# CORPORATE HEADQUARTERS

Great Lakes Region, U.S.A.

TECHNICAL REPORT 1

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# 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. In keeping with that building 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 and have 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 for the column spread footings and piers to sit upon. In addition to the spread footings, a large portion of the building's foundation features slab on grade and a few grade beams.

The floor system in floors 2-5 is a composite floor framing structure consisting of metal deck on top of steel wide flange members. Average bays are rectangular and have slight variation in size although average sizes are around 38' and beams typically span 40'. 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.

The following report will provide further information on these topics. Due to security reasons, location maps are not currently permitted. Further consultation with the owner to follow for subsequent technical reports.

# Purpose and Scope

The purpose of this technical report is to describe the existing structural conditions of the Corporate Headquarters, located in the Great Lakes Region of the Midwestern United States.

The scope of this technical report 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.

A full structural analysis of the design of the Corporate Headquarters will be provided in subsequent technical reports.

# 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, the Corporate Headquarters will serve as the last component of the retail area and aims to become the cornerstone of an already thriving community. Ground was broken on the Corporate Headquarters in August 2014 and the project's projected completion date is Spring 2016.

The building features an interior courtyard which begins on the third level of the building and allows workers within the offices to bring 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 design engineer chose to utilize grade beams and braced frames, as well as aggregate piers below the foundation to help beef up the poor soil conditions.

The Corporate Headquarters serves as the south port of entry into a retail plaza and will incorporate retail space on its ground floor.  The upper levels are dedicated to larger open office spaces that allow for spatial transitions and mobility. Pending acquisition of land adjacent to the site, a bridge will connect the upper 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, grade beams, and partial slab on grade. Floors 2-5 of the building are framed with a composite system of wide flange members and metal deck. Braced frames near the core of the building are the primary lateral force resisting system and the roof is also a composite system of wide flange members and 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 X: 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 X: CONCRETE SPECIFICATIONS

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

TABLE X: REINFORCING SPECIFICATIONS

## Foundation System

A geotechnical report of the future site of the Corporate Headquarters was performed by in February 2012 by Geo-Sci, Inc. Following the completion of the report, it was determined that the soil bearing capacity would not be sufficient to support the weight of the building. In order to increase the soil capacity, an aggregate pier soil reinforcement systems was utilized below each free standing column footing. The size of the aggregate pier was determined by the size of the column footing.

Due to the soil's sensitivity to both weather and construction activity, it is required that all footings, both column and wall, be excavated and poured on the same day so as not to disturb the soil. If this cannot be achieved, a 3" concrete mud mat must be poured over top of the excavated soil. For ease of constructability, the foundation is comprised of spread footings, wall footings, column piers, grade beams, partial slab on grade.

This foundation of the Corporate Headquarters required the use of grade beams in order to transmit the large dead load of the trees planted in the upper level courtyard. 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 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 required to sit on aggregate piers due to the poor soil quality on the site.

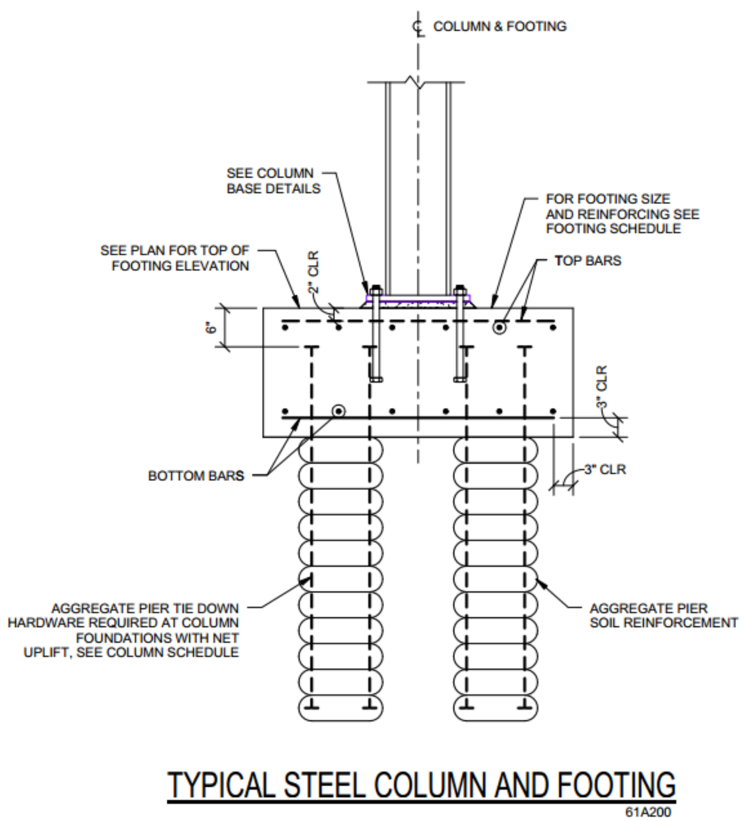



FIGURE 1- TYPICAL STEEL COLUMN AND FOOTING

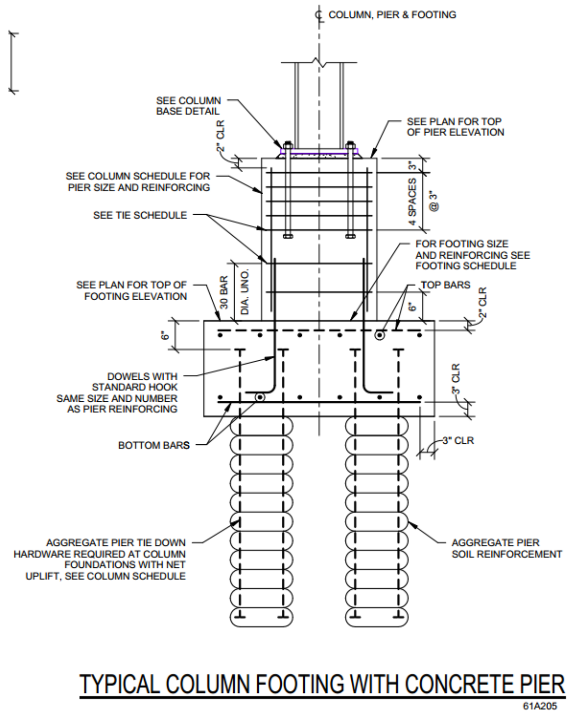



FIGURE 2- TYPICAL COLUMN FOOTING WITH CONCRETE PIER

Wall footings are used at all exterior wall locations along the perimeter of the building, and most of the building rests on a slab on grade foundation. The larger slab depth (Type S-2 in) is used throughout most of the northern half of the building since it is slightly below grade. 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.

