VT FOREST HARVESTING LAB

STRUCTURAL CALCULATIONS

For Preliminary Foundation Design and Slab On Grade

Prepared by: Craig M. Favor, PE, SE

Bennett & Pless Structural Engineers

October 28, 2026



Craig M Favor

Digitally signed by Craig M. Favor
DN: CN=Craig M Favor, dnQualifier=A01410D0001A0B4F09AD2000EF1FE, O=Unaffiliated, C=US
Date: 2026.10.27 17:38:49-04'00'

bennett & pless
STRUCTURAL ENGINEERS

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Design Loads

Bennett & Pless Structural Engineers
Address
City, State
Phone

JOB TITLE VT Forest Harvesting Lab
JOB NO. 26.04.060 SHEET NO.
CALCULATED BY Craig Favor DATE 8/20/26
CHECKED BY DATE

www.struware.com

CODE SUMMARY

Code: ASCE 7 - 22

Live Loads:

Roof	0 to 200 sf:	20 psf
	200 to 600 sf:	24 - 0.02Area, but not less than 12 psf
	over 600 sf:	12 psf
Roofs used for roof gardens		100 psf
Typical Floor		250 psf
Partitions		15 psf
Corridors above first floor		80 psf
Lobbies & first floor corridors		100 psf
Stairs and exit ways		100 psf

Dead Loads:

Floor	80.0 psf
Roof	20.0 psf

Roof Snow Loads:

Design Uniform Roof Snow load		=	34.8 psf
Flat Roof Snow Load	Pf	=	34.8 psf
Risk Category		=	II
Balanced Snow Load	Ps	=	34.8 psf
Ground Snow Load	Pg	=	46.0 psf
Importance Factor	I	=	1.00
Snow Exposure Factor	Ce	=	0.90
Thermal Factor	Ct	=	1.20
Sloped-roof Factor	Cs	=	1.00
Drift Surcharge load	Pd	=	
Width of Snow Drift	w	=	
Winter wind Parameter	W2	=	0.55

Earthquake Design Data:

Risk Category		=	II
Importance Factor	I	=	1.00
Mapped spectral response acceleratio	Ss	=	0.29 g
	S1	=	0.08 g
Site Class		=	CD
Spectral Response Coef.	Sds	=	0.213
	Sd1	=	0.087
Seismic Design Category		=	B
Basic Structural System		=	Structural steel systems not specifically detailed for seismic resistance
Seismic Resisting System		=	Structural steel systems not specifically detailed for seismic resistance
Design Base Shear	V	=	0.071W
Seismic Response Coef.	Cs	=	0.071
Response Modification Factor	R	=	3
Analysis Procedure		=	Equivalent Lateral-Force Analysis

Rain Design Data:

Rain intensity	*i* =	4.98 in/hr
Rain Load	R =	31.5 psf

Wind Design Data:

Ultimate Design Wind Speed	108 mph
Nominal Design Wind Speed	83.66 mph
Risk Category	II
Mean Roof Ht (h)	26.5 ft
Exposure Category	C
Enclosure Classif.	Partially Enclosed
Internal pressure Coef.	+/-0.55
Directionality (Kd)	0.85

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Component and Cladding Ultimate Wind Pressures

Roof	Surface Pressure (psf)							
Area	10 sf	100 sf	200 sf	300 sf				
Negative Zone 1	-61.9	-37.2	-29.8	-25.5				
Negative Zone 2	-78.9	-47.2	-37.6	-37.6				
Negative Zone 3	-100.7	-57.0	-57.0	-57.0				
Positive All Zones	27.9	22.3	20.6	20.6				
Overhang Zone 1	-75.2	-46.3	-37.6	-32.5				
Overhang Zone 2 @zone 4	-92.2	-56.2	-45.4	-44.6				
Overhang Zone 2 @zone 5	-99.5	-59.2	-47.1	-45.6				
Overhang Zone 3	-114.0	-66.1	-64.8	-64.0				

Overhang soffit pressure equals adj wall pressure (which includes internal pressure of 13.3 psf)

Parapet		Solid Parapet Pressure (psf)					
	Area	10 sf	50 sf	100 sf	200 sf	300 sf	500 sf
CASE A:	Zone 1	0.0	0.0	0.0	0.0	0.0	0.0
	Zone 2	0.0	0.0	0.0	0.0	0.0	0.0
	Zone 3	0.0	0.0	0.0	0.0	0.0	0.0
CASE B:	Interior zone :	0.0	0.0	0.0	0.0	0.0	0.0
	Corner zone :	0.0	0.0	0.0	0.0	0.0	0.0

Wall	Surface Pressure (psf)			
Area	10 sf	100 sf	200 sf	500 sf
Negative Zone 4	-40.0	-35.7	-34.5	-32.8
Negative Zone 5	-47.3	-38.7	-36.2	-32.8
Positive Zone 4 & 5				

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PEMB LOADS FOR ESTIMATED FRAME REACTIONS

ROOF DEAD

Deck and Insulation	3 psf
Purlins and Framing	3 psf
Collateral/MEP	5 psf
Total	11 psf

ROOF LIVE 20 psf

SNOW 35 psf

WIND - MWFRS

Wind Loads - MWFRS all h (Except for Open Buildings)

		Kh =	0.957	GCpi =	+/-0.55
Base pressure (qh) =	**24.3 psf**	Bldg dim parallel to ridge =	78.0 ft	G =	0.85
Roof Angle (θ) =	18.4 deg	Bldg dim normal to ridge =	48.0 ft	z for qi:	26.5 ft
Roof tributary area:		h =	26.5 ft	qi =	24.3 psf for positive internal pressures
Wind normal to ridge =(h/2)*L:	1034 sf	ridge ht =	30.5 ft		
Wind parallel to ridge =(h/2)*L:	636 sf				

Ultimate Wind Surface Pressures (psf)

	Wind Normal to Ridge L/B = 0.62		h/L = 0.55		Wind Parallel to Ridge L/B = 1.63		h/L = 0.34	
Surface	Cp	$q_h GC_p$	w/ $+q_h GC_{pi}$	w/ $-q_h GC_{pi}$	Dist.*	Cp	$q_h GC_p$	w/ $+q_h GC_{pi}$	w/ $-q_h GC_{pi}$
Windward Wall (WW)	0.80	16.5	see table below			0.80	16.5	see table below	
Leeward Wall (LW)	-0.50	-10.3	-23.7	3.0		-0.38	-7.7	-21.1	5.6
Side Wall (SW)	-0.70	-14.5	-27.8	-1.1		-0.70	-14.5	-27.8	-1.1
Leeward Roof (LR)	-0.57	-11.8	-25.2	1.6		Included in windward roof			
Neg Windward Roof pressure	-0.53	-10.8	-24.2	2.5	0 to h/2*	-0.90	-18.6	-31.9	-5.2
Pos/min Windward Roof press.	-0.07	-1.4	-14.8	11.9	h/2 to h*	-0.90	-18.6	-31.9	-5.2
					h to 2h*	-0.50	-10.3	-23.7	3.0
					> 2h*	-0.30	-6.2	-19.6	7.2
					Min press.	-0.18	-3.7	-17.1	9.6

