

Project Name: VAMC DC Parking Garage Expansion
Project Number: PHL13108.00
Project Engineer: ARN
Lead Engineer: PCA
Calculation Date: August 1, 2014

Calculation Reviewer: SHH
Date Reviewed: x



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Description:	Calculation Table of Contents

Engineer:	ARN
Date:	8/1/14
Chkd by:	SHH
Chkd date:	x

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Chapter 2: Seismic Loads

- A USGS Seismic Info
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Chapter 3: Wind Loads

Building Code: IBC 2012
References: PCI Manual 7th Edition
ASCE 7-10

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Dead Loads

Spandrel	=	0ft- 10in	x	6ft- 8in	x	0.150kcf	=	0.83kif
IT Girder	=			40IT36 (PCI p2-47)			=	1.10kif
Double Tee	=	12'x30"		DT (PCI p2-22) w/ 3" topping			=	0.085ksf
Slab	=	0ft- 10in			x	0.150kcf	=	0.125ksf
2'-0" x 2'-0" Column	=	2ft- 0in	x	2ft- 0in	x	0.150kcf	=	0.60kif
2'-0" x 2'-6" Column	=	2ft- 0in	x	2ft- 6in	x	0.150kcf	=	0.75kif
2'-6" x 2'-6" Column	=	2ft- 6in	x	2ft- 6in	x	0.150kcf	=	0.94kif
Stackwall	=	0ft- 10in	x	60% Solid	x	0.150kcf	=	0.075ksf
Lightwall	=	1ft- 0in	x	70% Solid	x	0.150kcf	=	0.105ksf
Shearwall	=	1ft- 0in	x	100% Solid	x	0.150kcf	=	0.150ksf

Live Loads

Parking	=		=	0.040ksf
Parking Reduced	=	with 20% LL reduction (ASCE 7-05 4.8.3)	=	0.032ksf
Stairs	=	IBC 2012 - Table 1607.1 (page 286)	=	0.100ksf
Lobbies, Corridor, Etc.	=	IBC 2012 - Table 1607.1 (page 285)	=	0.100ksf
Roof Live	=	IBC 2012 - Table 1607.1 (page 285)	=	0.020ksf

Snow Load

Snow Load	=	(see below for calculation)	=	0.0210ksf
Snow Drift Load	=	(see next sheet for calculation)	=	0.22kif

p_g	=	25.0 psf	(IBC 2009 Figure 1608.2)
c_e	=	1.0	(ASCE 7-10 Table 7-2; assuming partially exposed and terrain category C)
c_t	=	1.2	(ASCE 7-10 Table 7-3; assuming unheated structure)
i_s	=	1.0	(ASCE 7-10 Table 7-4, assuming occupancy category II)
p_f	=	$0.7 C_e C_t I p_g$	= 21.0 psf

Garage Floor Heights

Typical Elevation		
Level	Level Hght	Supp. Hght.
B2 (existing)	0.00 ft	7.50 ft
B1 (existing)	11.00 ft	11.00 ft
G (existing)	22.00 ft	11.25 ft
2nd	33.50 ft	11.50 ft
3rd	45.00 ft	11.50 ft
4th	56.50 ft	11.50 ft
5th (future)	68.00 ft	11.50 ft
6th (future)	79.50 ft	9.50 ft
Assumed extent of foundation below basement tier		= 2.00 ft
Assumed extent of precast above top pier		= 3.75 ft
Total Height above foundation		= 85.25 ft

Assumptions:

- (1) Supported heights are used for distributing dead loads of columns & walls to respective tiers for lateral analysis. See drawing to the right for clarification.

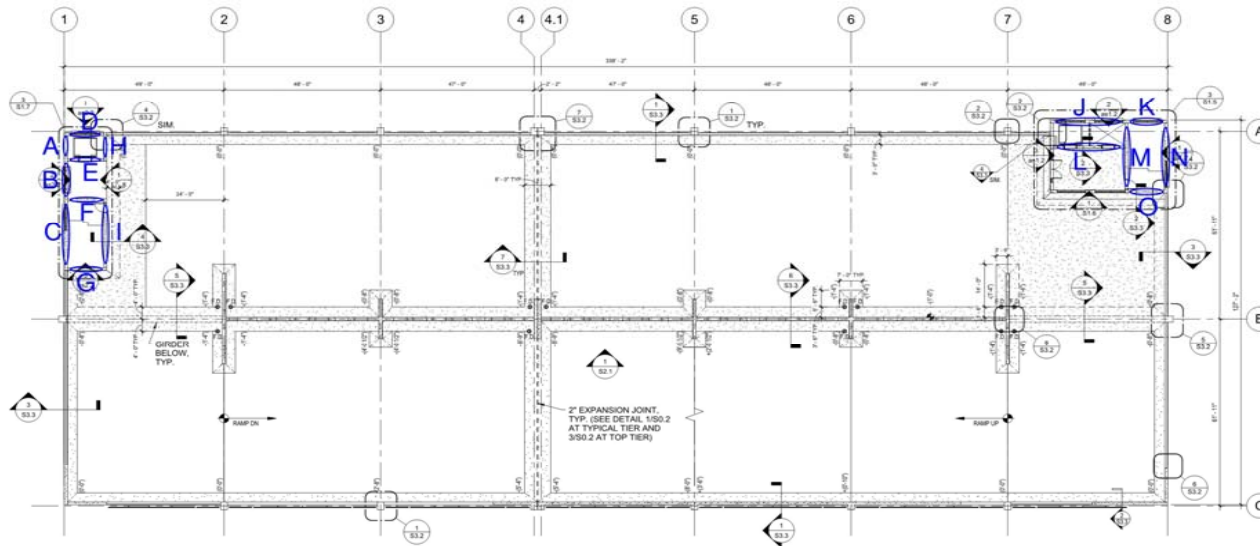
Snow Drift Load (see ASCE Section 7.7.1)

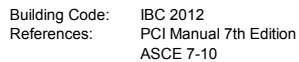
$$\begin{aligned} \gamma &= 0.13 \rho_g + 14 = 17.3 \text{ pcf} && \text{(ASCE 7-10 Equation 7-3)} \\ h_b &= P_f / \gamma = 1.2 \text{ ft} && \text{(height of balanced snow load)} \\ h_c &= 2.53 \text{ ft} && \text{(height of Parapet above balanced snow)} \\ h_d/h_b &= 2.08 > 0.2 && \text{Snow drift must be accounted for (ASCE 7-10 7.7.1)} \\ l_u &= 272.0 \text{ ft} && \text{(east/west) } (l_u \text{ is longest length of roof upwind of drift)} \\ &= 120.0 \text{ ft} && \text{(north/south)} \\ h_d &= 2.5 \text{ ft} && \text{(ASCE 7-10 Figure 7-9, use greater } l_u \text{ to be conservative) } (h_d \text{ is height of snow drift)} \\ &&& \text{(Only windward snow drift may occur; therefore, } h_d \text{ must be reduced by a factor of } 3/4 \text{ per ASCE 7-10 Section 7.7.1)} \\ W &= 4h_d = 10.1 \text{ ft} && \text{(W is horz. distance from eave to ridge)} \\ &\leq 8h_c = 20.3 \text{ ft} && W \leq 8h_c, \text{ Use } W \end{aligned}$$

Drift Ht	=	2.53 ft
W	=	10.1 ft

$$\begin{aligned} \text{Snow Drift Linear Load} &= \\ 0.5 \gamma (\text{Drift Ht}) W &= 221 \text{ plf} \end{aligned}$$

Typical Tier Plan





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Assumptions:

- (1) Snow drift linear loads are applied at exterior walls and lightwalls throughout.
- (2) Loads from spandrels and girders are split in half between gridlines for simplicity.
- (3) For simplicity and to be conservative, beam lengths (spandrels, IT Girders) span between gridlines.

Typical Exterior Column (Grids A & C)

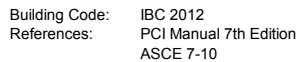
Load Source		North/South	East/West	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total	
D	2'-0" x 2'-6" Column	:		85ft- 3in	x 0.75 klf	=	5.6k	8.3k	8.4k	8.6k	8.6k	8.6k	8.6k	7.1k	= 63.9k
D	Stackwall	:		48ft- 0in	x 0.075 ksf	=		39.6k	40.5k						= 80.1k
D	Spandrel	:		48ft- 0in	x 0.83 klf	=				40.0k	40.0k	40.0k	40.0k	40.0k	= 200.0k
D	Double Tee	:	30ft- 3in	x 48ft- 0in	x 0.085 ksf	=		123.4k	123.4k	123.4k	123.4k	123.4k	123.4k	123.4k	= 863.9k
							5.6k	171.3k	172.4k	172.0k	172.0k	172.0k	172.0k	170.5k	= 1208.0k
L	Parking	:	30ft- 3in	x 48ft- 0in	x 0.040 ksf	=								58.1k	= 58.1k
L	Parking Reduced	:	30ft- 3in	x 48ft- 0in	x 0.032 ksf	=	0.0k	46.5k	46.5k	46.5k	46.5k	46.5k	46.5k		= 278.8k
															= 336.9k
S	Snow Load	:	30ft- 3in	x 48ft- 0in	x 0.021 ksf	=								30.5k	= 30.5k
S	Snow Drift Load	:		48ft- 0in	x 0.22 klf	=								10.6k	= 10.6k
															= 41.1k
										Total				= 1586.0k	

Exterior Column @ EJ (Grid 4)

Load Source		North/South	East/West	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total	
D	2'-0" x 2'-6" Column	:		85ft- 3in	x 0.75 klf	=	5.6k	8.3k	8.4k	8.6k	8.6k	8.6k	8.6k	7.1k	= 63.9k
D	Stackwall	:		24ft- 0in	x 0.075 ksf	=		19.8k	20.3k						= 40.1k
D	Spandrel	:		24ft- 0in	x 0.83 klf	=				20.0k	20.0k	20.0k	20.0k	20.0k	= 100.0k
D	Double Tee	:	30ft- 3in	x 24ft- 0in	x 0.085 ksf	=		61.7k	61.7k	61.7k	61.7k	61.7k	61.7k	61.7k	= 432.0k
							5.6k	89.8k	90.4k	90.3k	90.3k	90.3k	90.3k	88.8k	= 636.0k
L	Parking	:	30ft- 3in	x 24ft- 0in	x 0.040 ksf	=							29.0k		= 29.0k
L	Parking Reduced	:	30ft- 3in	x 24ft- 0in	x 0.032 ksf	=	0.0k	23.2k	23.2k	23.2k	23.2k	23.2k	23.2k		= 139.4k
															= 168.4k
S	Snow Load	:	30ft- 3in	x 24ft- 0in	x 0.021 ksf	=								15.2k	= 15.2k
S	Snow Drift Load	:		24ft- 0in	x 0.22 klf	=							5.3k		= 5.3k
															= 20.6k
										Total					= 824.9k

Interior Shearwall (Longer Wall) Grid B/2 & B/7

[illegible]

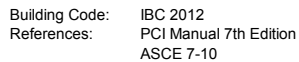


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Load Source		East/West	North/South	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total	
D	Lightwall	:		85ft- 3in	x 0.105 ksf	=	0.79 klf	1.16 klf	1.18 klf	1.21 klf	1.21 klf	1.21 klf	1.21 klf	1.00 klf	= 8.95 klf
D	Double Tee	:	1ft- 0in x 60ft- 6in		x 0.085 ksf	=		5.14 klf	5.14 klf	5.14 klf	5.14 klf	5.14 klf	5.14 klf	5.14 klf	= 36.00 klf
							0.79 klf	6.30 klf	6.32 klf	6.35 klf	6.35 klf	6.35 klf	6.35 klf	6.14 klf	= 44.95 klf
L	Parking	:	1ft- 0in x 60ft- 6in		x 0.040 ksf	=								2.42 klf	= 2.42 klf
L	Parking Reduced	:	1ft- 0in x 60ft- 6in		x 0.032 ksf	=	0.00 klf	1.94 klf	1.94 klf	1.94 klf	1.94 klf	1.94 klf	1.94 klf		= 11.62 klf
															= 14.04 klf
S	Snow Load	:	1ft- 0in x 60ft- 6in		x 0.021 ksf	=								1.27 klf	= 1.27 klf
S	Snow Drift Load	:	(2ft- 0in + 0ft- 0in)		x 0.22 klf	=								0.44 klf	= 0.44 klf
															= 1.71 klf
										Total					= 60.70 klf

Load Source		North/South	East/West	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total
D	2'-0" x 2'-6" Column	:		85ft- 3in	x	0.75 kif	=	5.6k	8.3k	8.4k	8.6k	8.6k	7.1k	= 63.9k
D	Stackwall	:		22ft- 4in	x	0.075 ksf	=		34.7k	35.4k				= 70.1k
D	Spandrel	:		42ft- 0in	x	0.83 kif	=			35.0k	35.0k	35.0k	35.0k	= 175.0k
D	Double Tee	:	30ft- 3in	x	42ft- 0in	x	0.085 ksf	=		108.0k	108.0k	108.0k	108.0k	= 755.9k
								5.6k	150.9k	151.9k	151.6k	151.6k	151.6k	150.1k = 1065.0k
L	Parking	:	30ft- 3in	x	42ft- 0in	x	0.040 ksf	=					50.8k	= 50.8k
L	Parking Reduced	:	30ft- 3in	x	42ft- 0in	x	0.032 ksf	=	0.0k	40.7k	40.7k	40.7k	40.7k	= 243.9k
														= 294.8k
S	Snow Load	:	30ft- 3in	x	42ft- 0in	x	0.021 ksf	=					26.7k	= 26.7k
S	Snow Drift Load	:			42ft- 0in	x	0.22 kif	=					9.3k	= 9.3k
														= 36.0k
										Total	= 1395.7k			

Load Source		North/South	East/West	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total			
D	Shearwall	: 13ft- 0in	+ 13ft- 0in	x	85ft- 3in	x	0.150 ksf	=	29.3k	42.9k	43.9k	44.9k	44.9k	44.9k	37.1k	=	332.5k
D	Stackwall	: 23ft- 9in	+ 18ft- 0in	x	22ft- 4in	x	0.075 ksf	=		34.4k	35.2k					=	69.7k
D	Spandrel	: 23ft- 9in	+ 18ft- 0in			x	0.83 kif	=			34.8k	34.8k	34.8k	34.8k	34.8k	=	174.0k
D	Double Tee	: 30ft- 3in	x 30ft- 0in			x	0.085 ksf	=		77.1k	77.1k	77.1k	77.1k	77.1k	77.1k	=	540.0k
									29.3k	154.5k	156.2k	156.8k	156.8k	156.8k	149.0k	=	1116.1k
L	Parking	: 30ft- 3in	x 30ft- 0in			x	0.040 ksf	=							36.3k	=	36.3k
L	Parking Reduced	: 30ft- 3in	x 30ft- 0in			x	0.032 ksf	=	0.0k	29.0k	29.0k	29.0k	29.0k	29.0k		=	174.2k
																=	210.5k
S	Snow Load	: 30ft- 3in	x 30ft- 0in			x	0.021 ksf	=							19.1k	=	19.1k
S	Snow Drift Load	: 30ft- 3in	+ 30ft- 0in			x	0.22 kif	=							13.3k	=	13.3k
																=	32.4k
										Total				= 1359.0k			

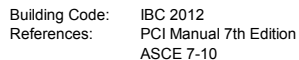


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Load Source		North/South	East/West		Vertical	=	B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	=	Total	
D	2'-0" x 2'-6" Column	:			85ft- 3in	x	0.75 kif	=	5.6k	8.3k	8.4k	8.6k	8.6k	8.6k	7.1k	=	63.9k
D	Stackwall	:			42ft- 0in	x	0.075 ksf	=		34.7k	35.4k					=	70.1k
D	Spandrel	:			42ft- 0in	x	0.83 kif	=				35.0k	35.0k	35.0k	35.0k	=	175.0k
D	Double Tee	:	30ft- 3in	x	42ft- 0in	x	0.085 ksf	=		108.0k	108.0k	108.0k	108.0k	108.0k	108.0k	=	755.9k
									5.6k	150.9k	151.9k	151.6k	151.6k	151.6k	151.6k	=	1065.0k
L	Parking	:	30ft- 3in	x	42ft- 0in	x	0.040 ksf	=							50.8k	=	50.8k
L	Parking Reduced	:	30ft- 3in	x	42ft- 0in	x	0.032 ksf	=	0.0k	40.7k	40.7k	40.7k	40.7k	40.7k		=	243.9k
																=	294.8k
S	Snow Load	:	30ft- 3in	x	42ft- 0in	x	0.021 ksf	=							26.7k	=	26.7k
S	Snow Drift Load	:			42ft- 0in	x	0.22 kif	=							9.3k	=	9.3k
																=	36.0k
											Total	= 1395.7k					

Load Source		North/South	East/West	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total
D	2'-0" x 2'-6" Column	:		85ft- 3in	x 0.75 kif	=	5.6k	8.3k	8.4k	8.6k	8.6k	8.6k	7.1k	= 63.9k
D	Stackwall	:		36ft- 0in	x 0.075 ksf	=		29.7k	30.4k					= 60.1k
D	Spandrel	:		36ft- 0in	x 0.83 kif	=				30.0k	30.0k	30.0k	30.0k	= 150.0k
D	Double Tee	:	30ft- 3in x	36ft- 0in	x 0.085 ksf	=		92.6k	92.6k	92.6k	92.6k	92.6k	30.0k	= 648.0k
							5.6k	130.5k	131.4k	131.2k	131.2k	131.2k	129.7k	= 922.0k
L	Parking	:	30ft- 3in x	36ft- 0in	x 0.040 ksf	=							43.6k	= 43.6k
L	Parking Reduced	:	30ft- 3in x	36ft- 0in	x 0.032 ksf	=	0.0k	34.8k	34.8k	34.8k	34.8k	34.8k		= 209.1k
														= 252.6k
S	Snow Load	:	30ft- 3in x	36ft- 0in	x 0.021 ksf	=							22.9k	= 22.9k
S	Snow Drift Load	:	4ft- 5in +	36ft- 0in	x 0.22 kif	=							8.9k	= 8.9k
														= 31.8k
										Total	= 1206.4k			

Load Source	North/South	East/West	Vertical	B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total	
D 2'-0" x 2'-6" Column	:		85ft- 3in	x	0.75 klf	=	5.6k	8.3k	8.4k	8.6k	8.6k	8.6k	63.9k
D Stackwall	:		22ft- 4in	x	0.075 ksf	=		31.6k	32.3k				63.8k
D Spandrel	:			x	0.83 klf	=							
D IT Girder	:			x	1.10 klf	=		26.4k	26.4k	31.9k	31.9k	31.9k	159.4k
D Double Tee	:	60ft- 6in	x 24ft- 0in	x	0.085 ksf	=		123.4k	123.4k	123.4k	123.4k	123.4k	184.8k
							5.6k	189.6k	190.5k	190.3k	190.3k	190.3k	863.9k
L Parking	:	60ft- 6in	x 24ft- 0in	x	0.040 ksf	=						58.1k	1335.9k
L Parking Reduced	:	60ft- 6in	x 24ft- 0in	x	0.032 ksf	=	0.0k	46.5k	46.5k	46.5k	46.5k	46.5k	58.1k
													278.8k
													336.9k
S Snow Load	:	60ft- 6in	x 24ft- 0in	x	0.021 ksf	=						30.5k	30.5k
S Snow Drift Load	:	38ft- 3in		x	0.22 klf	=					8.5k	8.5k	8.5k
													39.0k
								Total					1711.7k



