TECH REPORT 1

Harry Baker | Structural Option| Advised By Dr. Aly Said

GENERIC BUILDING NAME

NOWHERE, USA

I EXECUTIVE SUMMARY

The purpose of this report is to discuss the structural systems of the Generic Building Name. The Generic Building Name is a Cancer research and treatment center. It is 10 floors and 10800 sf total. The main architectural feature is a two floor canopy on the northern side of the building. In this report the main gravity system, lateral system, loads and their paths and other structural features will be detailed.

The Generic Building name is a concrete building. The floor slabs are reinforced two way concrete slabs. These slabs are supported by reinforced concrete columns. The canopy is supported by four large concrete post tensioned beams. These beams are supported on both sides by large circular columns. The lateral system is ordinary reinforced shear walls. An auger cast piles system is the foundation system.

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1 INTRODUCTION

1.1 Purpose

The purpose of this report is to describe the existing structural conditions of the Generic Building Name. A deeper understanding of the structural systems and how they interact, will be achieved by the depth of the analysis in this report. The analysis in this report will provide a base knowledge of the building required to complete future assignments.

1.2 Scope

Included in this assignment will be a description of the gravity structural system, lateral structural system, loads used, load paths, joint details, and design codes and standards. Not included in this report are any redesigns or engineering calculations pertaining to the building.

1.3 General Building Description

The Generic Building Name is being built in a larger Medical campus of a notable university. Its purpose is to provide clinical services to cancer patients with solid tumors and provide diagnostic and treatment planning to new patients. The tenth floor will house a special breast cancer center. It is entirely funded by philanthropic donations.

In form, The Generic Building Name is a rectangular box. It's most prominent architectural feature is the large, 2 story canopy below the building on its north edge. This creates a covered space for drop off and an access road to the parking garage on the other side. The main entrance is a two-story mezzanine. Above the two bottom floors, the floor plans maintain a consistent rectangular shape with little variation. Refer to figure 1.3-1 for a typical architectural floor plan. The second floor features a connection bridge to the adjacent parking garage. Refer to Figure 1.3-2 for the space programing per floor. It is zoned in a community business district. No set backs are required in the zoning laws. The plot is 302,607 square feet. The building is total 108,000 square feet.

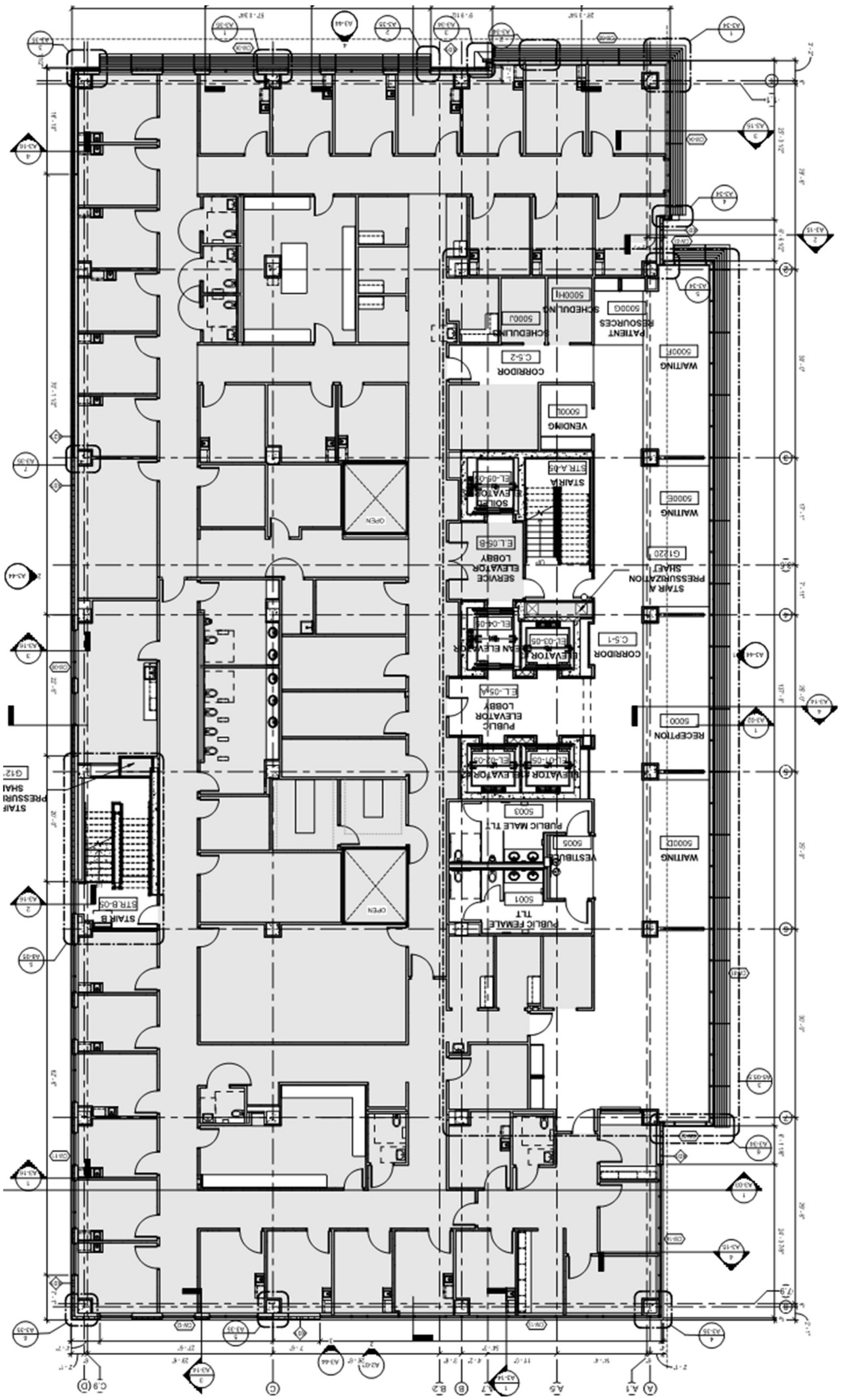


Figure 1.3-1: Typical Architectural floor plan

1st	Intake, Pharmacy, Phlebotomy
2nd	Patient Services, Clinical Research
3rd	Mechanical
4th	Imaging, Parking Garage Connection
5th	Clinic, Administration
6th	Infusion
7th	Clinical Research, Clinic
8th	Clinical Research
9th	Clinical Research
10th	Breast Clinic, Food Service
Roof	Elevator Rooms

Figure 1.3-2: Programing by floor

1.4 Brief Structural Framing Description

The Generic Building Name is a reinforced concrete building with two way reinforced concrete slabs. The Lateral system is ordinary reinforced concrete shear walls. Post tensioned beams act as transfer girders to create the canopy on the norther edge of the building. The foundation system is reinforced concrete auger piles.

