246 West 17th Street

New York, NY

1st Technical Report

Lateral System Analysis

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Executive Summary

The new 246 West 17th Street of New York, NY is a ten-story residential building holding 34 high-end condominium units; however, this building was once a three-story garage circa 1925. The current design project includes the renovation of the existing building and the addition of seven new floors above. The garage building now serves as a solid base for the above floors; much of the original brick façade and terracotta details have been left intact, although large punched windows have been added to open up the base façade for light and air. The addition features aluminum and glass window walls, metal paneling, and dark brick veneer. Like the change in materials, many set-backs also serve to add depth and diversity to the north and south elevations. This skillful combination of new and old allows 246 West 17th Street to blend with the historical neighborhood while simultaneously catering to modern architectural tastes.

The structural system of the existing garage portion (through the 3rd floor) includes a steel frame with an 8" concrete slab surrounded by mass masonry walls. The newly added stories (floors 4 through 10, the roof, and the bulkhead) consist of a concrete moment frame with both circular and rectangular columns and a two-way flat slab system. Two pairs of shear walls extend up the entire height of the building for lateral load resistance.

This report discusses the basic structural features and concepts of 246 West 17th Street. Loading and analysis requirements were taken from ASCE 7-05 for gravitational and lateral loading applications. This standard was used in lieu of the New York City Building Code (NYCBC), which was used in the original design of the 246 West 17th Street condominium building. In addition, gravitational design checks utilizing the newly calculated loads were performed for a typical bay on the typical floor plan; lateral design checks will be looked at in future reports.

Please Note
To clearly distinguish between the various structures present in 246 West 17th Street, the terms *existing*, *historic*, and *original* shall refer to the 1925 structure. The terms *current*, *as-designed*, and *new* shall refer to the 2008 renovation design.

Table of Contents

Introduction 1

Building Codes 1

Structural System Overview 2

Framing Plans and Elevations 3

Building Load Summary 4

Preliminary Design Analysis 9

Analysis and Conclusions 10

Appendix 11

Introduction

The original structure of 246 West 17th Street in New York, NY was a three-story brick garage built in 1925. The current design includes an architectural renovation of the existing building along with the addition of seven stories atop the garage structure to transform this garage into a 34-unit, high-end condominium building.

Figure F1 Rendering of Original Garage Building

The addition – featuring a mix of glass and aluminum curtain walls, metal paneling, and dark brick veneers – adds a modern look to the upper two-thirds of the structure, while the brick and original ornamentation of the lower half holds fast to the charm and historical context of the surrounding area. The addition also brings 246 West 17th Street up to the heights of the adjacent buildings, which sit tightly on either side of the site.

As with the original building, the cellar of 246 West 17th Street contains garage parking with added mechanical and storage spaces. The 1st floor has been altered to include three condominium units and two recreational spaces. The 2nd and 3rd floors of the original garage building each accommodate five condo units. The 4th floor – the start of the new construction – steps back from the brick structure below, providing residents in each of the three units on this floor with a personal terrace space. The 5th, 6th, and 7th floors have identical floor plans: each holds four units, and each unit features a balcony. The 8th floor again steps back, providing terrace spaces for each of the two condo units. The 9th and 10th floors feature two condo units as well, each with personal balconies. The floor-to-floor heights range between 10'-7 ½" on a majority of the middle floors to 16'-6" on the first floor.

Building Codes

Building codes used in the renovation design of 246 West 17th Street:

- New York City Building Code (NYCBC)
- NFPA Code

Building codes used in the thesis analysis:

- ASCE 7-05
- ACI 318-08

Structural System Overview

Foundation

The soils under the existing slab of 246 West 17th Street are considered to be stable and have high bearing pressures when classified according to the NYCBC. The geotechnical investigation provided by Pillory Associates found there to be a layer of fill soil directly below the existing slab, followed by Glacial Alluvium and Mica Schist Bedrock below this. The bearing pressure of the Glacial Alluvium is rather high at 3.5 tons/sf (7000 psf), and Pillory states in their report that any new slab may hence be designed as slab-on-grade; the geotechnical engineers specifically recommend the use of either a footing foundation or a mat slab to replace the existing slab on grade. Ultimately, after the original slab was removed, both systems were utilized on site: Spread footings measuring 3'-10" thick were placed on a 2" rat slab on gravel on the southern half of the cellar, while a 3'-10" thick mat slab was placed on the same 2" rat slab on gravel on the northern half of the cellar.

Fortunately, no underpinning was required for the project because the cellar walls and perimeter foundations were kept intact.

Floor System

There are two distinct floor types within 246 West 17th Street: those with steel framing (existing) and those without (new construction).

The existing floor systems (floors 1, 2, and 3) consist of a steel frame with an 8" concrete slab on deck. The frame is comprised of steel w-shape beams (sizes unknown) at 5'-6" O/C framing into 24" to 26" deep steel girders at 20'-8" O/C. The typical bay size is 20'-8" by 35'-8", with the girders spanning the entire 35'-8" length. The original girders frame into steel columns on the interior and into mass brick piers on the perimeter edge. Both of these vertical elements have been reinforced in the new design.

The top existing floor system (floor 3) has been structurally reinforced through the addition of new steel long-span beams and diagonal angle bracing beneath the slab level. The redundancy of these new beams will help the original long-span girder beams act as transfer beams to carry the weight of the seven new stories above.

The addition stories (floors 7 through 10) are constructed of 8" two-way, concrete, flat-plate moment frames. Circular concrete columns between 14", 16" or 18" in diameter are placed throughout the interior on a relatively irregular pattern due to the various condominium layouts. Rectangular concrete columns flank the perimeter, and range in size between 10"x18" and 24"x24".

Roof System

Multiple set-backs in 246 West 17th Street provide a variety of private terraces for the condominium owners. Façade set-backs occur at the 2nd, 4th, and 8th floors, in addition to a large decrease in the floor plan area at the roof level, as the building narrows around the stair and machine room bulkhead area. This decrease in area provides penthouse tenants with a private roof terrace. Each of these terraces is finished with concrete pavers and wrapped by 3'-8" tall glass railings or a 5' tall parapet.

The typical roof system of 246 West 17th Street – which includes these terrace areas – features a single-ply EPDM roofing membrane topped with 4" of extruded polystyrene insulation, filter fabric, and 2'x2' pavers on adjustable pedestals to ensure that the interior finish level matches that of the outside terrace. This system rests on a low-slope topping slab, which is supported by the structural slab below.

Building Envelope

The mass brick wall of the original garage building remains intact on the lower three levels and in the cellar of 246 West 17th Street. This wall has been opened up through to allow for more light into the condominiums, and filled with large glass and aluminum punched windows. Rather than attempt to match the quality of the brick below, the new stories feature a drastic change in material, including aluminum and glass window walls, metal paneling, and dark brick veneer. The structural backing to the paneling and veneer systems typically consists of cold-formed metal framing filled with batting insulation, although areas around the seismic joint are backed by a concrete wall, and the parapets are backed by 6" CMU to account for the higher seismic and wind loading on these areas, respectively.

Special Features

Due to the close proximity of the neighboring buildings to 246 West 17th Street, special seismic joints were placed along adjacent walls to prevent them from damaging each other in the case that an earthquake was to occur. These structural properties of these joints will be looked at in closer detail in future reports.