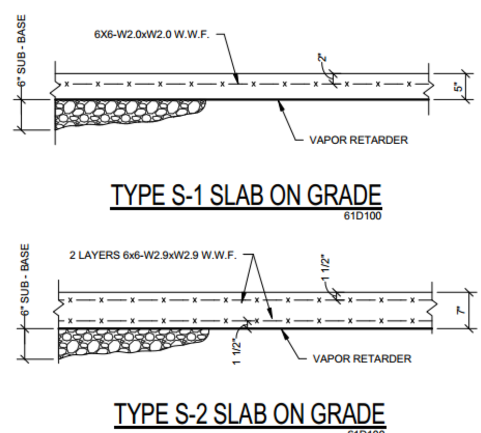



FIGURE 3- SLAB ON GRADE DETAILS

# 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 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 beam span is 38'-0" to 40'-0" and a typical bay is between 33'-0" and 38'-0". Two typical member sizes used in all levels of floor framing are W21x44 W24x55, with slight variation when spans are smaller. In the 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.

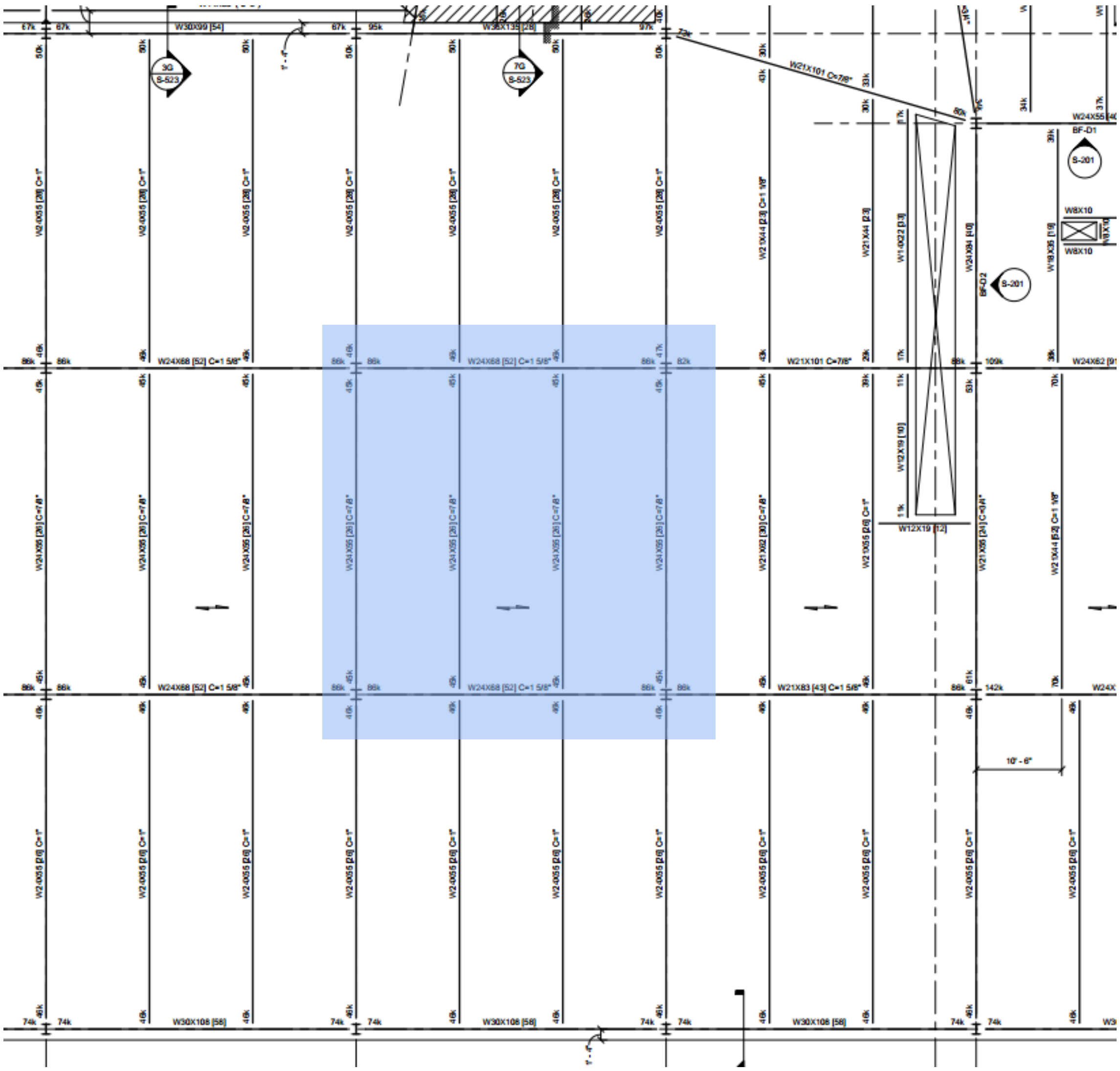
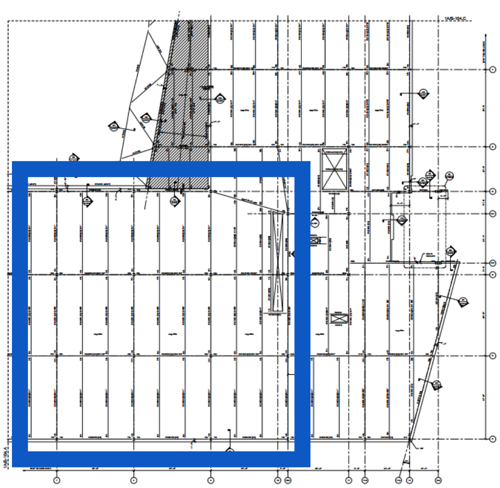
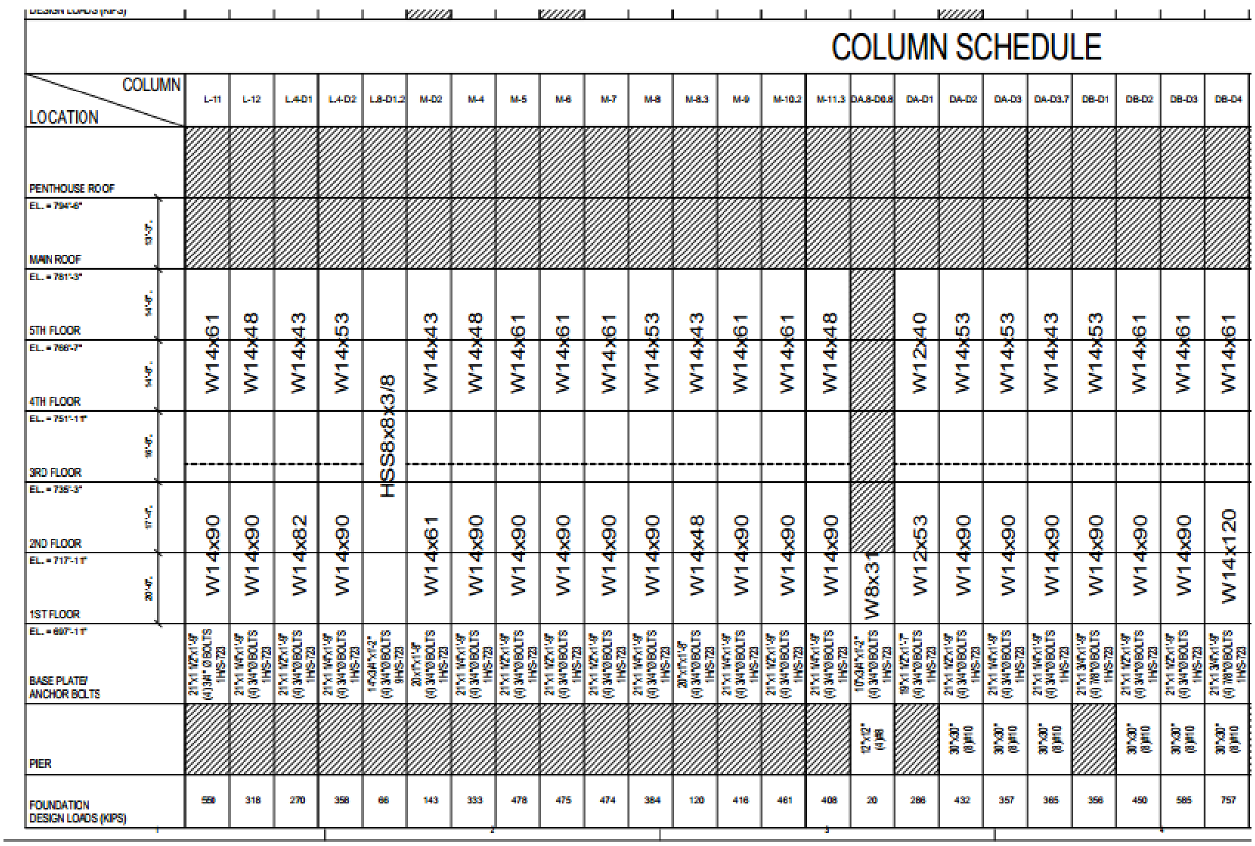