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	Load Source	North/South	East/West	Vertical	B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total					
D	2'-0" x 2'-6" Column	:		85ft- 3in	x	0.75 klf	=	5.6k	8.3k	8.4k	8.6k	8.6k	8.6k	8.6k	7.1k	=	63.9k	
D	Stackwall	:	44ft- 10in	x	22ft- 4in	x	0.075 ksf	=	37.0k	37.8k						=	74.8k	
D	Spandrel	:	44ft- 10in	x		x	0.83 klf	=			37.4k	37.4k	37.4k	37.4k	37.4k	=	186.8k	
D	IT Girder	:		24ft- 0in	x	1.10 klf	=	26.4k	26.4k	26.4k	26.4k	26.4k	26.4k	26.4k		=	184.8k	
D	Double Tee	:	58ft- 8in	x	24ft- 0in	x	0.085 ksf	=	5.6k	191.2k	192.3k	192.0k	192.0k	192.0k	192.0k	190.5k	=	1347.5k
L	Parking	:	58ft- 8in	x	24ft- 0in	x	0.040 ksf	=							56.3k	=	56.3k	
L	Parking Reduced	:	58ft- 8in	x	24ft- 0in	x	0.032 ksf	=	0.0k	45.0k	45.0k	45.0k	45.0k	45.0k	45.0k	=	270.1k	
																=	326.4k	
S	Snow Load	:	58ft- 8in	x	24ft- 0in	x	0.021 ksf	=							29.5k	=	29.5k	
S	Snow Drift Load	:	44ft- 10in	x		x	0.22 klf	=							9.9k	=	9.9k	
																=	39.5k	
									Total		= 1713.4k							

Load Source		North/South	East/West	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total	
D	Shearwall	:		x	85ft- 3in x 0.150 ksf =	13.5k	19.8k	20.3k	20.7k	20.7k	20.7k	20.7k	17.1k	= 153.5k	
D	Stackwall	:	8ft- 0in	x	22ft- 4in x 0.075 ksf =		6.6k	6.8k						= 13.4k	
D	Spandrel	:	8ft- 0in		x 0.83 klf =			8.2k	6.7k	6.7k	6.7k	6.7k	6.7k	= 33.3k	
D	Double Tee	:	8ft- 0in x	12ft- 0in	x 0.085 ksf =		8.2k	8.2k	8.2k	8.2k	8.2k	8.2k	8.2k	= 57.1k	
D	Slab	:	11ft- 6in x	12ft- 0in	x 0.125 ksf =	13.5k	17.3k	17.3k	17.3k	17.3k	17.3k	17.3k	17.3k	= 120.8k	
						13.5k	51.8k	52.4k	52.8k	52.8k	52.8k	52.8k	49.2k	= 378.0k	
L	Parking	:	8ft- 0in x	12ft- 0in	x 0.040 ksf =								3.8k	= 3.8k	
L	Parking Reduced	:	8ft- 0in x	12ft- 0in	x 0.032 ksf =	0.0k	3.1k	3.1k	3.1k	3.1k	3.1k	3.1k		= 18.4k	
L	Stairs	:	11ft- 6in x	12ft- 0in	x 0.100 ksf =		13.8k	13.8k	13.8k	13.8k	13.8k	13.8k	13.8k	= 96.6k	
														= 118.9k	
S	Snow Load	:	19ft- 6in x	12ft- 0in	x 0.021 ksf =								4.9k	= 4.9k	
S	Snow Drift Load	:	8ft- 0in +	12ft- 0in	x 0.22 klf =								4.4k	= 4.4k	
														= 9.3k	
										Total					= 506.2k

Load Source		North/South	East/West	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)		Total	
D	Shearwall	:	8ft- 4in	x	85ft- 3in	x	0.150 ksf	=	9.4k	13.8k	14.1k	14.4k	14.4k	14.4k	=	106.6k
D	Stackwall	:			18ft- 0in	x	0.075 ksf	=		14.9k	15.2k				=	30.0k
D	Spandrel	:			18ft- 0in	x	0.83 kif	=				15.0k	15.0k	15.0k	=	75.0k
D	Double Tee	:	30ft- 3in	x	18ft- 0in	x	0.085 ksf	=		46.3k	46.3k	46.3k	46.3k	46.3k	=	324.0k
									9.4k	74.9k	75.5k	75.7k	75.7k	75.7k	=	535.6k
L	Parking	:	30ft- 3in	x	18ft- 0in	x	0.040 ksf	=					21.8k		=	21.8k
L	Parking Reduced	:	30ft- 3in	x	18ft- 0in	x	0.032 ksf	=	0.0k	17.4k	17.4k	17.4k	17.4k	17.4k	=	104.5k
															=	126.3k
S	Snow Load	:	30ft- 3in	x	18ft- 0in	x	0.021 ksf	=						11.4k	=	11.4k
S	Snow Drift Load	:	30ft- 3in	+	18ft- 0in	x	0.22 kif	=						10.7k	=	10.7k
															=	22.1k
										Total						= 684.0k

Wall "F" on plan (West Tower, North Stair Wall)

Load Source	North/South		East/West		Vertical			B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total	
D Shearwall	:		12ft- 0in	x	85ft- 3in	x	0.150 ksf	=	13.5k	19.8k	20.3k	20.7k	20.7k	20.7k	17.1k	=	153.5k
D Slab	:	18ft- 1in	x	12ft- 0in		x	0.125 ksf	=		27.1k	27.1k	27.1k	27.1k	27.1k	27.1k	=	189.9k
									13.5k	46.9k	47.4k	47.8k	47.8k	47.8k	44.2k	=	343.3k
L Stairs	:	18ft- 1in	x	12ft- 0in		x	0.100 ksf	=		21.7k	21.7k	21.7k	21.7k	21.7k	21.7k	=	151.9k
																=	151.9k
S Snow Load	:	18ft- 1in	x	12ft- 0in		x	0.021 ksf	=							4.6k	=	4.6k
S Snow Drift Load	:			0ft- 0in		x	0.22 klf	=							0.0k	=	0.0k
																=	4.6k
													Total		= 499.8k		

Wall "A" on plan (West Tower, West Elevator Wall)

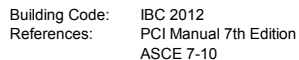
Load Source		North/South		East/West		Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)		Total			
D	Shearwall	:		8ft- 4in		x	85ft- 3in	x	0.150 ksf	=	9.4k	13.8k	14.1k	14.4k	14.4k	14.4k	14.4k	11.9k	=	106.6k
											9.4k	13.8k	14.1k	14.4k	14.4k	14.4k	11.9k		=	106.6k
L	Stairs	:		0ft- 0in	x		0ft- 0in		x	0.100 ksf	=	0.0k	0.0k	0.0k	0.0k	0.0k	0.0k	0.0k	=	0.0k
																			=	0.0k
S	Snow Load	:		0ft- 0in	x		0ft- 0in		x	0.021 ksf	=							0.0k	=	0.0k
S	Snow Drift Load	:					0ft- 0in		x	0.22 klf	=							0.0k	=	0.0k
																			=	0.0k
												Total					= 106.6k			

Wall "B" on plan (West Tower, West Lobby Wall)

Load Source		North/South	East/West	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)		Total		
D	Shearwall	:	13ft- 2in	x	85ft- 3in	x	0.150 ksf	=	14.8k	21.7k	22.2k	22.7k	22.7k	22.7k	18.8k	=	168.4k
									14.8k	21.7k	22.2k	22.7k	22.7k	22.7k	18.8k	=	168.4k
L	Stairs	:	0ft- 0in	x	0ft- 0in		x	0.100 ksf	=	0.0k	0.0k	0.0k	0.0k	0.0k	0.0k	=	0.0k
																=	0.0k
S	Snow Load	:	0ft- 0in	x	0ft- 0in		x	0.021 ksf	=						0.0k	=	0.0k
S	Snow Drift Load	:			0ft- 0in		x	0.22 klf	=						0.0k	=	0.0k
																=	0.0k
										Total					= 168.4k		

Wall "C" and "I" on plan (West Tower, West Stair Wall)

Load Source		North/South	East/West	Vertical			B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)		Total		
D	Shearwall	:	23ft- 0in		x	85ft- 3in	x	0.150 ksf	=	25.9k	38.0k	38.8k	39.7k	39.7k	39.7k	32.8k	=	294.1k
										25.9k	38.0k	38.8k	39.7k	39.7k	39.7k	32.8k	=	294.1k
L	Stairs	:	0ft- 0in	x		0ft- 0in		x	0.100 ksf	=	0.0k	0.0k	0.0k	0.0k	0.0k	0.0k	=	0.0k
																	=	0.0k
S	Snow Load	:	0ft- 0in	x		0ft- 0in		x	0.021 ksf	=						0.0k	=	0.0k
S	Snow Drift Load	:				0ft- 0in		x	0.22 klf	=						0.0k	=	0.0k
																	=	0.0k
											Total					=	294.1k	



Project Name:	VAMC DC Parking Garage Expansion
Project Number:	PHL13108.00
Description:	Gravity Loads
Engineer:	ARN
Calculation Date:	8/1/2014
Chkd by:	SHH
Chkd date:	x

Wall "D" on plan (West Tower, North Elevator Wall)

Load Source		North/South	East/West	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total			
D	Shearwall	:	12ft- 0in	x	85ft- 3in	x	0.150 ksf	=	13.5k	19.8k	20.3k	20.7k	20.7k	20.7k	17.1k	=	153.5k
									13.5k	19.8k	20.3k	20.7k	20.7k	20.7k	17.1k	=	153.5k
L	Stairs	:	0ft- 0in	x	0ft- 0in			=	0.0k	0.0k	0.0k	0.0k	0.0k	0.0k	0.0k	=	0.0k
																=	0.0k
S	Snow Load	:	4ft- 2in	x	12ft- 0in		x	0.021 ksf	=						1.1k	=	1.1k
S	Snow Drift Load	:			0ft- 0in		x	0.22 kif	=						0.0k	=	0.0k
																=	1.1k
										Total					=	154.5k	

Total	=	154.5k
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Wall "E" on plan (West Tower, South Elevator Wall)

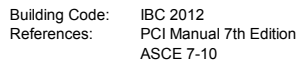
[illegible]

Total	=	280.6k
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Wall "O" on plan (East Tower, South Stair Wall)

Load Source		North/South	East/West	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total					
D	Shearwall	:			x	85ft- 3in	x	0.150 ksf	=	14.6k	21.5k	21.9k	22.4k	22.4k	22.4k	22.4k	18.5k	=	166.2k
D	Stackwall	:	21ft- 1in			x		0.075 ksf	=		17.4k	17.8k						=	35.2k
D	Spandrel	:	21ft- 1in				x	0.83 klf	=				17.6k	17.6k	17.6k	17.6k	17.6k	=	87.8k
D	Double Tee	:	21ft- 1in	x		12ft- 0in		x	0.085 ksf	=	21.5k	21.5k	21.5k	21.5k	21.5k	21.5k	21.5k	=	150.5k
D	Slab	:	11ft- 6in	x		13ft- 0in		x	0.125 ksf	=	18.7k	18.7k	18.7k	18.7k	18.7k	18.7k	18.7k	=	130.8k
										14.6k	79.0k	79.9k	80.2k	80.2k	80.2k	80.2k	76.3k	=	570.6k
L	Parking	:	21ft- 1in	x		12ft- 0in		x	0.040 ksf	=							10.1k	=	10.1k
L	Parking Reduced	:	21ft- 1in	x		12ft- 0in		x	0.032 ksf	=	0.0k	8.1k	8.1k	8.1k	8.1k	8.1k	8.1k	=	48.6k
L	Stairs	:	11ft- 6in	x		13ft- 0in		x	0.100 ksf	=		15.0k	15.0k	15.0k	15.0k	15.0k	15.0k	=	104.7k
																		=	163.3k
S	Snow Load	:	32ft- 7in	x		12ft- 0in		x	0.021 ksf	=							8.2k	=	8.2k
S	Snow Drift Load	:	21ft- 1in	+		13ft- 0in		x	0.22 klf	=							7.5k	=	7.5k
																		=	15.8k

Total	=	749.7k
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Project Name:	VAMC DC Parking Garage Expansion
Project Number:	PHL13108.00
Description:	Gravity Loads
Engineer:	ARN
Calculation Date:	8/1/2014
Chkd by:	SHH
Chkd date:	x

Wall "L" on plan (East Tower, South Elevator Wall)

Load Source		North/South	East/West	Vertical		B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)		Total	
D	Shearwall	:	23ft- 0in	x	85ft- 3in	x	0.150 ksf	=	25.9k	38.0k	38.8k	39.7k	39.7k	39.7k	32.8k	= 294.1k
D	Double Tee	:	28ft- 5in	x	24ft- 0in	x	0.085 ksf	=		57.9k	57.9k	57.9k	57.9k	57.9k	57.9k	= 405.2k
								=	25.9k	95.8k	96.7k	97.6k	97.6k	97.6k	90.7k	= 699.3k
L	Parking	:	28ft- 5in	x	24ft- 0in	x	0.040 ksf	=							27.2k	= 27.2k
L	Parking Reduced	:	28ft- 5in	x	24ft- 0in	x	0.032 ksf	=	0.0k	21.8k	21.8k	21.8k	21.8k	21.8k		= 130.8k
								=								= 158.0k
S	Snow Load	:	32ft- 7in	x	24ft- 0in	x	0.021 ksf	=							16.4k	= 16.4k
S	Snow Drift Load	:	14ft- 7in	+	23ft- 0in	x	0.22 kif	=							8.3k	= 8.3k
								=								= 24.7k
										Total						= 882.0k

Wall "K" on plan (East Tower, North Stair Wall)

	Load Source	:	North/South	x	East/West	x	Vertical	=	B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	=	Total	
D	Shearwall	:			13ft- 0in	x	85ft- 3in	x 0.150 ksf	=	14.6k	21.5k	21.9k	22.4k	22.4k	22.4k	22.4k	18.5k	=	166.2k
D	Slab	:	11ft- 6in	x	13ft- 0in			x 0.125 ksf	=		18.7k	18.7k	18.7k	18.7k	18.7k	18.7k		=	130.8k
										14.6k	40.1k	40.6k	41.1k	41.1k	41.1k	41.1k	37.2k	=	297.1k
L	Stairs	:	11ft- 6in	x	13ft- 0in			x 0.100 ksf	=		15.0k	15.0k	15.0k	15.0k	15.0k	15.0k		=	104.7k
S	Snow Load	:	11ft- 6in	x	13ft- 0in			x 0.021 ksf	=								3.1k	=	3.1k
S	Snow Drift Load	:			0ft- 0in			x 0.22 kif	=								0.0k	=	0.0k
																		=	3.1k
													Total					= 404.8k	

Wall "J" on plan (East Tower, North Elevator Wall)

Load Source	North/South	East/West	Vertical	B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total
D Shearwall	:	23ft- 0in x	85ft- 3in x 0.150 ksf	=	25.9k	38.0k	38.8k	39.7k	39.7k	39.7k	39.7k	294.1k
					25.9k	38.0k	38.8k	39.7k	39.7k	39.7k	39.7k	294.1k
L Stairs	:	0ft- 0in x	0ft- 0in x 0.100 ksf	=		0.0k	0.0k	0.0k	0.0k	0.0k	0.0k	0.0k
												0.0k
S Snow Load	:	4ft- 3in x	23ft- 0in x 0.021 ksf	=							2.0k	2.0k
S Snow Drift Load	:		0ft- 0in x 0.22 klf	=							0.0k	0.0k
												2.0k
								Total				= 296.1k

Wall "M" and "N" on plan (East Tower, West Stair Wall)

Wall W and R on plan (East/West, West/East W/R)		Load Source	North/South	East/West	Vertical	B2 (existing)	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total
D	Shearwall	:	23ft- 0in	x	85ft- 3in x 0.150 ksf	= 25.9k	38.0k	38.8k	39.7k	39.7k	39.7k	39.7k	32.8k	= 294.1k
						25.9k	38.0k	38.8k	39.7k	39.7k	39.7k	39.7k	32.8k	= 294.1k
L	Stairs	:	0ft- 0in	x	0ft- 0in x 0.100 ksf	=	0.0k	0.0k	0.0k	0.0k	0.0k	0.0k	0.0k	= 0.0k
														= 0.0k
S	Snow Load	:	0ft- 0in	x	0ft- 0in x 0.021 ksf	=							0.0k	= 0.0k
S	Snow Drift Load	:			0ft- 0in x 0.22 kif	=							0.0k	= 0.0k
														= 0.0k
										Total				= 294.1k

SEISMIC BASE SHEAR, V:

$V = C_s \cdot W$ (ASCE 7-05: Eq. 12.8-1)

C_s = Seismic Response Coefficient
 W = Effective Seismic Weight

Site Location: 39.687° North, 75.727° West

1) **DETERMINE C_s**

$C_s = S_{DS} / (R/I)$

(ASCE 7-05: Eq. 12.8-2)

I = Occupancy Importance Factor

$I = 1.00$

(Table 11.5.1)

Occupancy Category = II

(Table 1-1)

R = Response Modification Factor

(Table 12.2-1)

$R = 4$ Bearing wall systems - Intermediate precast shear walls
Spanning North/South

$C_d = 4$

$R = 4$ Bearing wall systems - Intermediate precast shear walls
Spanning East/West

$C_d = 4$

S_{DS} = Design Spectral Response Acceleration at Short Period

$S_{DS} = (2/3) S_{MS} = 0.208$

(11.4-3)

$S_{MS} = F_a S_s = 0.312$

(11.4-1)

S_s = Mapped max. considered earthquake spectral response
acceleration at short periods

(Figure 22-1; USGS Site)

$S_s = 0.195$

F_a = Site Class coefficient per site class
and S_s

(Table 11.4.1)

$F_a = 1.60$ per $S_s = 0.195$
Site Class

D

(Section 11.4.2; Geotech)

$C_s = 0.0520$ Bearing wall systems - Intermediate precast shear walls
Spanning North/South

$C_s = 0.0520$ Bearing wall systems - Intermediate precast shear walls
Spanning East/West

2) **DETERMINE $C_{s \min}$**

$C_{s \min} = 0.010$ (ASCE 7-05: Eq. 12.8-5)

$C_{s \min} = 0.010$

3) **DETERMINE C_s max**

$C_s \text{ max} = S_{D1} / [T(R/I)]$ (ASCE 7-05: Eq. 12.8-3) only if $T \leq T_L$ (which is true, see below)