*Horizontal distance from windward edge

Windward roof overhangs : 16.5 psf (upward - add to qhGCp windward roof pressure)

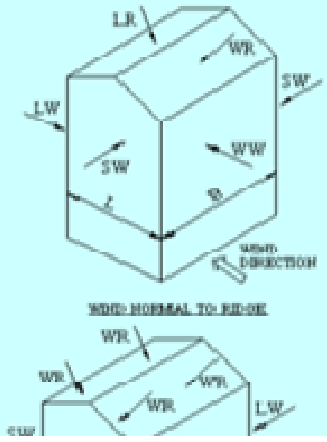
Parapet

z	Kz	Kzt	qp (psf)
0.0 ft	0.849	1.00	0.0

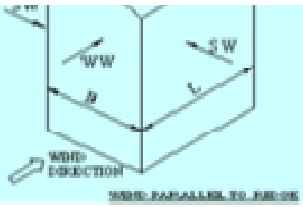
Windward parapet: 0.0 psf (GCpn = +1.5)
Leeward parapet: 0.0 psf (GCpn = -1.0)

Windward Wall Pressures at "z" (psf)

z	Kz	Kzt	Windward Wall $q_z GC_p$	Windward Wall w/ $+q_z GC_{pi}$	Windward Wall w/ $-q_z GC_{pi}$	Combined WW + LW Wind Normal to Ridge	Combined WW + LW Wind Parallel to Ridge
0 to 15'	0.85	1.00	14.7	1.3	28.0	25.0	22.4
20.0 ft	0.90	1.00	15.6	2.2	28.9	25.9	23.3
25.0 ft	0.95	1.00	16.3	3.0	29.7	26.6	24.1
h= 26.5 ft	0.96	1.00	16.5	3.2	29.9	26.8	24.3



ridge =	30.5 ft	0.99	1.00	17.0	3.7	30.4	27.3	24.8



INTERIOR RIGID FRAME (Grids 2, 3, 4)

	Vertical	Horizontal	
Dead	1.5	1	kips
Snow	20	8	kips
Wind	-24	16	kips

END WALL BRACED FRAME (Grids 1 & 5)

	Vertical	Horizontal	
Dead	2.5	0	kips
Snow	5	0	kips
Wind	-10	4	kips

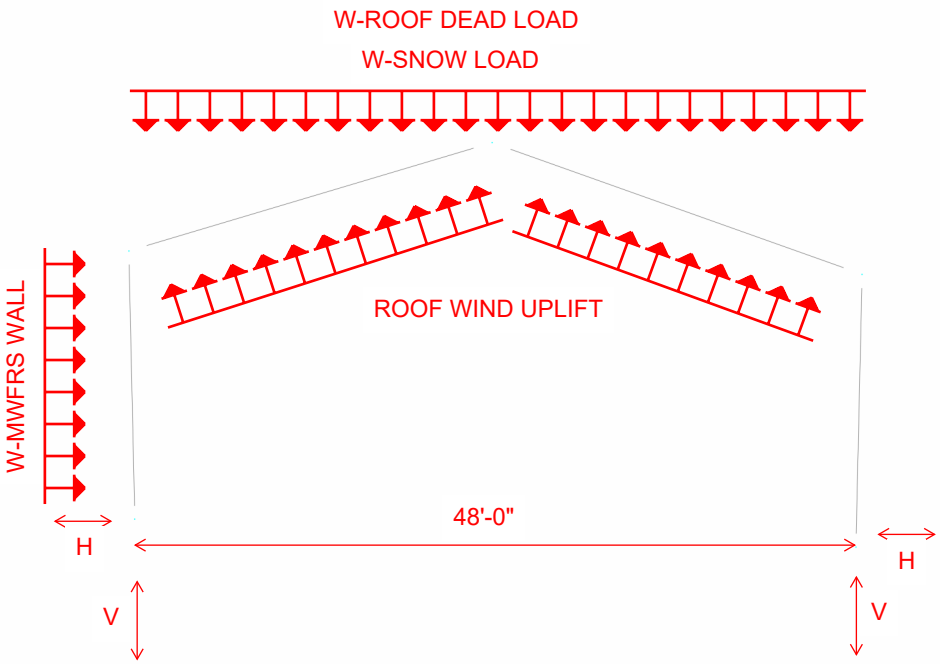
Tie Beam Reinforcing at Rigid Frames (Grids 2, 3, 4)

Tu	19.6	kips - axial tension (1.2D+1.0W+0.3S)	
As (2-#5)	0.62	in^2	
Fy	60	ksi	
Phi-Tn	33.48	kips	=0.9AsFy

OK, Phi-Tn>Tu

TYPICAL INTERIOR FRAME LOADS

TRIB WIDTH = (24' + 20.5')/2 = 22.25'
W-ROOF DEAD LOAD = 11 PSF X 22.25' = 0.245 KLF
W-SNOW LOAD = 35 PSF X 22.25' = 0.779 KLF
W-ROOF WIND UPLIFT = -30 PSF X 22.25' = 0.67 KLF
W-MWFRS WALL = 26 PSF X 22.25' = 0.58 KLF





RAM Elements

Current Date: 10/2/2026 10:27 AM

Units system: English

File name: Z:\Shared\Projects\2026\26.04.000 - Knoxville\26.04.060 - CLARKNEXSENI - VT Forest Harvesting Lab\Structural\01 Calcs\RAM Elements\typ interior bent frame.retx

Analysis result

Nodes

Reactions



Direction of positive forces and moments

		Forces [Kip]			Moments [Kip*ft]		
Node	**FX**	**FY**	**FZ**	**MX**	**MY**	**MZ**
Condition	**DL=Dead Load**					
1	1.85603	7.07628	0.00000	0.00000	0.00000	0.00000
2	-1.85603	7.07628	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	14.15255	0.00000	0.00000	0.00000	0.00000
Condition	**SL=SNOW LOAD**					
1	5.58734	19.70731	0.00000	0.00000	0.00000	0.00000
2	-5.58734	19.70731	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	39.41463	0.00000	0.00000	0.00000	0.00000
Condition	**WL=WIND LOAD**					
1	-12.63161	-18.01970	0.00000	0.00000	0.00000	0.00000
2	1.92011	-14.14030	0.00000	0.00000	0.00000	0.00000
SUM	-10.71150	-32.16000	0.00000	0.00000	0.00000	0.00000
Condition	**S1=DL**					
1	1.85603	7.07628	0.00000	0.00000	0.00000	0.00000
2	-1.85603	7.07628	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	14.15255	0.00000	0.00000	0.00000	0.00000
Condition	**S2=DL+0.7SL**					
1	5.75839	20.87140	0.00000	0.00000	0.00000	0.00000
2	-5.75839	20.87140	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	41.74279	0.00000	0.00000	0.00000	0.00000
Condition	**S3=DL+0.525SL**					
1	4.78586	17.42262	0.00000	0.00000	0.00000	0.00000
2	-4.78586	17.42262	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	34.84523	0.00000	0.00000	0.00000	0.00000
Condition	**S4=DL+0.6WL**					
1	-5.70301	-3.79632	0.00000	0.00000	0.00000	0.00000
2	-0.72389	-1.34713	0.00000	0.00000	0.00000	0.00000
SUM	-6.42690	-5.14345	0.00000	0.00000	0.00000	0.00000