2 BODY

2.1 Full Structural Description

The Generic Building Name is a reinforced concrete structure. Figure 2.1-1 shows a full 3D view of the structure and Figure 2.1-2 shows a typical floor plan. The gravity system is made of concrete columns and concrete flat slabs. All floors above grade and the roof are reinforced two way slabs with a 30”x30” typical bay. Every column has a 10’x10’x8” drop cap at its connection to the slab above in order to provide punching shear capacity. Due to the building medical use, some floor areas include thicker slab to carry a heavy equipment load.

Columns above the canopy come down on to four large concrete post tensioned beams. These beams are braced by smaller concrete infill beams. The beams are supported on either side by larger columns.

The lateral system is ordinary reinforced concrete shear walls. There are 9 individual shear walls placed around fire stairs and elevators. Most shear walls extend the height of the building while some taper after the third floor.

The first floor is a slab on grade. The buildings foundation system is reinforced concrete auger cast piles. Gravity load piles sit under the columns and lateral load piles sit underneath the shear walls.

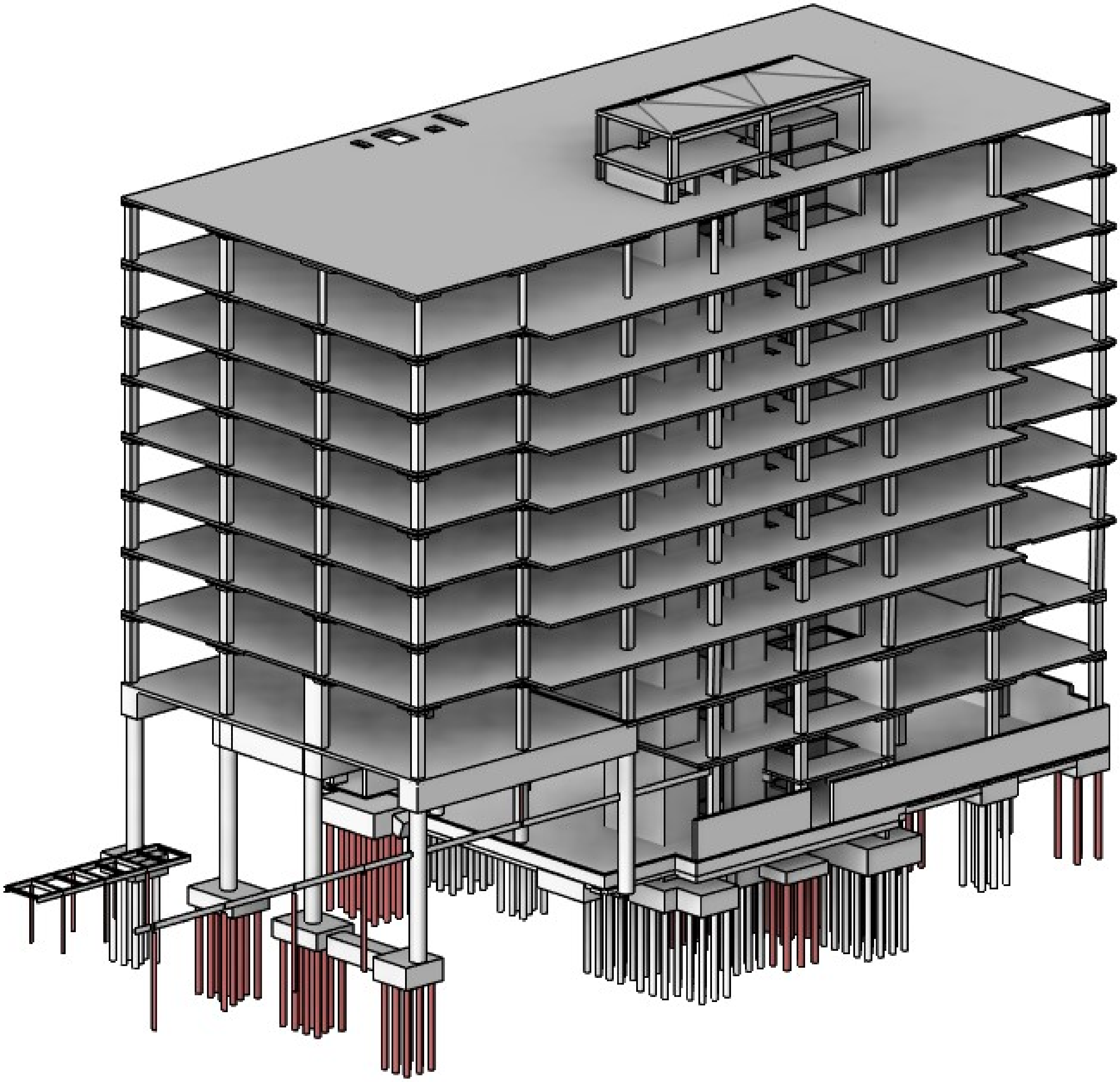
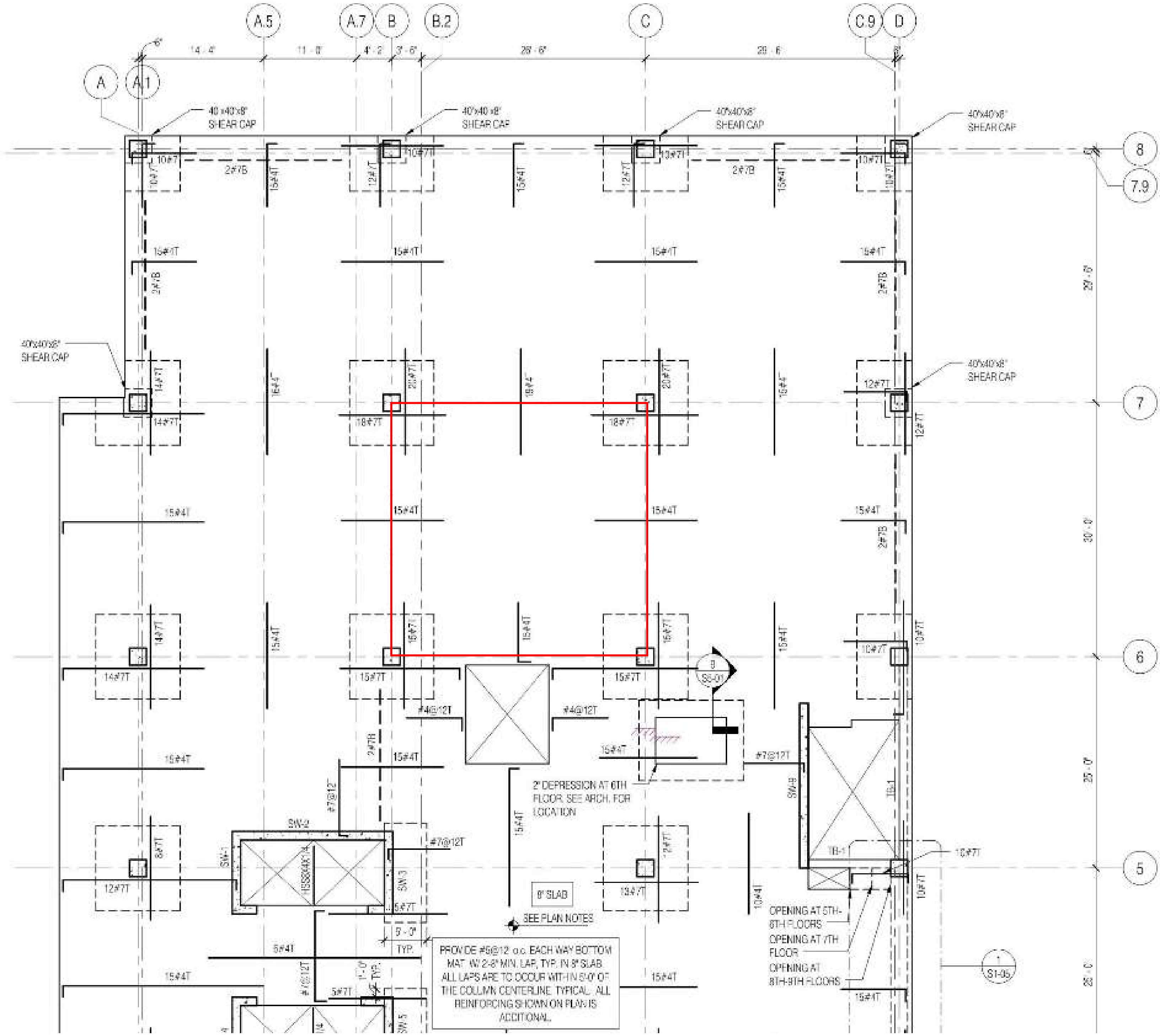


