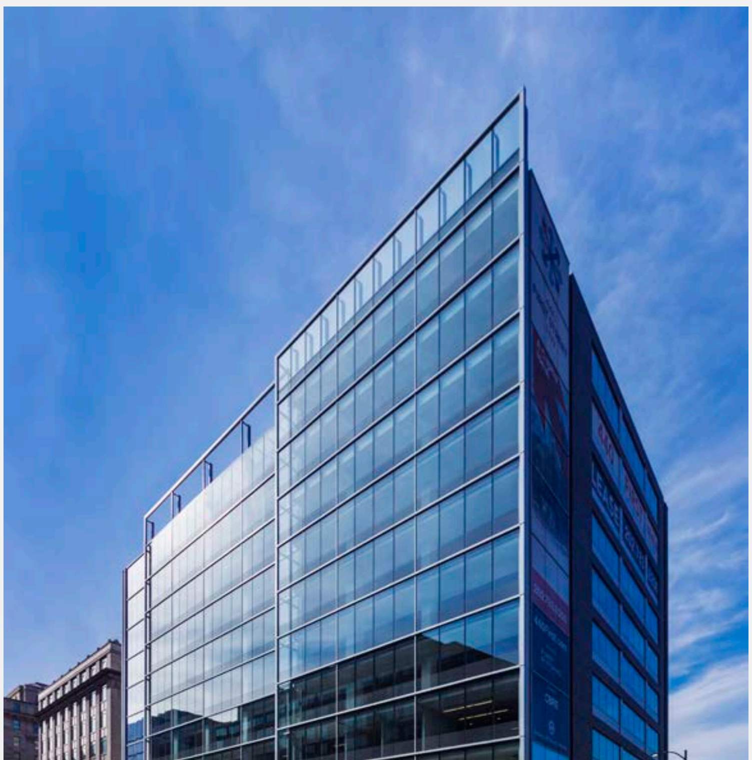
440 FIRST STREET, NW
WASHIGNTON, D.C.



TECHNICAL REPORT I

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EXECUTIVE SUMMARY

440 First Street is a mixed use building located in Washington, D.C. The existing 8-story building, constructed in the early 80's began renovation in 2012 and was completed in 2013. Three stories were added to the building, including a penthouse, resulting in a 20.6 foot increase in building height and a total gross square footage of about 142000 GSF. The new 10-story architectural design provided a seamless transformation of the existing building into a more modern, state-of-the-art building, well on its way to a platinum LEED certification.

The existing building, floors 1 to 7, comprises of a frame assembly of cast-in-place concrete structural slabs and column, with low story heights. The foundation system is mainly supported by the spread footings. The new, additional framing (8^{th} floor and above) uses composite framing, with wide flange steel shapes used in the majority of the added structural system.

Building codes and design standards typically used in the project include the ASCE and the IBC, with gravity, lateral, and seismic loads all considered.

This report will cover the codes, design loads, existing framing, framing renovations and additional framing in more detail and in a wider perspective.

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Introduction

Purpose

The purpose of this report is to outline and describe the design concepts behind the structural system, looking in-depth into the various systems such as the gravity, lateral, and the foundation systems. Furthermore, there will be a description of the codes used in 440 First Street

General Description

FP 440 First Street, NW, as seen in Figure 1, is located between D and E streets in downtown Washington, DC near the United States Capitol. The existing building was originally an 8-story building constructed in 1982 and had no major upgrades until the renovation was begun in 2012. The renovation comprised of adding three floors, an additional 34,500 square feet, which resulted in a 32% increase over the existing 106,850 GSF. The building height was raised 20.6 feet and 2 floors as the existing roof (story height = 11'-8") was removed through the use of Transfer Development Rights, thus allowing three 10'-9" stories within a total of 32'-3". The renovated building comprises of 11 stories above grade, which includes a penthouse level and 2 stories below grade.

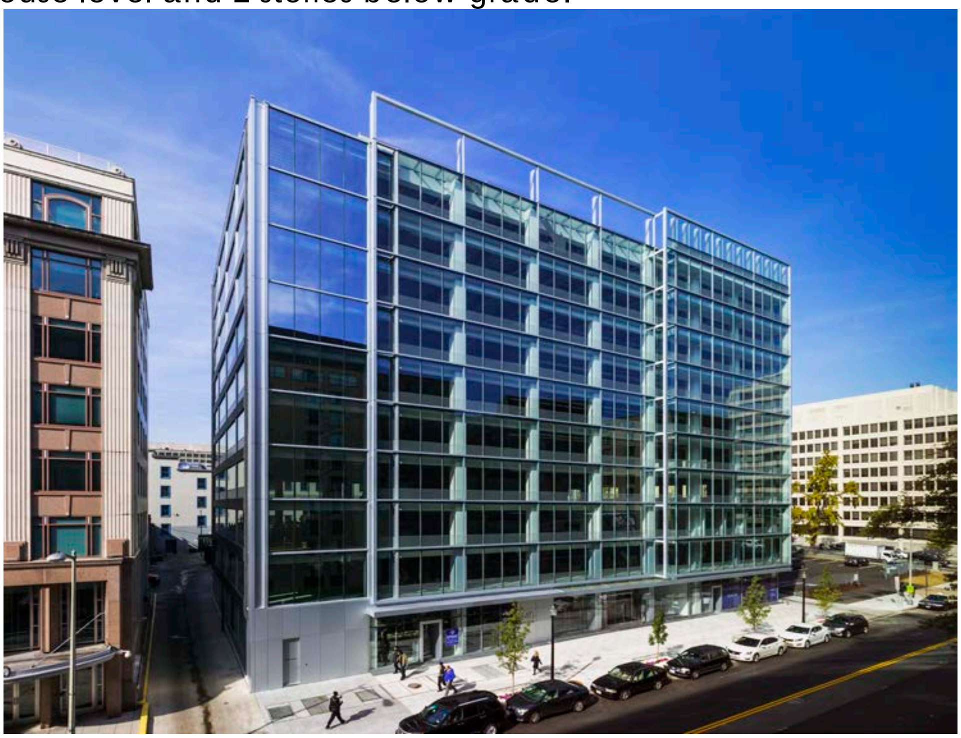


Figure 1 | View from adjacent building

440 First Street is an office/retail building that has been re-constructed to fit the modern day requirements, while remaining aesthetically appealing.

Structural Design

This section offers a broad description of the overall structural design, including an in-depth look into the design criteria and the structural systems proposed for the renovation and addition.

Overview of the Structural System

Building Materials

The following ASTM standards and design stresses shall be used for the appropriate materials used in the construction of this project.