S_{D1} = Design Spectral Response Acceleration at 1 Second Period

$S_{D1} = (2/3) S_{M1} = 0.094$ (Eq. 11.4-4)

$S_{M1} = F_v S_1 = 0.142$ (Eq. 11.4-2)

S_1 = Mapped max. considered earthquake spectral response acceleration at 1 second period (Figure 22-2; USGS Site)

$S_1 = 0.059$

F_v = Site Class coefficient per site class and S_1 (Table 11.4.2)

$F_v = 2.4$ per $S_1 = 0.0590$
Site Class D (Section 11.4.2; Geotech)

$T_L = 6$ (ASCE 7-05: Figure 22-15)

$T = T_a$ = Approximate Structure Fundamental Period

$T_a = C_T h_n^x = 0.542$ (ASCE 7-05: Eq. 12.8-7)

$C_T = 0.02$ (ASCE 7-05: Table 12.8-2)

$h_n = 81.50 \text{ ft}$

$x = 0.75$ (ASCE 7-05: Table 12.8-2)

$T = T_a$ = Approximate Structure Fundamental Period for Masonry or Concrete Shear Wall Structures

$T_a = 0.0019 * h_n / (C_w)^{0.5} = 0.389$ East/West (ASCE 7-05: Eq. 12.8-9)

$T_a = 0.0019 * h_n / (C_w)^{0.5} = 0.927$ North/South (ASCE 7-05: Eq. 12.8-9)

$$C_w = \frac{100}{A_B} \sum_{i=1}^n \left(\frac{h_n}{h_i} \right)^2 \left(\frac{A_i}{1 + 0.83 \left(\frac{h_i}{D_i} \right)^2} \right) = .158 \text{ East/West}$$

$$= .028 \text{ North/South}$$

D_i = Length of SW or LW

A_i = Area of SW or LW

A_B = Structural base area

n = Number of SW

(ASCE 7-05: Eq. 12.8-10)

$A_B = 17,856.0 \text{ ft}^2$

N/S Shearwall	h_n (ft)	h_i (ft)	D_i (ft)	h/D_i	$(h/D_i)^2$	A_i (ft ²)	Sumation
SW1 (B/2)	81.50	81.50	30.00	2.717	7.3803	30.00	4.21
SW2 (B/3)	81.50	81.50	13.00	6.269	39.3033	13.00	0.39
SW3 (B/4)	81.50	81.50	13.00	6.269	39.3033	13.00	0.39
							4.98
E/W Shearwall	h_n (ft)	h_i (ft)	D_i (ft)	h/D_i	$(h/D_i)^2$	A_i (ft ²)	Sumation
LW1 (B/2-3)	81.50	81.50	48.00	1.698	2.8829	48.00	14.15
LW2 (B/3-4)	81.50	81.50	48.00	1.698	2.8829	48.00	14.15
							28.30

$C_s \text{ max} = 0.025$ Bearing wall systems - Intermediate precast shear walls
Spanning North/South

$C_s \text{ max} = 0.044$ Bearing wall systems - Intermediate precast shear walls
Spanning East/West

4) **SELECT Cs**

Bearing wall systems - Intermediate precast shear walls
Spanning North/South

Cs min < Cs < Cs max
0.010 0.052 0.025

Use Cs = 0.052

Bearing wall systems - Intermediate precast shear walls
Spanning East/West

Cs min < Cs < Cs max
0.010 0.052 0.044

Use Cs = 0.044

5) **DETERMINE SEISMIC DESIGN CATEGORY (SDC)**

Table 11.6-1

Per S_{DS} =
& Occupancy
Category =

0.208

II

SDC =

B

Use SDC = B

Table 11.6-2

Per S_{D1} =
& Occupancy
Category =

0.094

II

SDC =

B

6) **LOCATE CENTER OF MASS**

A/1 = (0,0)

X (long direction)
Y (short direction)

	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total	x	y
Wall "G"	51.8 k	52.4 k	52.8 k	52.8 k	52.8 k	52.8 k	49.2 k	365 kips	6.00 ft	44.50 ft
Wall "H"	74.9 k	75.5 k	75.7 k	75.7 k	75.7 k	75.7 k	73.2 k	526 kips	12.00 ft	4.17 ft
Wall "F"	46.9 k	47.4 k	47.8 k	47.8 k	47.8 k	47.8 k	44.2 k	330 kips	6.00 ft	21.50 ft
Wall "A"	9.4 k	13.8 k	14.1 k	14.4 k	14.4 k	14.4 k	14.4 k	95 kips	0.00 ft	4.17 ft
Wall "B"	14.8 k	21.7 k	22.2 k	22.7 k	22.7 k	22.7 k	22.7 k	150 kips	0.00 ft	14.92 ft
Wall "C"	25.9 k	38.0 k	38.8 k	39.7 k	39.7 k	39.7 k	39.7 k	261 kips	0.00 ft	33.00 ft
Wall "D"	13.5 k	19.8 k	20.3 k	20.7 k	20.7 k	20.7 k	20.7 k	136 kips	6.00 ft	0.00 ft
Wall "E"	13.5 k	29.7 k	30.1 k	30.6 k	30.6 k	30.6 k	30.6 k	196 kips	6.00 ft	8.33 ft
Wall "I"	25.9 k	38.0 k	38.8 k	39.7 k	39.7 k	39.7 k	39.7 k	261 kips	12.00 ft	33.00 ft
A/2	150.9 k	151.9 k	151.6 k	151.6 k	151.6 k	151.6 k	150.1 k	1059 kips	49.00 ft	0.00 ft
A/3	171.3 k	172.4 k	172.0 k	172.0 k	172.0 k	172.0 k	170.5 k	1202 kips	97.00 ft	0.00 ft
A/4	89.8 k	90.4 k	90.3 k	90.3 k	90.3 k	90.3 k	88.8 k	630 kips	145.00 ft	0.00 ft
B/1	189.6 k	190.5 k	190.3 k	190.3 k	190.3 k	190.3 k	188.8 k	1330 kips	0.00 ft	60.50 ft
SW 1	199.3 k	200.4 k	201.6 k	201.6 k	201.6 k	201.6 k	192.6 k	1399 kips	49.00 ft	60.50 ft
SW 2	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0 kips	97.00 ft	60.50 ft
SW 3	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0 kips	145.00 ft	60.50 ft
LW	604.6 k	607.1 k	609.6 k	609.6 k	609.6 k	609.6 k	589.4 k	4239 kips	97.00 ft	60.50 ft
C/1	154.5 k	156.2 k	156.8 k	156.8 k	156.8 k	156.8 k	149.0 k	1087 kips	3.25 ft	117.75 ft
C/2	150.9 k	151.9 k	151.6 k	151.6 k	151.6 k	151.6 k	150.1 k	1059 kips	49.00 ft	121.00 ft
C/3	171.3 k	172.4 k	172.0 k	172.0 k	172.0 k	172.0 k	170.5 k	1202 kips	97.00 ft	121.00 ft
C/4	89.8 k	90.4 k	90.3 k	90.3 k	90.3 k	90.3 k	88.8 k	630 kips	145.00 ft	121.00 ft
Σ	2248 kips	2320 kips	2327 kips	2330 kips	2330 kips	2330 kips	2273 kips	16159 kips		

	Wx*B1 (existing)	Wx*G (existing)	Wx*2nd	Wx*3rd	Wx*4th	Wx*5th (future)	Wx*6th (future)	Wx*Total
Wall "G"	311 k*ft	314 k*ft	317 k*ft	317 k*ft	317 k*ft	317 k*ft	295 k*ft	2,187 k*ft
Wall "H"	899 k*ft	906 k*ft	908 k*ft	908 k*ft	908 k*ft	908 k*ft	878 k*ft	6,314 k*ft
Wall "F"	282 k*ft	284 k*ft	287 k*ft	287 k*ft	287 k*ft	287 k*ft	265 k*ft	1,979 k*ft
Wall "A"	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
Wall "B"	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
Wall "C"	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
Wall "D"	81 k*ft	119 k*ft	122 k*ft	124 k*ft	124 k*ft	124 k*ft	124 k*ft	818 k*ft
Wall "E"	81 k*ft	178 k*ft	181 k*ft	183 k*ft	183 k*ft	183 k*ft	183 k*ft	1,174 k*ft
Wall "I"	311 k*ft	455 k*ft	466 k*ft	476 k*ft	476 k*ft	476 k*ft	476 k*ft	3,136 k*ft
A/2	7,394 k*ft	7,442 k*ft	7,429 k*ft	7,429 k*ft	7,429 k*ft	7,429 k*ft	7,356 k*ft	51,908 k*ft
A/3	16,613 k*ft	16,719 k*ft	16,688 k*ft	16,688 k*ft	16,688 k*ft	16,688 k*ft	16,543 k*ft	116,628 k*ft
A/4	13,015 k*ft	13,108 k*ft	13,099 k*ft	13,099 k*ft	13,099 k*ft	13,099 k*ft	12,881 k*ft	91,398 k*ft
B/1	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
SW 1	9,767 k*ft	9,822 k*ft	9,877 k*ft	9,877 k*ft	9,877 k*ft	9,877 k*ft	9,436 k*ft	68,532 k*ft
SW 2	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
SW 3	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
LW	58,642 k*ft	58,887 k*ft	59,131 k*ft	59,131 k*ft	59,131 k*ft	59,131 k*ft	57,176 k*ft	411,230 k*ft
C/1	502 k*ft	508 k*ft	510 k*ft	510 k*ft	510 k*ft	510 k*ft	484 k*ft	3,532 k*ft
C/2	7,394 k*ft	7,442 k*ft	7,429 k*ft	7,429 k*ft	7,429 k*ft	7,429 k*ft	7,356 k*ft	51,908 k*ft
C/3	16,613 k*ft	16,719 k*ft	16,688 k*ft	16,688 k*ft	16,688 k*ft	16,688 k*ft	16,543 k*ft	116,628 k*ft
C/4	13,015 k*ft	13,108 k*ft	13,099 k*ft	13,099 k*ft	13,099 k*ft	13,099 k*ft	12,881 k*ft	91,398 k*ft
Σ	144,919 k*ft	146,009 k*ft	146,230 k*ft	146,245 k*ft	146,245 k*ft	146,245 k*ft	142,877 k*ft	1,018,771 k*ft

	Wy*B1 (existing)	Wy*G (existing)	Wy*2nd	Wy*3rd	Wy*4th	Wy*5th (future)	Wy*6th (future)	Wy*Total
Wall "G"	2,306 k*ft	2,332 k*ft	2,349 k*ft	2,349 k*ft	2,349 k*ft	2,349 k*ft	2,188 k*ft	16,220 k*ft
Wall "H"	312 k*ft	315 k*ft	315 k*ft	315 k*ft	315 k*ft	315 k*ft	305 k*ft	2,193 k*ft
Wall "F"	1,009 k*ft	1,019 k*ft	1,028 k*ft	1,028 k*ft	1,028 k*ft	1,028 k*ft	951 k*ft	7,091 k*ft
Wall "A"	39 k*ft	57 k*ft	59 k*ft	60 k*ft	60 k*ft	60 k*ft	60 k*ft	395 k*ft
Wall "B"	221 k*ft	324 k*ft	331 k*ft	339 k*ft	339 k*ft	339 k*ft	339 k*ft	2,232 k*ft
Wall "C"	854 k*ft	1,252 k*ft	1,281 k*ft	1,309 k*ft	1,309 k*ft	1,309 k*ft	1,309 k*ft	8,624 k*ft
Wall "D"	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
Wall "E"	112 k*ft	247 k*ft	251 k*ft	255 k*ft	255 k*ft	255 k*ft	255 k*ft	1,630 k*ft
Wall "I"	854 k*ft	1,252 k*ft	1,281 k*ft	1,309 k*ft	1,309 k*ft	1,309 k*ft	1,309 k*ft	8,624 k*ft
A/2	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
A/3	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
A/4	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
B/1	11,472 k*ft	11,527 k*ft	11,514 k*ft	11,514 k*ft	11,514 k*ft	11,514 k*ft	11,424 k*ft	80,481 k*ft
SW 1	12,059 k*ft	12,127 k*ft	12,195 k*ft	12,195 k*ft	12,195 k*ft	12,195 k*ft	11,650 k*ft	84,616 k*ft
SW 2	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
SW 3	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
LW	36,576 k*ft	36,728 k*ft	36,881 k*ft	36,881 k*ft	36,881 k*ft	36,881 k*ft	35,661 k*ft	256,489 k*ft
C/1	18,190 k*ft	18,397 k*ft	18,461 k*ft	18,461 k*ft	18,461 k*ft	18,461 k*ft	17,542 k*ft	127,973 k*ft
C/2	18,258 k*ft	18,376 k*ft	18,346 k*ft	18,346 k*ft	18,346 k*ft	18,346 k*ft	18,164 k*ft	128,181 k*ft
C/3	20,724 k*ft	20,855 k*ft	20,817 k*ft	20,817 k*ft	20,817 k*ft	20,817 k*ft	20,636 k*ft	145,485 k*ft
C/4	10,861 k*ft	10,938 k*ft	10,931 k*ft	10,931 k*ft	10,931 k*ft	10,931 k*ft	10,749 k*ft	76,270 k*ft
Σ	133,847 k*ft	135,748 k*ft	136,039 k*ft	136,109 k*ft	136,109 k*ft	136,109 k*ft	132,543 k*ft	946,502 k*ft

Center of Mass:	x _{CM} B1	x _{CM} G	x _{CM} 2nd	x _{CM} 3rd	x _{CM} 4th	x _{CM} 5th	x _{CM} 6th	x _{CM} Total
	64.45 ft	62.94 ft	62.85 ft	62.76 ft	62.76 ft	62.76 ft	62.86 ft	63.05 ft

Center of Mass:	y _{CM} B1	y _{CM} G	y _{CM} 2nd	y _{CM} 3rd	y _{CM} 4th	y _{CM} 5th	y _{CM} 6th	y _{CM} Total
	59.53 ft	58.52 ft	58.47 ft	58.41 ft	58.41 ft	58.41 ft	58.31 ft	58.58 ft

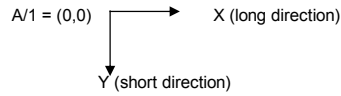
7) **DETERMINE SHEARWALL RELATIVE STIFFNESSES**

North/South Direction: **Shearwall relative rigidities are calculated following the ELF section.

East/West Direction: It is assumed that only the lightwall takes shear, thus giving each lightwall bay equal relative stiffnesses



8) **LOCATE CENTER OF RIGIDITY**



LEVEL B1

Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW1 (B/2-3)	0.500			60.50 ft	30.25 ft
LW2 (B/3-4)	0.500			60.50 ft	30.25 ft
SW1 (B/2)	0.657	49.00 ft	32.17 ft		
SW2 (B/3)	0.172	97.00 ft	16.66 ft		
SW3 (B/4)	0.172	145.00 ft	24.90 ft		
$\Sigma y \text{ stiffness}$	1.000				
$\Sigma x \text{ stiffness}$	1.000				
		$\Sigma k \cdot x =$	73.73ft	$\Sigma k \cdot y =$	60.50ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness} \quad y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$			
		$x_{bar} = \quad \mathbf{73.73 \text{ ft}} \quad y_{bar} = \quad \mathbf{60.50 \text{ ft}}$			

LEVEL G

Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW1 (B/2-3)	0.500			60.50 ft	30.25 ft
LW2 (B/3-4)	0.500			60.50 ft	30.25 ft
SW1 (B/2)	0.765	49.00 ft	37.51 ft		
SW2 (B/3)	0.117	97.00 ft	11.37 ft		
SW3 (B/4)	0.117	145.00 ft	17.00 ft		
$\Sigma y \text{ stiffness}$	1.000				
$\Sigma x \text{ stiffness}$	1.000				
		$\Sigma k \cdot x =$	65.88ft	$\Sigma k \cdot y =$	60.50ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness} \quad y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$			
		$x_{bar} = \quad \mathbf{65.88 \text{ ft}} \quad y_{bar} = \quad \mathbf{60.50 \text{ ft}}$			

LEVEL 2

Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW1 (B/2-3)	0.500			60.50 ft	30.25 ft
LW2 (B/3-4)	0.500			60.50 ft	30.25 ft
SW1 (B/2)	0.806	49.00 ft	39.49 ft		
SW2 (B/3)	0.097	97.00 ft	9.41 ft		
SW3 (B/4)	0.097	145.00 ft	14.07 ft		
$\Sigma y \text{ stiffness}$	1.000				
$\Sigma x \text{ stiffness}$	1.000				
		$\Sigma k \cdot x =$	62.97ft	$\Sigma k \cdot y =$	60.50ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness} \quad y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$			
		$x_{bar} = \quad \mathbf{62.97 \text{ ft}} \quad y_{bar} = \quad \mathbf{60.50 \text{ ft}}$			

LEVEL 3

Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW1 (B/2-3)	0.500			60.50 ft	30.25 ft
LW2 (B/3-4)	0.500			60.50 ft	30.25 ft
SW1 (B/2)	0.822	49.00 ft	40.29 ft		
SW2 (B/3)	0.089	97.00 ft	8.62 ft		
SW3 (B/4)	0.089	145.00 ft	12.89 ft		
$\Sigma y \text{ stiffness}$	1.000				
$\Sigma x \text{ stiffness}$	1.000				
		$\Sigma k \cdot x =$	61.80ft	$\Sigma k \cdot y =$	60.50ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness} \quad y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$			
		$x_{bar} = \quad \mathbf{61.80 \text{ ft}} \quad y_{bar} = \quad \mathbf{60.50 \text{ ft}}$			

LEVEL 4					
Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW1 (B/2-3)	0.500			60.50 ft	30.25 ft
LW2 (B/3-4)	0.500			60.50 ft	30.25 ft
SW1 (B/2)	0.833	49.00 ft	40.81 ft		
SW2 (B/3)	0.084	97.00 ft	8.10 ft		
SW3 (B/4)	0.084	145.00 ft	12.11 ft		
Σ y stiffness	1.000				
Σ x stiffness	1.000				
		Σ k*x =	61.03ft	Σ k*y =	60.50ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness}$		$y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$	
		$x_{bar} =$		$y_{bar} =$	
		61.03 ft		60.50 ft	
LEVEL 5					
Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW1 (B/2-3)	0.500			60.50 ft	30.25 ft
LW2 (B/3-4)	0.500			60.50 ft	30.25 ft
SW1 (B/2)	0.840	49.00 ft	41.15 ft		
SW2 (B/3)	0.080	97.00 ft	7.77 ft		
SW3 (B/4)	0.080	145.00 ft	11.61 ft		
Σ y stiffness	1.000				
Σ x stiffness	1.000				
		Σ k*x =	60.53ft	Σ k*y =	60.50ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness}$		$y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$	
		$x_{bar} =$		$y_{bar} =$	
		60.53 ft		60.50 ft	
LEVEL 6					
Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW1 (B/2-3)	0.500			60.50 ft	30.25 ft
LW2 (B/3-4)	0.500			60.50 ft	30.25 ft
SW1 (B/2)	0.844	49.00 ft	41.34 ft		
SW2 (B/3)	0.078	97.00 ft	7.58 ft		
SW3 (B/4)	0.078	145.00 ft	11.34 ft		
Σ y stiffness	1.000				
Σ x stiffness	1.000				
		Σ k*x =	60.26ft	Σ k*y =	60.50ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness}$		$y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$	
		$x_{bar} =$		$y_{bar} =$	
		60.26 ft		60.50 ft	

