The following is the work of an entire year combined into one paper. The building picked for this senior thesis was Two Freedom Square, located in Reston, Virginia. The objective of the project was to understand the existing structural system and then propose alternative solutions for the design of the building. After researching Two Freedom Square, it was determined that a proposed solution was to rearrange the columns to the column lines and then redesign the building in steel and concrete to see what difference could be found from the existing structure.

The proposed changes also affect other areas of the design of the building, for example changing to a steel building from a concrete building requires the addition of fireproofing all steel members. Also changing to a steel building increases the floor to floor height to allow room for the ductwork to be run.

The structures were designed to IBC 2000 instead of BOCA 1996, which was the original code, to see how the new code affects the design of the building. Also not all areas of the building was investigated because the time frame does not allow for the same kind of design an engineering firm would take to design the entire building.

Most of the design centered on the wind loading and torsion affects due the height of the building and also the unique shape of the building. These considerations drove the design of the concrete and steel structures. And spreadsheets and structural analysis programs were used to aid in the redesign of the building.

Owner:	Boston Properties, Inc. 111 Huntington Avenue Boston, MA 02199-7602
Architect:	SmithGroup 1825 Eye Street NW Washington, DC 20006
Structural:	Tadjer Cohen Edelson Associates, Inc. 1109 Spring St. Silver Spring, MD 20910
Mechanical:	Tolk, Inc. 8401 Arlington Boulevard Suite 600 Fairfax, VA 22031
Lighting:	Moran Coventry
General Contractor:	Centex Construction 3924 Pender Dr. Fairfax, VA 22030

Special thanks to William Hendrix and Joel Kelty from SmithGroup for providing Two Freedom Square as a thesis building for this year's project. Also thanks for their willingness to answering questions which arose during the research portion of this project.

Introduction

Throughout the fall of 2002 and the spring of 2003 I have been working on a Senior Thesis Project for the Architectural Engineering Program at Penn State University. The fall requirements were to do three technical assignments in our focus, which happens to be structural engineering for me, and then do a variety of other assignments to get a broader scope of the entire building process. The first of the technical assignments was to get a better understanding of the building by find basic loading of the building and codes used for design. The second technical assignment was to understand the existing floor system and then to investigate several different floor systems which could possibly replace the existing system. The final technical assignment was to do a full lateral analysis of the build to find out which controlled the design of the lateral system, seismic or wind.

At the conclusion of the fall semester, a proposal was created to define what areas of research would be followed up on in the spring semester. Also the creation of a thesis problem/statement was created to guide the research. After finishing the fall assignments I concluded that the column layout for the building needed to change to allow for symmetric design and easier calculations. This also allowed for the removal of some of the interior columns, however, this created the need for a redesign of the core of the building. This solution also posed the question of how the building's columns would be different if moved and then redesigned in concrete. Another proposed solution was to investigate the building if it was designed out of steel instead of concrete, with the proposed new column layout. This proposed solution created the problem of where to put the mechanical ductwork if the floor to floor height remained the same. So the steel design also proposed an increased floor to floor height to allow the installation of ductwork. The final proposed solution was to investigate how the intermediate beams would be different if design compositely compared to non-compositely.

The spring semester was spent investigating these different options and figuring out which solution was the best for the building. The following pages are the compilation of the research done throughout the year.

Background

To be able to understand this project some basic background information about Two Freedom Square is necessary. More in depth information about the structural system and architectural features can be found in later sections.

The Two Freedom Square Building is a 450,000 square foot building located at 11995 Freedom Drive, Reston, Virginia which is in a community surrounding Washington D.C. The building is 16-stories in addition to two basements and its primary use is an office building; however the first floor is occupied by shops. Two Freedom Square is also part of a building complex with its neighboring building being One Freedom Square and a shared parking garage lies between the two buildings. Two Freedom Square is owned by Boston Properties and designed by SmithGroup. The Structural Engineer was Tadjer Cohen Edelson, the Mechanical Engineer was Tolk, Inc., and the General Contractor was Centex Construction. The project was started on October 24, 2000 and finished June 15, 2002. The major codes used were BOCA 1996 and the Virginia Uniform Statewide Building Code 1996.

The Two Freedom Square project was a negotiated bid between Boston Properties and SmithGroup because the two companies had already worked together on the One Freedom Square project. The original bid was for $39,500,000 which ended up being $42,000,000 after all the change orders which mostly involved changes to the street level shops.

The Two Freedom Square site is located seven miles from Dulles Airport in the heart of the Reston Town Center. The building's major tenets are Wilson Sonsini, Finnegan Henderson, and Latham & Watkins

General Information

As mentioned before, Two Freedom Square is part of a building complex in Reston, VA. It was the second building built in the complex and as part of the construction an addition was to be made to the existing parking garage. Also it was a negotiated bid between Boston Properties and SmithGroup. SmithGroup also designed One Freedom Square and because of that prior relationship with Boston Properties they got the Two Freedom Square project. Even though both One and Two Freedom Square were design by the same architecture firm they have distinct difference which can be seen in the rendering of the buildings on the abstract of the building right after the title page.

Architecturally One and Two Freedom Square look different but do have some similarities. They are both office buildings with pre-cast concrete panels making up the facade. The main structure of both buildings are cast-in-place concrete with a two-way drop panel flat slab floor system with some areas of post-tensioning. The main difference is One Freedom Square has a crowned top with a company's name on top, while Two Freedom Square is larger however it looks more like a plain office building.

Existing Concrete Structure

Introduction to the Structural System:

The structural system for Two Freedom Square is primarily a cast-in-place concrete system. All interior and exterior columns are cast-in-place concrete with varying concrete strength from 4,000 psi to 10,000 psi. Column widths vary from 12" to 32", depths vary from 12" to 36", and floor to floor height is 11'-11". The beams and girders are also cast-in-place concrete with widths varying from 8" to 66" and depths varying from 16" to 81". Sloping columns can be found on floors C2, C1, 4, 10, and 14; while post tensioning can be found on floors 2, 3, 5, 11, and 14. The distance between columns ranges from 14'-7 ¼" to 31'-6". The floor system is a two-way drop panel flat slab which is 8" on all the floors except for on levels C2, C1, and ground. The floor area between column lines 7 and 8 ceases after the 5th floor, the floor area between column lines 6 and 7 ceases after the 11th floor, 25% of the area between column lines 5 and 6 also ceases after the 11th floor, and the remaining floor area between column lines 5 and 6 ceases after the 14th floor. The exterior of the building is primarily pre-cast concrete panels, with some curtin wall and a few metal panels.

The building code used for Two Freedom Square was BOCA 1996. Concrete construction followed the ACI Code 318-95. Reinforcement steel for the concrete followed ASTM-A615 with grade 60 steel. The detailing of the reinforcement steel followed ACI 315-88. For checking the design loads, BOCA 1996 was used for live, wind, seismic and snow loads. The CRSI Handbook was used to spot check the two-way drop panel flat slab floor system.

National Design Code: BOCA 1996

Live Load:

Table 1

Roof (minimum)	30 psf
Penthouse Machine Room	150 psf
Floor	80 psf + 20 psf partitions
Stairways & Corridors	100 psf

Dead Loads:

Table 2

Superimposed Dead Load	25 psf
Slab Self-weight	100 psf
Beams & Girders Self-weight	400 plf

Snow Loads:

Table 3

Snow Load	$P_f = C_e I P_g = 0.7*1*30 = 21$ psf
Roof Snow Load (P_g)	30 psf
Snow Exposure Factor (C_e)	0.7
Importance Factor (I)	1.0
Snow Drift	$P_{dmax} = 30$ psf

Accumulation of Loads: available upon request, they are listed in my column schedule

Wind Load:

BOCA 1996 was used to find wind and seismic loads. The wind load is controlling over seismic in the design of the lateral system. This is known from the analysis performed on the different frames comparing the wind loading to the seismic loading, this also proves the assumption that wind will control on the east coast. This building is in a seismic area of category A which is the lowest level while the wind is in an exposure B which is in the middle to low end of wind loads. The windward, leeward and sidewall pressures can be found in Table 4. A graphical representation of the distribution of the windward and leeward pressures on the building can be found in Diagrams 1 and 2.

- Based on 80 mph, exposure B and importance factor I = 1 with frame design pressure P = 22 psf to 30 psf.
- Windward wall design pressure, $P = P_v I [K_z G_h C_p - K_h (G C_{pi})]$
- Leeward wall, side walls and roof design pressure, $P = P_v I [K_h G_h C_p - K_h (G C_{pi})]$

Table 4

Height above ground level, z (feet)	Coefficients K_z and K_h Exposure B	Coefficients G_z and G_h Exposure B	Windward wall design pressure, P (psf)	Leeward wall design pressure, P (psf)	Side wall design pressure, P (psf)
0-15	0.37	1.65	6.5	-17.7	-22.7
20	0.42	1.59	7.0	-17.7	-22.7
25	0.46	1.54	7.4	-17.7	-22.7
30	0.50	1.51	7.9	-17.7	-22.7
40	0.57	1.46	8.6	-17.7	-22.7
50	0.63	1.42	9.2	-17.7	-22.7
60	0.68	1.39	9.6	-17.7	-22.7
70	0.73	1.36	10.0	-17.7	-22.7
80	0.77	1.34	10.4	-17.7	-22.7
90	0.82	1.32	10.8	-17.7	-22.7
100	0.86	1.31	11.3	-17.7	-22.7
120	0.93	1.28	11.8	-17.7	-22.7
140	0.99	1.26	12.3	-17.7	-22.7
160	1.05	1.24	12.8	-17.7	-22.7
180	1.11	1.23	13.4	-17.7	-22.7
200	1.16	1.21	13.7	-17.7	-22.7
250	1.28	1.19	14.7	-17.7	-22.7

Wall Pressures Coefficients (C_p):

Table 5

Surface	L/B	C_p	For use with
Windward wall	All Values	0.8	K_z
Leeward wall	0 to 1	-0.5	K_h
	2	-0.3	
	≥4	-0.2	
Side walls	all values	-0.7	K_h

Table 6

Importance Factor (I)	1
Basic Wind Speed	80 mph
Basic Velocity Pressure (P_v)	16.4
G * C_{pi}	0.25

Diagram 1 - Elevation

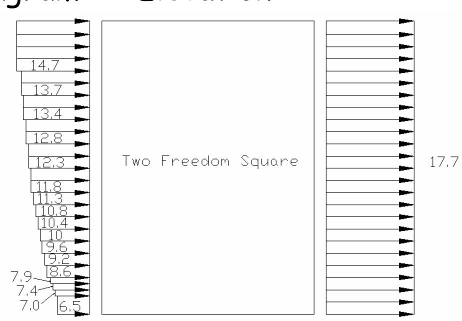
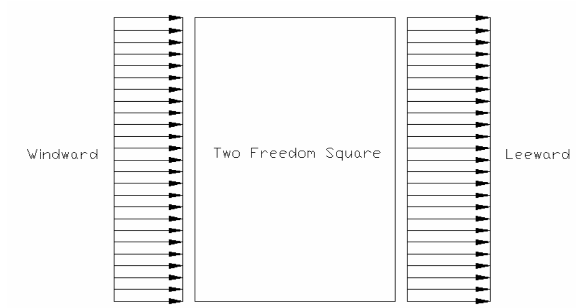


Diagram 2 - Plan



Seismic Loads:

For the seismic calculations an average column size was used to calculate the floor weights, which can be found in Table 10. The results of distributing the base shear to each story can be found in Table 8. A graphical representation of the story forces can be found on Diagram 3. For the seismic calculations an average column size was used to calculate the floor weights. The total weight of the building was found to be 50,077.7 kips. The results of distributing the base shear to each story can be found in Table 7. In the appendix, tables can be found showing the distribution of the forces to each frame; these numbers can also be found in Table 14. A graphical representation of the total story forces can be found on Diagram 3. The calculations of the forces for Diagram 3 can be found on a spreadsheet in the appendix.

Table 7

Peak Velocity (A_V)	0.05
Peak Acceleration (A_A)	0.05
Seismic Hazard Group	1
Seismic Performance Category	A
Soil-type Profile	S3
Deflection Modification Factor (C_D)	4
Response Modification Factor (R)	7
Approximate Fundamental Period (T_A)	1.83
Seismic Coefficient (C_S)	0.0086
Maximum Seismic Coefficient (C_{Smax})	0.0178
Seismic Base Shear (V)	430.7^k

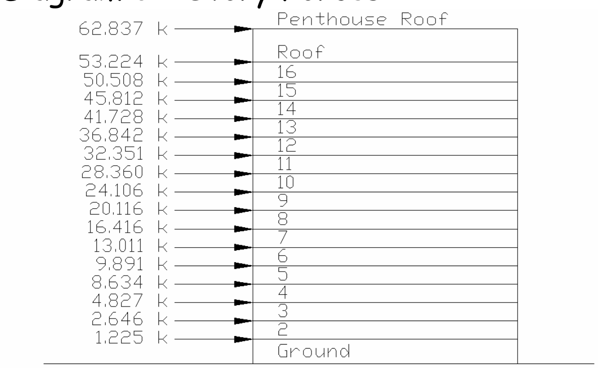
- Basic Structural System – Building frame system with eccentrically braced frame
- Analysis Procedure Utilized – calculation of base shear

Table 8

	Floor Force F_x (kips)	**Floor Shear V_x (kips)**	**Floor Force per Frame for 5 frames (kips)**	**Floor Force per Frame for 7 frames (kips)**
Ground	1.225	452.535	0.25	0.18
2nd Floor	2.646	451.309	0.53	0.38
3rd Floor	4.827	448.664	0.97	0.69
4th Floor	8.634	443.836	1.73	1.23
5th Floor	9.891	435.203	1.98	1.41
6th Floor	13.011	425.312	2.60	1.86
7th Floor	16.416	412.301	3.28	2.35
8th Floor	20.116	395.885	4.02	2.87
9th Floor	24.106	375.769	4.82	3.44
10th Floor	28.360	351.663	5.67	4.05

11th Floor	32.351	323.302	6.47	4.62
12th Floor	36.842	290.951	7.37	5.26
13th Floor	41.728	254.109	8.35	5.96
14th Floor	45.812	212.381	9.16	6.54
15th Floor	50.508	166.569	10.10	7.22
16th Floor	53.224	116.061	10.64	7.60
Penthouse Roof	62.837	62.837	12.57	8.98

Diagram 3 – Story Forces



<u>Soil Bearing Capacity:</u>

- 20,000 psf for Footings
- 100,000 psf for Caissons

<u>Concrete:</u> ACI Code 318-95

- 28-day concrete strength
- stone concrete: coarse aggregate shall conform to ASTM C33

Table 9

f'c = 3,000 psi	for footings and grade beams, slab on grade, interior and exterior beams
f'c = 4,000 psi	for framed floor, basement wall columns, columns on 13th to penthouse roof
f'c = 6,000 psi	for precast concrete units, columns on 9th to 12th floors
f'c = 8,000 psi	for columns on 4th to 8th floors
f'c = 10,000 psi	for columns on cellar 2 to 3rd floors

Floor Heights and Miscellaneous Information: elevation is from sea level

Table 10

Level	Elevation	# of columns	Average Column Size	Weight of Floors
Cellar 2	377'-0"	82	21.9" x 24.9"	3275.1 kips
Cellar 1	389'-0"	78	21.8" x 25.5"	3275.1 kips
Ground Floor	401'-0"	90	22.3"x 26.3"	3275.1 kips
2nd Floor	417'-0"	86	22" x 26.3"	2905.2 kips
3rd Floor	428'-11"	86	22" x 26.2"	3002.8 kips
4th Floor	440'-10"	84	21.6" x 25.7"	2966.3 kips
5th Floor	452'-9"	78	21.4" x 25.1"	2907.6 kips
6th Floor	464'-8"	78	21.4" x 25.1"	2907.6 kips
7th Floor	476'-7"	78	21.3" x 25"	2903.1 kips
8th Floor	488'-6"	78	21.2" x 25"	2900.7 kips
9th Floor	500'-5"	78	21.2" x 25"	2900.7 kips
10th Floor	512'-4"	78	21.2" x 25"	2900.7 kips
11th Floor	524'-3"	72	20.6" x 25.4"	2855.1 kips
12th Floor	536'-2"	67	20.8" x 26.2"	2840.7 kips
13th Floor	548'-1"	67	20.8" x 26.2"	2840.7 kips
14th Floor	560'-0"	63	20" x 25"	2778.5 kips
15th Floor	571'-11"	63	19.1" x 24.3"	2750.5 kips
16th Floor	583'-10"	63	19.1" x 24.3"	2600.6 kips
Penthouse	596'-8"	20	18.8" x 27.8"	2600.6 kips
Penthouse Roof	618'-1"	16	21.3" x 25"	2600.6 kips

Framing System:

The framing system for Two Freedom Square is a combination of cast-in-place concrete columns and a two-way drop panel flat slab. The slab takes the lateral load while the columns transfer everything to the foundation which in turn transfers the loads out to the ground. Diagrams 4 and 5 show a typical column; Diagram 4 shows an example of one with a drop panel and Diagram 5 shows an example of one without a drop panel. Diagram 6 shows an example of on of the bays in Two Freedom Square.

The existing floor system is a two-way drop panel flat slab, which has an 8 inch slab and 10 to 12 inch drop panels. This system is an excellent system to use when face with shallow floor to floor heights and also it is used around the Washington D.C. area because concrete is the primary material used for buildings so the general contracting firms specialize in concrete construction and the construction of two-way slabs.

Some of the issues which arise when designing two-way slabs are the area around the columns. Of major concern are the columns punching through the slab. When this problem arises, drop panels have to be designed to prevent the columns from punching through the slab.

In Tables 11 and 12 are information from the CRSI Handbook which was used to design two-slabs. However these charts lack some basic information need to accurately design for the existing conditions of my building. First the concrete strength is only 3,000 psi and my building has concrete strengths of 4,000 to 10,000 psi. Also the greatest span is only 24 feet and the spans in Two Freedom Square reach 31'-6".

Table 11

f'c = 3,000 psi, Grade 60 bars					**Square Edge Panel**					
	Factored	Square Drop		Square	Reinforcing Bars (E. W.)					
								middle		
	Superimposed	Panel		Column	column strip			strip		Total
Span	Load (psf)	Depth	Width	Size	Top	Bot.	Top	Bot.	Top	Steel

(ft.)		(in)	(in)	(in)	Ext.		Int.		Int.	(psf)
24	100	5.00	8.00	12	12-#4	15-#5	14-#5	10-#5	12-#4	2.33
24	200	6.50	8.00	14	12-#4	11-#7	12-#6	20-#4	11-#5	3.11
24	**300**	**8.00**	**8.00**	**16**	12-#4	18-#6	14-#6	**9-#7**	**10-#6**	**3.92**

Table 12

f'c = 3,000 psi, Grade 60 bars				**Square Interior Panel**					
Span (ft.)	Factored Superimposed Load (psf)	Square Drop Panel		Square Column Size (in)	Reinforcing Bars (E. W.)				Total Steel (psf)
					column strip		middle strip		
		Depth (in)	Width (in)		Top	Bot.	Top	Bot.	
24	100	5.00	8.00	12	19-#4	14-#4	12-#4	11-#4	2.01
24	200	6.50	8.00	17	15-#5	13-#5	10-#5	13-#4	2.65
24	**300**	**8.00**	**8.00**	**20**	12-#6	9-#7	**19-#4**	**16-#4**	**3.36**

Below is information about existing columns in Two Freedom Square and the amount of reinforcing in the drop panels.

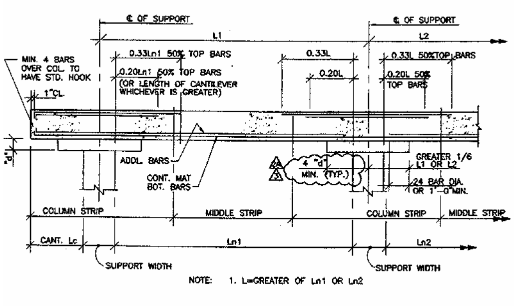
Edge Panel: Column 75 is a 28”x20” throughout the building, with reinforcing bars of 16-#6 & 10-#6 in the drop panels

Interior Panel: Column 65 is a 32”x32” at the ground floor and 24”x24” at the 16^{th} floor, with reinforcing bars of 22-#6 & 22-#6 in the drop panels

The existing system in Two Freedom Square has an 8” concrete slab with 10” to 12” drop panels. The drop panels are as large as 11’-6” square. The overall depth of the floor system is 20” maximum. One advantage of the two-way drop panel flat slab system is because of the 8” slab the system has a fire rating of at least 2-

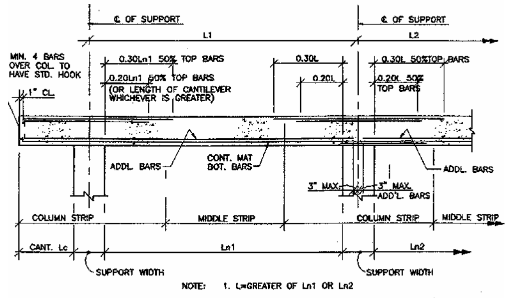
hours, actually more. One possible investigation to further develop this system is to increase the slab thickness which would in turn decrease the size of the drop panels.

Diagram 4



TYP. COLUMN STRIP W/ DROP PANELS

Diagram 5



TYP. COLUMN STRIP W/O DROP PANELS

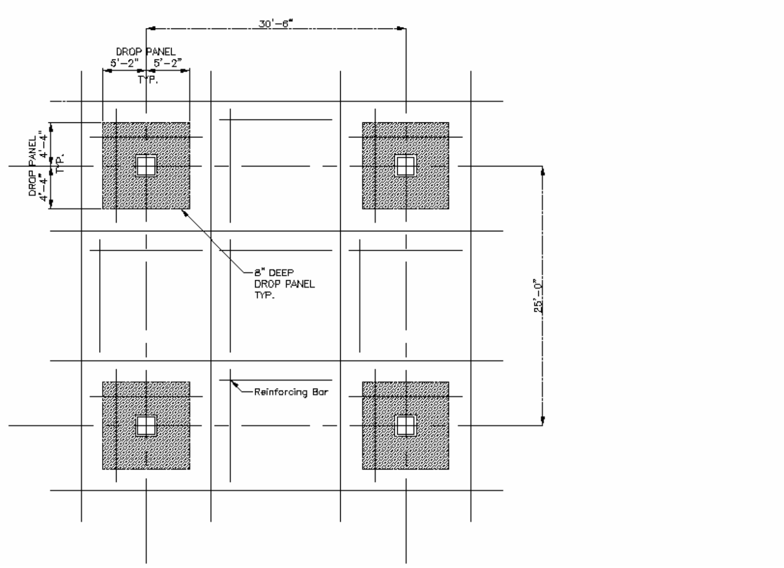
<u>Distance between Columns Lines:</u>

Table 13

A to B	30'-0"
B to C	28'-0"
C to D	25'-0"
D to E	25'-0"
E to F	28'-0"
F to G	30'-0"
1 to 2	30'-6"
2 to 3	29'-0"
3 to 4	29'-0"
4 to 5	30'-6"
5 to 6	30'-0"
6 to 7	31'-1 ¾"
7 to 8	14'-7 ¼"

Diagram 6

Example of a Bay



Lateral Load Resisting Elements:

Two Freedom Square is a concrete building with a two-way flat slab 8" thick with 12" drop panels around the columns. The primary lateral system is a building frame system with eccentrically braced frames. The frames are in both directions of the building making for a system that resists torsion and wind loads in whatever what they are applied to the building.

In the north-south direction the frames are considered to have equal relative stiffness (k) and therefore take an equal amount of the wind load. However in the east-west direction two different frames are considered to take the loads. In these five frames have a relative stiffness equal to 1.107 while the remaining two frames have a relative stiffness equal to 0.729. The distribution of the wind force to each frame can be found in Table 14 and in the appendix the calculations can be seen.

Torsion was investigated and found to have and eccentricity of 73.3 inches, however the accidental eccentricity was found to be 101.4 inches. The accidental eccentricity was taken to be 5% of the total building length. Also the eccentricity was found to only happen for the E-W frames because the N-S frames were symmetric. The 73.3 inch displacement was found in the y-direction, which can be seen in the end of the appendix. The results of the torsion where found to be very small, in the magnitude of 1 to 2 inch-pounds/foot. This makes sense considering the building is a relatively big concrete building having the shape of a cube. Because of the shape being like a cube it is less likely to rotate or bend much.

This building has a few areas of concern when looking at lateral loading. First, on the side closest to One Freedom Square, the building steps down like a staircase. The second area of concern is the area around the elevators. In this area, instead of continuing with the typical series of columns spaced along the column lines, there are numerous columns scattered throughout the area. However this area around the elevators is in the center of the building which means it is along the bending and torsion lines and so columns outside of the core take more of the loads.

Table 14

	Wind Force in N-S (kips) frames 1-5	Wind Force in E-W (kips) frames C-G	Wind Force in E-W (kips) frames A-B
2nd Floor	5.5	6.09	4.01
3rd Floor	6.5	7.20	4.74
4th Floor	7.1	7.86	5.18
5th Floor	7.7	8.52	5.61
6th Floor	8.1	8.97	5.90
7th Floor	8.5	9.41	6.20
8th Floor	8.9	9.85	6.49
9th Floor	9.3	10.30	6.78
10th Floor	9.6	10.63	7.0
11th Floor	9.8	10.85	7.14
12th Floor	10.1	11.18	7.36
13th Floor	10.3	11.40	7.51
14th Floor	10.6	11.73	7.73
15th Floor	10.8	11.96	7.87
16th Floor	11.1	12.29	8.09
Penthouse Roof	11.3	12.51	8.24

Strength, Drift, Story Drift, and Overturning:

Two Freedom Square is a unique building in many aspects and simple in others. Because it is a concrete building, the building itself is very massive, and heavy, yet the interior has a relatively open floor area great for offices. The buildings strength was to resist live and dead loads, but because it is shaped like a cube is easily resists lateral loads as well.

Once again the overall controlling factor was wind over seismic for design. In some cases it was almost two to one. The overall drift in the N-S direction was 2.181 inches for wind loading and 1.679 inches for seismic loading. In the E-W direction the overall drift for wind was 2.45 inches which was adjusted from 2.216 inches in frames C to G and 3.367 inches in frames A and B, all of which can be seen in the appendix. For seismic the it was 1.25 inches in frames C to G and 1.861 inches in frames A and B. The allowable drift for the building taken from h/400 is equal to 6.51 inches, and since in all cases the actual drift is less than h/400. Below in Table 15 are the story drifts for the wind cases.

Table 15

	Story Drift N-S (inches)	**Story Drift E-W (inches)**
Ground	0	0
2nd Floor	0.190	0.193
3rd Floor	0.206	0.222
4th Floor	0.206	0.228
5th Floor	0.199	0.222
6th Floor	0.192	0.216
7th Floor	0.18	0.203
8th Floor	0.169	0.193
9th Floor	0.155	0.176
10th Floor	0.14	0.16
11th Floor	0.124	0.144
12th Floor	0.11	0.126
13th Floor	0.096	0.114
14th Floor	0.079	0.094
15th Floor	0.062	0.074
16th Floor	0.043	0.053
Penthouse Roof	0.03	0.036

The two different directions of wind loading, as seen above, have slightly different story drift values. This make sense that the E-W direction would be larger because the actual length of the frames is shorter than in the N-S direction, causing the drift to be slightly larger.

The overturning moment for this building was found to be significantly smaller than the allowable overturning moment of 1.5 times the weight times the distance from the center of the building to the edge of the building. The difference was over 300 times more. Two Freedom Square has two basements making it that much harder to turn over. So the impact of overturning due to the wind loading is almost insignificant. This has to do with the weight of the building being large and the length almost equal to the height.

Drift Values vs. Allowable Code:

The largest drift value calculated was 2.45 inches which a little less than half of the allowable drift from h/400. As stated before this makes sense because the building is a stiff building due to the fact it is made out of concrete.

Foundation System:

The foundation system is a combination on caissons, footings and slab on grade. Footings are 3,000 psi strength concrete poured on soil with a 20,000 psi bearing capacity. Footings are to project at least 1'-0" into undisturbed soil and exterior footings are to be at least 2'-6" under finished grade. Caissons are to be placed on soil with a 100,000 psi bearing capacity. The slab on grade is to 4" of concrete placed on a layer of 4" gravel. Control joints are to be placed in every 20'-0" O.C. for exterior slabs and 30'-0" max O.C. for interior slabs.

Depth Option #1: Concrete Structure

Introduction to Structural System:

The first redesign option for Two Freedom Square is simplify the column layout and then design in concrete with a two-way flat slab with drop panels. The columns will be placed on the column lines to simplify the design and reduce the number of columns. However this design will cause the redesign of the core of the building, which will be discussed later in this report. The framing system for the lateral loads will continue to be an eccentrically braced frame and the slab will be increased from 8 inches to 10 inches. The drop panels have a depth of 12 inches. The floor plans for the new layout of the columns can be found in Appendix 3, and will be discussed further in later sections.

For the design of this new structural system the IBC 2000 code will be used instead of BOCA 1996 which was used in the original design. The concrete construction followed the ACI Code 318-95 and the design of the reinforcement steel was designed according to ASTM-A615 with grade 60 steel, while the detailing of the reinforcement follows ACI 315-88.

National Design Code: IBC 2000

Live Load:

Table 16

Roof (minimum)	30 psf
Penthouse Machine Room	150 psf
Floor	80 psf + 20 psf partitions
Stairways & Corridors	100 psf

Dead Loads:

Table 17

Superimposed Dead Load	25 psf
Slab Self-weight	100 psf

Snow Loads:

Table 18

Snow Load	$P_f = C_e I P_g$ = 0.7*1*30 = 21 psf
Roof Snow Load (P_g)	30 psf
Snow Exposure Factor (C_e)	0.7
Importance Factor (I)	1.0
Snow Drift	P_{dmax} = 30 psf

Wind Load:

IBC 2000 was used to find wind and seismic loads. The wind load is controlling over seismic in the design of the lateral system. This is known from the analysis performed on the different frames comparing the wind loading to the seismic loading. This building is in a seismic area of category A which is the lowest level while the wind is in an exposure B which is in the middle to low end of wind loads. The windward and leeward pressures can be found in Table 19. A graphical representation of the distribution of the windward and leeward pressures on the building can be found in Diagrams 7 and 8.

- Based on 90 mph, exposure B and importance factor I = 1.15
- Windward wall design pressure, $P = q_z G C_p$
- Leeward wall design pressure, $P = q_h G C_p$
- $q_z = 0.00256 K_z K_{zr} K_d V^2 I$
- $q_h = K_z$ (at top of buiding) q_z
- $G = 0.925 \left(\frac{1 + 1.7 g_Q I_z Q}{1 + 1.7 g_v I_z} \right)$

- $I_z = c\left(\frac{33}{z}\right)^{1/6}$, z = 0.6 h , c = 0.30
- $Q = \sqrt{\frac{1}{1+.063\left(\frac{B+h}{L_z}\right)^{0.63}}}$
- $L_z = l\left(\frac{z}{33}\right)^{\varepsilon}$, έ = 1/3, l = 320

Table 19

Height above ground level, z (feet)	Coefficients K_z and K_h Exposure B	Windward wall design pressure, P (psf)	Leeward wall design pressure, P (psf)	Windward + Leeward wall design pressure, P (psf)
0-15	0.57	8.14	-8.44	16.58
20	0.62	8.85	-8.44	17.30
25	0.66	9.42	-8.44	17.87
30	0.70	10.00	-8.44	18.44
40	0.76	10.85	-8.44	19.30
50	0.81	11.57	-8.44	20.01
60	0.85	12.14	-8.44	20.58
70	0.89	12.71	-8.44	21.15
80	0.93	13.28	-8.44	21.72
90	0.96	13.71	-8.44	22.15
100	0.99	14.14	-8.44	22.58
120	1.04	14.85	-8.44	23.30
140	1.09	15.56	-8.44	24.01
160	1.13	16.14	-8.44	24.58
180	1.17	16.71	-8.44	25.15
200	1.20	17.14	-8.44	25.58
250	1.28	18.28	-8.44	26.72

Wall Pressures Coefficients (C_p):

Table 20

Surface	**L/B**	**C_p**	**For use with**
Windward wall	All Values	0.8	q_z
Leeward wall	All Values	-0.5	q_h

Side walls	All Values	-0.7	q_h

Table 21

Importance Factor (I)	1.15
Basic Wind Speed	90 mph
G	0.822
I_z	0.238
L/B	0.68
Q	0.808
z	132 ft
L_z	507.97
K_d	0.85

Diagram 7

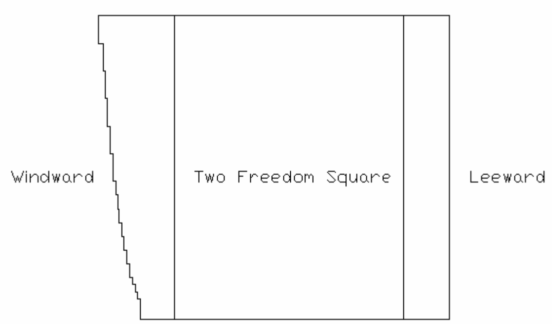
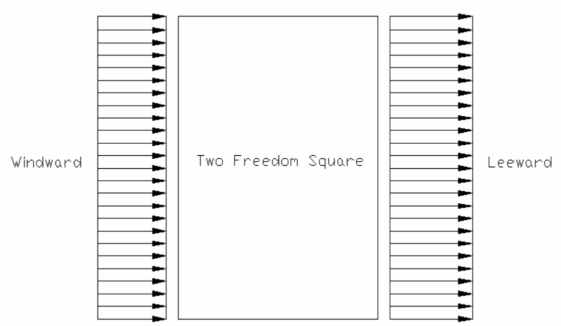


Diagram 8



Seismic Loads:

The results of distributing the base shear to each story can be found in Table 23. A graphical representation of the story forces can be found on Diagram 9. For the seismic calculations an average column size was used to calculate the floor weights. The total weight of the building was found to be 46,000 kips. The results of distributing the base shear to each story can be found in Table 23.

Table 22

Peak Velocity (A_V)	0.05
Peak Acceleration (A_A)	0.05
Seismic Hazard Group	1

Seismic Performance Category	A
Soil-type Profile	S3
Deflection Modification Factor (C_D)	4
Response Modification Factor (R)	7
Approximate Fundamental Period (T_A)	1.70
Seismic Coefficient (C_S)	0.0090
Maximum Seismic Coefficient (C_{Smax})	0.0178
Seismic Base Shear (V)	433.7^k

- Basic Structural System – Building frame system with eccentrically braced frame
- Analysis Procedure Utilized – calculation of base shear

Table 23

	Floor Force F_x (kips)	**Floor Shear V_x (kips)**	**Floor Force per Frame for 5 frames (kips)**	**Floor Force per Frame for 7 frames (kips)**
Ground	1.174496	433.7593	0.23	0.17
2nd Floor	2.536125	432.5848	0.51	0.36
3rd Floor	4.626852	430.0486	0.93	0.66
4th Floor	8.275569	425.4218	1.66	1.18
5th Floor	9.480152	417.1462	1.90	1.35
6th Floor	12.47144	407.6661	2.49	1.78
7th Floor	15.73518	395.1946	3.15	2.25
8th Floor	19.28131	379.4595	3.86	2.75
9th Floor	23.10587	360.1781	4.62	3.30
10th Floor	27.18373	337.0723	5.44	3.88
11th Floor	31.0091	309.8885	6.20	4.43
12th Floor	35.31373	278.8794	7.06	5.04
13th Floor	39.99652	243.5657	8.00	5.71
14th Floor	43.91082	203.5692	8.78	6.27
15th Floor	48.41263	159.6584	9.68	6.92
16th Floor	51.01623	111.2457	10.20	7.29
Penthouse Roof	60.22952	60.22952	12.05	8.60

Framing System:

The framing system for Two Freedom Square is a combination of cast-in-place concrete columns and a two-way drop panel flat slab. The slab takes the lateral load while the columns transfer everything to the foundation which in turn transfers the loads out to the ground. Diagrams 4 and 5 (above) show a typical column; Diagram 4 shows an example of one with a drop panel and Diagram 5 shows an example of one without a drop panel. Diagram 6 (above) shows an example of on of the bays in Two Freedom Square.

The redesigned floor system is a two-way drop panel flat slab, which has a 10 inch slab and 12 inch drop panels. This system, like the existing system, is an excellent system to use when face with shallow floor to floor heights and also it is used around the Washington D.C. area because concrete is the primary material used for buildings so the general contracting firms specialize in concrete construction and the construction of two-way slabs.

Some of the issues which arise when designing two-way slabs are the area around the columns. Of major concern are the columns punching through the slab. When this problem arises, drop panels have to be designed to prevent the columns from punching through the slab. Because the columns were designed to be 24 by 24 inches, this forced the drop panels to be 12 inches deep and the slab to be 10 inches instead of 9 inches. The drop panels are also 12 foot squares around columns. The reinforcement information can be found in Appendix 2, which includes ADOSS runs for both the N-S and E-W directions.

Lateral Load Resisting Elements:

The primary lateral load resisting elements for the redesigned building is a two-way flat slab 10" thick with 12" drop panels around the columns. The elements make up a frame system composed of eccentrically braced frames. The frames are in both directions of the building making for a system that resists torsion and wind loads in whatever what they are applied to the building.

In the north-south direction the frames are considered to have equal relative stiffness (k) and therefore take an equal amount of the wind load. However in the east-west direction two different frames are considered to take the loads. In these five frames have a relative stiffness equal to 1.107 while the remaining two frames have a relative stiffness equal to 0.729. The distribution of the wind force to each frame can be found in Table 1, located in Appendix 1.

This building has a few areas of concern when looking at lateral loading. First, on the side closest to One Freedom Square, the building steps down like a staircase. In the area around the elevators, columns have been added along the column lines to reduce the number of columns scattered throughout the area. However this area around the elevators is in the center of the building which means it is along the bending and torsion lines and so columns outside of the core take more of the loads.

Strength, Drift, Story Drift, and Overturning:

Two Freedom Square is a unique building in many aspects and simple in others. Because it is a concrete building, the building itself is very massive, and heavy, yet the interior has a relatively open floor area great for offices. The buildings strength was to resist live and dead loads.

Once again the overall controlling factor was wind over seismic for design. In some cases it was almost two to one. The overall drift in the N-S direction was 4.212 inches for wind loading. In the E-W direction the overall drift for wind was 5.994 inches. The allowable drift for the building taken from h/400 is equal to 6.51 inches, and since in all cases the actual drift is less than h/400. Below in Table 25 are the story drifts for the wind cases.

Table 25

	Story Drift N-S (inches)	**Story Drift E-W (inches)**
Ground	0	0
2nd Floor	0.266	0.36
3rd Floor	0.605	0.829
4th Floor	0.963	1.333
5th Floor	1.317	1.832
6th Floor	1.659	2.327
7th Floor	1.983	2.792
8th Floor	2.287	3.229
9th Floor	2.57	3.636
10th Floor	2.836	4.017
11th Floor	3.088	4.38
12th Floor	3.315	4.706
13th Floor	3.514	4.991
14th Floor	3.686	5.238
15th Floor	3.829	5.444
16th Floor	3.946	5.613
Penthouse Roof	4.044	5.752

The two different directions of wind loading, as seen above, have slightly different story drift values. This make sense that the E-W direction would be larger because the actual length of the frames is shorter than in the N-S direction, causing the drift to be slightly larger.

The overturning moment for this building was found to be significantly smaller than the allowable overturning moment of 1.5 times the weight times the distance from the center of the building to the edge of the building. The difference was over 300 times more. Two Freedom Square has two basements making it that much harder to turn over. So the impact of overturning due to the wind loading is almost insignificant. This has to do with the weight of the building being large and the length almost equal to the height.