STRUCTURAL STEEL		
Member	Grade	Fy
Rolled Shapes	ASTM A992, Grade 50	50
Channels, Angles and Plates	ASTM A36	36
Structural Tubing	ASTM A500, Grade B	46
High Strength Bolts	ASTM A325-N	
Expansion Anchors	HILTI KWIK Bolt TZ	

MASONRY		
Use	Grade	Strength (PSI)
Load Bearing Concrete (Hollow and Solid)	ASTM C90	1900
Load Bearing Concrete (Brick)	ASTM C55	2000
Mortar	ASTM C270	
Grout	ASTM C476	2000
Horizontal Joint Reinforcing	ASTM A82	
Compressive Strength of Masonry		F'm = 1500 PSI

CONCRETE AND REINFORCING		
Use	Weight	Strength (PSI)
Slabs-on-grade (Interior)	145	3000
Slabs-on-grade(Exterior)	145	4500
Fill on metal deck	115	3500
Topping	145	3000
REINFORCEMENT		
Use	Grade	
Deformed Reinforcing Bars	ASTM A615, Grade 60	
Welded Wire Fabric (WWF)	ASTM A185	

Existing Framing

The existing building is a cast-in-place concrete structure consisting of two-way structural concrete slabs and reinforced concrete columns. A concrete slab on grade occurs at the lowest level of the garage. Furthermore, concrete columns and foundation walls are supported by spread footings

Existing slab, garage and framing renovations

The existing roof slab and penthouse were removed and the existing slab edges were added to on all four sides for two reasons: increasing the net rentable space for each floor, and to provide a consistent location for new façade connections, as seen in Figure 2. Also, at the front of the building, slab edge and curtain wall at the corner column bays were extended to the property line, requiring cantilevered channel sections which were through bolted to the existing concrete columns, and support a new composite concrete slab.

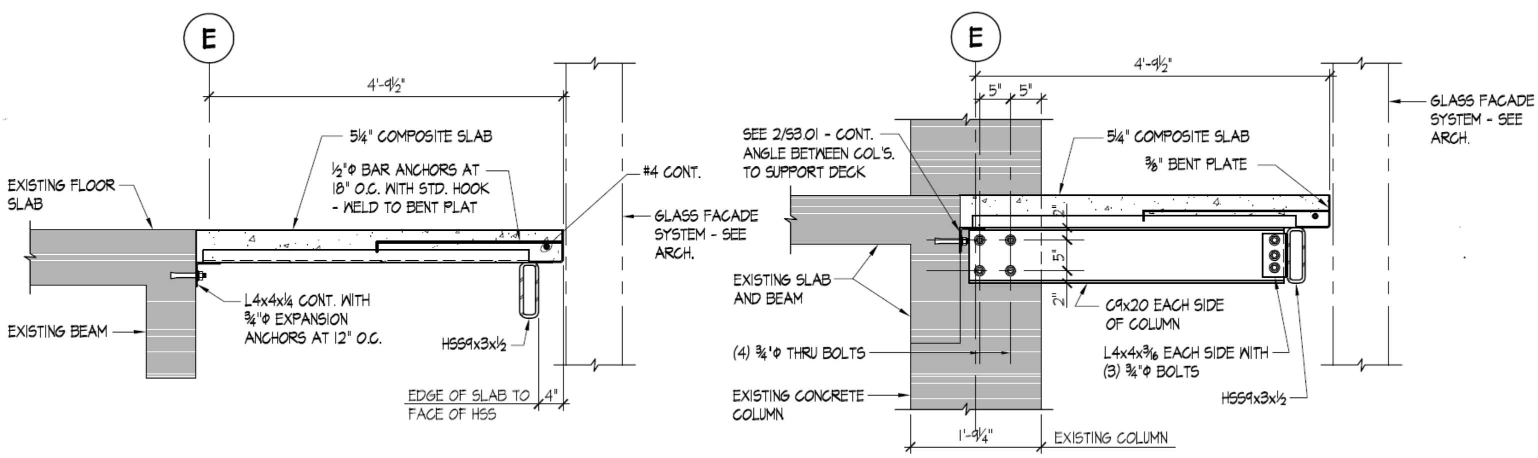


Figure 2 | Slab Extension Details

Slab extension at floors 2-8 will occur at the east side of the building toward the north, to match the new upper floors.

The existing garage levels had experienced serious deterioration due to road salts brought in on cars, and the design drawings contained repair plans and details. This work was performed first, and allowed parking for workers of all trades as the construction progressed.

Floor System

As aforementioned, the floor system is comprised of steel reinforced cast-in-place concrete two-way slab system on typical floors (2-8). The system consists of 7” lightweight concrete on 2” deep, 18 gage galvanized composite metal deck (total thickness = 7”) reinforced with 6x6-W2.9xW2.9 WWF on typical floors, unless noted otherwise. Other slab thickness vary from 5 ¼” – 9 ½”, as seen in Figure 3, depending on the location.