Summary				
	Center of Rigidity		Center of Mass	
	X_{bar}	Y_{bar}	x	y
B1	73.73 ft	60.50 ft	64.45 ft	59.53 ft
G	65.88 ft	60.50 ft	62.94 ft	58.52 ft
2nd	62.97 ft	60.50 ft	62.85 ft	58.47 ft
3rd	61.80 ft	60.50 ft	62.76 ft	58.41 ft
4th	61.03 ft	60.50 ft	62.76 ft	58.41 ft
5th	60.53 ft	60.50 ft	62.76 ft	58.41 ft
6th	60.26 ft	60.50 ft	62.86 ft	58.31 ft

9) DETERMINE POLAR MOMENT OF STIFFNESS

$$\Delta x_{bar} = x_{bar} - x_{SW \text{ centroid}}$$

$$\Delta y_{bar} = y_{bar} - y_{SW \text{ centroid}}$$

LEVEL B1

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW1 (B/2-3)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
LW2 (B/3-4)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
SW1 (B/2)					0.657	24.73 ft	611.4 ft ²	401.4 ft ²
SW2 (B/3)					0.172	-23.27 ft	541.7 ft ²	93.0 ft ²
SW3 (B/4)					0.172	-71.27 ft	5,079.9 ft ²	872.3 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	1,366.7 ft ²

$$\text{Polar Moment of Stiffness} = \Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) = 1,367 \text{ ft}^2$$

LEVEL G

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW1 (B/2-3)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
LW2 (B/3-4)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
SW1 (B/2)					0.765	16.88 ft	285.1 ft ²	218.2 ft ²
SW2 (B/3)					0.117	-31.12 ft	968.2 ft ²	113.5 ft ²
SW3 (B/4)					0.117	-79.12 ft	6,259.3 ft ²	733.9 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	1,065.7 ft ²

$$\text{Polar Moment of Stiffness} = \Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) = 1,066 \text{ ft}^2$$

LEVEL 2

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW1 (B/2-3)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
LW2 (B/3-4)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
SW1 (B/2)					0.806	13.97 ft	195.3 ft ²	157.4 ft ²
SW2 (B/3)					0.097	-34.03 ft	1,157.7 ft ²	112.4 ft ²
SW3 (B/4)					0.097	-82.03 ft	6,728.2 ft ²	652.9 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	922.7 ft ²

$$\text{Polar Moment of Stiffness} = \Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) = 923 \text{ ft}^2$$

LEVEL 3

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW1 (B/2-3)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
LW2 (B/3-4)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
SW1 (B/2)					0.822	12.80 ft	163.8 ft ²	134.7 ft ²
SW2 (B/3)					0.089	-35.20 ft	1,239.1 ft ²	110.1 ft ²
SW3 (B/4)					0.089	-83.20 ft	6,922.3 ft ²	615.3 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	860.2 ft ²

$$\text{Polar Moment of Stiffness} = \Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) = 860 \text{ ft}^2$$

LEVEL 4

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW1 (B/2-3)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
LW2 (B/3-4)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
SW1 (B/2)					0.833	12.03 ft	144.7 ft ²	120.5 ft ²
SW2 (B/3)					0.084	-35.97 ft	1,294.0 ft ²	108.1 ft ²
SW3 (B/4)					0.084	-83.97 ft	7,051.2 ft ²	589.0 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	817.6 ft ²
Polar Moment of Stiffness = $\Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) =$					818 ft ²			

LEVEL 5

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW1 (B/2-3)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
LW2 (B/3-4)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
SW1 (B/2)					0.840	11.53 ft	132.9 ft ²	111.6 ft ²
SW2 (B/3)					0.080	-36.47 ft	1,330.2 ft ²	106.5 ft ²
SW3 (B/4)					0.080	-84.47 ft	7,135.5 ft ²	571.2 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	789.4 ft ²
Polar Moment of Stiffness = $\Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) =$					789 ft ²			

LEVEL 6

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW1 (B/2-3)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
LW2 (B/3-4)	0.500	0.00 ft	0.0 ft ²	0.0 ft ²				
SW1 (B/2)					0.844	11.26 ft	126.8 ft ²	106.9 ft ²
SW2 (B/3)					0.078	-36.74 ft	1,349.9 ft ²	105.5 ft ²
SW3 (B/4)					0.078	-84.74 ft	7,181.0 ft ²	561.5 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	774.0 ft ²
Polar Moment of Stiffness = $\Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) =$					774 ft ²			

10) **DISTRIBUTE SHEAR FROM TORSIONAL AND ACCIDENTAL TORSIONAL MOMENTS**

Incorporate additional incurred by Torsional and Accidental Torsional Moments

Tier B1		Spanning East/West			
		Base Shear, V =		27 k	(Calculated in Step 11)
		Torsional Moment, M_t =		26 k*ft	
		East/West Structure Width =		145 ft	
		Acc. Torsional Moment, M_{at} =		196 k*ft	
		Polar Moment of Stiffness, I_p =		1,367 ft ²	
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$	
LW1 (B/2-3)	0.500	0 ft	0.00 k	0.00 k	
LW2 (B/3-4)	0.500	0 ft	0.00 k	0.00 k	
Σ			0.00 k	0.00 k	

Tier G		Spanning East/West			
		Base Shear, V =		51 k	(Calculated in Step 11)
		Torsional Moment, M_t =		102 k*ft	
		East/West Structure Width =		145 ft	
		Acc. Torsional Moment, M_{at} =		372 k*ft	
		Polar Moment of Stiffness, I_p =		1,066 ft ²	
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$	
LW1 (B/2-3)	0.500	0 ft	0.00 k	0.00 k	
LW2 (B/3-4)	0.500	0 ft	0.00 k	0.00 k	
Σ			0.00 k	0.00 k	

Tier 2		Spanning East/West			
		Base Shear, V =		76 k	(Calculated in Step 11)
		Torsional Moment, M_t =		155 k*ft	
		East/West Structure Width =		145 ft	
		Acc. Torsional Moment, M_{at} =		553 k*ft	
		Polar Moment of Stiffness, I_p =		923 ft ²	
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$	
LW1 (B/2-3)	0.500	0 ft	0.00 k	0.00 k	
LW2 (B/3-4)	0.500	0 ft	0.00 k	0.00 k	
Σ			0.00 k	0.00 k	

Tier 3		Spanning East/West			
		Base Shear, V =		101 k	(Calculated in Step 11)
		Torsional Moment, M_t =		211 k*ft	
		East/West Structure Width =		145 ft	
		Acc. Torsional Moment, M_{at} =		733 k*ft	
		Polar Moment of Stiffness, I_p =		860 ft ²	
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$	
LW1 (B/2-3)	0.500	0 ft	0.00 k	0.00 k	
LW2 (B/3-4)	0.500	0 ft	0.00 k	0.00 k	
Σ			0.00 k	0.00 k	

Tier 4		Spanning East/West		
		Base Shear, V =	126 k	(Calculated in Step 11)
		Torsional Moment, M_t =	263 k*ft	
		East/West Structure Width =	145 ft	
		Acc. Torsional Moment, M_{at} =	912 k*ft	
		Polar Moment of Stiffness, I_p =	818 ft ²	
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$
LW1 (B/2-3)	0.500	0 ft	0.00 k	0.00 k
LW2 (B/3-4)	0.500	0 ft	0.00 k	0.00 k
Σ			0.00 k	0.00 k

Tier 5		Spanning East/West		
		Base Shear, V =	151 k	(Calculated in Step 11)
		Torsional Moment, M_t =	315 k*ft	
		East/West Structure Width =	145 ft	
		Acc. Torsional Moment, M_{at} =	1,091 k*ft	
		Polar Moment of Stiffness, I_p =	789 ft ²	
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$
LW1 (B/2-3)	0.500	0 ft	0.00 k	0.00 k
LW2 (B/3-4)	0.500	0 ft	0.00 k	0.00 k
Σ			0.00 k	0.00 k

Tier 6		Spanning East/West		
		Base Shear, V =	171 k	(Calculated in Step 11)
		Torsional Moment, M_t =	374 k*ft	
		East/West Structure Width =	145 ft	
		Acc. Torsional Moment, M_{at} =	1,239 k*ft	
		Polar Moment of Stiffness, I_p =	774 ft ²	
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$
LW1 (B/2-3)	0.500	0 ft	0.00 k	0.00 k
LW2 (B/3-4)	0.500	0 ft	0.00 k	0.00 k
Σ			0.00 k	0.00 k

Tier B1		Spanning North/South		
		Base Shear, V =	32 k	(Calculated in Step 11)
		Torsional Moment, M_t =	299 k*ft	
		North/South Structure Width =	120.66 ft	
		Acc. Torsional Moment, M_{at} =	195 k*ft	
		Polar Moment of Stiffness, I_p =	1,367 ft ²	
	R_y	Δx_{bar}	Torsional Shear, V_t $V_t = R_y * \Delta x_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_y * \Delta x_{bar} * M_{at} / I_p$
SW1 (B/2)	0.657	24.73ft	3.55 k	2.31 k
SW2 (B/3)	0.172	-23.27ft	-0.87 k	0.57 k
SW3 (B/4)	0.172	-71.27ft	-2.68 k	1.74 k
Σ			0.00 k	4.62 k

Tier G		Spanning North/South		
		Base Shear, V =	61 k	(Calculated in Step 11)
		Torsional Moment, M_t =	181 k*ft	
		North/South Structure Width =	120.66 ft	
		Acc. Torsional Moment, M_{at} =	371 k*ft	
		Polar Moment of Stiffness, I_p =	1,066 ft ²	
	R_y	Δx_{bar}	Torsional Shear, V_t $V_t = R_y * \Delta x_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_y * \Delta x_{bar} * M_{at} / I_p$
SW1 (B/2)	0.765	16.88 ft	2.19 k	4.49 k
SW2 (B/3)	0.117	-31.12 ft	-0.62 k	1.27 k
SW3 (B/4)	0.117	-79.12 ft	-1.57 k	3.23 k
Σ			0.00 k	8.99 k

Tier 2		Spanning North/South		
		Base Shear, V =	91 k	(Calculated in Step 11)
		Torsional Moment, M_t =	12 k*ft	
		North/South Structure Width =	120.66 ft	
		Acc. Torsional Moment, M_{at} =	550 k*ft	
		Polar Moment of Stiffness, I_p =	923 ft ²	
	R_y	Δx_{bar}	Torsional Shear, V_t $V_t = R_y * \Delta x_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_y * \Delta x_{bar} * M_{at} / I_p$
SW1 (B/2)	0.806	13.97 ft	0.14 k	6.71 k
SW2 (B/3)	0.097	-34.03 ft	-0.04 k	1.97 k
SW3 (B/4)	0.097	-82.03 ft	-0.10 k	4.74 k
Σ			0.00 k	13.42 k

Tier 3		Spanning North/South		
		Base Shear, V =	121 k	(Calculated in Step 11)
		Torsional Moment, M_t =	-116 k*ft	
		North/South Structure Width =	120.66 ft	
		Acc. Torsional Moment, M_{at} =	729 k*ft	
		Polar Moment of Stiffness, I_p =	860 ft ²	
	R_y	Δx_{bar}	Torsional Shear, V_t $V_t = R_y * \Delta x_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_y * \Delta x_{bar} * M_{at} / I_p$
SW1 (B/2)	0.822	12.80 ft	-1.42 k	8.92 k
SW2 (B/3)	0.089	-35.20 ft	0.42 k	2.65 k
SW3 (B/4)	0.089	-83.20 ft	1.00 k	6.27 k
Σ			0.00 k	17.84 k

Tier 4		Spanning North/South		
		Base Shear, V =	150 k	(Calculated in Step 11)
		Torsional Moment, M_t =	-260 k*ft	
		North/South Structure Width =	120.66 ft	
		Acc. Torsional Moment, M_{at} =	907 k*ft	
		Polar Moment of Stiffness, I_p =	818 ft ²	
	R_y	Δx_{bar}	Torsional Shear, V_t $V_t = R_y * \Delta x_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_y * \Delta x_{bar} * M_{at} / I_p$
SW1 (B/2)	0.833	12.03 ft	-3.19 k	11.12 k
SW2 (B/3)	0.084	-35.97 ft	0.96 k	3.33 k
SW3 (B/4)	0.084	-83.97 ft	2.23 k	7.78 k
Σ			0.00 k	22.23 k

Tier 5		Spanning North/South		
		Base Shear, V =	180 k	(Calculated in Step 11)
		Torsional Moment, M_t =	-402 k*ft	
		North/South Structure Width =	120.66 ft	
		Acc. Torsional Moment, M_{at} =	1,086 k*ft	
		Polar Moment of Stiffness, I_p =	789 ft ²	
	R_y	Δx_{bar}	Torsional Shear, V_t $V_t = R_y * \Delta x_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_y * \Delta x_{bar} * M_{at} / I_p$
SW1 (B/2)	0.840	11.53 ft	-4.93 k	13.32 k
SW2 (B/3)	0.080	-36.47 ft	1.49 k	4.02 k
SW3 (B/4)	0.080	-84.47 ft	3.44 k	9.30 k
Σ			0.00 k	26.63 k

Tier 6		Spanning North/South		
		Base Shear, V =	204 k	(Calculated in Step 11)
		Torsional Moment, M_t =	-531 k*ft	
		North/South Structure Width =	120.66 ft	
		Acc. Torsional Moment, M_{at} =	1,233 k*ft	
		Polar Moment of Stiffness, I_p =	774 ft ²	
	R_y	Δx_{bar}	Torsional Shear, V_t $V_t = R_y * \Delta x_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_y * \Delta x_{bar} * M_{at} / I_p$
SW1 (B/2)	0.844	11.26 ft	-6.51 k	15.13 k
SW2 (B/3)	0.078	-36.74 ft	1.97 k	4.58 k
SW3 (B/4)	0.078	-84.74 ft	4.54 k	10.55 k
Σ			0.00 k	30.26 k

SEISMIC BASE SHEAR, V:

$V = C_s \cdot W$ (ASCE 7-05: Eq. 12.8-1)

C_s = Seismic Response Coefficient
 W = Effective Seismic Weight

Site Location: 39.687° North, 75.727° West

1) **DETERMINE C_s**

$C_s = S_{DS} / (R/I)$ (ASCE 7-05: Eq. 12.8-2)

I = Occupancy Importance Factor

$I = 1.00$

(Table 11.5.1)

Occupancy Category = II (Table 1-1)

R = Response Modification Factor

(Table 12.2-1)

$R = 4$ Bearing wall systems - Intermediate precast shear walls
Spanning North/South

$C_d = 4$

$R = 4$ Bearing wall systems - Intermediate precast shear walls
Spanning East/West

$C_d = 4$

S_{DS} = Design Spectral Response Acceleration at Short Period

$S_{DS} = (2/3) S_{MS} = 0.208$ (11.4-3)

$S_{MS} = F_a S_s = 0.312$ (11.4-1)

S_s = Mapped max. considered earthquake spectral response
acceleration at short periods

(Figure 22-1; USGS Site)

$S_s = 0.195$

F_a = Site Class coefficient per site class
and S_s

(Table 11.4.1)

$F_a = 1.60$ per $S_s = 0.195$
Site Class

D (Section 11.4.2; Geotech)

$C_s = 0.0520$ Bearing wall systems - Intermediate precast shear walls
Spanning North/South

$C_s = 0.0520$ Bearing wall systems - Intermediate precast shear walls
Spanning East/West

2) **DETERMINE C_s min**

C_s min = 0.010 (ASCE 7-05: Eq. 12.8-5)

C_s min = 0.010

3) **DETERMINE C_s max**

$C_s \text{ max} = S_{D1} / [T(R/I)]$ (ASCE 7-05: Eq. 12.8-3) only if $T \leq T_L$ (which is true, see below)

S_{D1} = Design Spectral Response Acceleration at 1 Second Period

$S_{D1} = (2/3) S_{M1} = 0.094$ (Eq. 11.4-4)

$S_{M1} = F_v S_1 = 0.142$ (Eq. 11.4-2)

S_1 = Mapped max. considered earthquake spectral response acceleration at 1 second period (Figure 22-2; USGS Site)

$S_1 = 0.059$

F_v = Site Class coefficient per site class and S_1 (Table 11.4.2)

$F_v = 2.4$ per $S_1 = 0.0590$
Site Class D (Section 11.4.2; Geotech)

$T_L = 6$ (ASCE 7-05: Figure 22-15)

$T = T_a$ = Approximate Structure Fundamental Period

$T_a = C_T h_n^x = 0.542$ (ASCE 7-05: Eq. 12.8-7)

$C_T = 0.02$ (ASCE 7-05: Table 12.8-2)

$h_n = 81.50 \text{ ft}$

$x = 0.75$ (ASCE 7-05: Table 12.8-2)

$T = T_a$ = Approximate Structure Fundamental Period for Masonry or Concrete Shear Wall Structures

$T_a = 0.0019 * h_n / (C_w)^{0.5} = 0.367$ East/West (ASCE 7-05: Eq. 12.8-9)

$T_a = 0.0019 * h_n / (C_w)^{0.5} = 1.031$ North/South (ASCE 7-05: Eq. 12.8-9)

$$C_w = \frac{100}{A_B} \sum_{i=1}^n \left(\frac{h_n}{h_i} \right)^2 \left(\frac{A_i}{1 + 0.83 \left(\frac{h_i}{D_i} \right)^2} \right) = .178 \text{ East/West}$$

$$= .023 \text{ North/South}$$

D_i = Length of SW or LW

A_i = Area of SW or LW

A_B = Structural base area

n = Number of SW

(ASCE 7-05: Eq. 12.8-10)

$A_B = 23,808.0 \text{ ft}^2$

N/S Shearwall	h_n (ft)	h_i (ft)	D_i (ft)	h/D_i	$(h/D_i)^2$	A_i (ft ²)	Sumation
SW4 (B/4)	81.50	81.50	13.00	6.269	39.3033	13.00	0.39
SW5 (B/5)	81.50	81.50	13.00	6.269	39.3033	13.00	0.39
SW6 (B/6)	81.50	81.50	13.00	6.269	39.3033	13.00	0.39
SW 7 (B/7)	81.50	81.50	30.00	2.717	7.3803	30.00	4.21
							5.37
E/W Shearwall	h_n (ft)	h_i (ft)	D_i (ft)	h/D_i	$(h/D_i)^2$	A_i (ft ²)	Sumation
LW3 (B/4-5)	81.50	81.50	48.00	1.698	2.8829	48.00	14.15
LW4 (B/5-6)	81.50	81.50	48.00	1.698	2.8829	48.00	14.15
LW5 (B/6-7)	81.50	81.50	48.00	1.698	2.8829	48.00	14.15
							42.44