FIGURE 4: LEVEL 4 FRAMING PLAN SHOWING TYPICAL BAY (S104.D)



## Framing System

The primary structural 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. The one exception to this is the lone HSS column that spans from the first floor to the roof. One feature that makes the building unique is the number of column splices. Nearly every column in the building has a column splice, and many of the spices are 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 several columns in the building feature tension column splices.



COLUMN SCHEDULE

| COLUMN | 3RD FLOOR – MAIN ROOF | 1ST FLOOR – 3RD FLOOR | BASE PLATE/ ANCHOR BOLTS | PIER | FOUNDATION DESIGN LOADS (KIPS) |
|---|---|---|---|---|---|
| L-11 | W14x61 | W14x90 | [illegible] | | 550 |
| L-12 | W14x48 | W14x90 | [illegible] | | 318 |
| L4-D1 | W14x43 | W14x82 | [illegible] | | 270 |
| L4-D2 | W14x53 | W14x90 | [illegible] | | 358 |
| L8-D1.2 | HSS8x8x3/8 | HSS8x8x3/8 | [illegible] | | 66 |
| M-D2 | W14x43 | W14x61 | [illegible] | | 143 |
| M-4 | W14x48 | W14x90 | [illegible] | | 333 |
| M-5 | W14x61 | W14x90 | [illegible] | | 478 |
| M-6 | W14x61 | W14x90 | [illegible] | | 475 |
| M-7 | W14x61 | W14x90 | [illegible] | | 474 |
| M-8 | W14x53 | W14x90 | [illegible] | | 384 |
| M-8.3 | W14x43 | W14x48 | [illegible] | | 120 |
| M-9 | W14x61 | W14x90 | [illegible] | | 416 |
| M-10.2 | W14x61 | W14x90 | [illegible] | | 461 |
| M-11.3 | W14x48 | W14x90 | [illegible] | | 408 |
| DA.8-D0.8 | | W8x31 | [illegible] | 12"x12" (4)#8 | 20 |
| DA-D1 | W12x40 | W12x53 | [illegible] | | 286 |
| DA-D2 | W14x53 | W14x90 | [illegible] | 30"x30" (8)#10 | 432 |
| DA-D3 | W14x53 | W14x90 | [illegible] | 30"x30" (8)#10 | 357 |
| DA-D3.7 | W14x43 | W14x90 | [illegible] | 30"x30" (8)#10 | 365 |
| DB-D1 | W14x53 | W14x90 | [illegible] | | 356 |
| DB-D2 | W14x61 | W14x90 | [illegible] | 30"x30" (8)#10 | 450 |
| DB-D3 | W14x61 | W14x90 | [illegible] | 30"x30" (8)#10 | 585 |
| DB-D4 | W14x61 | W14x120 | [illegible] | 30"x30" (8)#10 | 757 |



FIGURE 5- COLUMN SCHEDULE

## Lateral System

The lateral system of the Corporate Headquarters is made up of a series of braced frames near the interior of the building. In six locations the braced frames rise from the first floor to the roof, and in two locations the braced frames begin on the second floor level.