Drift Values vs. Allowable Code:

The largest drift value calculated was 5.99 inches which a little less than the allowable drift from h/400. As stated before this makes sense because the building is a stiff building due to the fact it is made out of concrete.

Depth Option #2: Non-Composite Steel Structure

Introduction to Structural System

For my final design, I looked at the modified column layout, which can be seen in Appendix 3, with a steel structure compared to a concrete structure. For the lateral system moment frames were used in both direction and shear walls in the core around some of the elevator shafts. The slab is a combination of 2 inch LOK deck with 4½ inches of cover to provide enough depth to not require additional fireproofing on the underside of the deck. Also with this design the intermediate beams were designed both compositely and non-compositely.

The IBC 2000 was used as the primary code to determine loading of the building. It was also used to provide information about the requirements for fireproofing, torsion, and accidental torsion.

National Design Code: IBC 2000

Live Load:

Table 26

Roof (minimum)	30 psf
Penthouse Machine Room	150 psf
Floor	80 psf + 20 psf partitions
Stairways & Corridors	100 psf

Dead Loads:

Table 27

Superimposed Dead Load	25 psf
Slab Self-weight	81.25 psf

Snow Loads:

Table 28

Snow Load	$P_f = C_e I P_g$ = 0.7*1*30 = 21 psf
Roof Snow Load (P_g)	30 psf
Snow Exposure Factor (C_e)	0.7
Importance Factor (I)	1.0
Snow Drift	P_{dmax} = 30 psf

Wind Load:

Wind loads were determined by IBC 2000 which references ASCE 7-02. The wind load is controlling over seismic in the design of the lateral system. And actually because of the shape of my building accidental torsion is the controlling factor in the lateral system based on relative stiffness. This is known from the analysis performed on the different frames comparing the wind loading to the seismic loading. This building is in a seismic area of category A which is the lowest level while the wind is in an exposure B which is in the middle to low end of wind loads. The windward and leeward pressures can be found in Table 29. A graphical representation of the distribution of the windward and leeward pressures on the building can be found in Diagrams 9 and 10.

- Based on 90 mph, exposure B and importance factor I = 1.15
- Windward wall design pressure, $P = q_z G C_p$
- Leeward wall design pressure, $P = q_h G C_p$
- $q_z = 0.00256\, K_z K_{zr} K_d V^2 I$
- $q_h = K_z$ (at top of buiding) q_z
- $G = 0.925 \left(\frac{1 + 1.7 g_Q I_z Q}{1 + 1.7 g_v I_z} \right)$
- $I_z = c \left(\frac{33}{z} \right)^{1/6}$, z = 0.6 h , c = 0.30

- $Q = \sqrt{\dfrac{1}{1+.063\left(\dfrac{B+h}{L_z}\right)^{0.63}}}$
- $L_z = l\left(\dfrac{z}{33}\right)^{\varepsilon}$, ἐ = 1/3, l = 320

Table 29

Height above ground level, z (feet)	Coefficients K_z and K_h Exposure B	Windward wall design pressure, P (psf)	Leeward wall design pressure, P (psf)	Windward + Leeward wall design pressure, P (psf)
0-15	0.57	7.57	-10.62	18.19
20	0.62	8.23	-10.62	18.86
25	0.66	8.77	-10.62	19.39
30	0.70	9.30	-10.62	19.92
40	0.76	10.09	-10.62	20.72
50	0.81	10.76	-10.62	21.38
60	0.85	11.29	-10.62	21.91
70	0.89	11.82	-10.62	22.44
80	0.93	12.35	-10.62	22.97
90	0.96	12.75	-10.62	23.37
100	0.99	13.15	-10.62	23.77
120	1.04	13.81	-10.62	24.43
140	1.09	14.48	-10.62	25.10
160	1.13	15.01	-10.62	25.63
180	1.17	15.54	-10.62	26.16
200	1.20	15.94	-10.62	26.56
250	1.28	17.00	-10.62	27.62

Wall Pressures Coefficients (C_p):

Table 30

Surface	**L/B**	**C_p**	**For use with**
Windward wall	All Values	0.8	q_z
Leeward wall	All Values	-0.5	q_h
Side walls	All Values	-0.7	q_h

Table 31

Importance Factor (I)	1.15
Basic Wind Speed	90 mph
G	0.822
I_z	0.238
L/B	0.68
Q	0.808
Z	132 ft
L_z	507.97
K_d	0.85

Diagram 9

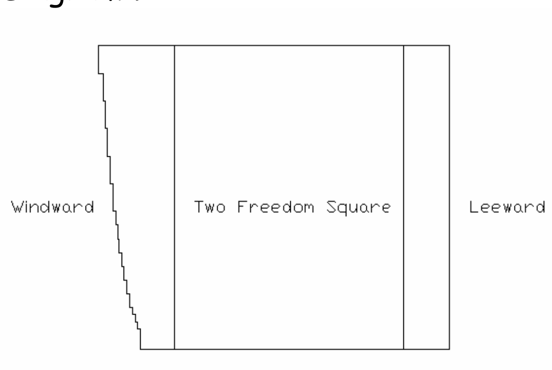
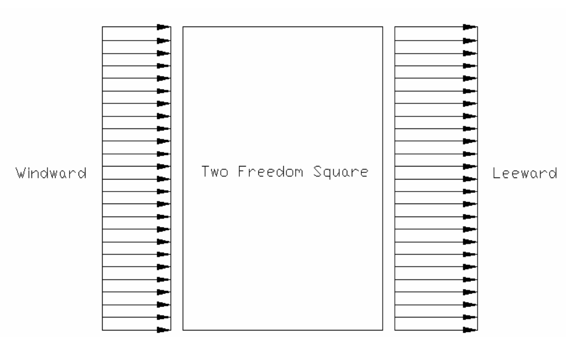


Diagram 10



Seismic Loads:

The results of distributing the base shear to each story can be found in Table 33. A graphical representation of the story forces can be found on Diagram 12. For the seismic calculations an average column size was used to calculate the floor weights. The total weight of the building was found to be 43,495 kips. The results of distributing the base shear to each story can be found in Table 33.

Table 32

Peak Velocity (A_V)	0.05
Peak Acceleration (A_A)	0.05
Seismic Hazard Group	1
Seismic Performance Category	A
Soil-type Profile	S3

Deflection Modification Factor (C_D)	4
Response Modification Factor (R)	7
Approximate Fundamental Period (T_A)	1.88
Seismic Coefficient (C_S)	0.0084
Maximum Seismic Coefficient (C_{Smax})	0.0178
Seismic Base Shear (V)	366.3^k

- Basic Structural System – moment frame system with shear walls
- Analysis Procedure Utilized – calculation of base shear

Table 33

	Floor Force F_x (kips)	**Floor Shear V_x (kips)**	**Floor Force per Frame for 5 frames (kips)**	**Floor Force per Frame for 7 frames (kips)**
Ground	0.678634	366.2511	0.14	0.10
2nd Floor	1.797616	365.5725	0.36	0.26
3rd Floor	3.323065	363.7748	0.66	0.47
4th Floor	5.068556	360.4518	1.01	0.72
5th Floor	7.229201	355.3832	1.45	1.03
6th Floor	9.693839	348.154	1.94	1.38
7th Floor	12.39858	338.4602	2.48	1.77
8th Floor	15.41499	326.0616	3.08	2.20
9th Floor	18.69501	310.6466	3.74	2.67
10th Floor	21.8828	291.9516	4.38	3.13
11th Floor	25.60499	270.0688	5.12	3.66
12th Floor	29.56315	244.4638	5.91	4.22
13th Floor	33.3358	214.9007	6.67	4.76
14th Floor	37.69395	181.5649	7.54	5.38
15th Floor	42.26887	143.8709	8.45	6.04
16th Floor	46.84762	101.602	9.37	6.69
Penthouse Roof	54.75443	54.75443	10.95	7.82

Framing System:

The framing system for the redesign of Two Freedom Square into steel is a combination of both moment frames and shear walls. The moment frames are made up of the columns and beams along the column likes. There are seven frames in the E-W direction and eight frames in the N-S direction. Frames 1 and 5 are the same and frames 2 and 4 are the same however the rest of the frames are different due to the shape of the building and the distribution of the loading. Pictures of the frames can be seen in Appendix 4. In the E-W direction there are two shear walls along the outside walls of the stairwells. Those shear walls are each 20 feet long and 8 inches thick. Details for the reinforcement and distribution for the loading can be found in Appendix 2. In the N-S direction there are four shear walls along the elevator shafts each 10 feet long and 18 inches thick. Details for reinforcement and distribution for loads can also be found in Appendix 2.

Along with the moment frames and the shear walls, as mentioned before the floor system is concrete on 2 inch LOK deck which spans a maximum distance of 10 feet. The specification for the deck was found in a decking manual put out by industry. Two options were looked at for the floor system. First was just a normal non-composite slab on deck. The second was a composite system for the intermediate beams only. This reduced the size of the intermediate beams from W18s to W12s.

One thing which changed when switching from concrete to steel was what the floor to floor height was going to be. One advantage in using a two-way flat slab system was being about the place mechanical ductwork around the drop panels and thus get a lower floor to floor height. With a steel frame, ductwork cannot be place between the beams, and therefore it has to be hung underneath the beams. This adds height to the overall height of the floors because the depth about the drop ceiling is comprised of ductwork plus beam and slab depth compare to the great of ductwork plus slab depth or drop panel and slab depth. For the redesign of Two

Freedom Square into steel with keeping in mind the mechanical ductwork, added two feet to the floor to floor height of each floor to keep the same drop ceiling height. Also by adding height to the floor to floor height, this required that an additional 4 to 5 feet be added to the excavation depth. Below in Table 34 are the new elevations of each floor level.

Table 34

Level	Elevation
Cellar 2	373'-0"
Cellar 1	387'-0"
Ground Floor	401'-0"
2nd Floor	419'-0"
3rd Floor	433'-0"
4th Floor	447'-0"
5th Floor	461'-0"
6th Floor	475'-0"
7th Floor	489'-0"
8th Floor	503'-0"
9th Floor	517'-0"
10th Floor	531'-0"
11th Floor	545'-0"
12th Floor	559'-0"
13th Floor	573'-0"
14th Floor	587'-0"
15th Floor	601'-0"
16th Floor	615'-0"
Penthouse	629'-0"
Penthouse Roof	651'-0"

Lateral Load Resisting Elements:

As mentioned above the lateral load resisting elements are a combination of moment frames and shear walls. The distribution of the lateral loads and torsion affects is determined by the relative stiffness of each frame or shear wall. To analyze the different frames RISA was used in combination with an extensive spreadsheet, which can be found in Appendix 1.

After analyzing each frame for wind loading, wind plus torsion and wind plus accidental torsion, it was determined that the wind plus accidental torsion would be the controlling lateral loading on the building. This is due to the shape of the building which causes the center of mass to change position as one moves up through the building. The center of masses for each floor can be seen in Table 35. All the distances are taken from the intersection of column line 1 and column line G, which can be found in Appendix 3.

Table 35

	x bar	y bar
Ground to 4th	87.72 ft	75.02 ft
5th to 10th	82.36 ft	76.41 ft
11th to 13th	68.24 ft	83.21 ft
14th to roof	59.5 ft	83 ft

Drift and Story Drift:

The maximum drift in the E-W direction is 7.336 inches and in the N-S direction is 7.246 inches due to wind plus accidental torsion loading. This is under maximum loading; however it might be a little too much for the pre-cast concrete panels to take without cracking. This was not part of my research, but further work could be put into the design of the connections of the pre-cast panels to the frame to allow for more movement. Below in Table 36, story forces for both the N-S and E-W directions.

Table 36

	Story Drift N-S (inches)	% of Ht.	Story Drift E-W (inches)	% of Ht.
Ground	0	0	0	0
2nd Floor	0.399	0.185	0.415	0.192
3rd Floor	0.464	0.276	0.412	0.245
4th Floor	0.484	0.288	0.412	0.245
5th Floor	0.554	0.33	0.504	0.3
6th Floor	0.53	0.316	0.488	0.29
7th Floor	0.497	0.296	0.468	0.279
8th Floor	0.523	0.311	0.535	0.318
9th Floor	0.473	0.282	0.501	0.298
10th Floor	0.425	0.253	0.464	0.276
11th Floor	0.448	0.267	0.502	0.299
12th Floor	0.388	0.231	0.454	0.27
13th Floor	0.325	0.194	0.391	0.233
14th Floor	0.463	0.275	0.476	0.283
15th Floor	0.36	0.214	0.384	0.229
16th Floor	0.256	0.153	0.293	0.174
Penthouse Roof	0.294	0.175	0.276	0.164

Drift Values vs. Allowable Code:

The redesign of Two Freedom Square into steel increased the height of the building which in turn increased the h/400 drift limit from 6.5 inches to 7.5 inches. The actual drift the building undergoes is at a maximum 7.336 inches in the E-W direction and 7.246 inches in the N-S direction. Both of these numbers are less than the allowable drift, however more time would have allowed for a more research into limiting the drift vales more.

Breadth #1: Construction Management Issues

As investigation into alternative structural systems developed, construction management issues became more important. Some of the obvious areas of concern were cost differences between a concrete structure and a steel structure, the need for a crane large enough to erect a steel structure, and then the amount of time difference for a concrete verses a steel structure construction.

First, the cost differences between a concrete building and a steel building. R.S. Means was used to do a square foot estimate for Two Freedom Square. The model number used was M.480, which is an 11-20 story office building.

R.S. Means Estimate: Steel building

Two Freedom Floor Area:		=	405,881 sq. ft.
Two Freedom Basement Area:		=	44,349 sq. ft.
Two Freedom Total Area:		=	450,230 sq. ft.
Two Freedom Perimeter:		=	750 ft.
Cost per Sq. Ft.:		=	\$86.28
Cost per Sq. Ft. Basement:		=	\$24.65
Perimeter Adjustment:	1.88×1.46	=	\$2.74
Story Height Adjustment:	4×1.09	=	\$4.36
Adjusted Cost per Sq. Ft.:	$86.28 + 2.74 + 4.36$	=	\$93.38
Floor Area:	$405{,}881 \times 93.38$	=	\$37,901,167.78
Basement Area:	$44{,}349 \times 24.65$	=	\$1,093,202.85
Elevator Adjustment:	$4 \times 226{,}000$	=	\$904,000.00
Total Cost:		=	\$39,898,370.63
Total Cost per Sq. Ft.:		=	\$88.62
Location Factor (Alexandria, VA):		=	0.92
Historical Factor (Alexandria, VA):		=	0.91
Adjusted Cost per Sq. Ft.:		=	\$74.19
Contractor Fee 25%:		=	\$18.55
Architect Fee 6%:		=	\$4.45
Final Cost per Sq. Ft.:	$74.19 + 18.55 + 4.45$	=	**\$97.19**

<u>R.S. Means Estimate:</u> Concrete building

Two Freedom Floor Area:		=	405,881 sq. ft.
Two Freedom Basement Area:		=	44,349 sq. ft.
Two Freedom Total Area:		=	450,230 sq. ft.
Two Freedom Perimeter:		=	750 ft.
Cost per Sq. Ft.:		=	$82.13
Cost per Sq. Ft. Basement:		=	$24.65
Perimeter Adjustment:	1.88×1.46	=	$2.74
Story Height Adjustment:	2×1.09	=	$2.18
Adjusted Cost per Sq. Ft.:	$82.13 + 2.74 + 2.18$	=	$87.05
Floor Area:	$405{,}881 \times 87.05$	=	$35,331,941.05
Basement Area:	$44{,}349 \times 24.65$	=	$1,093,202.85
Elevator Adjustment:	$4 \times 226{,}000$	=	$904,000.00
Total Cost:		=	$37,329,143.90
Total Cost per Sq. Ft.:		=	$82.91
Location Factor (Alexandria, VA):		=	0.92
Historical Factor (Alexandria, VA):		=	0.91
Adjusted Cost per Sq. Ft.:		=	$69.41
Contractor Fee 25%:		=	$17.35
Architect Fee 6%:		=	$4.16
Final Cost per Sq. Ft.:	$69.41 + 17.35 + 4.16$	=	**$90.92**

A comparison of the two estimates shows that the concrete design is cheaper. Mainly this is due to the fact that the steel building has a larger floor to floor height.

Table 37

	Cost
Estimated Project Cost	$39,500,000.00
Total Project Cost (TC)	$42,000,000.00
R.S. Means Estimate – Concrete Building	$40,934,911.60
R.S. Means Estimate – Steel Building	$43,757,853.70

Secondly, the need to size a crane large enough for the erection of the steel structure was investigated. For this the largest steel member was chosen at the largest reach which happened to be a W30x191, thirty feet in length which is a weight of 5,730 pounds. This member is located 200 feet from the placement of the crane, which can be seen on a site plan in Appendix 3. To find a crane the Liebherr website was accessed. The 290 HC crane, which is a tower crane, was chosen because of its reach and ability to lift the weight at the distance away from the tower. The cost to rent this crane is $11,500 per month and it has a capacity of 9,070 pounds at a distance of 197 ft from the tower. Specifications for this specific crane can be found in Appendix 4.

Finally, the time to erect a steel structure compared to a concrete structure was determined. The time to erect a steel structure was determined from the R.S. Means unit cost per square foot estimate. The steel structure weighs 6,932.958 kips or 3,466.479 tons. The Means estimate is the daily output is 13.9 tons per day of steel with one crew; which translates into 250 days. A summary of the information from Means can be found in Table 38. The numbers in Table 38 are based on one crew working, which in reality could be sped up by increasing the number of people working on each area of work.

Table 38

	Daily Output	Amount	Days	Crews
Steel Erection	13.9 ton/day	3,466.479 tons	249.39	E-6
Non-Composite Deck	4,000 sq. ft./day	450,230 sq. ft.	112.56	E-4
Composite Deck	3,600 sq. ft./day	450,230 sq. ft.	125.06	E-4
Slab – pumped	140 cy/day	18,759.58 cy	134	C-20
Slab – crane & bucket	100 cy/day	18,759.58 cy	187.6	C-7

Breadth #2: Architectural Issues

For the second breath option architectural issues were investigated. This seems like a logical area to look at in depth because the column layout was rearranged which disturbed the core of the building. So a redesign of the core of the building was necessary to make room for the new columns introduced to that area. The major problem which arose was one of the columns was right in the middle of an elevator shaft. Also some of the bathrooms where rearranged to placement of the columns in that space.

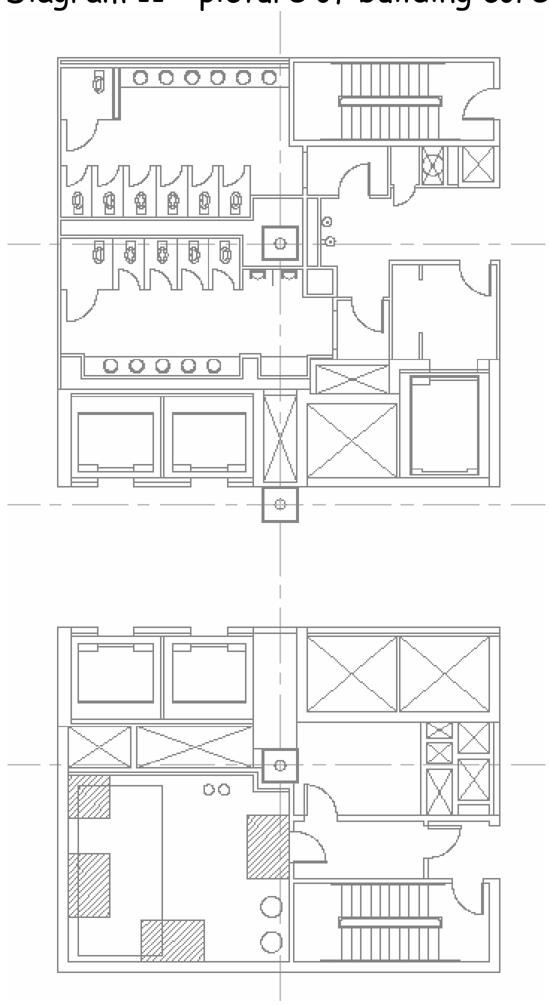
The solution to the problem of the elevator going through the middle of an elevator was to separate the elevators to two on each side of the column to allow room for the beams to be placed through the core of the building. Also the whole core was moved towards the northern part of the building, which places the column in the floor space between the elevators, however this was necessary to be able to put a beam in from of the elevator shaft. All of this can be seen in Diagram 11.

Some other things which were changed were the Men's and Women's bathrooms where switched due to the configuration around the introduction of a new column. The bathrooms are still in the same spot, however because the addition width added from separating the elevators, an addition stall was added to each restroom. Also by moving the core, the core is now closer to some columns, so a check was done to make sure there was still adequate room to get around the columns.

Most of the layout of the building stayed the same because it was just open office space. And because the way the core was designed not much in the core changed. Most of the elements in the core are stacked which allowed for fluid redesign.

One thing which was not address was the exterior of the building. My focus was to look at the interior space, however if the building was redesigned in steel the floor to floor height would be increased two feet which would necessitate the redesign of the exterior elevations and most likely the pre-cast concrete panels used to make up the facade of the building.

Diagram 11 – picture of building core

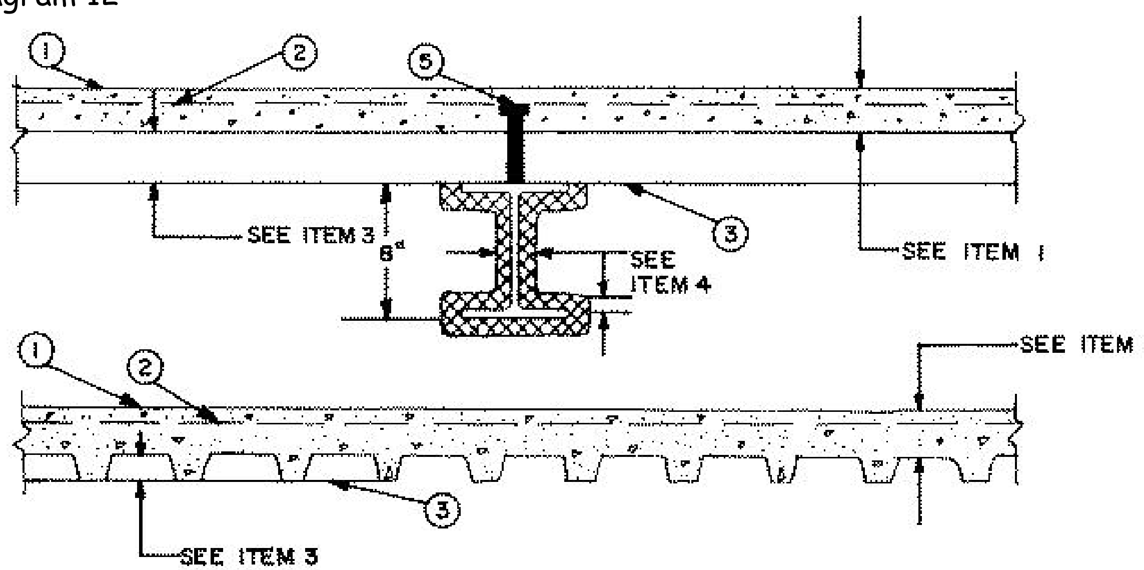


Fireproofing for Steel Design

One final area of interest which arose while investigating other structural systems for Two Freedom Square was how to fireproof the steel structure. This was not a concern in the original design because it was made out of concrete which is inherently fire resistant. Upon further investigation it was found that only the beams and columns would require fireproofing. The metal deck would not have to be fireproofed if the slab depth on top of the slab was $4\frac{1}{2}$ inch on top of the corrugation. When investigating options for fireproofing, several options arose.

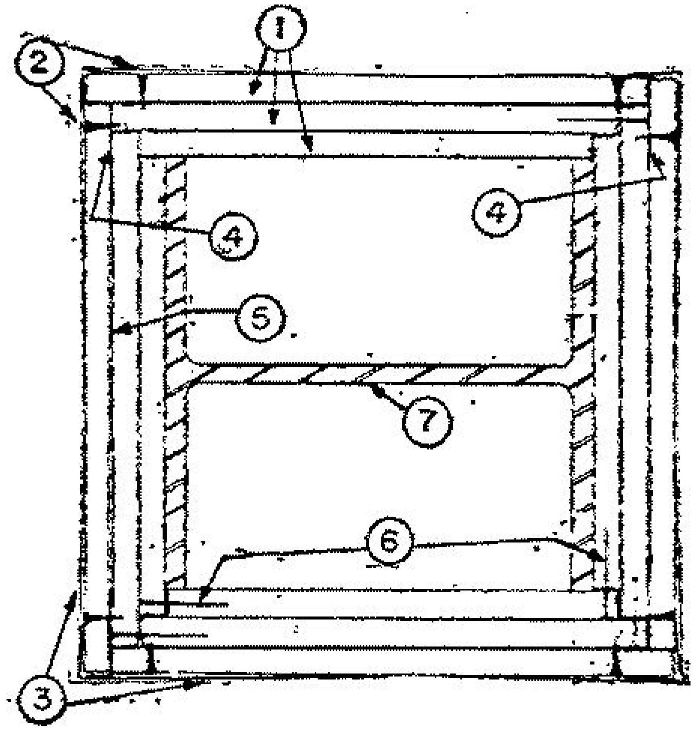
For the beams, the D916 assembly was determined to work. Diagram 12 shows a picture of the assembly. The requirement for a 2-hour fire rating is 1-1/16 inches of spray-on fireproofing.

Diagram 12



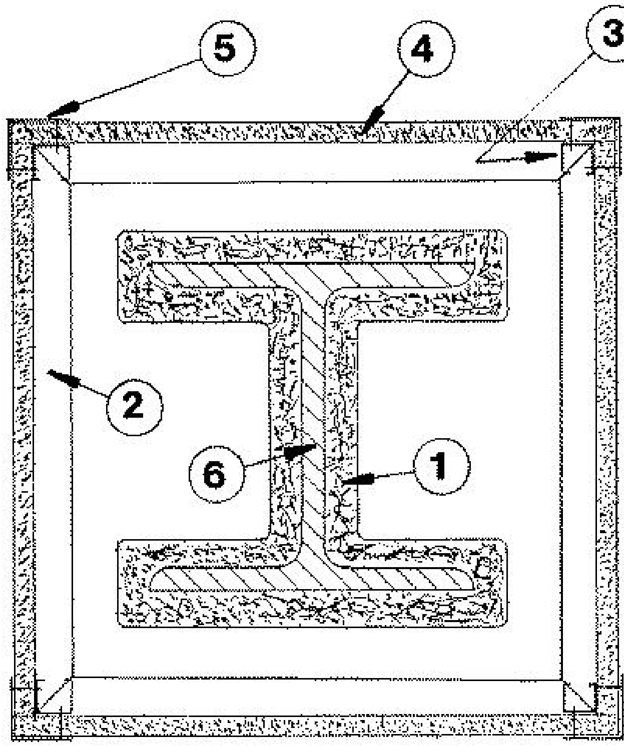
For the column fireproofing, there are several options. The first is X516 which is three layers of gypsum board, each being at least 5/8 in thick to get the required 2-hour fire rating. A picture of the assembly can be seen in Diagram 13.

Diagram 13



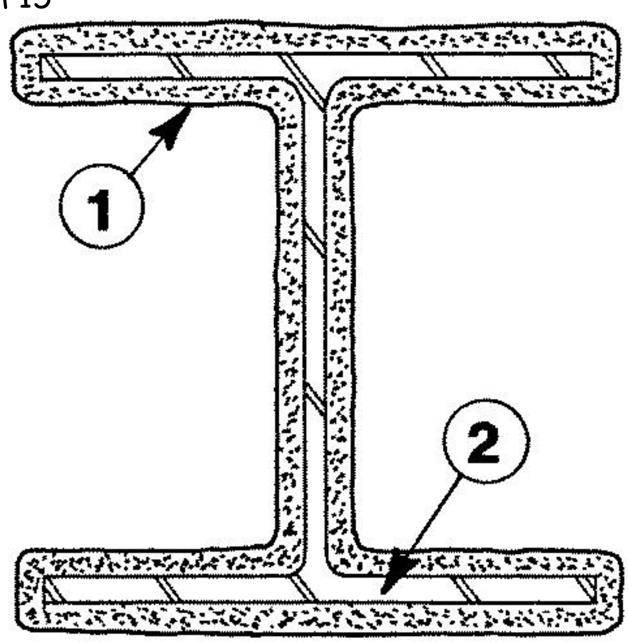
The second assembly for columns is X525, which is a combination of spray on fireproofing and gypsum board. The required thickness of the spray on fire proofing is 1-1/4 inches and the gypsum board is to be 5/8 inches thick. Also the corners are supposed to be sealed. A picture of the assembly can be seen in Diagram 14.

Diagram 14



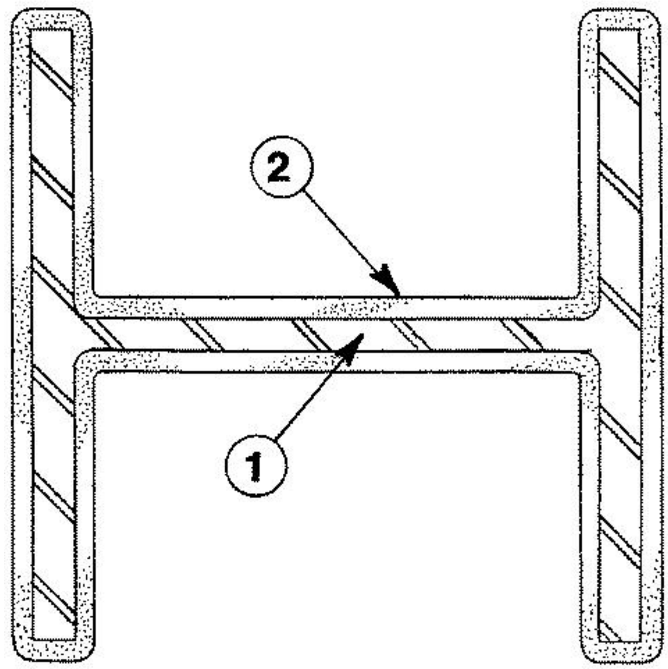
The third assembly is X603, which is just spray on fireproofing on the column. A picture of this can be seen in Diagram 15.

Diagram 15



The final assembly is a mastic coating on the columns. This is normally used for exposed members, which leaves the option of exposing the columns in Two Freedom Square. A picture of the assembly can be seen in Diagram 16. To receive a 2-hour fire rating a thickness of 0.110 inches is required of the film.

Diagram 16



Summary and Conclusions

Above is all the information about the structures investigated, mostly the loading and what went into the design process. It produced a lot of data which had to be interpreted.

So, after completing this thesis project some of the research leads to dead ends while others gave reasons to continue with further investigation. The original design of Two Freedom Square was a good design, efficient, constructible, and attractive.

Looking at the areas in which the research was developed, most of it came out of a new column layout which seems to make sense, however the proposed redesigns would still need some work to get to the point at which the existing structure is at. For the concrete structure, large columns would be required to achieve the same efficiency as the existing structure, also the addition of shear walls could drastically help drift. In the steel structure, a more in depth look which frames should be used as moment frames instead of using them all. Because the building is not symmetric, large affect from torsion exist. The affect from torsion greatly increased the size of a few of the frames which were distanced from the center of mass.

Other things to consider when analyzing the redesigns, for the steel structure specifically the need for fireproofing is required. Also the additional height to the building will increase the cost of the building, and increase the size of the crane needed. Focusing on the new column layout causes a redesign of the core and causes some interesting maneuvering around the elevators.

All of these problems or hitches are things which could be refined with more work and time to tweak the designs. They are both viable solutions to the design of Two Freedom Square.

In conclusion a lot was learned over the course of the year, mostly have to learn on my own and teach myself things needed to complete the design. Also it has helped me get a greater picture of what goes into the design a building.

Appendix 1: Loads

Table 1 – Wind Loads

Concrete Building: 220 ft											
		A&G	B&F	C&E	D	1&5	2&4	3	6	7	8
ground	254.05	3.81	7.37	6.73	6.35	3.87	7.56	7.37	7.62	5.72	1.91
2nd	251.7	3.78	7.30	6.67	6.29	3.84	7.49	7.30	7.55	5.66	1.89
3rd	264.45	3.97	7.67	7.01	6.61	4.03	7.87	7.67	7.93	5.95	1.98
4th	273.31	4.10	7.93	7.24	6.83	4.17	8.13	7.93	8.20	6.15	2.05
5th	281.08	4.22	8.15	7.45	7.03	4.29	8.36	8.15	8.43	6.32	2.11
6th	289.73	4.35	8.40	7.68	7.24	4.42	8.62	8.40	8.69	6.52	2.17
7th	295.91	4.44	8.58	7.84	7.40	4.51	8.80	8.58	8.88	6.66	2.22
8th	303.29	4.55	8.80	8.04	7.58	4.63	9.02	8.80	9.10	6.82	2.27
9th	308	4.62	8.93	8.16	7.70	4.70	9.16	8.93	9.24	6.93	2.31
10th	314.67	4.72	9.13	8.34	7.87	4.80	9.36	9.13	9.44	7.08	2.36
11th	317.1	4.76	9.20	8.40	7.93	4.84	9.43	9.20	9.51	7.13	2.38
12th	323.25	4.85	9.37	8.57	8.08	4.93	9.62	9.37	9.70	7.27	2.42
13th	326.22	4.89	9.46	8.64	8.16	4.97	9.70	9.46	9.79	7.34	2.45
14th	330.05	4.95	9.57	8.75	8.25	5.03	9.82	9.57	9.90	7.43	2.48
15th	333.83	5.01	9.68	8.85	8.35	5.09	9.93	9.68	10.01	7.51	2.50
16th	517.89	7.77	15.02	13.72	12.95	7.90	15.41	15.02	15.54	11.65	3.88
roof	382.85	5.74	11.10	10.15	9.57	5.84	11.39	11.10	11.49	8.61	2.87

Table 2 – Wind Loads per Frame, Steel Design

1	2	3	4	5	6	7	8	A	B	C	D	E	F	G
2.8705	2.8705	2.8705	2.8705	2.8705	9.1777	4.5888	0.2118	2.8896	2.8896	2.8896	2.8896	2.8896	2.8896	2.8896
4.5900	4.5900	3.0600	4.5900	4.5900	8.8633	4.4317	0.2127	2.6895	2.6895	2.6895	2.6895	2.6895	4.0343	8.0686
6.6735	5.0051	4.0041	5.0051	6.6735	9.6179	4.4391	0.3124	3.5773	3.5773	3.5773	3.5773	3.5773	4.4716	8.9432
7.7802	6.2242	4.4458	6.2242	7.7802	10.0728	4.5327	0.3108	4.4537	4.4537	3.8970	3.8970	3.8970	5.1960	10.3920
10.7758	7.6970	5.9866	7.6970	10.7758	10.4815	4.6585		4.6387	5.1541	4.6387	4.2170	4.6387	5.7984	11.5968
11.3721	7.5814	6.2030	7.5814	11.3721	10.6165	4.9960		4.9552	5.3682	4.9552	4.6013	4.9552	6.4418	12.8836
12.0307	7.6559	6.0153	7.6559	12.0307	11.3151	4.8149		5.2568	5.6073	5.2568	4.9476	5.2568	7.0091	14.0183
11.7782	8.1541	6.2355	8.1541	11.7782	11.5881	4.8284		5.4368	5.7388	5.4368	5.1649	5.7388	7.3785	14.7569
12.2000	8.1333	6.4210	8.1333	12.2000	11.8638	4.9432		5.5013	6.0252	5.5013	5.5013	6.0252	7.4429	15.8162
12.3412	8.2275	6.7316	8.2275	12.3412	11.7879	5.3326		5.9299	6.1671	5.9299	5.7103	6.1671	8.1146	15.4178
12.6798	8.2419	6.5935	8.2419	12.6798	17.3485			5.9822	6.1885	5.9822	5.7893	6.4095	8.1576	16.3152
12.5857	8.5812	6.7424	8.5812	12.5857	17.6050			6.1810	6.3683	6.1810	6.0044	6.7792	8.4062	16.1657
12.6100	8.7300	7.0931	8.7300	12.6100	1.2575			6.4113	6.4113	6.2510	6.0985	6.7578	8.6220	16.6693
12.8091	8.9663	7.2700	8.9663	12.8091				6.7066	6.7066	6.2785	6.1477	6.8626	8.6791	17.3583
12.8702	9.3602	7.3544	9.3602	12.8702				6.9904	6.8506	6.2278	6.2278	6.8506	9.0139	18.0278
16.1168	11.7928	9.4805	11.7928	16.1168				9.5908	8.9514	7.6727	7.3574	8.3920	10.9610	24.4130
9.6397	7.7117	6.0091	7.7117	9.6397				7.1853	4.9799	4.3736	3.8690	4.7006	5.9173	15.7178

Table 3 – Wind Loads per Shear Wall

sw1	sw2	sw3	sw4	sw5	sw6
6.4749	6.4749	6.4749	6.4749	14.8186	14.8186
4.2287	4.2287	4.2287	4.2287	10.9694	10.9694
3.2180	3.2180	3.2180	3.2180	9.2702	9.2702
2.2864	2.2864	2.2864	2.2864	7.6741	7.6741
2.1249	2.1249	2.1249	2.1249	6.2512	6.2512
1.6065	1.6065	1.6065	1.6065	5.2417	5.2417
1.2764	1.2764	1.2764	1.2764	4.4373	4.4373
1.0941	1.0941	1.0941	1.0941	3.7288	3.7288
0.8956	0.8956	0.8956	0.8956	3.2594	3.2594
0.8006	0.8006	0.8006	0.8006	2.9317	2.9317
0.6750	0.6750	0.6750	0.6750	2.5897	2.5897
0.5995	0.5995	0.5995	0.5995	2.3550	2.3550
0.5702	0.5702	0.5702	0.5702	2.2189	2.2189
0.5437	0.5437	0.5437	0.5437	2.1088	2.1088
0.5098	0.5098	0.5098	0.5098	2.0001	2.0001
0.6599	0.6599	0.6599	0.6599	2.5952	2.5952
0.4792	0.4792	0.4792	0.4792	1.8453	1.8453

Table 4 – Wind plus Torsion per Frame

1	2	3	4	5	6	7	8	A	B	C	D	E	F	G
2.8705	2.8705	2.8705	4.3654	7.1339	12.6708	7.0427	0.2118	2.8896	2.8896	2.8896	2.9252	4.4228	6.1001	7.8972
12.4290	9.1681	4.0450	4.5900	4.5900	8.8633	4.4317	0.2127	2.6895	2.6895	2.6895	2.6895	3.0515	5.6214	13.4804
14.5713	8.5165	4.9786	5.0051	6.6735	9.6179	4.4391	0.3124	3.5773	3.5773	3.5773	3.5773	3.6052	4.5696	9.2744
16.9578	10.5431	5.4776	6.2242	7.7802	10.0728	4.5327	0.3108	4.4537	4.4537	3.8970	3.8970	4.0912	5.9393	12.9164
32.1586	16.5215	8.0808	7.6970	10.7758	10.4815	4.6585		4.6387	5.1541	4.6387	4.2170	5.4751	8.9753	22.5179
35.5354	16.8421	8.4524	7.5814	11.3721	10.6165	4.9960		4.9552	5.3682	4.9552	4.6013	5.7165	9.7199	24.3438
37.5630	16.9247	8.0841	7.6559	12.0307	11.3151	4.8149		5.2568	5.6073	5.2568	4.9476	5.9947	10.5193	26.4524
35.6289	17.5587	8.2595	8.1541	11.7782	11.5881	4.8284		5.4368	5.7388	5.4368	5.1649	6.4318	10.7816	26.9464
36.2522	17.2095	8.3630	8.1333	12.2000	11.8638	4.9432		5.5013	6.0252	5.5013	5.5013	6.6505	10.6394	28.1277
32.4777	15.8050	8.3829	8.2275	12.3412	11.7879	5.3326		5.9299	6.1671	5.9299	5.7103	6.8255	11.4117	26.6307
49.4565	21.0111	8.3385	8.2419	12.6798	17.3485			5.9822	6.1885	5.9822	5.7893	7.9691	16.4037	46.2244
43.7705	19.8535	8.1360	8.5812	12.5857	17.6050			6.1810	6.3683	6.1810	6.0044	8.3290	16.0379	42.6072
38.5374	18.2416	8.3025	8.7300	12.6100	1.2575			6.4113	6.4113	6.2510	6.0985	8.0089	15.0987	39.3003
39.2851	18.0719	7.3849	8.9663	12.8091				6.7066	6.7066	6.2785	6.1477	8.2148	15.6331	42.5027
32.8890	16.5088	7.4351	9.3602	12.8702				6.9904	6.8506	6.2278	6.2278	7.8078	14.2984	37.2220
29.1166	16.4642	9.5358	11.7928	16.1168				9.5908	8.9514	7.6727	7.3574	8.9890	14.2656	37.7986
14.0407	9.4429	6.0321	7.7117	9.6397				7.1853	4.9799	4.3736	3.8690	4.9279	7.0137	20.9362

