Image Courtesy RTKL

CORPORATE HEADQUARTERS

Great Lakes Region, U.S.A.

TECHNICAL REPORT 1
REVISIONS

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12 DECEMBER 2014

Contents

Executive Summary

The Corporate Headquarters, located in the Great Lakes Region of the United States, is a new 5 story office and retail space designed to serve as new home base for an established and successful US based company. The building's architecture was designed to mirror its surrounding buildings, namely, the newer retail area situated directly to the north of the building. It aims to mirror those buildings through its façade, which changes materials in order to break up the large building. In keeping with that architectural style, the Corporate Headquarters features a façade of glass and face brick, construction crews broke ground on the roughly 660,000 SF building in August 2014 with a projected completion date of Spring 2016.

A challenge in the design of the Corporate Headquarters is the poor existing soil conditions on part of the site. To remedy this problem, aggregate piers will be pushed down below foundation level to support the column spread footings and piers. Grade beams are also utilized in the foundation system.

The floor system in floors 2-5 is a composite floor framing consisting of metal deck on top of steel wide flange members. Average bays are rectangular with typical sizes around 38'-0" x 40'-0". The primary lateral system of the building is HSS braced frames near the building's core.

The primary loading conditions considered in the design of this structure were live loads, dead loads, snow loads, wind loads, seismic loads, and soil loads. To consider these loading conditions, the 2011 Ohio Building Code was set as primary design criteria. 2011 Ohio Building Code adopts IBC 2009, which references ASCE 7-05.

Due to security reasons, detailed location maps are not permitted for this report.

Purpose and Scope

The purpose of Technical Report 1 is to describe the existing structural conditions of the Corporate Headquarters, which is located in the Great Lakes Region of the Midwestern United States.

The scope of Technical Report 1 includes descriptions of structural systems, building materials, applicable building design codes, design loads, and load paths. This report will focus primarily on a detailed description of the building's structural system. This includes descriptions of the foundation, floor system, lateral system, and roof system. Within the foundation system description, soil conditions will also be discussed.

Subsequent technical reports will include calculations of typical gravity framing, load calculations, lateral load analysis, and spot checks of later members.

General Description of Building

The Corporate Headquarters will be constructed at the South end of an existing retail park in the Great Lakes Region of the Midwestern United States. It is a five story office a retail space designed to serve as the new headquarters for an established and successful US based company. The new 659,000 SF building's architecture was designed to blend in with the style of the surrounding buildings in the retail park. Designed in the contemporary "Americana" style, serving as the last component of the planned retail are. Ground broke in August 2014 and the project is anticipated to reach substantial completion in Spring 2016.

The building features an interior open courtyard with entry access on the third floor and many large view windows, allowing workers within the offices to bring the atmosphere of the outside in. Additionally, this grassy courtyard is meant to help enrich the sense of creativity and community within employees. To achieve this courtyard, the structural engineer chose laterally braced the building with braced frames, which are tied at the base by grade beams at the foundation.

The Corporate Headquarters serves as the south port of entry into a retail park and will incorporate retail space on its ground floor. The upper levels are dedicated to larger open office spaces that allow for spatial flexibility and mobility. Pending acquisition of land adjacent to the site, a proposed bridge will connect the upper two floors of the Corporate Headquarters with a parking structure, as is commonplace in the rest of the retail park. The proposed face brick and curtain wall façade mimics the "Main Street America" feel of the retail park but speaks to how the company has evolved throughout the generations to stay classic, but feel current.

Plans and elevations of the project can be found in Appendix A and B.

Structural Overview

Brief Description of the Structural System

The Corporate Headquarters is supported on a foundation comprised of spread footings, column piers, and grade beams. Floors 2-5 of the building are framed with a composite system of wide flange members and metal deck. Eight braced frames near the core of the building are the lateral force resisting system and the roof is concrete on metal deck. In the pages to follow, each component will be explained in more detail.

Building Materials

The tables below lists the building materials and specifications used in the design of the Corporate Headquarters.

Structural Steel	
Member	**Grade**
Wide Flange Shapes & WT Shapes	ASTM A992,UNO
Channels	ASTM A36, UNO
Angles	ASTM A36, UNO
Rectangular and Square Hollow Structural Sections	ASTM A500 GRADE B, UNO
Round Hollow Structural Sections	ASTM A500 GRADE B, UNO
Steel Pipe	ASTM A53 GRADE B
Steel Plates	ASTM A36, UNO
High Strength Bolts	ASTM A325 OR A490
Anchor Bolts	ASTM F1554, GRADE 36 AND GRADE 105
Standard Fasteners	ASTM A307

*UNO= unless nothed otherwise in drawings

TABLE 1: STURCTURAL STEEL SPECIFICATIONS

Concrete		
Application	Strength (psi)	Weight (pcf)
Spread Footings	3500	150
Walls, Piers, Grade Beams	4000	150
Slab on Grade	3500	150
Mud Mat	2000	150

TABLE 2: CONCRETE SPECIFICATIONS

Reinforcement	
Application	Grade
Deformed Bars	ASTM A615, Grade 60
Deformed Bars (Weldable)	ASTM A706
Welded Wire Fabric	ASTM A185

TABLE 3: REINFORCING SPECIFICATIONS

Foundation System

A geotechnical report of the future site of the Corporate Headquarters was written by in February 2012 by Geo-Sci, Inc. Following the completion of the report, the geotechnical engineer determined that the original soil bearing capacity of 4ksf would not be sufficient to support the weight of the building. In order to increase the soil bearing capacity, aggregate pier soil reinforcement system was recommended. These piers are to be placed below each column footing. Aggregate pier sizing varies with column footing size, with an average diameter of approximately 18".

The geotechnical report required that all footings, both column and wall, be excavated and poured on the same day. If this cannot be achieved, a 3" concrete mud mat must be poured over all of the excavated soil. The foundation is comprised of spread footings, wall footings, column piers, and grade beams.

The foundation of the Corporate Headquarters required the use of grade beams in order to resolve the large dead load of the courtyard trees into the site soil below. This is evident due to the placement of the grade beams near the areas with courtyard access, namely, the southwestern corner of the courtyard and the northwestern corner. The grade beams take the load from the large columns located near the building core.

The typical spread footings (Figure 1) are centered under the base of the steel columns and are placed directly above the aggregate piers used for soil reinforcement. Since there are no moment frames within the structure of the building, it can be reasonably assumed that the connections are pinned. For columns that sit on both a spread footing and concrete pier (Figure 2), the connection can also be assumed to be pinned. All spread footings in this building are supported by aggregate piers due to the poor soil quality on the site.