Figure 2.1-1: 3D analytical view of concrete structure



Typical Bay used in Section 2.2

Figure 2.1-2: Typical floor plan (rebar excluded for clarity)

2.2 Typical Bay

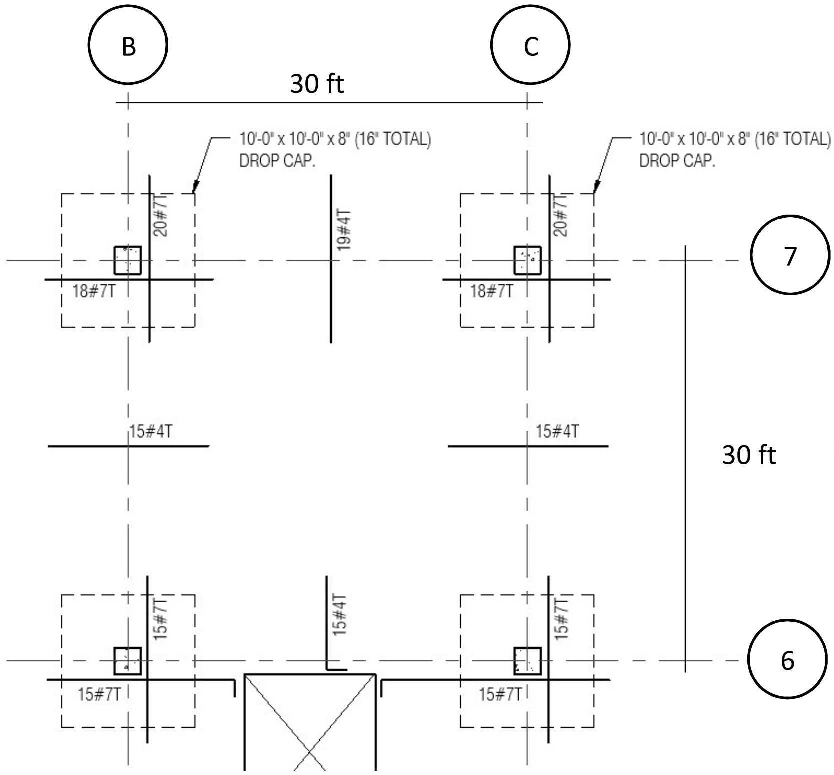


Figure 2.2-1: Typical floor bay

A typical bay in Generic Buildings Name is a 30' by 30' by 8 inch Concrete slab. All reinforced floors are 5000 psi concrete. See Appendix B for complete concrete strength chart. The slab is a two way system, therefore the slab must transfer loads in each direction to the columns. A uniform mat of #5 bars at 12" each way covers the entire bay. A minimum of two bottom bars continue through the columns. Additional bottom bars exist in special cases in other bays. See Figure 2.2-1 for rebar locations.

Top bar reinforcing is shown in Figure 2.2-1. The middle strip is 15' wide each way and the column strip is 15' each way. Top bars in the middle strip are typically #4 bars that spaced at least 12". Top bars in the column strip are typically #7 bars spaced at least 12". Each column has a 10'x10'x8" drop cap to help with punching shear.

2.3 Columns

The columns in Generic Building Name are assumed to only contribute to the gravity system; they are not designed to take any lateral load. All columns are reinforced. Five thousand psi or 6000 psi concrete mix was used. The majority of columns are 24"x24" with 8 #8 rebar in equally spaced along all sides. Forty two inch and thirty two inch circular columns support the transfer girders on either side. The circular columns have a corresponding circular rebar layout with # 10 rebar. More in depth information about the columns and their reinforcing can be found in the column schedule in Appendix B. Either #4 or #3 ties were used on all columns with between 10" and 22" spacing.

2.4 Lateral System

Lateral Loads applied to Generic Building name are resisted by ordinary reinforced concrete shear walls. Shear wall are constructed using 5000 psi concrete. See figure 2.4-1 for location of shear walls. The lengths of shear walls 8 and 9 decreases above the 3rd floor.