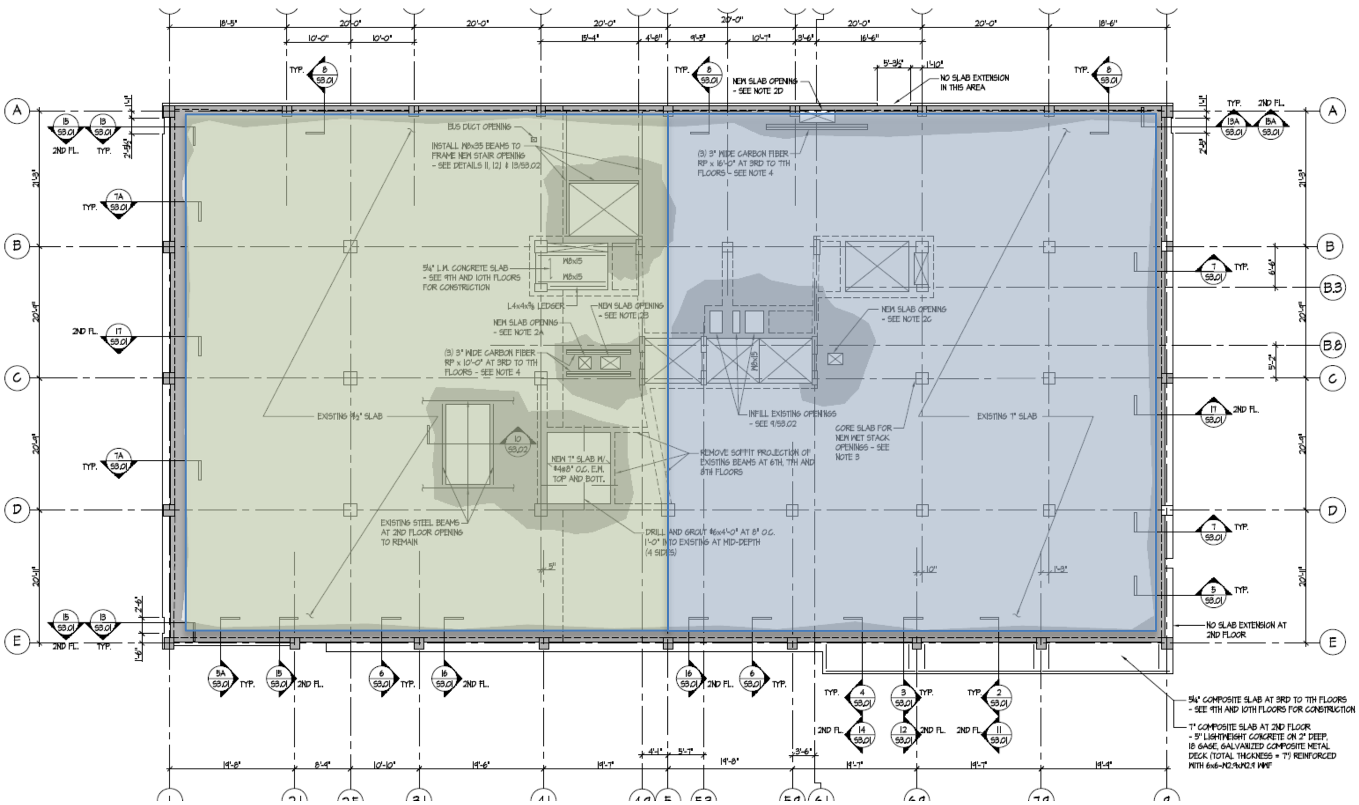
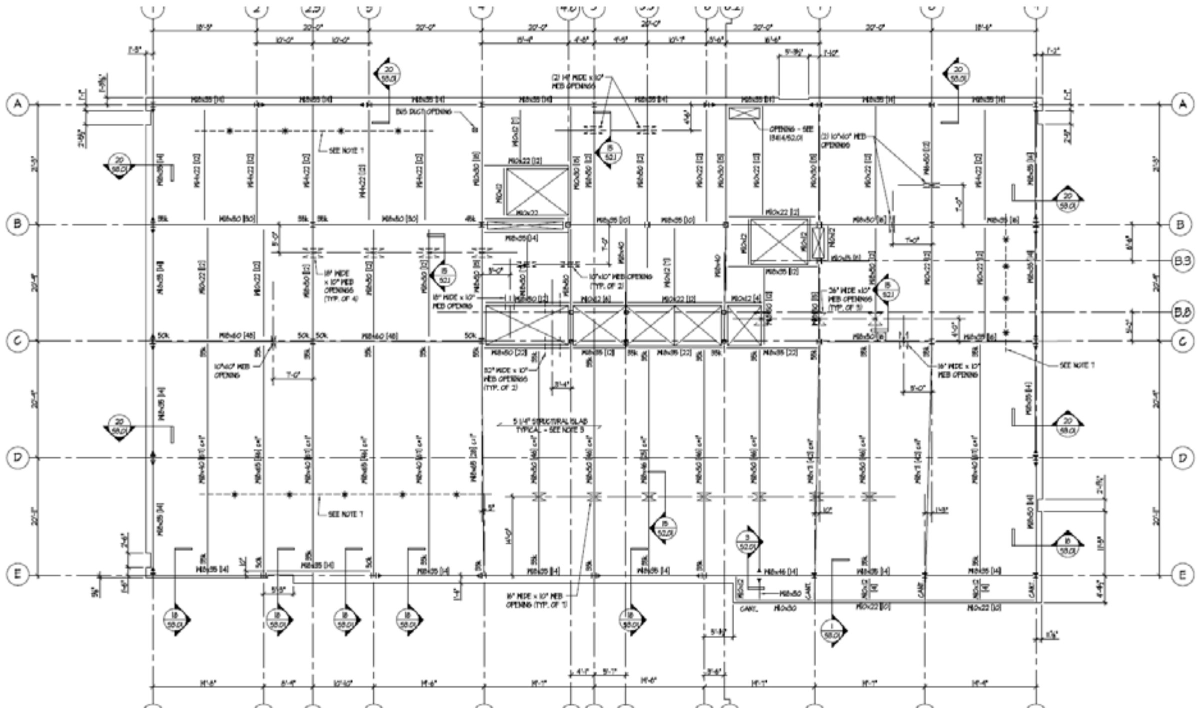


Figure 3 | Typical floor plan of the building

9 ½” slab   7” slab

Addition Framing System Overview

There is an addition of three stories of steel framing (two new floors and a roof/penthouse) above the existing 8th floor. The new framed floors and roof are constructed using composite framing with a 5 ¼” thick structural slab (comprised of 3 ¼” of lightweight concrete fill on a 2” thick, 18 gage metal deck), reinforced with 6x6-W2.0xW2.0 WWF. Figures 4 and 5 show a partial typical structural steel framing plan, with beams spaced at 10’-0” on center and girders spanning 20’-0” between columns. Beam and girder sizes are typically W10’s, W14’s and W18’s.



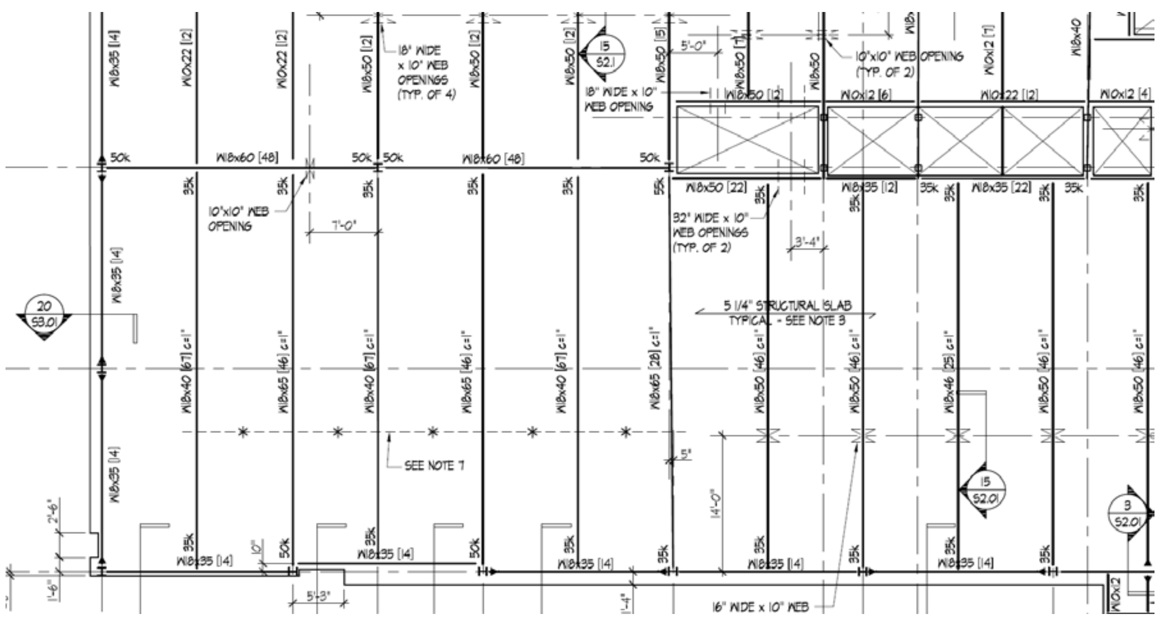


Figure 4 & 5 | Typical structural framing plan of the building
(Partial Plan below)

A two hour fire rating is achieved by spray proofing the beams and girders.

Roof system

The roof framing system as hinted earlier, is a structural steel system. It can be broken down into two parts: the main roof/penthouse framing plan and the penthouse roof framing, as shown in Figures 6 and 7. The penthouse roof deck is a 1 ½” deep, wide rib, 20 gage galvanized metal deck.