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

The brace frames were used as the primary lateral force resistance method in their respective areas due to their lightweight in comparison to shear walls and their ease of constructability. The majority of the braced frames transfer their loads down to grade beams at the building's foundation level.

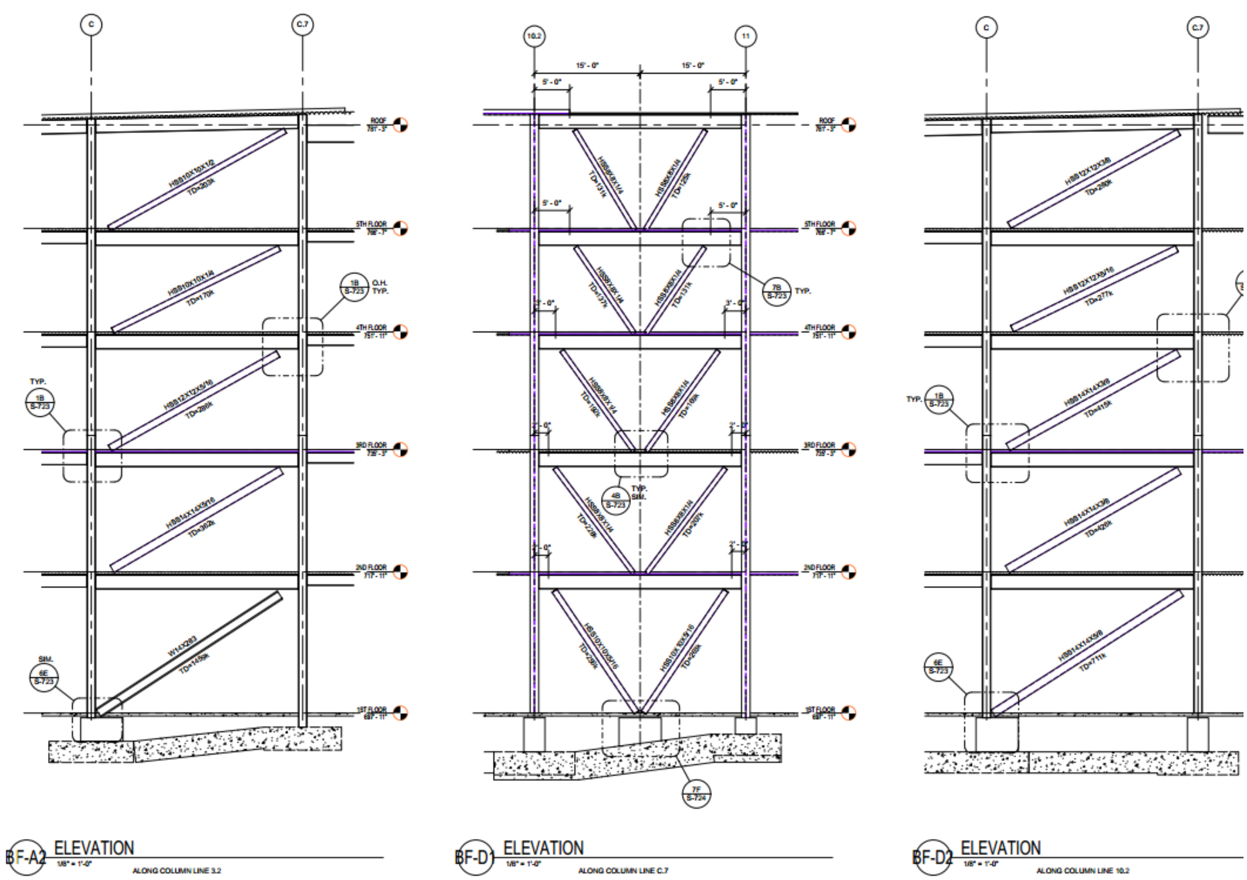



**FIGURE 6- SAMPLE BRACED FRAME ELEVATIONS**

# Joint Details

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

## Column Splices

Column splices typically occur between floor 2 and floor 3 within the corporate headquarters. 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.

