Y-Dir.: Base

WIND PRESSURES:

X-Direction: Natural Frequency = 12.983 Structure is Rigid
Y-Direction: Natural Frequency = 24.312 Structure is Rigid
CpWindward = 0.80
qLeeward (qh X-Dir.) = 24.44 psf
qLeeward (qh Y-Dir.) = 24.44 psf
GCpn (Parapet): Windward = 1.50 Leeward = -1.00

X-Direction:

Height (ft)	Kz	Kzt	qz (psf)	Gust Factor G	CpLeeward	Pressure (psf)
25.00	0.945	1.000	24.438	----	----	61.095
20.00	0.902	1.000	23.316	0.849	-0.500	26.197
0.00	0.849	1.000	21.946	0.849	-0.500	25.267

Y-Direction:

Height (ft)	Kz	Kzt	qz (psf)	Gust Factor G	CpLeeward	Pressure (psf)
25.00	0.945	1.000	24.438	----	----	61.095
20.00	0.902	1.000	23.316	0.869	-0.296	22.494
0.00	0.849	1.000	21.946	0.869	-0.296	21.542

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_1_X

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	88.98	0.00	57.00	97.83

APPLIED STORY FORCES

Type: Wind_ASCE716_1_X

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	88.98	0.00
		88.98	0.00

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_1_Y

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	0.00	40.07	57.00	97.83

APPLIED STORY FORCES

Type: Wind_ASCE716_1_Y

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	0.00	40.07
		0.00	40.07

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_2_X+E

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	66.73	0.00	57.00	121.48

APPLIED STORY FORCES

Type: Wind_ASCE716_2_X+E

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	66.73	0.00
		66.73	0.00

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_2_X-E

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	66.73	0.00	57.00	74.18

APPLIED STORY FORCES

Type: Wind_ASCE716_2_X-E

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	66.73	0.00
		66.73	0.00

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_2_Y+E

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	0.00	30.05	68.40	97.83

APPLIED STORY FORCES

Type: Wind_ASCE716_2_Y+E

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	0.00	30.05
		0.00	30.05

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_2_Y-E

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	0.00	30.05	45.60	97.83

APPLIED STORY FORCES

Type: Wind_ASCE716_2_Y-E

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	0.00	30.05
		0.00	30.05

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_3_X+Y

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	66.73	30.05	57.00	97.83

APPLIED STORY FORCES

Type: Wind_ASCE716_3_X+Y

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	66.73	30.05
		66.73	30.05

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_3_X-Y

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	66.73	-30.05	57.00	97.83

APPLIED STORY FORCES

Type: Wind_ASCE716_3_X-Y

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	66.73	-30.05
		66.73	-30.05

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_4_X+Y_CW

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	50.05	22.54	45.60	121.48

APPLIED STORY FORCES

Type: Wind_ASCE716_4_X+Y_CW

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	50.05	22.54
		50.05	22.54

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_4_X+Y_CCW

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	50.05	22.54	68.40	74.18

APPLIED STORY FORCES

Type: Wind_ASCE716_4_X+Y_CCW

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	50.05	22.54
		50.05	22.54

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_4_X-Y_CW

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	50.05	-22.54	68.40	121.48

APPLIED STORY FORCES

Type: Wind_ASCE716_4_X-Y_CW

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	50.05	-22.54
		50.05	-22.54

APPLIED DIAPHRAGM FORCES

Type: Wind_ASCE716_4_X-Y_CCW

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	50.05	-22.54	45.60	74.18

APPLIED STORY FORCES

Type: Wind_ASCE716_4_X-Y_CCW

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	50.05	-22.54
		50.05	-22.54

LOAD CASE: Seismic

Seismic ASCE 7-16 Equivalent Lateral Force
Importance Factor: 1.00 TL: 12.00 s
Site Class C: Very Dense Soil and Soft Rock
Ss: 0.100 g S1: 0.069 g
Fa: 1.300 Fv: 1.500 SDs: 0.087 g SD1: 0.069 g
Risk Category: II Seismic Design Category: B
Provisions for: Force
Ground Level: Base