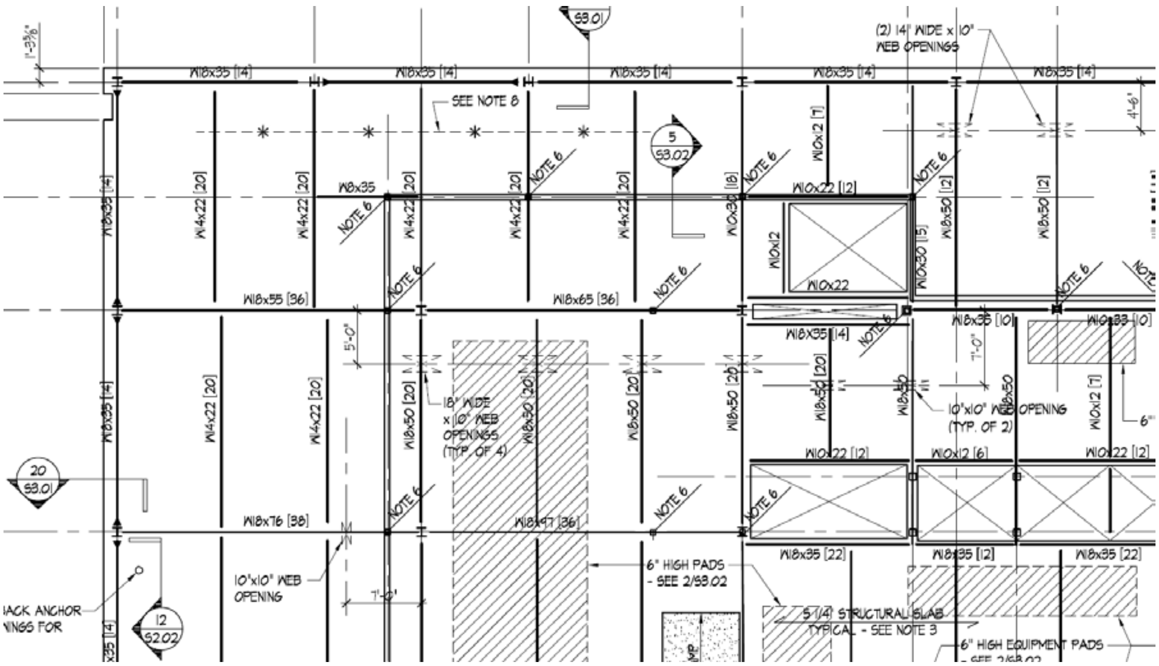


Figure 6 | *Partial* Main Roof/Penthouse framing plan

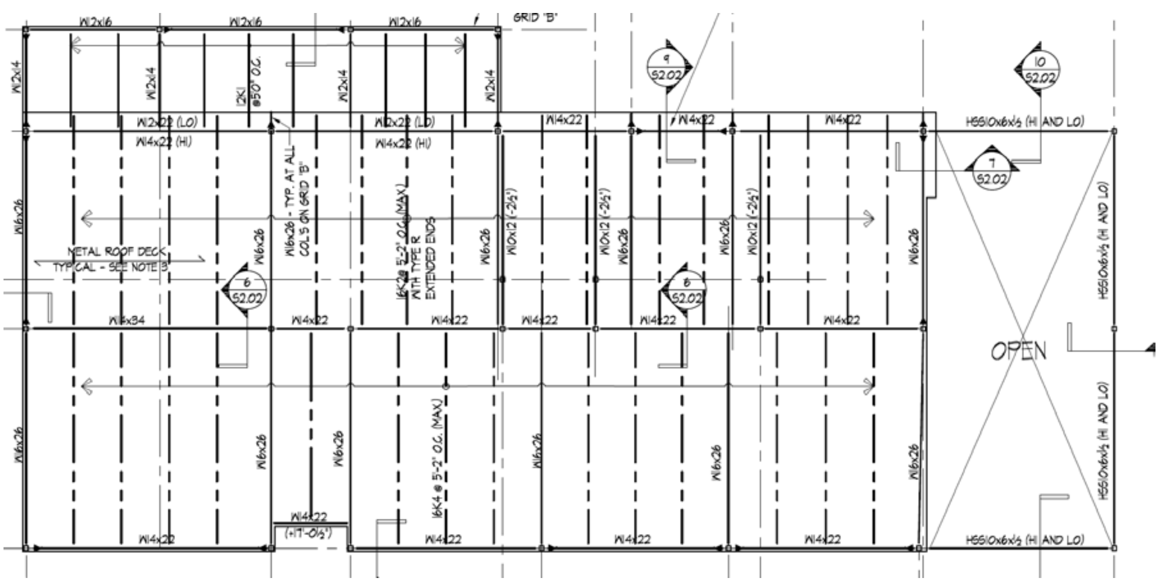


Figure 7 | Penthouse roof framing plan

The penthouse floor framing plan includes an additional framing for the 12000 LBS cooling tower, as seen in figure 8 and provides requirements for the 6" high equipment pads, as shown in Figure 9

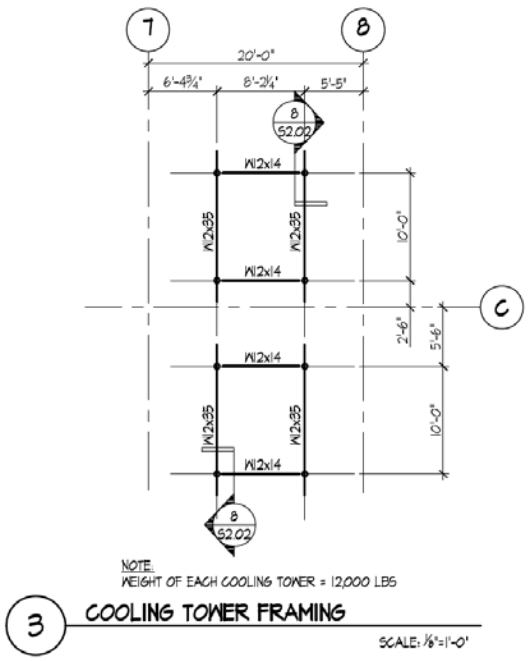


Figure 8 | Cooling Tower Framing Plan

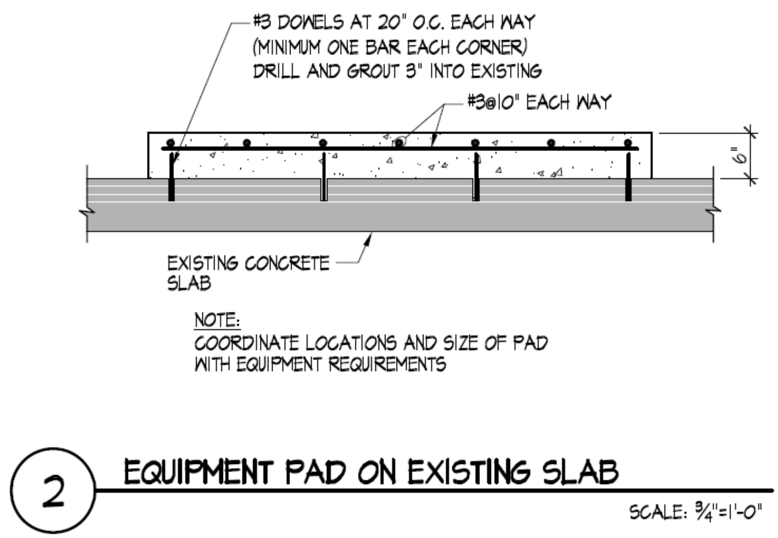


Figure 9 | Equipment Pad Framing

Typical Bay – Floor system

There are multiple bay sizes used in 440 First Street. A typical bay, 20' x 20'-11", was selected from the framing plans for floors 2 – 7, and is highlighted in Figure 10 below. Due to the different thicknesses of slabs (7" and 9 ½") on the typical floors, slab reinforcements vary.