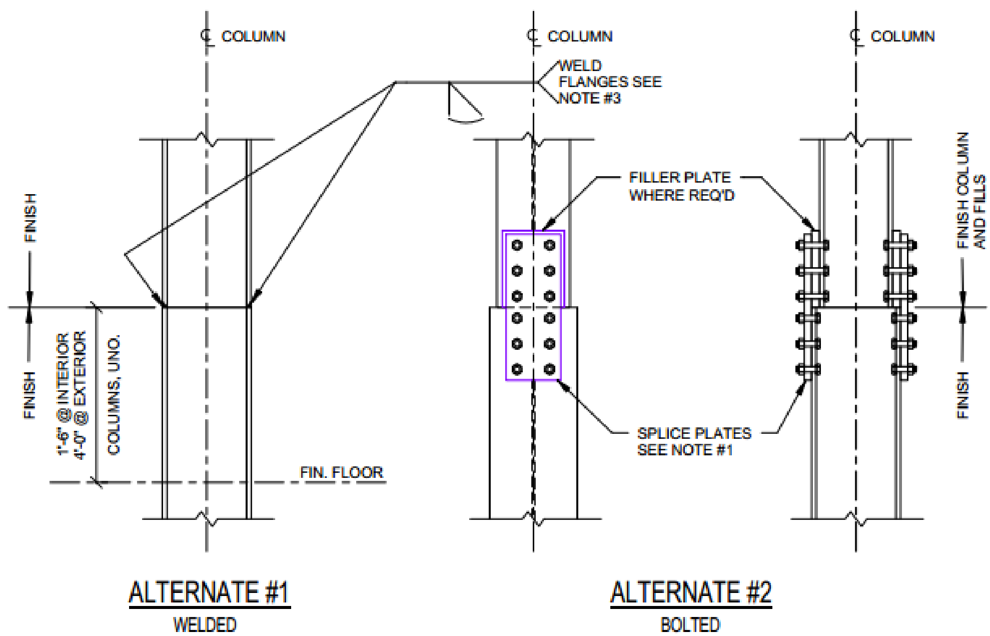



FIGURE 7- TYPICAL COLUMN SPLICE

## Floor to Curtain Wall 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.

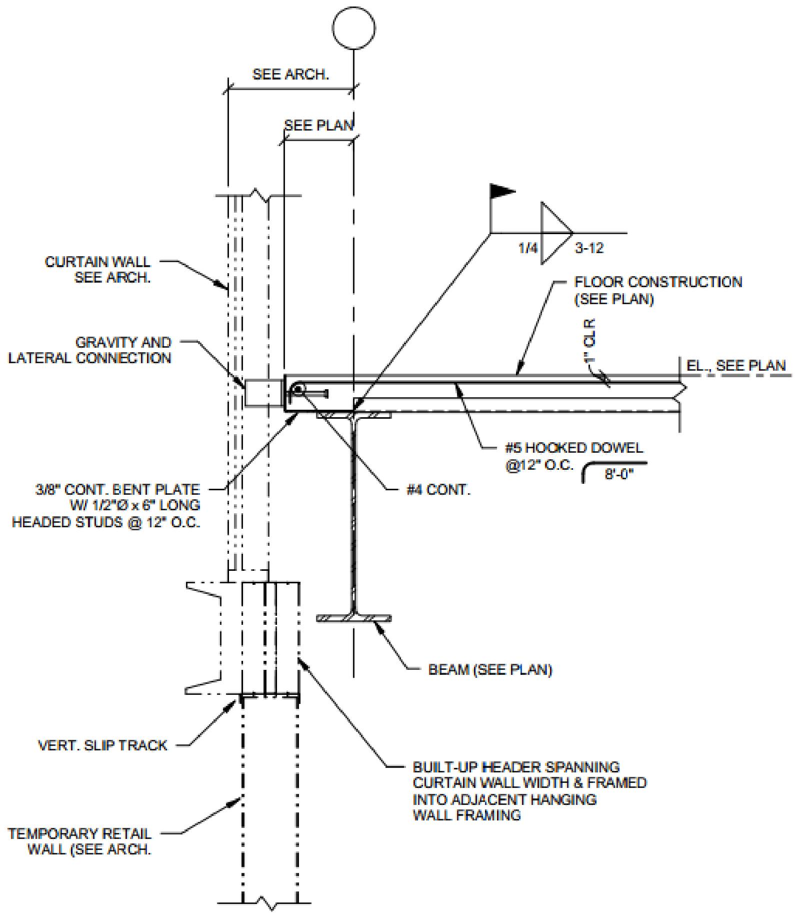



FIGURE 8-TYPICAL FLOOR TO CURTAIN WALL CONNECTION

## 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.

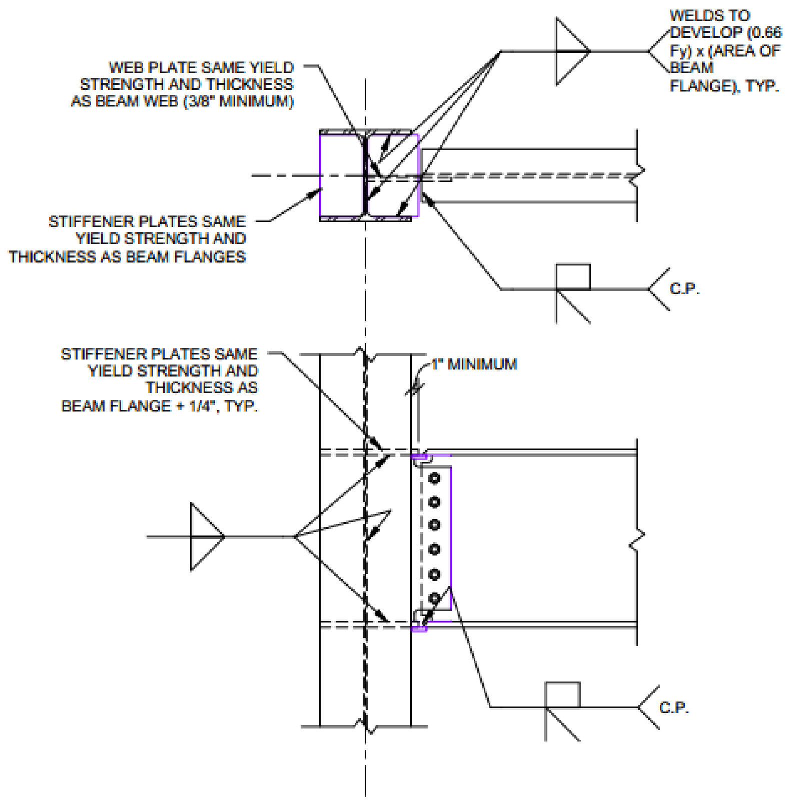



FIGURE 9- TYPICAL MOMENT CONNECTION TO COLUMN

# Design Codes and Standards

The following design codes and standards used during 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: 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 are 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, which 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.

## 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 based off assumptions.

## Snow Loads

The design snow loads are based on the snow load maps found in IBC 2009, which reference 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 criteria for the building’s structural design are 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.

# Load Paths

## Gravity Load Path

As loads are applied to a floor, the composite floor decking 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 shifted down the columns and is transferred onto the column footings, grade beams, and piers. At that point, the foundation dissipates the load into the soil below.

The roof and courtyard green space follow a similar load path, taking loads and carrying them through the 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 carries the load to the brace frames throughout the building and send the force down to the foundation, where the load is dissipated 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.

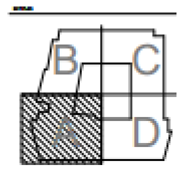
A major challenge in the building design was the poor soil quality and the request for the interior courtyard. The poor soil quality required that aggregate piers be placed down in the soil for column spread footings and piers to brace on. The interior courtyard also provided a challenge since gravity 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.

The braced frame system will be challenging in future assignments due to its placement. The braced frames lie near the core of the building, rather than on the perimeter, so designing around them will be challenging. Additionally, the brace frames must be more fully considered in future load paths. Since the interior composition of the space is so important to the company, the braced frame must be completely hidden from view in future design and analysis.