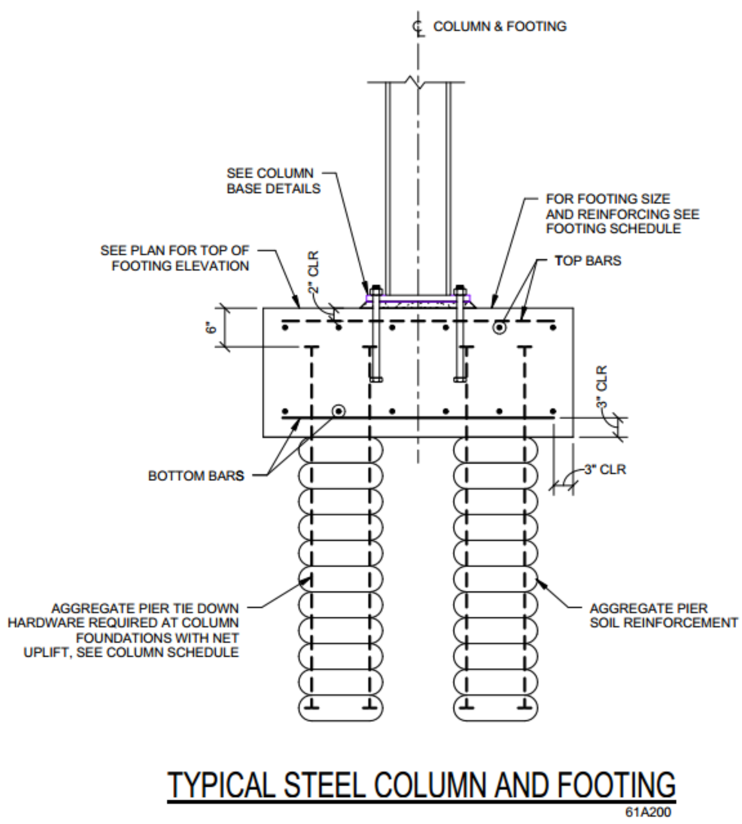


FIGURE 1- TYPICAL STEEL COLUMN AND FOOTING

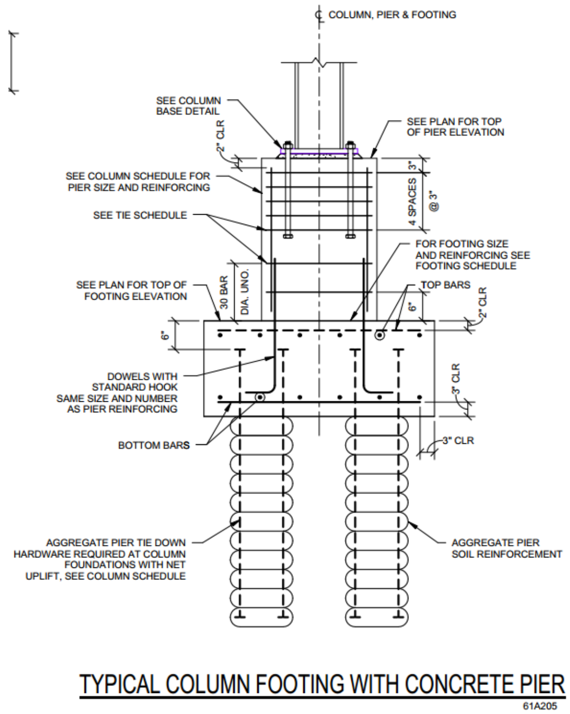


FIGURE 2- TYPICAL COLUMN FOOTING WITH CONCRETE PIER

Wall footings are used at all exterior cavity wall locations along the perimeter of the building, and the building rests on two different types of slab on grade. The larger slab depth (Type S-2 in) is used throughout the northern half of the building since it is slightly below grade and carries larger dead loads. Slab Type S-1 is used primarily near the center of the building, near the area of the courtyard, and is typical slab on grade construction. Both slab types can be seen in Figure 3.

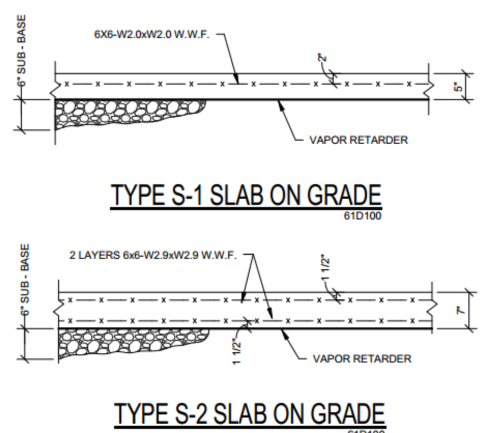


FIGURE 3- SLAB ON GRADE DETAILS

Floor System

The Corporate Headquarter features two different construction assemblies for the floor system. The first assembly (F-1) features 3 ¼" lightweight concrete with 6x6-W1.4xW1.4 welded wire fabric reinforcement on top of a 2" 18 gage composite metal deck. Assembly F-2 has 4 ¼" of lightweight concrete reinforced with 6x6-W2.0xW2.0 draped welded wire fabric on 3" 16 gage composite metal deck. The decking runs perpendicular to the wide flange beams.

Typical Floor Bay

Many of the bays in the Corporate Headquarters are rectangular, and shapes only differ near the edges of the building and the interior courtyard area. A typical bay is 38'x40'. Two typical member sizes used in all levels of floor framing are W21x44 and W24x55, with slight variation in depth (+/- 3") and weight (+/- 13 psf) when spans differ. In smaller span areas, such as around stair and elevator openings and the courtyard, W18 shapes and W21 shapes are common. Typical interior girders for a standard bay are W24x68, and in areas with smaller bays are typically W21 shapes or lighter W24 shapes. Figure 4 below shows a typical 38' bay and W24x55 beams.