Dir	Eccent	R	Ta Equation	Building Period-T
X	+ And -	3.0	Std,Ct=0.030,x=0.75	Calculated
Y	+ And -	3.0	Std,Ct=0.030,x=0.75	Calculated

Dir	Ta	Cu	T	T-used	Cs Eq12.8-2	Cs(max) Eq12.8-3	Cs(min) Eq12.8-5	Cs-used	k
X	0.284	1.700	0.077	0.077	0.029	0.299	0.010	0.029	1.000

Dir	Ta	Cu	T	T-used	Cs Eq12.8-2	Cs(max) Eq12.8-3	Cs(min) Eq12.8-5	Cs-used	k
Y	0.284	1.700	0.041	0.041	0.029	0.559	0.010	0.029	1.000

Total Building Weight (kips) = 815.06

APPLIED DIAPHRAGM FORCES

Type: EQ_ASCE716_X_+E_F

Level	Diaph.#	Ht ft	Fx kips	Fy kips	X ft	Y ft
Roof	1	20.00	23.55	0.00	53.25	103.21

APPLIED STORY FORCES

Type: EQ_ASCE716_X_+E_F

Level	Ht ft	Fx kips	Fy kips
Roof	20.00	23.55	0.00
		23.55	0.00

APPLIED DIAPHRAGM FORCES

Type: EQ_ASCE716_X_-E_F

Level	Diaph.#	Ht ft	Fx kips	Fy kips	X ft	Y ft
Roof	1	20.00	23.55	0.00	53.25	87.44

APPLIED STORY FORCES

Type: EQ_ASCE716_X_-E_F

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	23.55	0.00
		23.55	0.00

APPLIED DIAPHRAGM FORCES

Type: EQ_ASCE716_Y_+E_F

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	0.00	23.55	57.05	95.33

APPLIED STORY FORCES

Type: EQ_ASCE716_Y_+E_F

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	0.00	23.55
		0.00	23.55

APPLIED DIAPHRAGM FORCES

Type: EQ_ASCE716_Y_-E_F

Level	Diaph.#	Ht	Fx	Fy	X	Y
		ft	kips	kips	ft	ft
Roof	1	20.00	0.00	23.55	49.45	95.33

APPLIED STORY FORCES

Type: EQ_ASCE716_Y_-E_F

Level	Ht	Fx	Fy
	ft	kips	kips
Roof	20.00	0.00	23.55
		0.00	23.55

BOB D. CAMPBELL & CO.
Structural Engineers Since 1957
4338 Belleview Ave. 816.531.4144
Kansas City, MO 64111 www.bdc-engrs.com

Project Title: Crash Champions
Engineer: MJF
Project ID: RCI2112
Project Descr:

Torsional Analysis of Rigid Diaphragm

Lic. # : KW-06011403 Bob D. Campbell and Co., Inc.

DESCRIPTION: Wind Loads

General Information

1.0W

IBC 2018, CBC 2019, ASCE 7-16

Applied Lateral Force in "X" DIrection 90.0 k
Applied Lateral Force in "Y" DIrection 40.0 k

Note: These loads are resolved into X & Y components when applied to the system of elements at angular increments.