# Appendices

## Appendix A: Typical Building Floor Plans

Building Key Plan



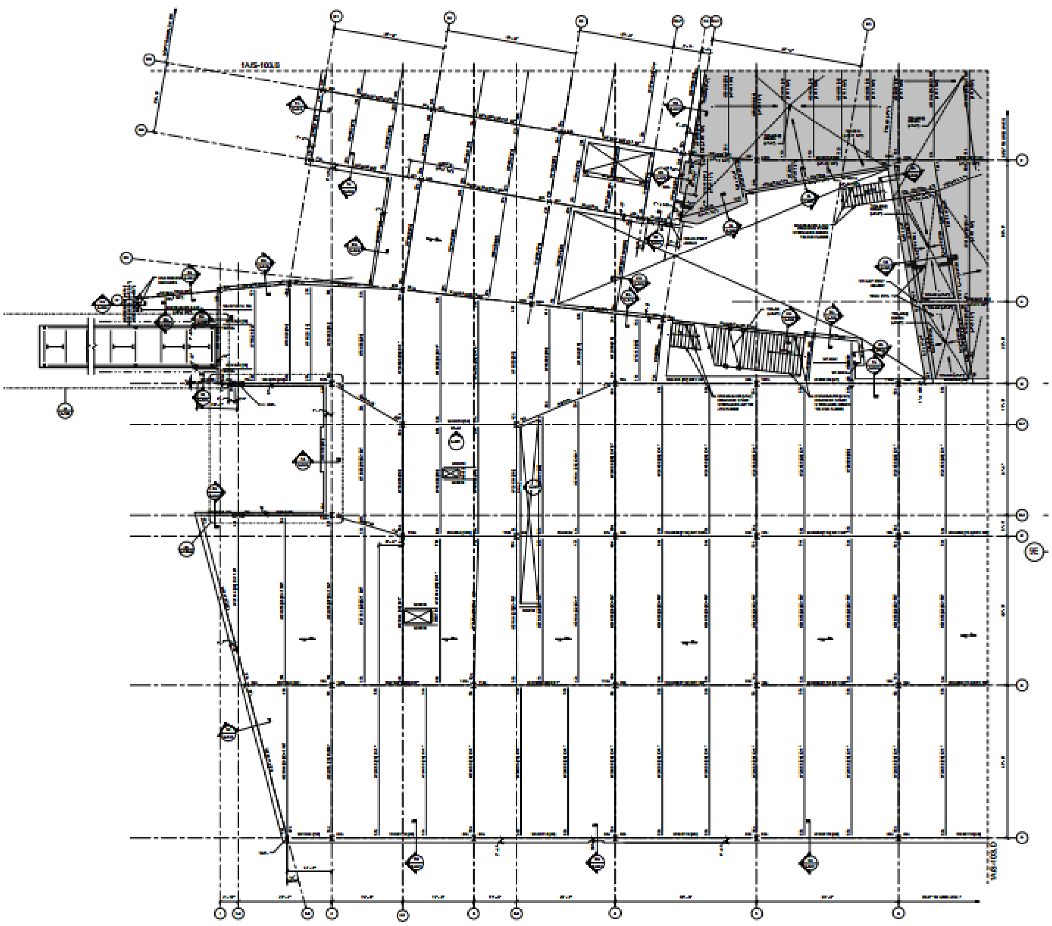



**FIGURE 10- TYPICAL SEGMENT A FLOOR FRAMING PLAN**

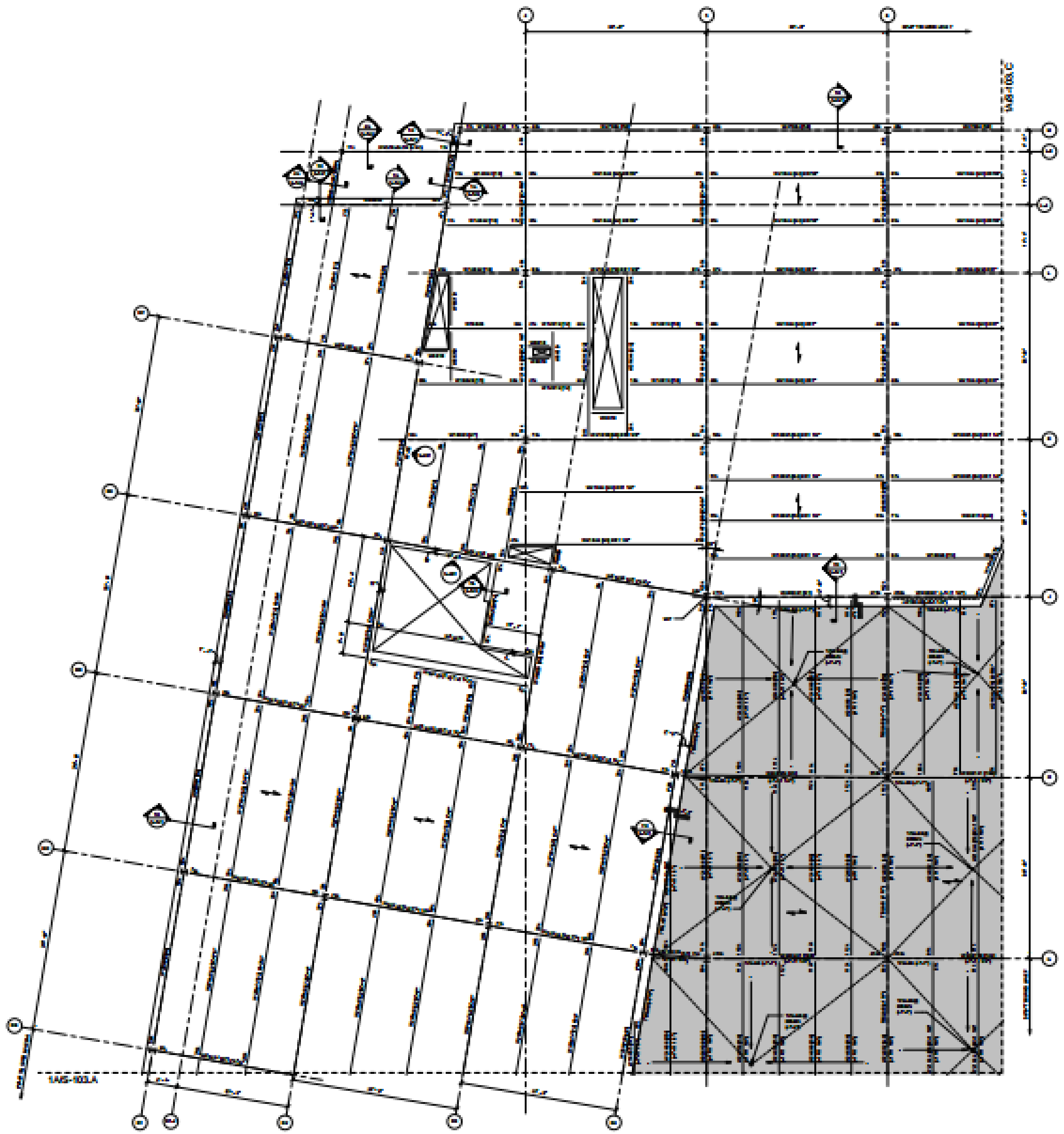


