Letter of Transmittal

November 17, 2014

Ali Said
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Dear Doctor Said,

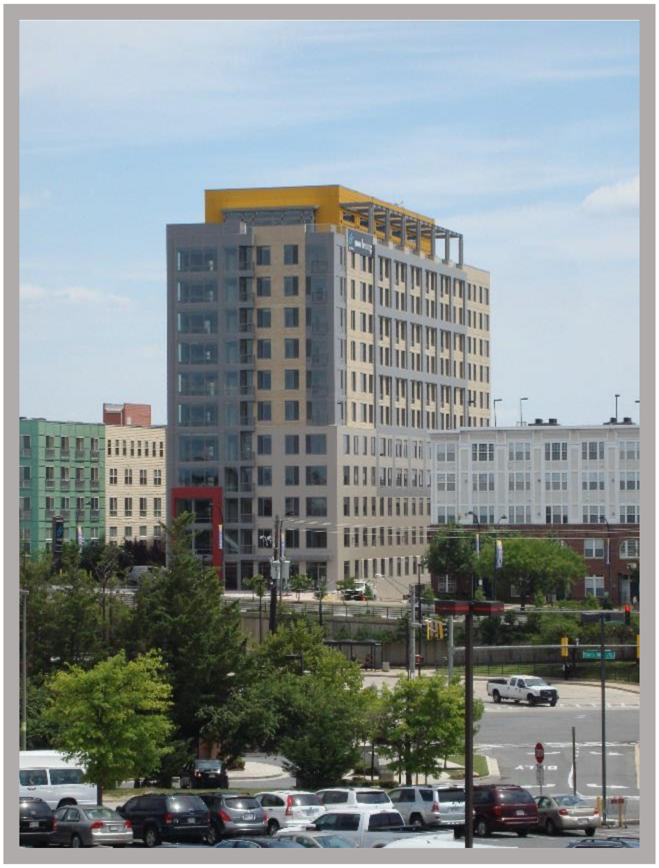
The following technical report fulfills the fourth Technical Report assigned by the structural faculty for senior thesis.

Technical Report 4 includes a structural analysis of the lateral system in 11141 Georgia Ave in Wheaton, MD. Included is a list of codes and documents used to compile this report. A review of the lateral load calculations and values is included as well as typical member spot checks for lateral loads and lateral load modeling.

Thank you for your time in reviewing this report. I look forward to hearing your feedback and discussing it with you.

Sincerely,
Samantha deVries

Enclosed: Technical Report 4



11141 Georgia Avenue

Located in Wheaton, MD

Technical Report 4

Samantha deVries

Structural Option

Advisor: Ali Said

November 17, 2014

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Executive Summary

11141 Georgia Avenue, located in Wheaton, MD, is a 1960's concrete office building on which a 7-story steel addition was completed in August 2014 for $20 million. The building is a high rise apartment building with one and two bedroom studios, a rooftop terrace and penthouse, and is conveniently located next to the metro station.

The Foundations are spread footings with piers and a foundation retaining wall where the building steps from the lowest basement level to the next. Modifications were required to the foundations and slab on grade only where a new elevator pit was added and the old pit was removed.

The structure of the original building is reinforced concrete with typical two-way concrete slab bays that are approximately 22' by 21'. Again, the slabs in the original building only required modifications where new stairwells and elevators were added and the original ones were removed. The addition's structure is framed in structural steel with rolled W-shapes for the columns, girders, and beams, and composites joists for the bays in the floors and on the roof. Each floor has metal deck with a concrete topping.

The lateral system consists of concrete moment frames in the original structure, and steel moment frames in the new structure. Some columns were expanded for additional stiffness to resist an increase in lateral loads due to an increased building height.

There are many joints and connections that involved tying the new columns, beams, and other structural elements into the original building through drilling a hole to embed and grout rebar, anchors, or other connections.

The loads used in the structural design on the project all followed IBC 2009, which allows the use of ASCE 7-05. Due to a change in building use which allows a smaller reduced live load, the removal of the original penthouse, and the use of steel rather than concrete for the addition, the total loads reaching the foundations were close to the original 1960's design loads.

Purpose

The Purpose of this report is to analyze the lateral system in 11141 Georgia Avenue in Wheaton, MD. Both hand methods and a three-dimensional computer model analysis will be used to compare to each other. These results will be used for the purpose of understanding how lateral loads are distributed in the building as well as spot checking a lateral frame for strength and drift. The lateral system analysis will be further used to guide the upcoming proposal for redesign work during the upcoming spring semester.

11141 Georgia Avenue: High Rise Residential Apartments
Located in: Wheaton, MD

Building Statistics

Full Height: 158 Feet
Number of Stories: 14
Size: 179,760 GSF Square Feet
Cost: $44 Million (for the addition)
Construction Dates: February 2013 - August 2014
Project Delivery Method: Contractor at Risk

Project Team

Owner: ML Wheaton, LLC c/o Lower Enterprises
General Contractor and CM: Whiting-Turner
Architect: Bonstra Haresign Architects, LLP
Structure: Rathgeber/Goss Associates
Mechanical: Brothers Ductwork HVAC, Inc.
Plumbing: KNI Engineering, Inc.
Lighting Design: Gilmore Lighting Design

Photo of building from nearby parking garage roof: Photo taken by Samantha deVries

Structural Systems

- Original Concrete Building
  - Concrete moment frames
  - Concrete floor slabs
  - Spread footings and retaining walls
- New Addition
  - Steel moment frames
  - Lightweight composite floor joists with deck
- Loads
  - Original loads for office building
  - New live loads smaller for residential
- Renovation Work
  - New stairwell and elevator locations
  - New utility openings
  - Façade modifications

Photo of typical apartment: Photo courtesy of The George (Apartment)

Architecture

- 5 story 1960's office building
- 7 story addition
- High rise apartment building with one and two bedroom studios.

Construction

- Underpin Foundations
- Renovations work in existing building
- Construct addition directly above existing

Mechanical

- Cooling by rooftop chiller condensing units
- Units have occupant operable windows
- Heating by electrical heaters and heat pumps.

Electrical/Lighting

- Recessed lighting in apartments
- Pendant and wall mounted fixtures in lobbies
- 2 Main Power Distributers fed from a transformer
- One 1400 KVA and one 1750 KVA

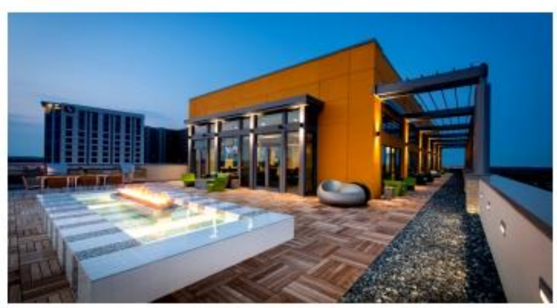


Photo of rooftop terrace: Photo courtesy of The George (Apartment)

Samantha deVries: Structural Option
Advisor: Ali Said

Project Sponsor: Rathgeger/Goss Associates
https://www.engr.psu.edu/ae/thesis/portfolios/2015/sjd5225/deVries_AE_Thesis/Home.html

Site Plan and Location of Building

11141 Georgia Ave is Located in Wheaton Maryland near the Wheaton Metro Station. To the west of the site is a mainly commercial zone, while to the east is a residential zone. The site itself is combined commercial-residential. Figures 1 and 2 below illustrate the building's location.

Figure 1: Building Location on Site, Courtesy of Bonstra Haresign Architects

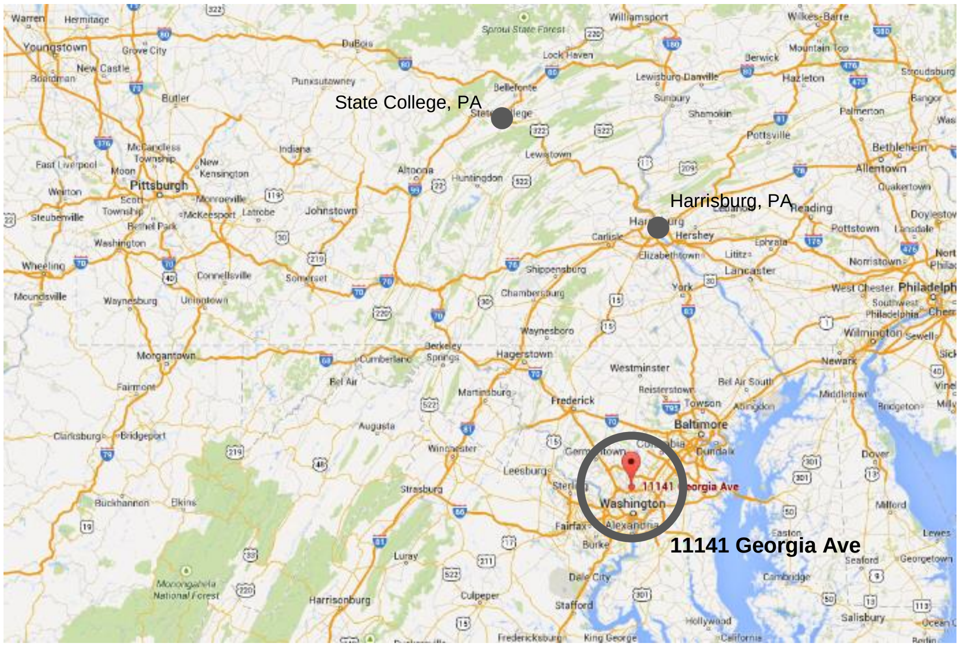


Figure 2: Map showing building location relative to State College and Harrisburg

Documents used during preparation of report

The following is a list of the structural codes used on the project. The codes used in the original 1962 drawings were not available. The codes used on the new addition to and renovation of the original building will be the referenced codes in this technical report.

International Code Council

International Building Code 2009

American Society of Civil Engineers

ASCE 7-05: Minimum Design Loads for Buildings and Other Structures

American Concrete Institute

ACI 318-11

American Institute of Steel Construction

AISC Steel Manual 14th Edition

Vulcraft Deck Catalog

Steel Joist Institute

Standard Specifications for Composite Steel Joists

Previous Course Notes

Concrete Design (AE 402)

Advanced Concrete Design (AE 431)

Advanced Steel Design (AE 403)

Computer Modeling of Building Structures (AE 530)

Gravity Loads Summary

Below is a summary of the gravity loads calculated in Technical Report 2:

Roof Dead Load (Penthouse) = 27 psf

Roof Dead Load (12th Level Terrace) = 98 psf

Roof Live Load (Penthouse) = 30 psf

Roof Live Load (12th Level Terrace) = 100 psf

Snow Load = 20 psf with max drift of 65 psf

Floor Dead Load (steel) = 75 psf

Floor Dead Load (concrete) = 105 psf for 6.5" slab

= 123 psf for 8" slab

Floor Live Load = 40 psf (Residential, Parking, Corridors above 1st level)

= 100 psf (Lobbies, Stairs, Exits)

Exterior Wall (original) = 992 plf

Exterior Wall (metal panels) = 443 plf

Exterior Wall (new brick) = 487 plf

At drop panels = 9 psf (additional to slab)

Wind Loads Summary

The following section includes a summary of the wind loads calculated in Technical Report 2. Below is the general wind design information.