Framing Plans and Elevations

Typical Floor Plan

The Typical Floor Plan encompasses floors 5 through 7 and consists of a concrete moment frame with a two-way flat plate slab system. These levels include a variety of column shapes and sizes, with rectangular columns (10”x18” or 12”x18”) running north-south along the east and west perimeter walls and circular columns (16” diameter) spanning between. Spans in the north-south direction are non-uniform in length, ranging from 10’-1¼” to 20’-8”. Spans in the east-west direction, however, are regularly 20’-8” except at the perimeter bays, which vary in length according to the location of the property line. The Typical Floor Plan is pictured at right in Figure F2. The Typical Bay analyzed for gravitational loading spot checks is highlighted in this figure.

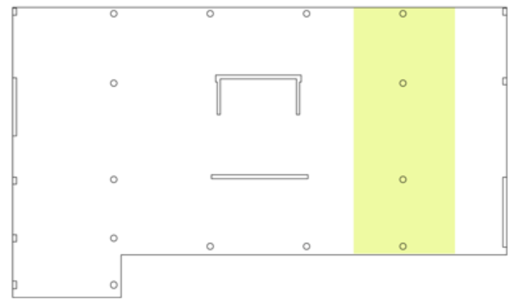


Figure F2 Typical Floor Plan showing Typical Bay

Lateral Framing Plan and Sections

The Lateral Framing Plan features two pairs of shear walls. These walls are highlighted in the Typical Floor Plan and Elevations pictured in Figures F3, F4, and F5.

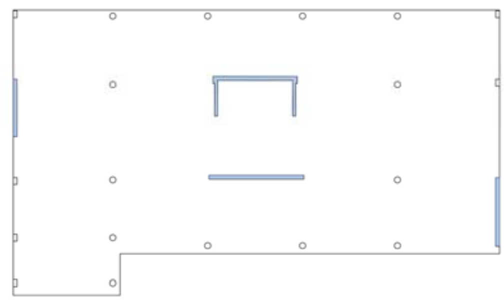


Figure F3 Typical Floor Plan with Lateral Elements Highlighted (in blue)

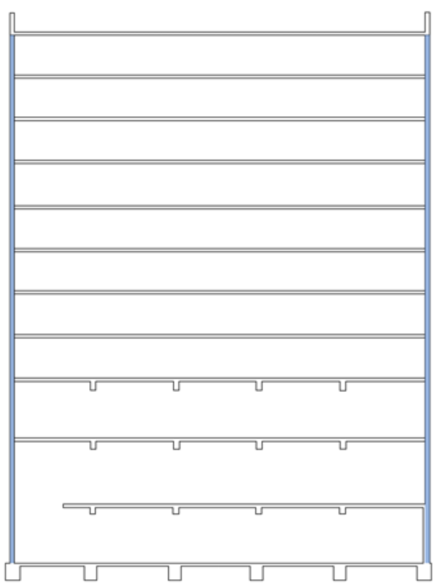


Figure F4 Elevation Looking West with Lateral Elements Highlighted (in blue)

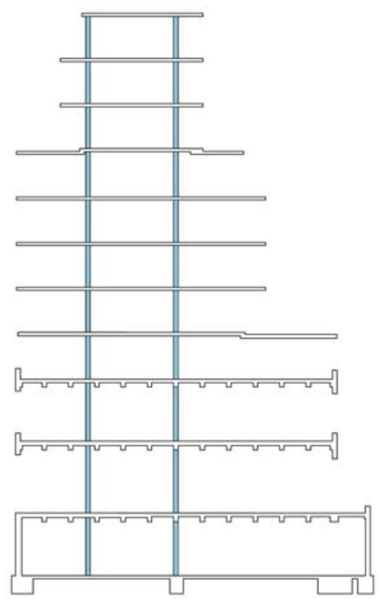


Figure F5 Elevation Looking West with Lateral Elements Highlighted (in blue)

Building Load Summary

Gravity Loads

The gravity loads of 246 West 17th Street are presented in Table T2 below. These loads have been calculated based on the physical properties of the materials used, industry and ASCE code standards, and data provided directly by the various manufacturers.

	Slab	Pavers	Roofing	Hung Clg	Mech	Partitions	Finished Floor	First Floor Finished Floor	Existing Steel	Total Dead Load
	100	*25*	*30*	*5*	*75*	*10*	*5*	*25*	*10*	
Bulkheads	100	25	30	-	75	-	-	-	-	**230**
Main Roof	100	25	30	5	-	10	5	-	-	**175**
Typ New Floor (Int)	100	-	-	5	-	10	5	-	-	**120**
Typ New Floor (Ext)	100	25	30	5	-	10	5	-	-	**175**
Typ Existing Floor	100	-	-	5	-	10	5	-	10	**120**
First Floor	100	-	-	5	75	10	-	25	10	**215**
Basement	100	-	-	-	-	10	-	-	-	**110**

Table T1 Dead Load Schedule

	Dead Load As Designed	Dead Load As Calculated
Bulkheads	**230**	**230**
Main Roof	**170**	**175**
Typ New Floor (Int)	**120**	**120**
Typ New Floor (Ext)	**170**	**175**
Typ Existing Floor	**120**	**120**
First Floor	**135**	**215**
Basement	**105**	**110**

Table T2 Dead Load Comparison

Table T2 provides a comparison between the design dead loads and the calculated dead loads of Table T1.

A comparison of the live loads as designed and as calculated is given in Table T3. Due to variations in the floor plans, the tributary areas for the framing elements vary throughout the building. Most of these areas are not large enough to permit live load reductions to be taken into account; therefore, no live load reductions were calculated. This serves as a conservative design measure and eased

	As Originally Designed [psf]	As Required by ASCE 7-05 [psf]
Bulkheads	30	20
Main Roof	30	60
New Floor (Interior)	40	40
New Floor (Exterior)	60	100
Existing Floor (Interior)	40	40
Existing Floor (Exterior)	40	100
First Floor	100	100
Basement as Garage	100	40
Basememt as Machine Room	100	40

Table T3 Live Load Comparison

calculations for the design checks in this report.

Lateral Loads

Wind Loads

The wind loads on 246 West 17th Street were determined in accordance with Chapter 6 of ASCE 7-05. The set-backs in the façade were neglected for this report, and instead the building was analyzed as being uniform in width from the base to the top. This resulted in a wider wind-affected area, so load calculations will be slightly conservative. A summary of the input values is presented in Table T4, and a summary of the findings is presented in Table T5. A graphical representation of the findings is illustrated in Figures F6 and F7. Detailed calculations can be found in the Appendix of this report.

In the original design of this building, the wind loads were calculated using the NYCBC, which assumes very simple and inaccurate wind loading. As with original calculations, though, the wind loading was found to control over seismic loading for this structure.