Table 5 – Wind plus Torsion per Shear Wall

sw1	sw2	sw3	sw4	sw5	sw6
6.4749	6.4749	8.0212	8.0212	28.0572	14.8186
5.3683	5.3683	4.2287	4.2287	14.2202	10.9694
3.8868	3.2180	3.2180	9.0709	9.4243	9.2702
-1.8396	-0.3426	2.2864	2.2864	8.5036	7.6741
2.7369	2.7369	2.1249	2.1249	8.8145	6.2512
2.0820	2.0820	1.6065	1.6065	7.2108	5.2417
1.6295	1.6295	1.2764	1.2764	6.0598	4.4373
1.3789	1.3789	1.0941	1.0941	4.9725	3.7288
1.1100	1.1100	0.8956	0.8956	4.2612	3.2594
0.9550	0.9550	0.8006	0.8006	3.7936	2.9317
0.7864	0.7864	0.6750	0.6750	4.4621	2.5897
0.6719	0.6719	0.5995	0.5995	3.8932	2.3550
0.6268	0.6268	0.5702	0.5702	3.4147	2.2189
0.5437	0.5437	0.5437	0.5437	3.3207	2.1088
0.5098	0.5098	0.5098	0.5098	2.8377	2.0001
0.6599	0.6599	0.6599	0.6599	3.1534	2.5952
0.4792	0.4792	0.4792	0.4792	2.0924	1.8453

Table 6 – Wind plus Accidental Torsion per Frame

1	2	3	4	5	6	7	8	A	B	C	D	E	F	G
8.3152	6.0098	3.8177	7.1053	14.9475	19.0730	11.5400	2.6390	11.6584	8.4661	5.4866	3.0241	8.6795	15.0136	21.8001
25.7770	16.9634	5.7222	5.7306	8.0222	11.7065	6.4387	0.9426	11.7042	8.8100	6.1086	3.6967	4.8182	13.3676	39.8930
30.6148	15.6496	6.9582	6.1141	11.4690	13.6469	7.0808	1.3985	15.2968	11.4965	7.9495	4.7826	5.5947	11.5534	32.8780
33.7934	18.4658	7.3702	7.4175	12.4251	13.5156	6.7265	1.3726	15.1538	11.7033	7.4224	4.9064	5.7921	12.4487	35.0243
48.3407	23.1996	9.6657	7.6970	10.7758	10.4815	4.6585		10.3094	9.4497	6.8203	4.8331	7.1377	15.2905	44.2274
51.6240	23.0081	9.9502	7.5814	11.3721	10.6165	4.9960		9.6524	8.8648	6.8113	5.1877	7.0708	15.5521	44.7329
53.1734	22.5916	9.3489	7.6559	12.0307	11.3151	4.8149		8.7792	8.2036	6.6751	5.4289	7.1281	15.9113	45.5521
49.3087	22.9529	9.4204	8.1541	11.7782	11.5881	4.8284		8.6460	8.0900	6.7480	5.6334	7.4679	15.8693	45.1697
49.2150	22.1011	9.4097	8.1333	12.2000	11.8638	4.9432		7.7482	7.7410	6.4329	5.8659	7.4974	14.9687	44.8025
44.0622	20.1643	9.3329	8.2275	12.3412	11.7879	5.3326		7.7995	7.5164	6.6933	5.9862	7.6818	15.7001	41.2147
58.3280	24.0914	8.7595	8.2419	12.6798	17.3485			5.9822	6.1885	5.9822	5.7893	8.6989	20.2628	60.2215
51.4288	22.6218	8.4782	8.5812	12.5857	17.6050			6.1810	6.3683	6.1810	6.0044	9.0321	19.5003	54.6033
44.8494	20.5571	8.5969	8.7300	12.6100	1.2575			6.4113	6.4113	6.2510	6.0985	8.5754	18.0314	49.5479
43.2866	19.4481	7.4022	8.9663	12.8091				6.7066	6.7066	6.2785	6.1477	8.7019	18.1380	51.5601
35.8863	17.5792	7.4472	9.3602	12.8702				6.9904	6.8506	6.2278	6.2278	8.1520	16.1991	44.1254
31.0574	17.1616	9.5441	11.7928	16.1168				9.5908	8.9514	7.6727	7.3574	9.2038	15.4547	42.6152
14.7188	9.7096	6.0356	7.7117	9.6397				7.1853	4.9799	4.3736	3.8690	5.0099	7.4093	22.8195

Table 7 – Wind plus Accidental Torsion per Shear Wall

sw1	sw2	sw3	sw4	sw5	sw6
8.2277	8.2277	10.8552	10.8552	64.8120	38.7777
7.3088	7.3088	4.6623	4.6623	30.0859	32.5873
5.2454	3.4634	3.4634	20.9603	20.4067	27.0019
3.5582	3.5582	2.4539	2.4539	15.7683	18.4810
3.2000	3.2000	2.1249	2.1249	13.9098	10.7720
2.3986	2.3986	1.6065	1.6065	10.7141	8.2156
1.8454	1.8454	1.2764	1.2764	8.5520	6.2316
1.5422	1.5422	1.0941	1.0941	6.8319	5.0657
1.2255	1.2255	0.8956	0.8956	5.6179	4.0734
1.0438	1.0438	0.8006	0.8006	4.9145	3.4930
0.8132	0.8132	0.6750	0.6750	5.3384	2.5897
0.6897	0.6897	0.5995	0.5995	4.5910	2.3550
0.6405	0.6405	0.5702	0.5702	3.9562	2.2189
0.5437	0.5437	0.5437	0.5437	3.7572	2.1088
0.5098	0.5098	0.5098	0.5098	3.1390	2.0001
0.6599	0.6599	0.6599	0.6599	3.3543	2.5952
0.4792	0.4792	0.4792	0.4792	2.1816	1.8453

Table 8 – Stiffness of Frames, Shear Walls and Distribution of Loads

roof		**Wind Loads (kips)**		40.7119		
Frame	**Δ**	**1/Δ**	**Stiffness**	**roof**	**plus torsion**	**plus actorsion**
1	0.048	20.8333	0.2368	9.6397	14.0407	14.7188
2	0.06	16.6667	0.1894	7.7117	9.4429	9.7096
3	0.077	12.9870	0.1476	6.0091	6.0321	6.0356
4	0.06	16.6667	0.1894	7.7117	7.7117	7.7117
5	0.048	20.8333	0.2368	9.6397	9.6397	9.6397
sw1		1.0356	0.0118	0.4792	0.4792	0.4792
sw2		1.0356	0.0118	0.4792	0.4792	0.4792
sw3		1.0356	0.0118	0.4792	0.4792	0.4792
sw4		1.0356	0.0118	0.4792	0.4792	0.4792
Total		87.9870	1.0000	40.7119		

16th		**Wind Loads (kips)**		66.6194		
Frame	**Δ**	**1/Δ**	**Stiffness**	**16th**	**plus torsion**	**plus actorsion**
1	0.03	33.3333	0.2419	16.1168	29.1166	31.0574
2	0.041	24.3902	0.1770	11.7928	16.4642	17.1616
3	0.051	19.6078	0.1423	9.4805	9.5358	9.5441
4	0.041	24.3902	0.1770	11.7928	11.7928	11.7928
5	0.03	33.3333	0.2419	16.1168	16.1168	16.1168

sw1		1.3648	0.0099	0.6599	0.6599	0.6599
sw2		1.3648	0.0099	0.6599	0.6599	0.6599
sw3		1.3648	0.0099	0.6599	0.6599	0.6599
sw4		1.3648	0.0099	0.6599	0.6599	0.6599
Total		137.7847	1.0000	66.6194		

15th		**Wind Loads (kips)**		51.8151		
Frame	**Δ**	**1/Δ**	**Stiffness**	**15th**	**plus torsion**	**plus actorsion**
1	0.024	41.6667	0.2484	12.8702	32.8890	35.8863
2	0.033	30.3030	0.1806	9.3602	16.5088	17.5792
3	0.042	23.8095	0.1419	7.3544	7.4351	7.4472
4	0.033	30.3030	0.1806	9.3602	9.3602	9.3602
5	0.024	41.6667	0.2484	12.8702	12.8702	12.8702
sw1		1.6503	0.0098	0.5098	0.5098	0.5098
sw2		1.6503	0.0098	0.5098	0.5098	0.5098
sw3		1.6503	0.0098	0.5098	0.5098	0.5098
sw4		1.6503	0.0098	0.5098	0.5098	0.5098
Total		167.7489	1.0000	51.8151		

14th		**Wind Loads (kips)**		50.8208		
Frame	**Δ**	**1/Δ**	**Stiffness**	**14th**	**plus torsion**	**plus actorsion**
1	0.021	47.6190	0.2520	12.8091	39.2851	43.2866
2	0.03	33.3333	0.1764	8.9663	18.0719	19.4481
3	0.037	27.0270	0.1431	7.2700	7.3849	7.4022
4	0.03	33.3333	0.1764	8.9663	8.9663	8.9663
5	0.021	47.6190	0.2520	12.8091	12.8091	12.8091
sw1		2.0212	0.0107	0.5437	0.5437	0.5437
sw2		2.0212	0.0107	0.5437	0.5437	0.5437
sw3		2.0212	0.0107	0.5437	0.5437	0.5437
sw4		2.0212	0.0107	0.5437	0.5437	0.5437
Total		188.9318	1.0000	50.8208		

13th		**Wind Loads (kips)**		49.7730		
Frame	**Δ**	**1/Δ**	**Stiffness**	**13th**	**plus torsion**	**plus actorsion**
1	0.018	55.5556	0.2533	12.6100	38.5374	44.8494
2	0.026	38.4615	0.1754	8.7300	18.2416	20.5571
3	0.032	31.2500	0.1425	7.0931	8.3025	8.5969
4	0.026	38.4615	0.1754	8.7300	8.7300	8.7300
5	0.018	55.5556	0.2533	12.6100	12.6100	12.6100

sw1		2.5121	0.0115	0.5702	0.6268	0.6405
sw2		2.5121	0.0115	0.5702	0.6268	0.6405
sw3		2.5121	0.0115	0.5702	0.5702	0.5702
sw4		2.5121	0.0115	0.5702	0.5702	0.5702
Total		219.2842	1.0000	49.7730		

12th		**Wind Loads (kips)**		49.0762		
Frame	**Δ**	**1/Δ**	**Stiffness**	**12th**	**plus torsion**	**plus actorsion**
1	0.015	66.6667	0.2565	12.5857	43.7705	51.4288
2	0.022	45.4545	0.1749	8.5812	19.8535	22.6218
3	0.028	35.7143	0.1374	6.7424	8.1360	8.4782
4	0.022	45.4545	0.1749	8.5812	8.5812	8.5812
5	0.015	66.6667	0.2565	12.5857	12.5857	12.5857
sw1		3.1756	0.0122	0.5995	0.6719	0.6897
sw2		3.1756	0.0122	0.5995	0.6719	0.6897
sw3		3.1756	0.0122	0.5995	0.5995	0.5995
sw4		3.1756	0.0122	0.5995	0.5995	0.5995
Total		259.9567	1.0000	49.0762		

11th		**Wind Loads (kips)**		48.4370		
Frame	**Δ**	**1/Δ**	**Stiffness**	**11th**	**plus torsion**	**plus actorsion**
1	0.013	76.9231	0.2618	12.6798	49.4565	58.3280
2	0.02	50.0000	0.1702	8.2419	21.0111	24.0914
3	0.025	40.0000	0.1361	6.5935	8.3385	8.7595
4	0.02	50.0000	0.1702	8.2419	8.2419	8.2419
5	0.013	76.9231	0.2618	12.6798	12.6798	12.6798
sw1		4.0949	0.0139	0.6750	0.7864	0.8132
sw2		4.0949	0.0139	0.6750	0.7864	0.8132
sw3		4.0949	0.0139	0.6750	0.6750	0.6750
sw4		4.0949	0.0139	0.6750	0.6750	0.6750
Total		293.8462	1.0000	48.4370		

10th		**Wind Loads (kips)**		47.8688		
Frame	**Δ**	**1/Δ**	**Stiffness**	**10th**	**plus torsion**	**plus actorsion**
1	0.012	83.3333	0.2578	12.3412	32.4777	44.0622
2	0.018	55.5556	0.1719	8.2275	15.8050	20.1643
3	0.022	45.4545	0.1406	6.7316	8.3829	9.3329
4	0.018	55.5556	0.1719	8.2275	8.2275	8.2275

5	0.012	83.3333	0.2578	12.3412	12.3412	12.3412
sw1		5.4058	0.0167	0.8006	0.9550	1.0438
sw2		5.4058	0.0167	0.8006	0.9550	1.0438
sw3		5.4058	0.0167	0.8006	0.8006	0.8006
sw4		5.4058	0.0167	0.8006	0.8006	0.8006
Total		323.2323	1.0000	47.8688		

9th		**Wind Loads (kips)**		47.0876		
Frame	**Δ**	**1/Δ**	**Stiffness**	**9th**	**plus torsion**	**plus actorsion**
1	0.01	100.0000	0.2591	12.2000	36.2522	49.2150
2	0.015	66.6667	0.1727	8.1333	17.2095	22.1011
3	0.019	52.6316	0.1364	6.4210	8.3630	9.4097
4	0.015	66.6667	0.1727	8.1333	8.1333	8.1333
5	0.01	100.0000	0.2591	12.2000	12.2000	12.2000
sw1		7.3411	0.0190	0.8956	1.1100	1.2255
sw2		7.3411	0.0190	0.8956	1.1100	1.2255
sw3		7.3411	0.0190	0.8956	0.8956	0.8956
sw4		7.3411	0.0190	0.8956	0.8956	0.8956
Total		385.9649	1.0000	47.0876		

8th		**Wind Loads (kips)**		46.1000		
Frame	**Δ**	**1/Δ**	**Stiffness**	**8th**	**plus torsion**	**plus actorsion**
1	0.009	111.1111	0.2555	11.7782	35.6289	49.3087
2	0.013	76.9231	0.1769	8.1541	17.5587	22.9529
3	0.017	58.8235	0.1353	6.2355	8.2595	9.4204
4	0.013	76.9231	0.1769	8.1541	8.1541	8.1541
5	0.009	111.1111	0.2555	11.7782	11.7782	11.7782
sw1		10.3211	0.0237	1.0941	1.3789	1.5422
sw2		10.3211	0.0237	1.0941	1.3789	1.5422
sw3		10.3211	0.0237	1.0941	1.0941	1.0941
sw4		10.3211	0.0237	1.0941	1.0941	1.0941
Total		434.8919	1.0000	46.1000		

7th		**Wind Loads (kips)**		45.3885		
Frame	**Δ**	**1/Δ**	**Stiffness**	**7th**	**plus torsion**	**plus actorsion**
1	0.007	142.8571	0.2651	12.0307	37.5630	53.1734
2	0.011	90.9091	0.1687	7.6559	16.9247	22.5916
3	0.014	71.4286	0.1325	6.0153	8.0841	9.3489

4	0.011	90.9091	0.1687	7.6559	7.6559	7.6559
5	0.007	142.8571	0.2651	12.0307	12.0307	12.0307
sw1		15.1564	0.0281	1.2764	1.6295	1.8454
sw2		15.1564	0.0281	1.2764	1.6295	1.8454
sw3		15.1564	0.0281	1.2764	1.2764	1.2764
sw4		15.1564	0.0281	1.2764	1.2764	1.2764
Total		538.9610	1.0000	45.3885		

6th		**Wind Loads (kips)**		44.1101		
Frame	**Δ**	**1/Δ**	**Stiffness**	**6th**	**plus torsion**	**plus actorsion**
1	0.006	166.6667	0.2578	11.3721	35.5354	51.6240
2	0.009	111.1111	0.1719	7.5814	16.8421	23.0081
3	0.011	90.9091	0.1406	6.2030	8.4524	9.9502
4	0.009	111.1111	0.1719	7.5814	7.5814	7.5814
5	0.006	166.6667	0.2578	11.3721	11.3721	11.3721
sw1		23.5440	0.0364	1.6065	2.0820	2.3986
sw2		23.5440	0.0364	1.6065	2.0820	2.3986
sw3		23.5440	0.0364	1.6065	1.6065	1.6065
sw4		23.5440	0.0364	1.6065	1.6065	1.6065
Total		646.4646	1.0000	44.1101		

5th		**Wind Loads (kips)**		42.9323		
Frame	**Δ**	**1/Δ**	**Stiffness**	**5th**	**plus torsion**	**plus actorsion**
1	0.005	200.0000	0.2510	10.7758	32.1586	48.3407
2	0.007	142.8571	0.1793	7.6970	16.5215	23.1996
3	0.009	111.1111	0.1394	5.9866	8.0808	9.6657
4	0.007	142.8571	0.1793	7.6970	7.6970	7.6970
5	0.005	200.0000	0.2510	10.7758	10.7758	10.7758
sw1		39.4377	0.0495	2.1249	2.7369	3.2000
sw2		39.4377	0.0495	2.1249	2.7369	3.2000
sw3		39.4377	0.0495	2.1249	2.1249	2.1249
sw4		39.4377	0.0495	2.1249	2.1249	2.1249
Total		796.8254	1.0000	42.9323		

4th		**Wind Loads (kips)**		41.6003		
Frame	**Δ**	**1/Δ**	**Stiffness**	**4th**	**plus torsion**	**plus actorsion**
1	0.004	250.0000	0.1870	7.7802	16.9578	33.7934
2	0.005	200.0000	0.1496	6.2242	10.5431	18.4658

3	0.007	142.8571	0.1069	4.4458	5.4776	7.3702
4	0.005	200.0000	0.1496	6.2242	6.2242	7.4175
5	0.004	250.0000	0.1870	7.7802	7.7802	12.4251
sw1		73.4694	0.0550	2.2864	-1.8396	3.5582
sw2		73.4694	0.0550	2.2864	-0.3426	3.5582
sw3		73.4694	0.0550	2.2864	2.2864	2.4539
sw4		73.4694	0.0550	2.2864	2.2864	2.4539
Total		1336.7347	1.0000	41.6003		

3rd		**Wind Loads (kips)**		40.2335		
Frame	**Δ**	**1/Δ**	**Stiffness**	**3rd**	**plus torsion**	**plus actorsion**
1	0.003	333.3333	0.1659	6.6735	14.5713	30.6148
2	0.004	250.0000	0.1244	5.0051	8.5165	15.6496
3	0.005	200.0000	0.0995	4.0041	4.9786	6.9582
4	0.004	250.0000	0.1244	5.0051	5.0051	6.1141
5	0.003	333.3333	0.1659	6.6735	6.6735	11.4690
sw1		160.7366	0.0800	3.2180	3.8868	5.2454
sw2		160.7366	0.0800	3.2180	3.2180	3.4634
sw3		160.7366	0.0800	3.2180	3.2180	3.4634
sw4		160.7366	0.0800	3.2180	9.0709	20.9603
Total		2009.6131	1.0000	40.2335		

2nd		**Wind Loads (kips)**		38.3347		
Frame	**Δ**	**1/Δ**	**Stiffness**	**2nd**	**plus torsion**	**plus actorsion**
1	0.002	500.0000	0.1197	4.5900	12.4290	25.7770
2	0.002	500.0000	0.1197	4.5900	9.1681	16.9634
3	0.003	333.3333	0.0798	3.0600	4.0450	5.7222
4	0.002	500.0000	0.1197	4.5900	4.5900	5.7306
5	0.002	500.0000	0.1197	4.5900	4.5900	8.0222
sw1		460.6460	0.1103	4.2287	5.3683	7.3088
sw2		460.6460	0.1103	4.2287	5.3683	7.3088
sw3		460.6460	0.1103	4.2287	4.2287	4.6623
sw4		460.6460	0.1103	4.2287	4.2287	4.6623
Total		4175.9175	1.0000	38.3347		

ground		**Wind Loads (kips)**		40.2523		
Frame	**Δ**	**1/Δ**	**Stiffness**	**ground**	**plus torsion**	**plus actorsion**
1	0.001	1000.0000	0.0713	2.8705	2.8705	8.3152

2	0.001	1000.0000	0.0713	2.8705	2.8705	6.0098
3	0.001	1000.0000	0.0713	2.8705	2.8705	3.8177
4	0.001	1000.0000	0.0713	2.8705	4.3654	7.1053
5	0.001	1000.0000	0.0713	2.8705	7.1339	14.9475
sw1		2255.6391	0.1609	6.4749	6.4749	8.2277
sw2		2255.6391	0.1609	6.4749	6.4749	8.2277
sw3		2255.6391	0.1609	6.4749	8.0212	10.8552
sw4		2255.6391	0.1609	6.4749	8.0212	10.8552
Total		14022.5564	1.0000	40.2523		

13th		**Wind Loads (kips)**		1.2575		
Frame	**Δ**	**1/Δ**	**Stiffness**	**13th**	**plus torsion**	**plus actorsion**
6	0.075	13.3333	1.0000	1.2575	1.2575	1.2575
Total		13.3333	1.0000	1.2575		

12th		**Wind Loads (kips)**		17.6050		
Frame	**Δ**	**1/Δ**	**Stiffness**	**12th**	**plus torsion**	**plus actorsion**
6	0.063	15.8730	1.0000	17.6050	17.6050	17.6050
Total		15.8730	1.0000	17.6050		

11th		**Wind Loads (kips)**		17.3485		
Frame	**Δ**	**1/Δ**	**Stiffness**	**11th**	**plus torsion**	**plus actorsion**
6	0.05	20.0000	1.0000	17.3485	17.3485	17.3485
Total		20.0000	1.0000	17.3485		

10th		**Wind Loads (kips)**		17.1205		
Frame	**Δ**	**1/Δ**	**Stiffness**	**10th**	**plus torsion**	**plus actorsion**
6	0.038	26.3158	0.6885	11.7879	11.7879	11.7879
7	0.084	11.9048	0.3115	5.3326	5.3326	5.3326
Total		38.2206	1.0000	17.1205		

9th		**Wind Loads (kips)**		16.8070		
Frame	**Δ**	**1/Δ**	**Stiffness**	**9th**	**plus torsion**	**plus actorsion**
6	0.03	33.3333	0.7059	11.8638	11.8638	11.8638
7	0.072	13.8889	0.2941	4.9432	4.9432	4.9432
Total		47.2222	1.0000	16.8070		

8th		Wind Loads (kips)		16.4165		
Frame	**Δ**	**1/Δ**	**Stiffness**	**8th**	**plus torsion**	**plus actorsion**
6	0.025	40.0000	0.7059	11.5881	11.5881	11.5881
7	0.06	16.6667	0.2941	4.8284	4.8284	4.8284
Total		56.6667	1.0000	16.4165		

7th		Wind Loads (kips)		16.1300		
Frame	**Δ**	**1/Δ**	**Stiffness**	**7th**	**plus torsion**	**plus actorsion**
6	0.02	50.0000	0.7015	11.3151	11.3151	11.3151
7	0.047	21.2766	0.2985	4.8149	4.8149	4.8149
Total		71.2766	1.0000	16.1300		

6th		Wind Loads (kips)		15.6125		
Frame	**Δ**	**1/Δ**	**Stiffness**	**6th**	**plus torsion**	**plus actorsion**
6	0.016	62.5000	0.6800	10.6165	10.6165	10.6165
7	0.034	29.4118	0.3200	4.9960	4.9960	4.9960
Total		91.9118	1.0000	15.6125		

5th		Wind Loads (kips)		15.1400		
Frame	**Δ**	**1/Δ**	**Stiffness**	**5th**	**plus torsion**	**plus actorsion**
6	0.012	83.3333	0.6923	10.4815	10.4815	10.4815
7	0.027	37.0370	0.3077	4.6585	4.6585	4.6585
Total		120.3704	1.0000	15.1400		

4th		Wind Loads (kips)		14.6055		
Frame	**Δ**	**1/Δ**	**Stiffness**	**4th**	**plus torsion**	**plus actorsion**
6	0.009	111.1111	0.6897	10.0728	10.0728	13.5156
7	0.02	50.0000	0.3103	4.5327	4.5327	6.7265
Total		161.1111	1.0000	14.6055		

3rd		Wind Loads (kips)		14.0570		
Frame	**Δ**	**1/Δ**	**Stiffness**	**3rd**	**plus torsion**	**plus actorsion**
6	0.006	166.6667	0.6842	9.6179	9.6179	13.6469
7	0.013	76.9231	0.3158	4.4391	4.4391	7.0808
Total		243.5897	1.0000	14.0570		

2nd		Wind Loads (kips)		13.2950

Frame	Δ	1/Δ	Stiffness	2nd	plus torsion	plus actorsion
6	0.004	250.0000	0.6667	8.8633	8.8633	11.7065
7	0.008	125.0000	0.3333	4.4317	4.4317	6.4387
Total		375.0000	1.0000	13.2950		

ground		Wind Loads (kips)		13.7665		
Frame	**Δ**	**1/Δ**	**Stiffness**	**ground**	**plus torsion**	**plus actorsion**
6	0.002	500.0000	0.6667	9.1777	12.6708	19.0730
7	0.004	250.0000	0.3333	4.5888	7.0427	11.5400
Total		750.0000	1.0000	13.7665		

4th		Wind Loads (kips)		2.9211		
Frame	**Δ**	**1/Δ**	**Stiffness**	**4th**	**plus torsion**	**plus actorsion**
8	0.047	21.2766	0.1064	0.3108	0.3108	1.3726
Total		21.2766	0.1064	0.3108		

3rd		Wind Loads (kips)		2.8114		
Frame	**Δ**	**1/Δ**	**Stiffness**	**3rd**	**plus torsion**	**plus actorsion**
8	0.036	27.7778	0.1111	0.3124	0.3124	1.3985
Total		27.7778	0.1111	0.3124		

2nd		Wind Loads (kips)		2.6590		
Frame	**Δ**	**1/Δ**	**Stiffness**	**2nd**	**plus torsion**	**plus actorsion**
8	0.025	40.0000	0.0800	0.2127	0.2127	0.9426
Total		40.0000	0.0800	0.2127		

ground		Wind Loads (kips)		2.7533		
Frame	**Δ**	**1/Δ**	**Stiffness**	**ground**	**plus torsion**	**plus actorsion**
8	0.013	76.9231	0.0769	0.2118	0.2118	2.6390
Total		76.9231	0.0769	0.2118		

roof		Wind Loads (kips)		50.4341		
Frame	**Δ**	**1/Δ**	**Stiffness**	**roof**	**plus torsion**	**plus actorsion**
G	0.07	14.2857	0.1425	7.1853	7.1853	7.1853
F	0.101	9.9010	0.0987	4.9799	4.9799	4.9799
E	0.115	8.6957	0.0867	4.3736	4.3736	4.3736

D	0.13	7.6923	0.0767	3.8690	3.8690	3.8690
C	0.107	9.3458	0.0932	4.7006	4.9279	5.0099
B	0.085	11.7647	0.1173	5.9173	7.0137	7.4093
A	0.032	31.2500	0.3116	15.7178	20.9362	22.8195
sw5		3.6688	0.0366	1.8453	2.0924	2.1816
sw6		3.6688	0.0366	1.8453	1.8453	1.8453
Total		100.2727	1.0000	50.4341		

16th		**Wind Loads (kips)**		82.5286		
Frame	**Δ**	**1/Δ**	**Stiffness**	**16th**	**plus torsion**	**plus actorsion**
G	0.056	17.8571	0.1162	9.5908	9.5908	9.5908
F	0.06	16.6667	0.1085	8.9514	8.9514	8.9514
E	0.07	14.2857	0.0930	7.6727	7.6727	7.6727
D	0.073	13.6986	0.0891	7.3574	7.3574	7.3574
C	0.064	15.6250	0.1017	8.3920	8.9890	9.2038
B	0.049	20.4082	0.1328	10.9610	14.2656	15.4547
A	0.022	45.4545	0.2958	24.4130	37.7986	42.6152
sw5		4.8319	0.0314	2.5952	3.1534	3.3543
sw6		4.8319	0.0314	2.5952	2.5952	2.5952
Total		153.6597	1.0000	82.5286		

15th		**Wind Loads (kips)**		64.1889		
Frame	**Δ**	**1/Δ**	**Stiffness**	**15th**	**plus torsion**	**plus actorsion**
G	0.049	20.4082	0.1089	6.9904	6.9904	6.9904
F	0.05	20.0000	0.1067	6.8506	6.8506	6.8506
E	0.055	18.1818	0.0970	6.2278	6.2278	6.2278
D	0.055	18.1818	0.0970	6.2278	6.2278	6.2278
C	0.05	20.0000	0.1067	6.8506	7.8078	8.1520
B	0.038	26.3158	0.1404	9.0139	14.2984	16.1991
A	0.019	52.6316	0.2809	18.0278	37.2220	44.1254
sw5		5.8391	0.0312	2.0001	2.8377	3.1390
sw6		5.8391	0.0312	2.0001	2.0001	2.0001
Total		187.3974	1.0000	64.1889		

14th		**Wind Loads (kips)**		62.9572		
Frame	**Δ**	**1/Δ**	**Stiffness**	**14th**	**plus torsion**	**plus actorsion**
G	0.044	22.7273	0.1065	6.7066	6.7066	6.7066
F	0.044	22.7273	0.1065	6.7066	6.7066	6.7066
E	0.047	21.2766	0.0997	6.2785	6.2785	6.2785

D	0.048	20.8333	0.0976	6.1477	6.1477	6.1477
C	0.043	23.2558	0.1090	6.8626	8.2148	8.7019
B	0.034	29.4118	0.1379	8.6791	15.6331	18.1380
A	0.017	58.8235	0.2757	17.3583	42.5027	51.5601
sw5		7.1464	0.0335	2.1088	3.3207	3.7572
sw6		7.1464	0.0335	2.1088	2.1088	2.1088
Total		213.3484	1.0000	62.9572		

13th		**Wind Loads (kips)**		61.6590		
Frame	**Δ**	**1/Δ**	**Stiffness**	**13th**	**plus torsion**	**plus actorsion**
G	0.039	25.6410	0.1040	6.4113	6.4113	6.4113
F	0.039	25.6410	0.1040	6.4113	6.4113	6.4113
E	0.04	25.0000	0.1014	6.2510	6.2510	6.2510
D	0.041	24.3902	0.0989	6.0985	6.0985	6.0985
C	0.037	27.0270	0.1096	6.7578	8.0089	8.5754
B	0.029	34.4828	0.1398	8.6220	15.0987	18.0314
A	0.015	66.6667	0.2703	16.6693	39.3003	49.5479
sw5		8.8743	0.0360	2.2189	3.4147	3.9562
sw6		8.8743	0.0360	2.2189	2.2189	2.2189
Total		246.5973	1.0000	61.6590		

12th		**Wind Loads (kips)**		60.7958		
Frame	**Δ**	**1/Δ**	**Stiffness**	**12th**	**plus torsion**	**plus actorsion**
G	0.034	29.4118	0.1017	6.1810	6.1810	6.1810
F	0.033	30.3030	0.1047	6.3683	6.3683	6.3683
E	0.034	29.4118	0.1017	6.1810	6.1810	6.1810
D	0.035	28.5714	0.0988	6.0044	6.0044	6.0044
C	0.031	32.2581	0.1115	6.7792	8.3290	9.0321
B	0.025	40.0000	0.1383	8.4062	16.0379	19.5003
A	0.013	76.9231	0.2659	16.1657	42.6072	54.6033
sw5		11.2061	0.0387	2.3550	3.8932	4.5910
sw6		11.2061	0.0387	2.3550	2.3550	2.3550
Total		289.2914	1.0000	60.7958		

11th		**Wind Loads (kips)**		60.0040		
Frame	**Δ**	**1/Δ**	**Stiffness**	**11th**	**plus torsion**	**plus actorsion**
G	0.03	33.3333	0.0997	5.9822	5.9822	5.9822

F	0.029	34.4828	0.1031	6.1885	6.1885	6.1885
E	0.03	33.3333	0.0997	5.9822	5.9822	5.9822
D	0.031	32.2581	0.0965	5.7893	5.7893	5.7893
C	0.028	35.7143	0.1068	6.4095	7.9691	8.6989
B	0.022	45.4545	0.1360	8.1576	16.4037	20.2628
A	0.011	90.9091	0.2719	16.3152	46.2244	60.2215
sw5		14.4299	0.0432	2.5897	4.4621	5.3384
sw6		14.4299	0.0432	2.5897	2.5897	2.5897
Total		334.3452	1.0000	60.0040		

10th		**Wind Loads (kips)**		59.3002		
Frame	**Δ**	**1/Δ**	**Stiffness**	**10th**	**plus torsion**	**plus actorsion**
G	0.026	38.4615	0.1000	5.9299	5.9299	7.7995
F	0.025	40.0000	0.1040	6.1671	6.1671	7.5164
E	0.026	38.4615	0.1000	5.9299	5.9299	6.6933
D	0.027	37.0370	0.0963	5.7103	5.7103	5.9862
C	0.025	40.0000	0.1040	6.1671	6.8255	7.6818
B	0.019	52.6316	0.1368	8.1146	11.4117	15.7001
A	0.01	100.0000	0.2600	15.4178	26.6307	41.2147
sw5		19.0150	0.0494	2.9317	3.7936	4.9145
sw6		19.0150	0.0494	2.9317	2.9317	3.4930
Total		384.6217	1.0000	59.3002		

9th		**Wind Loads (kips)**		58.3324		
Frame	**Δ**	**1/Δ**	**Stiffness**	**9th**	**plus torsion**	**plus actorsion**
G	0.023	43.4783	0.0943	5.5013	5.5013	7.7482
F	0.021	47.6190	0.1033	6.0252	6.0252	7.7410
E	0.023	43.4783	0.0943	5.5013	5.5013	6.4329
D	0.023	43.4783	0.0943	5.5013	5.5013	5.8659
C	0.021	47.6190	0.1033	6.0252	6.6505	7.4974
B	0.017	58.8235	0.1276	7.4429	10.6394	14.9687
A	0.008	125.0000	0.2711	15.8162	28.1277	44.8025
sw5		25.7603	0.0559	3.2594	4.2612	5.6179
sw6		25.7603	0.0559	3.2594	3.2594	4.0734
Total		461.0170	1.0000	58.3324		

8th		**Wind Loads (kips)**		57.1090

Frame	Δ	1/Δ	Stiffness	8th	plus torsion	plus actorsion
G	0.019	52.6316	0.0952	5.4368	5.4368	8.6460
F	0.018	55.5556	0.1005	5.7388	5.7388	8.0900
E	0.019	52.6316	0.0952	5.4368	5.4368	6.7480
D	0.02	50.0000	0.0904	5.1649	5.1649	5.6334
C	0.018	55.5556	0.1005	5.7388	6.4318	7.4679
B	0.014	71.4286	0.1292	7.3785	10.7816	15.8693
A	0.007	142.8571	0.2584	14.7569	26.9464	45.1697
sw5		36.0971	0.0653	3.7288	4.9725	6.8319
sw6		36.0971	0.0653	3.7288	3.7288	5.0657
Total		552.8542	1.0000	57.1090		

7th		Wind Loads (kips)		56.2275		
Frame	**Δ**	**1/Δ**	**Stiffness**	**7th**	**plus torsion**	**plus actorsion**
G	0.016	62.5000	0.0935	5.2568	5.2568	8.7792
F	0.015	66.6667	0.0997	5.6073	5.6073	8.2036
E	0.016	62.5000	0.0935	5.2568	5.2568	6.6751
D	0.017	58.8235	0.0880	4.9476	4.9476	5.4289
C	0.016	62.5000	0.0935	5.2568	5.9947	7.1281
B	0.012	83.3333	0.1247	7.0091	10.5193	15.9113
A	0.006	166.6667	0.2493	14.0183	26.4524	45.5521
sw5		52.7565	0.0789	4.4373	6.0598	8.5520
sw6		52.7565	0.0789	4.4373	4.4373	6.2316
Total		668.5033	1.0000	56.2275		

6th		Wind Loads (kips)		54.6439		
Frame	**Δ**	**1/Δ**	**Stiffness**	**6th**	**plus torsion**	**plus actorsion**
G	0.013	76.9231	0.0907	4.9552	4.9552	9.6524
F	0.012	83.3333	0.0982	5.3682	5.3682	8.8648
E	0.013	76.9231	0.0907	4.9552	4.9552	6.8113
D	0.014	71.4286	0.0842	4.6013	4.6013	5.1877
C	0.013	76.9231	0.0907	4.9552	5.7165	7.0708
B	0.01	100.0000	0.1179	6.4418	9.7199	15.5521
A	0.005	200.0000	0.2358	12.8836	24.3438	44.7329
sw5		81.3706	0.0959	5.2417	7.2108	10.7141
sw6		81.3706	0.0959	5.2417	5.2417	8.2156
Total		848.2724	1.0000	54.6439		

5th		Wind Loads (kips)		53.1847		
Frame	**Δ**	**1/Δ**	**Stiffness**	**5th**	**plus torsion**	**plus actorsion**
G	0.01	100.0000	0.0872	4.6387	4.6387	10.3094
F	0.009	111.1111	0.0969	5.1541	5.1541	9.4497
E	0.01	100.0000	0.0872	4.6387	4.6387	6.8203
D	0.011	90.9091	0.0793	4.2170	4.2170	4.8331
C	0.01	100.0000	0.0872	4.6387	5.4751	7.1377
B	0.008	125.0000	0.1090	5.7984	8.9753	15.2905
A	0.004	250.0000	0.2180	11.5968	22.5179	44.2274
sw5		134.7608	0.1175	6.2512	8.8145	13.9098
sw6		134.7608	0.1175	6.2512	6.2512	10.7720
Total		1146.5418	1.0000	53.1847		

4th		Wind Loads (kips)		51.5347		
Frame	**Δ**	**1/Δ**	**Stiffness**	**4th**	**plus torsion**	**plus actorsion**
G	0.007	142.8571	0.0864	4.4537	4.4537	15.1538
F	0.007	142.8571	0.0864	4.4537	4.4537	11.7033
E	0.008	125.0000	0.0756	3.8970	3.8970	7.4224
D	0.008	125.0000	0.0756	3.8970	3.8970	4.9064
C	0.008	125.0000	0.0756	3.8970	4.0912	5.7921
B	0.006	166.6667	0.1008	5.1960	5.9393	12.4487
A	0.003	333.3333	0.2017	10.3920	12.9164	35.0243
sw5		246.1538	0.1489	7.6741	8.5036	15.7683
sw6		246.1538	0.1489	7.6741	7.6741	18.4810
Total		1653.0220	1.0000	51.5347		