Shear walls are reinforced using #5 bars at 12" horizontally and vertically. Rebar chords are included in the ends of all shear walls. Six, eight and ten bar patterns of #8 bars are used in chords. Rebar in shear walls is to be spliced with a 2 foot minimum staggered splice.

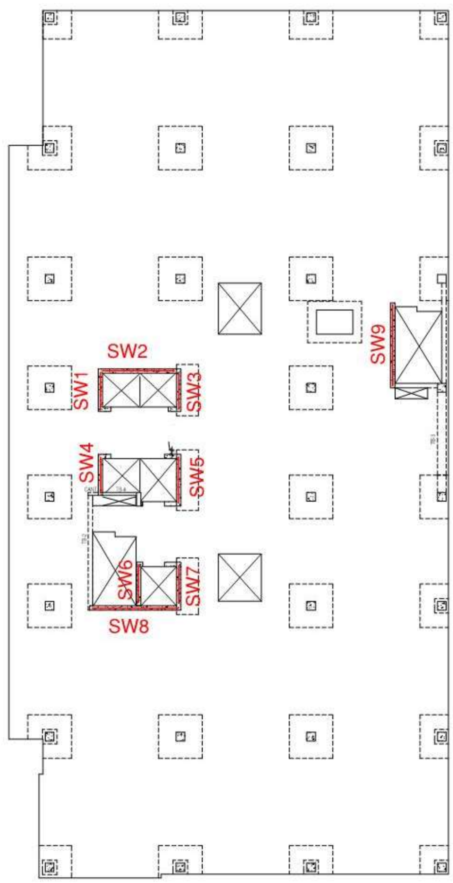


Figure 2.4-1: First Floor plan with highlighted shear wall locations

2.5 Load Paths

Gravity loads, such as dead, live, and snow loads are transferred from the two way slabs directly to the columns. The columns then take the loads down to the pile caps. Pile caps transfer the loads to the piles. Loads are transferred out of the building finally from friction between the piles and earth. In the case of columns above the canopy, loads are taken from the columns then transferred to the larger column by way of the large PT beams on the third floor (Figure 2.5-1 A). In the case of the column along column line D, the columns transfer the load to a grade beam then to the foundation system (Figure 2.5-1 B).

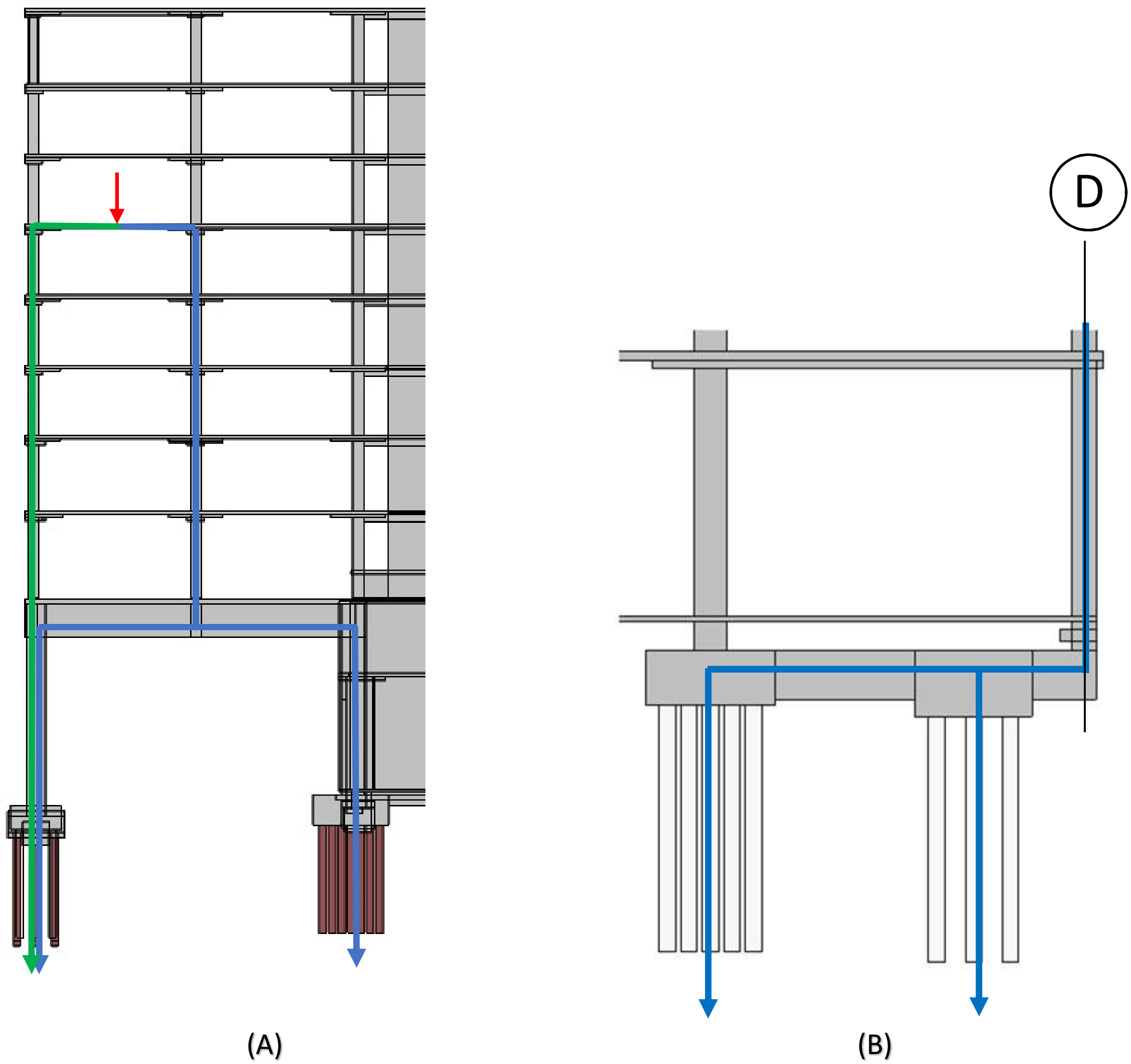


Figure 2.5-1: Special gravity load Paths for a sample load

Lateral wind pressure loads are transferred from the building envelope to the slabs. The slabs then transfer the loads to the shear walls which carry the loads down to the lateral foundations. Seismic equivalent loads are transferred from the slabs to the shear walls and from the shear walls down to the lateral foundations.