Condition	**S5=DL+0.45WL+0.525SL**					
1	-0.86817	9.21949	0.00000	0.00000	0.00000	0.00000
2	-3.95200	11.15375	0.00000	0.00000	0.00000	0.00000
SUM	-4.82017	20.37323	0.00000	0.00000	0.00000	0.00000

Condition	**S6=0.6DL+0.6WL**					
1	-6.44883	-6.61383	0.00000	0.00000	0.00000	0.00000
2	0.02193	-4.19064	0.00000	0.00000	0.00000	0.00000
SUM	-6.42690	-10.80447	0.00000	0.00000	0.00000	0.00000

Condition	**S7=DL+0.75SL**					
1	6.03591	21.85676	0.00000	0.00000	0.00000	0.00000
2	-6.03591	21.85676	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	43.71352	0.00000	0.00000	0.00000	0.00000

Envelope for nodal reactions

Note.- **lc** is the controlling load condition



Direction of positive forces and moments

Envelope of nodal reactions for :

DL=Dead Load

SL=SNOW LOAD

WL=WIND LOAD

S1=DL

S2=DL+0.7SL

S3=DL+0.525SL

S4=DL+0.6WL

S5=DL+0.45WL+0.525SL

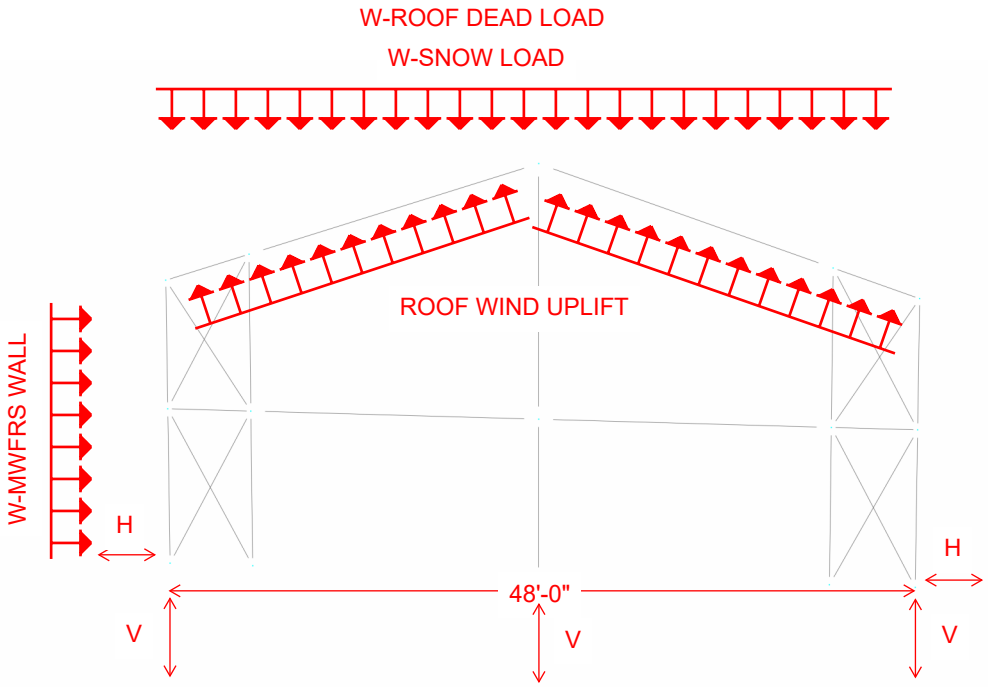
S6=0.6DL+0.6WL

S7=DL+0.75SL

		Forces						Moments					
Node		**Fx**	**lc**	**Fy**	**lc**	**Fz**	**lc**	**Mx**	**lc**	**My**	**lc**	**Mz**	**lc**
		[Kip]		[Kip]		[Kip]		[Kip*ft]		[Kip*ft]		[Kip*ft]	
1	Max	6.036	S7	21.857	S7	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
	Min	-12.632	WL	-18.020	WL	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
2	Max	1.920	WL	21.857	S7	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
	Min	-6.036	S7	-14.140	WL	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL

END WALL FRAME LOADS (GRID 5)

TRIB WIDTH = (18.17')/2 = 9.25'
W-ROOF DEAD LOAD = 11 PSF X 9.25' = 0.102 KLF
W-SNOW LOAD = 35 PSF X 9.25' = 0.324 KLF
W-ROOF WIND UPLIFT = -39 PSF X 9.25' = -0.361 KLF
W-MWFRS WALL = 34 PSF X 9.25' = 0.315 KLF



RAM Elements

Current Date: 10/2/2026 4:12 PM

Units system: English

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Analysis result

Nodes

Reactions



Direction of positive forces and moments

		Forces [Kip]			Moments [Kip*ft]		
Node	**FX**	**FY**	**FZ**	**MX**	**MY**	**MZ**
Condition	**DL=Dead Load**					
1	0.00075	0.60565	0.00000	0.00000	0.00000	0.00000
2	-0.00075	0.60565	0.00000	0.00000	0.00000	0.00000
6	0.00000	3.54047	0.00000	0.00000	0.00000	0.00000
7	0.01047	2.43847	0.00000	0.00000	0.00000	0.00000
8	-0.01047	2.43847	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	9.62872	0.00000	0.00000	0.00000	0.00000
Condition	**SL=SNOW LOAD**					
1	0.00292	0.57058	0.00000	0.00000	0.00000	0.00000
2	-0.00292	0.57058	0.00000	0.00000	0.00000	0.00000
6	0.00000	6.50941	0.00000	0.00000	0.00000	0.00000
7	0.00206	4.37134	0.00000	0.00000	0.00000	0.00000
8	-0.00206	4.37134	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	16.39325	0.00000	0.00000	0.00000	0.00000
Condition	**WL=WIND LOAD**					
1	-3.27040	-4.54267	0.00000	0.00000	0.00000	0.00000
2	-0.21311	4.08967	0.00000	0.00000	0.00000	0.00000
6	-0.24895	-6.30055	0.00000	0.00000	0.00000	0.00000
7	-0.27251	-1.15691	0.00000	0.00000	0.00000	0.00000
8	-1.82253	-9.41755	0.00000	0.00000	0.00000	0.00000
SUM	-5.82750	-17.32800	0.00000	0.00000	0.00000	0.00000
Condition	**S1=DL**					
1	0.00075	0.60565	0.00000	0.00000	0.00000	0.00000
2	-0.00075	0.60565	0.00000	0.00000	0.00000	0.00000
6	0.00000	3.54047	0.00000	0.00000	0.00000	0.00000
7	0.01047	2.43847	0.00000	0.00000	0.00000	0.00000
8	-0.01047	2.43847	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	9.62872	0.00000	0.00000	0.00000	0.00000
Condition	**S2=DL+0.7SL**					
1	0.00279	1.00499	0.00000	0.00000	0.00000	0.00000
2	-0.00279	1.00499	0.00000	0.00000	0.00000	0.00000
6	0.00000	8.09713	0.00000	0.00000	0.00000	0.00000
7	0.01188	5.49844	0.00000	0.00000	0.00000	0.00000
8	-0.01188	5.49844	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	21.10399	0.00000	0.00000	0.00000	0.00000