$C_s \text{ max} = 0.023$ Bearing wall systems - Intermediate precast shear walls
Spanning North/South

$C_s \text{ max} = 0.044$ Bearing wall systems - Intermediate precast shear walls
Spanning East/West

4) **SELECT Cs**

Bearing wall systems - Intermediate precast shear walls
Spanning North/South

Cs min < Cs < Cs max
0.010 0.052 0.023

Use Cs = 0.052

Bearing wall systems - Intermediate precast shear walls
Spanning East/West

Cs min < Cs < Cs max
0.010 0.052 0.044

Use Cs = 0.044

5) **DETERMINE SEISMIC DESIGN CATEGORY (SDC)**

Table 11.6-1

Per S_{DS} =
& Occupancy
Category =

0.208

II

SDC =

B

Use SDC = B

Table 11.6-2

Per S_{D1} =
& Occupancy
Category =

0.094

II

SDC =

B

6) **LOCATE CENTER OF MASS**

A/1 = (0,0)

X (long direction)
Y (short direction)

	B1 (existing)	G (existing)	2nd	3rd	4th	5th (future)	6th (future)	Total	x	y
A/4	89.8 k	90.4 k	90.3 k	90.3 k	90.3 k	90.3 k	88.8 k	630 kips	145.00 ft	0.00 ft
A/5	171.3 k	172.4 k	172.0 k	172.0 k	172.0 k	172.0 k	170.5 k	1202 kips	193.00 ft	0.00 ft
A/6	171.3 k	172.4 k	172.0 k	172.0 k	172.0 k	172.0 k	170.5 k	1202 kips	241.00 ft	0.00 ft
A/7	130.5 k	131.4 k	131.2 k	131.2 k	131.2 k	131.2 k	129.7 k	916 kips	289.00 ft	0.00 ft
Wall "O"	79.0 k	79.9 k	80.2 k	80.2 k	80.2 k	80.2 k	76.3 k	556 kips	331.50 ft	18.33 ft
Wall "L"	95.8 k	96.7 k	97.6 k	97.6 k	97.6 k	97.6 k	90.7 k	673 kips	313.50 ft	3.75 ft
Wall "K"	40.1 k	40.6 k	41.1 k	41.1 k	41.1 k	41.1 k	37.2 k	282 kips	331.50 ft	-4.67 ft
Wall "J"	38.0 k	38.8 k	39.7 k	39.7 k	39.7 k	39.7 k	32.8 k	268 kips	313.50 ft	-4.67 ft
Wall "M"	38.0 k	38.8 k	39.7 k	39.7 k	39.7 k	39.7 k	32.8 k	268 kips	325.00 ft	6.33 ft
Wall "N"	38.0 k	38.8 k	39.7 k	39.7 k	39.7 k	39.7 k	32.8 k	268 kips	338.00 ft	6.33 ft
SW 4	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0 kips	145.00 ft	60.50 ft
SW 5	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0 kips	193.00 ft	60.50 ft
SW 6	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0.0 k	0 kips	241.00 ft	60.50 ft
SW 7	199.3 k	200.4 k	201.6 k	201.6 k	201.6 k	201.6 k	192.6 k	1399 kips	289.00 ft	60.50 ft
LW	906.8 k	910.6 k	914.4 k	914.4 k	914.4 k	914.4 k	884.2 k	6359 kips	217.00 ft	60.50 ft
B/8	191.2 k	192.3 k	192.0 k	192.0 k	192.0 k	192.0 k	190.5 k	1342 kips	338.00 ft	60.50 ft
C/4	89.8 k	90.4 k	90.3 k	90.3 k	90.3 k	90.3 k	88.8 k	630 kips	145.00 ft	121.00 ft
C/5	171.3 k	172.4 k	172.0 k	172.0 k	172.0 k	172.0 k	170.5 k	1202 kips	193.00 ft	121.00 ft
C/6	171.3 k	172.4 k	172.0 k	172.0 k	172.0 k	172.0 k	170.5 k	1202 kips	241.00 ft	121.00 ft
C/7	150.9 k	151.9 k	151.6 k	151.6 k	151.6 k	151.6 k	150.1 k	1059 kips	289.00 ft	121.00 ft
C/8	154.5 k	156.2 k	156.8 k	156.8 k	156.8 k	156.8 k	149.0 k	1087 kips	334.75 ft	117.75 ft
Σ	2927 kips	2947 kips	2954 kips	2954 kips	2954 kips	2954 kips	2858 kips	20549 kips		

	Wx*B1 (existing)	Wx*G (existing)	Wx*2nd	Wx*3rd	Wx*4th	Wx*5th (future)	Wx*6th (future)	Wx*Total
A/4	13,015 k*ft	13,108 k*ft	13,099 k*ft	13,099 k*ft	13,099 k*ft	13,099 k*ft	12,881 k*ft	91,398 k*ft
A/5	33,055 k*ft	33,265 k*ft	33,205 k*ft	33,205 k*ft	33,205 k*ft	33,205 k*ft	32,915 k*ft	232,054 k*ft
A/6	41,276 k*ft	41,538 k*ft	41,463 k*ft	41,463 k*ft	41,463 k*ft	41,463 k*ft	41,101 k*ft	289,767 k*ft
A/7	37,719 k*ft	37,968 k*ft	37,914 k*ft	37,914 k*ft	37,914 k*ft	37,914 k*ft	37,480 k*ft	264,823 k*ft
Wall "O"	26,201 k*ft	26,493 k*ft	26,582 k*ft	26,582 k*ft	26,582 k*ft	26,582 k*ft	25,289 k*ft	184,311 k*ft
Wall "L"	30,044 k*ft	30,315 k*ft	30,585 k*ft	30,585 k*ft	30,585 k*ft	30,585 k*ft	28,422 k*ft	211,121 k*ft
Wall "K"	13,306 k*ft	13,467 k*ft	13,629 k*ft	13,629 k*ft	13,629 k*ft	13,629 k*ft	12,336 k*ft	93,624 k*ft
Wall "J"	11,897 k*ft	12,168 k*ft	12,438 k*ft	12,438 k*ft	12,438 k*ft	12,438 k*ft	10,275 k*ft	84,092 k*ft
Wall "M"	12,334 k*ft	12,614 k*ft	12,894 k*ft	12,894 k*ft	12,894 k*ft	12,894 k*ft	10,652 k*ft	87,177 k*ft
Wall "N"	12,827 k*ft	13,119 k*ft	13,410 k*ft	13,410 k*ft	13,410 k*ft	13,410 k*ft	11,078 k*ft	90,664 k*ft
SW 4	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
SW 5	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
SW 6	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
SW 7	57,603 k*ft	57,929 k*ft	58,254 k*ft	58,254 k*ft	58,254 k*ft	58,254 k*ft	55,653 k*ft	404,200 k*ft
LW	196,784 k*ft	197,605 k*ft	198,425 k*ft	198,425 k*ft	198,425 k*ft	198,425 k*ft	191,863 k*ft	1,379,951 k*ft
B/8	64,637 k*ft	64,984 k*ft	64,890 k*ft	64,890 k*ft	64,890 k*ft	64,890 k*ft	64,383 k*ft	453,562 k*ft
C/4	13,015 k*ft	13,108 k*ft	13,099 k*ft	13,099 k*ft	13,099 k*ft	13,099 k*ft	12,881 k*ft	91,398 k*ft
C/5	33,055 k*ft	33,265 k*ft	33,205 k*ft	33,205 k*ft	33,205 k*ft	33,205 k*ft	32,915 k*ft	232,054 k*ft
C/6	41,276 k*ft	41,538 k*ft	41,463 k*ft	41,463 k*ft	41,463 k*ft	41,463 k*ft	41,101 k*ft	289,767 k*ft
C/7	43,608 k*ft	43,890 k*ft	43,817 k*ft	43,817 k*ft	43,817 k*ft	43,817 k*ft	43,384 k*ft	306,151 k*ft
C/8	51,713 k*ft	52,301 k*ft	52,482 k*ft	52,482 k*ft	52,482 k*ft	52,482 k*ft	49,871 k*ft	363,812 k*ft
Σ	733,365 k*ft	738,673 k*ft	740,852 k*ft	740,852 k*ft	740,852 k*ft	740,852 k*ft	714,480 k*ft	5,149,926 k*ft

	Wy*B1 (existing)	Wy*G (existing)	Wy*2nd	Wy*3rd	Wy*4th	Wy*5th (future)	Wy*6th (future)	Wy*Total
A/4	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
A/5	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
A/6	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
A/7	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
Wall "O"	1,449 k*ft	1,465 k*ft	1,470 k*ft	1,470 k*ft	1,470 k*ft	1,470 k*ft	1,398 k*ft	10,191 k*ft
Wall "L"	359 k*ft	363 k*ft	366 k*ft	366 k*ft	366 k*ft	366 k*ft	340 k*ft	2,525 k*ft
Wall "K"	-187 k*ft	-190 k*ft	-192 k*ft	-192 k*ft	-192 k*ft	-192 k*ft	-174 k*ft	-1,318 k*ft
Wall "J"	-177 k*ft	-181 k*ft	-185 k*ft	-185 k*ft	-185 k*ft	-185 k*ft	-153 k*ft	-1,252 k*ft
Wall "M"	240 k*ft	246 k*ft	251 k*ft	251 k*ft	251 k*ft	251 k*ft	208 k*ft	1,699 k*ft
Wall "N"	240 k*ft	246 k*ft	251 k*ft	251 k*ft	251 k*ft	251 k*ft	208 k*ft	1,699 k*ft
SW 4	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
SW 5	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
SW 6	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft	0 k*ft
SW 7	12,059 k*ft	12,127 k*ft	12,195 k*ft	12,195 k*ft	12,195 k*ft	12,195 k*ft	11,650 k*ft	84,616 k*ft
LW	54,864 k*ft	55,093 k*ft	55,321 k*ft	55,321 k*ft	55,321 k*ft	55,321 k*ft	53,492 k*ft	384,733 k*ft
B/8	11,570 k*ft	11,632 k*ft	11,615 k*ft	11,615 k*ft	11,615 k*ft	11,615 k*ft	11,524 k*ft	81,185 k*ft
C/4	10,861 k*ft	10,938 k*ft	10,931 k*ft	10,931 k*ft	10,931 k*ft	10,931 k*ft	10,749 k*ft	76,270 k*ft
C/5	20,724 k*ft	20,855 k*ft	20,817 k*ft	20,817 k*ft	20,817 k*ft	20,817 k*ft	20,636 k*ft	145,485 k*ft
C/6	20,724 k*ft	20,855 k*ft	20,817 k*ft	20,817 k*ft	20,817 k*ft	20,817 k*ft	20,636 k*ft	145,485 k*ft
C/7	18,258 k*ft	18,376 k*ft	18,346 k*ft	18,346 k*ft	18,346 k*ft	18,346 k*ft	18,164 k*ft	128,181 k*ft
C/8	18,190 k*ft	18,397 k*ft	18,461 k*ft	18,461 k*ft	18,461 k*ft	18,461 k*ft	17,542 k*ft	127,973 k*ft
Σ	169,173 k*ft	170,221 k*ft	170,464 k*ft	170,464 k*ft	170,464 k*ft	170,464 k*ft	166,221 k*ft	1,187,471 k*ft

Center of Mass:	x _{CM} B1	x _{CM} G	x _{CM} 2nd	x _{CM} 3rd	x _{CM} 4th	x _{CM} 5th	x _{CM} 6th	x _{CM} Total
	250.57 ft	250.68 ft	250.77 ft	250.77 ft	250.77 ft	250.77 ft	249.96 ft	250.62 ft

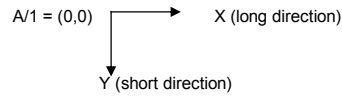
Center of Mass:	y _{CM} B1	y _{CM} G	y _{CM} 2nd	y _{CM} 3rd	y _{CM} 4th	y _{CM} 5th	y _{CM} 6th	y _{CM} Total
	57.80 ft	57.77 ft	57.70 ft	57.70 ft	57.70 ft	57.70 ft	58.15 ft	57.79 ft

7) **DETERMINE SHEARWALL RELATIVE STIFFNESSES**

North/South Direction: **Shearwall relative rigidities are calculated following the ELF section.

East/West Direction: It is assumed that only the lightwall takes shear, thus giving each lightwall bay a relative stiffness, k, of 0.333.

8) **LOCATE CENTER OF RIGIDITY**



LEVEL B1

Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW3 (B/4-5)	0.333			60.50 ft	20.16 ft
LW4 (B/5-6)	0.333			60.50 ft	20.16 ft
LW5 (B/6-7)	0.333			60.50 ft	20.16 ft
SW4 (B/4)	0.147	145.00 ft	21.25 ft		
SW5 (B/5)	0.147	193.00 ft	28.28 ft		
SW6 (B/6)	0.147	241.00 ft	35.32 ft		
SW 7 (B/7)	0.560	289.00 ft	161.94 ft		
Σ y stiffness	1.000				
Σ x stiffness	1.000				
$\Sigma k*x =$			246.79ft	$\Sigma k*y =$	60.49ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness} \quad y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$			
		$x_{bar} = 246.79 \text{ ft} \quad y_{bar} = 60.50 \text{ ft}$			

LEVEL G

Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW3 (B/4-5)	0.333			60.50 ft	20.16 ft
LW4 (B/5-6)	0.333			60.50 ft	20.16 ft
LW5 (B/6-7)	0.333			60.50 ft	20.16 ft
SW4 (B/4)	0.105	145.00 ft	15.22 ft		
SW5 (B/5)	0.105	193.00 ft	20.25 ft		
SW6 (B/6)	0.105	241.00 ft	25.29 ft		
SW 7 (B/7)	0.685	289.00 ft	198.01 ft		
Σ y stiffness	1.000				
Σ x stiffness	1.000				
$\Sigma k*x =$			258.78ft	$\Sigma k*y =$	60.49ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness} \quad y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$			
		$x_{bar} = 258.78 \text{ ft} \quad y_{bar} = 60.50 \text{ ft}$			

LEVEL 2

Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW3 (B/4-5)	0.333			60.50 ft	20.16 ft
LW4 (B/5-6)	0.333			60.50 ft	20.16 ft
LW5 (B/6-7)	0.333			60.50 ft	20.16 ft
SW4 (B/4)	0.088	145.00 ft	12.83 ft		
SW5 (B/5)	0.088	193.00 ft	17.07 ft		
SW6 (B/6)	0.088	241.00 ft	21.32 ft		
SW 7 (B/7)	0.735	289.00 ft	212.30 ft		
Σ y stiffness	1.000				
Σ x stiffness	1.000				
$\Sigma k*x =$			263.52ft	$\Sigma k*y =$	60.49ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness} \quad y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$			
		$x_{bar} = 263.52 \text{ ft} \quad y_{bar} = 60.50 \text{ ft}$			

LEVEL 3

Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW3 (B/4-5)	0.333			60.50 ft	20.16 ft
LW4 (B/5-6)	0.333			60.50 ft	20.16 ft
LW5 (B/6-7)	0.333			60.50 ft	20.16 ft
SW4 (B/4)	0.082	145.00 ft	11.84 ft		
SW5 (B/5)	0.082	193.00 ft	15.75 ft		
SW6 (B/6)	0.082	241.00 ft	19.67 ft		
SW 7 (B/7)	0.755	289.00 ft	218.23 ft		
Σ y stiffness	1.000				
Σ x stiffness	1.000				
$\Sigma k*x =$			265.49ft	$\Sigma k*y =$	60.49ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness} \quad y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$			
		$x_{bar} = 265.49 \text{ ft} \quad y_{bar} = 60.50 \text{ ft}$			

LEVEL 4					
Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW3 (B/4-5)	0.333			60.50 ft	20.16 ft
LW4 (B/5-6)	0.333			60.50 ft	20.16 ft
LW5 (B/6-7)	0.333			60.50 ft	20.16 ft
SW4 (B/4)	0.077	145.00 ft	11.18 ft		
SW5 (B/5)	0.077	193.00 ft	14.88 ft		
SW6 (B/6)	0.077	241.00 ft	18.58 ft		
SW 7 (B/7)	0.769	289.00 ft	222.16 ft		
Σ y stiffness	1.000				
Σ x stiffness	1.000				
		Σ k*x =	266.80ft	Σ k*y =	60.49ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness}$		$y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$	
		$x_{bar} =$	266.80 ft	$y_{bar} =$	60.50 ft

LEVEL 5					
Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW3 (B/4-5)	0.333			60.50 ft	20.16 ft
LW4 (B/5-6)	0.333			60.50 ft	20.16 ft
LW5 (B/6-7)	0.333			60.50 ft	20.16 ft
SW4 (B/4)	0.074	145.00 ft	10.75 ft		
SW5 (B/5)	0.074	193.00 ft	14.31 ft		
SW6 (B/6)	0.074	241.00 ft	17.86 ft		
SW 7 (B/7)	0.778	289.00 ft	224.74 ft		
Σ y stiffness	1.000				
Σ x stiffness	1.000				
		Σ k*x =	267.65ft	Σ k*y =	60.49ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness}$		$y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$	
		$x_{bar} =$	267.65 ft	$y_{bar} =$	60.50 ft

LEVEL 6					
Wall	Relative Stiffness, k	Wall Centroid x	k*x	Wall Centroid y	k*y
LW3 (B/4-5)	0.333			60.50 ft	20.16 ft
LW4 (B/5-6)	0.333			60.50 ft	20.16 ft
LW5 (B/6-7)	0.333			60.50 ft	20.16 ft
SW4 (B/4)	0.073	145.00 ft	10.52 ft		
SW5 (B/5)	0.073	193.00 ft	14.00 ft		
SW6 (B/6)	0.073	241.00 ft	17.48 ft		
SW 7 (B/7)	0.782	289.00 ft	226.13 ft		
Σ y stiffness	1.000				
Σ x stiffness	1.000				
		Σ k*x =	268.11ft	Σ k*y =	60.49ft
Center of Rigidity Coordinates:		$x_{bar} = \frac{\sum k \cdot x}{\sum x \cdot stiffness}$		$y_{bar} = \frac{\sum k \cdot y}{\sum y \cdot stiffness}$	
		$x_{bar} =$	268.11 ft	$y_{bar} =$	60.50 ft

Summary					
	Center of Rigidity		Center of Mass		
	X_{bar}	Y_{bar}	x	y	
B1	246.79 ft	60.50 ft	250.57 ft	57.80 ft	
G	258.78 ft	60.50 ft	250.68 ft	57.77 ft	
2nd	263.52 ft	60.50 ft	250.77 ft	57.70 ft	
3rd	265.49 ft	60.50 ft	250.77 ft	57.70 ft	
4th	266.80 ft	60.50 ft	250.77 ft	57.70 ft	
5th	267.65 ft	60.50 ft	250.77 ft	57.70 ft	
6th	268.11 ft	60.50 ft	249.96 ft	58.15 ft	