B = 60 ft

L = 214 ft

Basic Wind Speed = 90 mph

Mean Height = 145 ft

Occupancy Category II

Exposure Category B

Topographic Factor = 1

Gust Effect Factor = 0.85

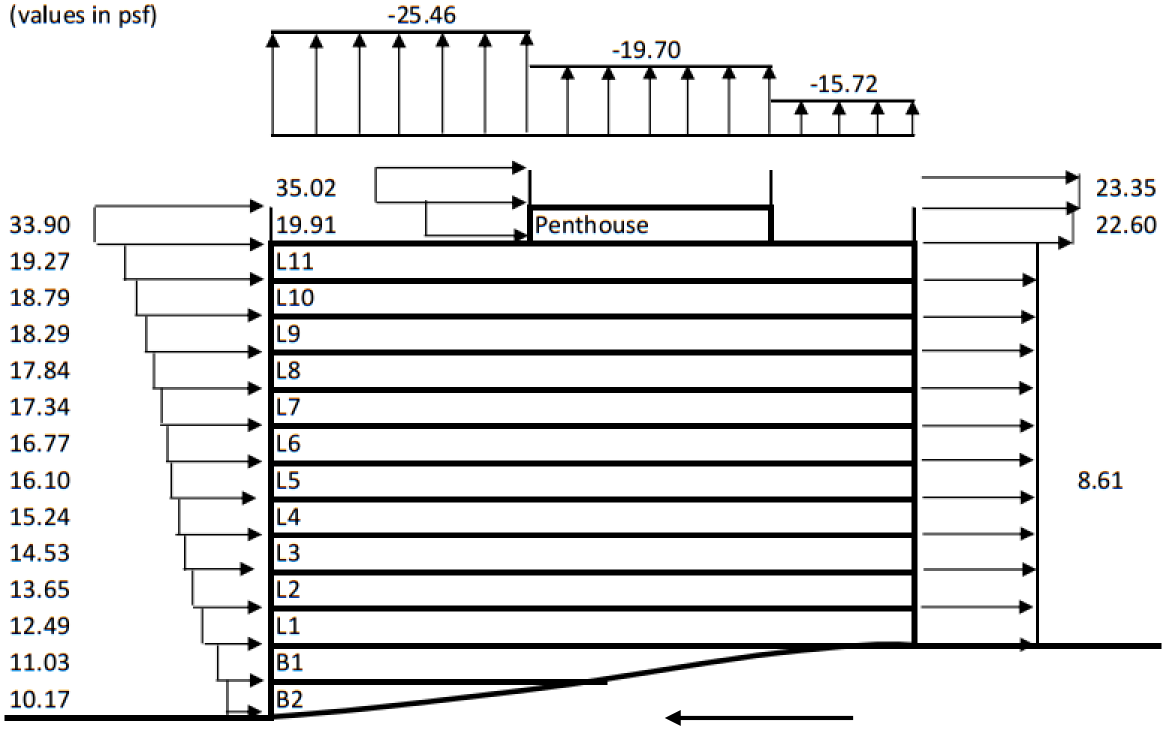
Wind Load at each level = $q_z G_f C_p - q_i (+/- GC_{pi})$

Base Shear = $\sum (P_{level\ i} * H_{story} * B \text{ or } L)$

Overturning Moment = $\sum (P_{level\ i} * H_{story} * B \text{ or } L * \text{distance from base at level})$

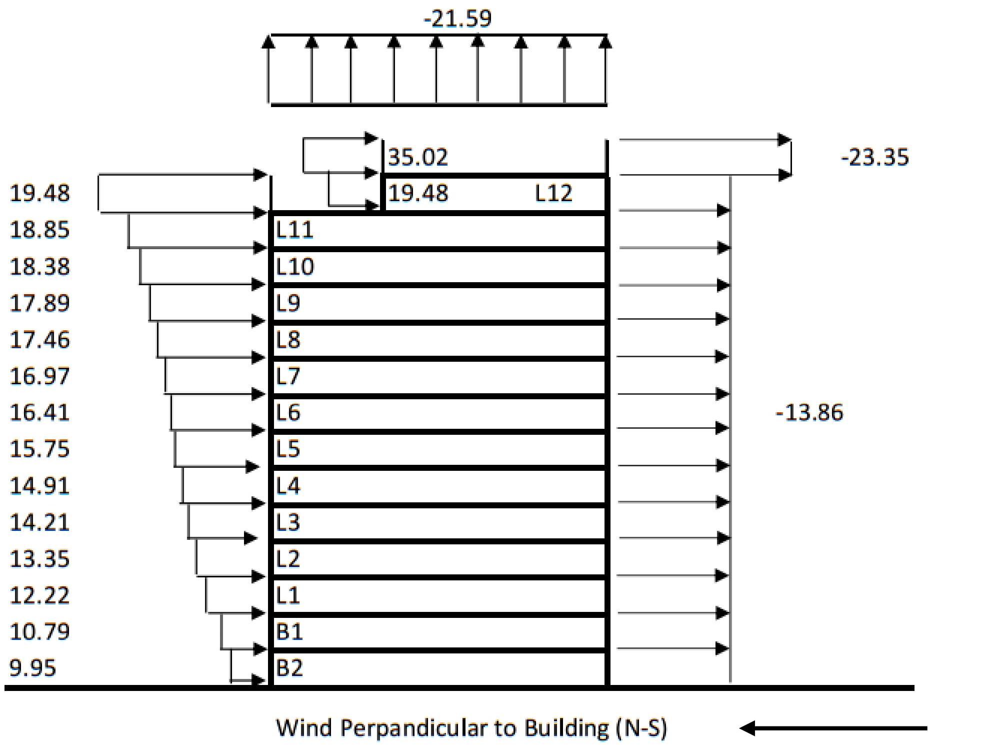
The Following Page includes a summary of the wind loads determined at each level and the Base Shear. Technical Report 2 determined that wind loads control over seismic loads for lateral.

Wind Diagrams
(values in psf)



Wind Parallel to Building (E-W)

Base Shear = 227 kips



Wind Perpandicular to Building (N-S)

Base Shear = 964 kips

Seismic Loads Summary

The following section includes a summary of the seismic loads calculated in Technical Report 2. Below is the general seismic design information.

Site Class C

S_S = 0.155g

S_1 = 0.050g

S_{DS} = 0.124g

S_{D1} = 0.057g

Seismic Design Category A

Total Seismic Weight = 20,864 kip

Response Modification Factor = 3.0

Ta = 1.4s

TL = 5.5S

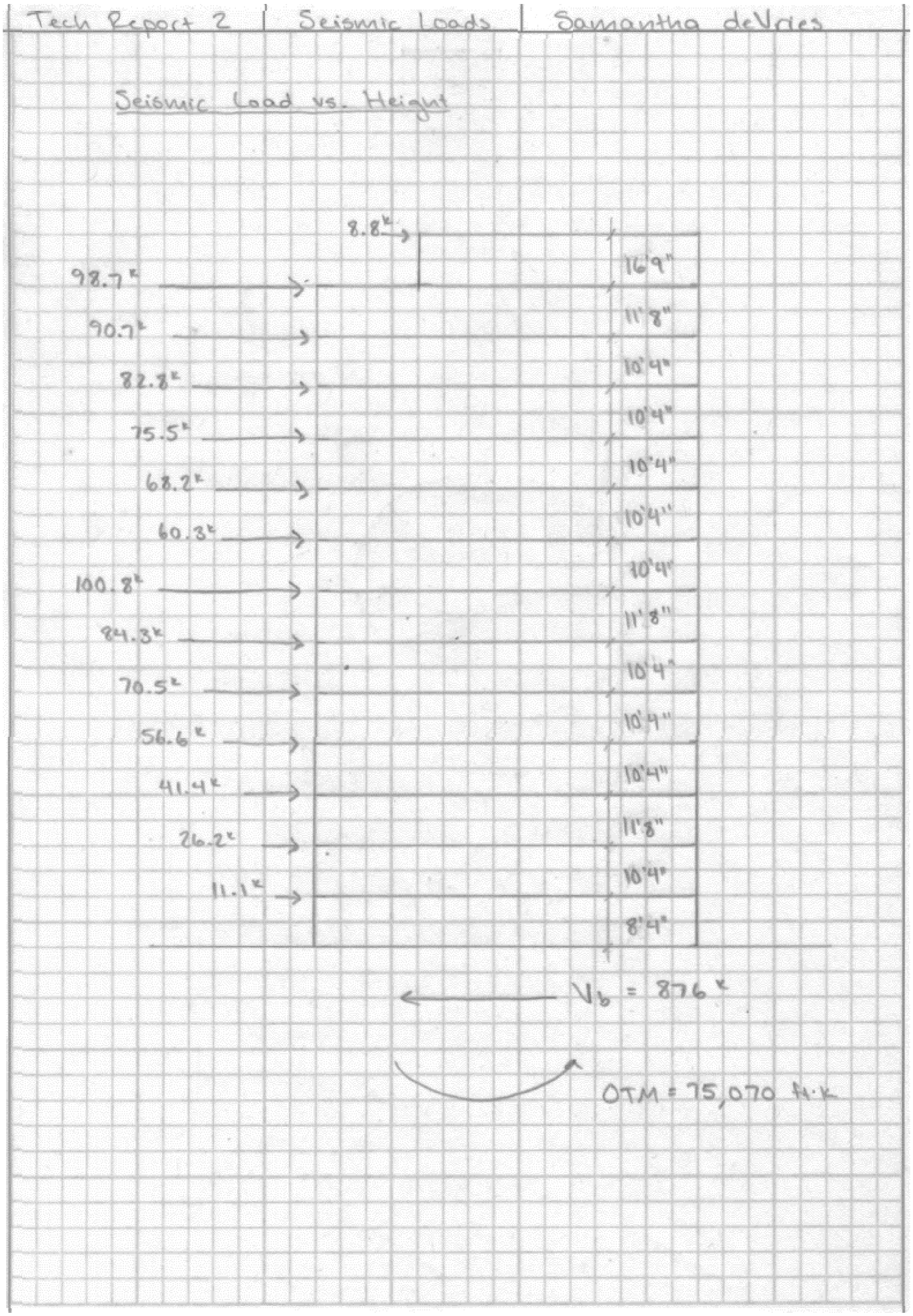
C_S = 0.116

Seismic Load at each level = $V * (w_x h_x^k / \sum w_i h_i^k)$

Base Shear = $\sum (P_{level\ i})$

Overturning Moment = $\sum$ ($P_{level\ i}$ * distance from base at level)

The Following Page includes a summary of the seismic loads determined at each level and the Base Shear and overturning moment. Technical Report 2 determined that wind loads control over seismic loads for lateral.


Tech Report 2
Seismic Loads
Samantha deVries
Seismic Load vs. Height
8.8k
98.7k
90.7k
82.8k
75.5k
68.2k
60.3k
100.8k
84.3k
70.5k
56.6k
41.4k
26.2k
11.1k
16'9"
11'8"
10'4"
10'4"
10'4"
10'4"
10'4"
11'8"
10'4"
10'4"
10'4"
11'8"
10'4"
8'4"
Vb = 876k
OTM = 75,070 ft·k

Lateral Load Modeling

Lateral loads in 11141 Georgia Ave were analyzed using a combination of hand methods and software analysis.

Hand Methods Overview and Assumptions

Hand calculations were completed by determining the stiffness of the frames relative to each other and then distributing loads based on relative stiffness at each level. Since wind was the controlling case over seismic, only wind was considered in the hand methods. Seismic will be studied in addition to wind in the 3D computer model. The distributed load at each level is the shear force at that level, which was found by converting the wind pressures into a point force at each level and summing up the total force at a given level and all of the levels above it. The next few pages include the calculation process, a chart of relative stiffness of the frames and walls, the shear loads used for distribution, and the final loads in the frames and shear walls at each level. Additional calculation charts and plans with the lateral elements highlighted and labeled for reference in the calculations are available in the Appendix.