Condition	**S3=DL+0.525SL**					
1	0.00228	0.90517	0.00000	0.00000	0.00000	0.00000
2	-0.00228	0.90517	0.00000	0.00000	0.00000	0.00000
6	0.00000	6.95795	0.00000	0.00000	0.00000	0.00000
7	0.01153	4.73344	0.00000	0.00000	0.00000	0.00000
8	-0.01153	4.73344	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	18.23517	0.00000	0.00000	0.00000	0.00000

Condition	**S4=DL+0.6WL**					
1	-1.93652	-2.07606	0.00000	0.00000	0.00000	0.00000
2	-0.13284	3.11343	0.00000	0.00000	0.00000	0.00000
6	-0.14921	-0.24634	0.00000	0.00000	0.00000	0.00000
7	-0.15563	1.70206	0.00000	0.00000	0.00000	0.00000
8	-1.12231	-3.26117	0.00000	0.00000	0.00000	0.00000
SUM	-3.49650	-0.76808	0.00000	0.00000	0.00000	0.00000

Condition	**S5=DL+0.45WL+0.525SL**					
1	-1.41618	-1.04025	0.00000	0.00000	0.00000	0.00000
2	-0.10520	2.85226	0.00000	0.00000	0.00000	0.00000
6	-0.11358	4.10897	0.00000	0.00000	0.00000	0.00000
7	-0.11654	4.11802	0.00000	0.00000	0.00000	0.00000
8	-0.87087	0.39858	0.00000	0.00000	0.00000	0.00000
SUM	-2.62238	10.43757	0.00000	0.00000	0.00000	0.00000

Condition	**S6=0.6DL+0.6WL**					
1	-1.94707	-2.33748	0.00000	0.00000	0.00000	0.00000
2	-0.13135	2.85125	0.00000	0.00000	0.00000	0.00000
6	-0.14873	-1.65994	0.00000	0.00000	0.00000	0.00000
7	-0.15876	0.74512	0.00000	0.00000	0.00000	0.00000
8	-1.11060	-4.21852	0.00000	0.00000	0.00000	0.00000
SUM	-3.49650	-4.61957	0.00000	0.00000	0.00000	0.00000

Condition	**S7=DL+0.75SL**					
1	0.00293	1.03351	0.00000	0.00000	0.00000	0.00000
2	-0.00293	1.03351	0.00000	0.00000	0.00000	0.00000
6	0.00000	8.42261	0.00000	0.00000	0.00000	0.00000
7	0.01198	5.71701	0.00000	0.00000	0.00000	0.00000
8	-0.01198	5.71701	0.00000	0.00000	0.00000	0.00000
SUM	0.00000	21.92365	0.00000	0.00000	0.00000	0.00000

Envelope for nodal reactions

Note.- **lc** is the controlling load condition



Direction of positive forces and moments

Envelope of nodal reactions for :

DL=Dead Load

SL=SNOW LOAD

WL=WIND LOAD

S1=DL

S2=DL+0.7SL

S3=DL+0.525SL

S4=DL+0.6WL

S5=DL+0.45WL+0.525SL

S6=0.6DL+0.6WL

S7=DL+0.75SL

		Forces						Moments					
Node		**Fx**	**lc**	**Fy**	**lc**	**Fz**	**lc**	**Mx**	**lc**	**My**	**lc**	**Mz**	**lc**
		[Kip]		[Kip]		[Kip]		[Kip*ft]		[Kip*ft]		[Kip*ft]	
1	Max	0.003	S7	1.034	S7	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
	Min	-3.270	WL	-4.543	WL	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
2	Max	-0.001	DL	4.090	WL	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
	Min	-0.213	WL	0.571	SL	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
6	Max	0.000	DL	8.423	S7	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
	Min	-0.249	WL	-6.301	WL	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
7	Max	0.012	S7	5.717	S7	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
	Min	-0.273	WL	-1.157	WL	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
8	Max	-0.002	SL	5.717	S7	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL
	Min	-1.823	WL	-9.418	WL	0.000	DL	0.00000	DL	0.00000	DL	0.00000	DL

Spread Footing Calculations

SPREAD FOOTING TO RESIST NET UPLIFT
Rigid Frame (Grids 2, 3, 4)

LOAD COMBINATION	**0.6D+/-0.6W**	INPUT
ALLOWABLE BRG (KSF):	2	OUTPUT
MOMENT (K-FT):	0	Horiz resisted by tie beam
AXIAL (K) (0.6D-0.6W):	-24	
SOIL WT (KCF):	0.13	
DEPTH TOF (FT):	2.5	
FTG WIDTH (FT):	7	
FTG LENGTH (FT):	7	
FTG THICK (FT):	1.5	
FTG WEIGHT (K):	11.025	
FTG SECTION MOD (FT^3):	57.16667	
FTG AREA (FT^2):	49	
SOIL OVBN WT (K):	29.33125	
TOTAL AXIAL (K):	0.21375	
P/A (KSF):	0.004362	
M/S (KSF):	0	
P/A + M/S (KSF):	0.004362	
P/A - M/S (KSF):	0.004362	

FOOTING SIZE FOR GRAVITY LOADS:
TOTAL AXIAL = 22 KIPS
ALLOW SOIL BEARING = 2.0 KSF
REQ'D AREA = 22 K / 2.0 KSF = 11 SF
SQUARE FOOTING WIDTH = SQRT (11 SF) = 3.3 FT < 7 FT, THEREFORE OK FOR GRAVITY LOADS.
REINFORCE WITH MINIMUM STEEL.