2.6 Other Structural Elements

The most notable additional structural elements in the Generic Building Name are the Post Tensioned concrete beams above the canopy. These beams act as transfer girders from the column above to the six columns below. In order to accommodate the loads from the upper floors, the beams are 72”x84” and 60”x84”. Figure 2.6-1 is a typical detail view of a PT beam.

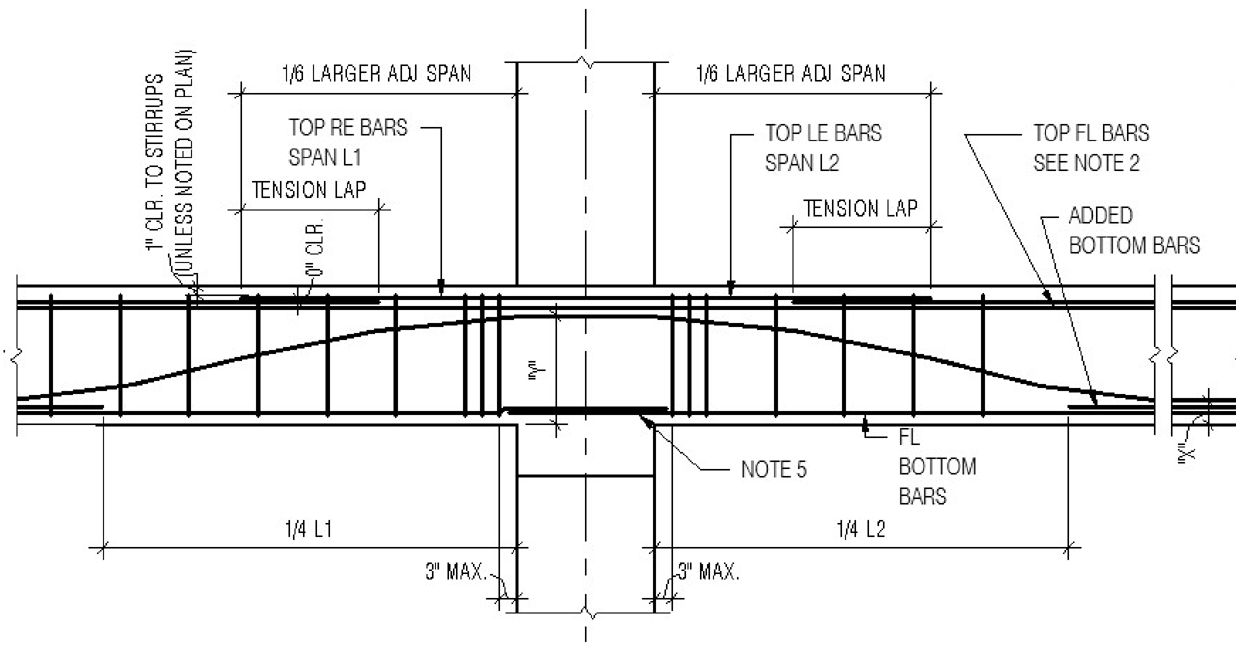


Figure 2.6-1: PT Beam detail

In order to support heavy medical equipment and HVAC equipment, there are drops in the 2nd ,3rd, 4th, and Roof Slabs. The Second floor connection bridge is an 7” and 8” cantilevered slab. The bridge roof is a similar 7” cantilevered slab.

2.7 Foundation System

The first floor of the Generic Building Name is a 5” slab on grade. The geotechnical report shows no suitable bed rock before 99 feet. All Foundations under the Generic Building Name are auger cast piles. All piles extend 46 feet into the ground. Each pile cap has between four and 21 piles. Two separate pile details are used, one for the lateral system and one for the gravity system. Lateral piles are reinforced with 6 #6 rebar. The reinforcing in the lateral piles extend 30 feet into the ground. Gravity piles are reinforced with 4 #5 vertical bars. The reinforcing in the gravity piles extend 12 feet into the ground. The piles have an axial capacity of 120 tons and a 28 kip lateral capacity.

Columns along column line D and south of column line 5 do not sit directly on pile caps. In these cases, grade beams are used to connect the column to the foundation system. A grade beam also extends underneath the retaining wall along southern side, see Figure 2.7-1.

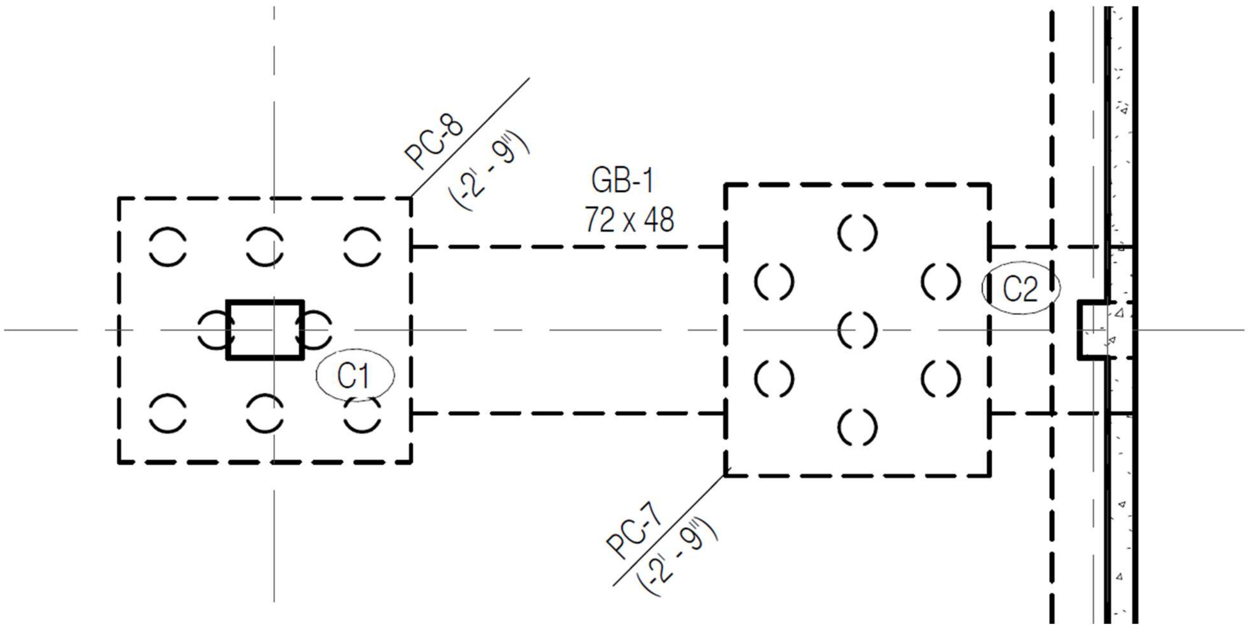


Figure 2.7-1: Grade Beam in Plan

2.8 Design Loads

Live loads per area type are as follows in Figure 2.8-1. The live loads were determined using ASCE 7-10. Loads followed by a [U] are unreducible. All other loads are reducible. A minimum of 30 psf roof live load was used.