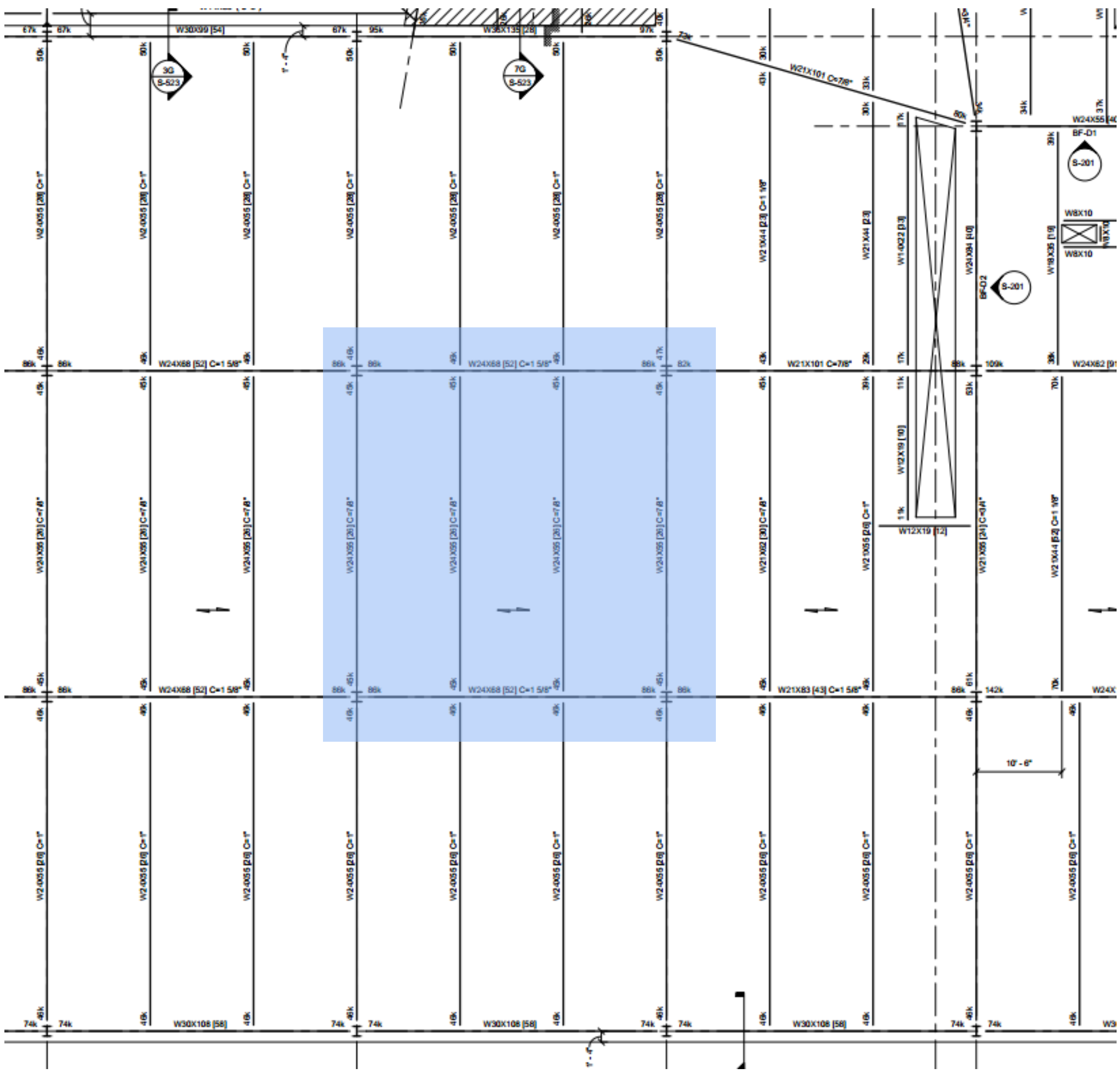
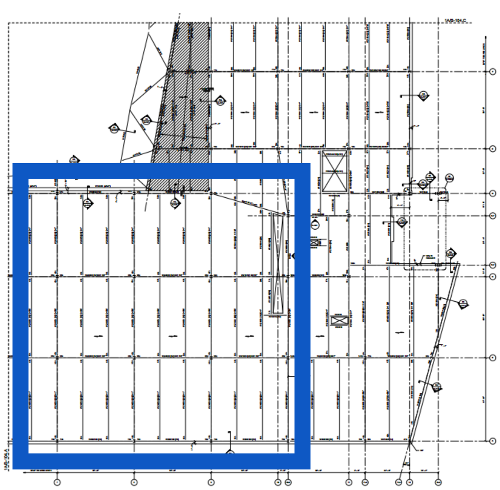


FIGURE 4: LEVEL 4 FRAMING PLAN SHOWING TYPICAL BAY (S104.D)



Framing System

The gravity framing of the building is composed of steel wide flange columns. All columns are W14 or W12, with the majority of weights between 61 and 170. One exception to this is a column that extends from the first floor to the roof. Nearly every column in the building has a column splice, all of which have larger shapes on the bottom than the top. Every combination of column splices varies slightly in size, with no predominant size majority. The columns are typically spliced between level 2 and level 3, and eleven columns in the building have tension spices. The columns are tension spliced because they are part of braced frames and carry a large axial load.

COLUMN SCHEDULE

LOCATION \ COLUMN	L-11	L-12	L4-D1	L4-D2	L8-D1.2	M-D2	M-4	M-5	M-6	M-7	M-8	M-8.3
PENTHOUSE ROOF												
EL. = 794'-6" / MAIN ROOF (13'-3")												
EL. = 781'-3" / 5TH FLOOR (14'-8"); EL. = 766'-7" / 4TH FLOOR (14'-8")	W14x61	W14x48	W14x43	W14x53	HSS8x8x3/8	W14x43	W14x48	W14x61	W14x61	W14x61	W14x53	W14x43
EL. = 751'-11" / 3RD FLOOR (16'-8")												
EL. = 735'-3" / 2ND FLOOR (17'-4"); EL. = 717'-11" / 1ST FLOOR (20'-10")	W14x90	W14x90	W14x82	W14x90		W14x61	W14x90	W14x90	W14x90	W14x90	W14x90	W14x48
EL. = 697'-11" BASE PLATE/ ANCHOR BOLTS	21"x1 1/2"x1'-9" (4) 3/4" Ø BOLTS 1HS-T23	21"x1 1/4"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/2"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/4"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	14"x3/4"x1'-2" (4) 3/4"Ø BOLTS 9HS-T23	20"x1"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/4"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/2"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/2"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/2"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/4"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	20"x1"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23
PIER												
FOUNDATION DESIGN LOADS (KIPS)	558	318	270	358	66	143	333	478	475	474	384	120

LOCATION \ COLUMN	M-9	M-10.2	M-11.3	DA.8-D0.8	DA-D1	DA-D2	DA-D3	DA-D3.7	DB-D1	DB-D2	DB-D3	DB-D4
PENTHOUSE ROOF												
EL. = 794'-6" / MAIN ROOF (13'-3")												
EL. = 781'-3" / 5TH FLOOR (14'-8"); EL. = 766'-7" / 4TH FLOOR (14'-8")	W14x61	W14x61	W14x48		W12x40	W14x53	W14x53	W14x43	W14x53	W14x61	W14x61	W14x61
EL. = 751'-11" / 3RD FLOOR (16'-8")												
EL. = 735'-3" / 2ND FLOOR (17'-4"); EL. = 717'-11" / 1ST FLOOR (20'-10")	W14x90	W14x90	W14x90	W8x31	W12x53	W14x90	W14x90	W14x90	W14x90	W14x90	W14x90	W14x120
EL. = 697'-11" BASE PLATE/ ANCHOR BOLTS	21"x1 1/4"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/2"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/4"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	10"x3/4"x1'-2" (4) 3/4"Ø BOLTS 1HS-T23	19"x1 1/2"x1'-7" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/2"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/4"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/4"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 3/4"x1'-9" (4) 7/8"Ø BOLTS 1HS-T23	21"x1 1/2"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 1/2"x1'-9" (4) 3/4"Ø BOLTS 1HS-T23	21"x1 3/4"x1'-9" (4) 7/8"Ø BOLTS 1HS-T23
PIER				12"x12" (4)#8		30"x30" (8)#10	30"x30" (8)#10	30"x30" (8)#10		30"x30" (8)#10	30"x30" (8)#10	30"x30" (8)#10
FOUNDATION DESIGN LOADS (KIPS)	416	461	408	20	286	432	357	365	356	450	585	757

FIGURE 5- COLUMN SCHEDULE

Lateral System

The lateral system of the Corporate Headquarters is made up of eight braced frames near the core of the building. In six locations braced frames extend from the first floor to the roof, and in two locations the braced member begins on the second floor level. These two frames do not have braced members on level one to accommodate a future retail shaft. The load of these frames is transferred using heavier columns than those used in the other six braced frames. The columns in turn transfer the load to the grade beams in the foundation system.

The braced members are made of Hollow Structural Sections varying from HSS8x8x1/4 to HSS 16x16x5/8. In two locations, the bottom member of the brace is made of a W14 shape. The braces take a diagonal shape in five locations, a chevron shape in one location, and an inverted chevron shape in two locations.