SPREAD FOOTING TO RESIST NET UPLIFT
End Wall Braced Frame Column

LOAD COMBINATION	**0.6D+/-0.6W**	INPUT
ALLOWABLE BRG (KSF):	2	OUTPUT
MOMENT (K-FT):	0	Pier restrained by grade wall
AXIAL (K) (0.6D-0.6W):	-5	
SOIL WT (KCF):	0.13	
DEPTH TOF (FT):	2.5	
FTG WIDTH (FT):	3	
FTG LENGTH (FT):	3	
FTG THICK (FT):	1	
FTG WEIGHT (K):	1.35	
FTG SECTION MOD (FT^3):	4.5	
FTG AREA (FT^2):	9	
SOIL OVBN WT (K):	9.83125	
TOTAL AXIAL (K):	1.70875	
P/A (KSF):	0.189861	
M/S (KSF):	0	
P/A + M/S (KSF):	0.189861	
P/A - M/S (KSF):	0.189861	

FOOTING SIZE FOR GRAVITY LOADS:
TOTAL AXIAL = 9 KIPS
ALLOW SOIL BEARING = 2.0 KSF
REQ'D AREA = 9 K / 2.0 KSF = 4.5 SF
SQUARE FOOTING WIDTH = SQRT (4.5 SF) = 2.1 FT < 3 FT, THEREFORE OK FOR GRAVITY LOADS.
REINFORCE WITH MINIMUM STEEL.

SPREAD FOOTING TO RESIST NET UPLIFT
Lean-To Canopy Columns

LOAD COMBINATION	**0.6D+/-0.6W**	INPUT
ALLOWABLE BRG (KSF):	2	OUTPUT
MOMENT (K-FT):	0	
AXIAL (K) (0.6D-0.6W):	-2	
SOIL WT (KCF):	0.13	
DEPTH TOF (FT):	2.5	
FTG WIDTH (FT):	3	
FTG LENGTH (FT):	3	
FTG THICK (FT):	1	
FTG WEIGHT (K):	1.35	
FTG SECTION MOD (FT^3):	4.5	
FTG AREA (FT^2):	9	
SOIL OVBN WT (K):	9.83125	
TOTAL AXIAL (K):	4.70875	
P/A (KSF):	0.523194	
M/S (KSF):	0	
P/A + M/S (KSF):	0.523194	
P/A - M/S (KSF):	0.523194	

FOOTING SIZE FOR GRAVITY LOADS:
TOTAL AXIAL = (0.02 KSF DEAD + 0.06 KSF SNOW)(17.25'/2 x 12'/2) = 4.2 KIPS
ALLOW SOIL BEARING = 2.0 KSF
REQ'D AREA = 4.2 K / 2.0 KSF = 2.1 SF
SQUARE FOOTING WIDTH = SQRT (2.1 SF) = 1.5 FT < 3 FT, THEREFORE OK FOR GRAVITY LOADS.
REINFORCE WITH MINIMUM STEEL.

Anchor Bolt Design

SIMPSON Strong-Tie

Anchor Designer™ for Concrete Software
Version 3.3.2410.2

Company:		Date:	10/27/2026
Engineer:		Page:	1
Project:			
Address:			
Phone:			
E-mail:			

1.Project information

Project description:
Location:
Design name: Design

Comment:

2. Input Data & Anchor Parameters

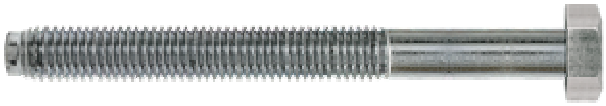
General
Design method:ACI 318-19
Units: Imperial units

Anchor Information:
Anchor type: Cast-in-place
Material: F1554 Grade 36
Diameter (inch): 0.750
Effective Embedment depth, h_{ef} (inch): 4.125
Anchor category: -
Anchor ductility: Yes
h_{min} (inch): 5.63
C_{min} (inch): 4.50
S_{min} (inch): 4.50

Base Material
Concrete: Normal-weight
Concrete thickness, h (inch): 13.78
State: Uncracked
Compressive strength, f'_c (psi): 3000
$\Psi_{c,V}$: 1.4
Reinforcement condition: B tension, B shear
Supplemental edge reinforcement: Yes
Reinforcement provided at corners: Yes
Ignore concrete breakout in tension: Yes
Ignore concrete breakout in shear: Yes
Ignore 6do requirement: No
Build-up grout pad: No

Base Plate
Length x Width x Thickness (inch): 14.00 x 12.00 x 0.75

Recommended Anchor
Anchor Name: Heavy Hex Bolt - 3/4"Ø Heavy Hex Bolt, F1554 Gr. 36



Assumed 3/4" diameter anchor bolts, to be confirmed by PEMB designer.

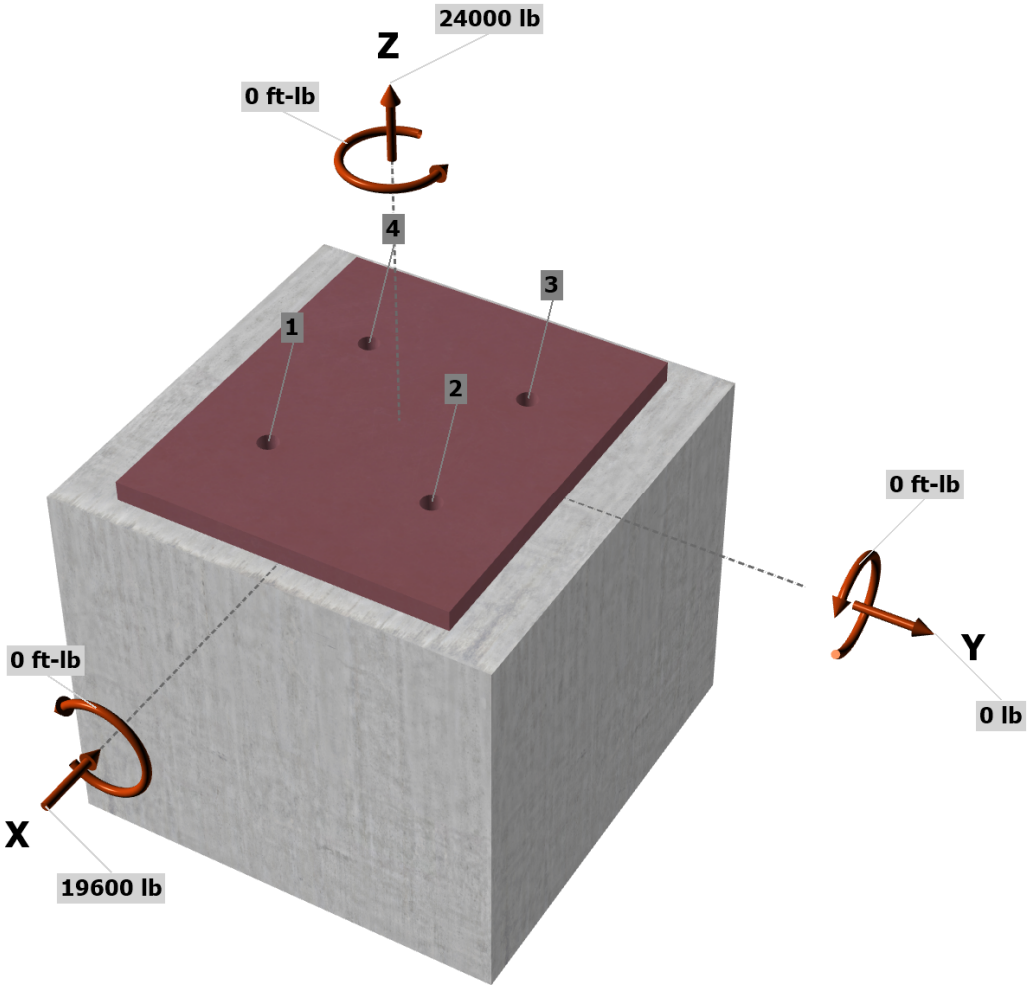
Supplemental reinforcing provided in piers and grade wall to resist concrete breakout in tension and shear.