9) DETERMINE POLAR MOMENT OF STIFFNESS

$$\Delta x_{bar} = x_{bar} - x_{SW \text{ centroid}}$$

$$\Delta y_{bar} = y_{bar} - y_{SW \text{ centroid}}$$

LEVEL B1

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW3 (B/4-5)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW4 (B/5-6)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW5 (B/6-7)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
SW4 (B/4)					0.147	101.79 ft	10,362.1 ft ²	1,518.5 ft ²
SW5 (B/5)					0.147	53.79 ft	2,893.8 ft ²	424.1 ft ²
SW6 (B/6)					0.147	5.79 ft	33.6 ft ²	4.9 ft ²
SW 7 (B/7)					0.560	-42.21 ft	1,781.3 ft ²	998.2 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	2,945.7 ft ²

$$\text{Polar Moment of Stiffness} = \Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) = 2,946 \text{ ft}^2$$

LEVEL G

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW3 (B/4-5)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW4 (B/5-6)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW5 (B/6-7)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
SW4 (B/4)					0.105	113.78 ft	12,944.8 ft ²	1,358.5 ft ²
SW5 (B/5)					0.105	65.78 ft	4,326.4 ft ²	454.0 ft ²
SW6 (B/6)					0.105	17.78 ft	316.0 ft ²	33.2 ft ²
SW 7 (B/7)					0.685	-30.22 ft	913.5 ft ²	625.9 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	2,471.6 ft ²

$$\text{Polar Moment of Stiffness} = \Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) = 2,472 \text{ ft}^2$$

LEVEL 2

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW3 (B/4-5)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW4 (B/5-6)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW5 (B/6-7)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
SW4 (B/4)					0.088	118.52 ft	14,047.8 ft ²	1,242.7 ft ²
SW5 (B/5)					0.088	70.52 ft	4,973.5 ft ²	440.0 ft ²
SW6 (B/6)					0.088	22.52 ft	507.3 ft ²	44.9 ft ²
SW 7 (B/7)					0.735	-25.48 ft	649.1 ft ²	476.8 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	2,204.3 ft ²

$$\text{Polar Moment of Stiffness} = \Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) = 2,204 \text{ ft}^2$$

LEVEL 3

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW3 (B/4-5)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW4 (B/5-6)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW5 (B/6-7)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
SW4 (B/4)					0.082	120.49 ft	14,517.9 ft ²	1,185.1 ft ²
SW5 (B/5)					0.082	72.49 ft	5,254.8 ft ²	429.0 ft ²
SW6 (B/6)					0.082	24.49 ft	599.8 ft ²	49.0 ft ²
SW 7 (B/7)					0.755	-23.51 ft	552.7 ft ²	417.4 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	2,080.4 ft ²

$$\text{Polar Moment of Stiffness} = \Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) = 2,080 \text{ ft}^2$$

LEVEL 4

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW3 (B/4-5)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW4 (B/5-6)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW5 (B/6-7)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
SW4 (B/4)					0.077	121.80 ft	14,834.7 ft ²	1,143.6 ft ²
SW5 (B/5)					0.077	73.80 ft	5,446.1 ft ²	419.8 ft ²
SW6 (B/6)					0.077	25.80 ft	665.5 ft ²	51.3 ft ²
SW 7 (B/7)					0.769	-22.20 ft	492.9 ft ²	378.9 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	1,993.7 ft ²

Polar Moment of Stiffness = $\Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) =$ **1,994 ft²**

LEVEL 5

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW3 (B/4-5)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW4 (B/5-6)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW5 (B/6-7)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
SW4 (B/4)					0.074	122.65 ft	15,043.6 ft ²	1,115.1 ft ²
SW5 (B/5)					0.074	74.65 ft	5,573.0 ft ²	413.1 ft ²
SW6 (B/6)					0.074	26.65 ft	710.4 ft ²	52.7 ft ²
SW 7 (B/7)					0.778	-21.35 ft	455.7 ft ²	354.4 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	1,935.2 ft ²

Polar Moment of Stiffness = $\Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) =$ **1,935 ft²**

LEVEL 6

Wall	R_y	Δy_{bar}	Δy_{bar}^2	$R_x \cdot \Delta y_{bar}^2$	R_x	Δx_{bar}	Δx_{bar}^2	$R_y \cdot \Delta x_{bar}^2$
LW3 (B/4-5)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW4 (B/5-6)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
LW5 (B/6-7)	0.333	0.00 ft	0.0 ft ²	0.0 ft ²				
SW4 (B/4)					0.073	123.11 ft	15,157.2 ft ²	1,099.2 ft ²
SW5 (B/5)					0.073	75.11 ft	5,642.2 ft ²	409.2 ft ²
SW6 (B/6)					0.073	27.11 ft	735.2 ft ²	53.3 ft ²
SW 7 (B/7)					0.782	-20.89 ft	436.2 ft ²	341.3 ft ²
	1.000		$\Sigma(R_x \cdot \Delta y_{bar}^2) =$	0 ft ²	1.000		$\Sigma(R_y \cdot \Delta x_{bar}^2) =$	1,903.0 ft ²

Polar Moment of Stiffness = $\Sigma(R_x \cdot \Delta y_{bar}^2) + \Sigma(R_y \cdot \Delta x_{bar}^2) =$ **1,903 ft²**

10) **DISTRIBUTE SHEAR FROM TORSIONAL AND ACCIDENTAL TORSIONAL MOMENTS**

Incorporate additional incurred by Torsional and Accidental Torsional Moments

Tier B1 Spanning East/West					
		Base Shear, V =	35 k	(Calculated in Step 11)	
		Torsional Moment, M_t =	95 k*ft		
		East/West Structure Width =	193 ft		
		Acc. Torsional Moment, M_{at} =	340 k*ft		
		Polar Moment of Stiffness, I_p =	2,946 ft ²		
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$	
LW3 (B/4-5)	0.333	0 ft	0.00 k	0.00 k	
LW4 (B/5-6)	0.333	0 ft	0.00 k	0.00 k	
LW5 (B/6-7)	0.333	0 ft	0.00 k	0.00 k	
Σ			0.00 k	0.00 k	

Tier G Spanning East/West					
		Base Shear, V =	66 k	(Calculated in Step 11)	
		Torsional Moment, M_t =	179 k*ft		
		East/West Structure Width =	193 ft		
		Acc. Torsional Moment, M_{at} =	632 k*ft		
		Polar Moment of Stiffness, I_p =	2,472 ft ²		
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$	
LW3 (B/4-5)	0.333	0 ft	0.00 k	0.00 k	
LW4 (B/5-6)	0.333	0 ft	0.00 k	0.00 k	
LW5 (B/6-7)	0.333	0 ft	0.00 k	0.00 k	
Σ			0.00 k	0.00 k	

Tier 2 Spanning East/West					
		Base Shear, V =	97 k	(Calculated in Step 11)	
		Torsional Moment, M_t =	272 k*ft		
		East/West Structure Width =	193 ft		
		Acc. Torsional Moment, M_{at} =	937 k*ft		
		Polar Moment of Stiffness, I_p =	2,204 ft ²		
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$	
LW3 (B/4-5)	0.333	0 ft	0.00 k	0.00 k	
LW4 (B/5-6)	0.333	0 ft	0.00 k	0.00 k	
LW5 (B/6-7)	0.333	0 ft	0.00 k	0.00 k	
Σ			0.00 k	0.00 k	

Tier 3 Spanning East/West					
		Base Shear, V =	129 k	(Calculated in Step 11)	
		Torsional Moment, M_t =	360 k*ft		
		East/West Structure Width =	193 ft		
		Acc. Torsional Moment, M_{at} =	1,241 k*ft		
		Polar Moment of Stiffness, I_p =	2,080 ft ²		
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$	
LW3 (B/4-5)	0.333	0 ft	0.00 k	0.00 k	
LW4 (B/5-6)	0.333	0 ft	0.00 k	0.00 k	
LW5 (B/6-7)	0.333	0 ft	0.00 k	0.00 k	
Σ			0.00 k	0.00 k	

Tier 4		Spanning East/West		
		Base Shear, V =	160 k	(Calculated in Step 11)
		Torsional Moment, M_t =	448 k*ft	
		East/West Structure Width =	193 ft	
		Acc. Torsional Moment, M_{at} =	1,545 k*ft	
		Polar Moment of Stiffness, I_p =	1,994 ft ²	
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$
LW3 (B/4-5)	0.333	0 ft	0.00 k	0.00 k
LW4 (B/5-6)	0.333	0 ft	0.00 k	0.00 k
LW5 (B/6-7)	0.333	0 ft	0.00 k	0.00 k
Σ			0.00 k	0.00 k

Tier 5		Spanning East/West		
		Base Shear, V =	192 k	(Calculated in Step 11)
		Torsional Moment, M_t =	536 k*ft	
		East/West Structure Width =	193 ft	
		Acc. Torsional Moment, M_{at} =	1,848 k*ft	
		Polar Moment of Stiffness, I_p =	1,935 ft ²	
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$
LW3 (B/4-5)	0.333	0 ft	0.00 k	0.00 k
LW4 (B/5-6)	0.333	0 ft	0.00 k	0.00 k
LW5 (B/6-7)	0.333	0 ft	0.00 k	0.00 k
Σ			0.00 k	0.00 k

Tier 6		Spanning East/West		
		Base Shear, V =	216 k	(Calculated in Step 11)
		Torsional Moment, M_t =	506 k*ft	
		East/West Structure Width =	193 ft	
		Acc. Torsional Moment, M_{at} =	2,082 k*ft	
		Polar Moment of Stiffness, I_p =	1,903 ft ²	
	R_x	Δy_{bar}	Torsional Shear, V_t $V_t = R_x * \Delta y_{bar} * M_t / I_p$	Acc. Tors. Shear, V_{at} $V_{at} = R_x * \Delta y_{bar} * M_{at} / I_p$
LW3 (B/4-5)	0.333	0 ft	0.00 k	0.00 k
LW4 (B/5-6)	0.333	0 ft	0.00 k	0.00 k
LW5 (B/6-7)	0.333	0 ft	0.00 k	0.00 k
Σ			0.00 k	0.00 k

Tier B1		Spanning North/South			
		Base Shear, V =	42 k	(Calculated in Step 11)	
		Torsional Moment, M _t =	-159 k*ft		
		North/South Structure Width =	120.66 ft		
		Acc. Torsional Moment, M _{at} =	254 k*ft		
		Polar Moment of Stiffness, I _p =	2,946 ft ²		
	R _y	Δx _{bar}	Torsional Shear, V _t	Acc. Tors. Shear, V _{at}	
			V _t = R _y *Δx _{bar} *M _t /I _p	V _{at} = R _y *Δx _{bar} *M _{at} /I _p	
SW4 (B/4)	0.147	101.79 ft	-0.81 k	1.29 k	
SW5 (B/5)	0.147	53.79 ft	-0.43 k	0.68 k	
SW6 (B/6)	0.147	5.79 ft	-0.05 k	0.07 k	
SW 7 (B/7)	0.560	-42.21 ft	1.28 k	2.04 k	
Σ			0.00 k	4.08 k	

Tier G		Spanning North/South			
		Base Shear, V =	78 k	(Calculated in Step 11)	
		Torsional Moment, M _t =	634 k*ft		
		North/South Structure Width =	120.66 ft		
		Acc. Torsional Moment, M _{at} =	472 k*ft		
		Polar Moment of Stiffness, I _p =	2,472 ft ²		
	R _y	Δx _{bar}	Torsional Shear, V _t	Acc. Tors. Shear, V _{at}	
			V _t = R _y *Δx _{bar} *M _t /I _p	V _{at} = R _y *Δx _{bar} *M _{at} /I _p	
SW4 (B/4)	0.105	113.78 ft	3.06 k	2.28 k	
SW5 (B/5)	0.105	65.78 ft	1.77 k	1.32 k	
SW6 (B/6)	0.105	17.78 ft	0.48 k	0.36 k	
SW 7 (B/7)	0.685	-30.22 ft	-5.31 k	3.96 k	
Σ			0.00 k	7.92 k	

Tier 2		Spanning North/South			
		Base Shear, V =	116 k	(Calculated in Step 11)	
		Torsional Moment, M _t =	1,481 k*ft		
		North/South Structure Width =	120.66 ft		
		Acc. Torsional Moment, M _{at} =	701 k*ft		
		Polar Moment of Stiffness, I _p =	2,204 ft ²		
	R _y	Δx _{bar}	Torsional Shear, V _t	Acc. Tors. Shear, V _{at}	
			V _t = R _y *Δx _{bar} *M _t /I _p	V _{at} = R _y *Δx _{bar} *M _{at} /I _p	
SW4 (B/4)	0.088	118.52 ft	7.04 k	3.33 k	
SW5 (B/5)	0.088	70.52 ft	4.19 k	1.98 k	
SW6 (B/6)	0.088	22.52 ft	1.34 k	0.63 k	
SW 7 (B/7)	0.735	-25.48 ft	-12.57 k	5.95 k	
Σ			0.00 k	11.90 k	

Tier 3		Spanning North/South			
		Base Shear, V =	154 k	(Calculated in Step 11)	
		Torsional Moment, M _t =	2,263 k*ft		
		North/South Structure Width =	120.66 ft		
		Acc. Torsional Moment, M _{at} =	927 k*ft		
		Polar Moment of Stiffness, I _p =	2,080 ft ²		
	R _y	Δx _{bar}	Torsional Shear, V _t	Acc. Tors. Shear, V _{at}	
			V _t = R _y *Δx _{bar} *M _t /I _p	V _{at} = R _y *Δx _{bar} *M _{at} /I _p	
SW4 (B/4)	0.082	120.49 ft	10.70 k	4.39 k	
SW5 (B/5)	0.082	72.49 ft	6.44 k	2.64 k	
SW6 (B/6)	0.082	24.49 ft	2.17 k	0.89 k	
SW 7 (B/7)	0.755	-23.51 ft	-19.31 k	7.91 k	
Σ			0.00 k	15.83 k	

Tier 4 Spanning North/South					
Base Shear, V =		191 k		(Calculated in Step 11)	
Torsional Moment, M _t =		3,066 k*ft			
North/South Structure Width =		120.66 ft			
Acc. Torsional Moment, M _{at} =		1,154 k*ft			
Polar Moment of Stiffness, I _p =		1,994 ft ²			
	R _y	Δx _{bar}	Torsional Shear, V _t	Acc. Tors. Shear, V _{at}	
			V _t = R _y * Δx _{bar} * M _t / I _p	V _{at} = R _y * Δx _{bar} * M _{at} / I _p	
SW4 (B/4)	0.077	121.80 ft	14.44 k	5.44 k	
SW5 (B/5)	0.077	73.80 ft	8.75 k	3.29 k	
SW6 (B/6)	0.077	25.80 ft	3.06 k	1.15 k	
SW 7 (B/7)	0.769	-22.20 ft	-26.25 k	9.88 k	
Σ			0.00 k	19.77 k	

Tier 5 Spanning North/South					
Base Shear, V =		229 k		(Calculated in Step 11)	
Torsional Moment, M _t =		3,865 k*ft			
North/South Structure Width =		120.66 ft			
Acc. Torsional Moment, M _{at} =		1,381 k*ft			
Polar Moment of Stiffness, I _p =		1,935 ft ²			
	R _y	Δx _{bar}	Torsional Shear, V _t	Acc. Tors. Shear, V _{at}	
			V _t = R _y * Δx _{bar} * M _t / I _p	V _{at} = R _y * Δx _{bar} * M _{at} / I _p	
SW4 (B/4)	0.074	122.65 ft	18.16 k	6.49 k	
SW5 (B/5)	0.074	74.65 ft	11.05 k	3.95 k	
SW6 (B/6)	0.074	26.65 ft	3.95 k	1.41 k	
SW 7 (B/7)	0.778	-21.35 ft	-33.15 k	11.85 k	
Σ			0.00 k	23.70 k	

Tier 6 Spanning North/South					
Base Shear, V =		258 k		(Calculated in Step 11)	
Torsional Moment, M _t =		4,682 k*ft			
North/South Structure Width =		120.66 ft			
Acc. Torsional Moment, M _{at} =		1,556 k*ft			
Polar Moment of Stiffness, I _p =		1,903 ft ²			
	R _y	Δx _{bar}	Torsional Shear, V _t	Acc. Tors. Shear, V _{at}	
			V _t = R _y * Δx _{bar} * M _t / I _p	V _{at} = R _y * Δx _{bar} * M _{at} / I _p	
SW4 (B/4)	0.073	123.11 ft	21.96 k	7.30 k	
SW5 (B/5)	0.073	75.11 ft	13.40 k	4.45 k	
SW6 (B/6)	0.073	27.11 ft	4.84 k	1.61 k	
SW 7 (B/7)	0.782	-20.89 ft	-40.20 k	13.36 k	
Σ			0.00 k	26.73 k	

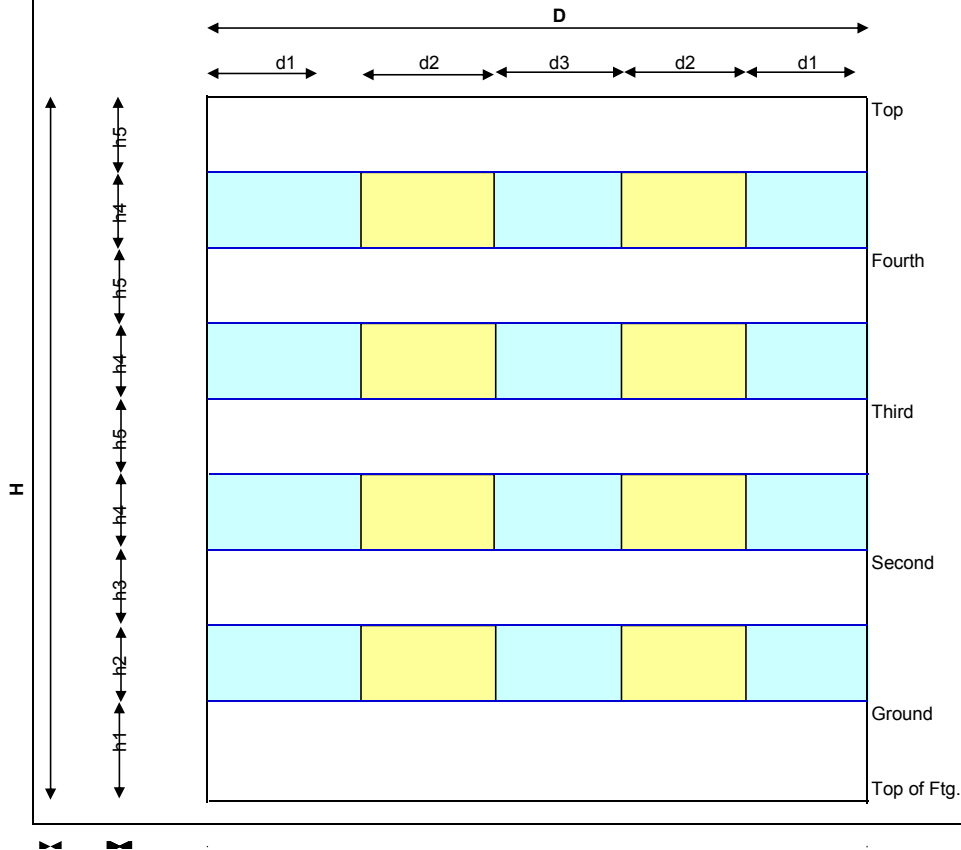
Level	Fir-Fir. Height
B1	11
G	11.25
2nd	11.5
3rd	11.5
4th	11.5
5th	11.5
6th	9.5
	77.75

7) **DETERMINE SHEARWALL RIGIDITIES & STIFFNESSES**

Utilizing 'Reinforced Masonry Design', 3rd edition 1994 by Schneider & Dickey: Section 'Rigidities of Fixed & Cantilever Piers (Pages 449-456)

Shearwall Deflection = (Deflection of Entire Solid Wall) - (Deflection of Opening Strip) + (Deflection of Fixed Piers)

Stiffness, $k = 1 / \text{Deflection}$



Shearwall Rigidity

Interior Shearwall (Longer)

*NOTE: If shear walls do not have the same thickness, use one wall as "datum" and multiply stiffness of other wall by thickness proportions.