AREA	LIVE LOAD	PARTITIONS
ASSEMBLY AREAS - LOBBIES	100 PSF [U]	N / A
BALCONIES - EXTERIOR	100 PSF	N / A
CORRIDORS	100 PSF	N / A
CORRIDORS - ABOVE 1ST FLOOR	80 PSF	N / A
HOSPITALS - PATIENT ROOMS	40 PSF	15 PSF
MECHANICAL ROOMS	150 PSF [U]	N / A
OFFICES	80 PSF	15 PSF
STAIRS & EXITWAYS	100 PSF [U]	N / A

Figure 2.8-1: Live Loads per area type

Superimposed Dead loads per area type are as follows. These loads were used in addition to self-weight of the structure.

AREA	SD LOAD
TYP. FLOORS	40 PSF
ROOF	30 PSF
MECHANICAL - 3RD	30 PSF
IMAGING - 4TH	30 PSF

Figure 2.8-2: Dead Loads per area type

Wind Loads were determined in accordance with ASCE 7-10. The design criteria is labeled in the Figure 2.8-3. See Appendix D for Cladding and components wind pressures.

Exposure Category	B
Ultimate Design Wind speed	115
Risk Category	III
Internal Pressure Coefficient	+/- 0.18

Figure 2.8-3: Wind load Design parameters

Seismic loads were determined using the equivalent force method. Figure 2.8-4 contains all factors used to determine the seismic loads on the structure. The seismic loads resulted in a base shear of 425 Kips.

Risk Category	III
Seismic Importance Factor, Ie	1.0
Mapped short Period spectral response acceleration, Ss	0.160
Mapped 1-second period spectral response acceleration, S1	0.053
Short period design spectral response coefficient, Sd1	0.085
Soil Site Class	D
Seismic design category	B
Response modification factor, R	4.5

Figure 2.8-4: Seismic load design parameters

In calculating the flat roof snow load conservative values of 1.0 were used for the exposure, and thermal factor. The Flat roof factor is 18 psf. Drifting and sliding loads were applied where applicable in the building. Figure 2.8-5 contains variables used in calculating flat roof snow load.

Ground Snow Load, Pg	25 psf
Snoe exposure factor	1.0
Snow Load importance Factor	1.0
Thermal Factor	1.0
Flat Roof Load	18 psf

Figure 2.8-5: Snow load design parameters

2.9 Design Codes and Standards

Generic Building name was built to the 2012 version of International Building Code (IBC). The concrete was designed to ACI 318 and ACI 117. ACI 336.1 was consulted in the design of the drilled piers. All welding was done to ANSI/AWS welding code. Additional standards used were: Manual of standard practice concrete reinforcing, Post tensioning manual from the Post tensioning institute, PCI design hand book, Steel Construction Manual, 14th edition, 2010, and Detailing for Steel construction from AISC.

2.10 Joint Details

Shown in Figure 2.10-1 is a typical detail of a floor slab to column connection. A minimum of two rebar must continue through all interior columns in both directions and a minimum of two rebar must terminate in 90 degree hook in all eternal columns.

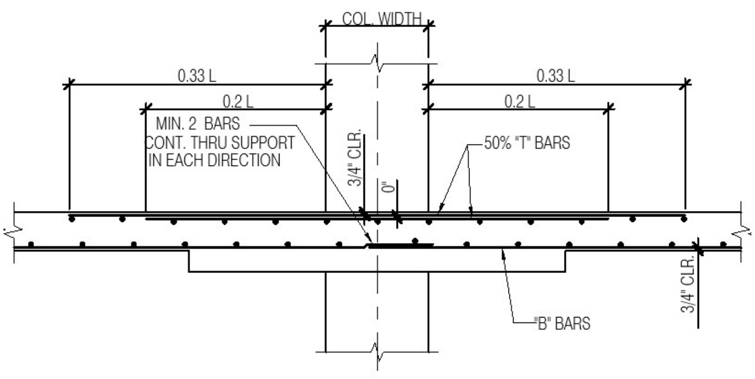


Figure 2.10-1: Slab to column connection detail

Figure 2.10-2 shows the joint detail between two slabs. The slab reinforcing should continue through the joint. Note 2 in the detail refers to additional required 4 foot #4 dowels placed at 18" on center in the middle of the joint.

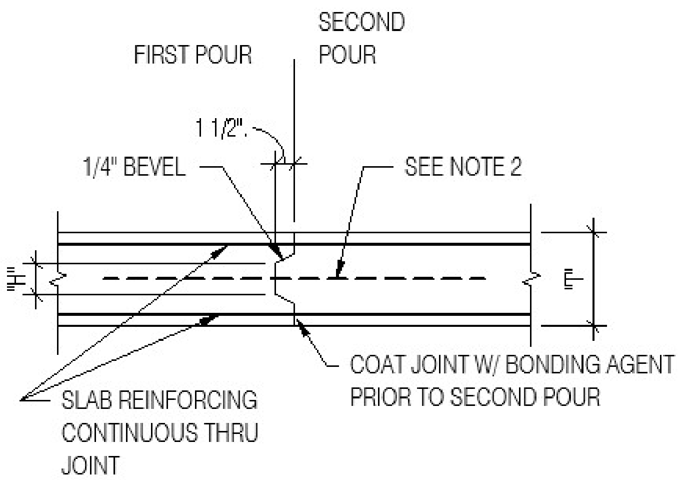


Figure 2.10-2: Slab joint detail

Figure 2.10-3 shows the Connection of the columns to pile caps. Additional top reinforcement is required at tension pile caps.

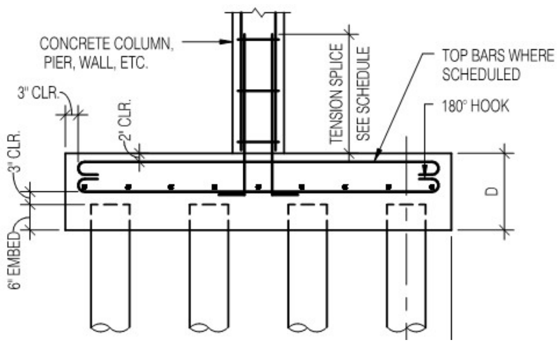


Figure 2.10-3: Column to foundation connection

3 PROPOSAL

3.1 Problem Statement

An analytical redesign of the Generic Building Name's structure. The redesign should aim to improve on the existing structure or to propose a learning opportunity. Two non-structural, breath, redesigns should be tied into the main redesign.