3rd		Wind Loads (kips)		49.8415		
Frame	**Δ**	**1/Δ**	**Stiffness**	**3rd**	**plus torsion**	**plus actorsion**
G	0.005	200.0000	0.0718	3.5773	3.5773	15.2968
F	0.005	200.0000	0.0718	3.5773	3.5773	11.4965
E	0.005	200.0000	0.0718	3.5773	3.5773	7.9495
D	0.005	200.0000	0.0718	3.5773	3.5773	4.7826
C	0.005	200.0000	0.0718	3.5773	3.6052	5.5947
B	0.004	250.0000	0.0897	4.4716	4.5696	11.5534
A	0.002	500.0000	0.1794	8.9432	9.2744	32.8780
sw5		518.2839	0.1860	9.2702	9.4243	20.4067
sw6		518.2839	0.1860	9.2702	9.2702	27.0019
Total		2786.5678	1.0000	49.8415		

2nd		Wind Loads (kips)		47.4893		
Frame	**Δ**	**1/Δ**	**Stiffness**	**2nd**	**plus torsion**	**plus actorsion**
G	0.003	333.3333	0.0566	2.6895	2.6895	11.7042
F	0.003	333.3333	0.0566	2.6895	2.6895	8.8100
E	0.003	333.3333	0.0566	2.6895	2.6895	6.1086
D	0.003	333.3333	0.0566	2.6895	2.6895	3.6967
C	0.003	333.3333	0.0566	2.6895	3.0515	4.8182
B	0.002	500.0000	0.0850	4.0343	5.6214	13.3676
A	0.001	1000.0000	0.1699	8.0686	13.4804	39.8930
sw5		1359.5166	0.2310	10.9694	14.2202	30.0859
sw6		1359.5166	0.2310	10.9694	10.9694	32.5873
Total		5885.6999	1.0000	47.4893		

ground		Wind Loads (kips)		49.8647		
Frame	**Δ**	**1/Δ**	**Stiffness**	**ground**	**plus torsion**	**plus actorsion**
G	0.001	1000.0000	0.0579	2.8896	2.8896	11.6584
F	0.001	1000.0000	0.0579	2.8896	2.8896	8.4661
E	0.001	1000.0000	0.0579	2.8896	2.8896	5.4866
D	0.001	1000.0000	0.0579	2.8896	2.9252	3.0241
C	0.001	1000.0000	0.0579	2.8896	4.4228	8.6795
B	0.001	1000.0000	0.0579	2.8896	6.1001	15.0136
A	0.001	1000.0000	0.0579	2.8896	7.8972	21.8001
sw5		5128.2051	0.2972	14.8186	28.0572	64.8120
sw6		5128.2051	0.2972	14.8186	14.8186	38.7777
Total		17256.4103	1.0000	49.8647		

Appendix 2: Structural Details, Schedules and Tables

ADOSS Runs – Concrete Redesign N-S Direction

NEGATIVE REINFORCEMENT

COLUMN NUMBER	PATT NO.	LOCATION @COL FACE	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
1	4	|| R	492.6	6.24	14.5	3.13	14.5
2	4	L ||	-1024.1	8.50	14.3	6.92	14.8
3	1	L ||	-704.9	6.19	14.3	4.71	14.8
4	4	|| R	1024.1	8.50	14.3	6.92	14.8
5	4	L ||	-492.6	6.24	14.5	3.13	14.5

POSITIVE REINFORCEMENT

SPAN NUMBER	PATT NO.	LOCATION FROM LEFT (ft)	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
2	4	13.0	289.6	4.65	14.5	3.13	14.5
3	2	15.2	182.4	3.08	14.3	3.19	14.8
4	3	13.8	182.4	3.08	14.3	3.19	14.8
5	4	17.5	289.6	4.65	14.5	3.13	14.5

DESIGN RESULTS

NEGATIVE REINFORCEMENT

COLUMN NUMBER	COLUMN STRIP LONG BARS NO	SIZE	BAR-LENGTH LEFT (ft)	BAR-LENGTH RIGHT (ft)	COLUMN STRIP SHORT BARS NO	SIZE	BAR-LENGTH LEFT (ft)	BAR-LENGTH RIGHT (ft)	MIDDLE STRIP LONG BARS NO	SIZE	BAR-LENGTH LEFT (ft)	BAR-LENGTH RIGHT (ft)
1	10	#5	2.00	10.41	10	#5	2.00	6.70	16	#4	2.00	9.41
2	10	#6	12.46	14.83	10	#6	7.12	8.31	23	#5	12.46	14.83
3	10	#5	11.86	11.86	10	#5	6.78	6.78	24	#4	11.84	11.84
4	10	#6	14.83	12.46	10	#6	8.31	7.12	23	#5	14.83	12.46
5	10	#5	10.41	2.00	10	#5	6.70	2.00	16	#4	9.41	2.00

POSITIVE REINFORCEMENT

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*             COLUMN STRIP          *       MIDDLE STRIP
      *  LONG BARS  *  SHORT BARS  *  LONG BARS  *  SHORT BARS
SPAN* -----BAR---- * ----BAR----- * -----BAR---- * ----BAR-----
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#	NO	SIZE	LENGTH (ft)	NO	SIZE	LENGTH (ft)	NO	SIZE	LENGTH (ft)	NO	SIZE	LENGTH (ft)
2	12	#4	26.19	12	#4	26.19	8	#4	30.25	8	#4	25.42
3	8	#4	21.75	8	#4	21.75	8	#4	29.50	8	#4	20.30
4	8	#4	21.75	8	#4	21.75	8	#4	29.50	8	#4	20.30
5	12	#4	26.19	12	#4	26.19	8	#4	30.25	8	#4	25.42

ADDITIONAL INFORMATION AT SUPPORTS

COL. #	REINF.SUMM W/O U.MOM. REQ (in^2)	REINF.SUMM PROV'D (in^2)	ADD'L R/F REQ'D DUE TO UNBAL(U.)MOMENT TRANSFER: MAX.U. MOMENT (ft-k)	GAMMA -f	FLEXURAL TRANSFER (ft-k)	PATT NO.	CRITICAL SECTION SLABW (ft)	AREA (in^2)	R/F	
1	9.37	9.40	607.1	.60	364.3	4	7.5	4.01	3	#5
2	15.42	15.93	-343.8	.60	-206.3	7	7.5	2.26	0	#6
3	10.90	11.00	-255.9	.60	-153.6	5	7.5	1.68	0	#5
4	15.42	15.93	343.8	.60	206.3	8	7.5	2.26	0	#6
5	9.37	9.40	-607.1	.60	-364.3	4	7.5	4.01	3	#5

ADDITIONAL INFORMATION FOR IN-SPAN CONDITIONS

SPAN NUMBER	REINF. SUMMARY AT MIDSPAN REQ'D. (sq.in)	PROV'D. (sq.in)	TOTAL FACTORED SPAN STATIC DESIGN MOMENT (W/O PARTIAL LOADS) (ft-k)
2	7.78	8.00	1001.1
3	6.26	6.40	898.5
4	6.26	6.40	898.5
5	7.78	8.00	1001.1

DEFLECTION ANALYSIS

SPAN NUMBER	DEAD LOAD Ieff. (in^4)	COLUMN STRIP DEFLECTION DUE TO: DEAD (in)	LIVE (in)	TOTAL (in)	MIDDLE STRIP DEFLECTION DUE TO: DEAD (in)	LIVE (in)	TOTAL (in)
1	189449.	-.016	-.010	-.026	-.016	-.010	-.026
2	109225.	.099	.059	.158	.062	.038	.099
3	109225.	.039	.022	.061	.015	.008	.023
4	109225.	.039	.022	.061	.015	.008	.023

5	109225.	.099	.059	.158	.062	.038	.099
6	189449.	-.016	-.010	-.026	-.016	-.010	-.026

ADOSS Runs – Concrete Redesign E-W Direction

NEGATIVE REINFORCEMENT

COLUMN NUMBER	PATT NO.	LOCATION @COL FACE	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
1	4	|| R	476.4	6.30	14.8	3.24	15.0
2	4	L ||	-1016.2	8.43	14.0	6.85	15.8
3	1	L ||	-640.2	5.81	12.5	4.26	17.3
4	1	|| R	570.5	5.81	12.5	3.79	17.3
5	1	|| R	640.2	5.81	12.5	4.26	17.3
6	4	|| R	1016.2	8.43	14.0	6.85	15.8
7	4	L ||	-476.4	6.30	14.8	3.24	15.0

POSITIVE REINFORCEMENT

SPAN NUMBER	PATT NO.	LOCATION FROM LEFT (ft)	TOTAL DESIGN (ft-k)	COLUMN STRIP AREA (sq.in)	COLUMN STRIP WIDTH (ft)	MIDDLE STRIP AREA (sq.in)	MIDDLE STRIP WIDTH (ft)
2	4	12.8	292.3	4.69	14.8	3.24	15.0
3	2	14.7	173.3	3.02	14.0	3.40	15.8
4	3	13.1	152.2	2.70	12.5	3.73	17.3
5	2	11.9	152.2	2.70	12.5	3.73	17.3
6	3	13.3	173.3	3.02	14.0	3.40	15.8
7	4	17.3	292.5	4.69	14.8	3.24	15.0

DESIGN RESULTS

NEGATIVE REINFORCEMENT

	COLUMN STRIP								MIDDLE STRIP			
	LONG BARS				SHORT BARS				LONG BARS			
COLUMN NUMBER	NO	SIZE	-BAR-LENGTH- LEFT (ft)	RIGHT (ft)	NO	SIZE	-BAR-LENGTH- LEFT (ft)	RIGHT (ft)	NO	SIZE	-BAR-LENGTH- LEFT (ft)	RIGHT (ft)
1	11	#5	2.00	10.24	10	#5	2.00	6.60	16	#4	2.00	9.25
2	10	#6	12.25	14.35	9	#6	7.00	8.05	22	#5	12.25	14.35
3	10	#5	11.51	12.96	9	#5	6.61	7.33	22	#4	11.43	12.88
4	10	#5	11.71	11.71	9	#5	6.71	6.71	19	#4	11.44	11.44
5	10	#5	12.96	11.51	9	#5	7.33	6.61	22	#4	12.88	11.43

6	10	#6	14.35	12.25	9	#6	8.05	7.00	22	#5	14.35	12.25
7	11	#5	10.24	2.00	10	#5	6.60	2.00	16	#4	9.25	2.00

P O S I T I V E R E I N F O R C E M E N T

SPAN #	COLUMN STRIP: LONG BARS NO	SIZE	LENGTH (ft)	COLUMN STRIP: SHORT BARS NO	SIZE	LENGTH (ft)	MIDDLE STRIP: LONG BARS NO	SIZE	LENGTH (ft)	MIDDLE STRIP: SHORT BARS NO	SIZE	LENGTH (ft)
2	12	#4	25.75	12	#4	25.75	8	#4	29.75	8	#4	25.00
3	8	#4	21.00	7	#4	21.00	9	#4	28.50	8	#4	19.60
4	7	#4	18.75	7	#4	18.75	10	#4	25.50	9	#4	17.50
5	7	#4	18.75	7	#4	18.75	10	#4	25.50	9	#4	17.50
6	8	#4	21.00	7	#4	21.00	9	#4	28.50	8	#4	19.60
7	12	#4	25.75	12	#4	25.75	8	#4	29.75	8	#4	25.00

A D D I T I O N A L I N F O R M A T I O N A T S U P P O R T S

COL. #	REINF.SUMM W/O U.MOM. REQ (in^2)	PROV'D (in^2)	ADD'L R/F REQ'D DUE TO UNBAL(U.)MOMENT TRANSFER: MAX.U. MOMENT (ft-k)	GAMMA -f	FLEXURAL TRANSFER (ft-k)	PATT NO.	CRITICAL SECTION SLABW (ft)	AREA (in^2)	R/F	
1	9.54	9.71	591.0	.60	354.6	4	7.5	3.90	3	#5
2	15.18	15.18	-300.1	.60	-180.1	3	7.5	1.97	0	#6
3	10.07	10.29	-185.1	.60	-111.0	2	7.5	1.21	0	#5
4	9.60	9.69	182.9	.60	109.7	6	7.5	1.20	0	#5
5	10.07	10.29	185.1	.60	111.0	3	7.5	1.21	0	#5
6	15.18	15.18	300.1	.60	180.1	2	7.5	1.97	0	#6
7	9.54	9.71	-591.0	.60	-354.6	4	7.5	3.90	3	#5

A D D I T I O N A L I N F O R M A T I O N F O R I N - S P A N C O N D I T I O N S

SPAN NUMBER	REINF. SUMMARY AT MIDSPAN REQ'D. (sq.in)	PROV'D. (sq.in)	TOTAL FACTORED SPAN STATIC DESIGN MOMENT (W/O PARTIAL LOADS) (ft-k)
2	7.93	8.00	991.3
3	6.40	6.40	854.7
4	6.43	6.60	668.9

5	6.43	6.60	668.9
6	6.40	6.40	854.7
7	7.93	8.00	991.3

D E F L E C T I O N   A N A L Y S I S

SPAN NUMBER	DEAD LOAD Ieff. (in^4)	COLUMN STRIP DEFLECTION DUE TO: DEAD (in)	LIVE (in)	TOTAL (in)	MIDDLE STRIP DEFLECTION DUE TO: DEAD (in)	LIVE (in)	TOTAL (in)
1	191378.	-.016	-.010	-.026	-.016	-.010	-.026
2	110564.	.095	.057	.152	.060	.036	.096
3	110564.	.037	.021	.058	.012	.007	.019
4	110564.	.031	.017	.048	.010	.006	.016
5	110564.	.031	.017	.048	.010	.006	.016
6	110564.	.037	.021	.058	.012	.007	.019
7	110564.	.095	.057	.152	.060	.036	.096
8	191378.	-.016	-.010	-.026	-.016	-.010	-.026

Shear Walls – Reinforcement Details

- Walls 1 to 4 are in N-S direction
- Walls 5 and 6 are in E-W direction

Wall 1	Reinforcement Req'd	Vu	Mu	ΦVn	ΦMn
ground	10-#9 each side	63.89	4505.15	611.25	4819.41
2nd	9-#8 each side	50.73	3355.12	523.05	3471.93
3rd	9-#7 each side	39.03	2644.96	443.25	2657.28
4th	8-#7 each side	30.64	2098.51	443.25	2368.38
5th	8-#6 each side	24.95	1669.55	376.05	1746.75
6th	7-#6 each side	19.83	1320.30	376.05	1531.39
7th	5-#6 each side	15.99	1042.73	376.05	1098.12
8th	4-#6 each side	13.04	818.89	376.05	880.21
9th	3-#6 each side	10.57	636.39	376.05	661.44
10th	3-#6 each side	8.61	488.43	376.05	661.44
11th	2-#6 each side	6.94	367.92	376.05	441.81
12th	2-#6 each side	5.64	270.80	376.05	441.81
13th	1-#6 each side	4.53	191.89	376.05	221.33
14th	1-#6 each side	3.51	128.43	376.05	221.33
15th	1-#6 each side	2.64	79.31	376.05	221.33
16th	1-#6 each side	1.82	42.38	376.05	221.33
roof	1-#6 each side	0.77	16.87	376.05	221.33

Wall 2	Reinforcement Req'd	Vu	Mu	ΦVn	ΦMn
ground	10-#9 each side	61.04	4374.00	611.25	4819.41
2nd	9-#8 each side	47.88	3275.29	523.05	3471.93
3rd	9-#7 each side	36.18	2605.04	443.25	2657.28
4th	8-#7 each side	30.64	2098.51	443.25	2368.38
5th	8-#6 each side	24.95	1669.55	376.05	1746.75
6th	7-#6 each side	19.83	1320.30	376.05	1531.39
7th	5-#6 each side	15.99	1042.73	376.05	1098.12
8th	4-#6 each side	13.04	818.89	376.05	880.21
9th	3-#6 each side	10.57	636.39	376.05	661.44
10th	3-#6 each side	8.61	488.43	376.05	661.44
11th	2-#6 each side	6.94	367.92	376.05	441.81
12th	2-#6 each side	5.64	270.80	376.05	441.81
13th	1-#6 each side	4.53	191.89	376.05	221.33
14th	1-#6 each side	3.51	128.43	376.05	221.33
15th	1-#6 each side	2.64	79.31	376.05	221.33
16th	1-#6 each side	1.82	42.38	376.05	221.33
roof	1-#6 each side	0.77	16.87	376.05	221.33

Wall 3	Reinforcement Req'd	Vu	Mu	ΦVn	ΦMn
ground	10-#8 each side	53.23	3587.93	523.05	3843.93
2nd	9-#8 each side	35.86	2629.75	523.05	3471.93
3rd	9-#7 each side	28.40	2127.66	443.25	2657.28
4th	8-#7 each side	22.86	1730.01	443.25	2368.38
5th	8-#6 each side	18.94	1409.93	376.05	1746.75
6th	7-#6 each side	15.54	1144.82	376.05	1531.39
7th	5-#6 each side	12.97	927.31	376.05	1098.12
8th	4-#6 each side	10.92	745.79	376.05	880.21
9th	3-#6 each side	9.17	592.85	376.05	661.44
10th	3-#6 each side	7.74	464.42	376.05	661.44
11th	2-#6 each side	6.46	356.06	376.05	441.81
12th	2-#6 each side	5.38	265.62	376.05	441.81
13th	1-#6 each side	4.42	190.31	376.05	221.33
14th	1-#6 each side	3.51	128.43	376.05	221.33
15th	1-#6 each side	2.64	79.31	376.05	221.33
16th	1-#6 each side	1.82	42.38	376.05	221.33
roof	1-#6 each side	0.77	16.87	376.05	221.33

Wall 4	Reinforcement Req'd	Vu	Mu	ΦVn	ΦMn
ground	8-#10 each side	81.23	4875.70	724.65	4892.94
2nd	9-#8 each side	63.86	3413.61	523.05	3471.93
3rd	9-#7 each side	56.40	2519.59	443.25	2657.28
4th	8-#6 each side	22.86	1730.01	376.05	1746.75
5th	7-#6 each side	18.94	1409.93	376.05	1531.39
6th	6-#6 each side	15.54	1144.82	376.05	1315.19
7th	5-#6 each side	12.97	927.31	376.05	1098.12
8th	4-#6 each side	10.92	745.79	376.05	880.21
9th	3-#6 each side	9.17	592.85	376.05	661.44
10th	3-#6 each side	7.74	464.42	376.05	661.44
11th	2-#6 each side	6.46	356.06	376.05	441.81
12th	2-#6 each side	5.38	265.62	376.05	441.81
13th	1-#6 each side	4.42	190.31	376.05	221.33
14th	1-#6 each side	3.51	128.43	376.05	221.33
15th	1-#6 each side	2.64	79.31	376.05	221.33
16th	1-#6 each side	1.82	42.38	376.05	221.33
roof	1-#6 each side	0.77	16.87	376.05	221.33

Wall 5	Reinforcement Req'd	Vu	Mu	ΦVn	ΦMn
ground	16-#11 each side	332.69	22706.41	1533.3	22966.14
2nd	12-#11 each side	228.99	16718.00	1533.3	17804.37
3rd	11-#10 each side	180.85	13512.13	1281	13616.05
4th	9-#10 each side	148.20	10980.19	1281	11284.5
5th	9-#9 each side	122.97	8905.36	1046.1	8993.98
6th	8-#9 each side	100.72	7183.74	1046.1	8034.35
7th	8-#8 each side	83.57	5773.71	863.38	6399.84
8th	6-#8 each side	69.89	4603.66	863.38	4837.05
9th	6-#7 each side	58.96	3625.19	698.08	3694.08
10th	5-#7 each side	49.97	2799.74	698.08	3087.33
11th	5-#6 each side	42.11	2100.14	558.88	2272.78
12th	5-#5 each side	33.57	1510.63	445.78	1606.28
13th	4-#5 each side	26.22	1040.69	445.78	1286.93
14th	3-#5 each side	19.89	673.59	445.78	966.63
15th	2-#4 each side	13.88	395.11	350.08	416.81
16th	1-#4 each side	8.86	200.80	350.08	208.6
roof	1-#4 each side	3.49	76.79	350.08	208.6

Wall 6	Reinforcement Req'd	Vu	Mu	ΦVn	ΦMn
ground	12-#11 each side	272.66	17595.78	1533.3	17804.37
2nd	11-#10 each side	210.62	12687.91	1281	13616.05
3rd	10-#9 each side	158.48	9739.30	1046.1	9943.68
4th	8-#9 each side	115.27	7520.65	1046.1	8034.35
5th	8-#8 each side	85.70	5906.83	863.38	6399.84
6th	8-#7 each side	68.47	4707.00	698.08	4896.85
7th	7-#7 each side	55.32	3748.45	698.08	4297.25
8th	7-#6 each side	45.35	2973.93	558.88	3168.44
9th	6-#6 each side	37.25	2339.00	558.88	2721.57
10th	4-#6 each side	30.73	1817.55	558.88	1822.07
11th	5-#5 each side	25.14	1387.33	558.88	1606.28
12th	5-#4 each side	21.00	1035.36	350.08	1039.04
13th	4-#4 each side	17.23	741.40	350.08	832.02
14th	3-#4 each side	13.68	500.19	350.08	624.61
15th	2-#4 each side	10.30	308.69	350.08	416.81
16th	1-#4 each side	7.10	164.42	350.08	208.6
roof	1-#4 each side	2.95	64.95	350.08	208.6

Relative Stiffness Calculations for Shear Walls

20' Shear Wall					
	E	L	h	t	R
ground	3600	20	18	8	5128.2051
2nd	3600	20	32	8	1359.5166
3rd	3600	20	46	8	518.2839
4th	3600	20	60	8	246.1538
5th	3600	20	74	8	134.7608
6th	3600	20	88	8	81.3706
7th	3600	20	102	8	52.7565
8th	3600	20	116	8	36.0971
9th	3600	20	130	8	25.7603
10th	3600	20	144	8	19.0150
11th	3600	20	158	8	14.4299
12th	3600	20	172	8	11.2061
13th	3600	20	186	8	8.8743
14th	3600	20	200	8	7.1464
15th	3600	20	214	8	5.8391
16th	3600	20	228	8	4.8319
roof	3600	20	250	8	3.6688

10' Shear Wall					
	E	L	h	t	R
ground	3600	10	18	18	2255.6391
2nd	3600	10	32	18	460.6460
3rd	3600	10	46	18	160.7366
4th	3600	10	60	18	73.4694
5th	3600	10	74	18	39.4377
6th	3600	10	88	18	23.5440
7th	3600	10	102	18	15.1564
8th	3600	10	116	18	10.3211
9th	3600	10	130	18	7.3411
10th	3600	10	144	18	5.4058
11th	3600	10	158	18	4.0949
12th	3600	10	172	18	3.1756
13th	3600	10	186	18	2.5121
14th	3600	10	200	18	2.0212
15th	3600	10	214	18	1.6503
16th	3600	10	228	18	1.3648
roof	3600	10	250	18	1.0356

Column Schedules

Concrete Design Column Table

Column Line /Level	1	2	3	4	5	6	7	8	9	10	11	12
roof	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9	18x18 4-#10	18x18 4-#9	18x18 8-#9	18x18 4-#9	18x18 8-#9
16	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9	18x18 4-#10	18x18 4-#9	18x18 8-#9	18x18 4-#9	18x18 8-#9
15	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9	18x18 4-#10	18x18 4-#9	18x18 8-#9	18x18 4-#9	18x18 8-#9
14	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9	18x18 4-#10	18x18 4-#9	18x18 8-#9	18x18 4-#9	18x18 8-#9
13	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9	18x18 4-#10	18x18 4-#9	18x18 8-#9	18x18 4-#9	18x18 8-#9
12	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9	18x18 4-#10	18x18 8-#10	18x18 8-#10	18x18 8-#9	18x18 8-#10
11	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9	18x18 4-#10	18x18 8-#10	18x18 8-#10	18x18 8-#9	18x18 8-#10
10	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9	18x18 4-#10	18x18 8-#10	18x18 8-#10	18x18 8-#9	18x18 8-#10
9	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
8	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
7	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
6	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 8-#11	24x24 8-#11	24x24 4-#11	24x24 8-#11
5	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 8-#11	24x24 8-#11	24x24 4-#11	24x24 8-#11
4	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 8-#11	24x24 8-#11	24x24 4-#11	24x24 8-#11
3	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 8-#11	24x24 8-#11	24x24 8-#11	24x24 8-#11
2	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 8-#11	24x24 8-#11	24x24 8-#11	24x24 8-#11
ground	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 8-#11	24x24 8-#11	24x24 8-#11	24x24 8-#11
cellar 1	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 8-#11	30x30 8-#11	30x30 8-#11	30x30 8-#11
cellar 2	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 8-#11	30x30 8-#11	30x30 8-#11	30x30 8-#11

13	14	15	16	17	18	19	20	21	22	23	24	25	26
18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18
4-#9	4-#10	4-#10	4-#9	8-#9	4-#9	8-#9	4-#9	4-#10	4-#10	4-#9	8-#9	4-#9	8-#9
18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18
4-#9	4-#10	4-#10	4-#9	8-#9	4-#9	8-#9	4-#9	4-#10	4-#10	4-#9	8-#9	4-#9	8-#9
18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18
4-#9	4-#10	4-#10	4-#9	8-#9	4-#9	8-#9	4-#9	4-#10	4-#10	4-#9	8-#9	4-#9	8-#9
18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18
4-#9	4-#10	4-#10	4-#9	8-#9	4-#9	8-#9	4-#9	4-#10	4-#10	4-#9	8-#9	4-#9	8-#9
18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18
4-#9	4-#10	4-#10	4-#9	8-#9	4-#9	8-#9	4-#9	4-#10	4-#10	4-#9	8-#9	4-#9	8-#9
18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18
8-#10	4-#10	4-#10	8-#10	8-#10	8-#8	8-#10	8-#10	4-#10	4-#10	8-#10	8-#10	8-#9	8-#10
18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18
8-#10	4-#10	4-#10	8-#10	8-#10	8-#8	8-#10	8-#10	4-#10	4-#10	8-#10	8-#10	8-#9	8-#10
18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18	18x18
8-#10	4-#10	4-#10	8-#10	8-#10	8-#8	8-#10	8-#10	4-#10	4-#10	8-#10	8-#10	8-#9	8-#10
24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24
4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11
24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24
4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11
24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24
4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11	4-#11
24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24
8-#11	4-#11	4-#11	8-#11	8-#11	4-#11	8-#11	8-#11	4-#11	4-#11	8-#11	8-#11	4-#11	8-#11
24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24
8-#11	4-#11	4-#11	8-#11	8-#11	4-#11	8-#11	8-#11	4-#11	4-#11	8-#11	8-#11	4-#11	8-#11
24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24
8-#11	4-#11	4-#11	8-#11	8-#11	4-#11	8-#11	8-#11	4-#11	4-#11	8-#11	8-#11	4-#11	8-#11
24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24
8-#11	4-#11	4-#11	8-#11	8-#11	4-#11	8-#11	8-#11	4-#11	4-#11	8-#11	8-#11	8-#11	8-#11
24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24
8-#11	4-#11	4-#11	8-#11	8-#11	4-#11	8-#11	8-#11	4-#11	4-#11	8-#11	8-#11	8-#11	8-#11
24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24	24x24
8-#11	4-#11	4-#11	8-#11	8-#11	4-#11	8-#11	8-#11	4-#11	4-#11	8-#11	8-#11	8-#11	8-#11
30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30
8-#11	4-#11	4-#11	8-#11	8-#11	4-#11	8-#11	8-#11	4-#11	4-#11	8-#11	8-#11	8-#11	8-#11
30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30	30x30
8-#11	4-#11	4-#11	8-#11	8-#11	4-#11	8-#11	8-#11	4-#11	4-#11	8-#11	8-#11	8-#11	8-#11

27	28	29	30	31	32	33	34	35	36	37	38	39	40
18x18 4-#9	18x18 4-#10	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9					
18x18 4-#9	18x18 4-#10	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9					
18x18 4-#9	18x18 4-#10	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9					
18x18 4-#9	18x18 4-#10	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9					
18x18 4-#9	18x18 4-#10	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9			18x18 4-#9	18x18 4-#9	18x18 4-#9
18x18 8-#10	18x18 4-#10	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9			18x18 4-#9	18x18 4-#9	18x18 4-#9
18x18 8-#10	18x18 4-#10	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9			18x18 4-#9	18x18 4-#9	18x18 4-#9
18x18 8-#10	18x18 4-#10	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 8-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
24x24 8-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
24x24 8-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
24x24 8-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
24x24 8-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
24x24 8-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
24x24 8-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
30x30 8-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11
30x30 8-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11

41	42	43	44	45	46	47	48	49	50	51
18x18 4-#9										
18x18 4-#9										
18x18 4-#9										
18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9	18x18 4-#9					
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11					
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11					
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11					
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11					
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11					
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11	24x24 4-#11
30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11
30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11	30x30 4-#11

Composite and Non-Composite Steel Design Column Table

Column Line /Level	1	2	3	4	5	6	7	8
roof	W18X86	W12X40	W16X36	W12X26	W16X36	W12X40	W18X86	W18X86
16	W18X86	W12X40	W16X36	W12X26	W16X36	W12X40	W18X86	W18X86
15	W21X111	W18X76	W16X67	W21X62	W16X67	W18X76	W21X111	W21X111
14	W21X111	W18X76	W16X67	W21X62	W16X67	W18X76	W21X111	W21X111
13	W21X111	W18X76	W16X67	W21X62	W16X67	W18X76	W21X111	W21X111
12	W27X146	W30X99	W30X99	W30X99	W30X99	W30X99	W27X146	W27X146
11	W27X146	W30X99	W30X99	W30X99	W30X99	W30X99	W27X146	W27X146
10	W27X146	W30X99	W30X99	W30X99	W30X99	W30X99	W27X146	W27X146
9	W30X173	W30X148	W30X148	W30X132	W30X148	W30X148	W30X173	W30X173
8	W30X173	W30X148	W30X148	W30X132	W30X148	W30X148	W30X173	W30X173
7	W30X173	W30X148	W30X148	W30X132	W30X148	W30X148	W30X173	W30X173
6	W40X174	W40X167	W36X160	W40X149	W36X160	W40X167	W40X174	W40X192
5	W40X174	W40X167	W36X160	W40X149	W36X160	W40X167	W40X174	W40X192
4	W40X174	W40X167	W36X160	W40X149	W36X160	W40X167	W40X174	W40X192
3	W44X290	W44X262	W44X230	W44X230	W44X230	W44X262	W44X290	W44X290
2	W44X290	W44X262	W44X230	W44X230	W44X230	W44X262	W44X290	W44X290
ground	W44X290	W44X262	W44X230	W44X230	W44X230	W44X262	W44X290	W44X290
cellar 1	W44X290	W44X262	W44X230	W44X230	W44X230	W44X262	W44X290	W44X290
cellar 2	W44X290	W44X262	W44X230	W44X230	W44X230	W44X262	W44X290	W44X290

9	10	11	12	13	14	15	16	17
W16X36	W12X30	W12X30	W12X30	W16X36	W18X86	W18X86	W12X30	W12X30
W16X36	W12X30	W12X30	W12X30	W16X36	W18X86	W18X86	W12X30	W12X30
W18X86	W16X67	W16X67	W16X67	W18X86	W21X111	W21X111	W18X86	W16X67
W18X86	W16X67	W16X67	W16X67	W18X86	W21X111	W21X111	W18X86	W16X67
W18X86	W16X67	W16X67	W16X67	W18X86	W21X111	W21X111	W18X86	W16X67
W24X131	W27X102	W30X99	W27X102	W24X131	W27X146	W27X146	W27X117	W24X104
W24X131	W27X102	W30X99	W27X102	W24X131	W27X146	W27X146	W27X117	W24X104
W24X131	W27X102	W30X99	W27X102	W24X131	W27X146	W27X146	W27X117	W24X104
W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X148
W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X148
W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X148
W40X174	W40X174	W40X174	W40X174	W40X174	W40X192	W40X192	W40X174	W40X174
W40X174	W40X174	W40X174	W40X174	W40X174	W40X192	W40X192	W40X174	W40X174
W40X174	W40X174	W40X174	W40X174	W40X174	W40X192	W40X192	W40X174	W40X174
W44X290	W44X230	W44X230	W44X230	W44X290	W44X290	W44X290	W44X262	W44X230
W44X290	W44X230	W44X230	W44X230	W44X290	W44X290	W44X290	W44X262	W44X230
W44X290	W44X230	W44X230	W44X230	W44X290	W44X290	W44X290	W44X262	W44X230
W44X290	W44X230	W44X230	W44X230	W44X290	W44X290	W44X290	W44X262	W44X230
W44X290	W44X230	W44X230	W44X230	W44X290	W44X290	W44X290	W44X262	W44X230

18	19	20	21	22	23	24	25	26
W12X30	W12X30	W12X30	W18X86	W18X86	W16X36	W12X30	W12X30	W12X30
W12X30	W12X30	W12X30	W18X86	W18X86	W16X36	W12X30	W12X30	W12X30
W16X67	W16X67	W18X86	W21X111	W21X111	W18X86	W16X67	W16X67	W16X67
W16X67	W16X67	W18X86	W21X111	W21X111	W18X86	W16X67	W16X67	W16X67
W24X104	W16X67	W18X86	W21X111	W21X111	W18X86	W16X67	W16X67	W16X67
W24X104	W24X104	W27X117	W27X146	W27X146	W24X131	W27X102	W30X99	W27X102
W24X104	W24X104	W27X117	W27X146	W27X146	W24X131	W27X102	W30X99	W27X102
W30X90	W24X104	W27X117	W27X146	W27X146	W24X131	W27X102	W30X99	W27X102
W30X148	W30X148	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173
W30X148	W30X148	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173
W30X148	W30X148	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173	W30X173
W40X174	W40X174	W40X174	W40X192	W40X192	W40X174	W40X174	W40X174	W40X174
W40X174	W40X174	W40X174	W40X192	W40X192	W40X174	W40X174	W40X174	W40X174
W40X174	W40X174	W40X174	W40X192	W40X192	W40X174	W40X174	W40X174	W40X174
W44X230	W44X230	W44X262	W44X290	W44X290	W44X290	W44X230	W44X230	W44X230
W44X230	W44X230	W44X262	W44X290	W44X290	W44X290	W44X230	W44X230	W44X230
W44X230	W44X230	W44X262	W44X290	W44X290	W44X290	W44X230	W44X230	W44X230
W44X230	W44X230	W44X262	W44X290	W44X290	W44X290	W44X230	W44X230	W44X230
W44X230	W44X230	W44X262	W44X290	W44X290	W44X290	W44X230	W44X230	W44X230

27	28	29	30	31	32	33	34	35
W16X36	W18X86	W18X86	W12X40	W16X36	W12X26	W16X36	W12X40	W18X86
W16X36	W18X86	W18X86	W12X40	W16X36	W12X26	W16X36	W12X40	W18X86
W18X86	W21X111	W21X111	W18X76	W16X67	W21X62	W16X67	W18X76	W21X111
W18X86	W21X111	W21X111	W18X76	W16X67	W21X62	W16X67	W18X76	W21X111
W18X86	W21X111	W21X111	W18X76	W16X67	W21X62	W16X67	W18X76	W21X111
W24X131	W27X146	W27X146	W30X99	W30X99	W30X99	W30X99	W30X99	W27X146
W24X131	W27X146	W27X146	W30X99	W30X99	W30X99	W30X99	W30X99	W27X146
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W30X173	W30X173	W30X173	W30X148	W30X148	W30X132	W30X148	W30X148	W30X173
W30X173	W30X173	W30X173	W30X148	W30X148	W30X132	W30X148	W30X148	W30X173
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W40X174	W40X192	W40X174	W40X167	W36X160	W40X149	W36X160	W40X167	W40X174
W44X290	W44X290	W44X290	W44X262	W44X230	W44X230	W44X230	W44X262	W44X290
W44X290	W44X290	W44X290	W44X262	W44X230	W44X230	W44X230	W44X262	W44X290
W44X290	W44X290	W44X290	W44X262	W44X230	W44X230	W44X230	W44X262	W44X290
W44X290	W44X290	W44X290	W44X262	W44X230	W44X230	W44X230	W44X262	W44X290
W44X290	W44X290	W44X290	W44X262	W44X230	W44X230	W44X230	W44X262	W44X290

36	37	38	39	40	41	42	43	44
		W14X48	W14X48	W14X48	W14X48			
		W14X48	W14X48	W14X48	W14X48			
		W14X48	W14X48	W14X48	W14X48			
W14X48	W14X48	W14X48	W14X48	W14X48	W14X48	W14X48	HP12X53	W14X48
W14X48	W14X48	W18X86	W18X86	W18X86	W18X86	W14X48	HP12X53	W14X48
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W24X131	W24X131	W24X131	W24X131	W24X131	W24X131	W16X67	W18X86	W18X86
W30X191	W30X191	W30X191	W36X160	W36X160	W30X191	W21X101	W27X146	W27X146
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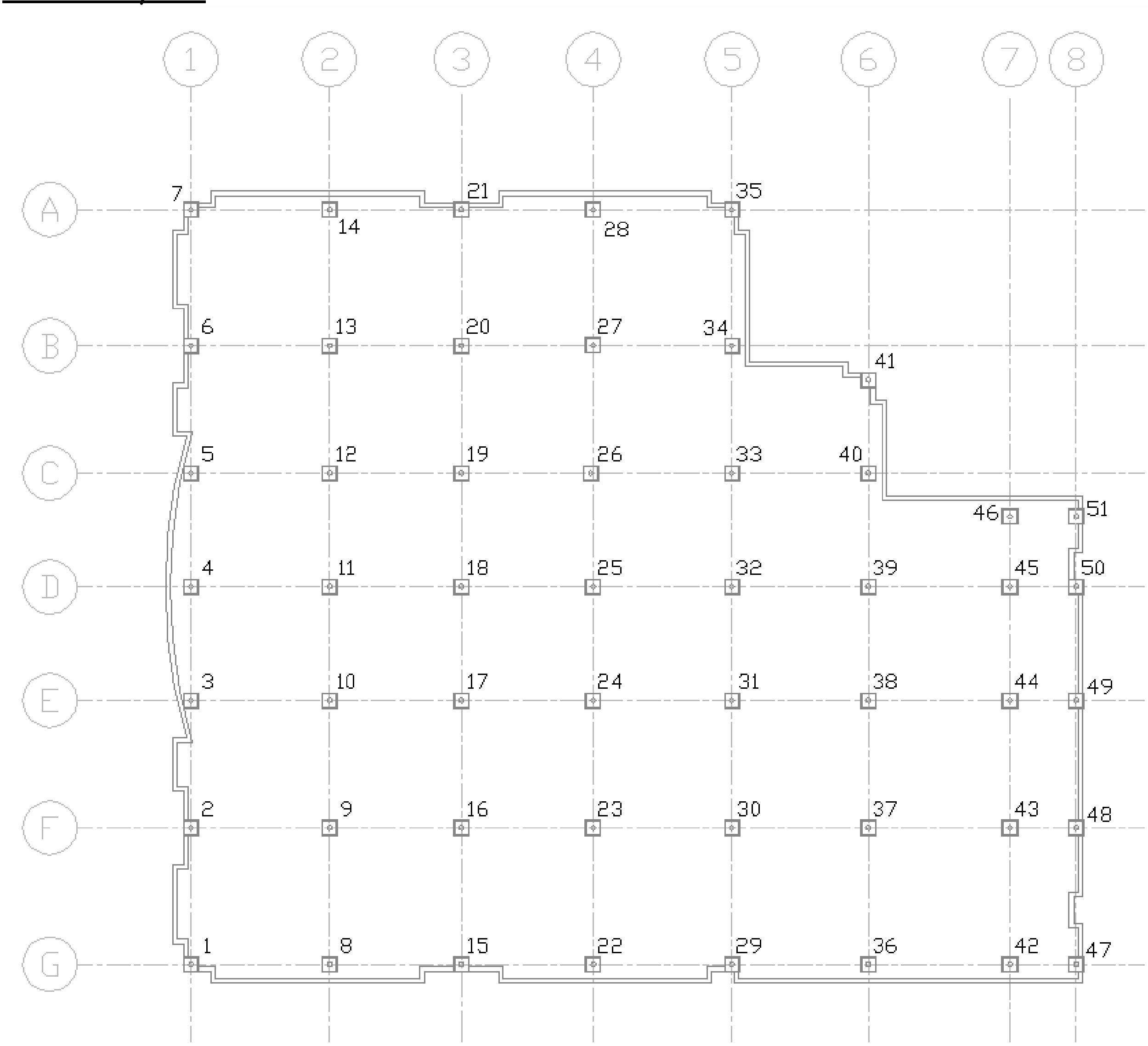
W30X191	W30X191	W30X191	W36X160	W36X160	W30X191	W21X101	W27X146	W27X146
W30X191	W30X191	W30X191	W36X160	W36X160	W30X191	W21X101	W27X146	W27X146