Deflection of Entire Solid Wall Cantilever (Delta c) =

a)	LEVEL B1	H (ft)	11.00	Delta c1 =	0.108	
		D (ft)	30	Stiffness, k =	9.252	(1/Delta C)
		H/D	0.367			
	LEVEL G	H (ft)	22.25	Delta c1 =	0.321	
		D (ft)	30	Stiffness, k =	3.113	(1/Delta C)
		H/D	0.742			
	LEVEL 2	H (ft)	33.75	Delta c1 =	0.755	
		D (ft)	30	Stiffness, k =	1.324	(1/Delta C)
		H/D	1.125			
	LEVEL 3	H (ft)	45.25	Delta c1 =	1.520	
		D (ft)	30	Stiffness, k =	0.658	(1/Delta C)
		H/D	1.508			
	LEVEL 4	H (ft)	56.75	Delta c1 =	2.727	
		D (ft)	30	Stiffness, k =	0.367	(1/Delta C)
		H/D	1.892			
	LEVEL 5	H (ft)	68.25	Delta c1 =	4.490	
		D (ft)	30	Stiffness, k =	0.223	(1/Delta C)
		H/D	2.275			
	LEVEL 6	H (ft)	77.75	Delta c1 =	6.445	
		D (ft)	30	Stiffness, k =	0.155	(1/Delta C)
		H/D	2.592			

Subtract Cantilever Deflection for Entire Strip at Openings (Delta c) =

b)	LEVEL B1 (existing)	h2 (ft)	0.001	Delta c2 =	0.000	
		D (ft)	30	Stiffness, k =	120000.000	(1/Delta C)
		H/D	0.000			
	LEVEL G (existing)	h4 (ft)	0.001	Delta c2 =	0.000	
		D (ft)	30	Stiffness, k =	60000.000	(1/Delta C)
		H/D	0.000			
	LEVEL 2	h2 (ft)	3.5	Delta c2 =	0.030	
		D (ft)	30	Stiffness, k =	33.656	(1/Delta C)
		H/D	0.117			
	LEVEL 3	h2 (ft)	6.5	Delta c2 =	0.087	
		D (ft)	30	Stiffness, k =	11.459	(1/Delta C)
		H/D	0.217			
	LEVEL 4	h2 (ft)	6.5	Delta c2 =	0.145	
		D (ft)	30	Stiffness, k =	6.905	(1/Delta C)
		H/D	0.217			
	LEVEL 5	h2 (ft)	6.5	Delta c2 =	0.202	
		D (ft)	30	Stiffness, k =	4.941	(1/Delta C)
		H/D	0.217			
	LEVEL 6	h2 (ft)	6.5	Delta c2 =	0.260	
		D (ft)	30	Stiffness, k =	3.847	(1/Delta C)
		H/D	0.217			

Add Fixed End Deflection of Remaining Piers (Delta f) =

c) LEVEL B1	h2 (ft)	0.001	Delta f =	0.000	
	d1 (ft)	30	Stiffness, k =	120000.000	(1/Delta f)
	H/D	0.000	Areas =	1	<----- number of piers
			Combo k =	120000.000	
			Total Delta f =	0.000	
LEVEL G	h2 (ft)	0.001	Delta f =	0.000	
	d1 (ft)	30	Stiffness, k =	120000.000	(1/Delta f)
	H/D	0.000	Areas =	1	
			Combo k =	120000.000	
			Total Delta f =	0.000	
LEVEL 2	h2 (ft)	3.5	Delta f =	0.162	
	d1 (ft)	6	Stiffness, k =	6.159	(1/Delta f)
	H/D	0.583	Areas =	3	
			Combo k =	18.477	
			Total Delta f =	0.054	
LEVEL 3	h4 (ft)	6.5	Delta f =	0.377	
	d1 (ft)	6	Stiffness, k =	2.654	(1/Delta f)
	H/D	1.083	Areas =	3	
			Combo k =	7.963	
			Total Delta f =	0.180	
LEVEL 4	h4 (ft)	6.5	Delta f =	0.377	
	d1 (ft)	6	Stiffness, k =	2.654	(1/Delta f)
	H/D	1.083	Areas =	3	
			Combo k =	7.963	
			Total Delta f =	0.305	
LEVEL 5	h4 (ft)	6.5	Delta f =	0.377	
	d1 (ft)	6	Stiffness, k =	2.654	(1/Delta f)
	H/D	1.083	Areas =	3	
			Combo k =	7.963	
			Total Delta f =	0.431	
LEVEL 6	h4 (ft)	6.5	Delta f =	0.377	
	d1 (ft)	6	Stiffness, k =	2.654	(1/Delta f)
	H/D	1.083	Areas =	3	
			Combo k =	7.963	
			Total Delta f =	0.556	

Obtain Shearwall Deflection

d)		Delta c1	Delta c2	Delta f	Deflection	Stiffness
	Level B1	0.108	0.000	0.000	0.108	9.252
	Level G	0.321	0.000	0.000	0.321	3.113
	Level 2	0.755	0.030	0.054	0.780	1.282
	Level 3	1.520	0.087	0.180	1.612	0.620
	Level 4	2.727	0.145	0.305	2.888	0.346
	Level 5	4.490	0.202	0.431	4.718	0.212
	Level 6	6.445	0.260	0.556	6.741	0.148

Shearwall Rigidity

Interior Shearwall (Shorter)

Deflection of Entire Solid Wall Cantilever (Delta c) =

a)	LEVEL B1	H (ft)	11.00	Delta c1 =	0.413	
		D (ft)	13	Stiffness, k =	2.420	(1/Delta C)
		H/D	0.846			
	LEVEL G	H (ft)	22.25	Delta c1 =	2.097	
		D (ft)	13	Stiffness, k =	0.477	(1/Delta C)
		H/D	1.712			
	LEVEL 2	H (ft)	33.75	Delta c1 =	6.476	
		D (ft)	13	Stiffness, k =	0.154	(1/Delta C)
		H/D	2.596			
	LEVEL 3	H (ft)	45.25	Delta c1 =	14.914	
		D (ft)	13	Stiffness, k =	0.067	(1/Delta C)
		H/D	3.481			
	LEVEL 4	H (ft)	56.75	Delta c1 =	28.793	
		D (ft)	13	Stiffness, k =	0.035	(1/Delta C)
		H/D	4.365			
	LEVEL 5	H (ft)	68.25	Delta c1 =	49.499	
		D (ft)	13	Stiffness, k =	0.020	(1/Delta C)
		H/D	5.250			
	LEVEL 6	H (ft)	77.75	Delta c1 =	72.734	
		D (ft)	13	Stiffness, k =	0.014	(1/Delta C)
		H/D	5.981			

Subtract Cantilever Deflection for Entire Strip at Openings (Delta c) =

b)	LEVEL B1 (existing)	h2 (ft)	0.001	Delta c2 =	0.000	
		D (ft)	13	Stiffness, k =	52000.000	(1/Delta C)
		H/D	0.000			
	LEVEL G (existing)	h4 (ft)	0.001	Delta c2 =	0.000	
		D (ft)	13	Stiffness, k =	26000.000	(1/Delta C)
		H/D	0.000			
	LEVEL 2	h2 (ft)	0.001	Delta c2 =	0.000	
		D (ft)	13	Stiffness, k =	17333.333	(1/Delta C)
		H/D	0.000			
	LEVEL 3	h2 (ft)	0.001	Delta c2 =	0.000	
		D (ft)	13	Stiffness, k =	13000.000	(1/Delta C)
		H/D	0.000			
	LEVEL 4	h2 (ft)	0.001	Delta c2 =	0.000	
		D (ft)	13	Stiffness, k =	10400.000	(1/Delta C)
		H/D	0.000			
	LEVEL 5	h2 (ft)	0.001	Delta c2 =	0.000	
		D (ft)	13	Stiffness, k =	8666.667	(1/Delta C)
		H/D	0.000			
	LEVEL 6	h2 (ft)	0.001	Delta c2 =	0.000	
		D (ft)	13	Stiffness, k =	7428.571	(1/Delta C)
		H/D	0.000			

Add Fixed End Deflection of Remaining Piers (Delta f) =

c) LEVEL B1	h2 (ft)	0.001	Delta f =	0.000	
	d1 (ft)	13	Stiffness, k =	52000.000	(1/Delta f)
	H/D	0.000	Areas =	1	<----- number of piers
			Combo k =	52000.000	
			Total Delta f =	0.000	
LEVEL G	h2 (ft)	0.001	Delta f =	0.000	
	d1 (ft)	13	Stiffness, k =	52000.000	(1/Delta f)
	H/D	0.000	Areas =	1	
			Combo k =	52000.000	
			Total Delta f =	0.000	
LEVEL 2	h2 (ft)	0.001	Delta f =	0.000	
	d1 (ft)	13	Stiffness, k =	52000.000	(1/Delta f)
	H/D	0.000	Areas =	1	
			Combo k =	52000.000	
			Total Delta f =	0.000	
LEVEL 3	h4 (ft)	0.001	Delta f =	0.000	
	d1 (ft)	13	Stiffness, k =	52000.000	(1/Delta f)
	H/D	0.000	Areas =	1	
			Combo k =	52000.000	
			Total Delta f =	0.000	
LEVEL 4	h4 (ft)	0.001	Delta f =	0.000	
	d1 (ft)	13	Stiffness, k =	52000.000	(1/Delta f)
	H/D	0.000	Areas =	1	
			Combo k =	52000.000	
			Total Delta f =	0.000	
LEVEL 5	h4 (ft)	0.001	Delta f =	0.000	
	d1 (ft)	13	Stiffness, k =	52000.000	(1/Delta f)
	H/D	0.000	Areas =	1	
			Combo k =	52000.000	
			Total Delta f =	0.000	
LEVEL 6	h4 (ft)	0.001	Delta f =	0.000	
	d1 (ft)	13	Stiffness, k =	52000.000	(1/Delta f)
	H/D	0.000	Areas =	1	
			Combo k =	52000.000	
			Total Delta f =	0.000	

Obtain Shearwall Deflection

d)		Delta c1	Delta c2	Delta f	Deflection	Stiffness
	Level B1	0.413	0.000	0.000	0.413	2.420
	Level G	2.097	0.000	0.000	2.097	0.477
	Level 2	6.476	0.000	0.000	6.476	0.154
	Level 3	14.914	0.000	0.000	14.914	0.067
	Level 4	28.793	0.000	0.000	28.793	0.035
	Level 5	49.499	0.000	0.000	49.499	0.020
	Level 6	72.734	0.000	0.000	72.734	0.014

DETERMINE RELATIVE SHEARWALL RIGIDITIES

WEST Structure

SPANNING NORTH/SOUTH DIRECTION

Shearwall Force Distribution

LEVEL B1	Shearwall	Stiffness	% Distributed (Ry)
	SW1 (B/2)	9.252	0.657
	SW2 (B/3)	2.420	0.172
	SW3 (B/4)	2.420	0.172
		14.092	1.000
LEVEL G	Shearwall	Stiffness	% Distributed (Ry)
	SW1 (B/2)	3.113	0.765
	SW2 (B/3)	0.477	0.117
	SW3 (B/4)	0.477	0.117
		4.066	1.000
LEVEL 2	Shearwall	Stiffness	% Distributed (Ry)
	SW1 (B/2)	1.282	0.806
	SW2 (B/3)	0.154	0.097
	SW3 (B/4)	0.154	0.097
		1.591	1.000
LEVEL 3	Shearwall	Stiffness	% Distributed (Ry)
	SW1 (B/2)	0.620	0.822
	SW2 (B/3)	0.067	0.089
	SW3 (B/4)	0.067	0.089
		0.754	1.000
LEVEL 4	Shearwall	Stiffness	% Distributed (Ry)
	SW1 (B/2)	0.346	0.833
	SW2 (B/3)	0.035	0.084
	SW3 (B/4)	0.035	0.084
		0.416	1.000
LEVEL 5	Shearwall	Stiffness	% Distributed (Ry)
	SW1 (B/2)	0.212	0.840
	SW2 (B/3)	0.020	0.080
	SW3 (B/4)	0.020	0.080
		0.252	1.000
LEVEL 6	Shearwall	Stiffness	% Distributed (Ry)
	SW1 (B/2)	0.148	0.844
	SW2 (B/3)	0.014	0.078
	SW3 (B/4)	0.014	0.078
		0.176	1.000

EAST Structure

SPANNING NORTH/SOUTH DIRECTION

Shearwall Force Distribution

LEVEL B1	Shearwall	Stiffness	% Distributed (Ry)
	SW4 (B/4)	2.420	0.147
	SW5 (B/5)	2.420	0.147
	SW6 (B/6)	2.420	0.147
	SW 7 (B/7)	9.252	0.560
		16.511	1.000
LEVEL G	Shearwall	Stiffness	% Distributed (Ry)
	SW4 (B/4)	0.477	0.105
	SW5 (B/5)	0.477	0.105
	SW6 (B/6)	0.477	0.105
	SW 7 (B/7)	3.113	0.685
		4.543	1.000
LEVEL 2	Shearwall	Stiffness	% Distributed (Ry)
	SW4 (B/4)	0.154	0.088
	SW5 (B/5)	0.154	0.088
	SW6 (B/6)	0.154	0.088
	SW 7 (B/7)	1.282	0.735
		1.746	1.000
LEVEL 3	Shearwall	Stiffness	% Distributed (Ry)
	SW4 (B/4)	0.067	0.082
	SW5 (B/5)	0.067	0.082
	SW6 (B/6)	0.067	0.082
	SW 7 (B/7)	0.620	0.755
		0.821	1.000
LEVEL 4	Shearwall	Stiffness	% Distributed (Ry)
	SW4 (B/4)	0.035	0.077
	SW5 (B/5)	0.035	0.077
	SW6 (B/6)	0.035	0.077
	SW 7 (B/7)	0.346	0.769
		0.451	1.000
LEVEL 5	Shearwall	Stiffness	% Distributed (Ry)
	SW4 (B/4)	0.020	0.074
	SW5 (B/5)	0.020	0.074
	SW6 (B/6)	0.020	0.074
	SW 7 (B/7)	0.212	0.778
		0.273	1.000
LEVEL 6	Shearwall	Stiffness	% Distributed (Ry)
	SW4 (B/4)	0.014	0.073
	SW5 (B/5)	0.014	0.073
	SW6 (B/6)	0.014	0.073
	SW 7 (B/7)	0.148	0.782
		0.190	1.000

11) DISTRIBUTE DIRECT, TORSIONAL, AND ACCIDENTAL TORSIONAL SHEAR

WEST Structure

North/South Direction

$C_s = 0.052$
 $W = 16159 \text{ k}$
 $V = C_s * W = 840 \text{ k}$
 $C_{vx} = (W_x h_x^k) / \sum (W_i h_i^k) \text{ (note } k=1 \text{ for } T < 0.5s)$
 $V_x = C_{vx} * V$

Level	W_x	h_x	$W_x h_x^k$	C_{vx}	V_x	Shearwall Panel (Longer) SW1					Total Shear	0.7Eh
						Relative Rigidity	Direct Shear	Torsional Shear	Acc. Torsional Shear			
6th	2273 k	81.50 ft	185,256	0.243	204 k	0.84	172.4 k	-6.51 k	15.13 k		194.0 k	135.8 k
5th	2330 k	70.00 ft	163,117	0.214	180 k	0.84	151.1 k	-4.93 k	13.32 k		169.4 k	118.6 k
4th	2330 k	58.50 ft	136,319	0.179	150 k	0.83	125.3 k	-3.19 k	11.12 k		139.6 k	97.7 k
3rd	2330 k	47.00 ft	109,521	0.144	121 k	0.82	99.3 k	-1.42 k	8.92 k		109.7 k	76.8 k
2nd	2327 k	35.50 ft	82,602	0.108	91 k	0.81	73.4 k	0.14 k	6.71 k		80.3 k	56.2 k
G	2320 k	24.00 ft	55,673	0.073	61 k	0.77	47.0 k	2.19 k	4.49 k		53.7 k	37.6 k
B1	2248 k	13.00 ft	29,229	0.038	32 k	0.66	21.2 k	3.55 k	2.31 k		27.0 k	18.9 k
Σ	16159 k		761,716	1.000	840 k		689.7 k	-10.2 k	62.0 k		773.7 k	541.6 k

**To be conservative, torsional / acc. tor. are assumed to be positive

Level	Typical Shearwall Panel (Shorter) SW 2					Total Shear	0.7Eh
	Relative Rigidity	Direct Shear	Torsional Shear	Acc. Torsional Shear			
6th	0.08	16.0 k	1.97 k	4.58 k		22.5 k	15.8 k
5th	0.08	14.4 k	1.49 k	4.02 k		19.9 k	13.9 k
4th	0.08	12.6 k	0.96 k	3.33 k		16.9 k	11.8 k
3rd	0.09	10.7 k	0.42 k	2.65 k		13.8 k	9.7 k
2nd	0.10	8.8 k	-0.04 k	1.97 k		10.9 k	7.6 k
G	0.12	7.2 k	-0.62 k	1.27 k		9.1 k	6.4 k
B1	0.17	5.5 k	-0.87 k	0.57 k		7.0 k	4.9 k
Σ		75.3 k	3.3 k	18.4 k		100.0 k	70.0 k

Level	Shearwall Panel (Shorter) SW3					Total Shear	0.7Eh
	Relative Rigidity	Direct Shear	Torsional Shear	Acc. Torsional Shear			
6th	0.08	16.0 k	4.54 k	10.55 k		31.1 k	21.8 k
5th	0.08	14.4 k	3.44 k	9.30 k		27.1 k	19.0 k
4th	0.08	12.6 k	2.23 k	7.78 k		22.6 k	15.8 k
3rd	0.09	10.7 k	1.00 k	6.27 k		18.0 k	12.6 k
2nd	0.10	8.8 k	-0.10 k	4.74 k		13.7 k	9.6 k
G	0.12	7.2 k	-1.57 k	3.23 k		12.0 k	8.4 k
B1	0.17	5.5 k	-2.68 k	1.74 k		10.0 k	7.0 k
Σ		75.3 k	6.9 k	43.6 k		134.4 k	94.1 k