Tech Report 4 | Samantha deVries

2D Frame Modeling & Load Distribution Process

Step 1: Model 2D Lateral Frames in ETABS and apply equal unit force to each

Step 2: Run program analysis and find drift for each frame. Compare drifts to obtain a relative stiffness for each frame:

$$R_{\text{for base frame}} = 1.0$$

$$R_{\text{other frames}} = \frac{\Delta x_{\text{base}}}{\Delta x_{\text{frame}}}$$

Step 3: Determine Center of Rigidity and Center of Mass

$$\bar{x}_R = \frac{\Sigma R_y x}{\Sigma R_y} \qquad \bar{y}_R = \frac{\Sigma R_x y}{\Sigma R_x}$$

$$\bar{x}_{cm} = \frac{\Sigma W x}{\Sigma W} \qquad \bar{y}_{cm} = \frac{\Sigma W y}{\Sigma W}$$

Step 4: Determine Torsional Rigidity

$$J = \Sigma R_i d_i^2 = \Sigma R_x d_y^2 + \Sigma R_y d_x^2$$

Step 5: Determine Direct Shear

$$V_d = \frac{R_i}{\Sigma R_i} V$$

Step 6: Determine V_t due to torsional moment

$$M_t = \text{Torsional Moment} = Ve$$

$$V_t = \frac{M_t}{J}(R_i d_i)$$

$$e = \text{eccentricity} = (\bar{x}_R - \bar{x}_{cm}) \times 1.15$$

where 1.15 multiplier gives 15% allowance for accidental eccentricity

$$d_i = \text{dist.} \perp \text{ from COR}$$

Note: $P_{\text{level } i} = \left[v_a\left(\frac{h_a}{2}\right) + v_b\left(\frac{h_b}{2}\right)\right] \times \frac{L \text{ or } B}{1000}$; where v = wind load (psf)
subscript$_a$ = story above level
subscript$_b$ = story below level

$V_{\text{level } i} = P_{\text{level } i} + \Sigma P_{\text{levels above } i}$

Steel Addition Frame Stiffness						
Frame	Drift due to Unit Force			Relative Stiffness		
	Typ. Level	Level 12	Penthouse	Typ. Level	Level 12	Penthouse
A	0.261	0.245	N/A	1.34	1.83	N/A
B	0.261	0.245	N/A	1.34	1.83	N/A
C	0.237	0.306	0.516	1.47	1.46	1.91
D	0.349	0.448	0.733	1.00	1.00	1.35
E	0.261	0.241	0.988	1.34	1.86	1.00
F	0.261	0.241	0.988	1.34	1.86	1.00
G	0.261	0.245	N/A	1.34	1.83	N/A
H	0.261	0.245	N/A	1.34	1.83	N/A

Concrete Portion Frame and Wall Stiffness							
Concrete Frames		Typical Level		Level 1		Level B1	
		Disp.	Rel. Stiffness	Disp.	Rel. Stiffness	Disp.	Rel. Stiffness
1		5.01	2.3	2.58	1.3	N/A	N/A
2		1.14	10.1	0.74	4.4	0.32	4.1
3		5.01	2.3	3.29	1.0	1.30	1.0
4		1.14	10.1	0.74	4.4	0.32	4.1
Shear Walls							
East to West	a	0.310	37.2	0.074	44.4	0.024	54.2
	b	0.751	15.4	0.297	11.1	0.094	13.8
	c	1.463	7.9	0.340	9.7	0.172	7.6
	d	11.538	1.0	2.654	1.2	1.260	1.0
	e	0.435	26.5	0.175	18.8	0.058	22.4
	l	N/A	N/A	0.161	20.4	0.026	50.0
	m	N/A	N/A	N/A	N/A	0.172	7.6
	o	N/A	N/A	N/A	N/A	0.172	7.6
North to South	f	1.029	11.2	0.404	8.1	0.125	10.4
	g	1.029	11.2	0.404	8.1	0.125	10.4
	h	0.131	88.1	0.055	59.7	0.023	56.5
	i	1.029	11.2	0.404	8.1	0.125	10.4
	j	1.029	11.2	0.404	8.1	0.125	10.4
	k	N/A	N/A	0.113	29.1	0.040	32.5
	n	5.9	N/A	N/A	N/A	0.048	27.1
	p	N/A	N/A	N/A	N/A	0.048	27.1
Base-ment Walls	1	N/A	N/A	0.0015	2190.0	0.0015	866.7
	2	N/A	N/A	0.0015	2190.0	0.0015	866.7
	3	N/A	N/A	0.0008	4106.3	0.0012	1083.3
	4	N/A	N/A	0.0015	2190.0	0.0015	866.7

For both concrete and steel portions: Relative stiffness was found by designating the highest drift frame as having a relative stiffness of 1, and the relative stiffness of all other frames was found by dividing the base frame deflection by the deflection of each frame.

Story Shear due to Wind Loads (Controlling Lateral Load)				
Level	X-direction		Y-direction	
	Load (psf)	Load (kips)	Load (psf)	Load (kips)
PH		20.40		73.41
	19.91		19.48	
12		49.42		182.87
	19.27		18.85	
11		66.51		254.45
	18.79		18.38	
10		83.28		324.98
	18.29		17.89	
9		99.77		394.49
	17.84		17.46	
8		115.96		462.98
	17.34		16.97	
7		131.82		530.32
	16.77		16.41	
6		147.30		596.31
	16.1		15.75	
5		162.31		660.65
	15.24		14.91	
4		176.83		723.30
	14.53		14.21	
3		190.85		784.22
	13.65		13.35	
2		204.25		842.95
	12.49		12.22	
1		216.84		898.86
	11.03		10.79	
B1		228.71		952.27
	10.17		9.95	

Note: By Inspection, center of mass in steel addition is at the center of geometry because there are no shear walls and the structural elements are evenly and equally distributed in the floor plan.

Summary of Distributed Lateral Forces to Frames and Walls (kips)

Level	Steel Addtion							
	Steel Moment Frame							
	A	B	C	D	E	F	G	H
PH	N/A	N/A	9.7	14.6	42.1	48.5	N/A	N/A
12	36.3	37.0	29.8	20.5	32.2	33.8	34.9	36.4
11	51.7	49.9	40.3	27.6	43.9	45.7	47.5	49.2
10	65.9	63.6	50.5	34.6	56.1	58.3	60.6	62.8
9	79.8	77.1	60.5	41.5	68.0	70.8	73.5	76.1
8	93.6	90.4	70.4	48.2	79.8	83.0	86.2	89.2
7	107.1	103.4	80.0	54.8	91.4	95.0	98.7	102.1

Level	Concrete Portion			
	Concrete Moment Frames			
	1	2	3	4
6	29.1	73.4	31.7	107.0
5	32.2	81.3	35.1	118.5
4	35.2	89.0	38.4	129.7
3	38.2	96.5	41.6	140.6
2	41.0	103.7	44.7	151.1
1	0.1	0.9	0.0	0.9
B1	-	2.1	0.1	2.1

Level	CMU Shear Walls															
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
6	240.4	85.3	54.5	5.9	160.0	32.3	22.8	97.7	22.6	26.4	-	-	-	-	-	-
5	266.3	94.5	60.4	6.5	177.3	35.7	25.1	107.7	25.0	29.2	-	-	-	-	-	-
4	291.6	103.5	66.1	7.1	194.1	39.0	27.5	117.4	27.3	31.9	-	-	-	-	-	-
3	316.1	112.2	71.7	7.7	210.4	42.2	29.7	126.7	29.5	34.5	-	-	-	-	-	-
2	339.8	120.6	77.0	8.3	226.2	45.3	31.8	135.6	31.6	37.0	-	-	-	-	-	-
1	8.9	2.2	1.9	0.2	3.8	0.3	0.3	2.2	0.3	0.3	1.2	4.1	-	-	-	-
B1	27.3	7.0	3.8	0.5	11.2	1.3	1.2	6.6	1.2	1.2	4.4	25.1	3.8	2.9	3.8	3.1

Level	Concrete Basement Walls			
	1	2	3	4
1	78	442	189	442
B1	108.6	439.0	134	439.5

Computer Analysis Process and Assumptions

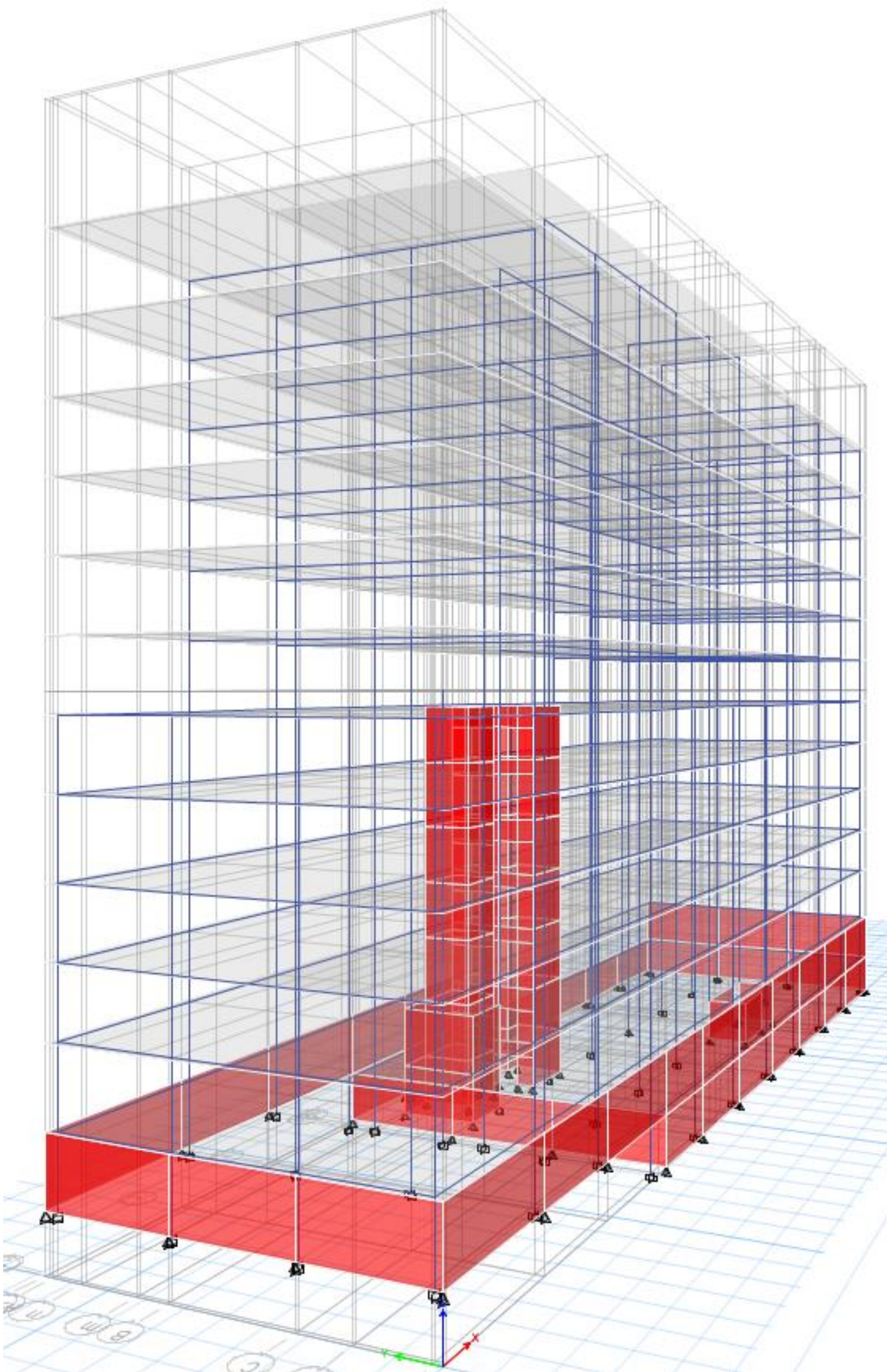
The building's full lateral system was modeled in ETABS with only lateral forces applied, with both wind loads and seismic loads included in the model. Gravity loads and members were neglected for the purpose of focusing the analysis on the lateral system. In addition to the wind and seismic loads, soil loads were applied to basement walls wherever applicable, using an at rest pressure of 60 psf per foot of depth per IBC 2009. Wind loads were applied to the center of pressure, seismic loads to the center of mass, and the soil loads were applied as a uniform area load to the applicable basement walls. A rigid diaphragm was modeled due to the rigid nature of the concrete slab in the original building and concrete on steel deck in the addition.

The elevator and stair core shear walls were modeled as concrete masonry unit walls, and the basement walls were modeled as poured concrete walls. Both wall types were modeled with a 0.35 Ig cracking modifier. The walls were also meshed using an automatic mesh with a mesh size no larger than 4 feet. Beams and columns were modeled as poured concrete, with a 0.35 Ig cracking modifier for the beams, and a 0.7 Ig modifier for the columns. There was a large variety of different beam sizes, so for simplification purposes, the beams were all modeled as an average size of 12 inches wide by 24 inches deep.