The braced frames were chosen as the lateral force resistance system due to their strength and stiffness properties. Additionally, braced frames use less material than moment resisting frames and don’t require formwork, as concrete shear walls do.

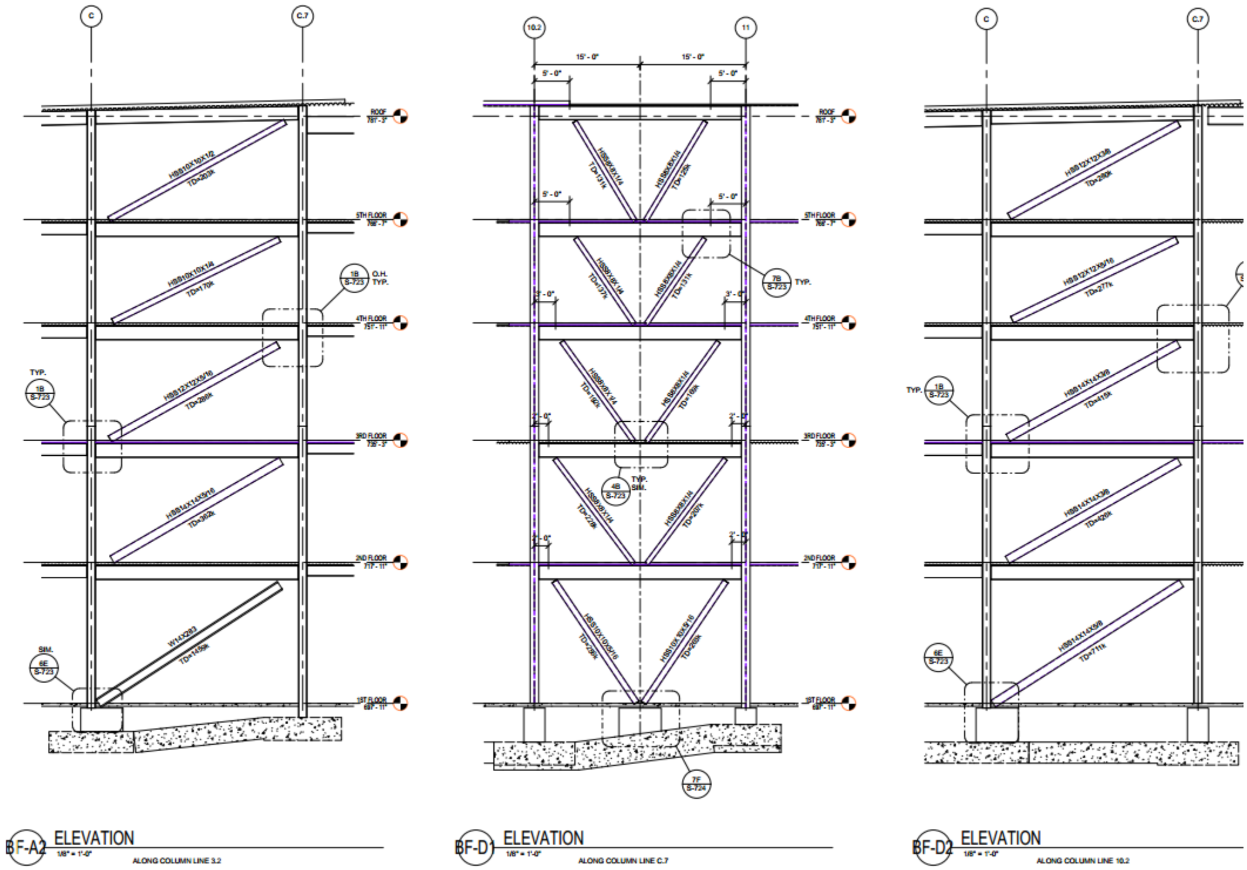


FIGURE 6- SAMPLE BRACED FRAME ELEVATIONS

Joint Details

The typical connections found in the Corporate Headquarters are column splices, curtain wall to floor system connections, and moment connections to columns. In the following section, each connection type will be briefly described and accompanied by an example from the structural details.

Column Splices

Column splices within the Corporate Headquarters occur a few feet above the third floor. The location of the splice was determined based on industry standard practice for maximum height per individual column. The columns are attached using welding or bolted splice plates and must be developed to have a minimum of 10% of the tensile capacity of the column flanges.

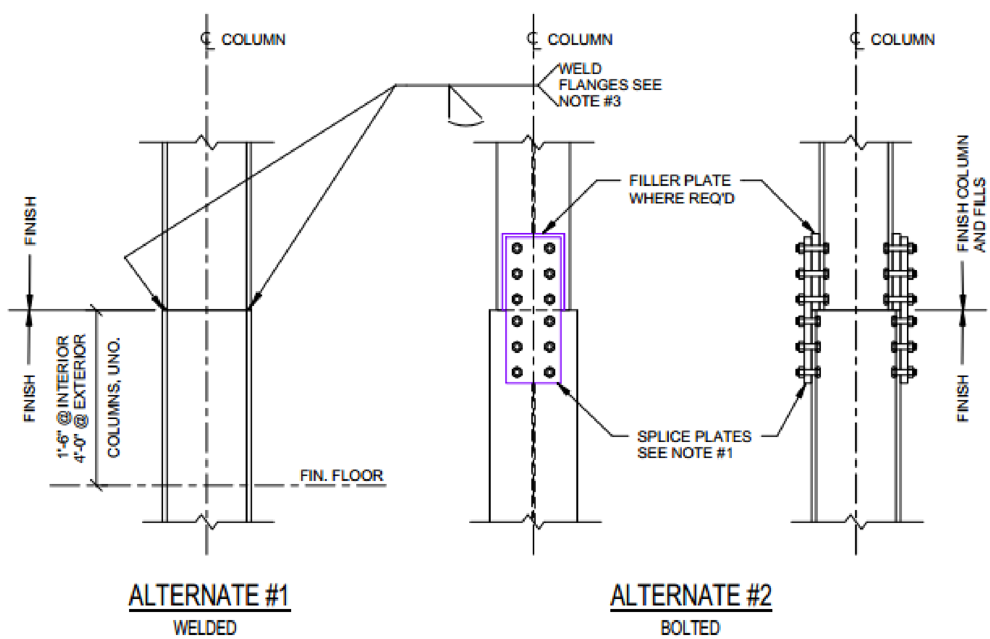


FIGURE 7- TYPICAL COLUMN SPLICE

Curtain Wall To Floor System Connection

The floor system is connection to the curtain wall via a gravity and lateral connection piece that sits in the middle of the curtain wall channel. The connection utilizes a bent plate with long headed studs for extra support.