Wind Loading Summary		
Occupancy Category	-	II
Importance Factor	I	1
Exposure Category	-	B
Enclosure Classification	-	Fully Enclosed
Directionality Factor	K_d	0.85
Topographic Factor	k_{zt}	1
Basic Wind Velocity [mph]	V	110
Stiffness Factor	n_1	0.5405
Gust Effect Factor (N-S)	G_f	0.9025
Gust Effect Factor (E-W)	G_f	0.9114
Cp Windward Pressure	C_p	+0.80
Leeward Pressure	C_p	-0.30
Parapet Windward Pressure	GC_{pn}	+1.50
Parapet Leeward Pressure	GC_{pn}	-1.00
Cp Internal	GC_{pi}	±0.18
Building Height [ft]	h_n	131.89
North/South Length [ft]	B	106.25
East/West Length [ft]	L	92

Table T4 Summary of Wind Design Input Values

Story Data						
Floor	Height [ft]	Story Height [ft]	Wind Forces		Story Shears	
			North-South	East-West	North-South	East-West
Parapet	136.144	5.10	38.9	33.8	38.9	33.8
BH/Roof	131.044	13.18	36.7	32.1	75.5	65.9
10	117.864	11.88	32.3	28.2	107.8	94.1
9	105.989	10.67	30.0	26.2	137.8	120.3
8	95.322	10.67	29.3	25.6	167.1	145.9
7	84.655	10.67	28.6	25.0	195.6	170.9
6	73.988	10.67	27.8	24.3	223.4	195.2
5	63.321	10.67	26.8	23.5	250.2	218.6
4	52.654	10.67	25.7	22.5	275.9	241.1
3	41.987	10.58	28.9	25.3	304.8	266.4
2	31.404	14.60	33.0	28.8	337.8	295.2
1	16.8	16.50	16.8	14.6	354.6	309.9
Base	0.30	0.30	0.2	0.2	354.7	310.0
			Overturning Moment	**Base Shear**	**Overturning Moment**	**Base Shear**
			29,924	2,466	26,144	2,824

Table T4 Summary of Wind Design Forces

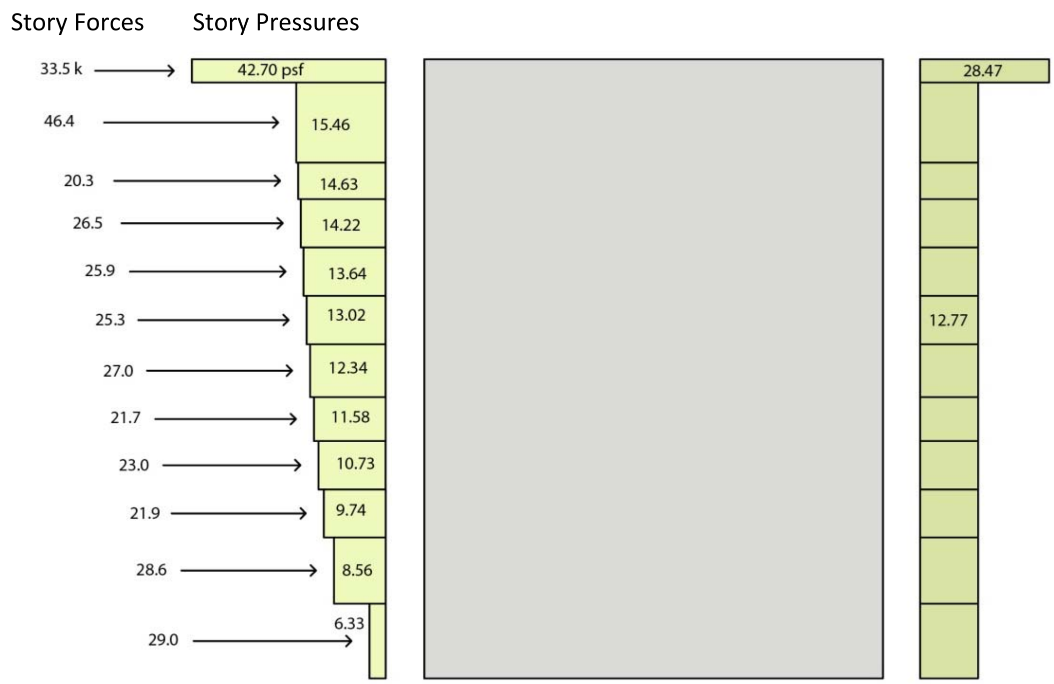


Figure F6 East-West Wind Design Forces

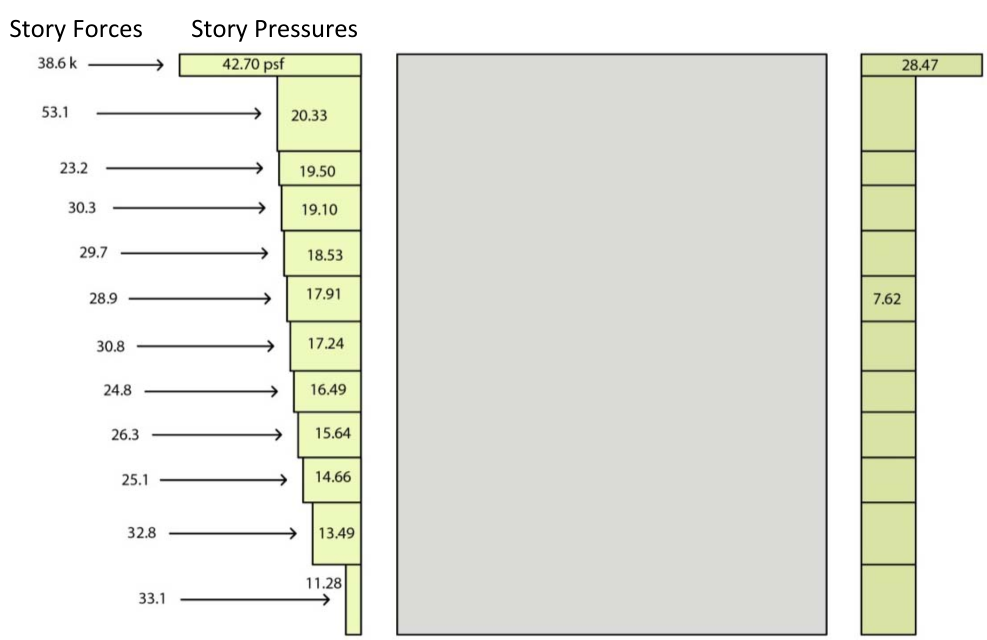


Figure F7 North-South Wind Design Forces

Seismic Loads

The seismic loads for 246 West 17th Street were determined in accordance with Section 9 of ASCE 7-05. The site class and associated seismic information were determined though the use of the Ground Motion Parameter Calculator provided by the U.S. Government Hazards Program, which can be found at http://earthquake.usgs.gov/research/hazmaps/design/index.php. The weight of the building was calculated using the dead loads of the framing system and of the various wall systems that make up the façade of 246 West 17th Street. A summary of these findings can be found in Table T5, below. Tables detailing the types of wall types and their associated weights, the overall calculation of the building weight, and the seismic loading calculations can be found in the Appendix.

Seismic Loading Information		
Occupancy Type	-	II
Occupancy Importance Factor	I	1
Site Class	-	B
Seismic Design Category	-	B
Short Period Spectral Response	S_S	0.363
Spectral Response at 1 Second	S_1	0.070
Maximum Short Period Spectral Reponse	S_{MS}	0.363
Maximum Spectral Reponse at 1 Second	S_{M1}	0.070
Design Short Period Spectral Response	S_{DS}	0.242
Design Spectral Response at 1 Second	S_{D1}	0.047
Period Parameter 1	C_t	0.016
Period Parameter 2	x	0.9
Response Modification Coefficient	R	4.5
Approximate Fundamental Period	T_a	1.288
Long-Period Transition Period	T_L	6.000
Short-Period Transition Period	T_S	0.194
Seismic Response Coefficient	C_S	0.054
Maximum Necessary C_s Value	$C_{S.max}$	0.008
Minimum Required C_s Value	**C_S**	**0.010**
Height Above Grade [ft]	h_n	131.044
Effective Weight [k]	**W**	**13804**
Base Shear	**V**	**138**
Overturning Moment	**M_o**	**11,383**

Table T5 North-South Wind Design Forces

Preliminary Design Analysis

The typical bay selected in the Typical Floor Plan (Figure F2) was analyzed under the interior gravitational loads for a new typical floor as determined by ASCE 7-05 and shown in the Dead Load Schedule (Table T1).