Fixities at the base included fixed connections for the concrete columns and pins at the edges of each mesh element in the basement and shear walls. All frames have fixed moment connections in all members. Going from the original concrete building to the steel addition, the connection of the steel columns to the concrete columns was considered pinned.

The following pages include drift checks, wind and seismic forces, base reactions, and an equilibrium check.

Image of ETABS model for Reference



Story Drift Checks

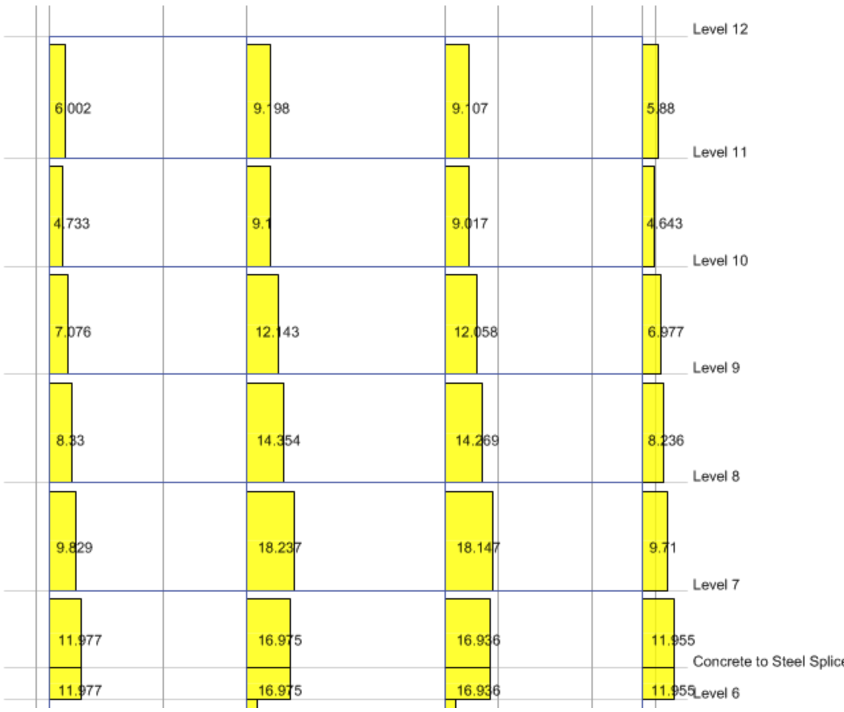
Wind				
Level	**Level Height (ft)**	**Max Service Drift (ft)**	**Drift Ratio**	**Acceptable?**
Penthouse	16.75	0.0586	1/ 286	No
12	11.67	0.0144	1/ 810	Yes
11	10.33	0.0163	1/ 634	Yes
10	10.33	0.0198	1/ 522	Yes
9	10.33	0.0237	1/ 436	Yes
8	10.33	0.0279	1/ 370	No
7	10.33	0.0322	1/ 321	No
Addition	80.07	0.1929	1/ 415	Yes
6	11.67	0.0039	1/ 3000	Yes
5	10.33	0.0042	1/ 2442	Yes
4	10.33	0.0041	1/ 2538	Yes
3	10.33	0.0039	1/ 2641	Yes
2	11.67	0.0031	1/ 3814	Yes
1	10.33	0.0001	1/ 178103	Yes
B1	8.33	0.0001	1/ 166600	Yes
Total	153.06	0.2122	1/ 721	Yes

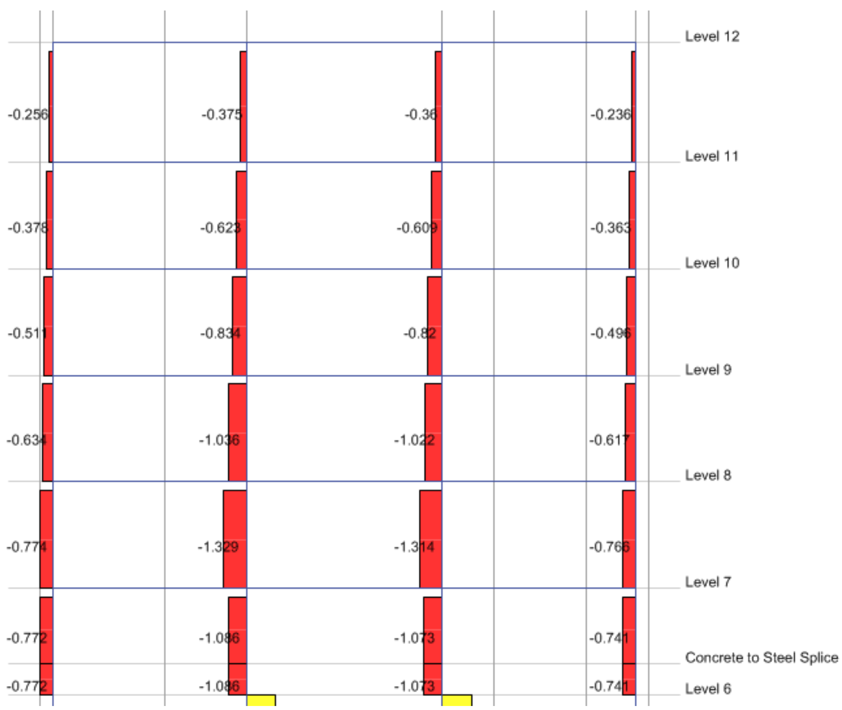
Seismic				
Level	**Level Height (ft)**	**Max Service Drift (ft)**	**Drift Ratio**	**Acceptable?**
Penthouse	16.75	0.0146	1/ 1147	Yes
12	11.67	0.0191	1/ 611	Yes
11	10.33	0.0252	1/ 410	Yes
10	10.33	0.0324	1/ 319	Yes
9	10.33	0.0400	1/ 258	Yes
8	10.33	0.0478	1/ 216	Yes
7	10.33	0.0555	1/ 186	Yes
Addition	80.07	0.2346	1/ 341	Yes
6	11.67	0.0065	1/ 1804	Yes
5	10.33	0.0069	1/ 1501	Yes
4	10.33	0.0065	1/ 1584	Yes
3	10.33	0.0061	1/ 1699	Yes
2	11.67	0.0046	1/ 2521	Yes
1	10.33	0.0001	1/ 101275	Yes
B1	8.33	0.0001	1/ 166600	Yes
Total	153.06	0.2653	1/ 577	Yes

Drift is checked against $0.02h_{sx}$ for seismic, where h_{sx} = story height below level x, and for l/400 for wind. Some of the individual steel stories do not meet the drift requirements for wind, however, the steel addition and overall building do meet drift requirements for both wind and seismic. The steel addition was modeled to have pinned connections at the base where it attaches to the original concrete building, but in reality, the connection has four bolts and will most likely take some moment, thus reducing the drift in those stories in the addition.

Shear in Frame G first due to wind, followed by seismic:

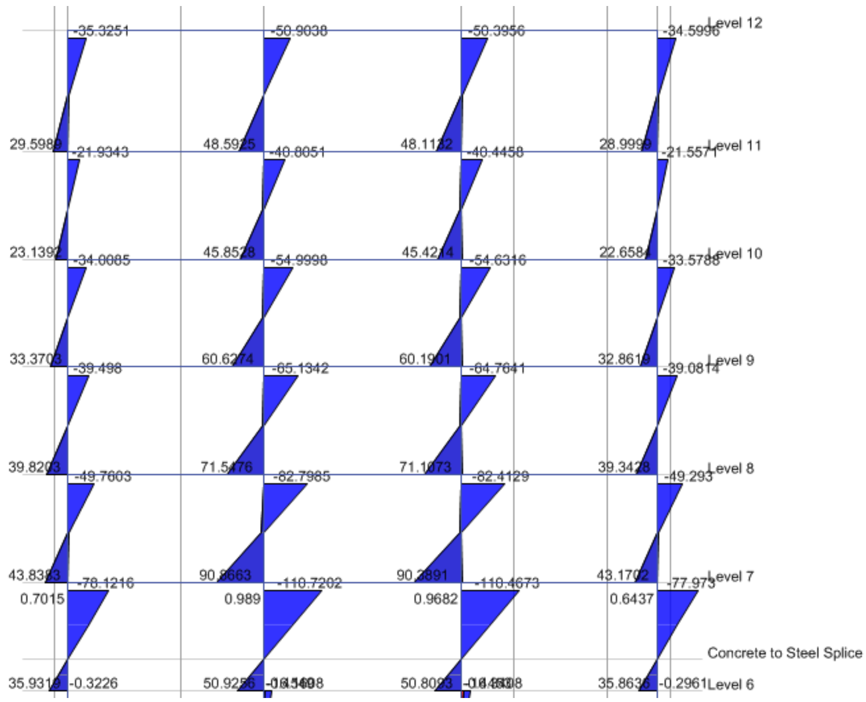
(Steel Moment Frame along Column Line 11)

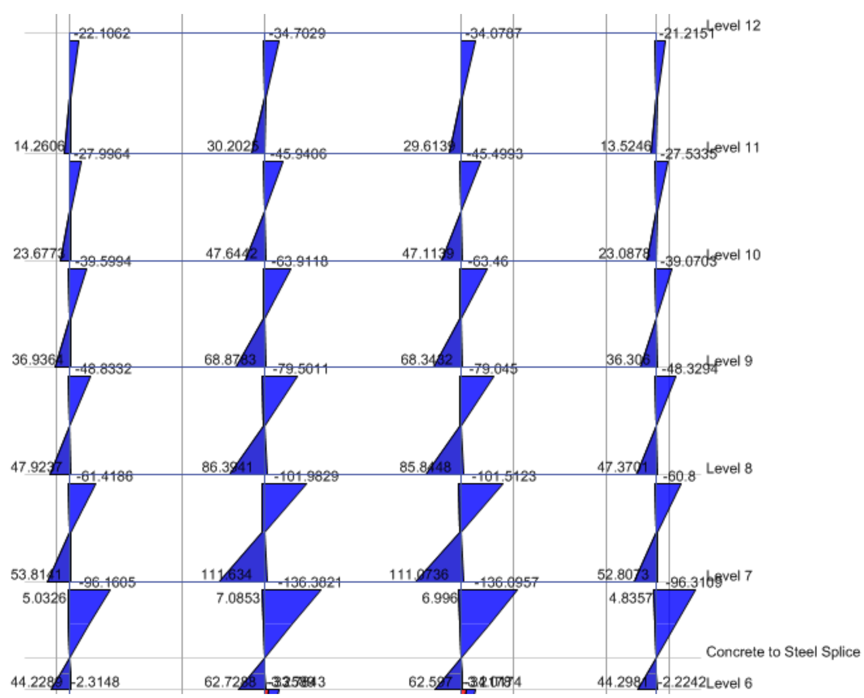




Moment in Frame G first due to wind, followed by seismic:

(Steel Moment Frame along Column Line 11)





Joint Reactions

ETABS Results						
Loading		**Fx (kips)**	**Fy (kips)**	**Mx (ft-kips)**	**My (ft-kips)**	**Mz (ft-kips)**
Seismic	x dir.	875.90	0	0	-75218	28851
	y dir.	0	875.90	75218	0	-108792
Wind	x dir.	-228.71	0	0	-12036	4228
	y dir.	0	-952.26	-41977	0	14739

Hand Calculations Results						
Loading		**Fx (kips)**	**Fy (kips)**	**Mx (ft-kips)**	**My (ft-kips)**	**Mz (ft-kips)**
Seismic	x dir.	876	0	0	75070	N/A
	y dir.	0	876	75070	0	N/A
Wind	x dir.	227	0	0	-12036	N/A
	y dir.	0	964	-41977	0	N/A

The joint reactions shown in the table above include force in the x and y directions and moment in the x, y, and z directions due to seismic and wind loading for both computer analysis and hand methods. The values found using both methods are very close, therefore verifying both processes.