**FIGURE 11- TYPICAL SEGMENT B FLOOR FRAMING PLAN**

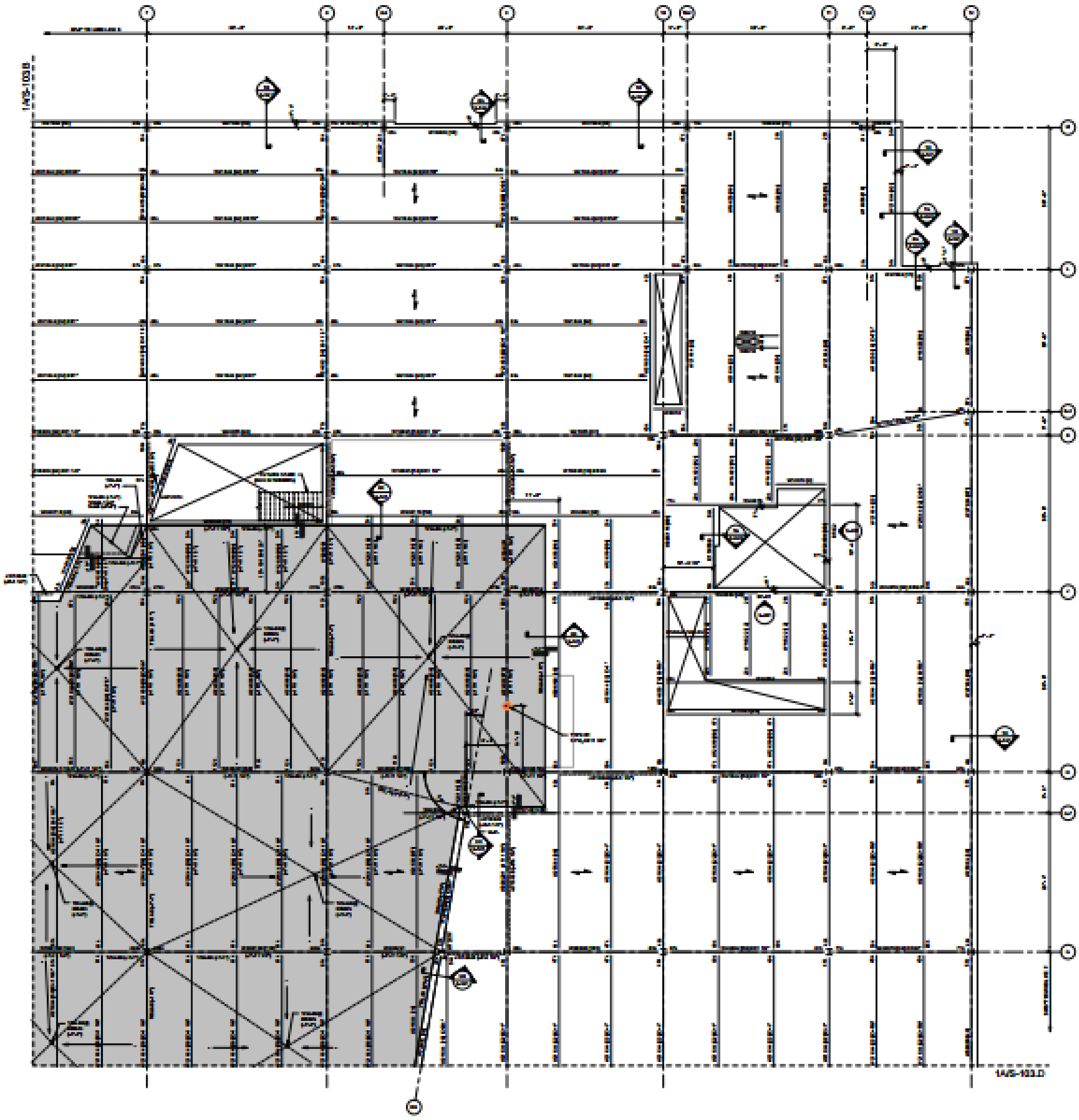


FIGURE 12-TYPICAL SEGMENT C FLOOR FRAMING PLAN

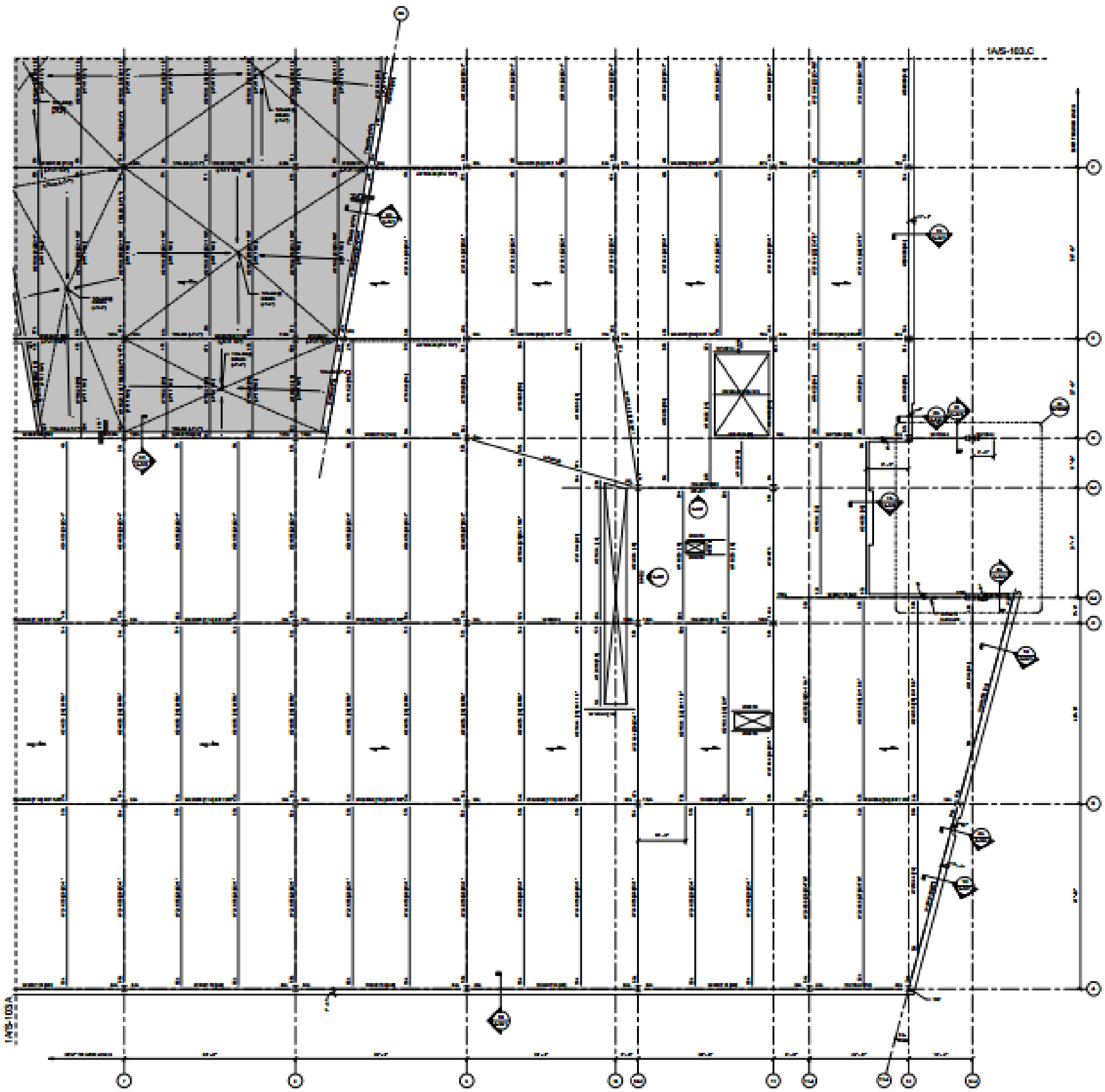