Column Spot Check

Based on the provided concrete strength of 5950 psi, a single interior column of the 4th floor was checked for axial loading as compared to axial strength. Combined lateral and gravitational loading was not taken into account for this column, but this will be looked at in future reports.

As shown previously in Tables T1 and T2, the dead loads of this floor area were calculated to match that which was found in the original design of 246 West 17th Street. As shown in Table T3, the required live loads for this floor were also found to be the same as in the original design.

The tributary area for this specific column was calculated to be 373 square feet on the 4th floor and it decreases towards the upper floors. Because these tributary areas are less than the 400 square feet required to perform live load reductions per ASCE 7-05, a reduced live load could not be taken into account here.

Based on the spot check calculations, the designed column axial strength was found to exceed the strength requirements by 4.8%. Seeing as the loads were found to be the same as in the original design, it appears that this column was originally designed as efficiently as possible. For detailed calculations of this column spot check, see the Appendix.

Slab System Spot Check

To analyze the original two-way flat slab design, the minimum required steel was calculated and checked against that which was provided. Although the bays are irregular in the north-south direction, they were assumed to be uniform in order to utilize the direct design method for this type of system. The largest span was conservatively chosen to represent these lengths.

This system has no edge beams, so the torsional resistance factor of these edges was calculated to be near zero. For this reason, it was neglected in the flat slab calculations.

With the given slab thickness of 8”, the area of steel provided was shown to exceed the calculated area required in the longitudinal direction in both the middle strip and column strip of the slab. For detailed calculations of this slab system spot check, see the Appendix.

Note Regarding the Existing Structure

The structural data provided on the drawings regarding the existing steel structure did not include the steel sizes of the members; therefore, a design check could not be carried out for the existing steel framing.

Conclusion

The original design of 246 West 17th Street was carried out using the NYCBC, and the analysis in this report was carried out using the guidelines of ASCE 7-05.

Gravity Loads

Many of the gravity loads calculated using and required by ASCE 7-05 were similar to that which was originally used in the design of 246 West 17th Street. Any changes in the dead loads were due to a variance in information available and potential design assumptions made by the original design engineer.

The live loads for the balcony and terrace areas increased between the original design values and the required values based on the assumption that these will be used more often and have heavier loading than a typical roof area. The basement garage and machine room however, decreased in required live loading. This could be due to the fact that the garage was assumed to have higher loading by the original engineer, but no indication of this could be found on the plans. The roof live loading also decreased. This is most likely due to snow loading requirements of New York City, but snow loading was not taken into account in this report.

Lateral Loads

As with the original design, the overturning moment calculated for the wind loading was higher than that of the seismic loading conditions; wind controlled in the design of 246 West 17th Street. This is expected in an area such as New York City, where the anticipated seismic loads are low when compared to the wind loads of the area.

Preliminary Design Analysis

The initial spot checks carried out for the Typical Bay slab and column resulted in adequate strength for both structural components. The room for error was rather slight, but the methods included many assumptions and rough approximations for ease of calculation. Future reports will include a computer analysis of these members, and will also incorporate lateral loading to provide a full understanding of the structural loading and capacity of these elements.

Appendix

Wind Calculation Tables

North-South Wind Analysis

Level	Height [ft]	Story Height [ft]	K_z	q_z	q_h	Windward $q_zG_fC_p$	Leeward $q_hG_fC_p$	Internal $q_h(GC_{pi})$	Net Windward p_z	Net Leeward p_h	Floor Wind Load [psf]	Story Force [k]	Story Shear [k]	Overturning Moment Contribution [ft-k]
Parapet	136.14	5.10	1.08	28.47	28.47	42.70	-28.47	0.00	42.70	-28.47	71.17	38.9	38.9	5290
BH/Roof	131.04	13.18	1.07	28.16	28.16	20.33	-7.62	5.07	15.26	-12.69	27.96	36.7	75.5	4808
10	117.86	11.88	1.03	27.01	28.16	19.50	-7.62	5.07	14.43	-12.69	27.13	32.3	108	3802
9	105.99	10.67	1.00	26.46	28.16	19.10	-7.62	5.07	14.03	-12.69	26.73	30.0	138	3176
8	95.32	10.67	0.97	25.67	28.16	18.53	-7.62	5.07	13.46	-12.69	26.15	29.3	167	2792
7	84.66	10.67	0.94	24.81	28.16	17.91	-7.62	5.07	12.84	-12.69	25.54	28.6	196	2418
6	73.99	10.67	0.91	23.87	28.16	17.24	-7.62	5.07	12.17	-12.69	24.86	27.8	223	2053
5	63.32	10.67	0.87	22.83	28.16	16.49	-7.62	5.07	11.42	-12.69	24.11	26.8	250	1700
4	52.65	10.67	0.82	21.66	28.16	15.64	-7.62	5.07	10.57	-12.69	23.26	25.7	276	1354
3	41.99	10.58	0.77	20.31	28.16	14.66	-7.62	5.07	9.59	-12.69	22.29	28.9	305	1214
2	31.40	14.60	0.71	18.69	28.16	13.49	-7.62	5.07	8.42	-12.69	21.12	33.0	338	1035
1	16.80	16.50	0.59	15.63	28.16	11.28	-7.62	5.07	6.21	-12.69	18.91	16.8	355	281.4
Base	0.30	0.30	0.19	4.90	28.16	3.54	-7.62	5.07	-1.53	-12.69	11.16	0.2	355	0.053

Kz values interpolated from Table 6-3, Exposure B

Total Base Shear	Total Overturning Moment
F [k]	**M_o [ft-k]**
2,824	**29,924**

Table A1 Calculations of North-South Wind Design Forces

East-West Wind Analysis														
Level	Height [ft]	Story Height	K_z	q_z	q_h	Windward $q_zG_fC_p$	Leeward $q_hG_fC_p$	Internal $q_h(GC_{pi})$	Net Windward p_z	Net Leeward p_h	Floor Wind Load [psf]	Story Force [k]	Story Shear [k]	Overturning Moment Contribution [ft-k]
Parapet	136.14	5.10	1.08	28.47	28.47	42.70	-28.47	0.00	42.70	-28.47	71.17	33.8	33.8	4604
BH/Roof	131.04	13.18	1.07	28.16	28.16	20.53	-7.70	5.07	15.46	-12.77	28.23	32.1	65.9	4204
10	117.86	11.88	1.03	27.01	28.16	19.70	-7.70	5.07	14.63	-12.77	27.40	28.2	94	3325
9	105.99	10.67	1.00	26.46	28.16	19.29	-7.70	5.07	14.22	-12.77	26.99	26.2	120	2777
8	95.32	10.67	0.97	25.67	28.16	18.71	-7.70	5.07	13.64	-12.77	26.41	25.6	146	2442
7	84.66	10.67	0.94	24.81	28.16	18.09	-7.70	5.07	13.02	-12.77	25.79	25.0	171	2114
6	73.99	10.67	0.91	23.87	28.16	17.41	-7.70	5.07	12.34	-12.77	25.11	24.3	195	1796
5	63.32	10.67	0.87	22.83	28.16	16.65	-7.70	5.07	11.58	-12.77	24.35	23.5	219	1487
4	52.65	10.67	0.82	21.66	28.16	15.79	-7.70	5.07	10.73	-12.77	23.49	22.5	241	1184
3	41.99	10.58	0.77	20.31	28.16	14.81	-7.70	5.07	9.74	-12.77	22.51	25.3	266	1062
2	31.40	14.60	0.71	18.69	28.16	13.62	-7.70	5.07	8.56	-12.77	21.32	28.8	295	905
1	16.80	16.50	0.59	15.63	28.16	11.39	-7.70	5.07	6.33	-12.77	19.09	14.6	310	246.1
Base	0.30	0.30	0.19	4.90	28.16	3.57	-7.70	5.07	-1.50	-12.77	11.27	0.2	310	0.047