Load Orientation Angular Increment 15.0 deg
Load Location Angular Increment 15.0 deg

Center of Rigidity Location (calculated) . . .
"X" dist. from Datum 31.191 ft
"Y" dist. from Datum 91.965 ft

Center of Shear Application :
Distance from "X" datum point 37.0 ft
Distance from "Y" datum point 77.830 ft

Accidental Torsion values per ASCE 7-05 12.8.4.2
Ecc. as % of Maximum Dimension 5.00 %

Maximum Dimensions :
Along "X" Axis 74.0 ft
Along "Y" Axis 155.670 ft

Accidental Eccentricity +/- from "Y" Coord. of Center of Load Application : 3.70 ft
Accidental Eccentricity +/- from "X" Coord. of Center of Load Application : 7.784 ft

Wall Information

Label : Wall 1

Wall Deflections (Stiffness) for 1.0 kip load :		X Wall C.G. Location	12 ft	Length	24 ft
		Y Wall C.G. Location	0 ft	Height	20 ft
		Wall Angle CCW	0 deg	Thickness	10 in
Along Wall "y" Dir	4.8148E-004 in	Wall Fixity	Fix-Pin	E - Bending	1 Mpsi
Along Wall "x" Dir	1.9225E+004 in			E - Shear	0.4 Mpsi

Label : Wall 2

Wall Deflections (Stiffness) for 1.0 kip load :		X Wall C.G. Location	74 ft	Length	71 ft
		Y Wall C.G. Location	43.5 ft	Height	20 ft
		Wall Angle CCW	90 deg	Thickness	10 in
Along Wall "y" Dir	8.6742E-005 in	Wall Fixity	Fix-Fix	E - Bending	1 Mpsi
Along Wall "x" Dir	1.6310E+003 in			E - Shear	0.4 Mpsi

Label : Wall 3

Wall Deflections (Stiffness) for 1.0 kip load :		X Wall C.G. Location	62 ft	Length	24 ft
		Y Wall C.G. Location	101 ft	Height	10 ft
		Wall Angle CCW	0 deg	Thickness	10 in
Along Wall "y" Dir	1.5394E-004 in	Wall Fixity	Fix-Pin	E - Bending	1 Mpsi
Along Wall "x" Dir	2.4125E+003 in			E - Shear	0.4 Mpsi

Label : Wall 4

Wall Deflections (Stiffness) for 1.0 kip load :		X Wall C.G. Location	12 ft	Length	24 ft
		Y Wall C.G. Location	155.67 ft	Height	20 ft
		Wall Angle CCW	0 deg	Thickness	10 in
Along Wall "y" Dir	4.8148E-004 in	Wall Fixity	Fix-Pin	E - Bending	1 Mpsi
Along Wall "x" Dir	1.9225E+004 in			E - Shear	0.4 Mpsi

Label : Wall 5

Wall Deflections (Stiffness) for 1.0 kip load :		X Wall C.G. Location	0 ft	Length	100 ft
		Y Wall C.G. Location	50 ft	Height	20 ft
		Wall Angle CCW	90 deg	Thickness	10 in
Along Wall "y" Dir	6.3200E-005 in	Wall Fixity	Fix-Pin	E - Bending	1 Mpsi
Along Wall "x" Dir	4.6140E+003 in			E - Shear	0.4 Mpsi

ANALYSIS SUMMARY

Maximum shear forces applied to resisting elements. Eccentricity with respect to Center of Rigidity

	Max Shear along Member Local "y-y" Axis				Max Shear along Member Local "x-x" Axis			
Resisting Element	Load Angle	X-Ecc (ft)	Y-Ecc (ft)	Shear Force (k)	Load Angle	X-Ecc (ft)	Y-Ecc (ft)	Shear Force (k)
Wall 1	0	-5.81	-21.92	**23.528**	90	-2.11	-14.14	**0.000**
Wall 2	45	-4.85	-21.65	**23.783**	0	-2.11	-14.14	**0.000**
Wall 3	0	-2.11	-14.14	**54.897**	90	-2.11	-14.14	**0.000**
Wall 4	0	-2.11	-14.14	**17.551**	90	-2.11	-14.14	**0.000**
Wall 5	240	-6.77	-21.65	**29.503**	0	-2.11	-14.14	**0.000**