FIGURE 13-TYPICAL SEGMENT D FLOOR FRAMING PLAN

# Appendix B: Building Elevations

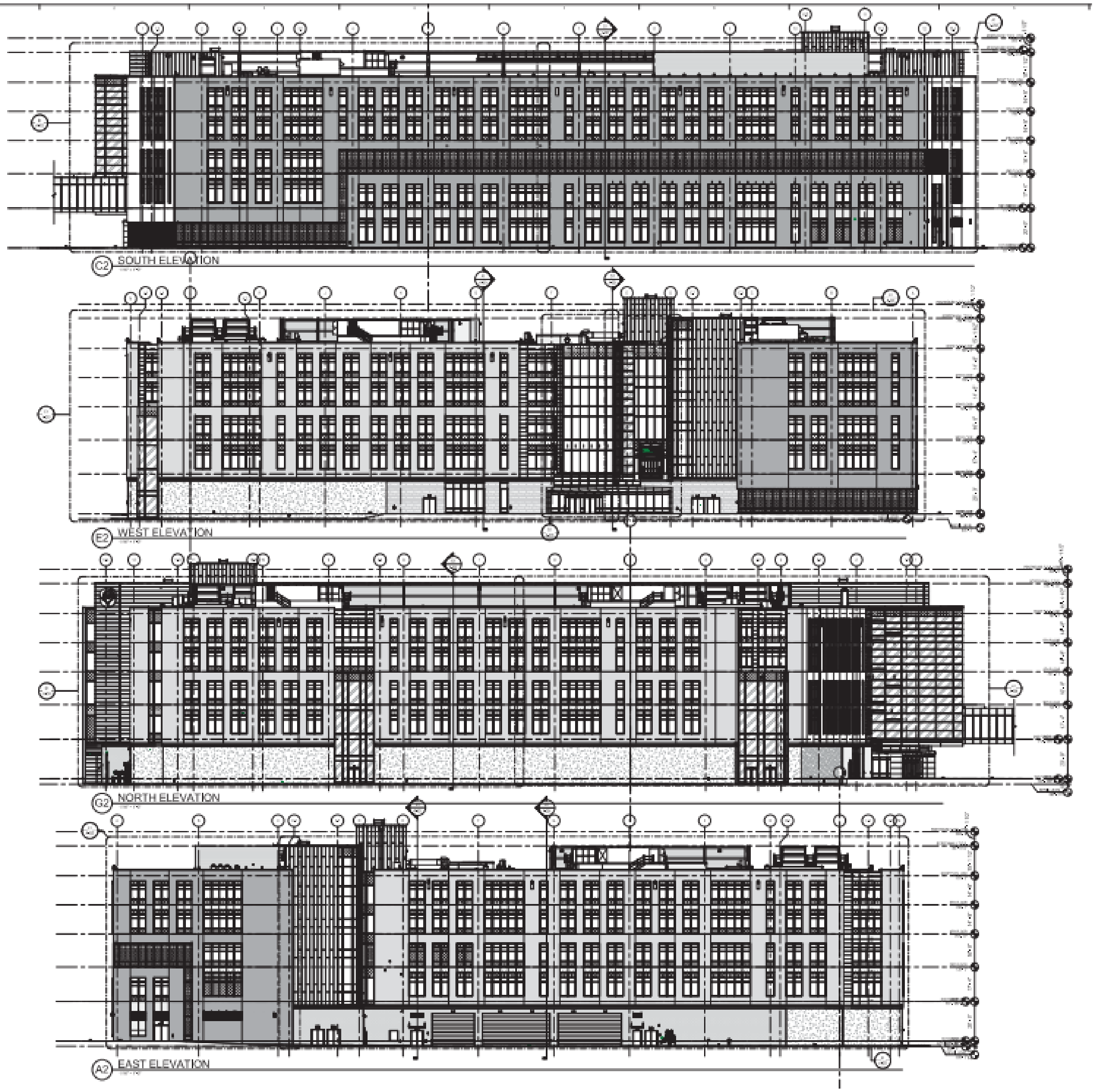



FIGURE 14- BUILDING ELEVATIONS, FROM TOP DOWN: SOUTH, WEST, NORTH, EAST