3.2 State Design alternative

Redesign the buildings structure with composite steel wide flange beams. Investigate a switch to a steel lateral system. Redesign the PT transfer girders to steel trusses. This option was primarily chosen as a learning opportunity to gain further design expertise with steel. The concrete flat slab is already optimized for the building structure and use. It is also very close do its deflection limits. Therefore a viable steel design will be a challenge but also offer many learning experiences. A switch to steel will also offer an opportunity to redesign the canopy framing to steel trusses. Deflection limits on the transfer girders above the canopy on the northern side of the building are close to their deflection limit. By switching to a steel composite frame the dead load of the building is reduced and therefore could be a viable redesign.

3.3 Methods

Ram concept will be used to assist with analysis of the existing pt beams. Etabs will be used to model the redesigned lateral system. Etabs or Sap2000 will also be used to design the transfer trusses to span the canopy.

Design loads will be check and revised using ASCE load calculations. The design of the composite steel girders will be based on AISC composite beam design. Design sizes will be generated from ram steel and check using AISC Tables. The steel trusses will be designed using AISC suggested material in conjunction with professional guidance.

3.4 Tasks

Task 1. Design Beams/Girders and Gravity Columns

a) Model floor plan in ram steel and analyzie

Hand check floor plan results

Task 2. Model Lateral systems in etabs

Compare Brace frame, moment frame, Shear walls

Design Lateral system

Hand check lateral system

Task 3. Model trusses in etabs

Design truss

Hand check truss

Task 4. Write Report

Task 5. Breath 1, Redesign Mechanical system to fit new floor height restrictions

Task 6. Breath 2, Analyze new schedule based on steel construction

Task 7. Final Presentation

3.5 Schedule

Week of (Monday)	8-Jan	15-Jan	22-Jan	29-Jan	5-Feb	12-Feb	19-Feb	26-Feb	5-Mar	12-Mar	19-Mar	26-Mar	2-Apr
	Start of Classes		Mile Stone 1		Mile Stone 2		Mile stone3		Spring Brake	Mile Stone 4			Mile Stone 4
	Task 1 Design Beams/Girders												
			Task 2 Design Lateral system										
					Task 3 Design Trusses								
					Write up								
											Presentation		
								Task 5 & 6 Breath topics					

3.6 Breath Topics

1. Impact on a new slab thickness on Mechanical Systems

The intended redesign in steel of the Generic Building Name will result in an addition of beams and girders in the ceiling cavity space. The mechanical system will have to be altered to fit the space constraints Therefore a short analysis of the duct work would be beneficial. An entire redesign of duct work is not part of this breath only a preliminary schematic layout.

2. Impact of steel on schedule

The Generic Building Name is being built in a region of primarily concrete construction. Therefore, a switch to a steel frame will affect the schedule and cost of the building. An analysis of the schedule would be a valid learning experience to learn the scheduling difference between concrete and steel construction.

3.7 Masters Requirements

To meet the requirement of AE 897. Three graduate level courses will be utilized. Two of which have been completed before the spring 2018 semester and one will be taken during the spring 2018 semester. Use AE 530 building modeling course to model the existing structure and to model the redesign in steel. Etabs. Use 597 Post tensioning to analyze existing PT transfer girders. Use AE 534 steel connection to help design the connections in the redesign and the connections between lateral systems and gravity systems and the connections between the main gravity system and the trusses above the canopy.

4 Conclusion

4.1 Summary

The Generic Building name has a concrete column and flat slab system that sits on auger cast piles. A typical bay in Generic Buildings Name is a 30’ by 30’ by 8 inch two way Concrete slab. The lateral system is ordinary reinforced concrete shear walls. Post tensioned concrete beams hold up the canopy. Lateral forces such as Wind and seismic forces were determined using ASCE 7-10. Seismic loads were determined using the equivalent force method.

4.2 Conclusion

The proposed redesign of The Generic Building will be a steel frame with composite steel beams and girders. The lateral system will be designed as either a moment frame or a braced frame. The more efficient of the two lateral systems will be chosen.

The Large transfer girders will pose the biggest challenge in a steel redesign. From communication with the design team the girders were barley with in service limits. A switch from concrete to steel could possibly require more redesign to keep those girders within service limits. The top heavy form of the building could propose a challenge in future seismic designs.

The in addition the main redesign two breath topics have been chosen. A study on the mechanical system will be conducted to analyze the introduction of beams and girders on the duct work. A study on construction will be conducted to analyze the effect of the change in construction type on the schedule.

4 APENDIX

Appendix A Column schedule

CONCRETE COLUMN SCHEDULE

LEVEL \ COLUMN	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18
MECHANICAL ROOF																		
ROOF																		
10TH FLOOR	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8					24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	18' Ø 8#8
9TH FLOOR	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8					24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8
8TH FLOOR	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8					24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8
7TH FLOOR	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8					24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8
6TH FLOOR	24x24 8#10	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8					24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#10	24x24 8#8
5TH FLOOR	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8					24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8
4TH FLOOR	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8	24x24 8#8					24x24 8#8	24x24 8#8	24x24 12#10	24x24 8#8	24x24 12#10	24x24 8#8	24x24 8#8	24x24 12#8	24x24 8#8
3RD FLOOR	24x24 16#10	24x24 12#8	24x24 8#8	24x24 8#8	24x24 12#11					24x24 16#8	24x24 16#8	24x24 16#11	24x24 16#8	24x24 16#11	24x24 8#8	24x24 8#8	24x26 16#10	24x24 16#8
2ND FLOOR	24x32 16#10	24x24 12#11	24x24 8#8	24x24 12#8	24x24 12#11 6 KSI	42' Ø 32#10 #4@12"	42' Ø 10#10 #4@12"	42' Ø 18#10 #4@12"	36' Ø 32#10 #4@12"	24x48 16#9 #4@12"					24x24 8#8	24x24 12#10	24x32 20#10	
1ST FLOOR/TOP OF FOUNDATION	24x32 20#10 #4@12"	24x24 16#11 #4@12"	24x24 8#8 #4@12"	24x24 16#8 #4@12"	24x24 16#11 #4@12" 6 KSI					24x48 16#9 #4@12"					24x24 8#8 #4@12"	24x24 16#10 #4@12"	24x32 24#10 #4@12"	
DOWELS	20#9	16#9	8#8	16#8	16#9	32#9	10#9	18#9	32#9	16#9	16#8	16#9	16#8	16#9	8#8	16#9	24#9	16#8
WORKING LOAD																		
REMARKS																		