Comparisons between Hand Methods and Computer Analysis

The following section contains some comparisons between results of the hand methods and the computer analysis including center of mass and center of rigidity and frame loads. Some discussion is included where results are not consistent between the two methods used.

COM and COR Comparison

Center of Mass												
Building	**Steel Addition**						**Concrete Portion**					
Level	**Typical Level**		**Penthouse**		**Level 12**		**Typical Level**		**Level 1**		**Level B1**	
Direction	x	y	x	y	x	y	x	y	x	y	x	y
ETABS	106.6	29.6	109.3	35.3	106.6	29.6	105.9	30.3	105.9	31.2	137.2	31.6
Hand Calc	107.0	30.0	110.0	38.0	107.0	30.0	106.5	31.6	104.0	31.4	137.4	31.7

Center of Rigidity												
Building	**Steel Addition**						**Concrete Portion**					
Level	**Typical Level**		**Penthouse**		**Level 12**		**Typical Level**		**Level 1**		**Level B1**	
Direction	x	y	x	y	x	y	x	y	x	y	x	y
ETABS	128.5	29.1	145.0	28.2	128.3	30.2	103.4	41.8	97.0	44.9	134.6	28.5
Hand Calc	133.3	27.8	161.2	31.3	133.5	27.9	102.0	44.6	138.5	30.4	146.3	31.1

All of the centers of mass for both the steel addition and the concrete portion are very close to each other when comparing the hand methods to the computer analysis, within a five percent difference, which shows that the results of the computer analysis verify the center of mass hand method calculations.

Most of the centers of rigidity are very similar between the hand methods and the computer analysis, again, mostly within five to ten percent. The center of rigidity of level 1 is very different between the 2 methods, which may be due to the simplifications made to the hand method calculations of the basement wall stiffness.

Frame Shear Comparison Checks (kips)

Steel Moment Frame G			
Level	**Hand Method**	**Computer Method**	**Ratio (Hand:Comp)**
11	34.9	30.2	1.15
10	47.5	27.5	1.73
9	60.6	38.3	1.58
8	73.5	45.2	1.63
7	86.2	55.9	1.54
6	98.7	57.8	1.71

Steel Moment Frame C			
Level	**Hand Method**	**Computer Method**	**Ratio (Hand:Comp)**
12	9.7	12.0	0.81
11	29.8	30.7	0.97
10	40.3	42.3	0.95
9	50.5	51.3	0.99
8	60.5	59.6	1.02
7	70.4	76.0	0.93
6	80.0	50.1	1.60

Concrete Moment Frame 3			
Level	**Hand Method**	**Computer Method**	**Ratio (Hand:Comp)**
6	31.7	26.0	1.22
5	35.1	26.3	1.33
4	38.4	29.0	1.32
3	41.6	28.0	1.48
2	44.7	35.5	1.26
1	0.0	8.7	0.00
B1	0.1	4.7	0.03

The shear in the frames was compared for a steel moment frame in both the x and y directions and for a concrete moment frame. The values of shear in frame C are fairly close among both methods, however the values for frames G and 3 are significantly larger using the hand method than the computer analysis. This could be due to difference in how the software analysis distributes the loads among the lateral frames relative to the simplified hand method of determining relative stiffness and distributing loads. Another reason behind the difference in values could be related to the effect of the pinned connection at the base of addition. Ultimately, all three frames followed similar loading patterns between the two methods.

Typical Member Spot Checks for Lateral Loads

Strength checks were completed for a critical column and a beam in the steel addition to the building. Both the column and the beam come from Frame C. This frame was chosen as a typical representative steel moment frame and because the shear forces in the frame closely matched the shear forces found using hand methods. The column strength check takes into account the combined interaction equations included flexure and compression, where the axial force was found by adding the axial force due to lateral loading to the force from gravity loads found in technical report 2. The beam strength check includes a check of shear forces due to lateral loads and moment due to load combinations including lateral load and gravity loads. Factored loads will be used in the strength checks.

The following page provides a plan showing Frame C for reference. The column studied is column C5 at level 6, and the beam being checked is the beam spanning between columns C7 and C8 on level 8.

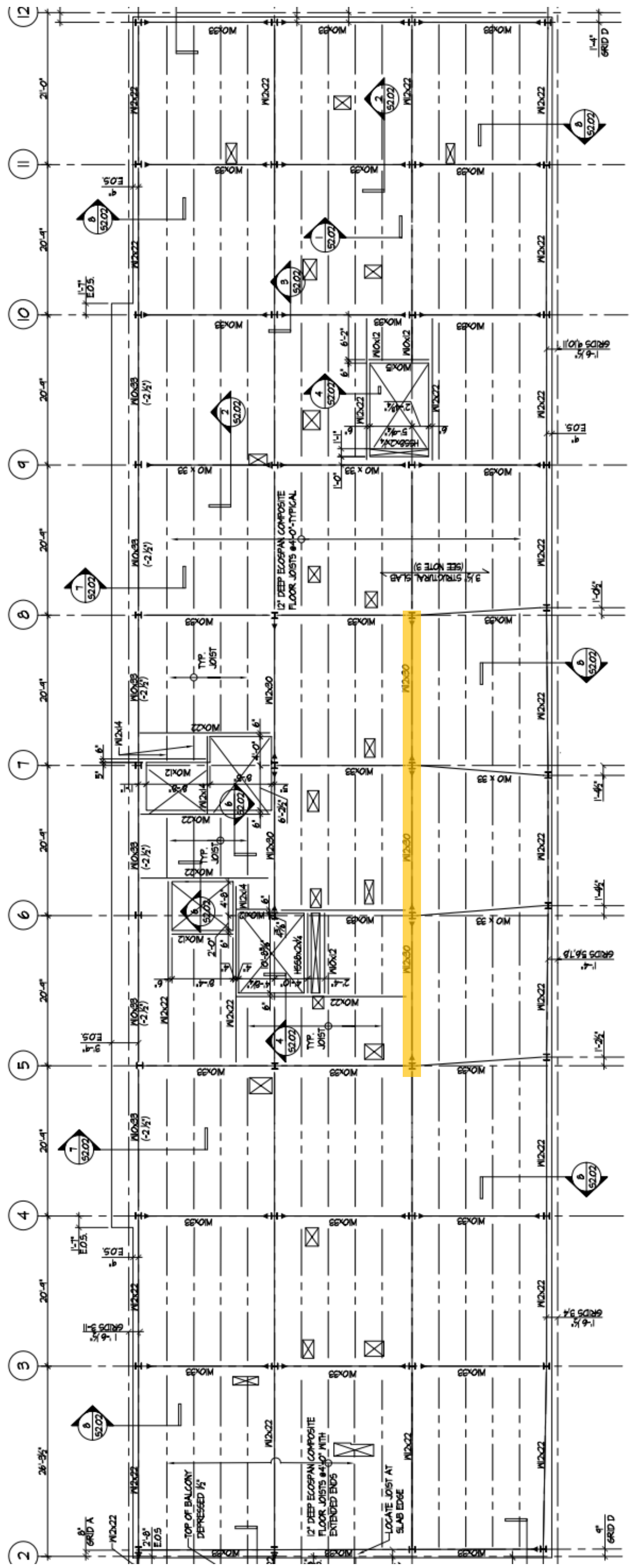


Figure 3: Plan Showing Lateral Frame Studied in Typical Spot Checks

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Strength Checks

Column C5 at Level 6: W10x49

From ETABS:
$M_{rx} = 7.05$ ft·kip
$M_{ry} = -0.15$ ft·kip
$P_{wind} = 55.8$ kip

Axial P due to gravity load

Live Load Reduction:
$A_T = (20')(20.75') = 415 \text{ ft}^2 > 400 \text{ ft}^2$

$L = L_o\left(0.25 + \frac{15}{\sqrt{A_T(k)}}\right)$ $k = 4$

$L_o = 40$ psf, 100 psf at level 12, 30 psf at penthouse

$L = 40\left(0.25 + \frac{15}{\sqrt{415(4)}}\right) = 24.73$ psf

$L = 100\left(0.25 + \frac{15}{\sqrt{415(4)}}\right) = 61.82$ psf

$L = 30\left(0.25 + \frac{15}{\sqrt{415(4)}}\right) = 18.54$ psf → however, assume unreduced live load.

Dead Load = 75 psf at floors
100 psf at 12th level
27 psf at penthouse

Snow Load = 20 psf

Controlling Load Combination: $1.2D + 1.6W + L + 0.5L_r$

$$P_u = \left[1.2(75\times4 + 100 + 27) + 1.6(55.8) + (24.75\times4 + 61.8) + 0.5(30)\right] \times \frac{415 \text{ ft}^2}{1000} = \underline{321.99 \text{ kips}}$$

$M_{u_x} = 1.6(7.05) = 11.3$ ft·k
$M_{u_y} = 1.6(0.15) = 0.24$ ft·k

Interaction Equation

$L_b = 10.33$ ft.
$K = 1.75$ (based on $G = 3.0$ using alignment charts
$KL = 1.75(10.33) = 18.0$ ft.

Table 6-1 in steel manual:

$p = 2.62\times10^{-3}$ $b_x = 4.60\times10^{-3}$ $b_y = 8.38\times10^{-3}$

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$pP_r = 2.62\times10^{-3}(321.99 \text{ kips}) = 0.844 > 0.2$

use $pP_r + b_x M_{rx} + b_y M_{ry}$

$0.844 + 4.60\times10^{-3}(0.24) + 8.38\times10^{-3}(11.3) = 0.94 < 1$

∴ Column is acceptable

Beam Checks: W12×30

Level 8 between columns C7 and C8

From ETABS: $M_{max} = 128.6$ ft·kip

From RISA 2D: M at location $M_{wind\,max}$:

$M_{Dead} = -8.79$ ft·k

$M_{Live} = -7.69$

Controlling Load Combination:

$1.2D + 1.6W + L$

$M_u = 1.2(-8.79) + 1.6(107.7) - 7.69 = 154.1$ ft·k

$\phi M_n = 162$ ft·k $> M_u = 154.1$ ft·k

∴ Beam is ok for flexure

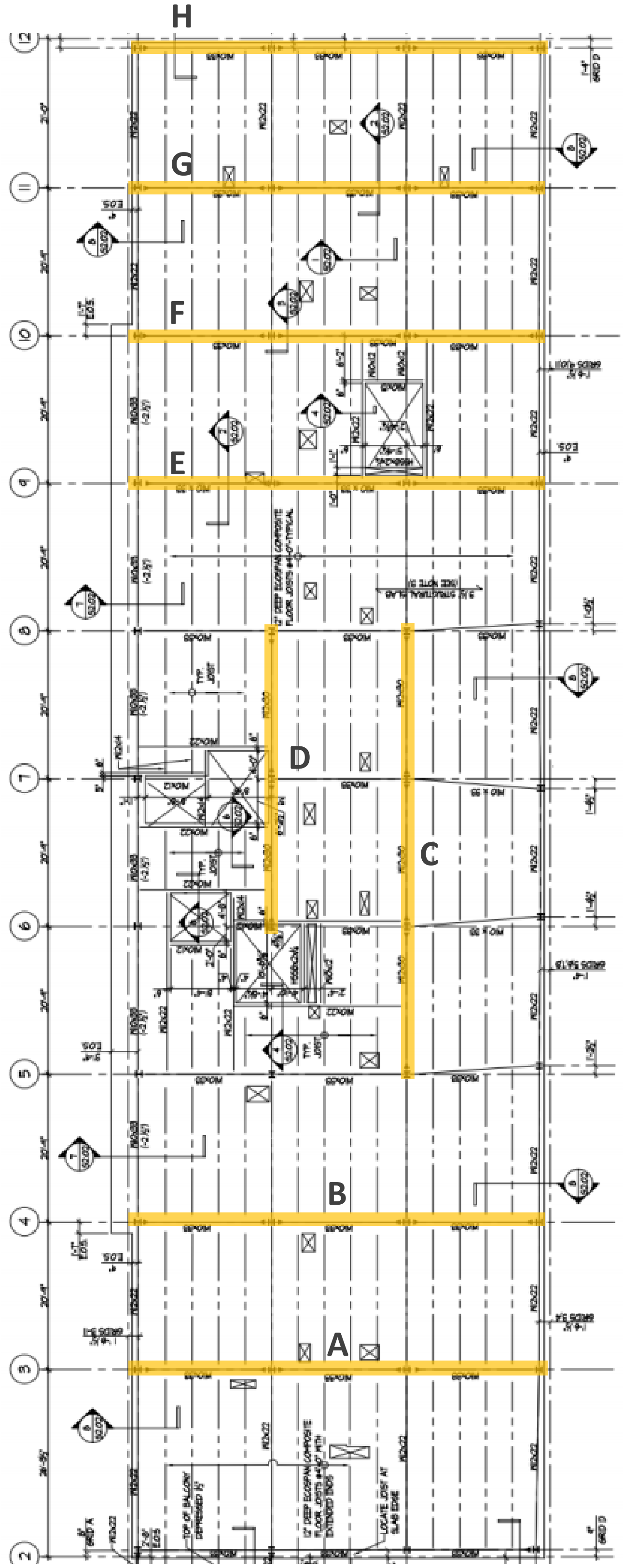
$\Delta_{max} = 0.318$ inches at 6.39 ft.