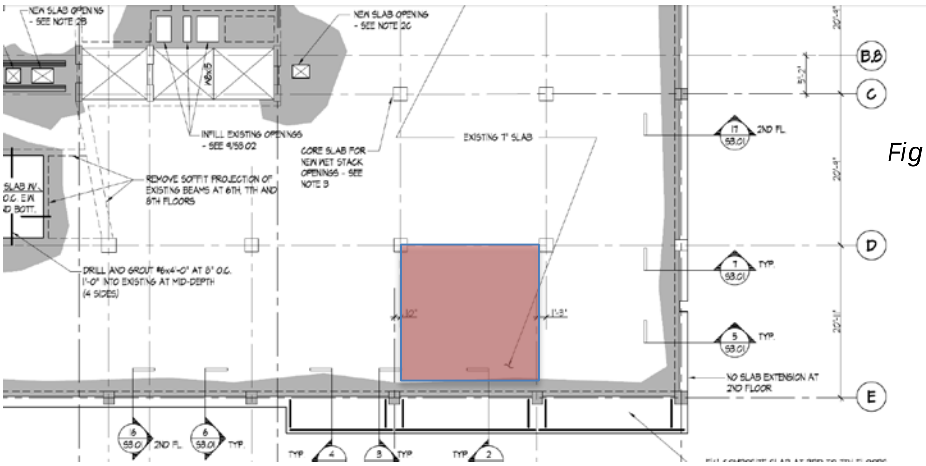


Figure 10 | Typical Bays shown

For the new additional floors, typical girders will span 20 feet between columns and beams are spaced at 10 feet on center. Figure 11 shows a typical bay size, with beam sizes varying. The most common sizes are W10's, W14's and W18's as mentioned earlier.

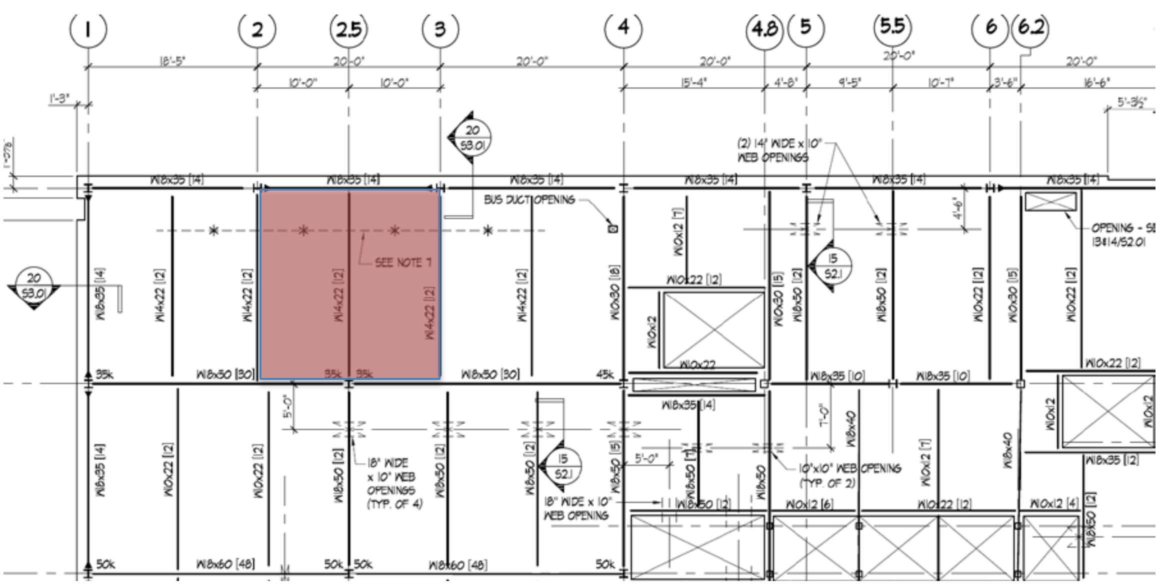


Figure 11 | Typical Bay in structural framing

Columns

From the 8th floor, new steel columns were added and centered to the existing columns. The additional framing provides a column layout that creates interior column free space by eliminating the first interior columns on the east side of the building, as shown in Figure 11. The new columns will typically be 10 inch wide by 10" deep steel wide flange shapes.

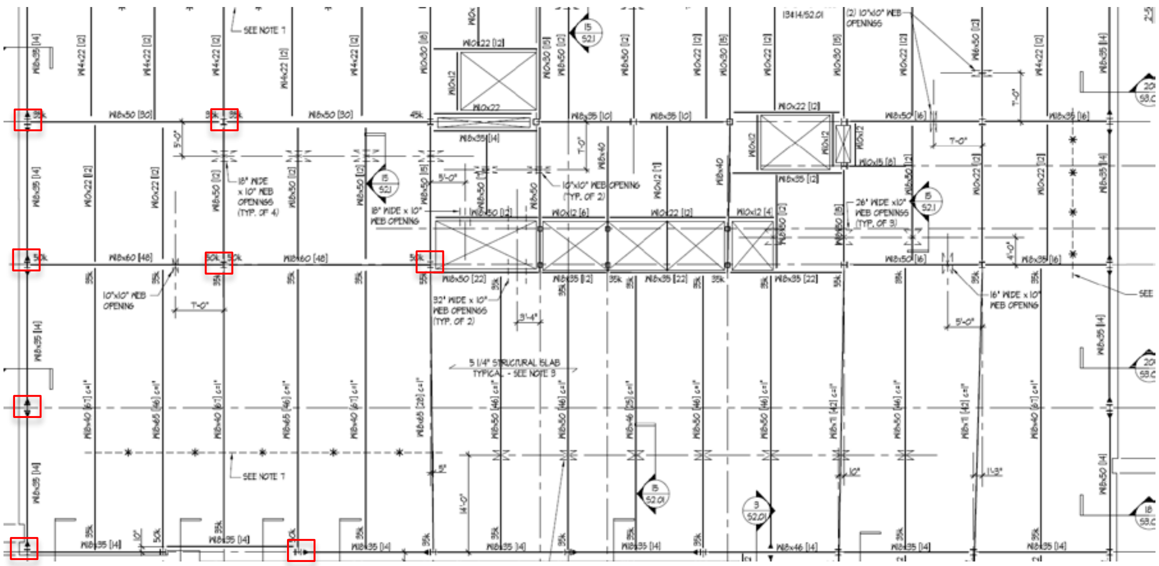


Figure 12 | Steel columns highlighted in red

The rebar for the existing concrete column was to be retained for a height of 2'-10" above the 8th floor slab, following the demolition of existing roof and penthouse removal, as shown in the column detail in figure 13.