Load and Geometry
Load factor source: ACI 318 Section 5.3
Load combination: not set
Seismic design: No
Anchors subjected to sustained tension: Not applicable
Apply entire shear load at front row: No
Anchors only resisting wind and/or seismic loads: No

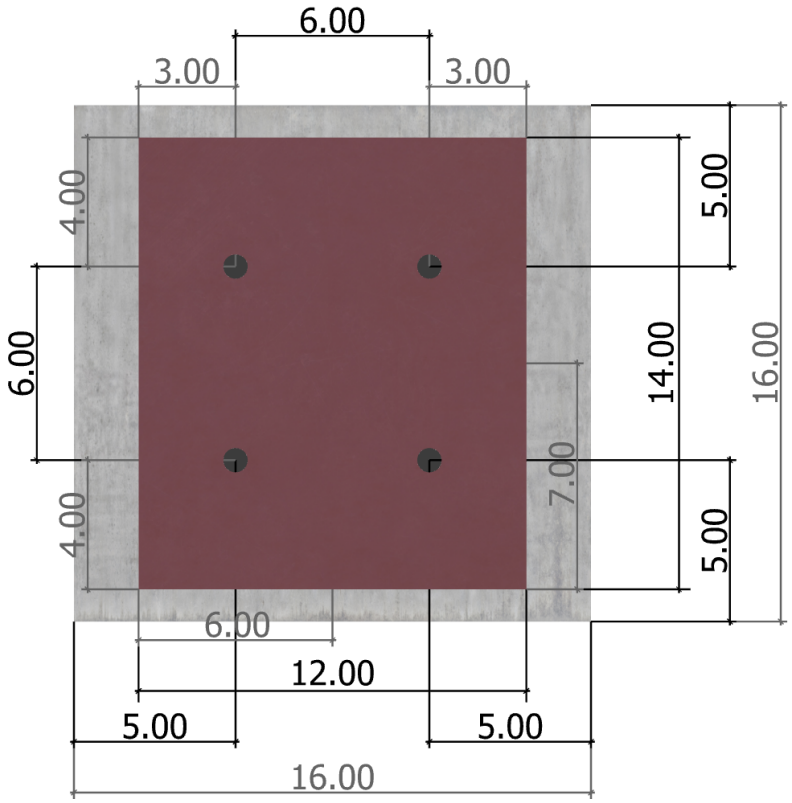
Strength level loads:

N_{ua} [lb]:	24000
V_{uax} [lb]:	-19600
V_{uay} [lb]:	0
M_{ux} [ft-lb]:	0
M_{uy} [ft-lb]:	0
M_{uz} [ft-lb]:	0

<Figure 1>



<Figure 2>

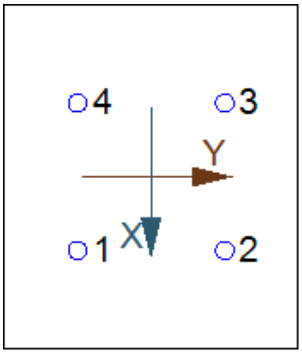


3. Resulting Anchor Forces

Anchor	Tension load, N_{ua} (lb)	Shear load x, V_{uax} (lb)	Shear load y, V_{uay} (lb)	Shear load combined, $\sqrt{(V_{uax})^2+(V_{uay})^2}$ (lb)
1	6000.0	-4900.0	0.0	4900.0
2	6000.0	-4900.0	0.0	4900.0
3	6000.0	-4900.0	0.0	4900.0
4	6000.0	-4900.0	0.0	4900.0
Sum	24000.0	-19600.0	0.0	19600.0

Maximum concrete compression strain (‰): 0.00
Maximum concrete compression stress (psi): 0
Resultant tension force (lb): 24000
Resultant compression force (lb): 0
Eccentricity of resultant tension forces in x-axis, e'_{Nx} (inch): 0.00
Eccentricity of resultant tension forces in y-axis, e'_{Ny} (inch): 0.00
Eccentricity of resultant shear forces in x-axis, e'_{Vx} (inch): 0.00
Eccentricity of resultant shear forces in y-axis, e'_{Vy} (inch): 0.00

<Figure 3>



4. Steel Strength of Anchor in Tension (Sec. 17.6.1)

N_{sa} (lb)	ϕ	ϕN_{sa} (lb)
19370	0.75	14528

6. Pullout Strength of Anchor in Tension (Sec. 17.6.3)

$\phi N_{pn} = \phi \Psi_{c,P} N_p = \phi \Psi_{c,P} 8 A_{brg} f'_c$ (Sec. 17.5.1.2, Eq. 17.6.3.1 & 17.6.3.2.2a)

$\Psi_{c,P}$	A_{brg} (in^2)	f'_c (psi)	ϕ	ϕN_{pn} (lb)
1.4	0.91	3000	0.70	21427

8. Steel Strength of Anchor in Shear (Sec. 17.7.1)

V_{sa} (lb)	ϕ_{grout}	ϕ	$\phi_{grout}\phi V_{sa}$ (lb)
11625	1.0	0.65	7556

10. Concrete Pryout Strength of Anchor in Shear (Sec. 17.7.3)

$\phi V_{cpg} = \phi k_{cp} N_{cbg} = \phi k_{cp}(A_{Nc} / A_{Nco}) \Psi_{ec,N} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b$ (Sec. 17.5.1.2 & Eq. 17.7.3.1b)

k_{cp}	A_{Nc} (in^2)	A_{Nco} (in^2)	$\Psi_{ec,N}$	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	ϕ	ϕV_{cpg} (lb)
2.0	256.00	100.00	1.000	1.000	1.250	1.000	8000	0.70	35840

11. Results

Interaction of Tensile and Shear Forces (Sec. R17.8)

Tension	Factored Load, N_{ua} (lb)	Design Strength, øN_n (lb)	Ratio	Status
Steel	**6000**	**14528**	**0.41**	**Pass (Governs)**
Pullout	6000	21427	0.28	Pass

Shear	Factored Load, V_{ua} (lb)	Design Strength, øV_n (lb)	Ratio	Status
Steel	**4900**	**7556**	**0.65**	**Pass (Governs)**
Pryout	19600	35840	0.55	Pass

Interaction check	$(N_{ua}/\phi N_{ua})^{5/3}$	$(V_{ua}/\phi V_{ua})^{5/3}$	Utilization Ratio	Permissible	Status
Sec. R17.8	0.23	0.49	71.5%	1.0	Pass

3/4"Ø Heavy Hex Bolt, F1554 Gr. 36 with hef = 4.125 inch meets the selected design criteria.