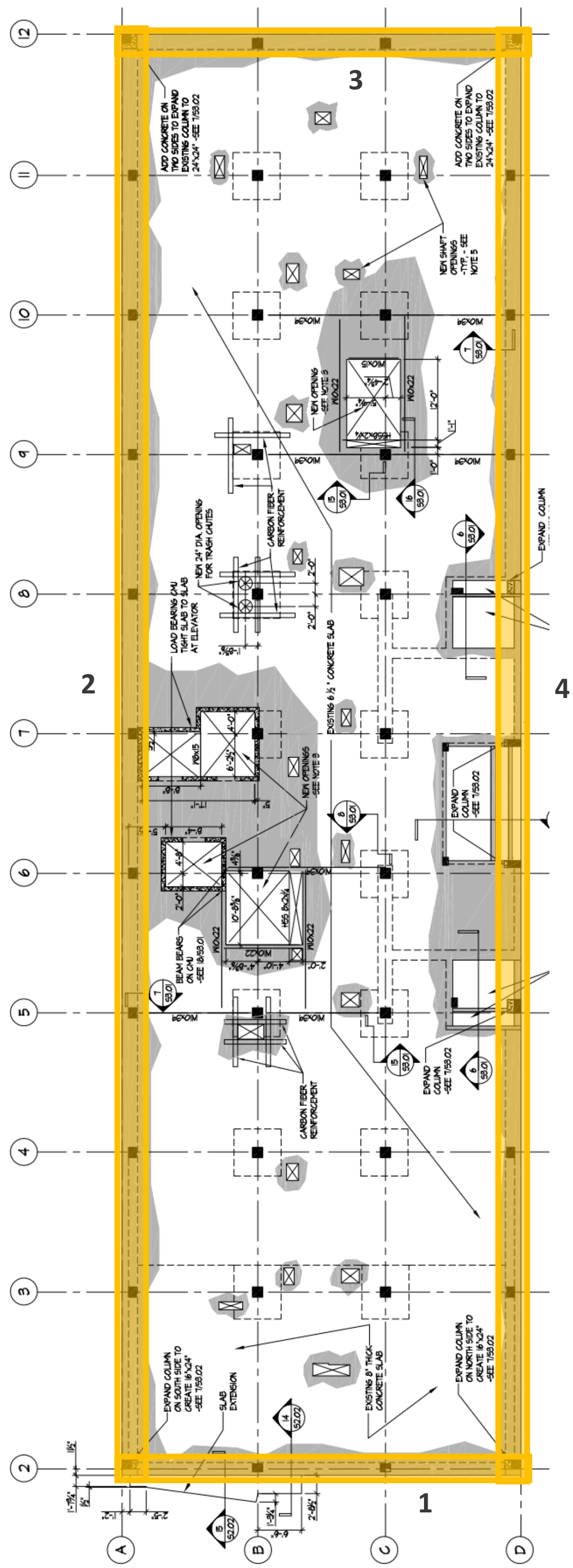
$\Delta_{w\,limit} = \frac{l}{360} = \frac{20.75(12)}{360} = 0.69"$

$0.69 > 0.318$ ∴ Deflection due to wind load is acceptable

Appendix

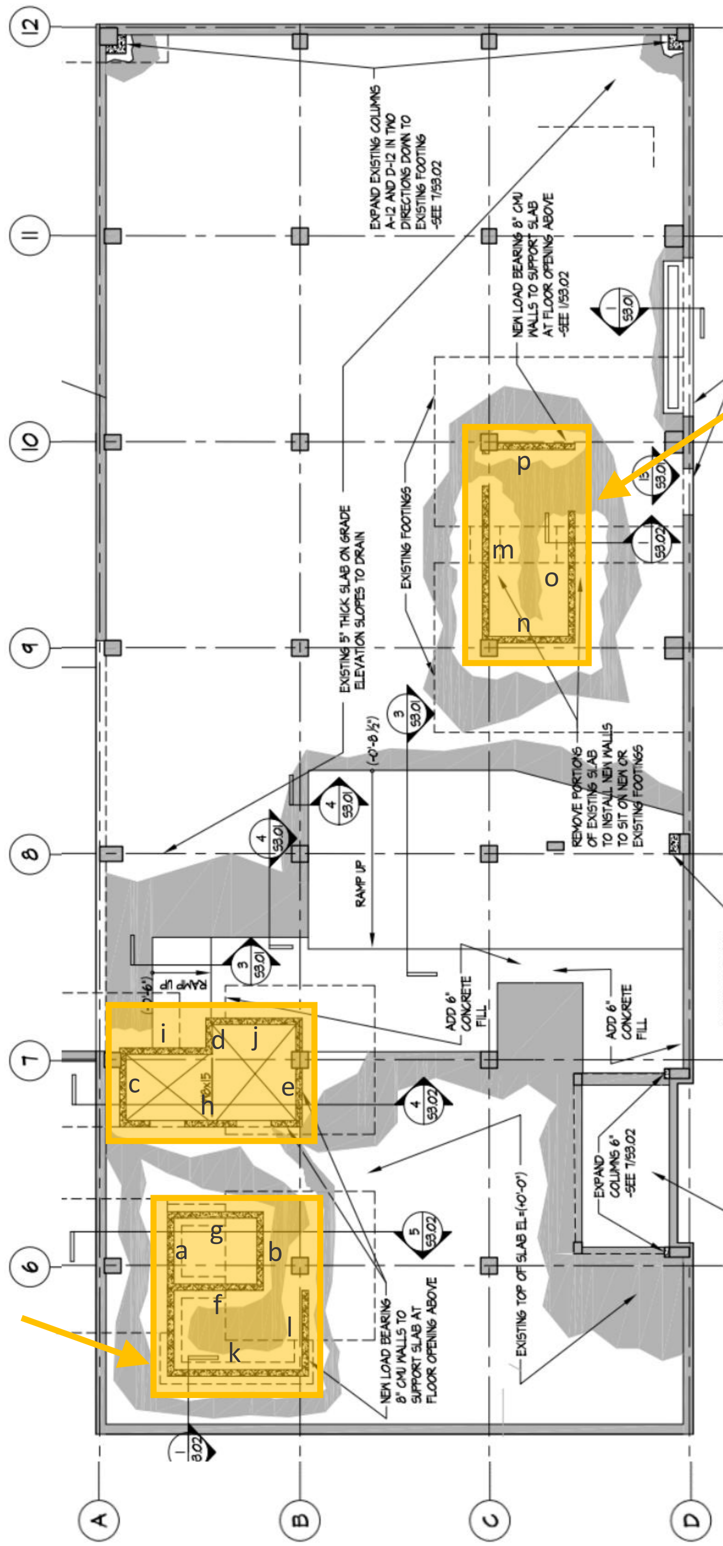
Steel Moment Frames





Perimeter Concrete Moment Frames

CMU Shear Walls



Walls Only on Level B2

Walls k, l, and the portion of a extending from the box are only on Level B2 and B12

Note: Building Drawing sets and images pulled from those sets which appear in this report are courtesy of Rathgeber Goss Association and Bonstra Haresign Architects.

Steel Addition Frame Stiffness						
Frame	Drift due to Unit Force			Relative Stiffness		
	Typ. Level	Level 12	Penthouse	Typ. Level	Level 12	Penthouse
A	0.261	0.245	N/A	1.34	1.83	N/A
B	0.261	0.245	N/A	1.34	1.83	N/A
C	0.237	0.306	0.516	1.47	1.46	1.91
D	0.349	0.448	0.733	1.00	1.00	1.35
E	0.261	0.241	0.988	1.34	1.86	1.00
F	0.261	0.241	0.988	1.34	1.86	1.00
G	0.261	0.245	N/A	1.34	1.83	N/A
H	0.261	0.245	N/A	1.34	1.83	N/A

Concrete Portion Frame and Wall Stiffness							
Concrete Frames		Typical Level		Level 1		Level B1	
		Disp.	Rel. Stiffness	Disp.	Rel. Stiffness	Disp.	Rel. Stiffness
1		5.01	2.3	2.58	1.3	N/A	N/A
2		1.14	10.1	0.74	4.4	0.32	4.1
3		5.01	2.3	3.29	1.0	1.30	1.0
4		1.14	10.1	0.74	4.4	0.32	4.1
Shear Walls							
East to West	a	0.310	37.2	0.074	44.4	0.024	54.2
	b	0.751	15.4	0.297	11.1	0.094	13.8
	c	1.463	7.9	0.340	9.7	0.172	7.6
	d	11.538	1.0	2.654	1.2	1.260	1.0
	e	0.435	26.5	0.175	18.8	0.058	22.4
	l	N/A	N/A	0.161	20.4	0.026	50.0
	m	N/A	N/A	N/A	N/A	0.172	7.6
	o	N/A	N/A	N/A	N/A	0.172	7.6
North to South	f	1.029	11.2	0.404	8.1	0.125	10.4
	g	1.029	11.2	0.404	8.1	0.125	10.4
	h	0.131	88.1	0.055	59.7	0.023	56.5
	i	1.029	11.2	0.404	8.1	0.125	10.4
	j	1.029	11.2	0.404	8.1	0.125	10.4
	k	N/A	N/A	0.113	29.1	0.040	32.5
	n	5.9	N/A	N/A	N/A	0.048	27.1
	p	N/A	N/A	N/A	N/A	0.048	27.1
Base-ment Walls	1	N/A	N/A	0.0015	2190.0	0.0015	866.7
	2	N/A	N/A	0.0015	2190.0	0.0015	866.7
	3	N/A	N/A	0.0008	4106.3	0.0012	1083.3
	4	N/A	N/A	0.0015	2190.0	0.0015	866.7

For both concrete and steel portions: Relative stiffness was found by designating the highest drift frame as having a relative stiffness of 1, and the relative stiffness of all other frames was found by dividing the base frame deflection by the deflection of each frame.

Story Shear due to Wind Loads (Controlling Lateral Load)				
Level	X-direction		Y-direction	
	Load (psf)	Load (kips)	Load (psf)	Load (kips)
PH		20.40		73.41
	19.91		19.48	
12		49.42		182.87
	19.27		18.85	
11		66.51		254.45
	18.79		18.38	
10		83.28		324.98
	18.29		17.89	
9		99.77		394.49
	17.84		17.46	
8		115.96		462.98
	17.34		16.97	
7		131.82		530.32
	16.77		16.41	
6		147.30		596.31
	16.1		15.75	
5		162.31		660.65
	15.24		14.91	
4		176.83		723.30
	14.53		14.21	
3		190.85		784.22
	13.65		13.35	
2		204.25		842.95
	12.49		12.22	
1		216.84		898.86
	11.03		10.79	
B1		228.71		952.27
	10.17		9.95	

Note: By Inspection, center of mass in steel addition is at the center of geometry because there are no shear walls and the structural elements are evenly and equally distributed in the floor plan.