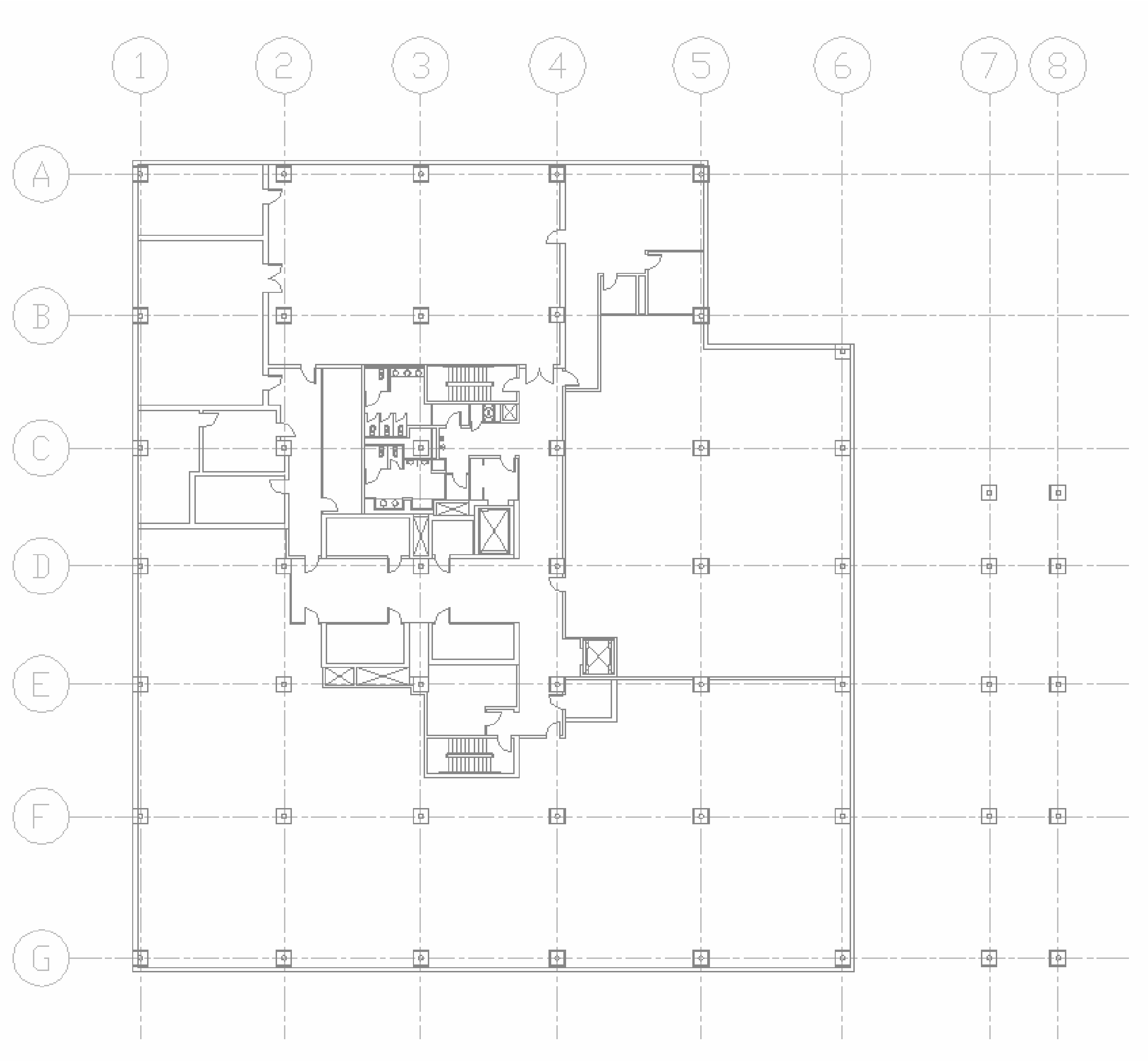
45	46	47	48	49	50	51
W10X49	W14X48					
W10X49	W14X48					
W10X49	W14X48					
W10X49	W14X48					
W16X67	W16X67					
W16X67	W16X67					
W16X67	W16X67	W18X60	W18X60	W18X50	W16X50	W12X35
W27X146	W21X101	W18X60	W18X60	W18X50	W16X50	W12X35
W27X146	W21X101	W18X60	W18X60	W18X50	W16X50	W12X35
W27X146	W21X101	W18X60	W18X60	W18X50	W16X50	W12X35
W27X146	W21X101	W18X60	W18X60	W18X50	W16X50	W12X35
W27X146	W21X101	W18X60	W18X60	W18X50	W16X50	W12X35

Appendix 3: Floor Plans

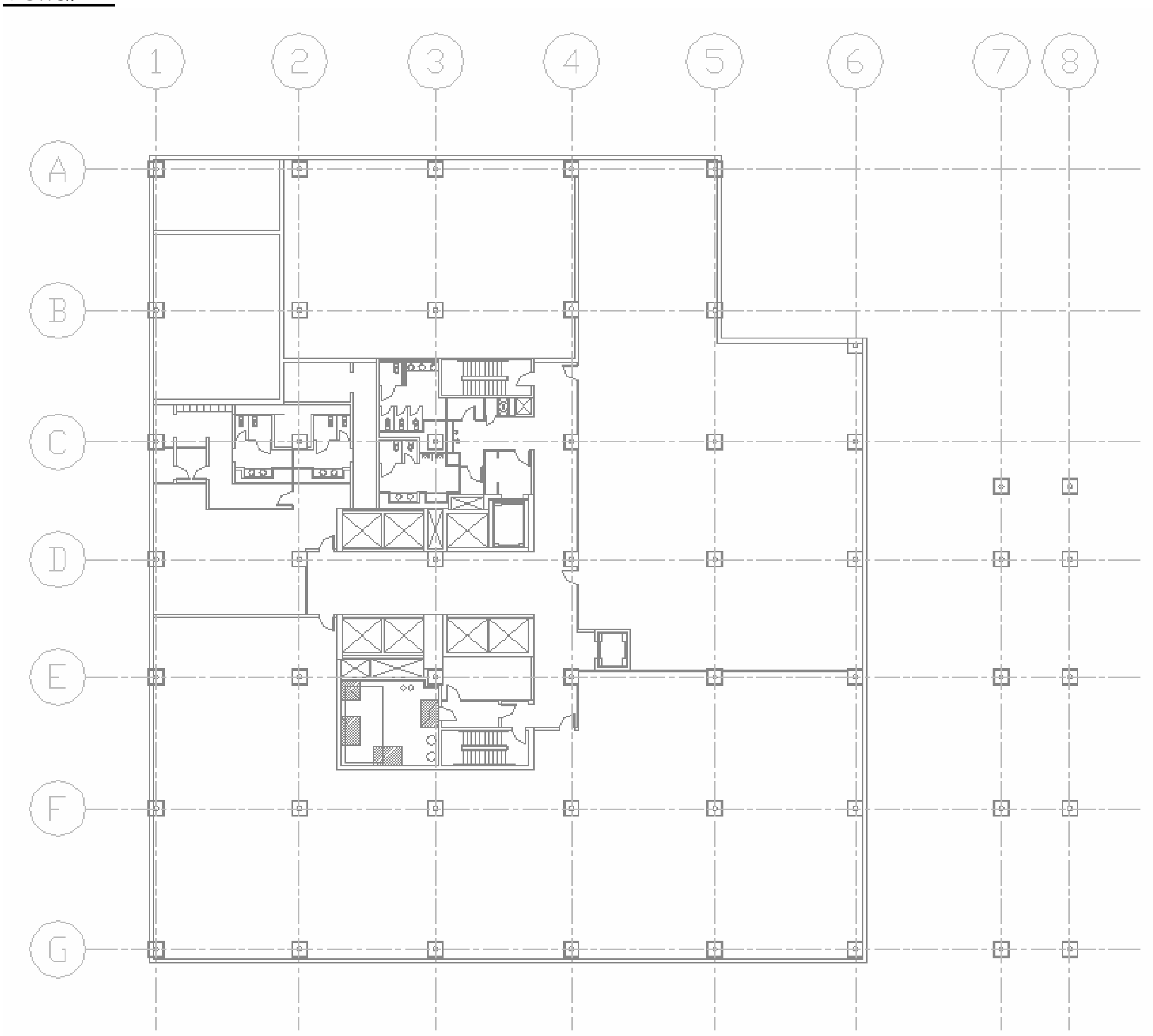
Column Layout:



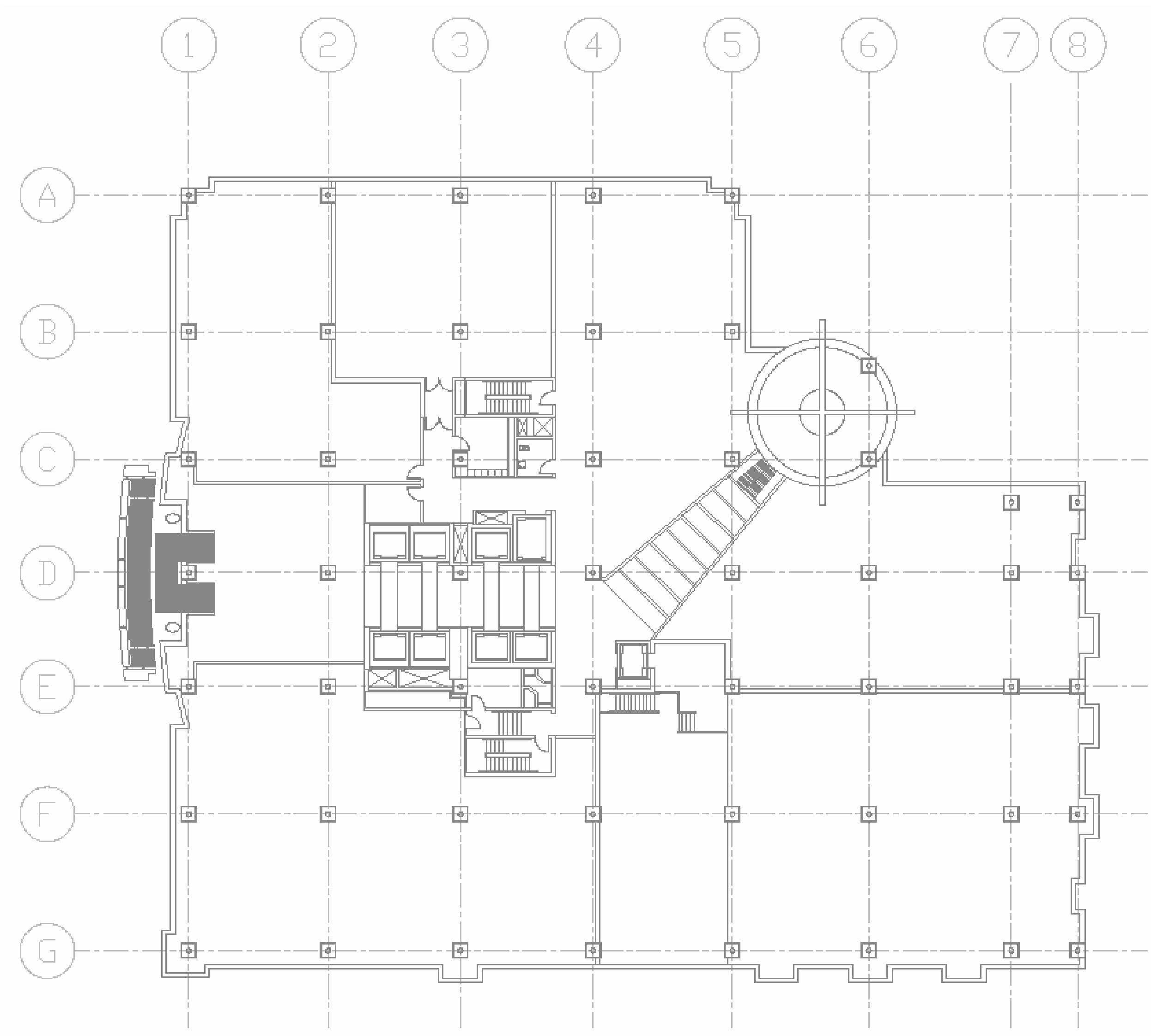
Cellar 2:



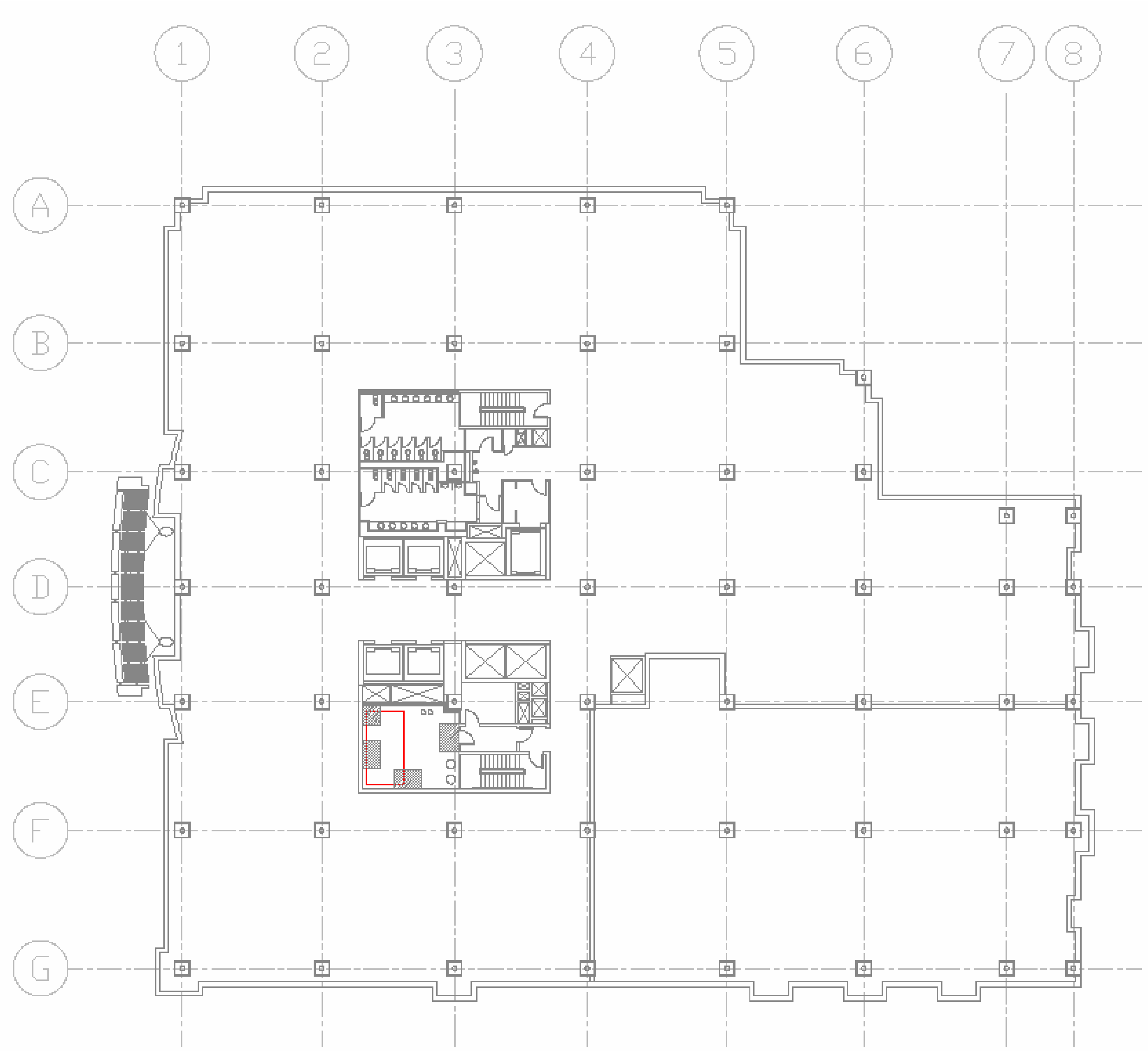
Cellar 1:



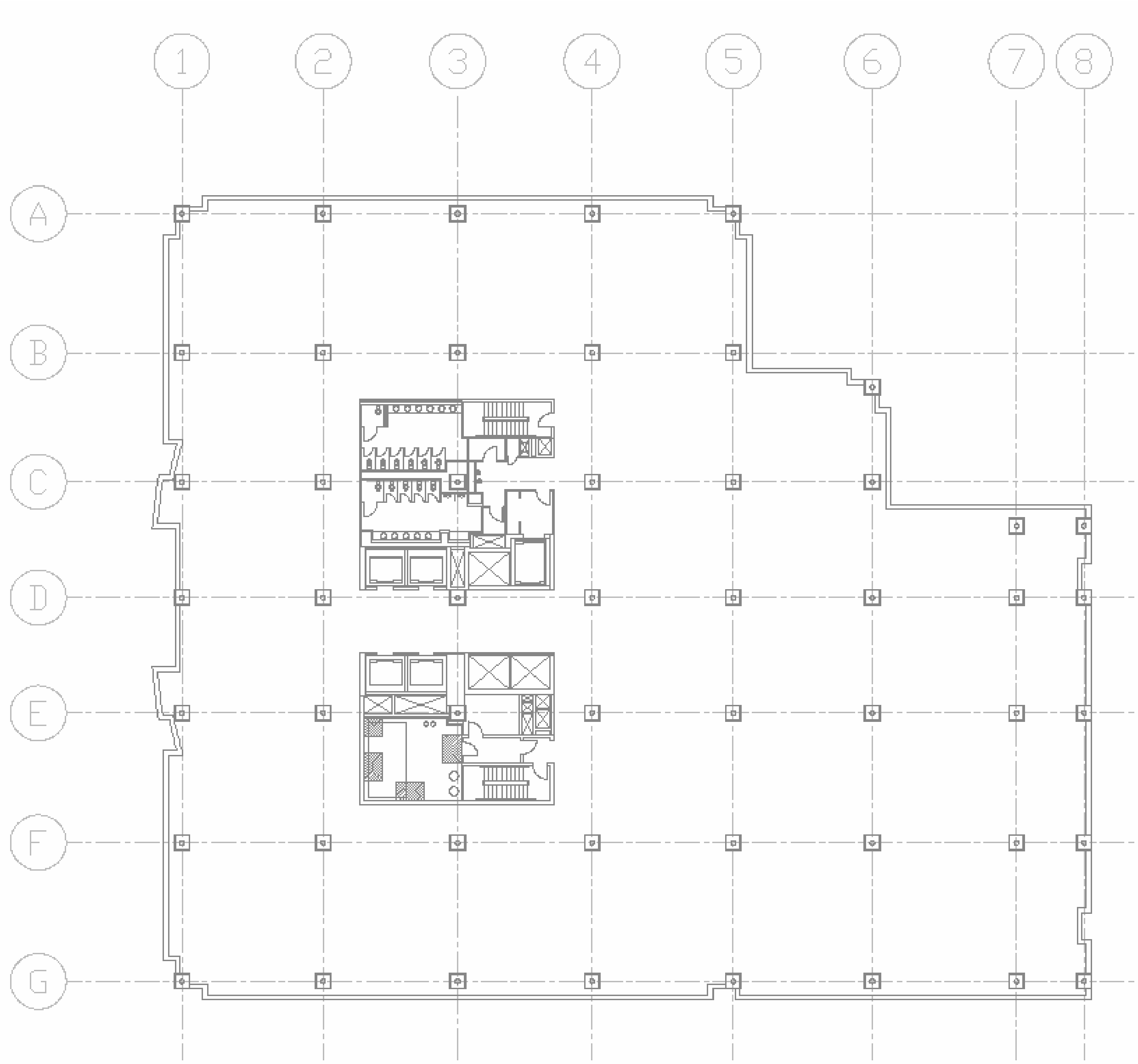
Ground Floor:



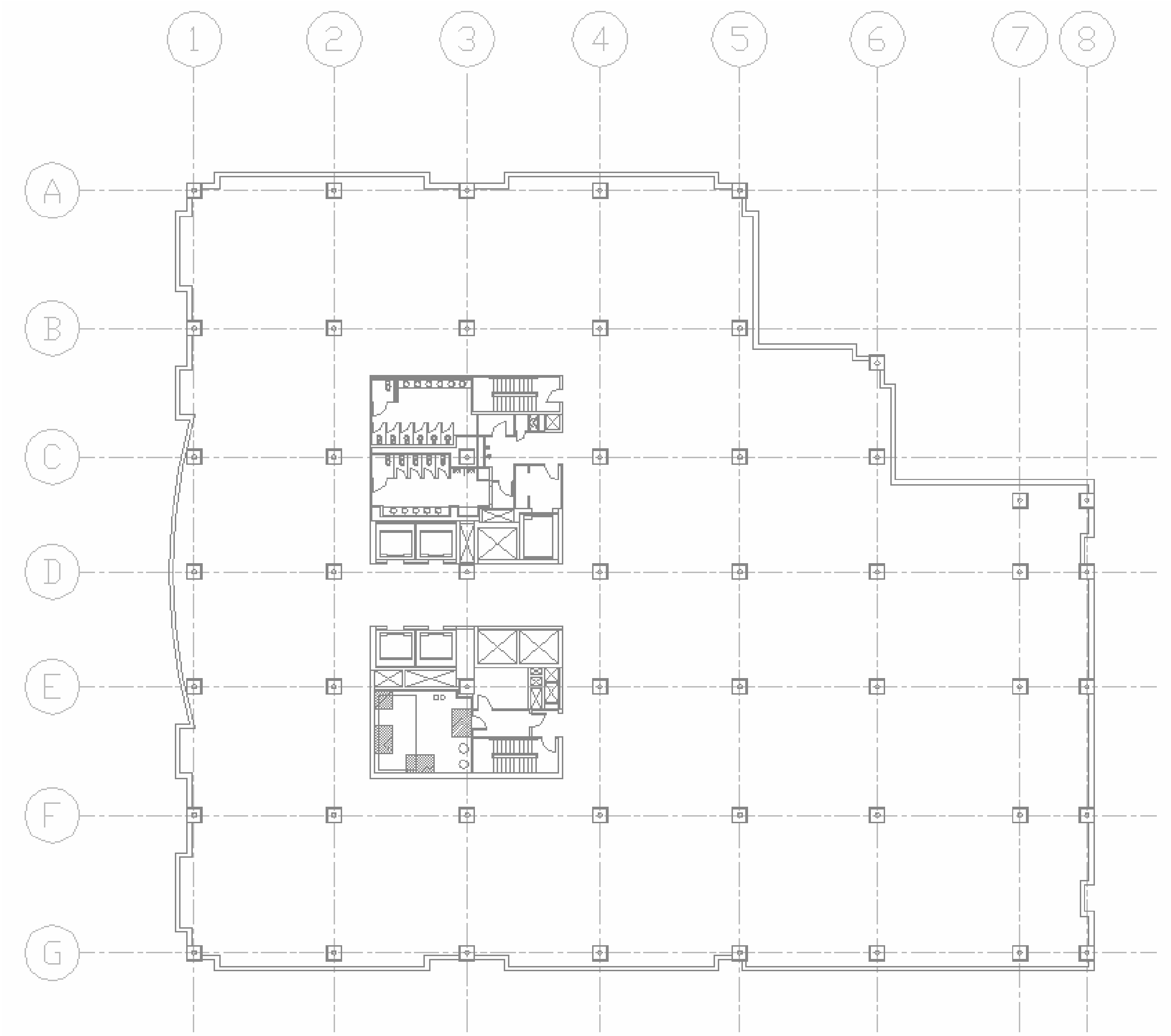
2nd Floor:



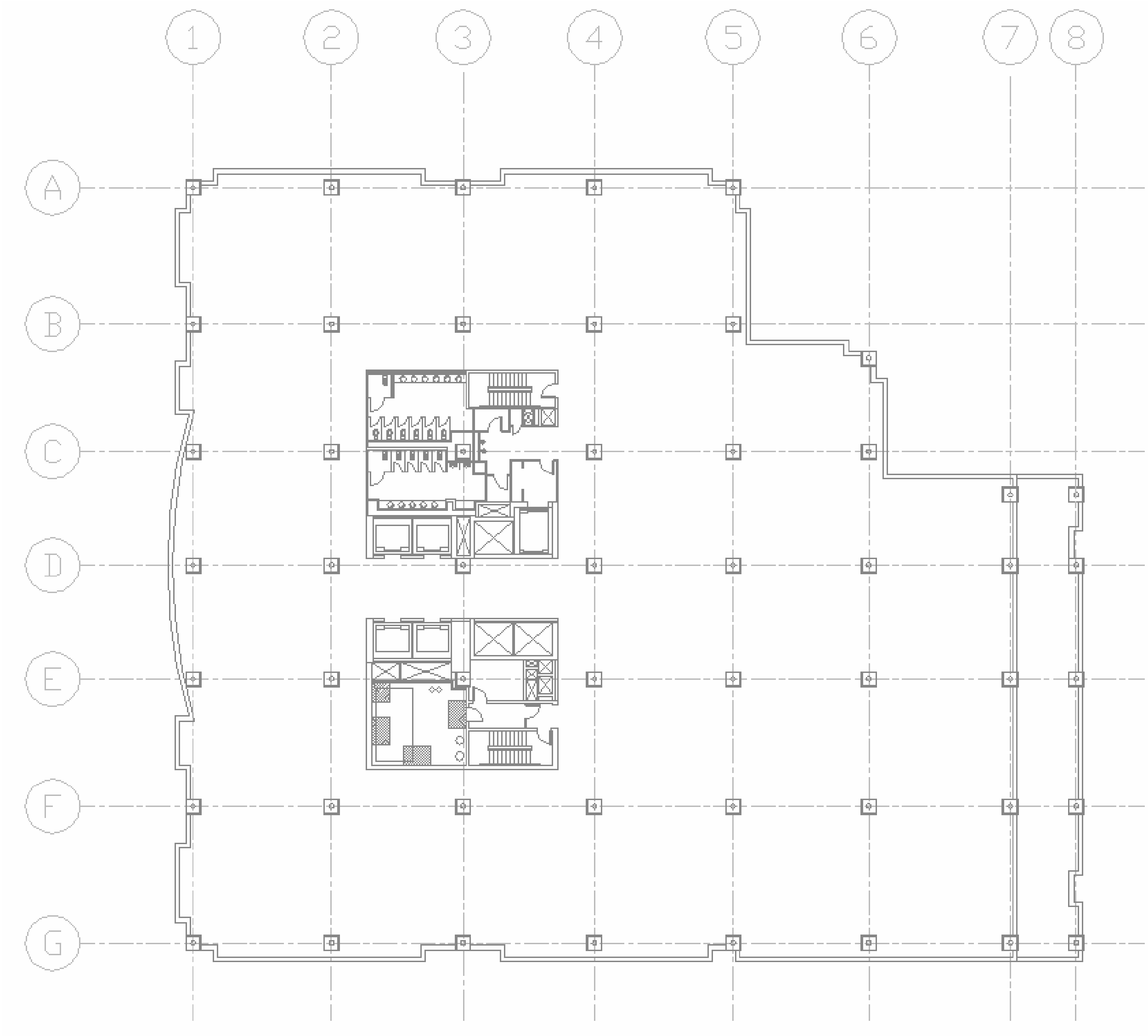
3rd Floor:



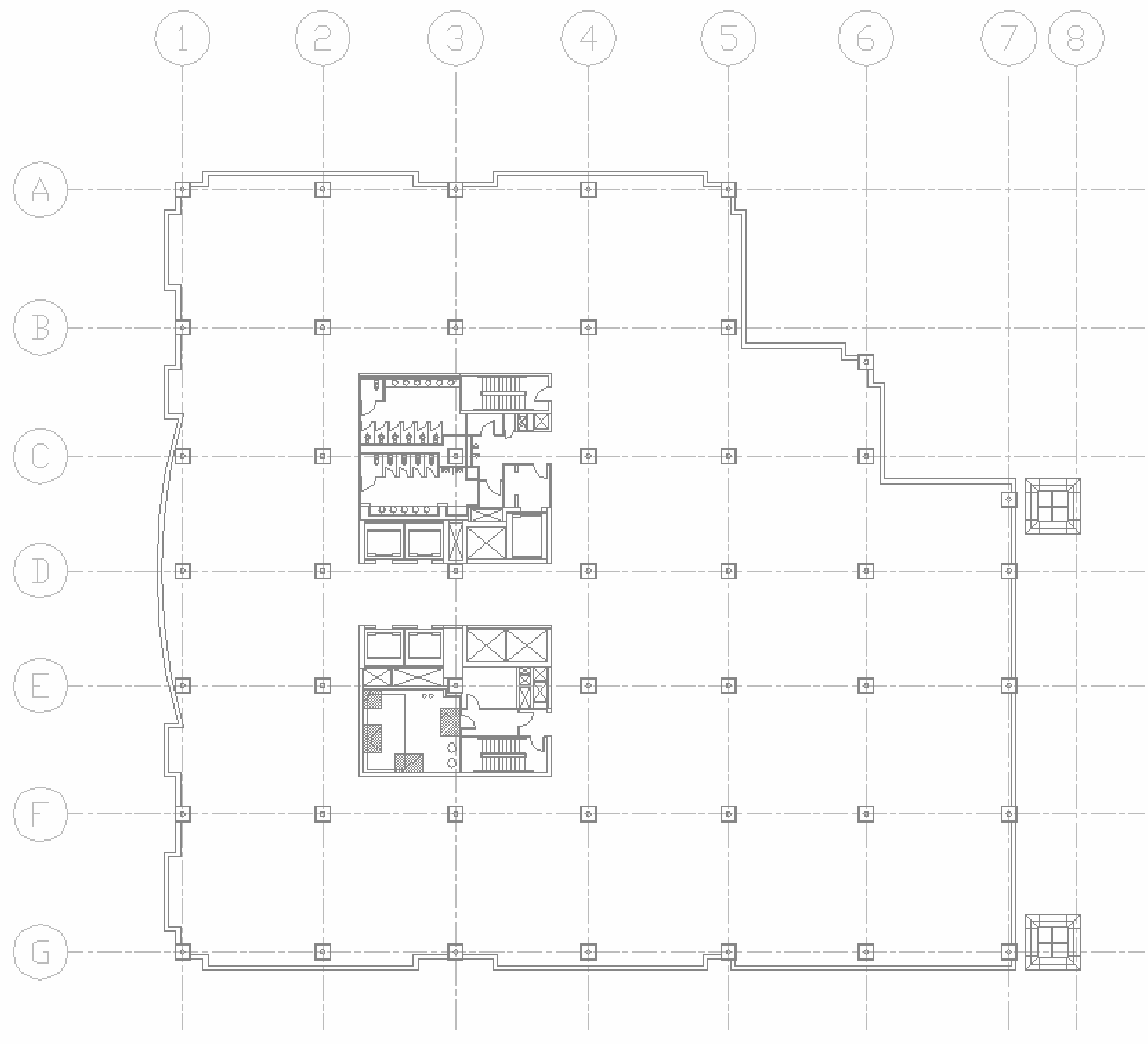
4th Floor:



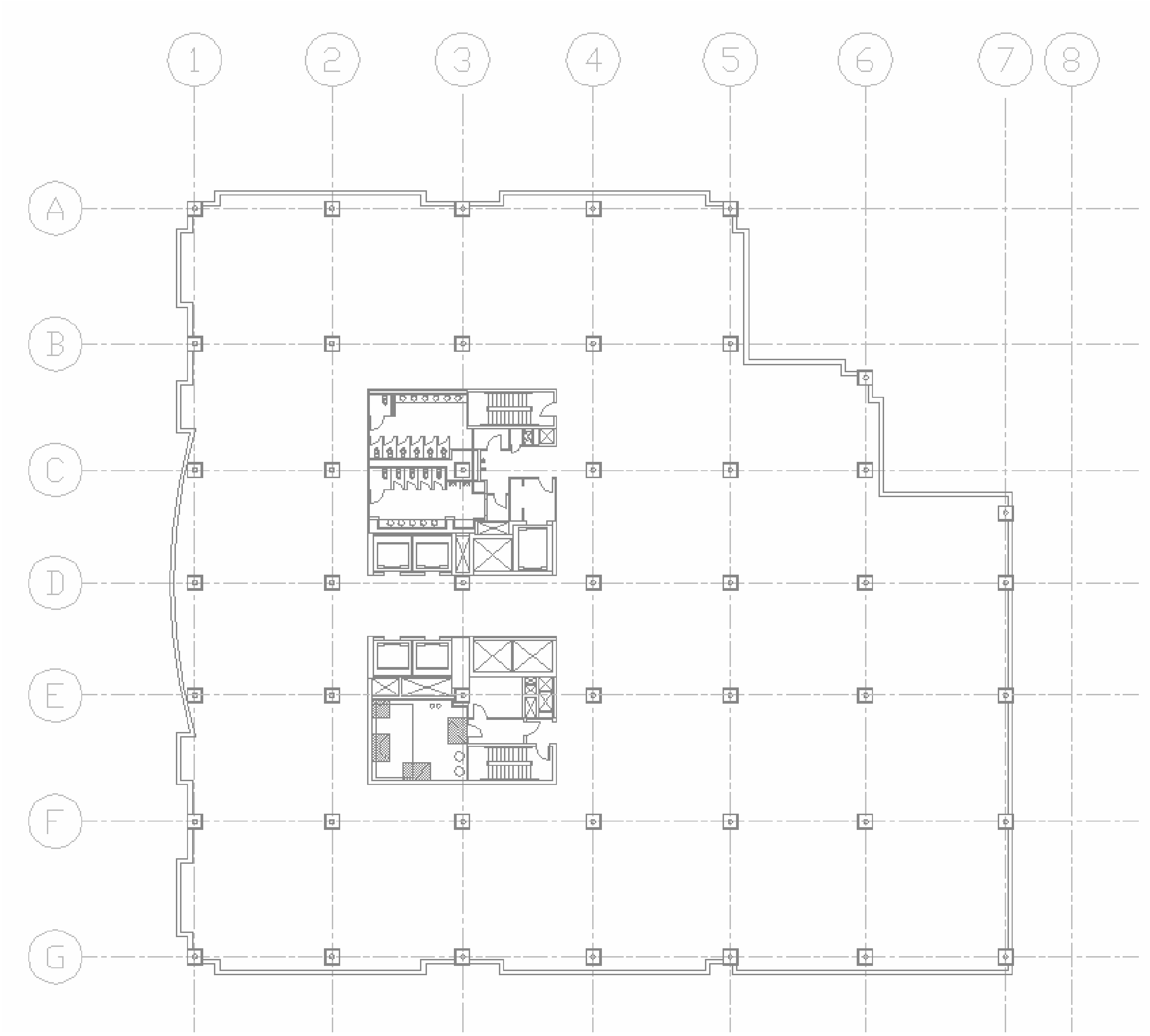
5th Floor:



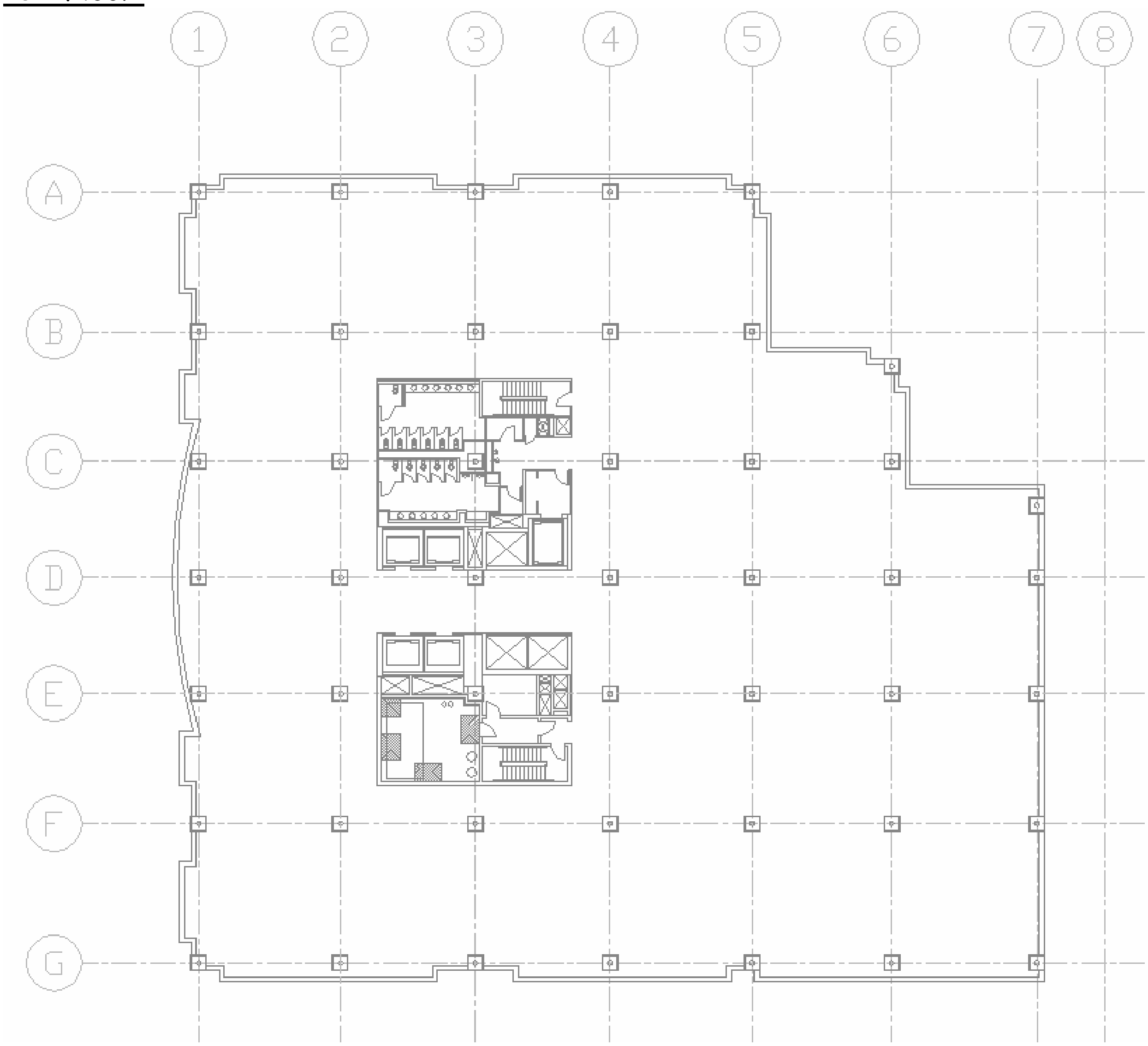
6th, 7th, 8th Floors:



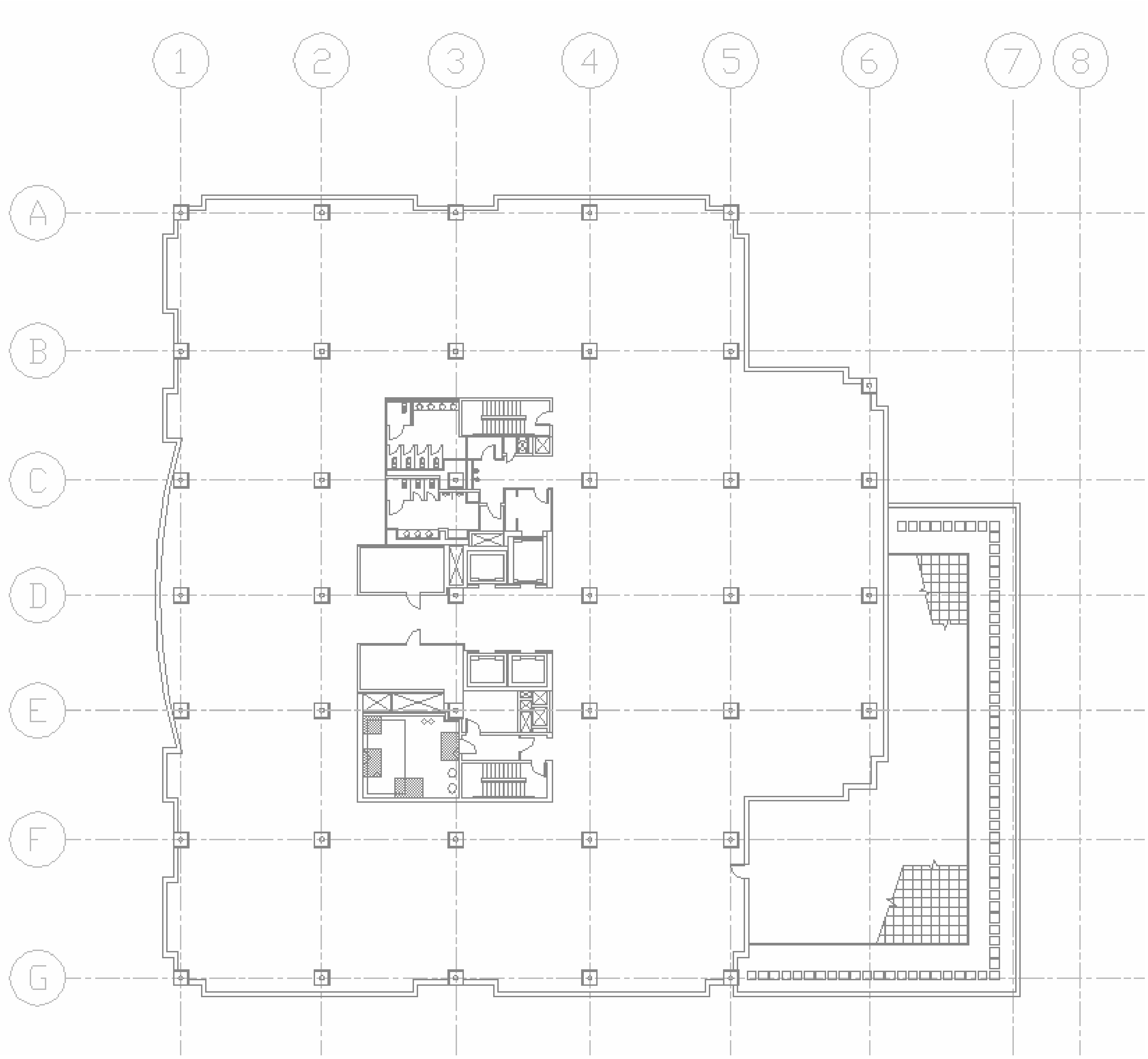
9th Floor:



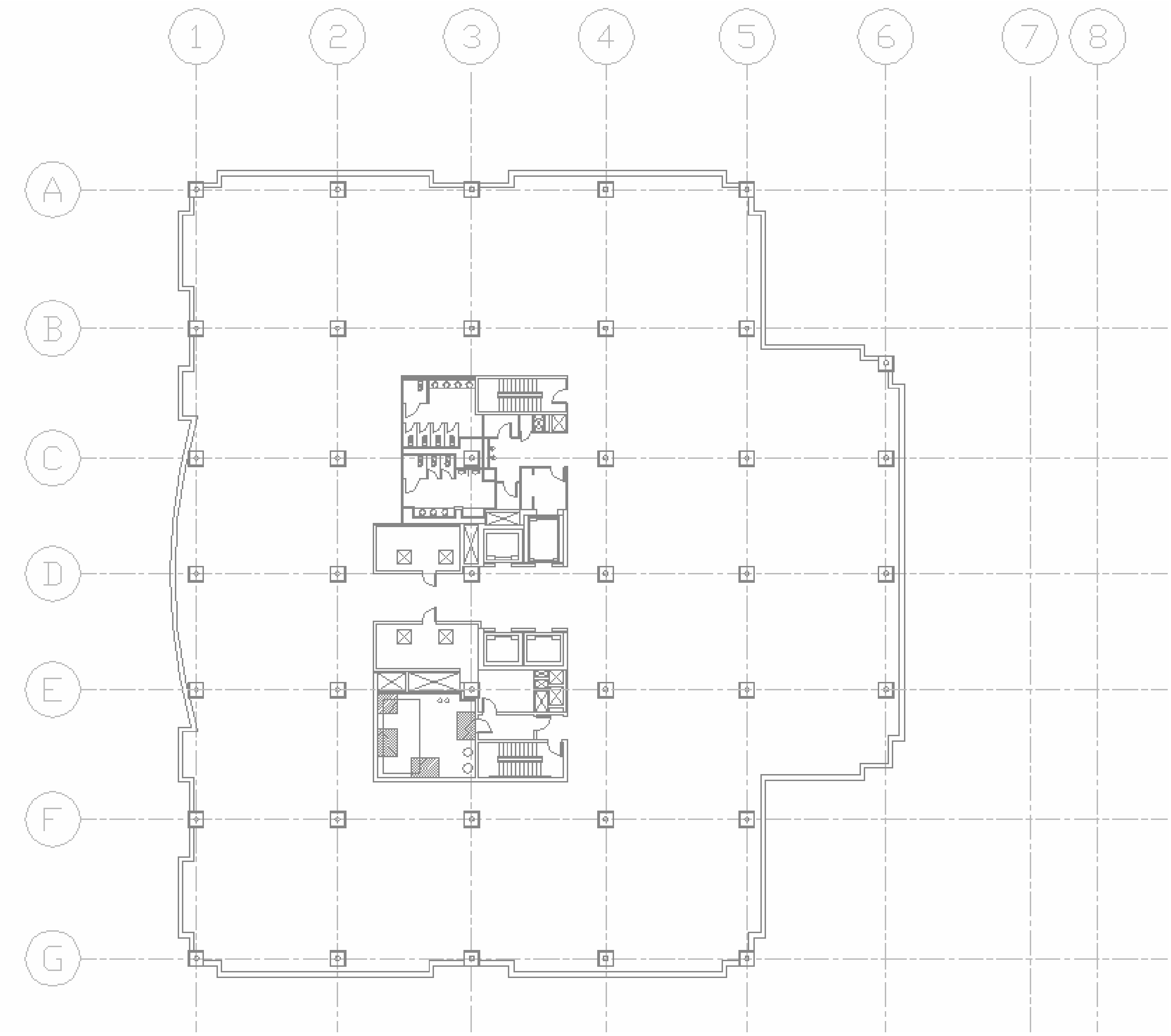
10th Floor:



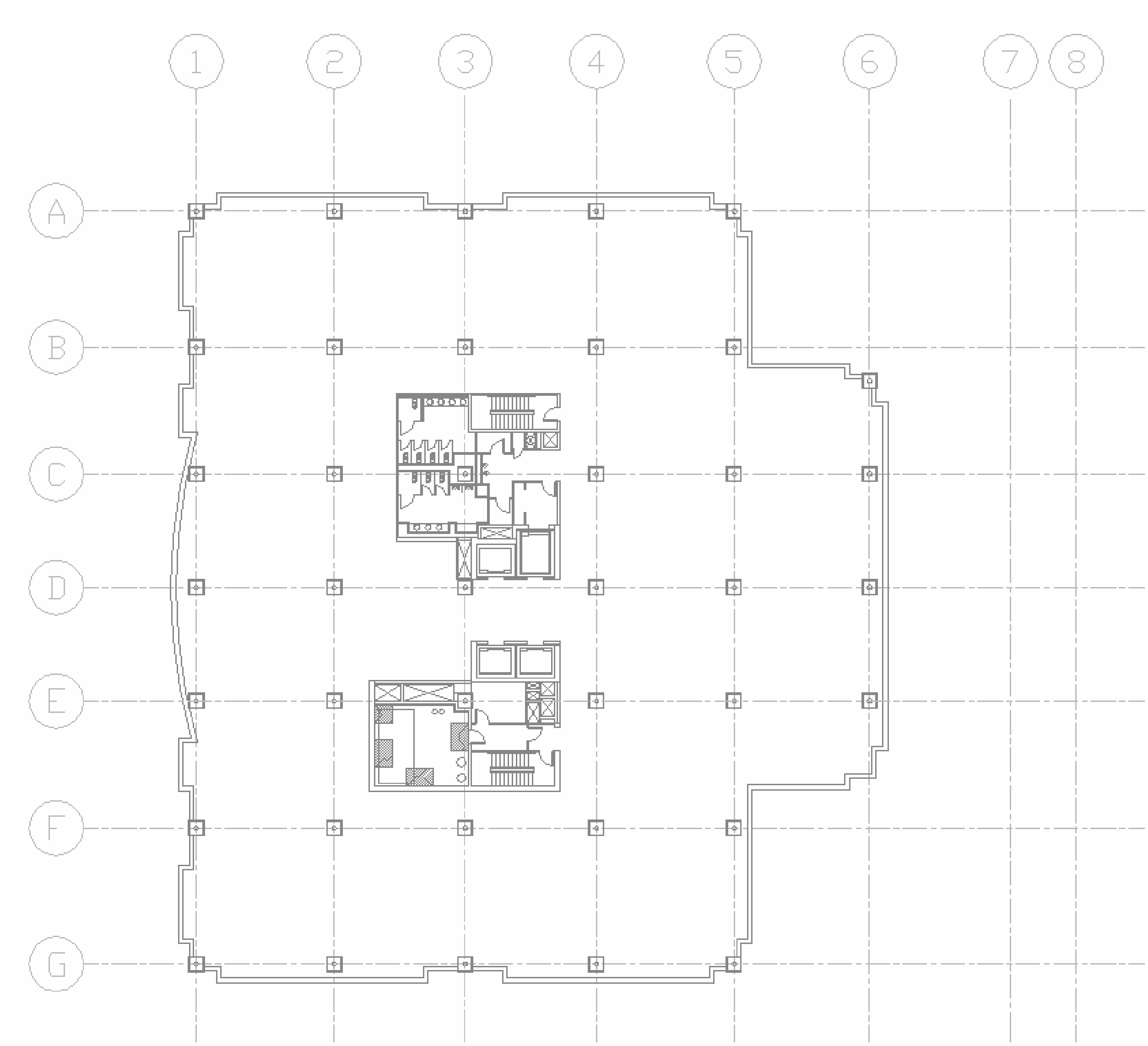
11th Floor:



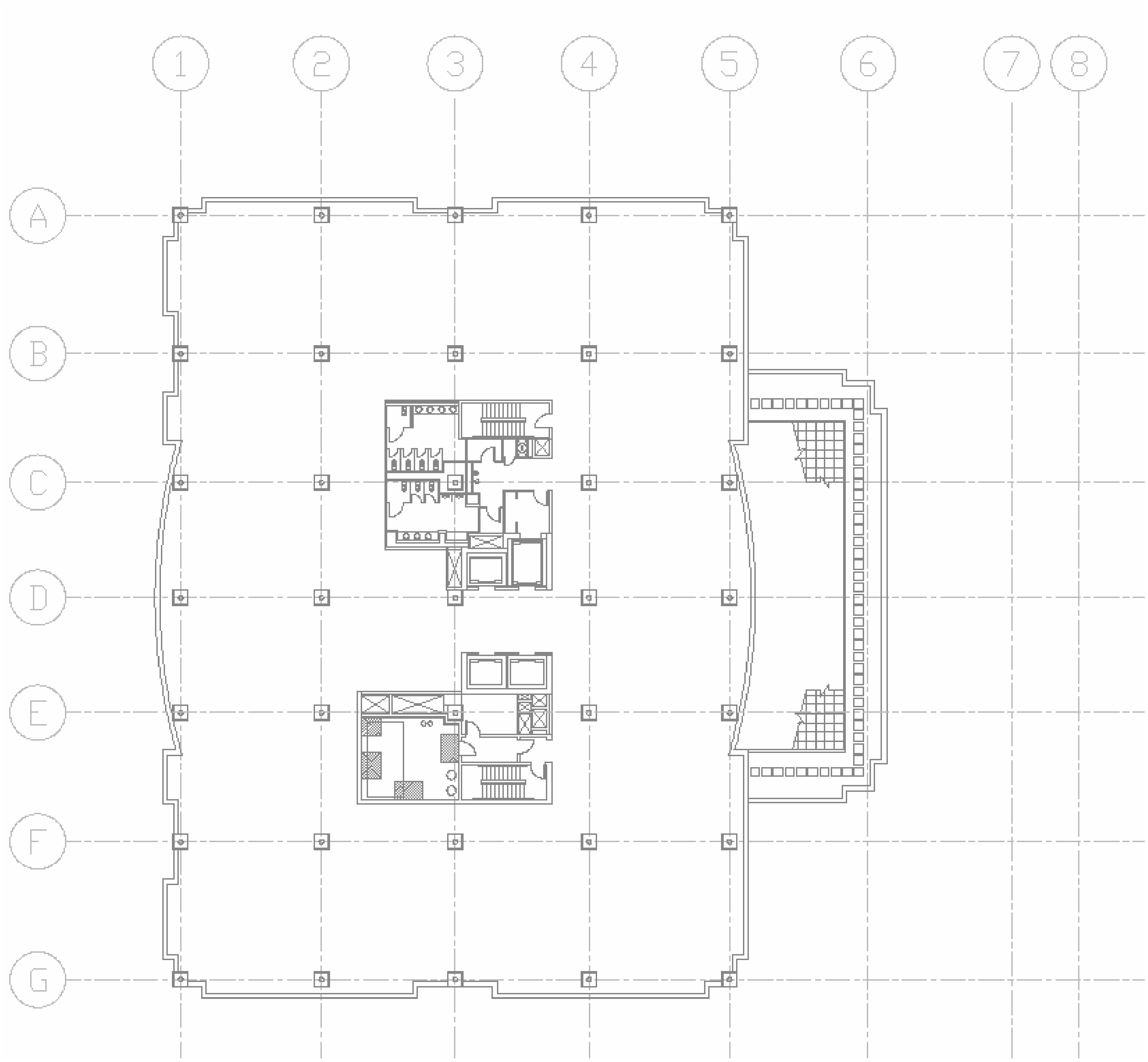
12th Floor:



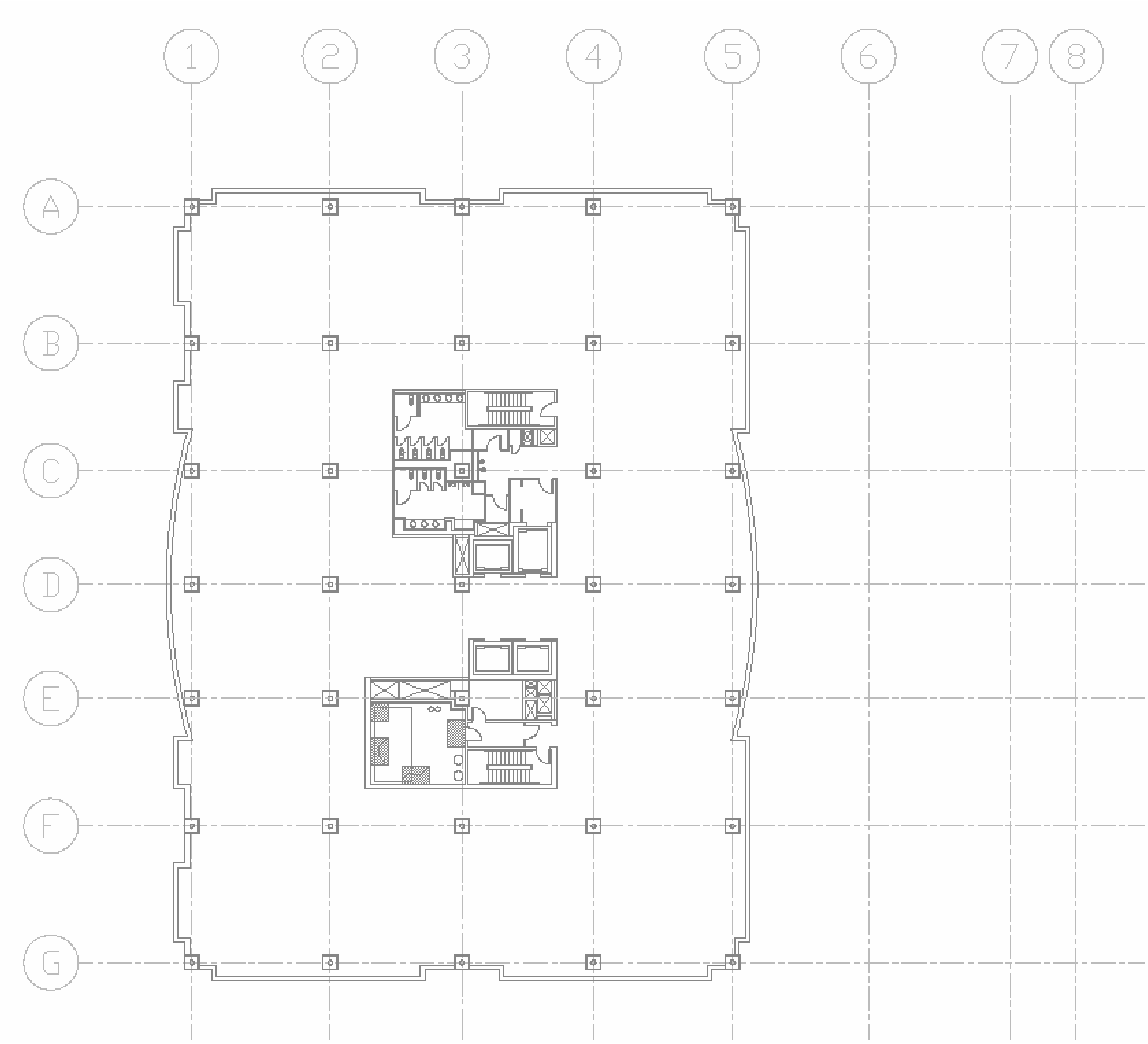
13th Floor:



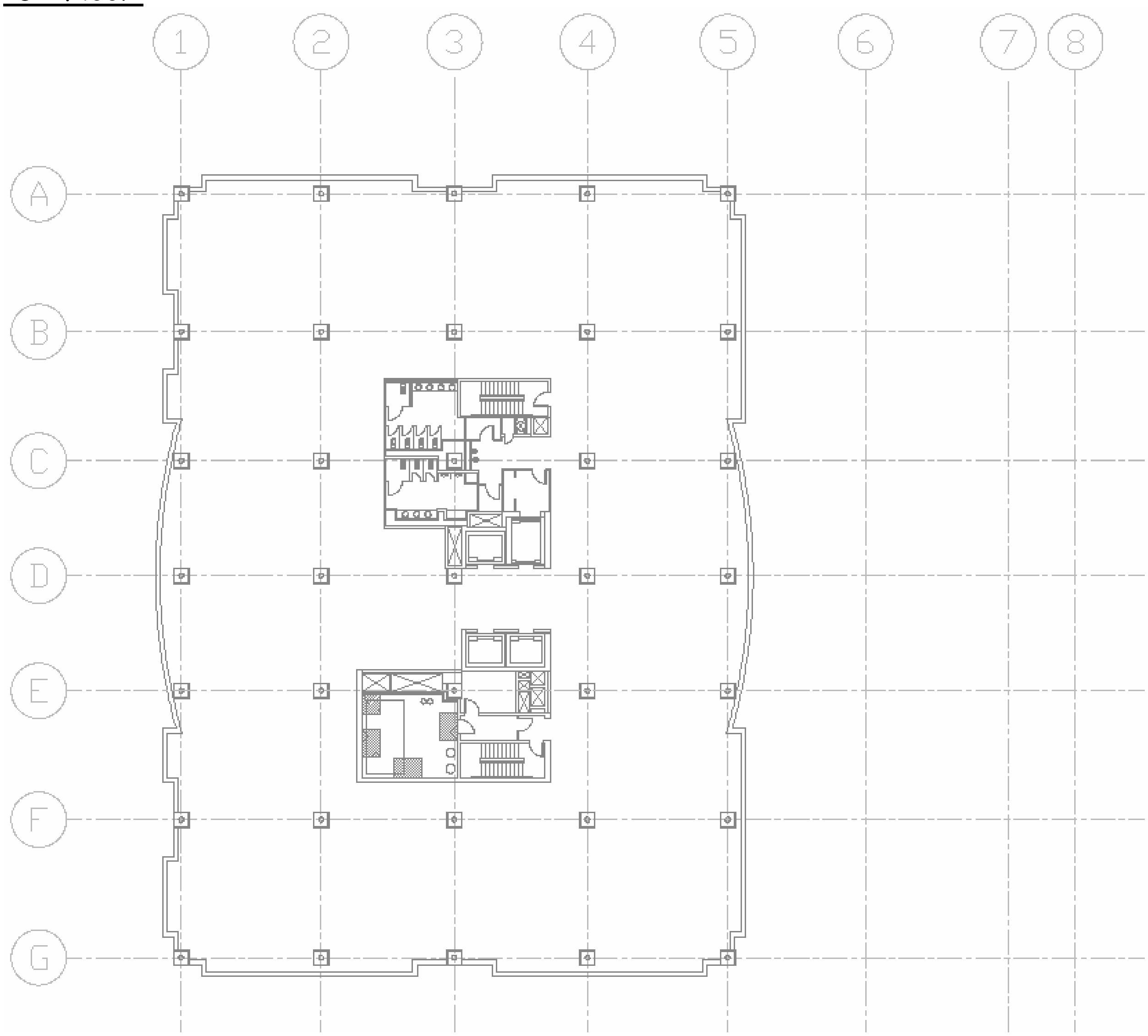
14th Floor:



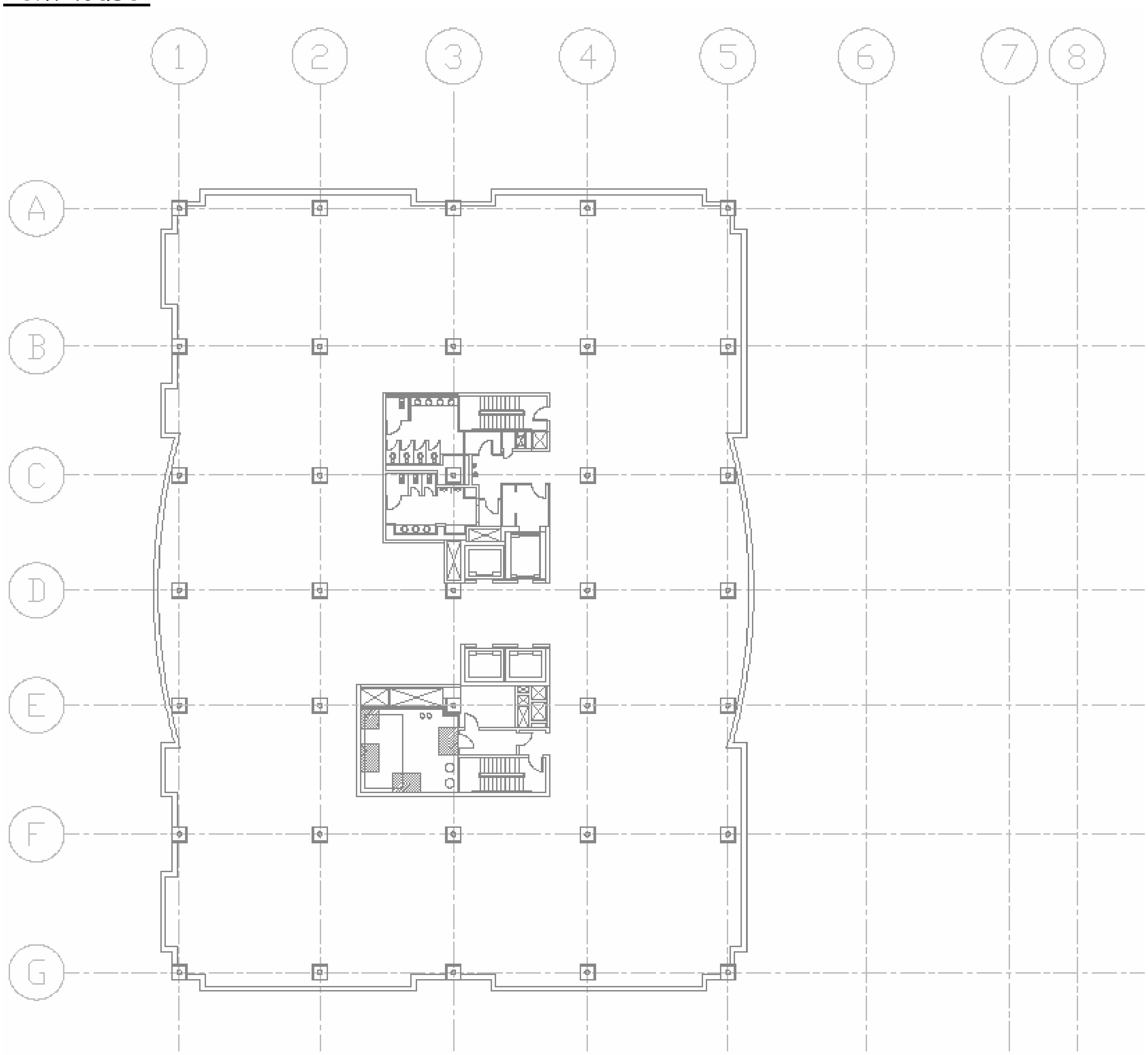
15th Floor:



16th Floor:



Penthouse:

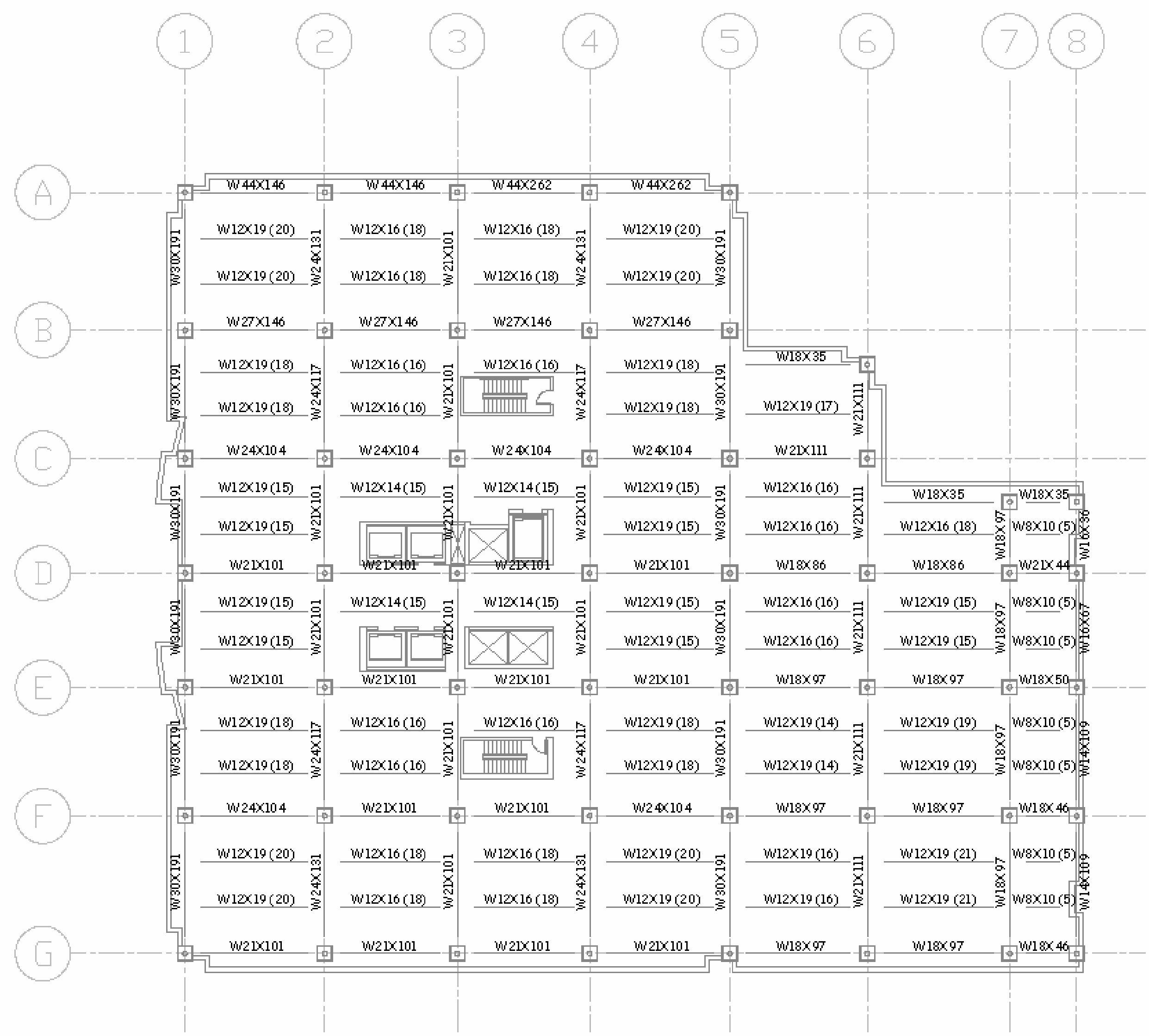


Ground Floor Framing Plan: Non-Composite

Ground Floor Framing Plan: Composite

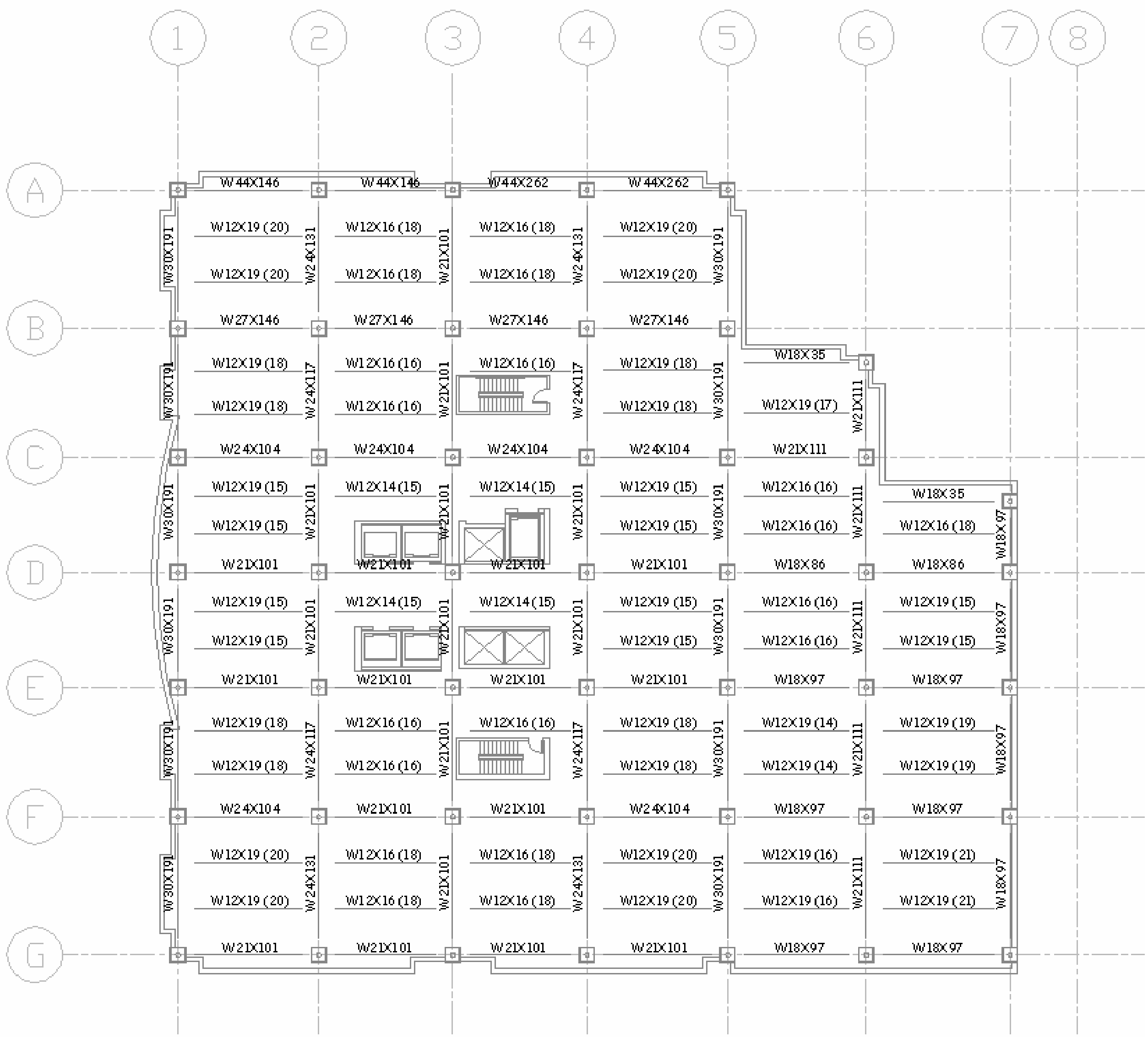
2nd, 3rd, 4th, 5th Floor Framing Plan: Non-Composite

2nd, 3rd, 4th, 5th Floor Framing Plan: Composite

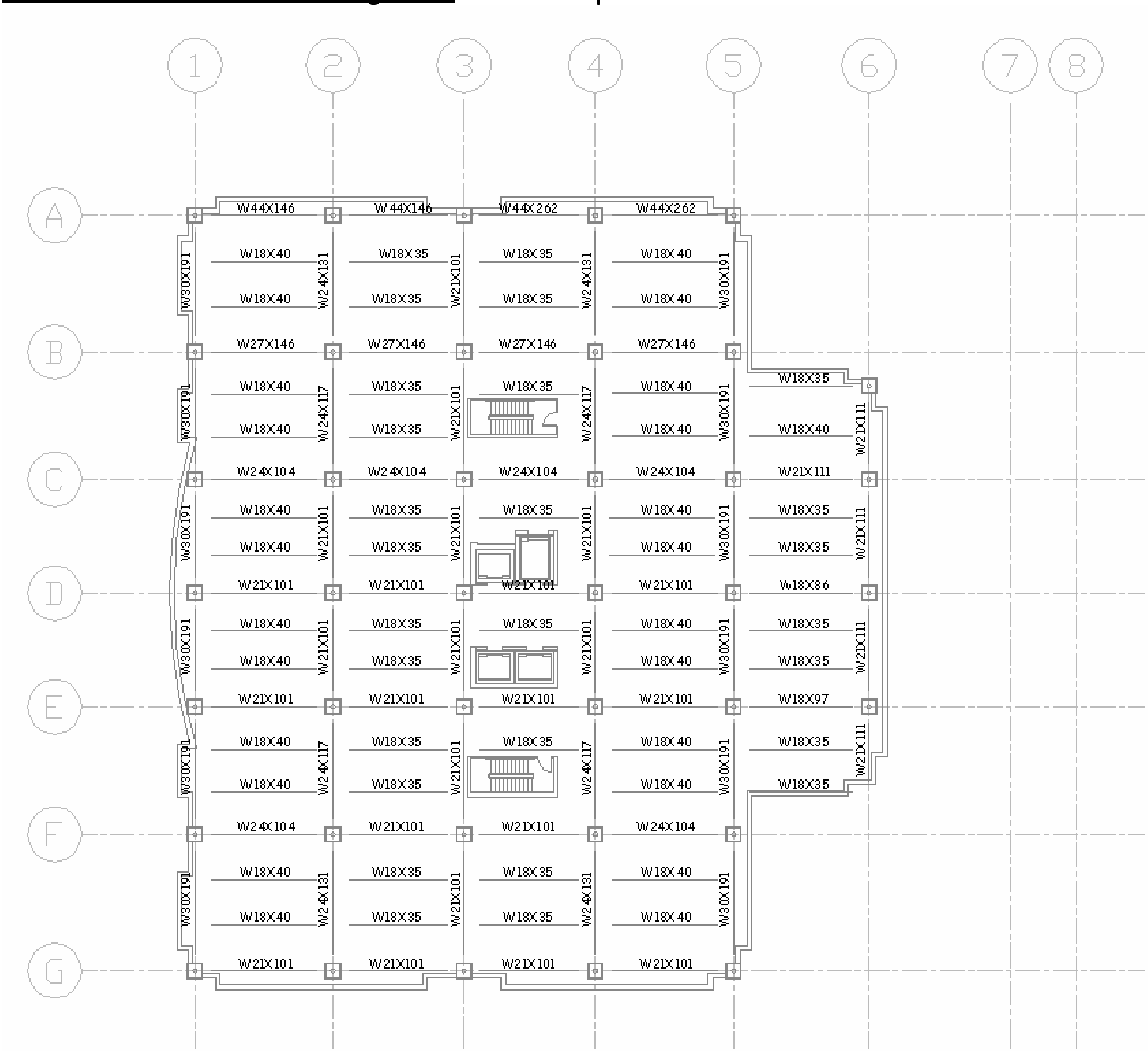


6th, 7th, 8th, 9th, 10th Floor Framing Plan: Non-Composite

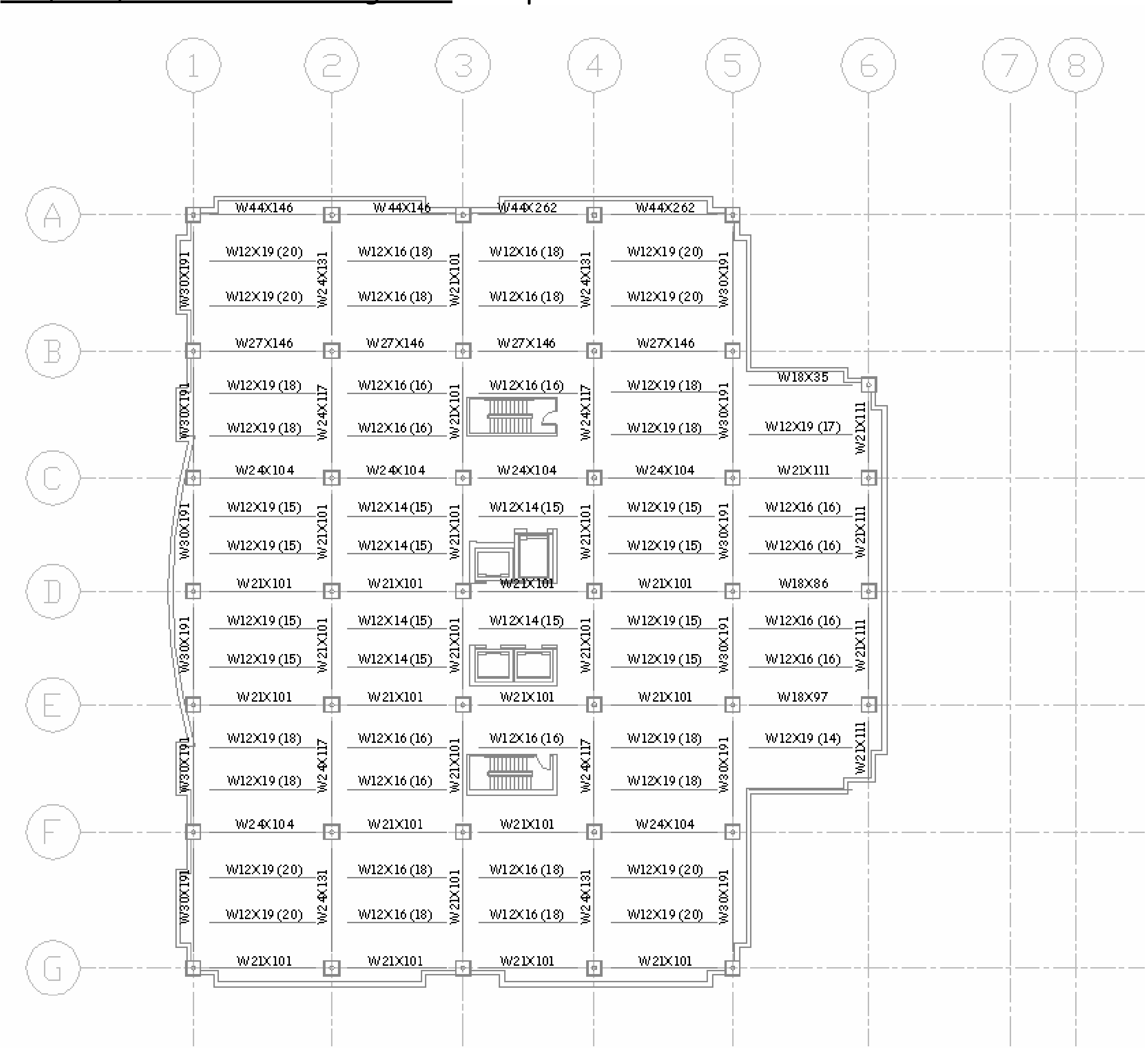
6th, 7th, 8th, 9th, 10th Floor Framing Plan: Composite