Kz values interpolated from Table 6-3, Exposure B

Total Base Shear	Total Overturning Moment
F [k]	$\mathbf{M_o}$ [ft-k]
2,467	**26,144**

Figure A2 Calculations of East-West Wind Design Forces

Seismic Calculation Tables

Vertical Distribution of Seismic Forces						
Level	Story Weight [k] w_x	Height [ft] h_x	$w_x.h_x$ [ft-k]	Vertical Distribution Factor C_{vx}	Lateral Seismic Force [k] F_x	Overturning Moment Contributions M_{oi}
BH / Roof	1067.831	131.044	139933	0.163	22.5	2945.952
10	655.244	117.864	77230	0.090	12.4	1462.360
9	647.963	105.989	68677	0.080	11.0	1169.394
8	1048.593	95.322	99954	0.116	16.1	1530.671
7	1023.788	84.655	86669	0.101	13.9	1178.702
6	1023.788	73.988	75748	0.088	12.2	900.371
5	1023.788	63.321	64827	0.075	10.4	659.469
4	1424.414	52.654	75001	0.087	12.0	634.436
3	1737.996	41.987	72973	0.085	11.7	492.229
2	1952.890	31.404	61329	0.071	9.9	309.412
1	2195.378	16.800	36882	0.043	5.9	99.544
			859,223		138.0	**Total Overturning Moment** [ft-k] **11,383**

Table A3 Calculations of Seismic Design Forces

Wall Loads Calculation Table

Notes: 1. Table A4 has been broken into two halves to fit on a single page.
2. See Table A5 for Wall Type Definitions

Exterior Wall Dead Loads							
Level	**Story Height [ft]**	**Walls Above**					
		Type	Height [ft]	Loading [psf]	Length [ft]	Linear Load [klf]	Floor Load [k]
Bulkhead (Parapet)	4.875	B	4.875	125	118	0.609	**71.906**
Roof (Bulkhead)	14.89	A	7.443	49.5	118	0.368	**43.473**
Roof (Parapet)	4.875	B	4.875	125	206.115	0.609	**125.601**
Roof Level	0	-		-			
		-		-			
		-		-			
10th Floor	11.88	A	5.938	49.5	139.716	0.294	**41.063**
		C	5.938	25	121.077	0.148	**17.972**
		E	5.938	84.5	31.667	0.502	**15.888**
9th Floor	10.67	A	5.333	49.5	139.716	0.264	**36.885**
		C	5.333	25	121.077	0.133	**16.144**
		E	5.333	84.5	31.667	0.451	**14.271**
8th Floor	10.67	A	5.333	49.5	139.716	0.264	**36.885**
		C	5.333	25	121.077	0.133	**16.144**
		E	5.333	84.5	31.667	0.451	**14.271**
7th Floor	10.67	A	5.333	49.5	36.67	0.264	**9.681**
		C	5.333	25	206.6	0.133	**27.547**
		F	5.333	174.5	81	0.931	**75.384**
6th Floor	10.67	A	5.333	49.5	36.67	0.264	**9.681**
		C	5.333	25	206.6	0.133	**27.547**
		F	5.333	174.5	81	0.931	**75.384**
5th Floor	10.67	A	5.333	49.5	36.67	0.264	**9.681**
		C	5.333	25	206.6	0.133	**27.547**
		F	5.333	174.5	81	0.931	**75.384**
4th Floor	10.67	A	5.333	49.5	36.67	0.264	**9.681**
		C	5.333	25	206.6	0.133	**27.547**
		F	5.333	174.5	81	0.931	**75.384**
3rd Floor	10.58	D	5.292	159.5	359.37	0.844	**303.316**
2nd Floor	14.60	D	7.302	159.5	359.37	1.165	**418.552**
1st Floor	16.5	D	8.250	159.5	359.37	1.316	**472.886**

(cont. below)

(cont. from above)

Exterior Wall Dead Loads								
Level	**Walls Below**						Partial-Story Wall Load	Full-Story Wall Load
	Type	Height [ft]	Loading [psf]	Length [ft]	Linear Load [klf]	Floor Load [k]		
Bulkhead (Parapet)	A	7.443	49.5	118	0.368414063	**43.473**	115.379	
Roof (Bulkhead)	-		-			**0.000**	43.473	
Roof (Parapet)	-		-			**0.000**	125.601	
Roof Level	A	5.938	49.5	139.716	0.294	**41.063**	41.063	
	C	5.938	25	121.077	0.148	**17.972**	17.972	
	E	5.938	84.5	31.667	0.502	**15.888**	15.888	**359.377**
10th Floor	A	5.333	49.5	139.716	0.264	**36.885**	77.948	
	C	5.333	25	121.077	0.133	**16.144**	34.116	
	E	5.333	84.5	31.667	0.451	**14.271**	30.159	**142.224**
9th Floor	A	5.333	49.5	139.716	0.264	**36.885**	73.770	
	C	5.333	25	121.077	0.133	**16.144**	32.287	
	E	5.333	84.5	31.667	0.451	**14.271**	28.543	**134.600**
8th Floor	A	5.333	49.5	36.67	0.264	**9.681**	46.566	
	C	5.333	25	206.6	0.133	**27.547**	43.690	
	F	5.333	174.5	81	0.931	**75.384**	89.655	**179.911**
7th Floor	A	5.333	49.5	36.67	0.264	**9.681**	19.362	
	C	5.333	25	206.6	0.133	**27.547**	55.093	
	F	5.333	174.5	81	0.931	**75.384**	150.768	**225.223**
6th Floor	A	5.333	49.5	36.67	0.264	**9.681**	19.362	
	C	5.333	25	206.6	0.133	**27.547**	55.093	
	F	5.333	174.5	81	0.931	**75.384**	150.768	**225.223**
5th Floor	A	5.333	49.5	36.67	0.264	**9.681**	19.362	
	C	5.333	25	206.6	0.133	**27.547**	55.093	
	F	5.333	174.5	81	0.931	**75.384**	150.768	**225.223**
4th Floor	D	5.292	159.5	359.37	0.844	**303.316**	312.997	
								312.997
3rd Floor	D	7.302	159.5	359.37	1.165	**418.552**	721.868	**721.868**
2nd Floor	D	8.250	159.5	359.37	1.316	**472.886**	891.438	**891.438**
1st Floor							472.886	**472.886**

Table A4 Calculation of Exterior Wall Dead Loads

Wall Type Definitions		A	B	C	D	E	F
		Brick Veneer on Metal Stud Backing	Brick Veneer Parapet on CMU Backing with Brick Veneer Interior	Curtain Wall	Exiting Masonry Wall with Metal Stud Interior	Metal Panel Wall on Metal Stud Backing	West Wall with Seismic Joint Wall
Aluminum/Glazing System	15			25			
Aluminum Panel (Exterior)	5					10	
Brick Veneer (Exterior)	40	40	40				40
Metal Stud (Exterior)	4	4			4		
CMU	45		45			45	
10" Concrete	125						125
15" Mass Brick Wall	150				150		
Batting Insulation	0.5	0.5			0.5	0.5	0.5
Gyp	5	5			5	20	5
Metal Stud (Interior)	4					4	4
Brick Veneer (Interior)	40		40				
Aluminum Panel (Interior)	5					5	
Total Weight for Wall System		**49.5**	**125**	**25**	**159.5**	**84.5**	**174.5**