Center of Rigidity of Steel Addition Typical Level							
Element Label	Element Direction	Dist. From Ref Datum x (ft)	y (ft)	R_x	R_y	R_xy	R_yx
A	y	26.3	-	-	1.34	-	35.2
B	y	47.1	-	-	1.34	-	63.0
C	x	-	20.1	1.47	-	29.6	-
D	x	-	39.2	1	-	39.2	-
E	y	150.8	-	-	1.34	-	201.6
F	y	171.5	-	-	1.34	-	229.3
G	y	192.3	-	-	1.34	-	257.1
H	y	212	-	-	1.34	-	283.5
			Sums	2.47	8.02	68.8	1069.7

x_R =	133.3	ft
y_R=	27.8	ft

x_{CM}=	107	ft
y_{CM}=	30	ft

Eccentricity	
X	26.3
Y	2.2

Level	V_x	V_y	M_{tx}	M_{ty}
11	66.51	254.45	2014.0	636.5
10	83.28	324.98	2522.1	812.9
9	99.77	394.49	3021.4	986.8
8	115.96	462.98	3511.7	1158.2
7	131.82	530.32	3992.0	1326.6

	Direct Shear		Torsional Shear		
Element Label	% V_d (y dir.)	% V_d (x dir.)	R_id_i	$R_id_i^2$	$R_iD_i/\Sigma R_id_i^2$
A	0.17	-	143.1	15318.7	0.004
B	0.17	-	115.3	9943.4	0.003
C	-	0.6	11.3	87.3	0.000
D	-	0.4	11.3	127.7	0.000
E	0.17	-	23.4	407.9	0.001
F	0.17	-	51.0	1947.8	0.001
G	0.17	-	78.8	4649.4	0.002
H	0.17	-	105.2	8275.0	0.003

Note: V_{tot} equals sum of (%V_d in the i direction * V_i) and ($R_iD_i/R_id_i^2$ * the sum of the moments at that level) for each level

Sum $R_id_i^2$ = 40757

V_{tot}	A	B	C	D	E	F	G	H
Level 11	51.7	49.9	40.3	27.6	43.9	45.7	47.5	49.2
Level 10	65.9	63.6	50.5	34.6	56.1	58.3	60.6	62.8
Level 9	79.8	77.1	60.5	41.5	68.0	70.8	73.5	76.1
Level 8	93.6	90.4	70.4	48.2	79.8	83.0	86.2	89.2
Level 7	107.1	103.4	80.0	54.8	91.4	95.0	98.7	102.1

(all values in kips)

Center of Rigidity of Steel Addition Level 12							
Element Label	Element Direction	Dist. From Ref Datum x (ft)	y (ft)	R_x	R_y	$R_x y$	$R_y x$
A	y	26.3	-	-	1.83	-	48.1
B	y	47.1	-	-	1.83	-	86.1
C	x	-	20.1	1.46	-	29.4	-
D	x	-	39.2	1	-	39.2	-
E	y	150.8	-	-	1.86	-	280.3
F	y	171.5	-	-	1.86	-	318.8
G	y	192.3	-	-	1.83	-	351.6
H	y	212	-	-	1.83	-	387.7
			Sums	2.46	11.03	68.6	1472.6

x_R =	133.5	ft
y_R =	27.9	ft

x_{CM} =	107	ft
y_{CM} =	30	ft

Eccentricity	
X	26.5
Y	2.1

V_x = 49.42 kips

V_y = 182.87 kips

M_{tx} = 1505.4 ft-kips

M_{ty} = 451.8 ft-kips

Direct Shear		
Element Label	V_d (y dir.)	V_d (x dir.)
A	30.3	-
B	30.3	-
C	-	29.4
D	-	20.1
E	30.8	-
F	30.8	-
G	30.3	-
H	30.3	-

Torsional Shear						
Element Label	$R_i d_i$	$R_i d_i^2$	V_{ty}	V_{tx}	$R_i D_i / \Sigma R_i d_i^2$	
A	143.12	15318.7	1.3929	4.641	0.003	
B	157.68	9943.41	1.5347	5.1132	0.003	
C	11.273	86.7979	0.1097	0.3655	2E-04	
D	11.3	127.696	0.11	0.3664	2E-04	
E	32.469	567.128	0.316	1.0529	7E-04	
F	70.949	2707.88	0.6905	2.3006	0.002	
G	107.82	6358.07	1.0494	3.4964	0.002	$\Sigma R_i d_i^2$ =
H	143.85	11316	1.4	4.6645	0.003	46426

Frame	A	B	C	D	E	F	G	H	
V_{tot}	36.3	37.0	29.8	20.5	32.2	33.8	34.9	36.4	(kips)

Center of Rigidity of Steel Addition Penthouse							
Element Label	Element Direction	Dist. From Ref Datum x (ft)	y (ft)	R_x	R_y	$R_x y$	$R_y x$
C	x	-	20.1	0.52	-	10.4	-
D	x	-	39.2	1	-	28.7	-
E	y	150.8	-	-	0.99	-	149.0
F	y	171.5	-	-	0.99	-	169.4
			Sums	1.25	1.98	39.11	318.43

x_R =	161.2	ft
y_R =	31.3	ft

x_{CM} =	110	ft
y_{CM} =	38	ft

Eccentricity	
X	51.2
Y	6.7

V_x = 20.40 kips

V_y = 73.41 kips

M_{tx} = 1200.3 ft-kips

M_{ty} = 564.9 ft-kips

Direct Shear		
Element Label	V_d (y dir.)	V_d (x dir.)
C	-	8.4
D	-	12.0
E	36.7	-
F	36.7	-

Torsional Shear						
Element Label	$R_i d_i$	$R_i d_i^2$	V_{ty}	V_{tx}	$R_i D_i / \Sigma R_i d_i^2$	
C	4.0	30.6	1.2	0.0	0.002	
D	8.3	93.6	2.5	0.1	0.004	
E	17.3	301.4	5.2	0.2	0.009	$\Sigma R_i d_i^2$ =
F	37.7	1439.2	11.4	0.4	0.02	1864.8

Frame	C	D	E	F
V_{tot}	9.7	14.6	42.1	48.5

Center of Mass of Concrete Portion Typical Level								
Element Label	Area	Height	Density	W	Dist. From Ref. x (ft)	Dist. From Ref. y (ft)	Wx	Wy
1	3.5	10.3	0.115	4.1	0	30	0.0	124.4
2	19.25	10.3	0.115	22.8	107	60	2439.8	1368.1
3	3.5	10.3	0.115	4.1	214	30	887.2	124.4
4	19.25	10.3	0.115	22.8	107	0	2439.8	0.0
a	6.67	10.3	0.115	7.9	90	53	711.1	418.7
b	6.67	10.3	0.115	7.9	90	45	711.1	355.5
c	5.333	10.3	0.115	6.3	105	57	663.3	360.1
d	2.667	10.3	0.115	3.2	111.3	48	351.6	151.6
e	8	10.3	0.115	9.5	108.3	40	1026.3	379.0
f	6	10.3	0.115	7.1	86	50	611.2	355.4
g	6	10.3	0.115	7.1	93.5	50	664.5	355.4
h	12	10.3	0.115	14.2	102.3	50	1454.1	710.7
i	6	10.3	0.115	7.1	110.3	53	783.9	376.7
j	6	10.3	0.115	7.1	113.3	45	805.2	319.8
Floor Slab	12840	0.542	0.115	800.32	107	30	85633.9	24009.5
			sum	932			99183	29409

x_{CM}= 106 ft

y_{CM}= 32 ft

Center of Mass of Concrete Portion Level 1								
Element Label	Area	Height	Density	W	Dist. From Ref. x (ft)	Dist. From Ref. y (ft)	Wx	Wy
1	3.5	10.3	0.115	4.1	0	30	0.0	124.4
2	19.25	10.3	0.115	22.8	107	60	2439.8	1368.1
3	3.5	10.3	0.115	4.1	214	30	887.2	124.4
4	19.25	10.3	0.115	22.8	107	0	2439.8	0.0
a	11.33	10.3	0.115	13.4	90	53	1207.8	711.3
b	6.67	10.3	0.115	7.9	90	45	711.1	355.5
c	5.333	10.3	0.115	6.3	105	57	663.3	360.1
d	2.667	10.3	0.115	3.2	111.3	48	351.6	151.6
e	8	10.3	0.115	9.5	108.3	40	1026.3	379.0
f	6	10.3	0.115	7.1	86	50	611.2	355.4
g	6	10.3	0.115	7.1	93.5	50	664.5	355.4
h	12	10.3	0.115	14.2	102.3	50	1454.1	710.7
i	6	10.3	0.115	7.1	110.3	53	783.9	376.7
j	6	10.3	0.115	7.1	113.3	45	805.2	319.8
Floor Slab	12840	0.542	0.115	800.32	107	30	85633.9	24009.5
k	9.33	10.3	0.115	11.051	32.2	46	355.9	508.4
l	11.33	10.3	0.115	13.42	87	39.2	1167.6	526.1
			sum	961.6			100035.5	30210.2

x_{CM}= 104 ft

y_{CM}= 31 ft

Center of Mass of Concrete Portion Level B1								
Element Label	Area	Height	Density	W	Dist. From Ref.		Wx	Wy
					x (ft)	y (ft)		
1	0	0	0	0.0	0	30	0.0	0.0
2	19.44	8.3	0.115	18.6	143	60	2653.4	1113.3
3	3.5	8.3	0.115	3.3	214	30	714.9	100.2
4	19.44	8.3	0.115	18.6	143	0	2653.4	0.0
a	11.33	8.3	0.115	10.8	90	53	973.3	573.2
b	6.67	8.3	0.115	6.4	90	45	573.0	286.5
c	5.333	8.3	0.115	5.1	105	57	534.5	290.1
d	2.667	8.3	0.115	2.5	111.3	48	283.3	122.2
e	8	8.3	0.115	7.6	108.3	40	827.0	305.4
f	6	8.3	0.115	5.7	86	50	492.5	286.4
g	6	8.3	0.115	5.7	93.5	50	535.5	286.4
h	12	8.3	0.115	11.5	102.3	50	1171.7	572.7
i	6	8.3	0.115	5.7	110.3	53	631.7	303.5
j	6	8.3	0.115	5.7	113.3	45	648.9	257.7
Floor Slab	8520	0.542	0.115	531.05	143	30	75940.4	15931.5
k	9.33	8.3	0.115	8.9055	32.2	46	286.8	409.7
l	11.33	8.3	0.115	10.814	87	39	940.9	421.8
m	8.67	8.3	0.115	8.2755	158	20	1307.5	165.5
n	5.33	8.3	0.115	5.0875	151	16	768.2	81.4
o	8.67	8.3	0.115	8.2755	158	12	1307.5	99.3
p	5.33	8.3	0.115	5.0875	172	16	875.0	81.4
			sum	684.8			94119.5	21688.2

x_{CM}= 137 ft

y_{CM}= 32 ft

Center of Rigidity of Concrete Portion Typical Level							
Element Label	Element Direction	Dist. From Ref Datum x (ft)	y (ft)	R_x	R_y	R_xy	R_yx
1	y	0	-	-	2.30	-	0.0
2	x	-	60	10.12	-	607.3	-
3	y	214	-	-	2.30	-	492.8
4	x	-	0	10.12	-	0.0	-
a	x	-	53	37.22	-	1972.6	-
b	x	-	45	15.36	-	691.4	-
c	x	-	57	7.89	-	449.5	-
d	x	-	48	1.00	-	48.0	-
e	x	-	40	26.52	-	1061.0	-
f	y	86	-	-	11.21	-	964.3
g	y	93.5	-	-	11.21	-	1048.4
h	y	102.3	-	-	88.08	-	9010.2
i	y	110.3	-	-	11.21	-	1236.8
j	y	113.3	-	-	11.21	-	1270.4
			Sums	108.24	137.53	4829.7	14023

x_R =	102.0	ft
y_R=	44.6	ft

x_{CM}=	106	ft
y_{CM}=	32	ft

Eccentricity	
X	4.5
Y	13.1

Level	V_x	V_y	M_{tx}	M_{ty}
6	147.30	596.31	763.0	8952.0
5	162.31	660.65	840.7	9918.0
4	176.83	723.30	915.9	10858.4
3	190.85	784.22	988.6	11773.0
2	204.25	842.95	1058.0	12654.7