Torsional Analysis of Rigid Diaphragm

DESCRIPTION: Wind Loads

Layout of Resisting Elements

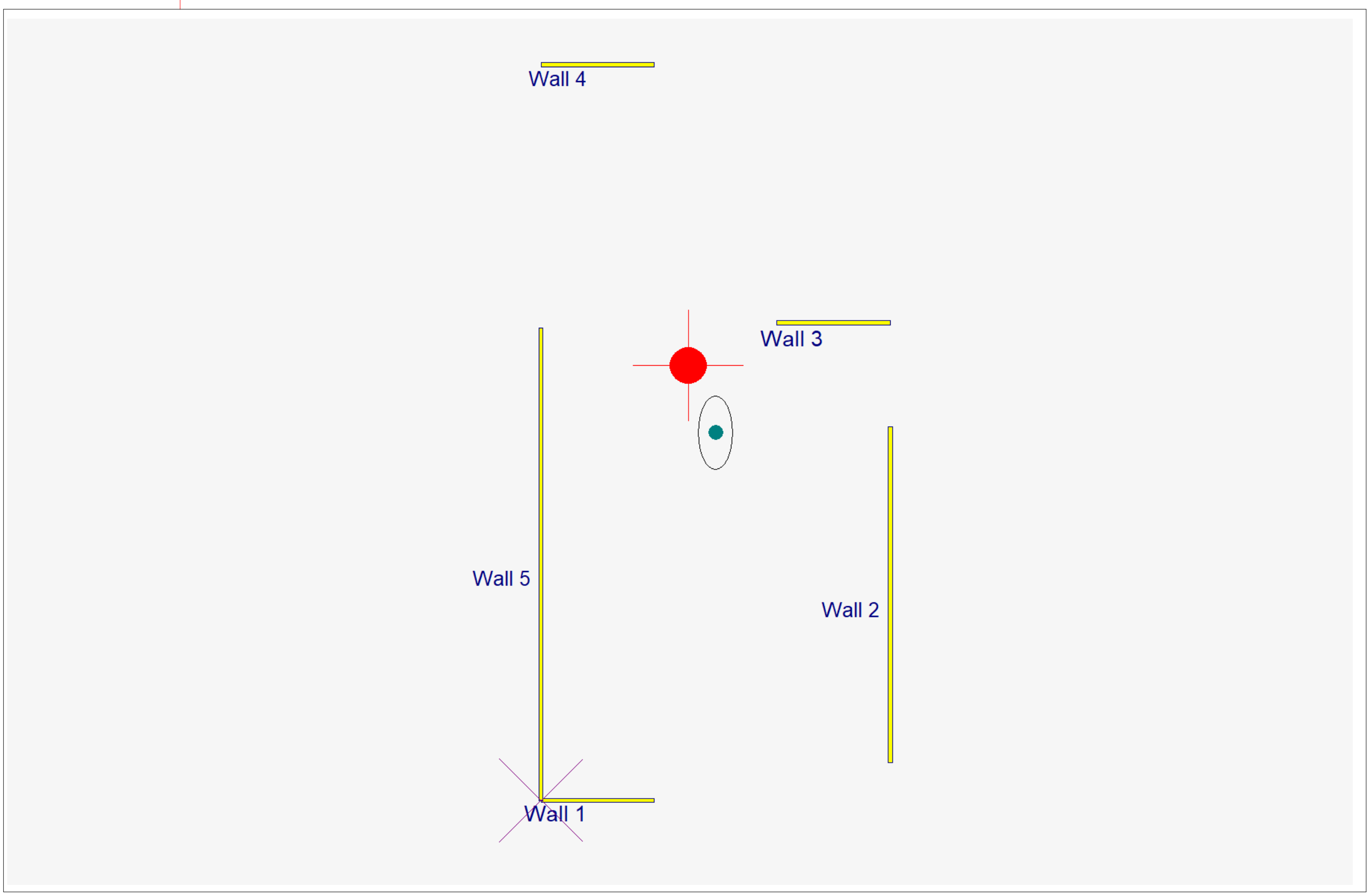
Legend : Defined Wall

Datum

Center of Rigidity

Center of Mass

Accidental eccentricity application boundary



Torsional Analysis of Rigid Diaphragm

DESCRIPTION: Wind Loads

Analysis Notes

This program is designed to distribute an applied shear load to a set of resisting elements.