Table A5 Wall Type Definitions and Associated Dead Loads

Column Dead Loads													
Story	**Floor Height [ft]**			**Circular Columns**				**Rectangular Columns**					**Story Total Load [k]**
				Diameter [in]	Area [sf]	Quantity	Circular Col. Total Load [k]	Dimensions [in]		Area [sf]	Quantity	Rectangular Col. Total Load [k]	
Roof/BH	14.89	14.885	Above	(none)									
		5.938	Below	14	1.069014	8	**7.617**	12	18	1.5	2		
								10	18	1.25	2	**4.898**	**12.515**
10th Floor	11.88	5.938	Above	14	1.069014	8	**7.617**	12	18	1.5	2		
								10	18	1.25	2	**4.898**	**12.515**
		5.333	Below	14	1.069014	8	**6.842**	12	18	1.5	2		
								10	18	1.25	2	**4.400**	**11.242**
9th Floor	10.67	5.333	Above	14	1.069014	8	**6.842**	12	18	1.5	2		
								10	18	1.25	2	**4.400**	**11.242**
		5.333	Below	14	1.069014	8	**6.842**	12	18	1.5	2		
								10	18	1.25	2	**4.400**	**11.242**
8th Floor	10.67	5.333	Above	14	1.069014	8	**6.842**	12	18	1.5	2		
								10	18	1.25	2	**4.400**	**11.242**
		5.333	Below	16	1.396263	13	**14.521**	12	18	1.5	2		
								10	18	1.25	6	**8.400**	**22.921**
7th Floor	10.67	5.333	Above	16	1.396263	13	**14.521**	12	18	1.5	2		
								10	18	1.25	6	**8.400**	**22.921**
		5.333	Below	16	1.396263	13	**14.521**	12	18	1.5	2		
								10	18	1.25	6	**8.400**	**22.921**
6th Floor	10.67	5.333	Above	16	1.396263	13	**14.521**	12	18	1.5	2		
								10	18	1.25	6	**8.400**	**22.921**
		5.333	Below	16	1.396263	13	**14.521**	12	18	1.5	2		
								10	18	1.25	6	**8.400**	**22.921**
5th Floor	10.67	5.333	Above	16	1.396263	13	**14.521**	12	18	1.5	2		
								10	18	1.25	6	**8.400**	**22.921**
		5.333	Below	16	1.396263	13	**14.521**	12	18	1.5	2		
								10	18	1.25	6	**8.400**	**22.921**
4th Floor	10.67	5.333	Above	16	1.396263	13	**14.521**	12	18	1.5	2		
								10	18	1.25	6	**8.400**	**22.921**
		5.292	Below	16	1.396263	13	**14.408**	12	18	1.5	2		
								10	18	1.25	6	**8.334**	**22.742**
3rd Floor	10.58	5.292	Above	16	1.396263	13	**14.408**	12	18	1.5	2		
								10	18	1.25	6	**8.334**	**22.742**
		7.302	Below	W14x	90	8	**5.258**	12	18	1.5	2		
								10	18	1.25	6		
								24	24	4	4	**29.026**	**34.283**
2nd Floor	14.60	7.302	Above	16	1.396263	13	**19.881**	12	18	1.5	2		
								10	18	1.25	6	**11.501**	**31.382**
		8.250	Below	W14x	90	8	**5.940**	12	18	1.5	2		
								10	18	1.25	6		
								24	24	4	4	**32.794**	**38.734**
1st Floor	16.50	8.250	Above	16	1.396263	13	**22.462**	12	18	1.5	2		
								10	18	1.25	6	**12.994**	**35.456**
		0.000	Below	W14x	90	8	**0.000**	12	18	1.5	2		
								10	18	1.25	6		
								24	24	4	4	**0.000**	**0.000**

Table A6 Calculations of Column Dead Loads

Shear Wall Dead Loads															
Story	Floor Ht. [ft]		North Wall Dimensions			South Wall Dimensions			East Wall Dimensions			West Wall Dimensions			Total Story Load
			Length [ft]	Thickness [ft]	Weight [k]	Length [ft]	Thickness [ft]	Weight [k]	Length [ft]	Thickness [ft]	Weight [k]	Length [ft]	Thickness [ft]	Weight [k]	
Roof/BH	14.89	7.443	40	0.833	*5.000*										
		5.938	40	0.833	*5.000*	20.5	0.833	*2.563*	6	0.833	*0.750*	11.33	0.833	*1.416*	**14.729**
10th Floor	11.88	5.938	40	0.833	*5.000*	20.5	0.833	*2.563*	6	0.833	*0.750*	11.33	0.833	*1.416*	
		5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	6	0.833	*0.750*	11.33	0.833	*1.416*	**19.458**
9th Floor	10.67	5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	6	0.833	*0.750*	11.33	0.833	*1.416*	
		5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	6	0.833	*0.750*	11.33	0.833	*1.416*	**19.458**
8th Floor	10.67	5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	6	0.833	*0.750*	11.33	0.833	*1.416*	
		5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	11.33	0.833	*1.416*	**20.499**
7th Floor	10.67	5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	11.33	0.833	*1.416*	
		5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	11.33	0.833	*1.416*	**21.540**
6th Floor	10.67	5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	11.33	0.833	*1.416*	
		5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	11.33	0.833	*1.416*	**21.540**
5th Floor	10.67	5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	11.33	0.833	*1.416*	
		5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	11.33	0.833	*1.416*	**21.540**
4th Floor	10.67	5.335	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	11.33	0.833	*1.416*	
		5.290	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	20.67	0.833	*2.584*	**22.708**
3th Floor	10.58	5.290	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	20.67	0.833	*2.584*	
		7.300	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	20.67	0.833	*2.584*	**23.875**
2nd Floor	14.60	7.300	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	20.67	0.833	*2.584*	
		8.250	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	20.67	0.833	*2.584*	**23.875**
1st Floor	16.50	8.250	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	20.67	0.833	*2.584*	
		0.000	40	0.833	*5.000*	20.5	0.833	*2.563*	14.33	0.833	*1.791*	20.67	0.833	*2.584*	**23.875**

Table A7 Calculation of Shear Wall Dead Loads

Floor Load Dead Loads							
Dead Load Type		**Loading**	**Floor with this Loading**	**Gross Area with this Loading [sf]**	**Deductions / Openings [sf]**	**Net Area with this Loading [sf]**	**Effective Weight [kips]**
Bulkheads		230	Bulkhead	870	0	870	**200.10**
Main Roof		175	Roof	3619.2	870	2749.2	**481.11**
Typical New Floor	Interior	120	10th Floor Apartments	3619.2	113.94	3505.26	**420.63**
	Exterior	175	Balconies	281	0	281	**49.18**
	Interior	120	9th Floor Apartments	3619.2	100.47	3518.73	**422.25**
	Exterior	175	Balconies	281	0	281	**49.18**
	Interior	120	8th Floor Apartments	3619.2	102.72	3516.48	**421.98**
	Exterior	175	Terrace	2240.24	0	2240.24	**392.04**
	Interior	120	7th Floor Apartments	5851.07	103.71	5747.36	**689.68**
	Exterior	175	Balconies	237.14	0	237.14	**41.50**
	Interior	120	6th Floor Apartments	5851.07	103.71	5747.36	**689.68**
	Exterior	175	Balconies	237.14	0	237.14	**41.50**
	Interior	120	5th Floor Apartments	5851.07	103.71	5747.36	**689.68**
	Exterior	175	Balconies	237.14	0	237.14	**41.50**
	Interior	120	4th Floor Apartments	5777.85	119.16	5658.69	**679.04**
	Exterior	175	Terrace	2080.02	0	2080.02	**364.00**
Typical Existing Floor	Interior	120	3rd Floor Apartments	8034.75	241.18	7793.57	**935.23**
	Exterior	175	Balconies	0	0	0	**0**
	Interior	120	2nd Floor Apartments	8034.77	243.84	7790.93	**934.91**
	Exterior	175	Terrace	186	0	186	**32.55**
First Floor		215	1st Floor	8077.91	342.28	7735.63	**1663.16**
Basement		110	Cellar			0	**0**