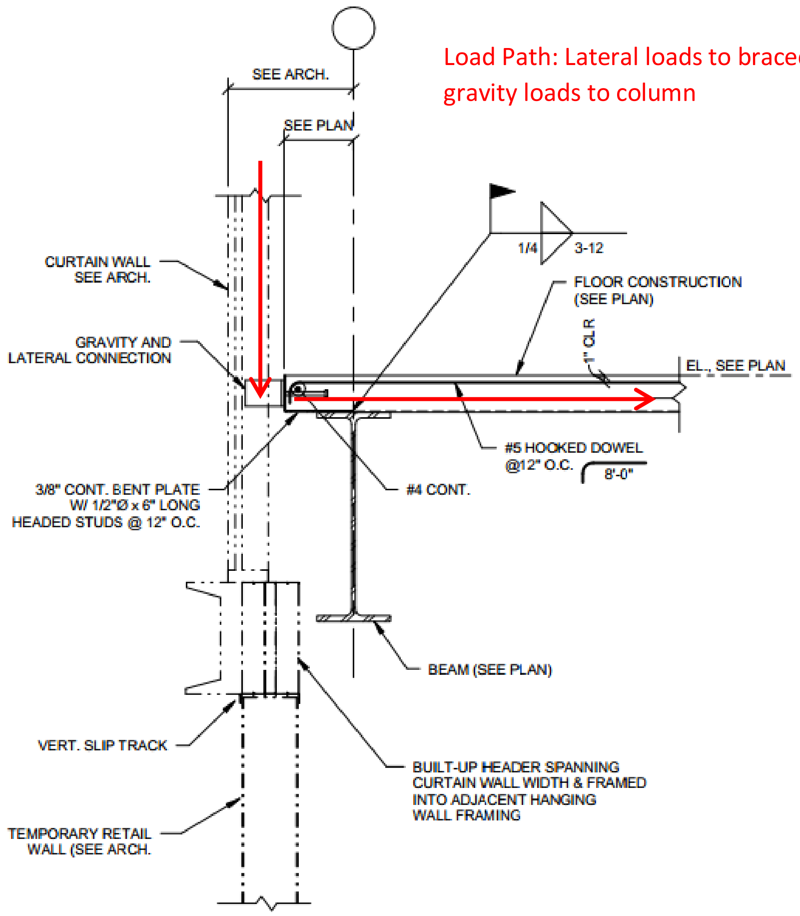


FIGURE 8-TYPICAL FLOOR TO CURTAIN WALL CONNECTION

Moment Connection to Columns

To achieve the moment connection to the column web, the members are welded in place using a weld plate. The stiffener plates used in the connection process are required to have the same yield strength and thickness as the flange of the beam, which is typically ¼". Additionally, each bolted connection used will be slip critical due to the possibility of oversized holes within the members. In the Corporate Headquarters, moment connections are most common at the top of columns. These connections are used in order to increase member strength and resistance against bending.

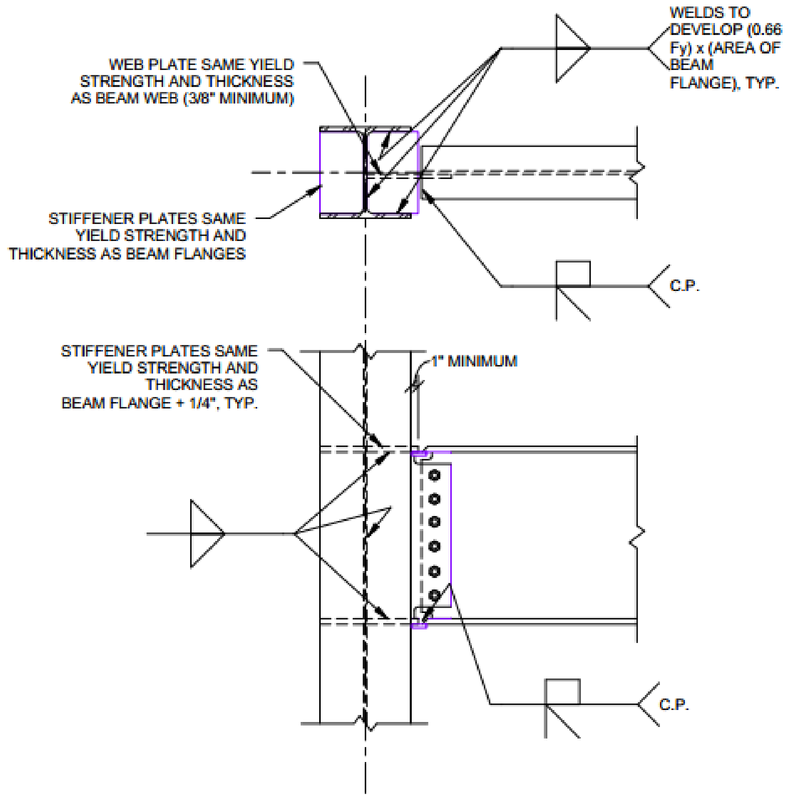


FIGURE 9- TYPICAL MOMENT CONNECTION TO COLUMN

Design Codes and Standards

The following codes and standards were used in the structural design of the Corporate Headquarters.

International Code Council

- International Building Code 2009
    - Incorporated by 2011 Ohio Building Code

American Society of Civil Engineers

- ASCE 7-05: Minimum Design Loads for Buildings and Other Structures
    - Referenced by IBC 2009

American Concrete Institute

- ACI 530-05: Building Code Requirements for Masonry Structures
    - ACI 530.1: Specifications for Masonry Structures

American Institute of Steel Construction

- AISC 360-05: Specifications for Structural Steel Buildings
    - Supersedes the *Load Resistance Factor Design Specification for Structural Steel Buildings*, as given on drawings

American Welding Society

- AWS D1.1: Structural Welding Code- Steel

Design Loads

The focus of this section is the load values used during the structural design of the Corporate Headquarters. Dead, live, snow, wind, and seismic loads were calculated using the 2011 Ohio Building Code, which adopts IBC 2009 and references ASCE 7-05.

National Code for Live Loads and Lateral Loadings

Live and Lateral loads for the Corporate Headquarters were calculated using 2011 Ohio Building Code, which adopts IBC 2009 and references ASCE 7-05. No local amendments to the code are applicable for the design of the Corporate Headquarters.

Gravity Loads

Live Loads:

The live loading schedule for this project is listed on sheet S-001. Nearly every value listed in the drawings can be found in ASCE 7-05, Table 4-1, except for Kitchen Refrigerator and Freezer Area, and Typical and RTU Roof Areas. The loads not able to be determined by ASCE 7-05 are explained in greater detail in the table below.

Load	Determination of Load
Kitchen Refrigerator and Freezer Area	Due to heavy traffic during the lunch hour as well as the weight of the equipment and its ability to move, the space was designed for a heavier load than a typical "light storage warehouse."
Typical Roof	A typical flat roof requires only 20 psf LL, but this was upsized by 5 psf since no live load reduction was utilized.
RTU Roof Areas	No live load reduction utilized, therefore higher initial live load.

Dead Loads:

The dead load values for this project can be found on sheet S-001 and are based on industry standards as well as the engineering judgment of the structural design engineer. Certain dead load values, such as ceiling weight, MEP, and insulation are calculated using manufacturer product specifications.

Snow Loads

The design snow loads are based on the snow load maps found in ASCE 7-05. The design loads and factors are listed on sheet S-001 and include the provisions for drifting snow.

Lateral Loads

Wind Loads:

The design wind loads for this building were split up into two different sets of criteria: wind loading for the main wind-force resisting system and wind loading for components and cladding. The overall design for the building's structure was created in accordance with the 2011 Ohio Building Code, which incorporates the 2009 IBC, which adopted ASCE 7-05. Section 6 of ASCE 7-05 describes the procedure for determining wind loads with given factors. Those factors, as well as the basic wind speed, can be found in the design criteria on sheet S-001.