Each resisting element data entry specifies a deflection along a "major" and "minor" axis due to a 1,000 lb load. Each resisting element may be entered as a wall or a column (whereby the deflection is calculated), or as a generic resisting element with specified deflection. The deflections define the stiffness of each resisting element.

Each resisting element is defined at an (X,Y) location from a datum the user has previously defined. A counter-clockwise rotation of the element can be entered with respect to a traditional "+X" axis line.

A main "shear" load and an optional orthogonal shear load are specified for distribution to the system of resisting elements. In addition the maximum orthogonal dimensions of the structure and minimum accidental eccentricity percentage are specified.

From the entered loads the program calculates resultant force vectors for each angular orientation that is requested. The force is applied to the resisting elements in angular increments to generate a series of resulting direct and torsional shear loads on each element. This application of force is then repeated at angular intervals along an elliptical path defined by the minimum accidental eccentricity.

The end result is a table of direct shear and torsional shear values for each element from the iterated angles of load application and accidental eccentricity. These values are then searched to find the maximum major and minor axis shears applied to each resisting element.

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Kansas City, MO 64111 www.bdc-engrs.com

Project Title: Crash Champions
Engineer: MJF
Project ID: RCI2112
Project Descr:

Torsional Analysis of Rigid Diaphragm

DESCRIPTION: Seismic Loads

General Information

1.0E

IBC 2018, CBC 2019, ASCE 7-16

Applied Lateral Force	25.0 k
.....Additional Orthogonal Force	k
Maximum Load Used for Analysis :	25.0 k

Note: This load is the vector resolved from the above two entries and will be applied to the system of elements at angular increments.

Load Orientation Angular Increment	15.0 deg
Load Location Angular Increment	15.0 deg

Center of Rigidity Location (calculated) . . .

"X" dist. from Datum	31.191 ft
"Y" dist. from Datum	91.965 ft

Center of Shear Application :

Distance from "X" datum point	33.250 ft
Distance from "Y" datum point	83.210 ft

Accidental Torsion values per ASCE 7-05 12.8.4.2

Ecc. as % of Maximum Dimension	5.00 %

Maximum Dimensions :

Along "X" Axis	74.0 ft
Along "Y" Axis	155.670 ft

Accidental Eccentricity +/- from "X" Coord. of Load Application :	3.70 ft
Accidental Eccentricity +/- from "Y" Coord. of Load Application :	7.784 ft

Wall Information

Label : Wall 1

Wall Deflections (Stiffness) for 1.0 kip load :					
		X Wall C.G. Location	12 ft	Length	24 ft
		Y Wall C.G. Location	0 ft	Height	20 ft
		Wall Angle CCW	0 deg	Thickness	10 in
Along Wall "y" Dir	4.8148E-004 in	Wall Fixity	Fix-Pin	E - Bending	1 Mpsi
Along Wall "x" Dir	1.9225E+004 in			E - Shear	0.4 Mpsi

Label : Wall 2

Wall Deflections (Stiffness) for 1.0 kip load :					
		X Wall C.G. Location	74 ft	Length	71 ft
		Y Wall C.G. Location	43.5 ft	Height	20 ft
		Wall Angle CCW	90 deg	Thickness	10 in
Along Wall "y" Dir	8.6742E-005 in	Wall Fixity	Fix-Fix	E - Bending	1 Mpsi
Along Wall "x" Dir	1.6310E+003 in			E - Shear	0.4 Mpsi