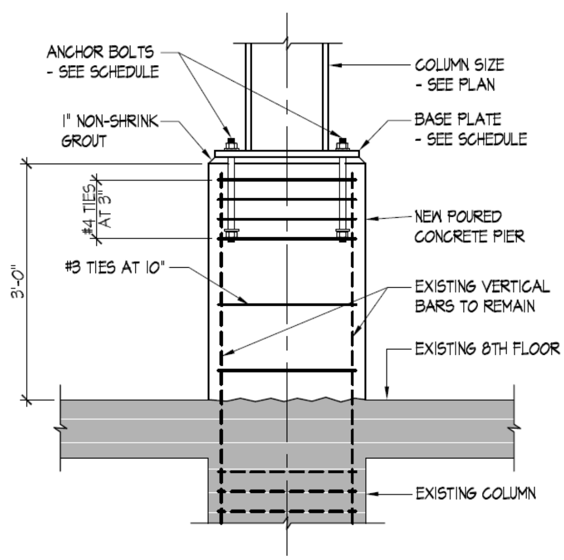


Figure 13 | Column Base Detail

A preliminary analysis was conducted and it indicated that removing the existing concrete roof and concrete penthouse roof, in addition to removing the building skin on all 4 sides, provided a column load reduction that enabled the new totals to be comparable to the column loads on the existing base building drawings, after the new steel frame loads were added

Lateral System

The lateral Force Resisting System consists of moment connections at the new steel framed levels, and will be used in conjunction with the slab-column frames at the existing levels.

The 2009 International Building Code chapter 34, Section 3403.4, which requires that an existing structure and its addition acting together as a single structure be shown to meet the requirements for wind and seismic design per 1609 and 1613. With that said, it allows an exception which states that load-carrying structural elements, columns and footings in this case, whose demand-capacity ratio with the addition is no more than 10 percent greater than its demand-capacity ratio with the addition shall be permitted unaltered.

The figures below show the location of the steel moment frames on the new levels and the slab-column frames on the existing levels.