12. Warnings

- Concrete breakout strength in tension has not been evaluated against applied tension load(s) per designer option. Refer to ACI 318 Section 17.5.2.1 for conditions where calculations of the concrete breakout strength may not be required.

- Concrete breakout strength in shear has not been evaluated against applied shear load(s) per designer option. Refer to ACI 318 Section 17.5.2.1 for conditions where calculations of the concrete breakout strength may not be required.

- Designer must exercise own judgement to determine if this design is suitable.

Slab On Grade Design

Minimum temp/shrinkage steel for 7 1/2" thick slab:
As min = 0.0018*12*7.5" = 0.162 in^2/ft
6x6-W4.0xW4.0 As = 0.08 in ^2/ft
2-layers As = 2*0.08 = 0.16 in^2/ft ~ 0.162 OK

Solution: thickness = 8.0 in.

Again, when the design thickness differs substantially from the assumed value, repeat the process until reasonable agreement is obtained.

APPENDIX 3—DESIGN EXAMPLES USING CORPS OF ENGINEERS' (COE) CHARTS

A3.1—Introduction

The following examples show the determination of thickness for a slab-on-ground using the procedures published by the COE. The procedures appear in publications issued by the Departments of Defense (1977), the Department of the Army (1984, 1987) and the Department of the Air Force (1987). The examples presented are in inch-pound units. A table for converting the examples to SI units, along with an example of the process, is provided at the end of the Appendixes.

The procedure is based on limiting the tension on the bottom of the concrete at an interior joint of the slab. The loading is generalized in design index categories (Table A3.1). The procedure uses an impact factor of 25%, a concrete modulus of elasticity of 4000 ksi, and a factor of safety of approximately 2. The joint transfer coefficient has been taken as 0.75 for this design chart (Fig. A3.1).

The six categories shown in Table A3.1 are commonly used. Figure A3.1 shows 10 categories.

Categories 7 through 10 for exceptionally heavy vehicles are not covered in this guide.

A3.2—Vehicle wheel loading

This example selects the thickness of the concrete slab for a vehicle in design index Category IV (noted as Design Index 4 in Fig. A3.1). The vehicle parameters are needed to select the design index category from Table A3.1. Use of the design chart is illustrated assuming the following:

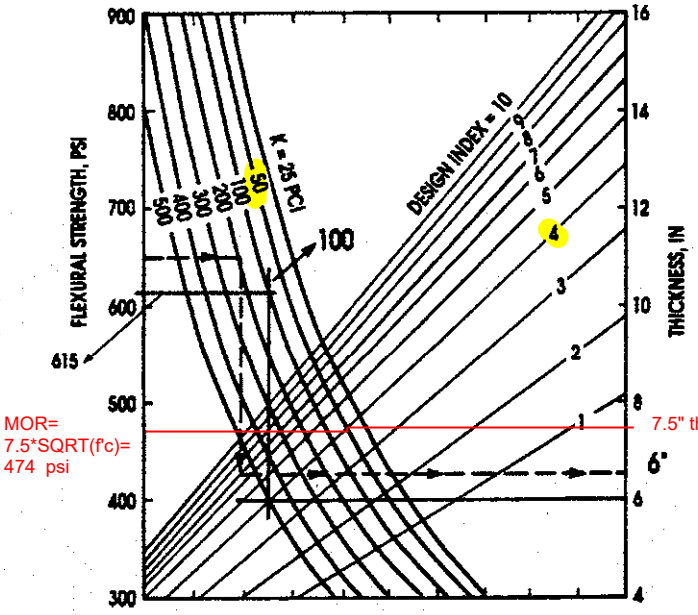
Loading: DI IV (Table A3.1)
Materials: concrete
Modulus of elasticity $E = 4000$ ksi
Modulus of rupture = 615 psi (28-day value)
Modulus of subgrade reaction $k = 100$ lb/in.^{3}
Solution: required thickness = 6 in. is determined from the design chart (Fig. A3.1) by entering with the flexural strength on the left and proceeding along the solid line.

A3.3—Heavy lift truck loading

This example selects the thickness of the concrete slab for a lift truck, assuming the following:

Loading: axle load 25,000 lb
Vehicle passes: 100,000
Concrete flexural strength: 500 psi
Modulus of subgrade reaction $k = 300$ lb/in.^{3}

Figure A3.2 shows the design curve. Enter at the flexural strength with 500 psi on the left. From there, proceed with the following steps: go across to the intersection with the curve of $k = 300$; go down to the line representing the axle load; go across to the curve for the number of vehicle passes;



MOR= 7.5*SQRT(f'c)= 474 psi

7.5" thickness

Fig. A3.1—COE curves for determining concrete floor thickness by design index.

Table A3.1—Design index categories used with the COE slab thickness selection method

Category	I	II	III	IV	V	VI
Capacity, lb	4000	6000	10,000	16,000	20,000	52,000
Design axle load, lb	10,000	15,000	25,000	36,000	43,000	120,000
No. of tires	4	4	6	6	6	6
Type of tire	Solid	Solid	Pneumatic	Pneumatic	Pneumatic	Pneumatic
Tire contact area, in.^{2}	27.0	36.1	62.5	100	119	316
Effect contact pressure, psi	125	208	100	90	90	95
Tire width, in.	6	7	8	9	9	16
Wheel spacing, in.	31	33	11.52.11	13.58.13	13.58.13	20.79.20
Aisle width, in.	90	90	132	144	144	192
Spacing between dual wheel tires, in.	—	—	3	4	4	4

and finally, go down to find the final solution for the slab thickness of 5-1/4 in.

APPENDIX 4—SLAB DESIGN USING POST-TENSIONING

This chapter includes:

- Design example: using post-tensioning to minimize cracking; and
- Design example: equivalent tensile stress design.

A4.1—Design example: Using post-tensioning to minimize cracking

Assume post-tensioned (PT) strip 500 x 12 ft.

Poly fiber slab reinforcing included as an option to welded wire reinforcing.

EUCLID CHEMICAL

REPORT SUMMARY

TUF-STRAND SF Fiber Reinforced Concrete Slab on Grade (Based on ACI 360 and TR34)

Project Name: 26.04.060 VT FOREST LAB

The Euclid Chemical Company
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Cleveland, OH 44110

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An RPM Company

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Introduction to Design of Slabs-on-Ground (SOG)

The classical design theories for slab-on-ground can be categorized into elastic or elastic-plastic. ACI 360R is a "Guide to Design of Slabs-on-Ground" and is the most frequently used document in North America for the design of these slabs. This guide briefly describes the two design methods and provides useful recommendations for engineers and architects. Concrete used in the construction of floors should comply with requirements specific to workability as well as strength and durability. The static loads that need to be accounted for are pallet racking loads (point loads), line loads from internal walls, and uniformly distributed loads commonly found in general storage spaces. Vehicle loads applied from trucks or fork lifts are dynamic in nature and are found on industrial floors. These loads can often govern the design thickness of a concrete floor. The SOG design software developed by Euclid Chemical is capable of implementing all these load cases as well as the concrete and sub-base properties for a customized design using the plastic (Yield-Line) method.