Seismic Loads:

Seismic design loads were determined based on ASCE 7-05, Section 12: Seismic Design Requirements for Building Structures. The factors needed to determine exact seismic loading can be found in the design criteria on sheet S-001.

Soil Loads

Soil loads for the building were calculated using the geotechnical report provided by Geo-Sci, Inc. as well as the 2011 Ohio Building Code, Section 1806. As recorded in the structural drawings, the modulus of subgrade reaction used to design the slab on grade is 125 pci. This stiffness makes sense because of the poor condition of the coarse grain soil on the site.

Load Paths

Gravity Load Path

As loads are applied to a floor, the composite floor system will carry the load and transfer it onto the beams and girders in the floor framing. Once the load is taken by the framing, it is transferred to the columns and is transferred onto the column footings, grade beams, and piers. At that point, the foundation resolves the load into the soil below.

The roof and courtyard green space follow a similar load path, taking loads and carrying them through the floor deck onto the framing until they hit columns, the foundation, and eventually, the soil.

Lateral Load Path

The building's façade takes the distributed wind load and transfers it through the floor system. The floor diaphragm carries the load to the brace frames throughout the building and sends the force down to the foundation, where the load is transmitted into the soil.

Conclusion

Technical Report 1 described the existing structural conditions of the Corporate Headquarters. The report included detailed descriptions of the foundations, floor systems, framing systems, lateral systems, typical joint conditions, design codes and standards, and loading.

The architectural design of the Corporate Headquarters was inspired by the surrounding existing buildings in the retail park just to the north of the site. Since the new building will serve as a south entrance to the park, it was determined that the architecture should blend and have a fluid feel as a guest walked from one end of the park to the other. The architectural design and precedent buildings will have an impact on future assignments since changes made to the building façade will have to keep the same basic architectural style of face brick and glass.

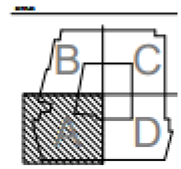
The location of the lateral force resisting system is of crucial importance to the building. The eight braced frames are placed in four different locations throughout the building, each one near the corner of the building's central void. In addition to providing adequate lateral force resistance, the placement of the frames helps to maximize the amount of open floor space on each floor.

Major challenges in the building design were the poor soil quality and the request for the interior courtyard. The poor soil quality required that aggregate piers be placed down in the soil for column spread footings and piers to brace on. The interior courtyard also provided a challenge since gravity loads from the upper floors had to take a different load path. The poor soil quality could be a challenge and must be considered in future assignments.