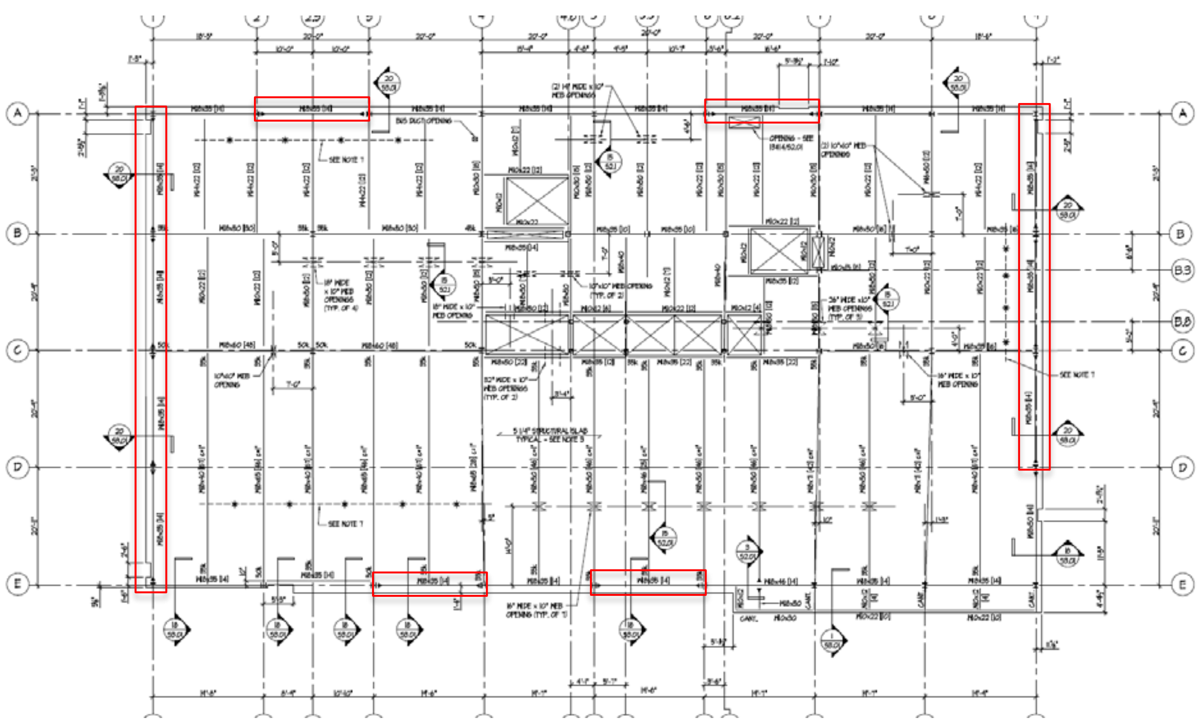


Figure 14 | Steel moment frames highlighted in red

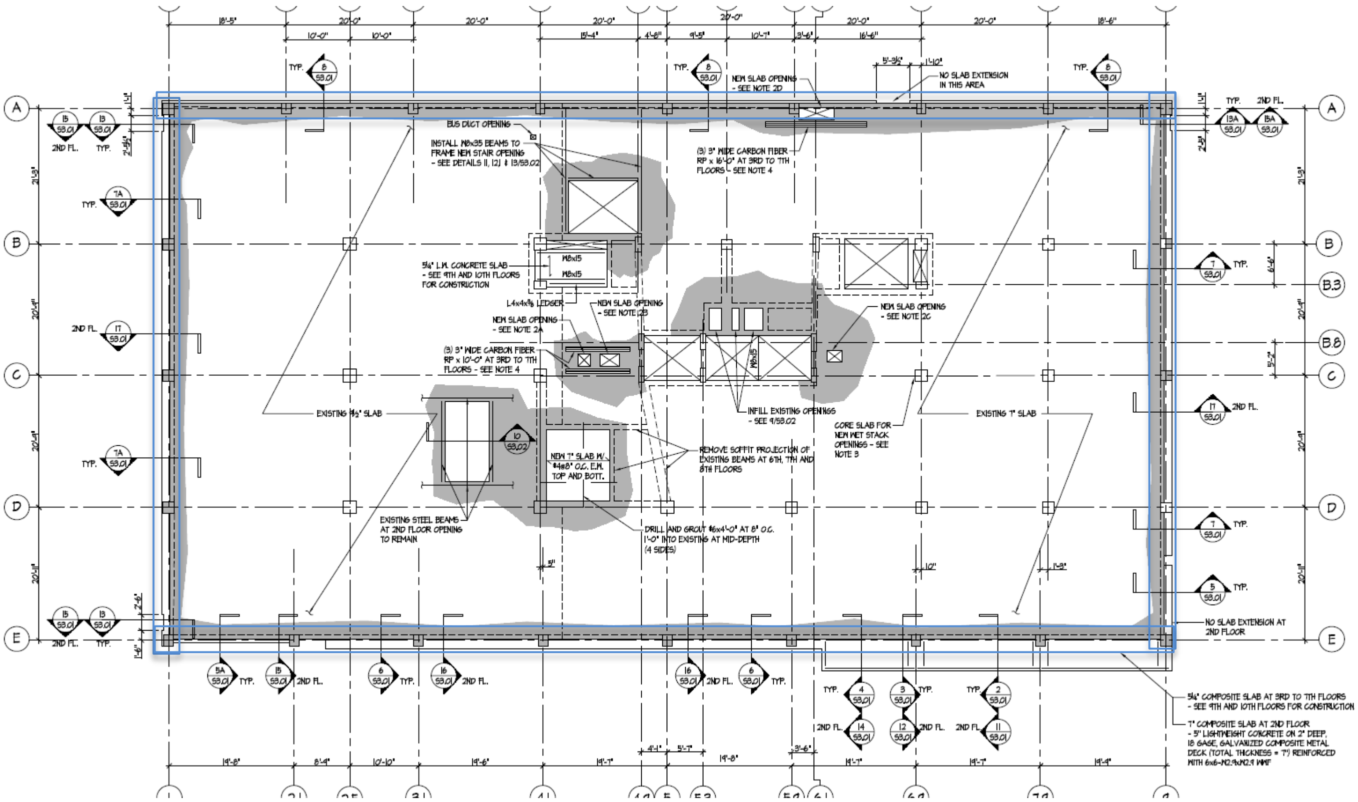


Figure 15 | Slab-Columns Moment Frames highlighted in blue

Foundation System

A geotechnical report was done by Schnabel Engineering Associates in the 1980's. They recommended foundation requirements for the support of the proposed building and floor slabs on grade, after an evaluation and analysis of subsurface conditions. Column footings and wall footings were determined to be used for the foundation system. Furthermore, the concrete columns and foundation walls are supported by spread footings.

Recommended design bearing values are 6000 PSF for the column footings and 4000 PSF for the wall footings. With the proposed addition of the new building, no new soil reports were performed as the addition loads were lighter than what was removed

A typical footing detail and a partial cellar plan are shown the figures below.

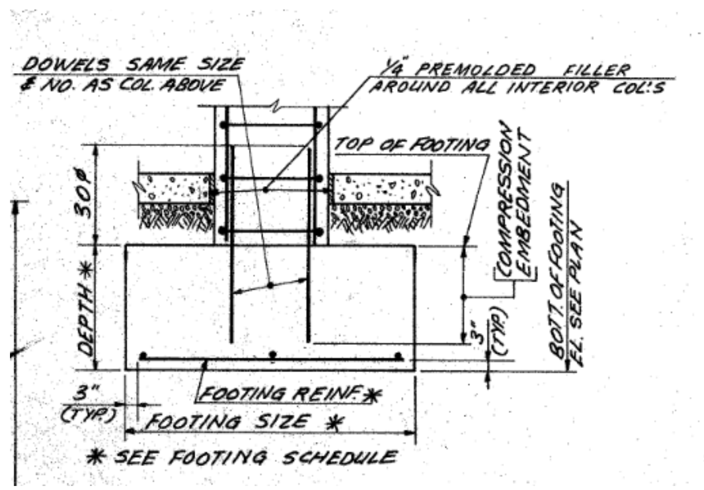


Figure 16 | Typical Footing Detail

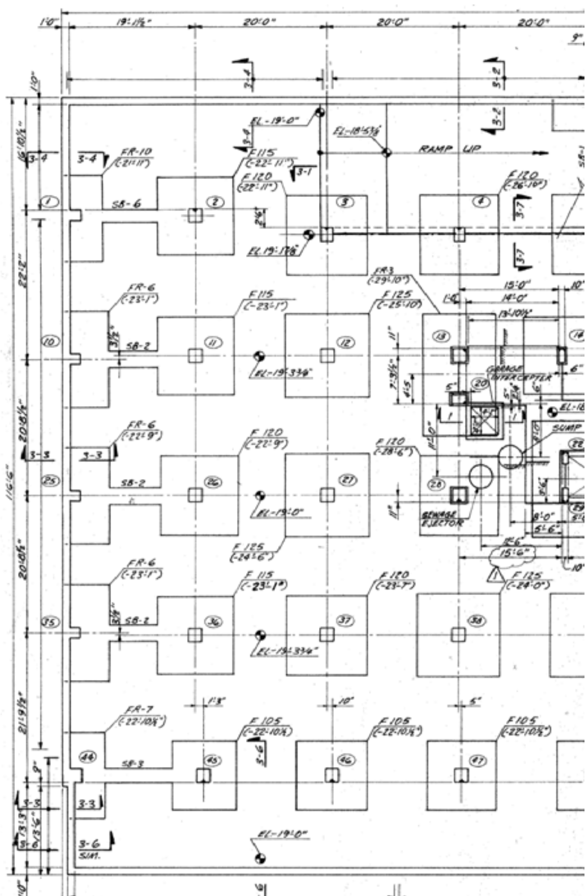


Figure 17 | Partial Cellar Plan

Joint Detailing and Design modifications

Joint detailing is key to the success of any building. It is imperative that the various types of connections are correctly detailed to prevent avoidable, disastrous circumstances.