East/West Direction

$C_s = 0.044$
 $W = 16159 \text{ k}$
 $V = C_s * W = 703 \text{ k}$
 $C_{vx} = (W_x h_x^k) / \sum (W_i h_i^k) \text{ (note } k=1 \text{ for } T < 0.5s)$
 $V_x = C_{vx} * V$

Level	W_x	h_x	$W_x h_x^k$	C_{vx}	V_x	Typical Lightwall Bay					Total Shear	0.7Eh
						Relative Rigidity	Direct Shear	Torsional Shear	Acc. Torsional Shear			
6th	2273 k	81.50 ft	185,256	0.243	171 k	0.50	85.5 k	0.00 k	0.00 k		85.5 k	59.8 k
5th	2330 k	70.00 ft	163,117	0.214	151 k	0.50	75.3 k	0.00 k	0.00 k		75.3 k	52.7 k
4th	2330 k	58.50 ft	136,319	0.179	126 k	0.50	62.9 k	0.00 k	0.00 k		62.9 k	44.0 k
3rd	2330 k	47.00 ft	109,521	0.144	101 k	0.50	50.5 k	0.00 k	0.00 k		50.5 k	35.4 k
2nd	2327 k	35.50 ft	82,602	0.108	76 k	0.50	38.1 k	0.00 k	0.00 k		38.1 k	26.7 k
G	2320 k	24.00 ft	55,673	0.073	51 k	0.50	25.7 k	0.00 k	0.00 k		25.7 k	18.0 k
B1	2248 k	13.00 ft	29,229	0.038	27 k	0.50	13.5 k	0.00 k	0.00 k		13.5 k	9.4 k
Σ	16159 k		761,716	1.000	703 k		351.5 k	0.0 k	0.0 k		351.5 k	246.0 k

EAST Structure

North/South Direction

$C_s = 0.052$
 $W = 20549 \text{ k}$
 $V = C_s * W = 1069 \text{ k}$
 $C_{vx} = (W_x h_x^k) / \sum (W_i h_i^k) \text{ (note } k=1 \text{ for } T < 0.5s)$
 $V_x = C_{vx} * V$

Level	W_x	h_x	$W_x h_x^k$	C_{vx}	V_x	Shearwall Panel (Shorter) SW 4				
						Relative Rigidity	Direct Shear	Torsional Shear	Acc. Torsional Shear	Total Shear
6th	2858 k	81.50 ft	232,954	0.241	258 k	0.07	18.7 k	21.96 k	7.30 k	48.0 k
5th	2954 k	70.00 ft	206,799	0.214	229 k	0.07	17.0 k	18.16 k	6.49 k	41.6 k
4th	2954 k	58.50 ft	172,825	0.179	191 k	0.08	14.8 k	14.44 k	5.44 k	34.6 k
3rd	2954 k	47.00 ft	138,851	0.144	154 k	0.08	12.5 k	10.70 k	4.39 k	27.6 k
2nd	2954 k	35.50 ft	104,877	0.109	116 k	0.09	10.3 k	7.04 k	3.33 k	20.6 k
G	2947 k	24.00 ft	70,721	0.073	78 k	0.10	8.2 k	3.06 k	2.28 k	13.6 k
B1	2927 k	13.00 ft	38,048	0.039	42 k	0.15	6.2 k	-0.81 k	1.29 k	8.3 k
Σ	20549 k		965,074	1.000	1069 k		87.6 k	74.6 k	30.5 k	194.3 k

**To be conservative, torsional / acc. tor. are assumed to be positive

Level	Shearwall Panel (Shorter) SW 5					Total Shear	0.7Eh
	Relative Rigidity	Direct Shear	Torsional Shear	Acc. Torsional Shear			
6th	0.07	18.7 k	13.40 k	4.45 k		36.6 k	25.6 k
5th	0.07	17.0 k	11.05 k	3.95 k		32.0 k	22.4 k
4th	0.08	14.8 k	8.75 k	3.29 k		26.8 k	18.8 k
3rd	0.08	12.5 k	6.44 k	2.64 k		21.6 k	15.1 k
2nd	0.09	10.3 k	4.19 k	1.98 k		16.4 k	11.5 k
G	0.10	8.2 k	1.77 k	1.32 k		11.3 k	7.9 k
B1	0.15	6.2 k	-0.43 k	0.68 k		7.3 k	5.1 k
Σ		87.6 k	45.2 k	18.3 k		152.0 k	106.4 k

Level	Shearwall Panel (Shorter) SW 6					Total Shear	0.7Eh
	Relative Rigidity	Direct Shear	Torsional Shear	Acc. Torsional Shear			
6th	0.07	18.7 k	4.84 k	1.61 k		25.2 k	17.6 k
5th	0.07	17.0 k	3.95 k	1.41 k		22.3 k	15.6 k
4th	0.08	14.8 k	3.06 k	1.15 k		19.0 k	13.3 k
3rd	0.08	12.5 k	2.17 k	0.89 k		15.6 k	10.9 k
2nd	0.09	10.3 k	1.34 k	0.63 k		12.2 k	8.6 k
G	0.10	8.2 k	0.48 k	0.36 k		9.1 k	6.3 k
B1	0.15	6.2 k	-0.05 k	0.07 k		6.3 k	4.4 k
Σ		87.6 k	15.8 k	6.1 k		109.6 k	76.8 k

Level	Shearwall Panel (Longer) SW 7					Total Shear	0.7Eh
	Relative Rigidity	Direct Shear	Torsional Shear	Acc. Torsional Shear			
6th	0.78	201.8 k	-40.20 k	13.36 k		255.4 k	178.8 k
5th	0.78	178.1 k	-33.15 k	11.85 k		223.1 k	156.1 k
4th	0.77	147.1 k	-26.25 k	9.88 k		183.2 k	128.3 k
3rd	0.76	116.1 k	-19.31 k	7.91 k		143.3 k	100.3 k
2nd	0.73	85.3 k	-12.57 k	5.95 k		103.8 k	72.7 k
G	0.69	53.7 k	-5.31 k	3.96 k		62.9 k	44.0 k
B1	0.56	23.6 k	1.28 k	2.04 k		26.9 k	18.8 k
Σ		805.6 k	-135.5 k	55.0 k		998.6 k	699.1 k

East/West Direction

$C_s = 0.044$
 $W = 20549 \text{ k}$
 $V = C_s * W = 894 \text{ k}$
 $C_{vx} = (W_x h_x^k) / \sum (W_i h_i^k) \text{ (note } k=1 \text{ for } T < 0.5s)$
 $V_x = C_{vx} * V$

Level	W_x	h_x	$W_x h_x^k$	C_{vx}	V_x	Typical Lightwall Bay				
						Relative Rigidity	Direct Shear	Torsional Shear	Acc. Torsional Shear	Total Shear
6th	2858 k	81.50 ft	232,954	0.241	216 k	0.33	71.9 k	0.00 k	0.00 k	71.9 k
5th	2954 k	70.00 ft	206,799	0.214	192 k	0.33	63.8 k	0.00 k	0.00 k	63.8 k
4th	2954 k	58.50 ft	172,825	0.179	160 k	0.33	53.4 k	0.00 k	0.00 k	53.4 k
3rd	2954 k	47.00 ft	138,851	0.144	129 k	0.33	42.9 k	0.00 k	0.00 k	42.9 k
2nd	2954 k	35.50 ft	104,877	0.109	97 k	0.33	32.4 k	0.00 k	0.00 k	32.4 k
G	2947 k	24.00 ft	70,721	0.073	66 k	0.33	21.8 k	0.00 k	0.00 k	21.8 k
B1	2927 k	13.00 ft	38,048	0.039	35 k	0.33	11.7 k	0.00 k	0.00 k	11.7 k
Σ	20549 k		965,074	1.000	894 k		297.9 k	0.0 k	0.0 k	297.9 k

Overturning Moment Analysis

WEST Structure

Shearwall Panel (Longer) SW1		
Level	Height	Shear
6th	79.50 ft	194.0 k
5th	68.00 ft	169.4 k
4th	56.50 ft	139.6 k
3rd	45.00 ft	109.7 k
2nd	33.50 ft	80.3 k
G	22.00 ft	53.7 k
B1	11.00 ft	27.0 k
M _{OT}	43932 k*ft	

x 0.75 for reduction = 32949 k*ft

Typical Shearwall Panel (Shorter) SW 2		
Level	Height	Shear
6th	79.50 ft	22.5 k
5th	68.00 ft	19.9 k
4th	56.50 ft	16.9 k
3rd	45.00 ft	13.8 k
2nd	33.50 ft	10.9 k
G	22.00 ft	9.1 k
B1	11.00 ft	7.0 k
M _{OT}	5358 k*ft	

x 0.75 for reduction = 4019 k*ft

Shearwall Panel (Shorter) SW3		
Level	Height	Shear
6th	79.50 ft	31.1 k
5th	68.00 ft	27.1 k
4th	56.50 ft	22.6 k
3rd	45.00 ft	18.0 k
2nd	33.50 ft	13.7 k
G	22.00 ft	12.0 k
B1	11.00 ft	10.0 k
M _{OT}	7234 k*ft	

x 0.75 for reduction = 5426 k*ft

Typical Lightwall Bay		
Level	Height	Shear
6th	79.50 ft	85.5 k
5th	68.00 ft	75.3 k
4th	56.50 ft	62.9 k
3rd	45.00 ft	50.5 k
2nd	33.50 ft	38.1 k
G	22.00 ft	25.7 k
B1	11.00 ft	13.5 k
M _{OT}	19732 k*ft	

x 0.75 for reduction = 14799 k*ft

EAST Structure

Shearwall Panel (Shorter) SW 4		
Level	Height	Shear
6th	79.50 ft	48.0 k
5th	68.00 ft	41.6 k
4th	56.50 ft	34.6 k
3rd	45.00 ft	27.6 k
2nd	33.50 ft	20.6 k
G	22.00 ft	13.6 k
B1	11.00 ft	8.3 k
M _{OT}	10925 k*ft	

x 0.75 for reduction = 8194 k*ft

Shearwall Panel (Shorter) SW 5		
Level	Height	Shear
6th	79.50 ft	36.6 k
5th	68.00 ft	32.0 k
4th	56.50 ft	26.8 k
3rd	45.00 ft	21.6 k
2nd	33.50 ft	16.4 k
G	22.00 ft	11.3 k
B1	11.00 ft	7.3 k
M _{OT}	8447 k*ft	

x 0.75 for reduction = 6336 k*ft

Shearwall Panel (Shorter) SW 6		
Level	Height	Shear
6th	79.50 ft	25.2 k
5th	68.00 ft	22.3 k
4th	56.50 ft	19.0 k
3rd	45.00 ft	15.6 k
2nd	33.50 ft	12.2 k
G	22.00 ft	9.1 k
B1	11.00 ft	6.3 k
M _{OT}	5970 k*ft	

x 0.75 for reduction = 4478 k*ft

Shearwall Panel (Longer) SW 7		
Level	Height	Shear
6th	79.50 ft	255.4 k
5th	68.00 ft	223.1 k
4th	56.50 ft	183.2 k
3rd	45.00 ft	143.3 k
2nd	33.50 ft	103.8 k
G	22.00 ft	62.9 k
B1	11.00 ft	26.9 k
M _{OT}	57431 k*ft	

x 0.75 for reduction = 43073 k*ft

Typical Lightwall Bay		
Level	Height	Shear
6th	79.50 ft	71.9 k
5th	68.00 ft	63.8 k
4th	56.50 ft	53.4 k
3rd	45.00 ft	42.9 k
2nd	33.50 ft	32.4 k
G	22.00 ft	21.8 k
B1	11.00 ft	11.7 k
M _{OT}	16697 k*ft	

x 0.75 for reduction = 12523 k*ft

Vertical Seismic Load Analysis

$$E_v = 0.2 S_{DS} D$$

$$S_{DS} = 0.208$$

	D	E _v
Lightwall Panel (West)	4315.1k	180 k
Lightwall Panel (East)	6472.6k	270 k
Shearwall (Longer) SW1	1432.4 k	60 k
Shearwall (Longer) SW7	1432.4 k	60 k

Location	D	L	S	E_H	E_V	$E_{M(OT)}$
Wall "G"	380 kips	120 kips	10 kips			
Wall "H"	540 kips	130 kips	30 kips			
Wall "F"	350 kips	160 kips	10 kips			
Wall "A"	110 kips	0 kips	0 kips			
Wall "B"	170 kips	0 kips	0 kips			
Wall "C"	300 kips	0 kips	0 kips			
Wall "D"	160 kips	0 kips	10 kips			
Wall "E"	230 kips	60 kips	10 kips			
Wall "I"	300 kips	0 kips	0 kips			
A/2	1070 kips	300 kips	40 kips			
A/3	1210 kips	340 kips	50 kips			
A/4	640 kips	170 kips	30 kips			
B/1	1340 kips	340 kips	40 kips			
SW 1	1440 kips	340 kips	40 kips	774 kips	60 kips	43932k-ft
SW 2	0 kips	0 kips	0 kips	100 kips	0 kips	5358k-ft
SW 3	0 kips	0 kips	0 kips	134 kips	0 kips	7234k-ft
LW	45 klf	15 klf	2 klf	246 kips	180 kips	19732k-ft
C/1	1120 kips	220 kips	40 kips			
C/2	1070 kips	300 kips	40 kips			
C/3	1210 kips	340 kips	50 kips			
C/4	640 kips	170 kips	30 kips			

Notes:

- 1) All loads are unfactored.
- 2) Center Lightwall lateral loads are in East-West direction.
- 3) Exterior Shearwall lateral loads are in North-South direction.
- 4) Seismic loads are per lightwall panel. There are 2 panels across the garage between grids 2&4, each 48' long. (i.e. total base shear across length of entire wall is $2 \times E_H$)

Location	D	L	S	E _H	E _V	E _{M(OT)}
A/4	640 kips	170 kips	30 kips			
A/5	1210 kips	340 kips	50 kips			
A/6	1210 kips	340 kips	50 kips			
A/7	930 kips	260 kips	40 kips			
Wall "O"	580 kips	170 kips	20 kips			
Wall "L"	700 kips	160 kips	30 kips			
Wall "K"	300 kips	110 kips	10 kips			
Wall "J"	300 kips	0 kips	10 kips			
Wall "M"	300 kips	0 kips	0 kips			
Wall "N"	300 kips	0 kips	0 kips			
SW 4	0 kips	0 kips	0 kips	194 kips	0 kips	10925k-ft
SW 5	0 kips	0 kips	0 kips	152 kips	0 kips	8447k-ft
SW 6	0 kips	0 kips	0 kips	110 kips	0 kips	5970k-ft
SW 7	1440 kips	340 kips	40 kips	999 kips	60 kips	57431k-ft
LW	45 klf	15 klf	2 klf	298 kips	270 kips	16697k-ft
B/8	1350 kips	330 kips	40 kips			
C/4	640 kips	170 kips	30 kips			
C/5	1210 kips	340 kips	50 kips			
C/6	1210 kips	340 kips	50 kips			
C/7	1070 kips	300 kips	40 kips			
C/8	1120 kips	220 kips	40 kips			

Notes:

- 1) All loads are unfactored.
- 2) Center Lightwall lateral loads are in East-West direction.
- 3) Exterior Shearwall lateral loads are in North-South direction.
- 4) Seismic loads are per lightwall panel. There are 3 panels across the garage between grids 4&7, each 48' long. (i.e. total base shear across length of entire wall is 3 x E_H)

WIND LOADING CALCULATIONS

Summary of Calculation Methods

Using: ASCE 7-10, Chapter 26: General Requirements
 ASCE 7-10, Chapter 27: MWFRS Directional Procedure for Buildings of All Heights
 ASCE 7-10, Chapter 30: Components and Cladding, Part 1: Low Rise Buildings

Procedures: ASCE 7-10, Figure 26.1-1
 ASCE 7-10, Table 27.2-1
 ASCE 7-10, Table 30.4-1

1. Assumptions Made:

Risk Category II
 Partially Enclosed
 Rigid Building
 Non-hurricane prone region
 No topographic features

2. Wind Load Parameters

Basic Wind Speed, $V = 115$ mph (ASCE 7-10, Figure 26.5-1A)
 $K_d = 0.85$ (ASCE 7-10, Table 26.6-1)
 Exposure Category = B (ASCE 7-10, Section 26.7)
 $K_{zt} = 1.0$ (ASCE 7-10, Section 26.8.2)
 $G = 0.85$ (ASCE 7-10, Section 26.9.1)
 $GC_{pi} = +/- 0.55$ (ASCE 7-10, Table 26.11-1)

3. Velocity Pressure

$$K_z = 2.01 (z/z_g)^{2/\alpha} \quad (\text{ASCE 7-10, Table 27.3-1})$$

$$\alpha = 7.0 \quad (\text{ASCE 7-10, Table 26.9-1})$$

$$z_g = 1200 \text{ ft} \quad (\text{ASCE 7-10, Table 26.9-1})$$

$$q_z = 0.00256 K_z K_{zt} K_d V^2 \quad (\text{ASCE 7-10, Equation 27.3-1})$$

Level	z	K_z	q_z
Tier 2	11.50 ft	0.57	16.54 psf
Tier 3	23.00 ft	0.65	18.69 psf
Tier 4	34.50 ft	0.73	20.98 psf
Tier 5	46.00 ft	0.79	22.78 psf
Tier 6	57.50 ft	0.84	24.28 psf

* $q_h = q_z$ @ Top Tier (q_z @ Height $z=h$)

4. Design Wind Pressure

Components & Cladding

$h < 60$ ft, Flat Roof

$$GC_{pi} = +/- 0.55 \quad (\text{ASCE 7-10, Table 26.11-1})$$

$$GC_p \quad (\text{Using ASCE 7-10, Figures 30.4-1 \& 30.4-2A})$$

	GC_p (Max)	GC_p (Min)	$ GC_p + GC_{pi} $	$ GC_p - GC_{pi} $
Zone 1	0.3	-1.0	0.85	1.55
Zone 2	0.9	-1.8	1.45	2.35
Zone 3	0.9	-1.8	1.45	2.35
Zone 4	0.9	-0.99	1.45	1.54
Zone 5	0.9	-1.26	1.45	1.81

$$p = q_h [GC_p - GC_{pi}] \quad (\text{ASCE 7-10, Equation 30.4-1})$$

C&C Design Wind Pressure		
Roof	Zone 1	37.63 psf
	Zone 2	57.06 psf
	Zone 3	57.06 psf
Walls	Zone 4	37.39 psf
	Zone 5	43.95 psf

* $p = 16$ psf min.