One and Two City Center Washington D.C.

Structural Existing Conditions

Report 1

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Option: Structural

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1. Executive Summary

One and Two City Center are commercial buildings that are a part of a multi-use development located in Washington D.C...Being approximately 312,000 square feet the building is part of a four lot project. Planning and Design began as early as April 2007 but due to the recession construction was delayed until April of 2011 and was finished later in 2014.

The twin office buildings now stand 12 stories tall with a floor to floor height of 12'. The shell of the structures is a glazed aluminum curtain wall with movable louvers. Like many roofs in D.C. there is a rooftop mezzanine on both One and Two City Center with several areas used as a green roof. Connecting the two buildings on every floor are glass coated walkways which span the alleyway separating the One and Two City Center. The building has achieved LEED Gold certification and the development has been one of the first to achieve LEED-ND (Neighborhood Development) certification.

The structural floor systems are two way post tensioned concrete slabs supported by typical 24" x 24" concrete columns. These columns run down through the building into the below grade parking and come to rest on shallow concrete footers. Lateral Loads are resisted by a series of shear walls which surround the elevators and stairwells. The glazed aluminum curtain wall is fastened to the structure at the concrete slab and supported by HSS sections. The penthouse roof and floor are supported by a series of w10's.

The additional lots feature commercial, residential, parking and public areas. To the north of One and Two City Center (Lot46) is an outside plaza with a captivating reflecting pool. To the east of the site is a four structure commercial and residential development (Lot 47). The two main lots are connected by an alleyway lined with retail stores. At the center of Lot 47 is a small courtyard offering relief from the city. Underneath Lot 46 and 47 is a four story parking garage for public access and the use of delivery trucks.

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2. Introduction

2.1 Purpose and Scope

This report will detail the structural existing conditions of One and Two City Center. Elements of the structure that shall be discussed are the buildings' general framing system consisting of typical bays and their columns, breams, slabs and how the load passes through them. Furthermore this preliminary report will also describe components such as the lateral systems, foundation systems, building loads, national codes and joint details. The following pages shall provide a general understanding of the building through details and images provided by the owner and design team.

2.2 General Building Information

One and Two City Center are type B mixed use buildings located in Washington D.C. that stand 12 stories above grade. Both buildings are similar enough to each other in that they are twins with identical structural systems. Each floor is approximately 26,000 square feet with the total square footage of one building nearing 312,000 square feet. The two buildings are a part of the larger city center development consisting of additional residential and retail complexes. The entire site sits on top of a four story below grade parking garage. City Center has also achieved LEED Gold certification and has become a popular, high end, area of central D.C.

Being located in D.C. One and Two City Center has to adhere to the height limitations due to zoning. The most common way to maximize floors and floor height is to have post tensioned slabs. The slabs system for One and Two City Center are 8.5" post tensioned concrete allowing for a greater floor to floor height of 12'. The two twin buildings are connected at every other floor by a concrete on steel deck bridge. Similar to other D.C. structures the City Center offices have a roof top mezzanine with a green roof. Foundations underneath the buildings are isolated concrete footers which support the columns above.

Figure 1: North West exterior view of One and Two City.