The elastic theory was developed in the early 1920's by Westegaard in order to determine the thickness of the slab. It is assumed that the concrete will be subjected to loading only in the elastic region of material behavior. Any crack that occurs in the concrete slab is considered as a failure. Charts have been developed based on the original equations to simplify the design process and can be found in ACI 360R and PCA publications. This design method is fully presented in Concrete Industrial Floors on the Ground by Marais & Perrie (1993). The Yield-Line theory was first proposed by Losberg in 1960's and is based on plastic theory which considers the structural behavior of a concrete slab not only in the elastic region, but also in the plastic region. This implies that the post-crack strength of the concrete is taken into consideration in determining the slab thickness. This theory assumes that cracking does occur in the slab; however, it provides means for measuring the moments by assessing the patterns of the yield-lines. This is done by incorporating the ductility provided by fibers or other types of reinforcement in the slab. If macro fibers are included in a concrete mix, the post-crack ductility provided by the fibers can be calculated and taken into account by this theory. The ratio between the residual flexural strength (after cracking) and the peak strength (at cracking) is called the equivalent flexural strength ratio, $R_{e,3}$ and is used in this design method. The Yield-Line theory is fully described in Technical Report No. 34 (TR-34) by the Concrete Society UK (2003 and 2014).

TUF-STRAND SF is a patented macro synthetic fiber produced by Euclid Chemical. It complies with ASTM C1116 type III and ASTM D7508 for concrete reinforcement. These fibers have been evaluated under various tests including flexural performance, impact resistance, abrasion, freeze-thaw, and salt scaling. ASTM C1609 is a closed-loop flexural test on beams with a size of 6"x6"x20" (150x150x500mm) that is used to determine the Re,3 values for fiber-reinforced concrete. This test has been performed with various dosages of TUF-STRAND SF fibers; the results have been incorporated into this software and used for the corresponding calculations. For more information about the design process and test data, please visit Euclid Chemical's website at www.euclidchemical.com or contact us via email or phone.

Project: 26.04.060 VT FOREST LAB

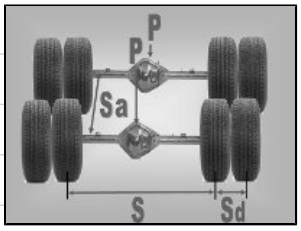
Date:	
Location:	
Engineer:	
Address:	

Loading Zone: Interior slab on grade - GMC Truck

Compressive Strength of Concrete [F_c] :	4,000 psi
Ultimate Flexural Strength [F_r] :	472 psi
Modulus of Elasticity [E]:	3,579,879 psi
Subgrade Modulus [k]:	50 pci
Coefficient of Friction:	0.70
Slab Thickness [t]:	7.5 in
Column Spacing:	20.5 ft
Joint Spacing:	20.5 ft
Temperature Difference:	9.0 F
Concrete Shrinkage Strain:	0.0004
Minimum Fiber Dosage:	**1.8 kg/m^3**
(0) Zone shrinkage and temperature stress.	$R_{e,3}$: 0%

Vehicle Loads:

Load Name:	GMC Truck wheel load
Load Type:	Dual Axle Quad
Static Load Factor:	1.2
Dynamic Load Factor:	1.4
Axle Load:	18,000 lb
Contact Pressure:	100 psi
Axle Distance [S]:	72.0 in
Wheel Distance [S_d] :	16.0 in
Distance between Axles [S_a] :	36.0 in
Fiber Dosage for SLS:	**0.0 kg/m^3**
(1) Single load at the center of the slab.	$R_{e,3}$: < 0%
Fiber Dosage for ULS:	**1.6 kg/m^3**
(12) Perpendicular loads at the edge of the slab.	$R_{e,3}$: 11%

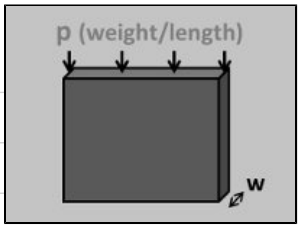


Recommended Fiber Dosages for Interior slab on grade - GMC Truck:

Minimum Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)
(0) Zone shrinkage and temperature stress.	$R_{e,3}$: 0%
SLS Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)
(0) Zone shrinkage and temperature stress.	$R_{e,3}$: 0%
ULS Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)
(0) Zone shrinkage and temperature stress.	$R_{e,3}$: 0%
Critical Load:	(0) Zone shrinkage and temperature stress.
Overall TUF-STRAND SF Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)

Line Loads:

Load Name:	Line Load - John Deere dozer
Line Load [P]:	111 lb/in
Static Load Factor:	1.2
Dynamic Load Factor:	1.4
Width of Load [W]:	16.0 in
Fiber Dosage for SLS:	**0.0 kg/m^3**
(1) Line load at the center of the slab.	$R_{e,3}$: < 0%
Fiber Dosage for ULS:	**0.0 kg/m^3**
(1) Line load at the center of the slab.	$R_{e,3}$: < 0%

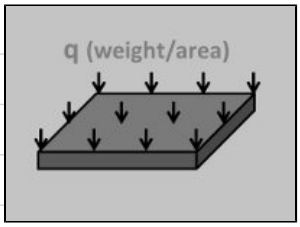


Recommended Fiber Dosages for Interior slab on grade:

Minimum Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)
(0) Zone shrinkage and temperature stress.	$R_{e,3}$: 0%
SLS Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)
(0) Zone shrinkage and temperature stress.	$R_{e,3}$: 0%
ULS Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)
(0) Zone shrinkage and temperature stress.	$R_{e,3}$: 0%
Critical Load:	(0) Zone shrinkage and temperature stress.
Overall TUF-STRAND SF Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)

Uniform Loads:

Load Name:	Uniform Load - Storage
Uniform Load Value [q]:	250 psf
Static Load Factor:	1.2
Dynamic Load Factor:	1.4
Fiber Dosage for SLS:	**0.0 kg/m^3**
(1) Uniform load applied to the slab.	$R_{e,3}$: < 0%
Fiber Dosage for ULS:	**1.3 kg/m^3**
(1) Uniform load applied to the slab.	$R_{e,3}$: 4%



Recommended Fiber Dosages for Interior slab on grade - Storage:

Minimum Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)
(0) Zone shrinkage and temperature stress.	$R_{e,3}$: 0%
SLS Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)
(0) Zone shrinkage and temperature stress.	$R_{e,3}$: 0%
ULS Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)
(0) Zone shrinkage and temperature stress.	$R_{e,3}$: 0%
Critical Load:	(0) Zone shrinkage and temperature stress.
Overall TUF-STRAND SF Fiber Dosage:	1.8 kg/m^3 (3.0 lb/yd^3)