Label : Wall 3

Wall Deflections (Stiffness) for 1.0 kip load :					
		X Wall C.G. Location	62 ft	Length	24 ft
		Y Wall C.G. Location	101 ft	Height	10 ft
		Wall Angle CCW	0 deg	Thickness	10 in
Along Wall "y" Dir	1.5394E-004 in	Wall Fixity	Fix-Pin	E - Bending	1 Mpsi
Along Wall "x" Dir	2.4125E+003 in			E - Shear	0.4 Mpsi

Label : Wall 4

Wall Deflections (Stiffness) for 1.0 kip load :					
		X Wall C.G. Location	12 ft	Length	24 ft
		Y Wall C.G. Location	155.67 ft	Height	20 ft
		Wall Angle CCW	0 deg	Thickness	10 in
Along Wall "y" Dir	4.8148E-004 in	Wall Fixity	Fix-Pin	E - Bending	1 Mpsi
Along Wall "x" Dir	1.9225E+004 in			E - Shear	0.4 Mpsi

Label : Wall 5

Wall Deflections (Stiffness) for 1.0 kip load :					
		X Wall C.G. Location	0 ft	Length	100 ft
		Y Wall C.G. Location	50 ft	Height	20 ft
		Wall Angle CCW	90 deg	Thickness	10 in
Along Wall "y" Dir	6.3200E-005 in	Wall Fixity	Fix-Pin	E - Bending	1 Mpsi
Along Wall "x" Dir	4.6140E+003 in			E - Shear	0.4 Mpsi

ANALYSIS SUMMARY

Maximum shear forces applied to resisting elements. Eccentricity with respect to Center of Rigidity

	Max Shear along Member Local "y-y" Axis				Max Shear along Member Local "x-x" Axis			
Resisting Element	Load Angle	X-Ecc (ft)	Y-Ecc (ft)	Shear Force (k)	Load Angle	X-Ecc (ft)	Y-Ecc (ft)	Shear Force (k)
Wall 1	0	-2.06	-16.54	**6.128**	90	1.64	-8.76	**0.000**
Wall 2	255	-1.10	-16.27	**11.211**	0	1.64	-8.76	**0.000**
Wall 3	0	1.64	-8.76	**15.249**	90	1.64	-8.76	**0.000**
Wall 4	0	1.64	-8.76	**4.875**	90	1.64	-8.76	**0.000**
Wall 5	75	-5.26	-12.65	**15.605**	0	1.64	-8.76	**0.000**