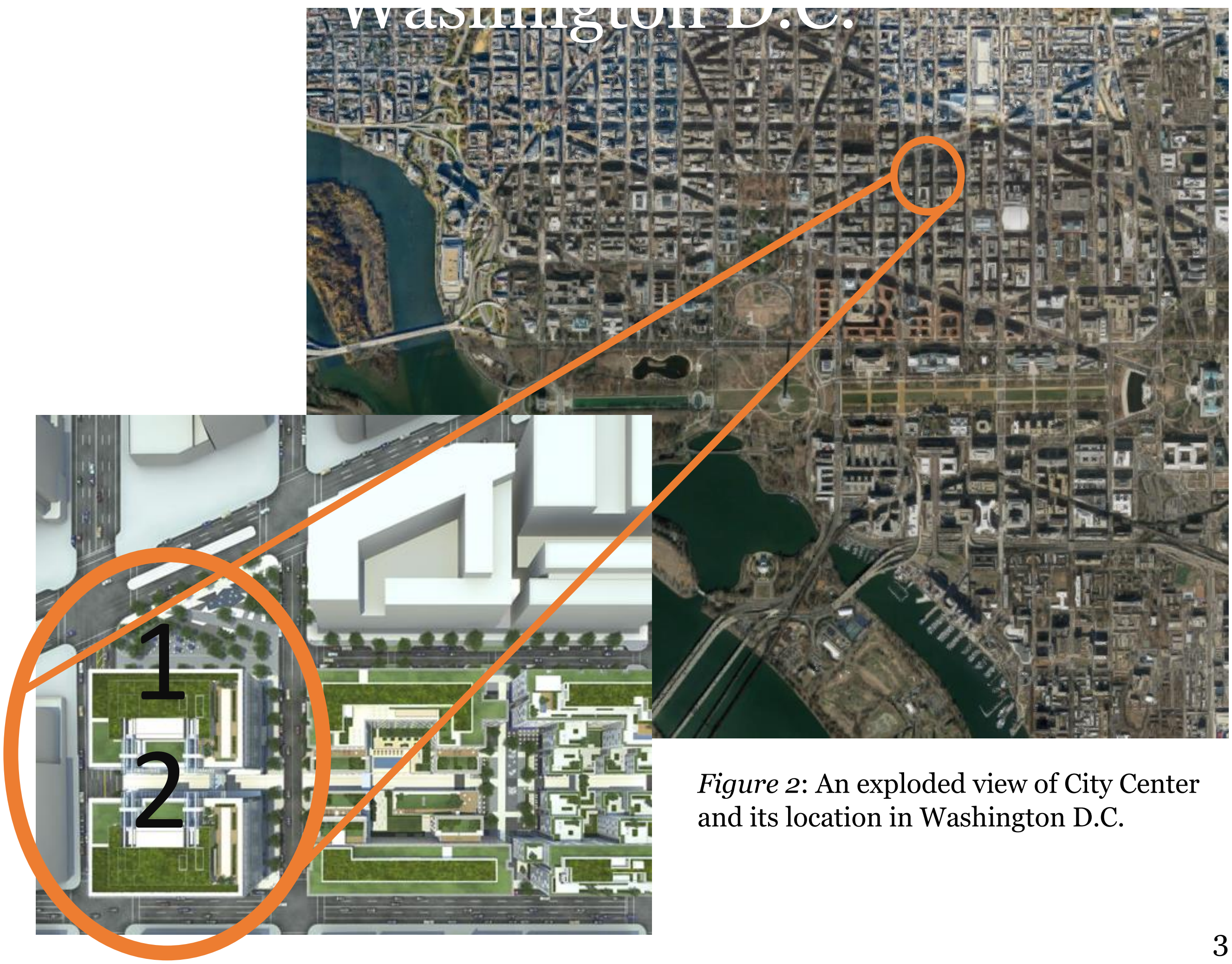


Figure 2: An exploded view of City Center and its location in Washington D.C.

2.3 Structural Framing System

The bulk of the structural framing for One and Two City Center is concrete. Slabs are 8.5" and have both post tensioned and reinforced steel inside. These slabs are supported by reinforced concrete columns which have dropped panels around them. These columns are supported by shallow isolated concrete footings. Resisting the lateral loads on the structure are 16 shear walls which are located near the main areas of egress. The rooftop mezzanine is supported by steel wide flange sections that are tied into the concrete structure. Bridges span between the two buildings and are connected through a pin and sliding mechanism.

Figure 3: Construction of One and Two City Center with structure exposed.

3. Structural Analysis

3.1 Floor Layout

The bays in both buildings are not typical in dimension. They range from the largest being 30’ x 30’ and the smallest being 25’ x 20’. The compressive strength f ‘c of the slabs are 5000 psi with the exception of the second floor which is 6000 psi. These slabs are typically 8.5” deep and contain 6” drop panels. Several floors are repetitive in structure. For example the structural floor layout of level 4 is repeated on levels 5-8. Also the structural floor plan of level 11 is the same as level 10. A more detailed description of the floor layout is shown in figure 8.