Steel Moment Connection Detail

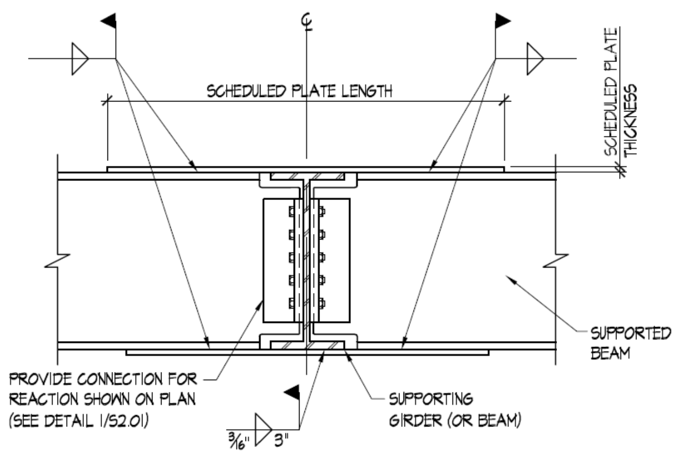


Figure 18 | Moment connection detail beam to girder

Beam to Column Connection Detail

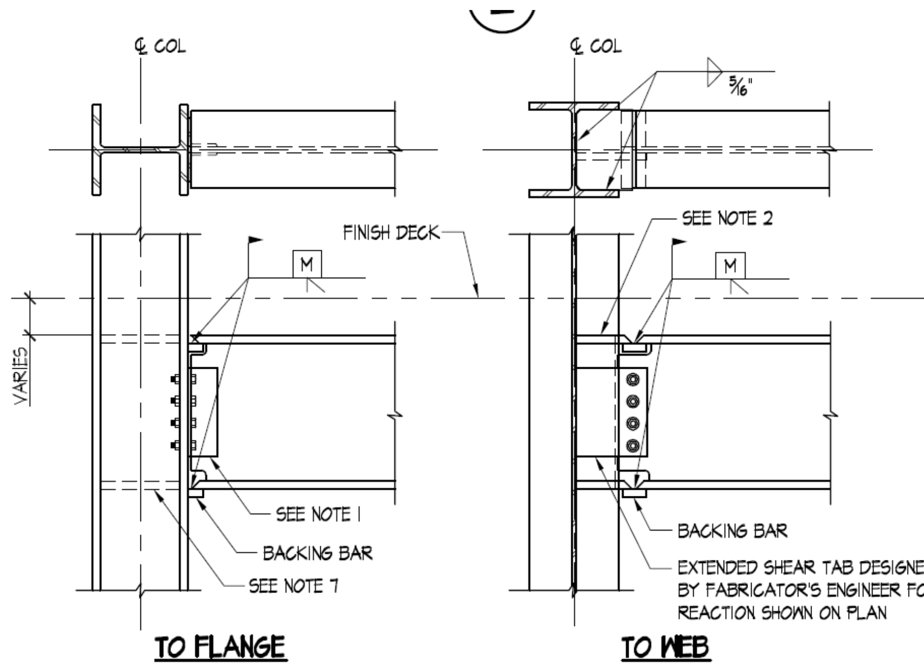


Figure 19 | Beam to Column – Fully restrained moment connection

Other additional details

With ceiling heights of 8'-4", and a steel frame used to limit the added loads to the existing columns and footings, there was not enough room to pass ductwork under the structure. After careful consideration, it was decided to design the steel beams and girders with openings for ductwork and piping. A total of 99 openings were detailed, as shown below, and included in the design.

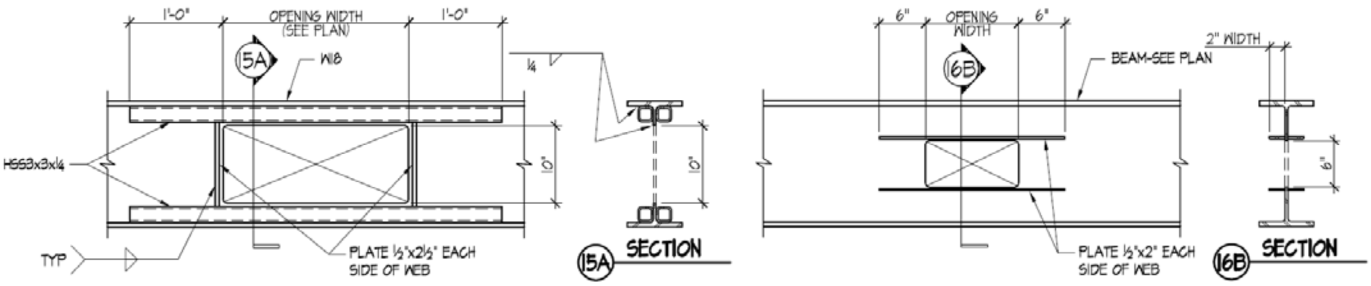


Figure 20 | Web opening detail

Building Design Codes and Standards

The structural design is in accordance with the International Building Code, 2006

In addition, the concrete and steel structural systems will conform to the;

I. "Building Code Requirements for Reinforced Concrete" **(ACI 318)**
II. "Specifications for Structural Steel Buildings" **(AISC)**

General codes are listed below;

a. "District of Columbia building code supplement of 2008, DCMR Building Code." **(D.C. Supplement to the 2006 International Building Code)**
b. "International Building Code – 2009", **International Code Council**
c. "Minimum Design Loads for Building and Other Structures", **(ANSI/ASCE 7-02-2005) American Society of Civil Engineers.**

Design Loads

This section focuses on the determination of the design loads. It highlights the building codes and standards used, as well as the load paths that occur in this project.

National Codes

Live Load – ASCE 7–05 Chapter 4 in accordance to IBC 2006
Lateral Load – ASCE 7–05 Chapter 6 in accordance to IBC 2006

Gravity Loads

Dead Loads

The structural elements will be designed to support the actual weight of the structural framing, mechanical system, and architectural finishes. Dead loads used in this project consists of the superimposed dead loads, in addition to structure dead loads. The load values are listed on sheet S0.01 of the structural drawings.

Live Loads

Live loads were calculated using chapter 4 of the ASCE 7-05 and chapter 16 of IBC 2006. The design live loads are not to be less than the minimum requirements of the Building Code. The following live loads will be used:

- Roof 30 PSF
- Roof Terrace 60 PSF
- Added Floors 100 PSF

Other Live load values are listed on sheet S0.01

Snow Load

Snow load is only used when the roof live load exceeds 30 PSF

Lateral Loads

Wind Load

Wind loads were determined using chapter 6 of ASCE 7-05, section 6.5, in accordance to the IBC 2006. For the purpose of checking design stresses in framing members, wind loads will be based on a 90 MPH wind speed using Exposure Category B. The net penthouse roof uplift is calculated to be 20 PSF.

Seismic Load

Seismic loads were calculated using Chapter 12 of the ASCE 7-05, section 12.8., which describes the Equivalent Lateral Force method. The building is considered to be in Risk Category II and seismic loading analysis will be based on design category A.

As stated earlier, the removal of the existing concrete roof, penthouse roof, and the building skin on all 4 sides, provided a column load reduction. The existing concrete footings also had some reserve capacity, and it appeared that no footing modifications were required. Using the International Building Code Chapter 34, Existing Structures, for our analysis (Specifically, Section 3403 – Additions) it was determined that the additional gravity load for the steel framing minus the gravity load for the existing roof and columns as well as precast skin/concrete penthouse loads result in a net increase of less than 5 percent. For seismic loading, thus the demand-capacity ratio increase was less than 10 percent. For wind loading, based on an assumed penthouse layout, the demand-capacity ratio increase was slightly greater than 10 percent which required further analysis during design. However, due to the frame assembly of cast-in-place concrete slabs and columns and the low story heights, the added wind loading for the addition required no reinforcing or strengthening of the existing columns or footings.

Load Path

The gravity loads are received by either the composite floor slab or the roof. These loads are then transferred to the beams and girders, ultimately brought down through the columns into the footings and foundation

Wind loads are first collected by the exterior façade. This load travels through the floor diaphragm in to the lateral force resisting systems, which are the steel moment frames and slab-column moment frames in this case. These loads are ultimately transferred into the footings and foundation.

Conclusion

440 First Street is an 11 story office/retail building (+ Penthouse) that carefully weaves the new and the old, in both design and technical execution.

The recent renovation that occurred in 440 First Street makes it a well-rounded structural system. The composite structural steel framing system coupled with the existing the cast-in-place concrete structure provide a seamless structural design balance.

Changes to the structural system will be explored, taken into consideration the architectural design and features, with the motive of improving an already well thought of structure

Furthermore, the lateral system will be further examined in the late reports. In future assignments, it will be interesting to see how changing the system will affect the structural design, in terms of loading and structural ability.