Center of Rigidity of Concrete Portion Level 1							
Element Label	Element Direction	Dist. From Ref Datum		R_x	R_y	R_xy	R_yx
		x (ft)	y (ft)				
1	y	0	-	-	1.27	-	0.0
2	x	-	60	4.44	-	266.4	-
3	y	214	-	-	1.00	-	214.0
4	x	-	0	4.44	-	0.0	-
a	x	-	53	44.39	-	2352.8	-
b	x	-	45	11.06	-	497.7	-
c	x	-	57	9.66	-	550.7	-
d	x	-	48	1.24	-	59.4	-
e	x	-	40	18.77	-	750.9	-
f	y	86	-	-	8.13	-	699.3
g	y	93.5	-	-	8.13	-	760.3
h	y	102.3	-	-	59.73	-	6110
i	y	110.3	-	-	8.13	-	896.9
j	y	113.3	-	-	8.13	-	921.3
k	y	32.2	-	-	29.071	-	936.08
l	x	-	39.2	20.4037	-	799.826	-
BW1	y	0	-	-	2190.0	-	0
BW2	x	-	60	2190.0	-	131400	-
BW3	y	214	-	-	4106	-	878738
BW4	x	-	0	2190.0	-	0	-
			Sums	4494.41	6419.8	136678	889275

x_R =	138.52
y_R =	30.411

x_{CM} =	104
y_{CM} =	31

Eccentricity	
X	34.5
Y	1.0

V_x	216.84
V_y	898.86

M_{tx}	8601
M_{ty}	1040

Center of Rigidity of Concrete Portion Level B1							
Element Label	Element Direction	Dist. From Ref Datum x (ft)	Dist. From Ref Datum y (ft)	R_x	R_y	$R_x y$	$R_y x$
2	x	-	60	4.13	-	247.6	-
3	y	214	-	-	1.00	-	214.0
4	x	-	0	4.13	-	0.0	-
a	x	-	53	54.17	-	2870.8	-
b	x	-	45	13.83	-	622.3	-
c	x	-	57	7.56	-	430.8	-
d	x	-	48	1.03	-	49.5	-
e	x	-	40	22.41	-	896.6	-
f	y	86	-	-	10.40	-	894.4
g	y	93.5	-	-	10.40	-	972.4
h	y	102.3	-	-	56.52	-	5782
i	y	110.3	-	-	10.40	-	1147.1
j	y	113.3	-	-	10.40	-	1178.3
k	y	32.2	-	-	32.5	-	1046.5
l	x	-	39.2	50	-	1960	-
m	x	-	20	7.55814	-	151.163	-
n	y	151	-	-	27.083	-	4089.6
o	x	-	12	7.55814	-	90.6977	-
p	y	172	-	-	27.083	-	4658.3
BW1	y	70	-	-	866.7	-	60667
BW2	x	-	60	866.7	-	52000	-
BW3	y	214	-	-	1083.3	-	231833
BW4	x	-	0	866.7	-	0	-
			Sums	1905.70	2136	59320	312483

x_R =	146.31
y_R =	31.127

x_{CM} =	137
y_{CM} =	32

Eccentricity	
X	8.9
Y	0.5

V_x	228.71
V_y	952.27

M_{tx}	2330
M_{ty}	597

Lateral Load Distribution in Concrete Portion Typical Levels

Direct Shear			Torsional Shear			
Element Label	% V_d (y dir.)	% V_d (x dir.)	$R_i d_i$	$R_i d_i^2$	$R_i d_i / \Sigma R_i d_i^2$	
1	-	0.02	234.8	23941.6	0.003	
2	0.09	-	155.6	2393.3	0.002	
3	-	0.02	258.0	28909.4	0.003	
4	0.09	-	451.6	20152.7	0.005	
a	0.34	-	311.8	2612.1	0.004	
b	0.14	-	5.8	2.2	0.000	
c	0.07	-	97.6	1208.2	0.001	
d	0.01	-	3.4	11.4	0.000	
e	0.25	-	122.6	566.8	0.001	
f	-	0.08	179.0	2856.2	0.002	
g	-	0.08	94.9	802.5	0.001	
h	-	0.64	29.9	10.2	0.000	
i	-	0.08	93.5	779.9	0.001	$\Sigma R_i d_i^2$ =
j	-	0.08	127.2	1441.9	0.001	85688

Concrete Moment Frames				
V_{tot}	1	2	3	4
Level 6	29.1	73.4	31.7	107.0
Level 5	32.2	81.3	35.1	118.5
Level 4	35.2	89.0	38.4	129.7
Level 3	38.2	96.5	41.6	140.6
Level 2	41.0	103.7	44.7	151.1

Concrete Shear Walls										
V_{tot}	a	b	c	d	e	f	g	h	i	j
Level 6	240.4	85.3	54.5	5.9	160.0	32.3	22.8	97.7	22.6	26.4
Level 5	266.3	94.5	60.4	6.5	177.3	35.7	25.1	107.7	25.0	29.2
Level 4	291.6	103.5	66.1	7.1	194.1	39.0	27.5	117.4	27.3	31.9
Level 3	316.1	112.2	71.7	7.7	210.4	42.2	29.7	126.7	29.5	34.5
Level 2	339.8	120.6	77.0	8.3	226.2	45.3	31.8	135.6	31.6	37.0

Lateral Load Distribution in Concrete Portion Level 1

Direct Shear			Torsional Shear			
Element Label	% V_d (y dir.)	% V_d (x dir.)	R_id_i	$R_id_i^2$	$R_iD_i/\Sigma R_id_i^2$	
1	-	0.00	176.4	24430.9	0.000	
2	0.00	-	131.4	3886.6	0.000	
3	-	0.00	75.5	5697.3	0.000	
4	0.00	-	135.0	4105.4	0.000	
a	0.01	-	1002.8	22652.3	0.000	
b	0.00	-	161.4	2354.2	0.000	
c	0.00	-	256.9	6830.8	0.000	
d	0.00	-	21.8	382.9	0.000	
e	0.00	-	180.0	1726.1	0.000	
f	-	0.00	427.0	22428.4	0.000	
g	-	0.00	366.1	16480.1	0.000	
h	-	0.01	2163.3	78354.4	0.000	
i	-	0.00	229.5	6475.3	0.000	
j	-	0.00	205.1	5171.7	0.000	
k	-	0.00	3090.8	328613	0.000	
l	0.00	-	179.3	1576.3	0.000	
BW1	-	0.34	66599.3	2025325	0.000	
BW2	0.49	-	64800.7	1917414	0.000	
BW3	-	0.64	753864	138401403	0.005	$\Sigma R_id_i^2$ =
BW4	0.49	-	66599.3	2025325	0.000	144900632

Concrete Moment Frames				
V_{tot}	1	2	3	4
Level 1	0.1	0.9	0.0	0.9

Concrete Shear Walls										
V_{tot}	a	b	c	d	e	f	g	h	i	j
Level 1	8.9	2.2	1.9	0.2	3.8	0.3	0.3	2.2	0.3	0.3

Concrete Shear Walls		
V_{tot}	k	l
Level 1	1.2	4.1

Basement Walls				
V_{tot}	1	2	3	4
Level 1	78	442	189	442

Lateral Load Distribution in Concrete Portion Level B1

Direct Shear			Torsional Shear			
Element Label	% V_d (y dir.)	% V_d (x dir.)	$R_i d_i$	$R_i d_i^2$	$R_i D_i / \Sigma R_i d_i^2$	
2	0.00	-	119.2	3440.4	0.000	
3	-	0.00	67.7	4582.2	0.000	
4	0.00	-	128.5	3998.7	0.000	
a	0.03	-	1184.8	25914.0	0.000	
b	0.01	-	191.9	2661.5	0.000	
c	0.00	-	195.5	5059.4	0.000	
d	0.00	-	17.4	293.7	0.000	
e	0.01	-	198.9	1764.5	0.000	
f	-	0.00	627.2	37825.3	0.000	
g	-	0.00	549.2	29002.3	0.000	
h	-	0.03	2487.4	109466	0.000	
i	-	0.00	374.5	13484.4	0.000	
j	-	0.00	343.3	11331.1	0.000	
k	-	0.02	3708.5	423170	0.000	
l	0.03	-	403.6	3258.4	0.000	
m	0.00	-	84.1	935.8	0.000	
n	-	0.01	127.1	596.2	0.000	
o	0.00	-	144.6	2765.2	0.000	
p	-	0.01	695.8	17877	0.000	
BW1	-	0.41	66133.6	5046516.6	0.005	
BW2	0.45	-	25022.9	722478.3	0.002	
BW3	-	0.51	73333.1	4964064.3	0.006	$\Sigma R_i d_i^2 =$
BW4	0.45	-	26977.1	839724.7	0.002	12270210

Concrete Moment Frames				
V_{tot}	1	2	3	4
Level B1	N/A	2.1	0.1	2.1

Concrete Shear Walls										
V_{tot}	a	b	c	d	e	f	g	h	i	j
Level B1	27.3	7.0	3.8	0.5	11.2	1.3	1.2	6.6	1.2	1.2

Concrete Shear Walls						
V_{tot}	k	l	m	n	o	p
Level B1	4.4	25.1	3.8	2.9	3.8	3.1

Basement Walls				
V_{tot}	1	2	3	4
Level B1	108.6	439.0	133.5	439.5

Summary of Distributed Lateral Forces to Frames and Walls (kips)

Level	Steel Addtion							
	Steel Moment Frame							
	A	B	C	D	E	F	G	H
PH	N/A	N/A	9.7	14.6	42.1	48.5	N/A	N/A
12	36.3	37.0	29.8	20.5	32.2	33.8	34.9	36.4
11	51.7	49.9	40.3	27.6	43.9	45.7	47.5	49.2
10	65.9	63.6	50.5	34.6	56.1	58.3	60.6	62.8
9	79.8	77.1	60.5	41.5	68.0	70.8	73.5	76.1
8	93.6	90.4	70.4	48.2	79.8	83.0	86.2	89.2
7	107.1	103.4	80.0	54.8	91.4	95.0	98.7	102.1

Level	Concrete Portion			
	Concrete Moment Frames			
	1	2	3	4
6	29.1	73.4	31.7	107.0
5	32.2	81.3	35.1	118.5
4	35.2	89.0	38.4	129.7
3	38.2	96.5	41.6	140.6
2	41.0	103.7	44.7	151.1
1	0.1	0.9	0.0	0.9
B1	-	2.1	0.1	2.1

Level	CMU Shear Walls															
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
6	240.4	85.3	54.5	5.9	160.0	32.3	22.8	97.7	22.6	26.4	-	-	-	-	-	-
5	266.3	94.5	60.4	6.5	177.3	35.7	25.1	107.7	25.0	29.2	-	-	-	-	-	-
4	291.6	103.5	66.1	7.1	194.1	39.0	27.5	117.4	27.3	31.9	-	-	-	-	-	-
3	316.1	112.2	71.7	7.7	210.4	42.2	29.7	126.7	29.5	34.5	-	-	-	-	-	-
2	339.8	120.6	77.0	8.3	226.2	45.3	31.8	135.6	31.6	37.0	-	-	-	-	-	-
1	8.9	2.2	1.9	0.2	3.8	0.3	0.3	2.2	0.3	0.3	1.2	4.1	-	-	-	-
B1	27.3	7.0	3.8	0.5	11.2	1.3	1.2	6.6	1.2	1.2	4.4	25.1	3.8	2.9	3.8	3.1

Level	Concrete Basement Walls			
	1	2	3	4
1	78	442	189	442
B1	108.6	439.0	134	439.5