Table A8 Calculation of Floor Dead Loads

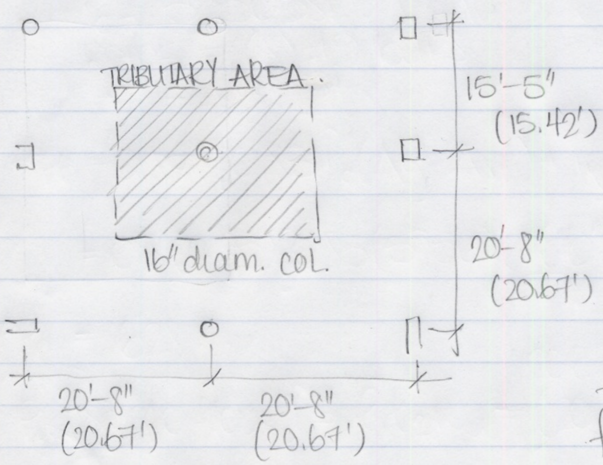
	Total Weight per Story [k]
Roof/BH	1067.8
10	655.2
9	648.0
8	1048.6
7	1023.8
6	1023.8
5	1023.8
4	1424.4
3	1738.0
2	1952.9
1	2195.4
Extras (Elevators)	5000.0
Total Building Weight [k]	18801.673

Table A9 Calculation of Total Building Weight

Column Spot Check

SPOT CHECK.

COLUMN CHECK.



TRIB. AREA = $\ell_1 \ell_2$

TRIB. AREA = $20.67\left(\frac{20.67+15.42}{2}\right)$

T.A. = 373 SF

373 < 400 SF ∴ Live load Reduction does not apply by ASCE 7-05 Section 4.8

$f'_c = 5950$ psi
$f_y = 29{,}000$ psi

strength:

$\phi P_n = 0.8\phi[0.85 f'_c(A_g - A_{st}) + f_y A_{st}]$

$\phi = 0.65$

$A_{st} = (8)\#9$ bars $= 8(1.0) = 8\ in^2$

$A_g = \frac{\pi d^2}{4} = \frac{\pi(16'')^2}{4} = 201.1\ in^2$

$= 0.8(0.65)[0.85(5950)(201.1-8.0) + 29{,}000(8.0)]$

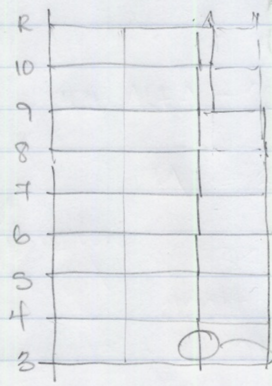
$= 628.5$ k.

$W_u = 1.2D + 1.6L = 1.2(120) + 1.6(40) = 208$ new floors.

$W_u = 1.2D + 1.6L = 1.2(175) + 1.6(60) = 306$ roof

SPOT CHECK

COL. CHECK CONT.



set back results in less trib. area, but added wt. of exterior wall. see below.

col. in question

Found $\phi P_n = 628.5$ k.

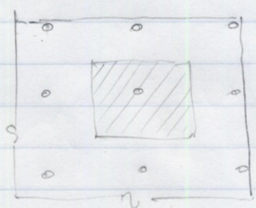
Find actual loading:

Pu FLOORS 4-8 (5 FLOORS)

$P_u = l_1 l_2 W_u = (T.A.) W_u$

$= 373 \left(\frac{208}{1000}\right)$

$P_{u_1} = 77.6$ k.



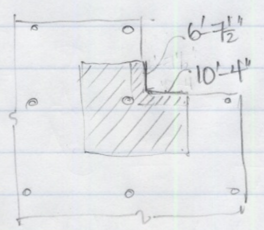
FLOORS 4-8

Pu FLOORS 9, 10: (2 FLOORS)

$P_u = \frac{3}{4}(373)\left(\frac{208}{1000}\right) + 19.958(85/1000)$

KLF — wall Type E

$P_{u_2} = 61.7$ k



FLOORS 9, 10, R.

trib. area reduces to 3/4 of that on Floors 4-8, but must carry add'l exter. walls.

Pu ROOF (1 FLOOR)

wall Type B

$P_u = \frac{3}{4}(373)\left(\frac{306}{1000}\right) + 19.958\left(\frac{125}{1000}\right)$

total wall length $= 6.625' + 10.333' = 19.958'$

$P_{u_3} = 88.1$ k.

$P_{u,total} = 5(P_{u_1}) + 2(P_{u_2}) + 1(P_{u_3}) = 5(77.6) + 2(61.7) + 1(88.1)$

$P_{u,total} = 599.5 \text{ k} < \phi P_n = 628.5 \text{ k}$ ∴ OK ✓

Flat Slab Spot Check

SPOT CHECK.

Flat Slab

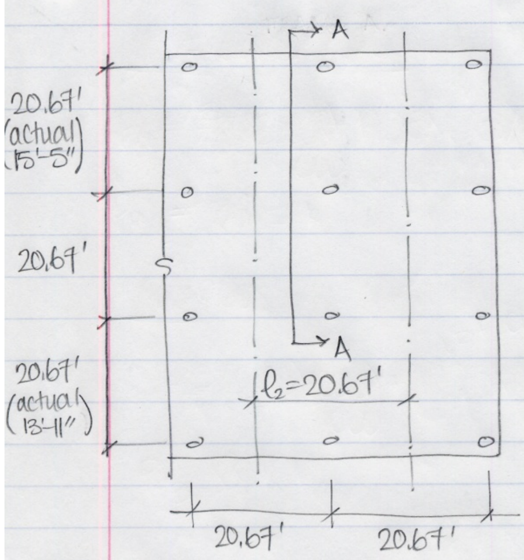
- total factored static moment

Interior Dead Load = 120 psf
Interior Live Load = 40 psf

$1.2D + 1.6L = 1.2(120) + 1.6(40)$
$w_u = 208 \text{ psf}$

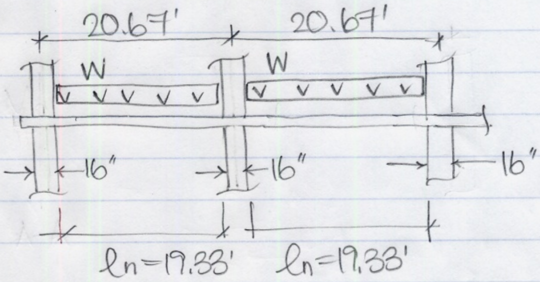
- bays assumed to be uniform in N-S direction (in actuality, the bays decrease in size so this will be conservative & ease calculations.)

TYPICAL BAY:



FRAME A.