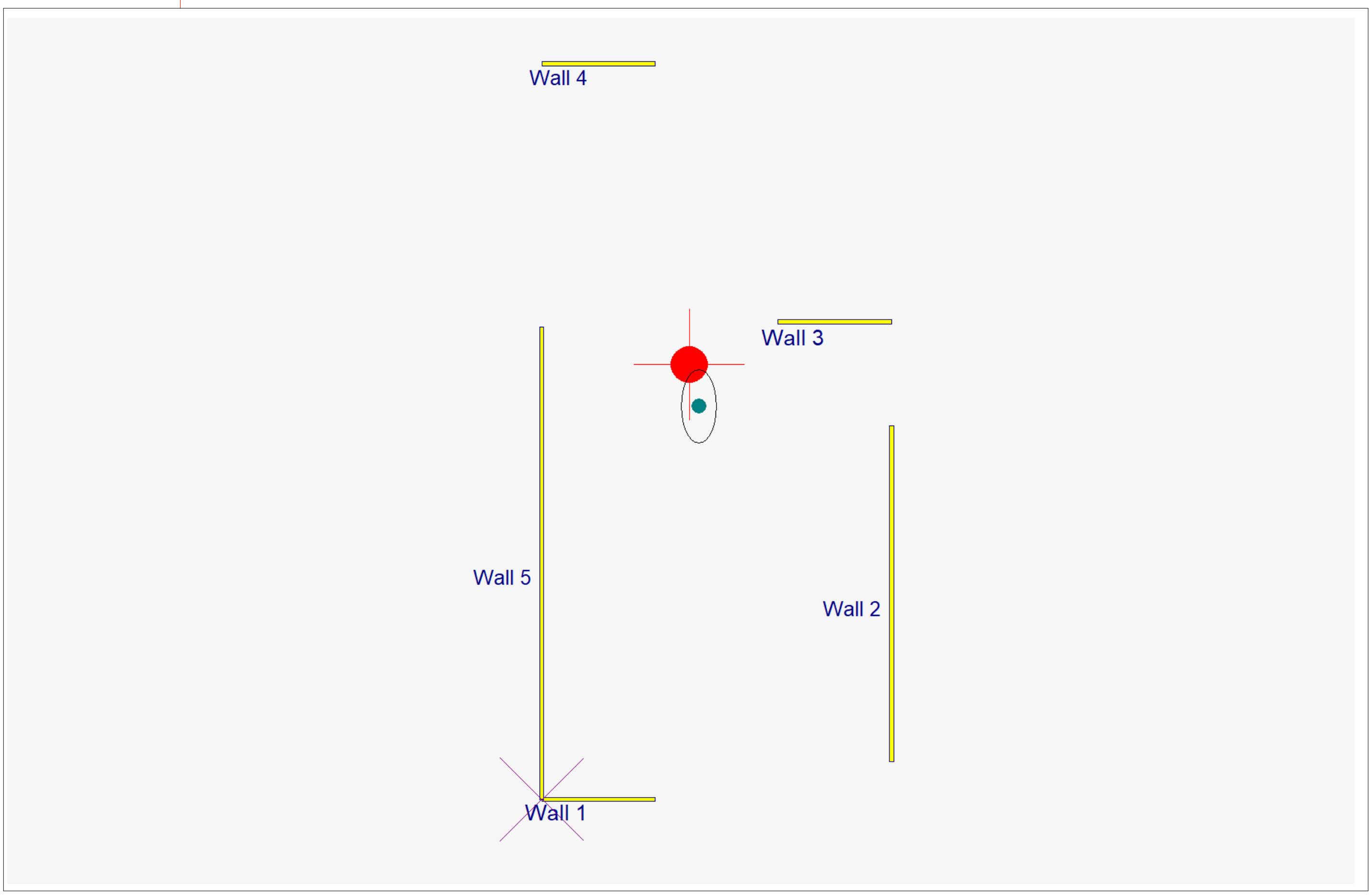
Torsional Analysis of Rigid Diaphragm

DESCRIPTION: Seismic Loads

Layout of Resisting Elements

Legend : Defined Wall X Datum

Center of Rigidity Center of Mass Accidental eccentricity application boundary



Torsional Analysis of Rigid Diaphragm

DESCRIPTION: Seismic Loads

Analysis Notes

This program is designed to distribute an applied shear load to a set of resisting elements.

Each resisting element data entry specifies a deflection along a "major" and "minor" axis due to a 1,000 lb load. Each resisting element may be entered as a wall or a column (whereby the deflection is calculated), or as a generic resisting element with specified deflection. The deflections define the stiffness of each resisting element.

Each resisting element is defined at an (X,Y) location from a datum the user has previously defined. A counter-clockwise rotation of the element can be entered with respect to a traditional "+X" axis line.

A main "shear" load and an optional orthogonal shear load are specified for distribution to the system of resisting elements. In addition the maximum orthogonal dimensions of the structure and minimum accidental eccentricity percentage are specified.

From the entered loads the program calculates resultant force vectors for each angular orientation that is requested. The force is applied to the resisting elements in angular increments to generate a series of resulting direct and torsional shear loads on each element. This application of force is then repeated at angular intervals along an elliptical path defined by the minimum accidental eccentricity.

The end result is a table of direct shear and torsional shear values for each element from the iterated angles of load application and accidental eccentricity. These values are then searched to find the maximum major and minor axis shears applied to each resisting element.