Appendices

Appendix A: Typical Building Floor Plans

Building Key Plan



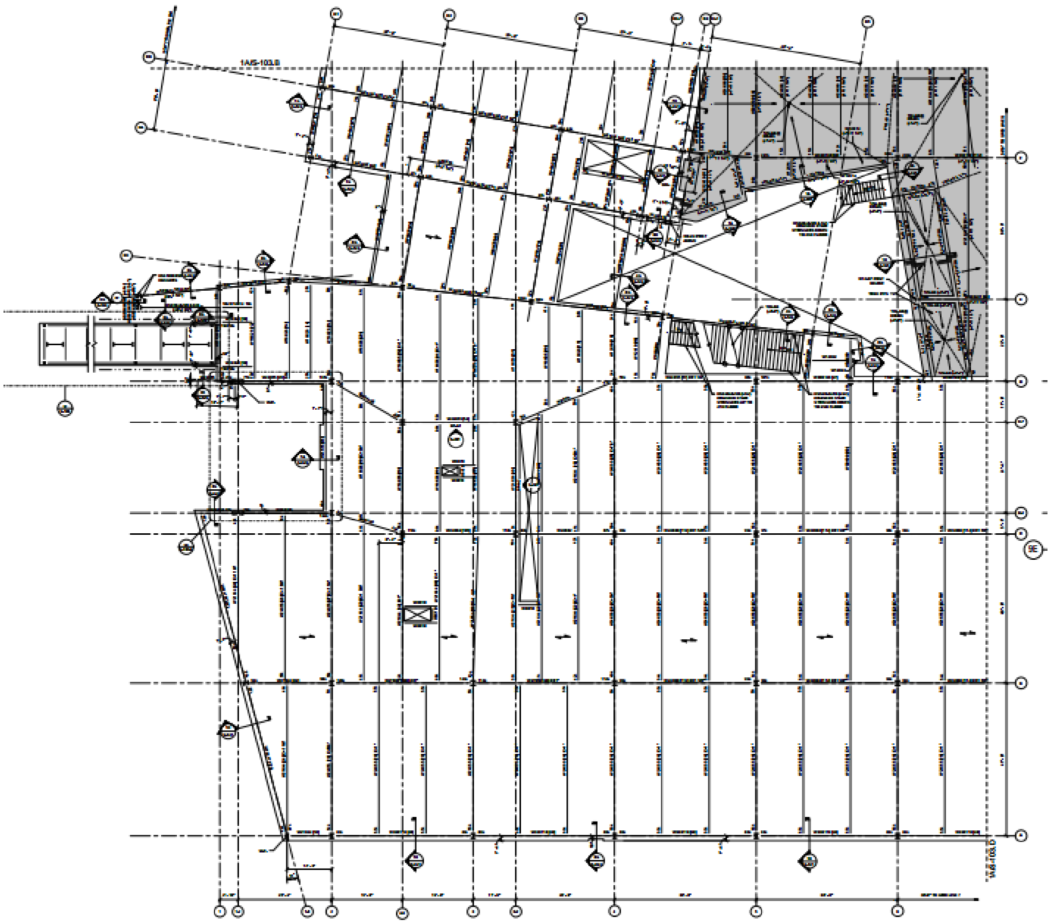


FIGURE 10- TYPICAL SEGMENT A FLOOR FRAMING PLAN

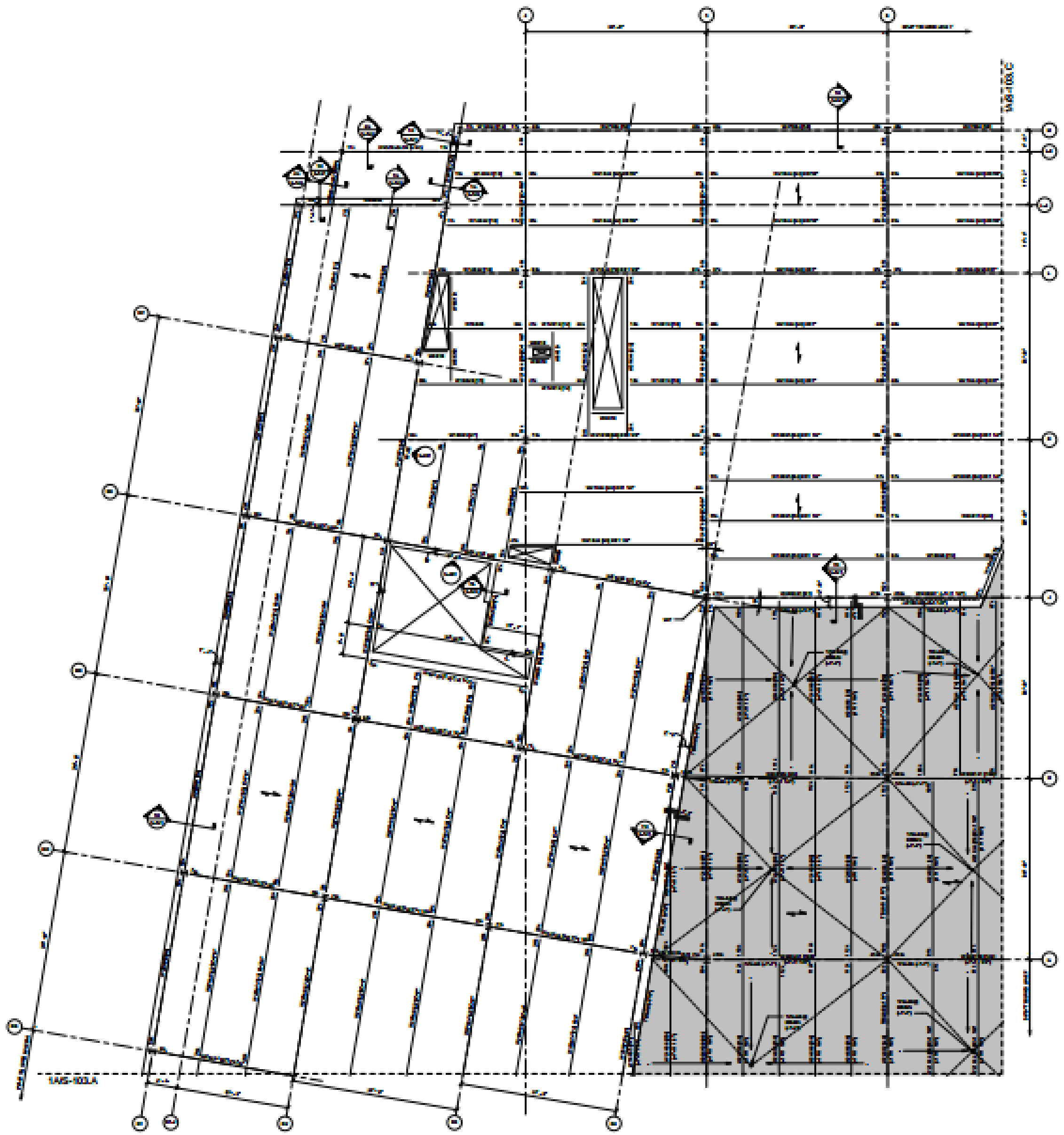


FIGURE 11- TYPICAL SEGMENT B FLOOR FRAMING PLAN

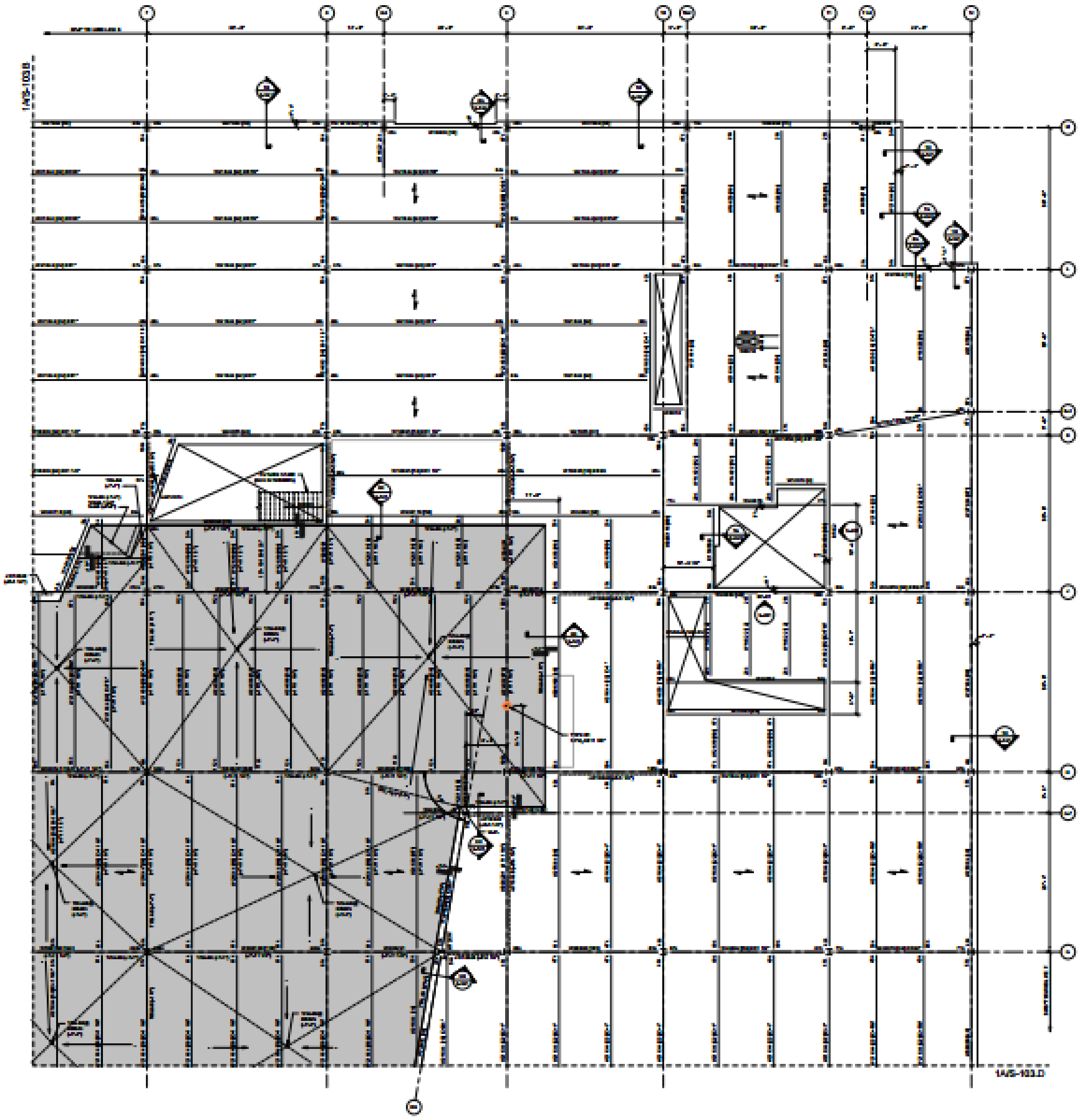