A:A:



$$l_n = 20.67' - \frac{16''}{12} = 19.33'$$

$$W = w_u l_2 = 208(20.67) = 4299 \text{ PLF} = 4.30 \text{ KLF}$$

$$M_o = \frac{W l_n^2}{8} = \frac{4.30(19.33')^2}{8} = \underline{200.8 \text{ ft}\cdot\text{K}}$$

$$\tfrac{1}{2} \text{ col. strip} \le \frac{l_1}{4} \le \frac{l_2}{4} \qquad l_1 = l_2 = 20.67'$$

$$\therefore \text{col. strip} = 2\left(\frac{20.67'}{4}\right) = 10.335' = b$$

$$\text{middle strip} = 20.67' - 10.335 = 10.335'$$

SPOT CHECK

FLAT Slab cont.

- Longitudinal Moments   Found M_o to be 200.8 ft·k

int. span   Factors taken from ACI 318-08: 13.6.3.2

$M^- = 0.65(200.8) = -130.5\ 'k$
$M^+ = 0.35(200.8) = 70.3\ 'k$

ext. span   Factors taken from ACI 318-08: 13.6.3.3

$M^-_{ext} = 0.26(200.8) = 52.2\ 'k$
$M^+_{ext} = 0.52(200.8) = 104.4\ 'k$
$M^-_{int} = 0.70(200.8) = 140.6\ 'k$

- Percentage of Longit. Moment going to Col. Strip, C.S.

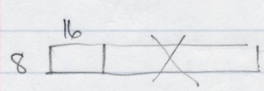
From Table 13.6.4.4 in ACI 318-08:
Knowing aspect ratio $\frac{l_2}{l_1} = 1.0$, $\alpha_1 = 0$ b/c no bm, $\therefore \alpha_1 \frac{l_2}{l_1} = 0$

C.S. must resist 75% of factored M^+

From Table 13.6.4.1 in ACI 318-08:
w/ same proportions as above:

C.S. must resist 75% of factored M^-_{int}

Torsional constant due to Slab Edge (no edge bm.)



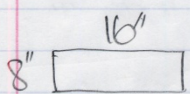
$b_E \leq b_w + h_w \leq b_w + 4t$
$\leq 16'' + 0 \leq 16'' + 4(8'')$
$b_E = 16''$

$b_E = 16'' =$ col. width $\therefore x_1 = 8''$, $y_1 = 16''$ → no x_2, y_2

SPOT CHECK.

Flat Slab Cont.

Finding Torsional Constant @ Edge:



$$C = \left[1 - 0.63\left(\frac{x}{y}\right)\right]\left(\frac{x^3 y}{3}\right) = \left[1 - 0.63\left(\frac{8}{16}\right)\right]\left(\frac{(8)^3(16)}{3}\right)$$

$$C = 1{,}870 \text{ in}^4$$

$$\beta_t = \frac{C}{2I_s} \qquad I_s = \frac{(\ell_2 \times 12'')t^3}{12} = \frac{(20.67 \cdot 12'')(8'')^3}{12} = 10{,}583 \text{ in}^4$$

$$\beta_t = \frac{1{,}870}{2(10{,}583)} = 0.08 \quad \text{negligible}$$

* assume $\beta_t = 0$ to conservatively ease calculations.

From Table 13.6.4.2 in ACI 318-08,
knowing $\frac{\ell_2}{\ell_1} = 1.0$, $\alpha_1 \frac{\ell_2}{\ell_1} = 0$, & $\beta_t = 0$

C.S. must resist 100% of factored Mext.

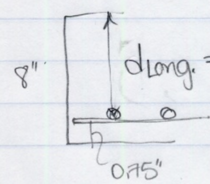
Summary [ft.k]

Factored Moment	-52.2	+104.4	-140.6	-130.5	+70.3
% to C.S.	100%	75%	75%	75%	75%
C.S. Moment	-52.2	+78.3	-105.5	-97.9	+52.7
M.S. Moment.	0	+26.1	-35.1	-32.6	+17.6

SPOT CHECK.

Flat Slab Cont.

$d_{\#4} = 0.5''$

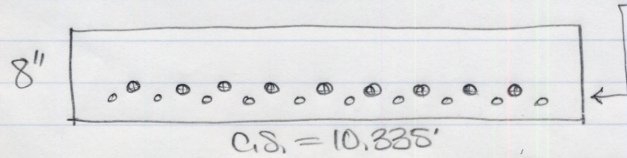


$8'' - 0.75'' - 1.5(0.5'') = 6.5''$

- Design of Slab Reinf. in C.S.

	Exterior			Interior	
	M^-_{ext}	M^+_{ext}	M^-_{int}	M^-	M^+
Moment, M_n	-52.2	+78.3	-105.5	-97.9	+52.7
C.S. Slab Width, b ($10.335' = 124''$)	124"	→	→	→	→
Effective Depth, d (#4 bars @12" o.c. each way)	6.5"	→	→	→	→
$M_u = \frac{M_n}{\phi}$, $\phi = 0.9$	-58.0	+87.0	-117.2	-108.8	+58.6
$R = \frac{M_u}{bd^2}$	133	199	268	249	134
ρ interpolated from A-5a	0.00222	0.00340	0.00459	0.00426	0.00226
$A_{s,req} = \rho bd$	1.79	2.74	3.70	3.43	1.82
$A_{s,min} = 0.002bt$	1.98	1.98	1.98	1.98	1.98
$A_s \geq A_{s,req}, A_{s,min}$	1.98	2.74	3.70	3.43	1.98

SECTION CHECK, by min. steel area.



$A_{s,prov.}$ = #4 @12" o.c. + (9)#6 (Longit.)

$A_{\#4} = 0.20\ in^2$ $A_{\#6} = 0.44\ in^2$

$10(0.20) + 9(0.44) = 5.96 > 3.70$

$2.00 + 3.96$ ∴ OK ✓

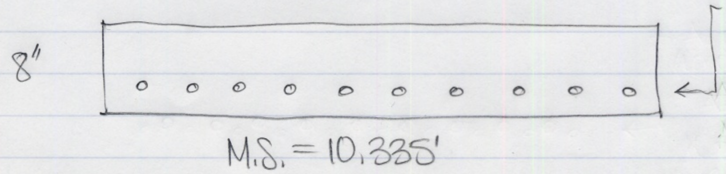
SPOT CHECK

Flat Slab Cont.

- Design of Slab Reinf. in M.S.

	Exterior M^-_{ext}	Exterior M^+_{ext}	Exterior M^-_{int}	Interior M^-	Interior M^+
Moment, M_n	0	+26.1	−35.1	−32.6	+17.6
M.S. slab width, b	124"	→	→	→	→
Effective depth, d	6.5"	→	→	→	→
$M_u = \frac{M_n}{\phi}$ $\phi = 0.9$	0	+29.9	+39.0	−36.2	+19.6
$R = \frac{M_u}{bd^2}$	0	68	89	83	45
ρ interpolated from A-5a	–	0.00114	0.0015	0.00145	0.00075
$A_{s,req} = \rho bd$	–	0.92	1.21	1.17	0.60
$A_{s,min} = 0.002bt$	1.98	1.98	1.98	1.98	1.98
$A_s \geq A_{s,req}, A_{s,min}$	1.98	1.98	1.98	1.98	1.98

SECTION CHECK, by min. steel area:



$A_{s,prov}$ = #4 bars @ 12" O.C.
$A_{\#4} = 0.20\ in^2$
$(10)(0.20) = 2.0\ in^2 > 1.98\ in^2$
∴ OK ✓