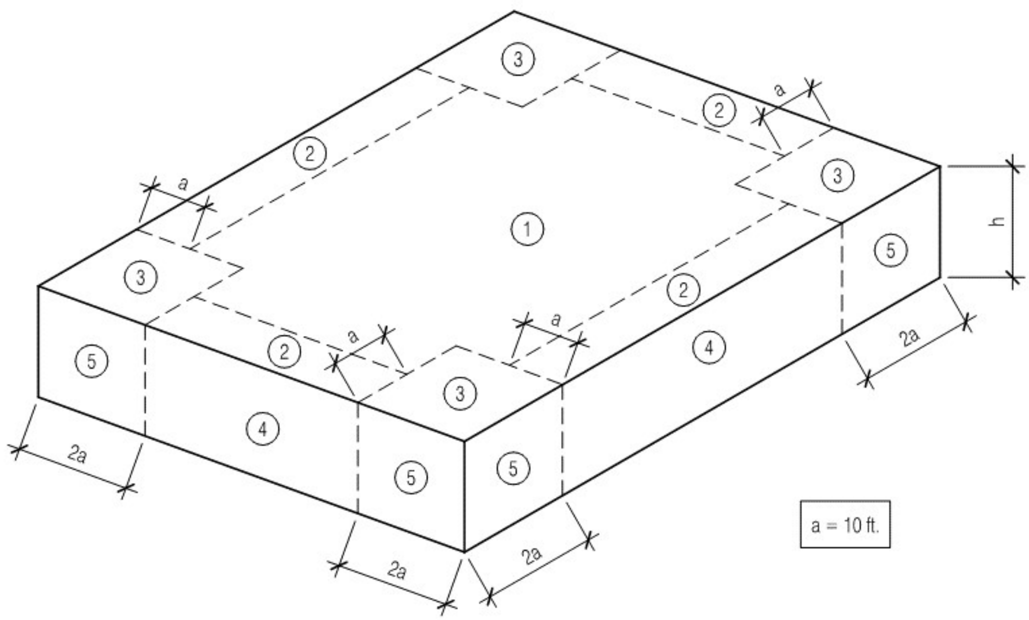
C19	C20	C21	C22	C23
18" Ø 8#8	18" Ø 8#8	18" Ø 8#8	12x37.5 8#8	24x24 8#8
24x24 8#8	24x24 8#8	24x24 8#8	12x37.5 8#8	24x24 8#8
24x24 8#8	24x24 8#8	24x24 8#8	12x37.5 8#8	24x24 8#8
24x24 8#8	24x24 8#8	24x24 8#8	12x37.5 8#8	24x24 8#8
24x24 8#8	24x24 8#8	24x24 8#8	12x37.5 8#8	24x24 8#8
24x24 8#8	24x24 8#8	24x24 8#8	12x37.5 8#8	24x24 8#8
24x24 8#8	24x24 12#10	24x24 8#8	12x37.5 8#8	24x24 8#8
24x24 16#8	24x24 16#11	24x24 8#8	12x37.5 8#8	17x31 12#8 #4@12"
		24x24 12#8	12x37.5 8#8	17x31 12#11 #4@12"
		24x24 16#8 #4@12"	12x37.5 8#8	17x31 16#11 #4@12"
16#8	16#9	16#8	8#8	16#9

Appendix B Concrete strength chart

CONCRETE MIX DESIGN TABLE									
MEMBER	LOCATION	f'c	W/C	EXPOSURE CATEGORY				ENTRAINED AIR CONTENT	
				F	S	P	C	3/4" AGGREGATE	1" AGGREGATE
CONCRETE PILES	N/A	5000 PSI	0.45	F0	S0	P0	C0	N/A	N/A
PILE CAPS	N/A	4500 PSI	0.45	F2	S0	P0	C1	N/A	N/A
GRADE BEAMS	INTERIOR	3000 PSI	0.55	F0	S0	P0	C0	N/A	N/A
FOUNDATION WALLS	INTERIOR	4500 PSI	0.45	F0	S0	P0	C0	N/A	N/A
	EXTERIOR			F2	S0	P0	C1	6 +/-1.5%	6 +/- 1.5%
SHEAR WALLS	N/A	5000 PSI	0.45	F0	S0	P0	C0	N/A	N/A
COLUMNS	INTERIOR	6000 PSI	0.42	F0	S0	P0	C0	N/A	N/A
	EXTERIOR			F1	S0	P0	C1	5 +/-1.5%	4.5 +/- 1.5%
COLUMNS	INTERIOR	5000 PSI	0.45	F0	S0	P0	C0	N/A	N/A
	EXTERIOR			F1	S0	P0	C1	5 +/-1.5%	4.5 +/- 1.5%
SLABS-ON-GRADE	N/A	3500 PSI	0.55	N/A	N/A	N/A	N/A	N/A	N/A
REINFORCED FLOOR FRAMING	INTERIOR	5000 PSI	0.50	F0	S0	P0	C0	N/A	N/A
	EXTERIOR	5000 PSI	0.45	F1	S0	P0	C1	5 +/-1.5%	4.5 +/- 1.5%
POST-TENSIONED GIRDERS	INTERIOR	6000 PSI	0.40	F0	S0	P0	C0	N/A	N/A
	EXTERIOR			F1	S0	P0	C1	5 +/-1.5%	4.5 +/- 1.5%

Appendix C Cladding and components

	WIND COMPONENT & CLADDING LOAD SCHEDULE LOADS ARE FACTORED						
	POSITIVE PRESSURE		NEGATIVE PRESSURE				
AREA (SQ. FT.)	ZONE 4 (PSF)	ZONE 5 (PSF)	ZONE 1 (PSF)	ZONE 2 (PSF)	ZONE 3 (PSF)	ZONE 4 (PSF)	ZONE 5 (PSF)
10	35	35	-50	-78	-106	-34	-63
20	35	35	-47	-74	-101	-34	-63
50	32	32	-44	-69	-95	-33	-55
100	30	30	-41	-65	-90	-31	-50



References

Architectural Floor Plans and exterior rendering created by Wilmot Sanz

Structural diagrams and plans created by Cagley and Associates

ASCE 7-10, ACI 318, IBC