FIGURE 12-TYPICAL SEGMENT C FLOOR FRAMING PLAN

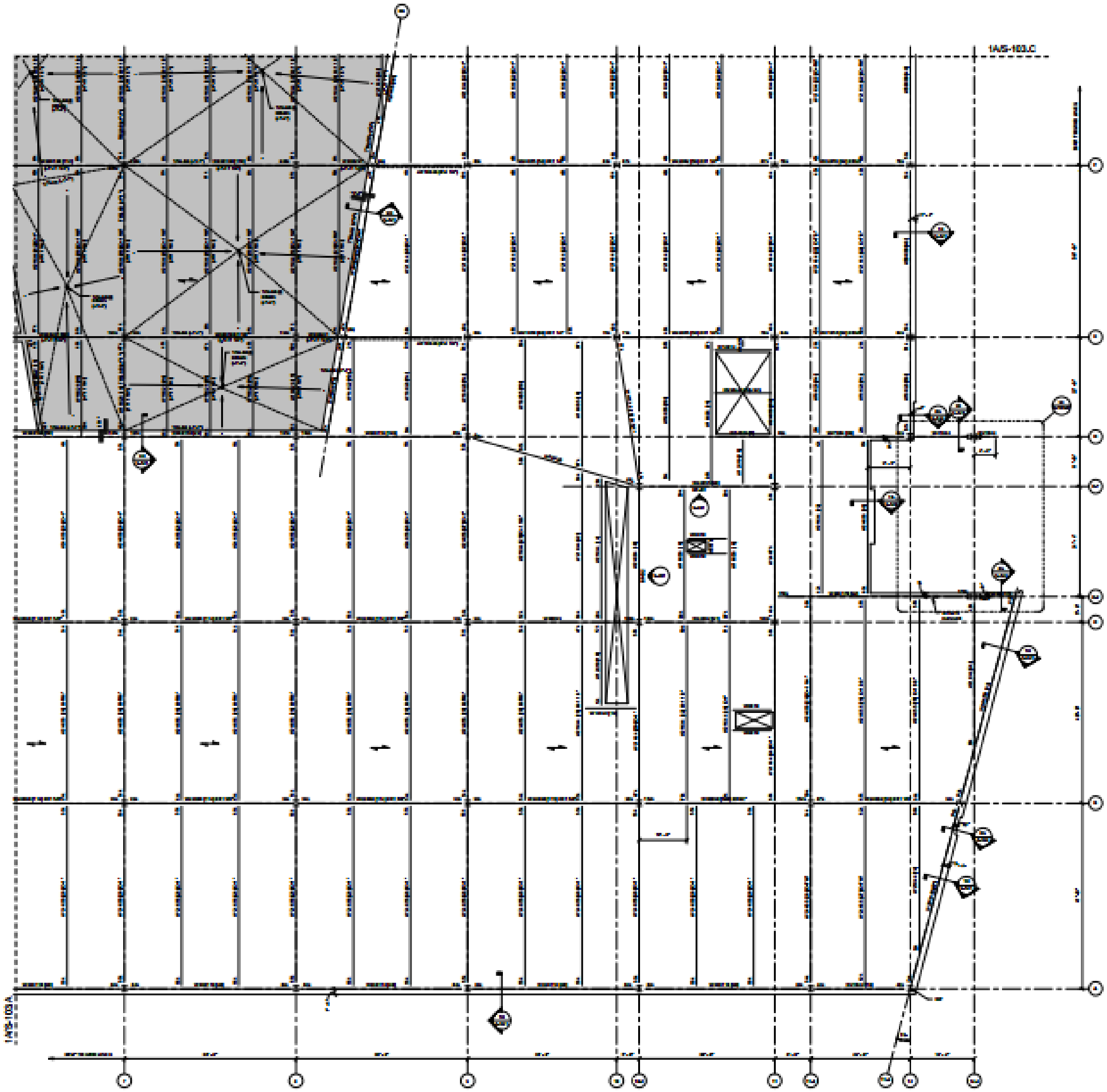


FIGURE 13-TYPICAL SEGMENT D FLOOR FRAMING PLAN

Appendix B: Building Elevations

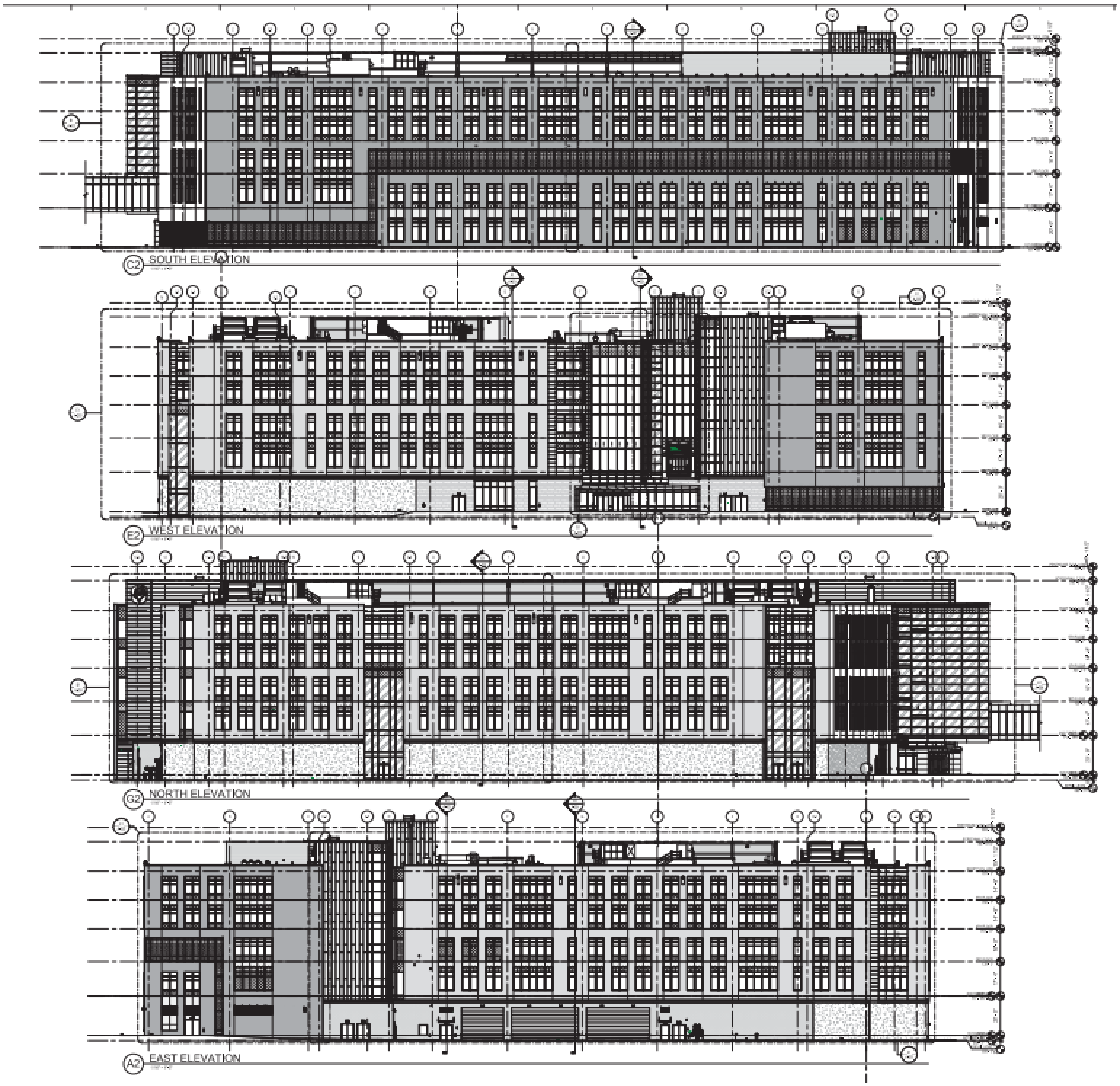


FIGURE 14- BUILDING ELEVATIONS, FROM TOP DOWN: SOUTH, WEST, NORTH, EAST