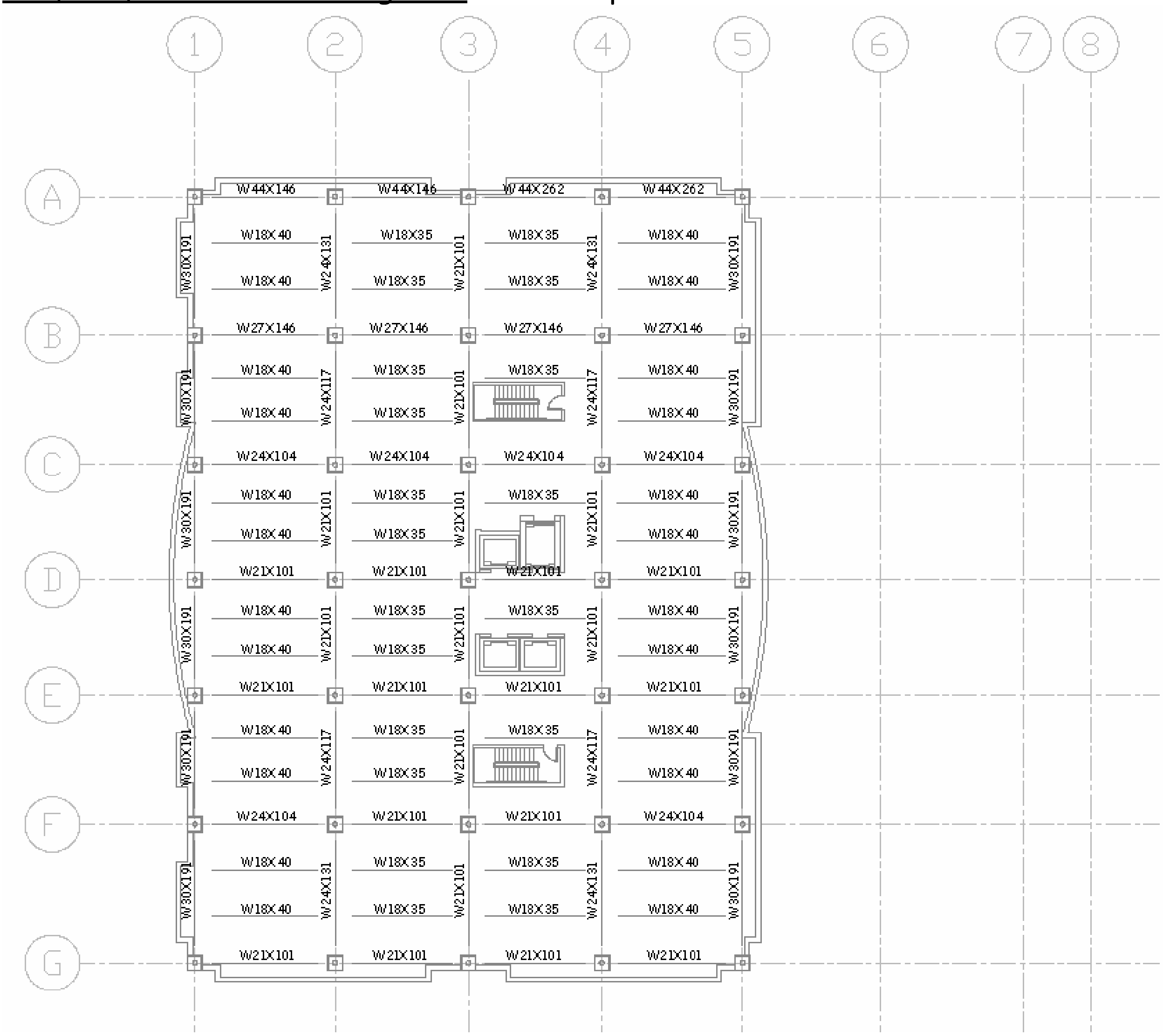
11th, 12th, 13th Floor Framing Plan: Non-Composite



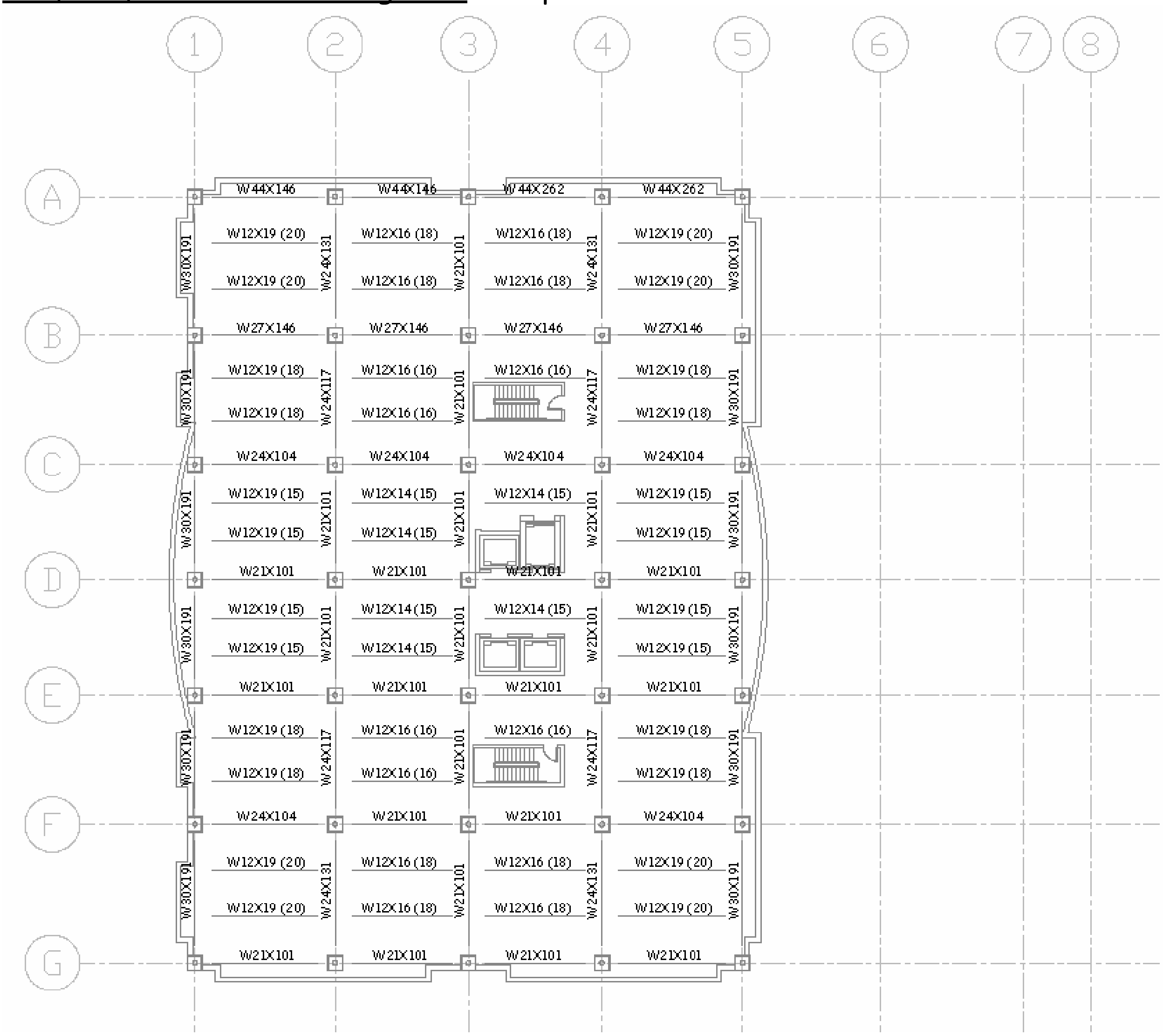
11th, 12th, 13th Floor Framing Plan: Composite



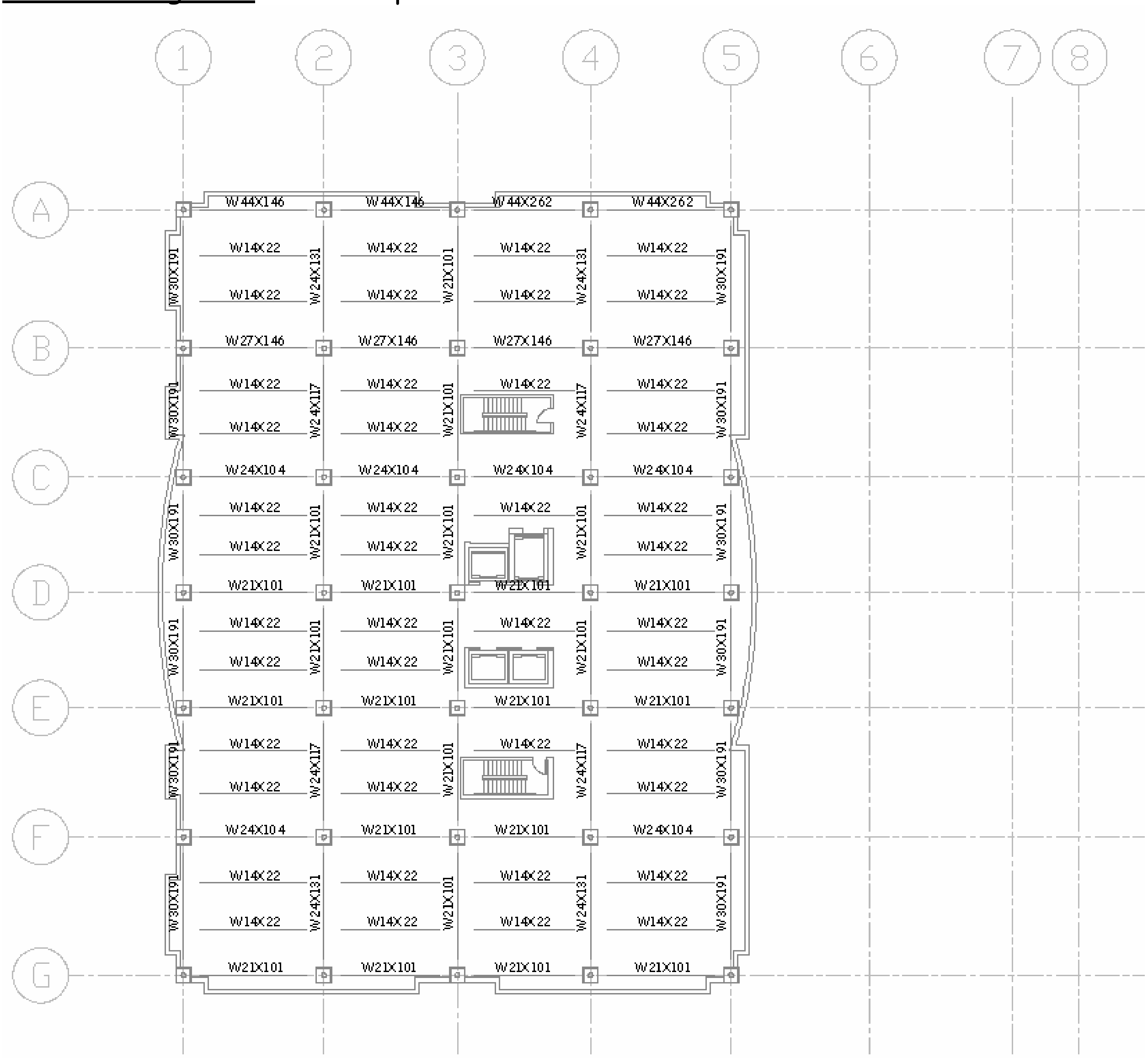
14th, 15th, 16th Floor Framing Plan: Non-Composite



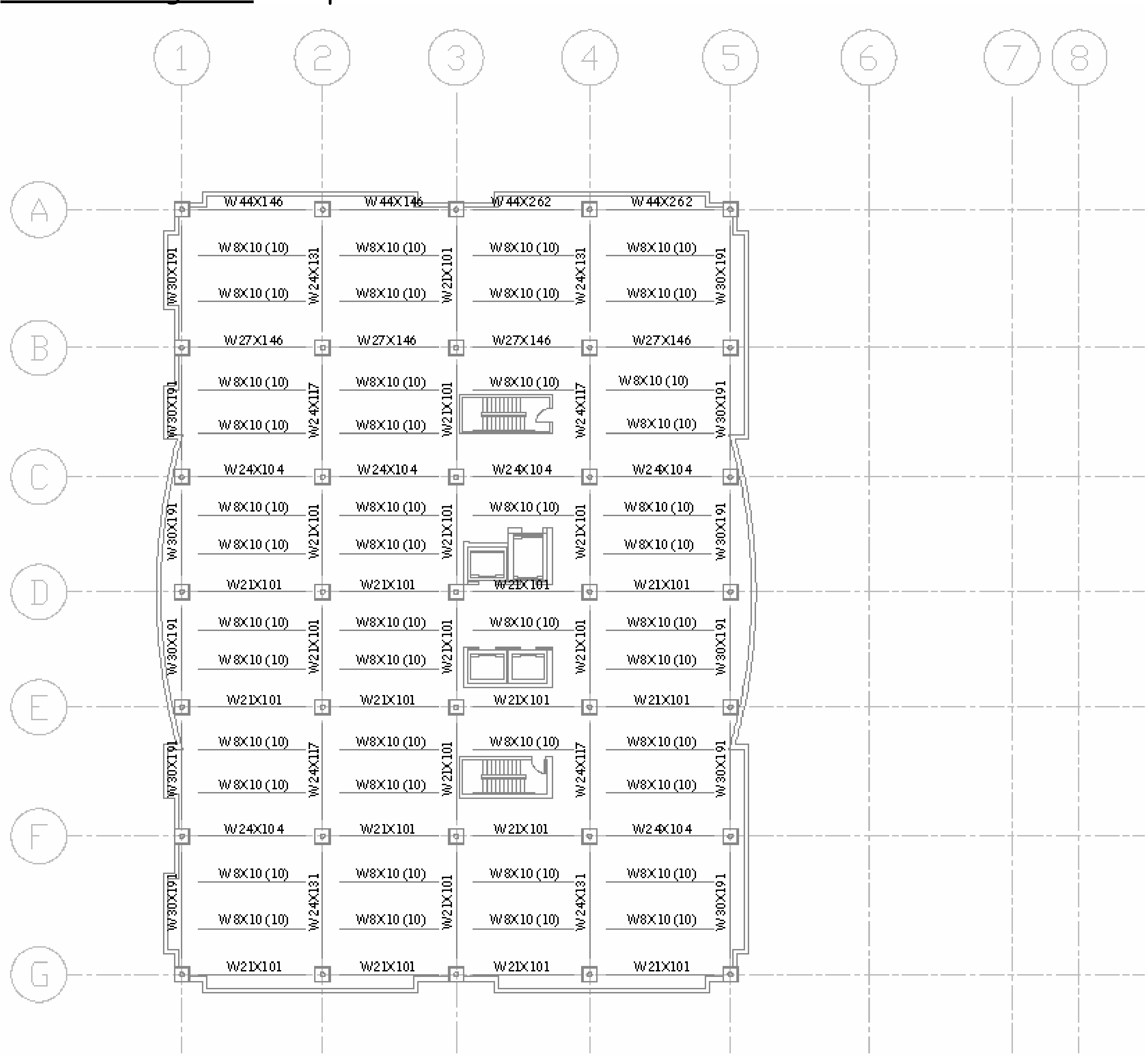
14^{th}, 15^{th}, 16^{th} Floor Framing Plan: Composite



Roof Framing Plan: Non-Composite



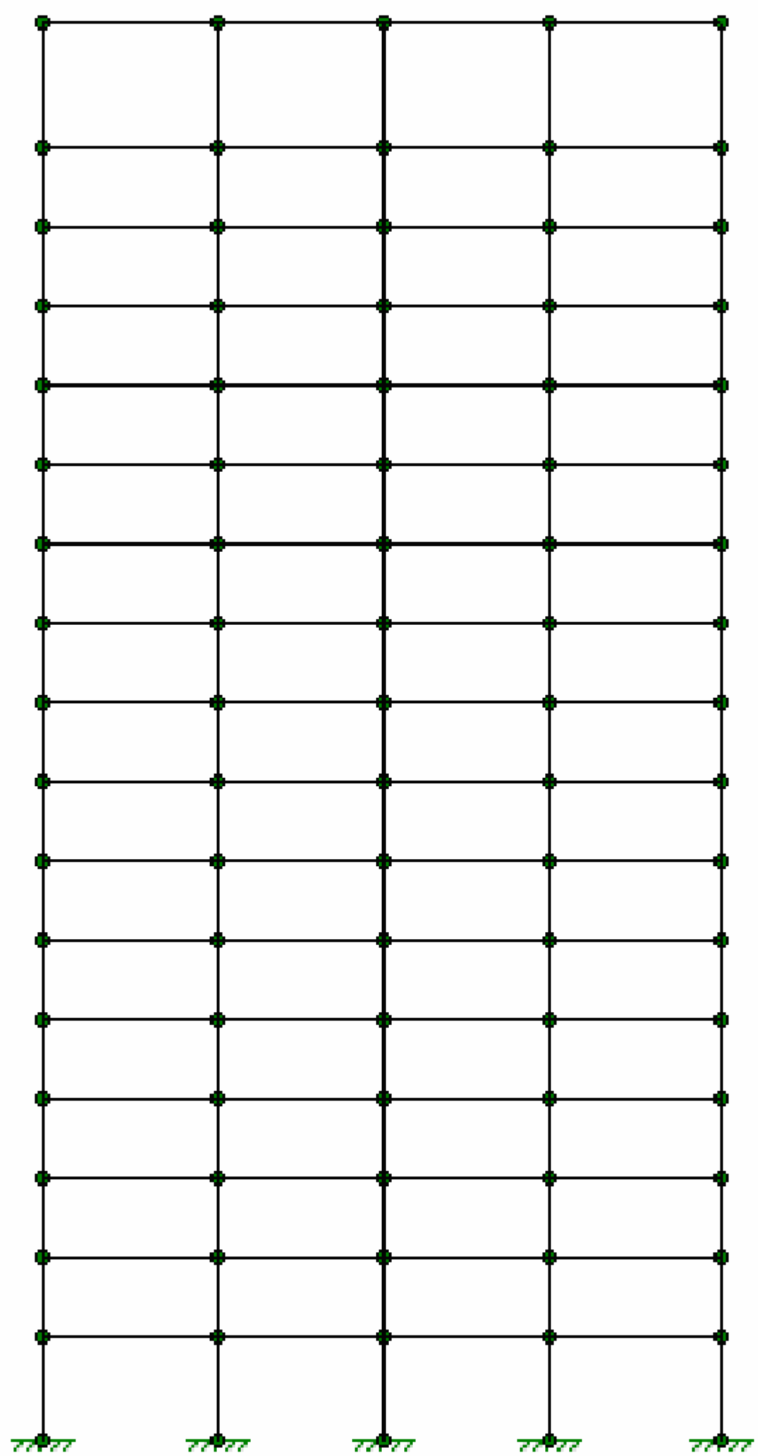
Roof Framing Plan: Composite



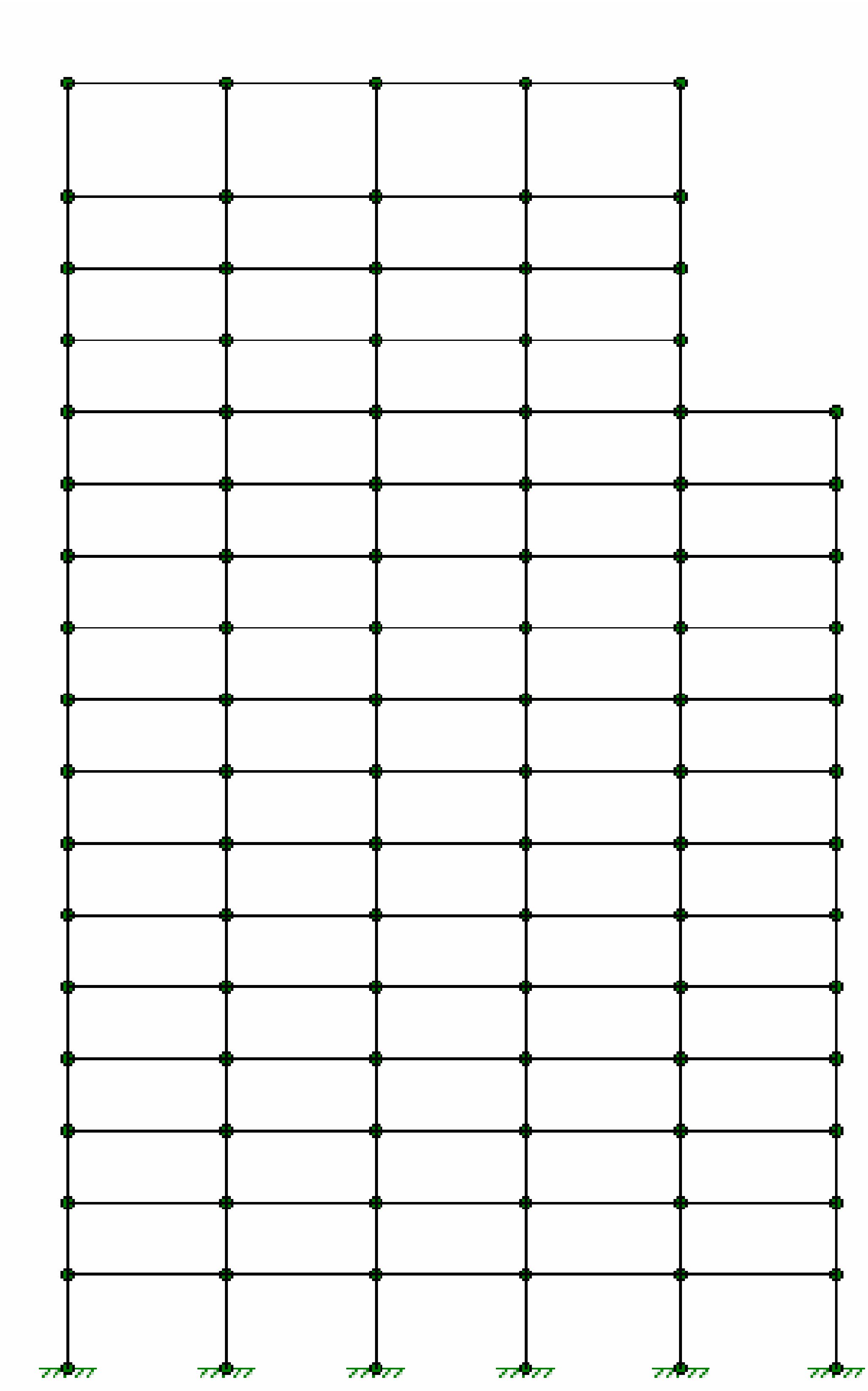
Appendix 4: Miscellaneous

Frames A through G are in E-W direction and 1-8 are in N-S direction

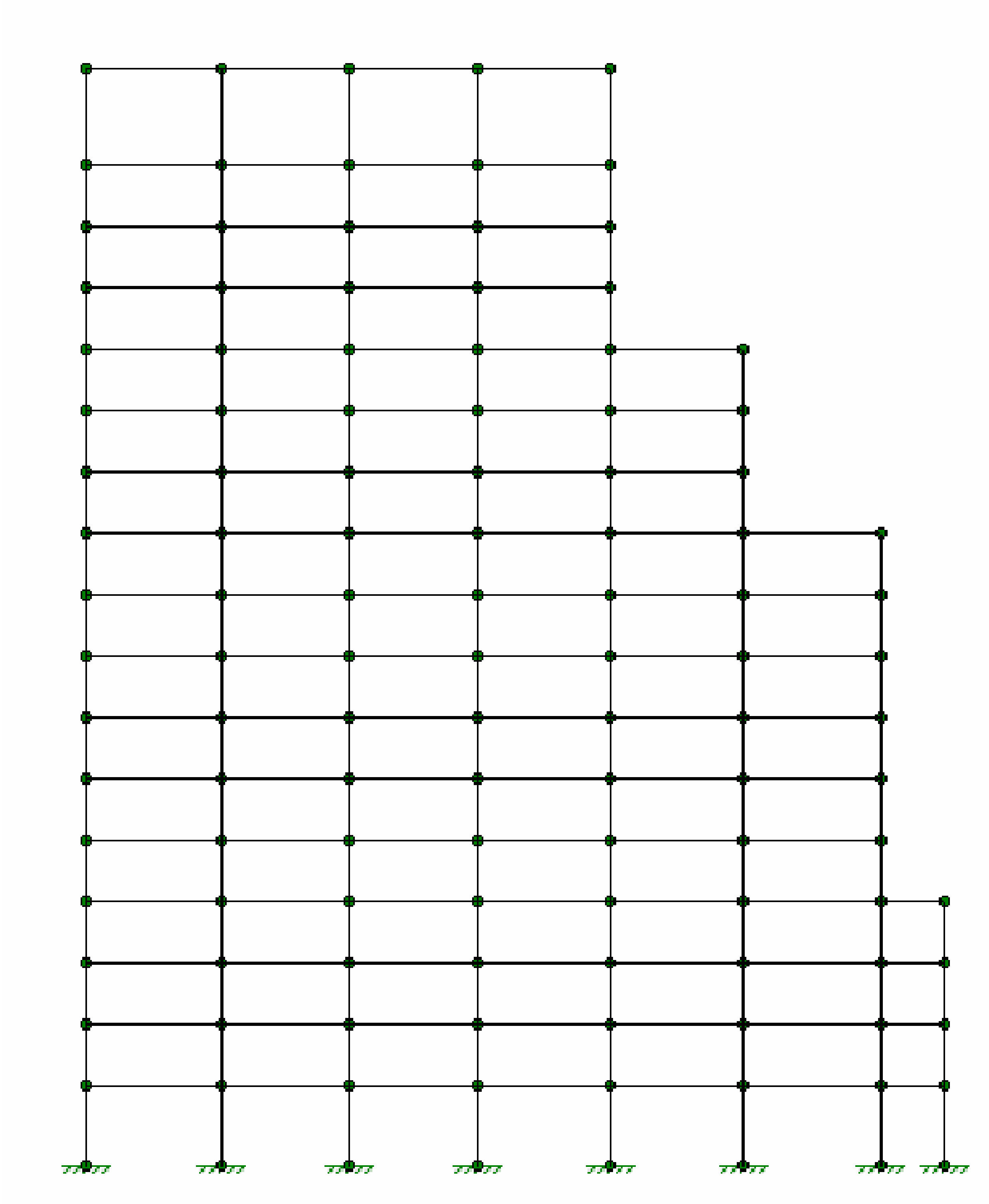
Frames A and B:



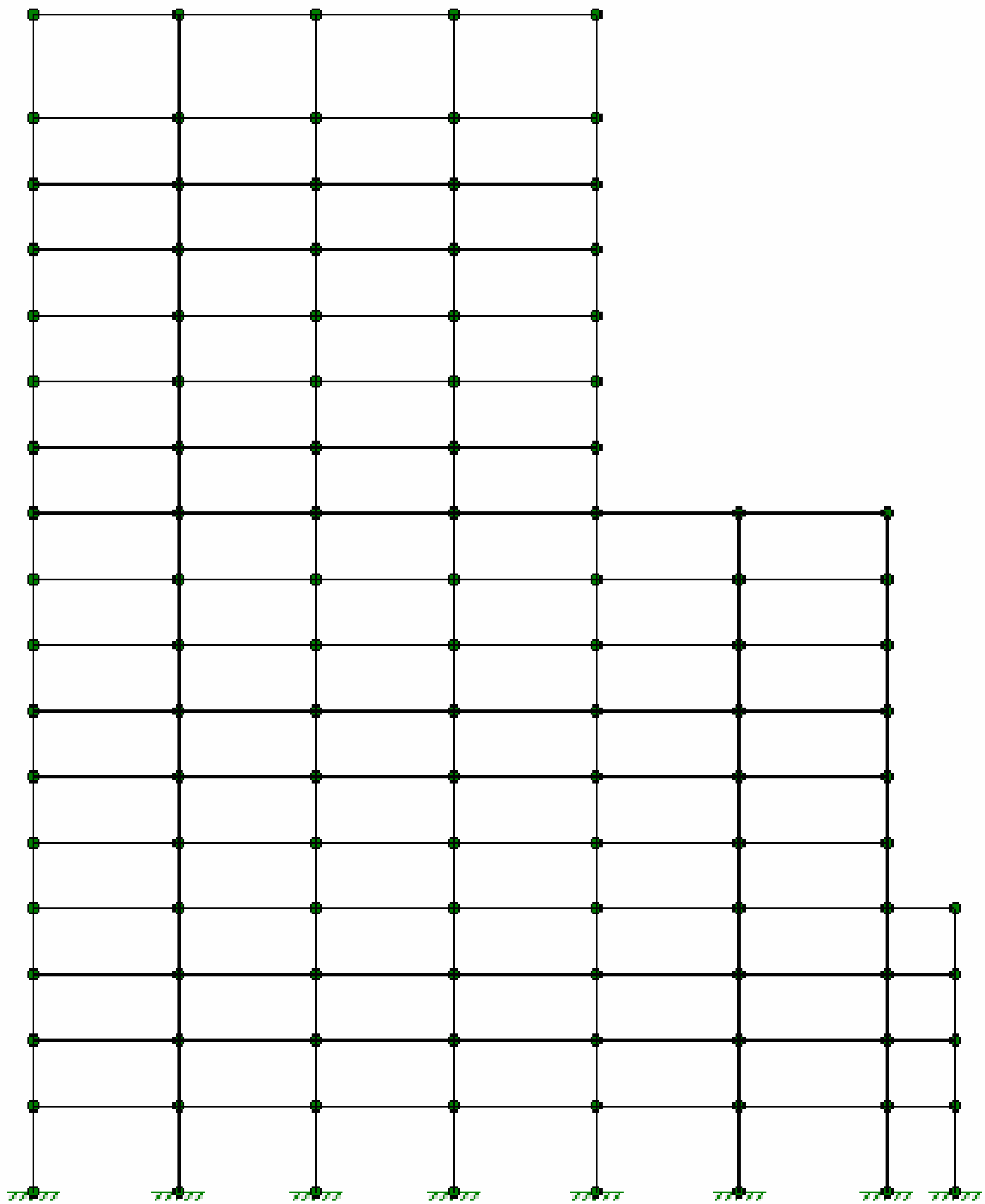
Frames C:



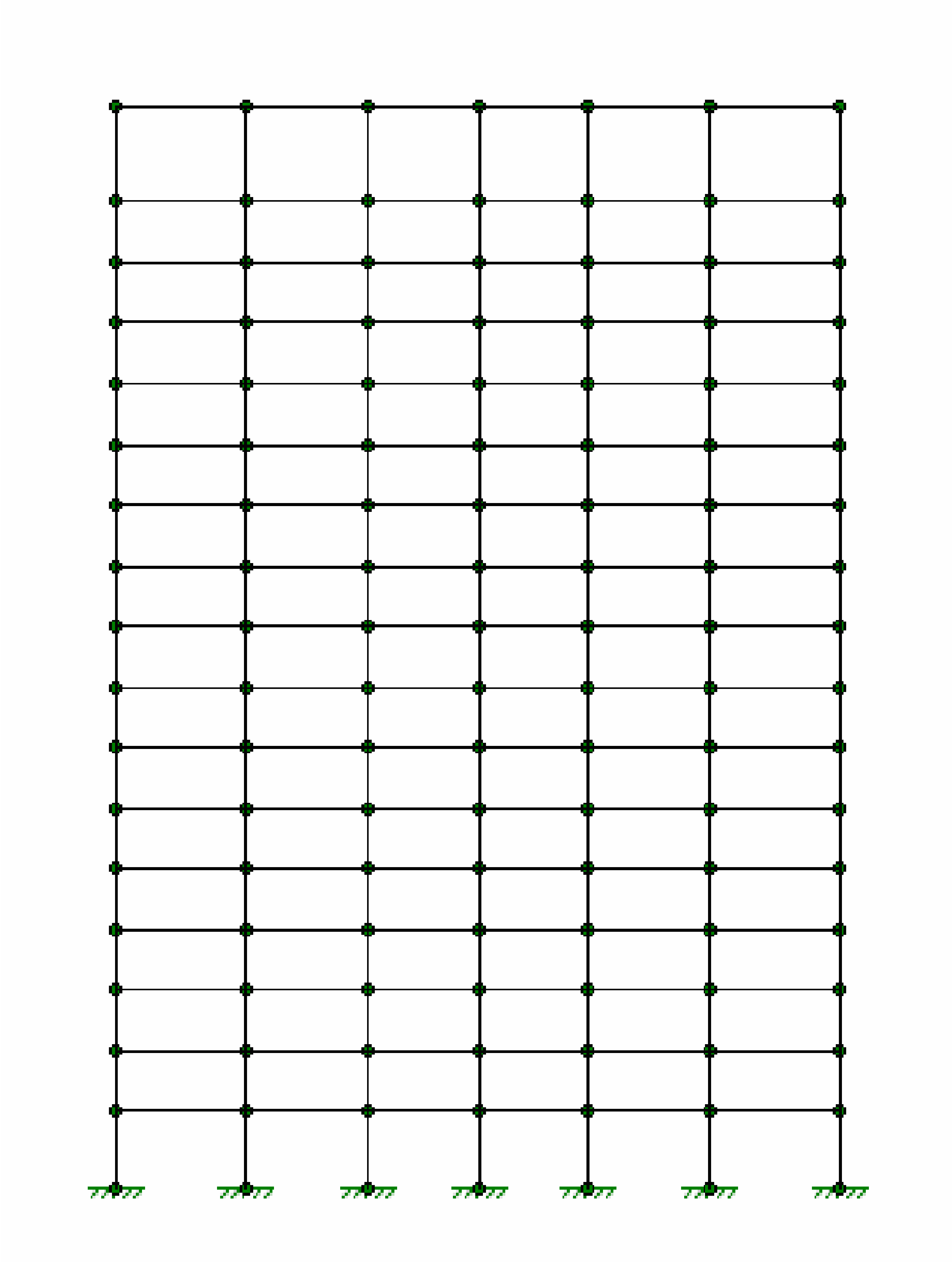
Frame D and E:



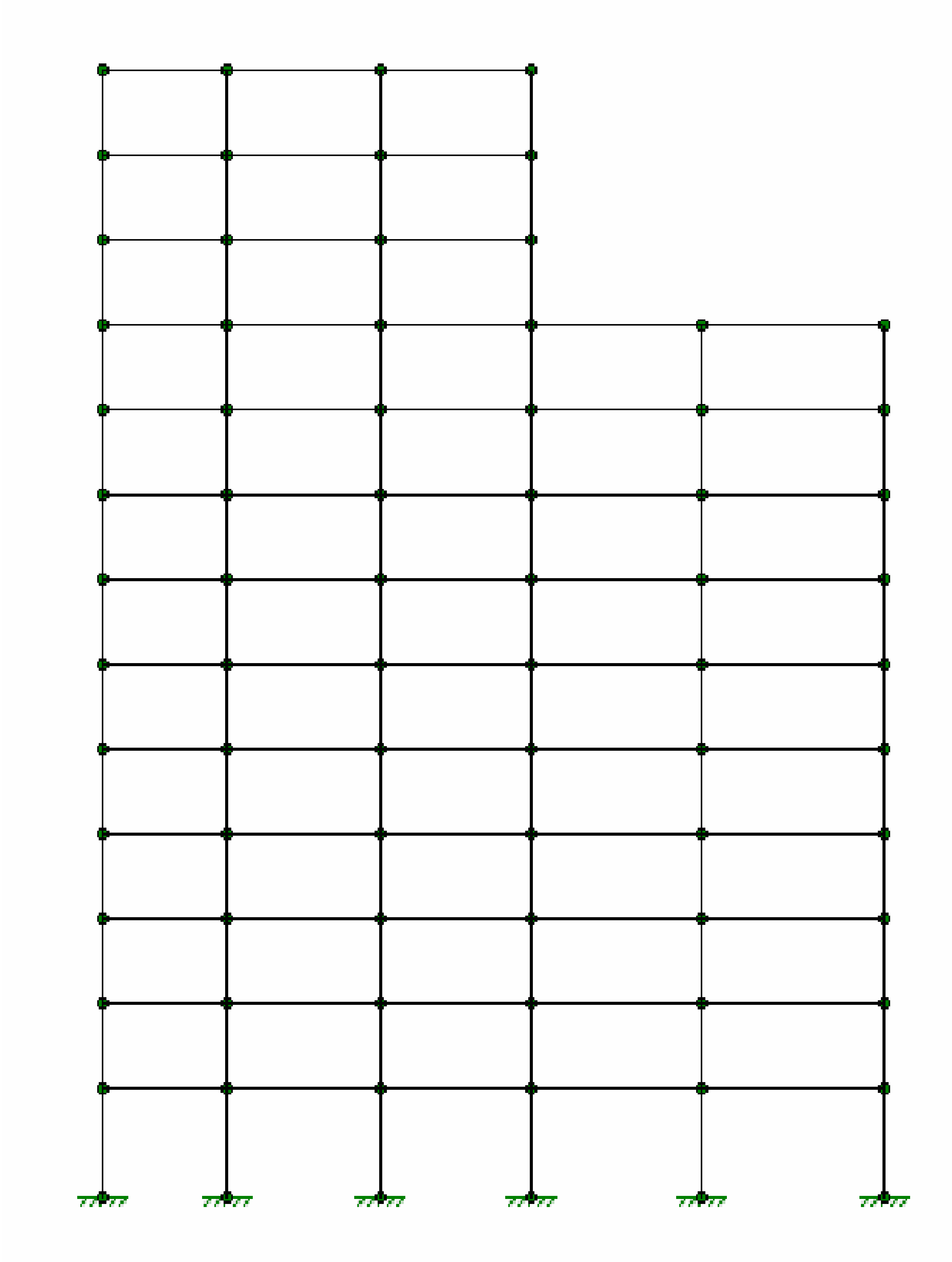
Frame F and G:



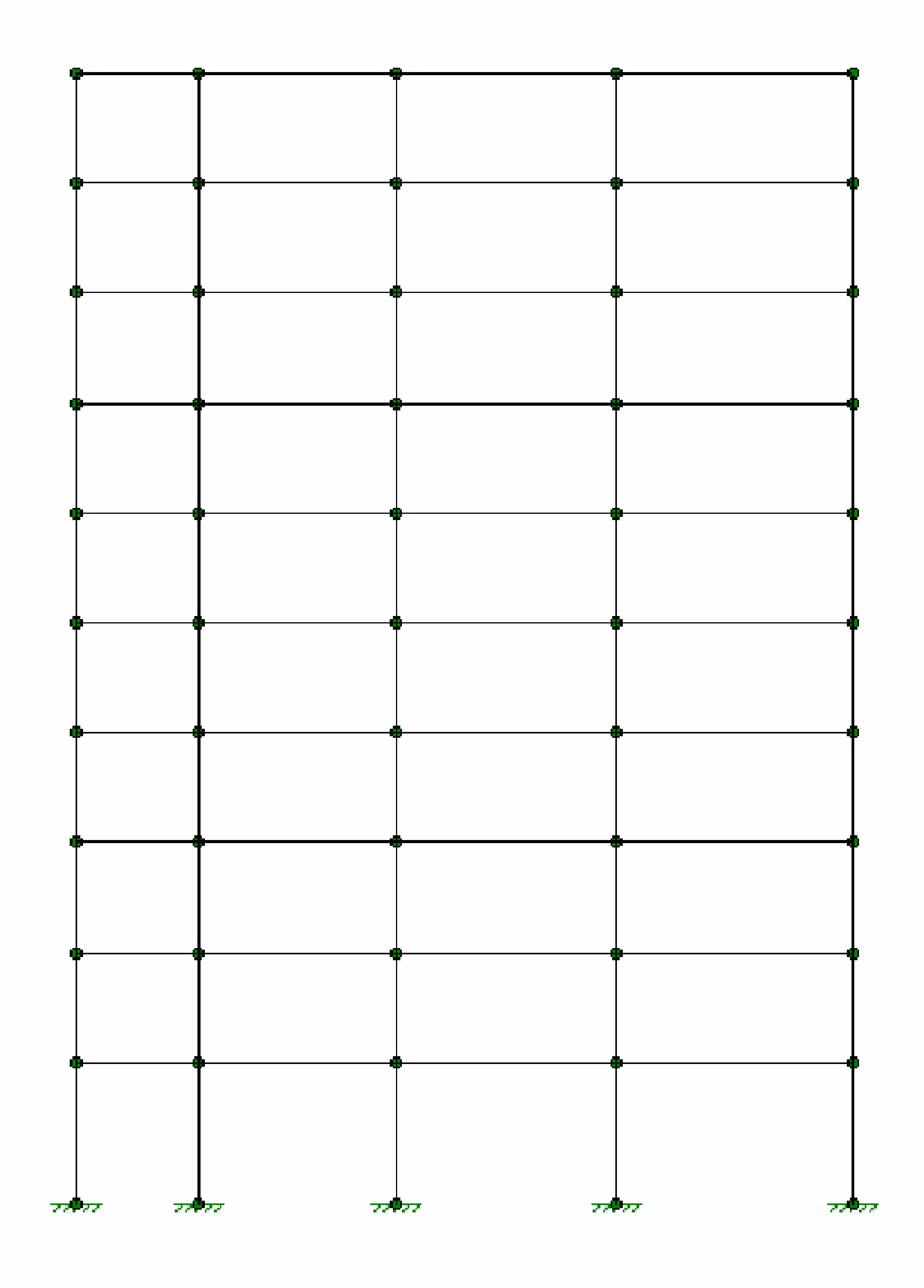
Frame 1 to 5:



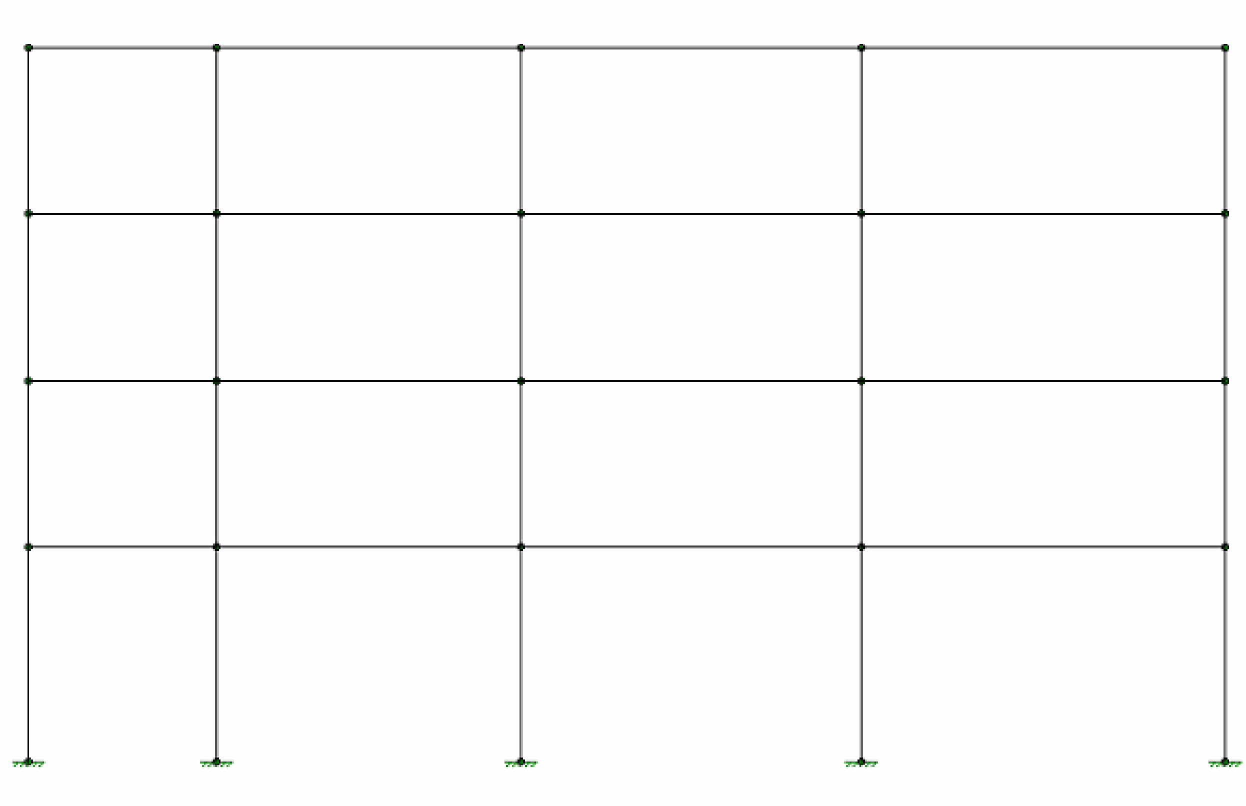
Frame 6:



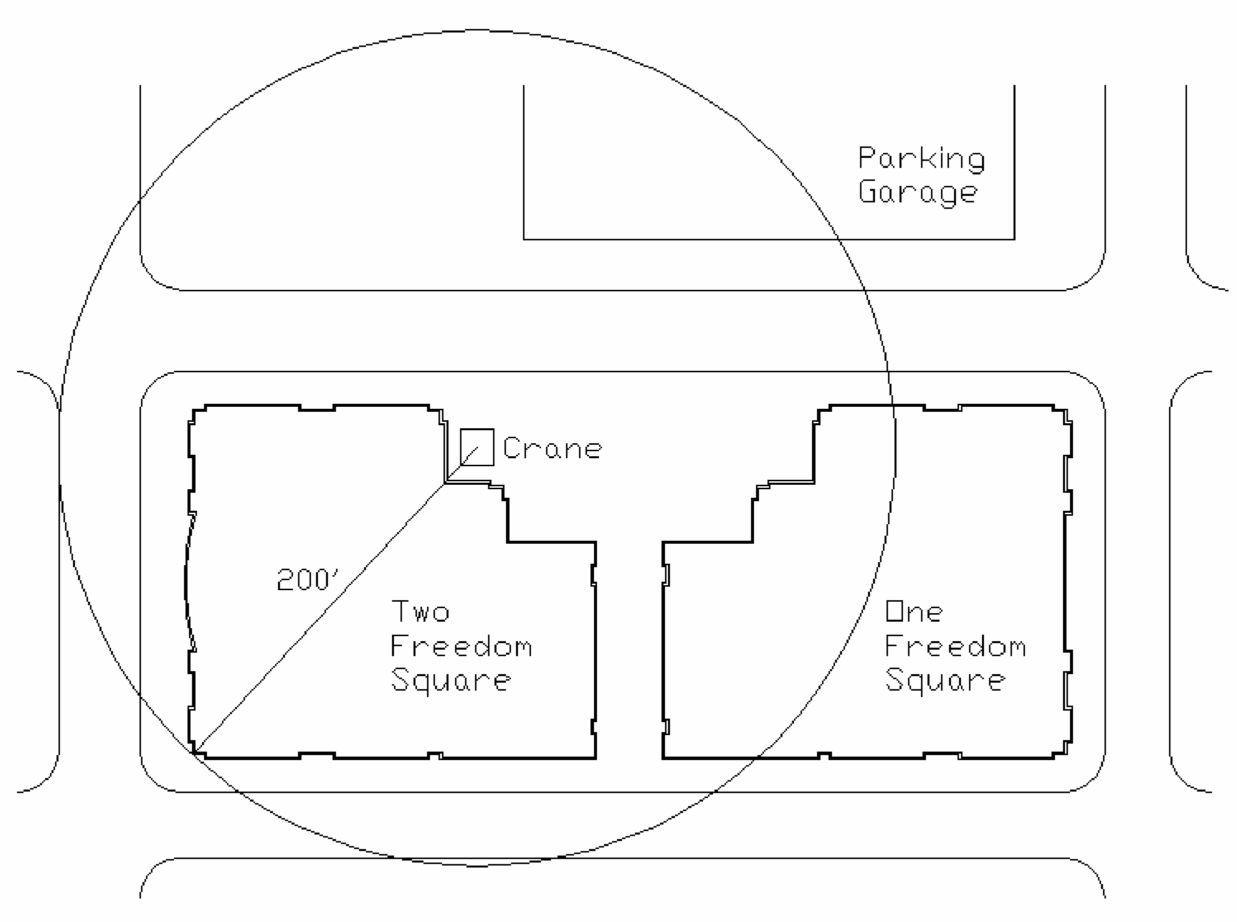
Frame 7:



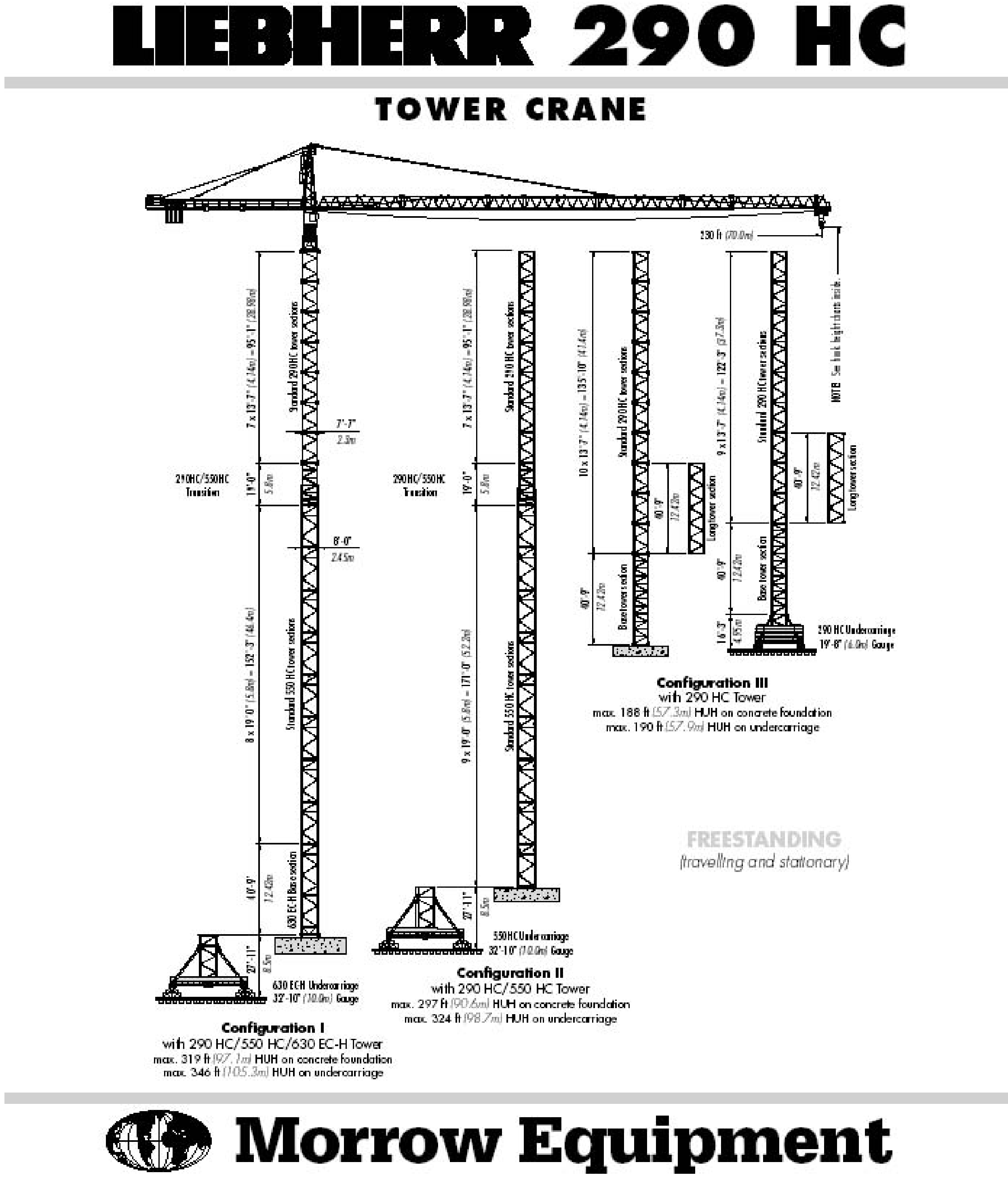
Frame 8:



Site Plan: Crane Location

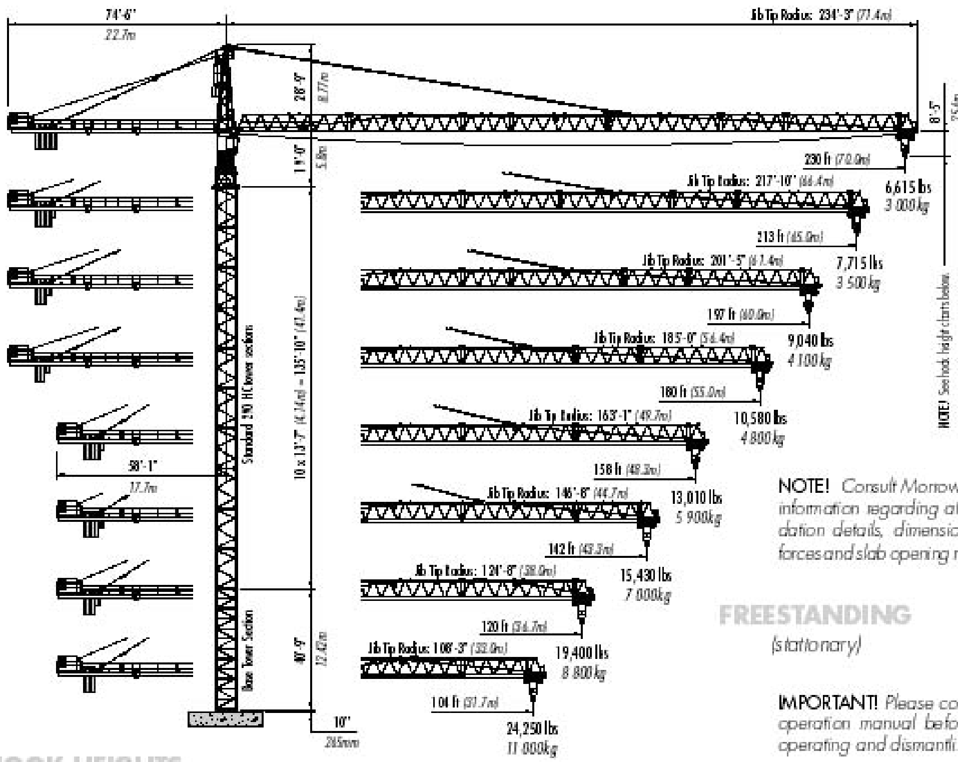


Crane Specifications: taken from the Liebherr website



Configurations

LIEBHERR 290 HC



NOTE! *Consult Morrow for specific information regarding alternate foundation details, dimensions, reaction forces and slab opening requirements.*

FREESTANDING

(stationary)

IMPORTANT! *Please consult crane's operation manual before erecting, operating and dismantling crane.*

HOOK HEIGHTS

No. of Tower Elements	Tower Configuration I	Hook Height Concrete Foundation		Hook Height 70m Undercarriage	
		ft	m	ft	m
1	630 EC-H BS	52.3	15.9	79.3	24.2
2	550 HC STS	71.3	21.7	98.3	30.0
3	550 HC STS	90.4	27.5	117.3	35.8
4	550 HC STS	109.4	33.3	136.4	41.6
5	550 HC STS	128.4	39.1	155.4	47.4
6	550 HC STS	147.4	44.9	174.4	53.2
7	550 HC STS	166.5	50.7	193.4	59.0
8	550 HC STS	185.5	56.5	212.5	64.8
9	550 HC STS	204.5	62.3	231.5	70.6
10	Transition	223.6	68.1	250.5	76.4
11	290 HC STS	237.1	72.2	264.1	80.5
12	290 HC STS	250.7	76.4	277.7	84.6
13	290 HC STS	264.3	80.6	291.3	88.8
14	290 HC STS	277.9	84.7	304.9	92.9
15	290 HC STS	291.5	88.8	318.4	97.1
16	290 HC STS	305.1	93.0	332.0	101.2
17	290 HC STS[1]	318.6	97.1	345.6	105.3

No. of Tower Elements	Tower Configuration II	Hook Height Concrete Foundation		Hook Height 70m Undercarriage	
		ft	m	ft	m
1	550 HC STS	31.0	9.4	57.5	17.5
2	550 HC STS	50.0	15.2	76.6	23.3
3	550 HC STS	69.0	21.0	95.6	29.1
4	550 HC STS	88.1	26.8	114.6	34.9
5	550 HC STS	107.1	32.6	133.7	40.7
6	550 HC STS	126.1	38.4	152.7	46.5
7	550 HC STS	145.1	44.2	171.7	52.3
8	550 HC STS	164.2	50.0	190.7	58.1
9	550 HC STS	183.2	55.8	209.8	63.9
10	Transition	202.2	61.6	228.7	69.7
11	290 HC STS	215.8	65.8	242.4	73.9
12	290 HC STS	229.4	69.9	256.0	78.0
13	290 HC STS	243.0	74.1	269.6	82.2
14	290 HC STS	256.6	78.2	283.1	86.3
15	290 HC STS	270.1	82.3	296.7	90.4
16	290 HC STS	283.7	86.5	310.3	94.6
17	290 HC STS[1]	297.3	90.6	323.9	98.7

No. of Tower Sections	Tower Configuration III	Hook Height Concrete Foundation		Hook Height 6m Undercarriage	
		ft	m	ft	m
0	290 HC BTS	52.2	15.9	67.6	20.6
1	290 HC STS	65.8	20.1	81.2	24.8
2	290 HC STS	79.4	24.2	94.8	28.9
3	290 HC STS	93.0	28.3	108.4	33.0
4	290 HC STS	106.6	32.5	121.9	37.2
5	290 HC STS	120.2	36.6	135.5	41.3
6	290 HC STS	133.7	40.8	149.1	45.5
7	290 HC STS	147.3	44.9	162.7	49.6
8	290 HC STS	160.9	49.0	176.3	53.7
9	290 HC STS	174.5	53.2	189.9[2]	57.9[2]
10	290 HC STS[3]	188.1[3]	57.3[3]		

NOTE! *Alternate tower combinations possible. Contact Morrow for additional information.*

[1] Remove top climbing unit from crane prior to operating crane at maximum hook height.

[2] Lower top climbing unit to base of crane prior to operating crane at maximum hook height [190 ft *(57.9m)*].

[3] Lower top climbing unit to base of crane prior to operating crane at maximum hook height [188 ft *(57.3m)*].

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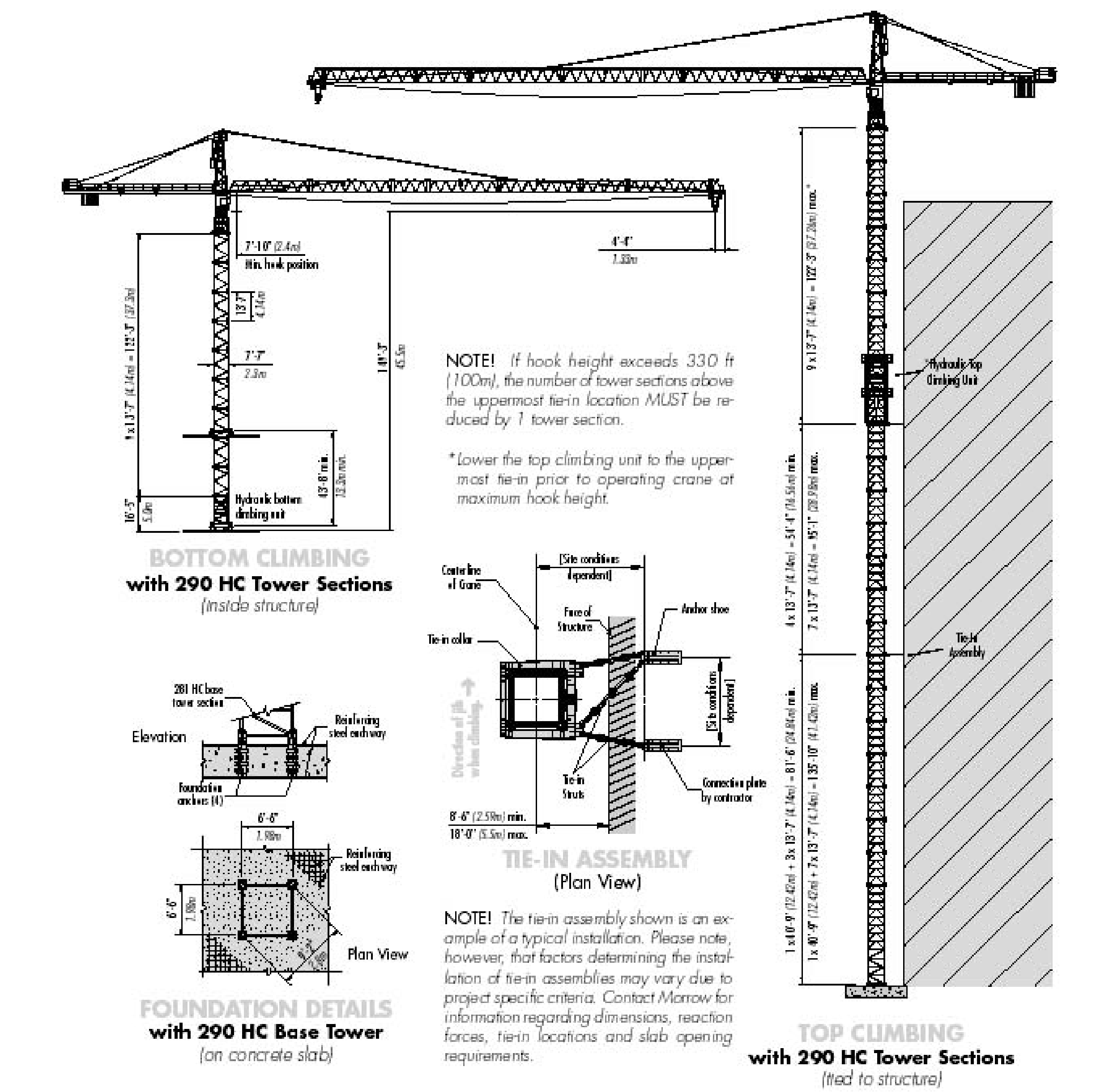
Configurations **LIEBHERR 290 HC**



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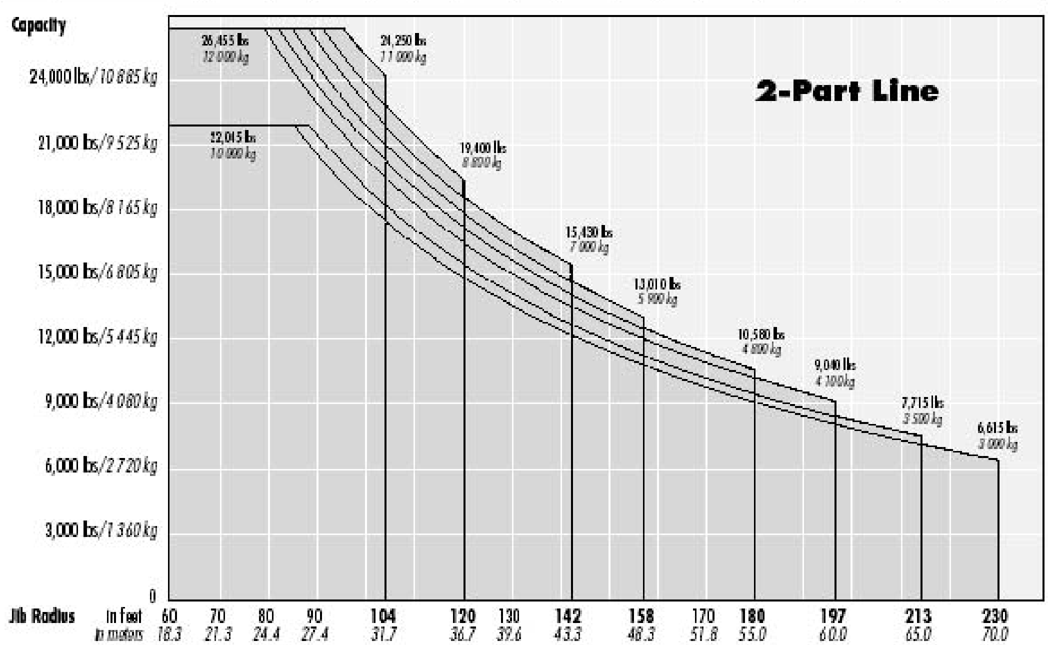
Radius and Capacities

LIEBHERR Tower Crane Model 290 HC

2-Part Line

Hook Radius	2-Part Line Max Capacity – Radius	ft m	60 18.3	70 21.3	80 24.4	90 27.4	104 31.7	110 33.5	120 36.7	130 39.6	142 43.3	150 45.7	158 48.3	170 51.8	180 55.0	190 58.0	197 60.0	213 65.0	230 70.0
230 ft 70.0m	22,045 lbs – 86 ft 10 000 kg – 26.2m	lbs kg	22,045 10 000	22,045 10 000	22,045 10 000	20,955 9 505	17,747 8 050	16,643 7 549	14,958 6 785	13,672 6 201	12,280 5 570	11,495 5 214	10,737 4 870	9,833 4 460	9,105 4 130	8,534 3 871	8,135 3 690	7,319 3 320	**6,615** **3 000**
213 ft 65.0m	22,045 lbs – 89 ft 10 000 kg – 27.3m	lbs kg	22,045 10 000	22,045 10 000	22,045 10 000	21,922 9 943	18,563 8 420	17,424 7 903	15,675 7 110	14,319 6 495	12,875 5 840	12,067 5 474	11,266 5 110	10,340 4 690	9,590 4 350	8,975 4 071	8,576 3 890	**7,715** **3 500**	
197 ft 60.0m	26,455 lbs – 79 ft 12 000 kg – 24.1m	lbs kg	26,455 12 000	26,455 12 000	26,132 11 853	22,897 10 386	19,445 8 820	18,253 8 280	16,424 7 450	15,033 6 819	13,514 6 130	12,688 5 755	11,861 5 380	10,882 4 936	10,097 4 580	9,469 4 295	**9,040** **4 100**		
180 ft 55.0m	26,455 lbs – 82 ft 12 000 kg – 25.0m	lbs kg	26,455 12 000	26,455 12 000	26,455 12 000	23,944 10 861	20,305 9 210	19,061 8 646	17,174 7 790	15,712 7 127	14,154 6 420	13,274 6 021	12,412 5 630	11,402 5 172	**10,580** **4 800**				
158 ft 48.3m	26,455 lbs – 85 ft 12 000 kg – 26.0m	lbs kg	26,455 12 000	26,455 12 000	26,455 12 000	24,987 11 334	21,219 9 625	19,932 9 041	17,957 8 145	16,435 7 455	14,815 6 720	13,904 6 307	**13,010** **5 900**						
142 ft 43.3m	26,455 lbs – 88 ft 12 000 kg – 26.9m	lbs kg	26,455 12 000	26,455 12 000	26,455 12 000	25,979 11 784	22,068 10 010	20,737 9 406	18,695 8 480	17,124 7 767	**15,430** **7 000**								
120 ft 36.7m	26,455 lbs – 91 ft 12 000 kg – 27.8m	lbs kg	26,455 12 000	26,455 12 000	26,455 12 000	26,455 12 000	22,906 10 390	21,522 9 762	**19,400** **8 800**										
104 ft 31.7m	26,455 lbs – 96 ft 12 000 kg – 29.3m	lbs kg	26,455 12 000	26,455 12 000	26,455 12 000	26,455 12 000	**24,250** **11 000**												



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SPECIFICATIONS

LIEBHERR Tower Crane Model 290 HC

Hoist Speed and Capacity

Hoist Unit WiW291RX040	2-Part Line				
	Gear	Capacity	Line Speed	*Capacity*	*Line Speed*
108 hp *(80 kW)* AC hoist unit 4-speed gearbox Electromagnetic gear shifting Eddy current brake	1	up to 26,455 lbs	@ 105 fpm	*up to 12 000 kg*	*@ 32 m/min*
	2	up to 15,650 lbs	@ 200 fpm	*up to 7 100 kg*	*@ 61 m/min*
	3	up to 9,260 lbs	@ 312 fpm	*up to 4 200 kg*	*@ 95 m/min*
31275	4	up to 4,520 lbs	@ 555 fpm	*up to 2 050 kg*	*@ 169 m/min*

NOTE! *Capacities and line speeds indicated will vary depending on the amount of hoist rope installed. This crane model may be equipped with a hoist unit other than that specified in the data above. To verify, check the serial number of the crane and refer to the Liebherr 290 HC Operation Manual for additional information.*

Motor Information

Drive Unit	Horsepower	Kilowatts	Speed	
Trolley	7.4 hp	*5.5 kW*	26 - 52 - 164 - 312 fpm	*8 - 16 - 50 - 95 m/min*
Swing *(fluid coupling)*	2 x 6.7 hp	*2 x 5.0 kW*	0.7 rpm	
Traveling *(fluid coupling)*	2 x 10 hp	*2 x 7.5 kW*	98 fpm	*30.0 m/min*

Power Requirements

480 V — 3-phase — 60 Hz — 225 Amperes

Specifications subject to change without prior notice. For additional information, contact Morrow Equipment.

Morrow Equipment Co., L.L.C.

Component List

LIEBHERR 290 HC

Description	Dimensions LxWxH	Weight
Tower Top	29'-3" x 5'-5" x 6'-1" 8.9m x 1.65m x 1.85m	6,000 lbs 2 720 kg
Slewing Assembly (Complete) [1]	20'-7" x 9'-0" x 8'-9" 6.27m x 2.74m x 2.67m	20,300 lbs 9 210 kg
Slewing Assembly Upper Part [2]	14'-8" x 9'-0" x 8'-9" 4.47m x 2.74m x 2.67m	11,925 lbs 5 410 kg
Slewing Assembly Lower Part [3]	6'-6" x 9'-0" x 7'-9" 1.98m x 2.74m x 2.36m	8,375 lbs 3 800 kg
Hoist Unit with Frame [4] 108 hp (80 kW)	8'-6" x 15'-10" x 7'-0" 2.59m x 4.83m x 2.13m	17,420 lbs 7 900 kg
Counterjib Section #1 (Inner)	27'-9" x 5'-10" x 5'-7" 8.46m x 1.77m x 1.7m	4,760 lbs 2 160 kg
Counterjib Section #2 (Intermediate)	17'-2" x 5'-10" x 5'-7" 5.23m x 1.77m x 1.7m	4,000 lbs 1 815 kg
Counterjib Section #3 (Outer)	27'-7" x 8'-0" x 5'-7" 8.41m x 2.44m x 1.7m	6,200 lbs 2 800 kg
Counterjib A [5]	54'-8" x 8'-0" x 5'-7" 16.67m x 2.44m x 1.7m	12,500 lbs 5 670 kg
Counterjib B [6]	71'-1" x 8'-0" x 5'-7" 21.67m x 2.44m x 1.7m	16,500 lbs 7 485 kg
Counterweight Block A	4'-4" x 11" x 8'-1" 1.32m x 0.28 x 2.46m	4,960 lbs 2 250 kg
Counterweight Block B	4'-4" x 11" x 5'-4" 1.32m x 0.28 x 1.63m	3,195 lbs 1 450 kg
Base Tower Section 290 HC	40'-9" x 7'-7" x 7'-7" 12.42m x 2.3m x 2.3m	17,505 lbs 7 940 kg
Long Tower Section 290 HC	40'-9" x 7'-7" x 7'-7" 12.42m x 2.3m x 2.3m	12,170 lbs 5 520 kg
Standard Tower Section 290 HC	13'-7" x 7'-7" x 7'-7" 4.14m x 2.3m x 2.3m	5,025 lbs 2 280 kg
Transition Section 290HC/550HC	20'-7" x 8'-5" x 8'-5" 6.28m x 2.57m x 2.57m	13,050 lbs 5 920 kg
Standard Tower Section 550 HC	20'-7" x 8'-0" x 8'-0" 6.28m x 2.44m x 2.44m	13,340 lbs 6 050 kg
Bottom Climbing Unit w/hydraulics	16'-5" x 7'-6" x 7'-10" 5.0m x 2.28m x 2.4m	13,200 lbs 5 990 kg
Tie-in Collar 290 HC	10'-10" x 1'-3" x 10'-1" 3.29m x 0.39m x 3.08m	4,850 lbs 2 200 kg

Description	Dimensions LxWxH	Weight
Jib Section ① #611	39'-0" x 6'-1" x 6'-4" 11.89m x 1.85m x 1.92m	6,950 lbs 3 150 kg
Jib Section ② #621	39'-5" x 5'-4" x 6'-2" 12.02m x 1.63m x 1.87m	4,870 lbs 2 210 kg
Jib Section ③ #633	17'-7" x 5'-4" x 6'-2" 5.36m x 1.63m x 1.87m	2,040 lbs 925 kg
Jib Section ④ #634	34'-0" x 5'-4" x 6'-1" 10.36m x 1.63m x 1.86m	4,110 lbs 1 865 kg
Jib Section ⑤ #622	39'-5" x 5'-5" x 6'-1" 12.02m x 1.65m x 1.86m	4,565 lbs 2 070 kg
Jib Section ⑥ #632	23'-1" x 5'-4" x 6'-1" 7.03m x 1.63m x 1.86m	2,240 lbs 1 015 kg
Jib Section ⑦ #631	39'-5" x 5'-4" x 6'-1" 12.02m x 1.63m x 1.86m	2,850 lbs 1 290 kg
Jib Section ⑧ #641	7'-4" x 6'-1" x 6'-10" 2.24m x 1.85m x 2.08m	730 lbs 330 kg
Jib Assembly [7] 230-ft (70.0m) ①②③④⑤⑥⑦⑧	231'-0" x 6'-1" x 6'-10" 70.4m x 1.85m x 2.08m	32,405 lbs 14 700 kg
Jib Assembly [7] 213-ft (65.0m) ①②④⑤⑥⑦⑧	214'-7" x 6'-1" x 6'-10" 65.4m x 1.85m x 2.08m	29,980 lbs 13 600 kg
Jib Assembly [7] 197-ft (60.0m) ①②③⑤⑥⑦⑧	198'-2" x 6'-1" x 6'-10" 60.4m x 1.85m x 2.08m	27,560 lbs 12 500 kg
Jib Assembly [7] 180-ft (55.0m) ①②⑤⑥⑦⑧	181'-9" x 6'-1" x 6'-10" 55.4m x 1.85m x 2.08m	24,690 lbs 11 200 kg
Jib Assembly [7] 158-ft (48.3m) ①②⑤⑦⑧	159'-11" x 6'-1" x 6'-10" 48.7m x 1.85m x 2.08m	22,485 lbs 10 200 kg
Jib Assembly [7] 142-ft (43.3m) ①②⑤⑥⑧	143'-6" x 6'-1" x 6'-10" 43.8m x 1.85m x 2.08m	21,605 lbs 9 800 kg
Jib Assembly [7] 120-ft (36.7m) ①②⑤⑧	121'-8" x 6'-1" x 6'-10" 37.1m x 1.85m x 2.08m	19,400 lbs 8 800 kg
Jib Assembly [7] 104-ft (31.7m) ①⑤⑥⑧	105'-3" x 6'-1" x 6'-10" 32.1m x 1.85m x 2.08m	16,315 lbs 7 400 kg
Top Climbing Unit w/hydraulics	27'-6" x 9'-2" x 8'-10" 8.38m x 2.79m x 2.69m	16,535 lbs 7 500 kg
Hook Block	2'-0" x 1'-7" x 3'-9" 0.62m x 0.48m x 1.14m	1,345 lbs 610 kg
Trolley	6'-2" x 6'-0" x 3'-11" 1.89m x 1.83m x 1.2m	835 lbs 380 kg

NOTE: Weights and dimensions are approximate. Scale components before lifting.
[1] Includes operator's cab, swing motors, slewing ring, ring support and 4 climbing shoes. Two climbing shoes are detachable; deduct 100 lbs (45 kg) each. Dimensions above are without detachable climbing shoes.
[2] Includes operator's cab and swing motors.
[3] Includes slewing ring, ring support and 4 climbing shoes. Two climbing shoes are detachable; deduct 100 lbs (45 kg) each. Dimensions above are without detachable climbing shoes.
[4] Includes 108 hp (80 kW) hoist unit, electrical panel and handrails. Does not include wire rope.
[5] Includes counterjib sections #1, #3, pendant bars and handrails. Counterjib A is required for jibs 158 ft (48.3m) and shorter.
[6] Includes counterjib sections #1, #2, #3, pendant bars and handrails. Counterjib B is required for jibs 180 ft (55.0m) and longer.
[7] Includes jib sections, pendant bars, pendant bar connecting pins and plates, trolley drive unit, trolley wire rope and trolley.