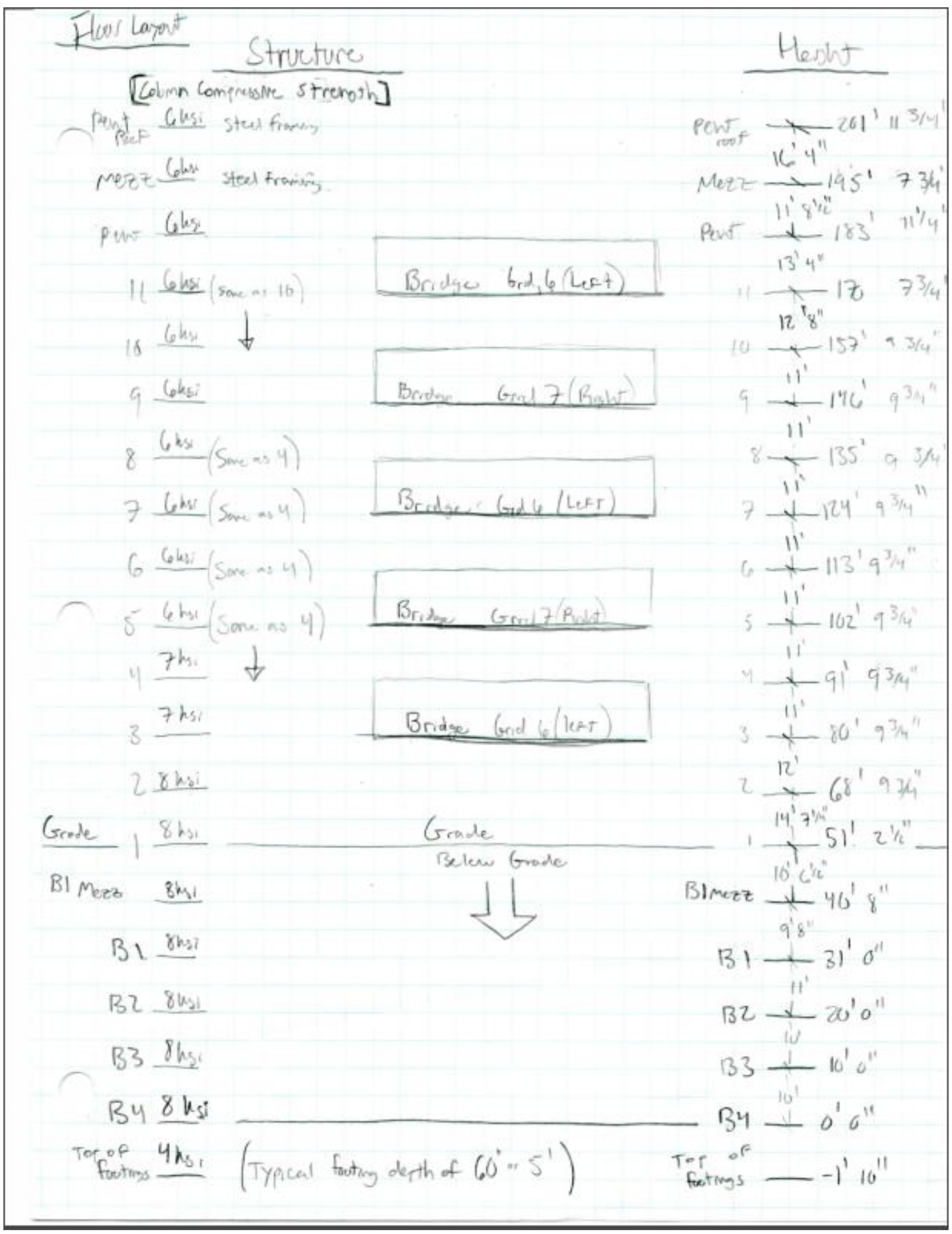


Figure 8: A hand drawn elevation showing basic structural elements throughout the building.

3.2 Post Tensioned Slabs

From level 2 to the penthouse (level 12) the floor system is post tensioned cables. These cables are ½" diameter, 7-wire strand, grade 270, low relaxation tendons which run in both directions of the building as seen in figure 4 below. The tendons that run north and south are embedded in the concrete and are stressed over time to a typical 20 kip/ft and 35 kip/ft.

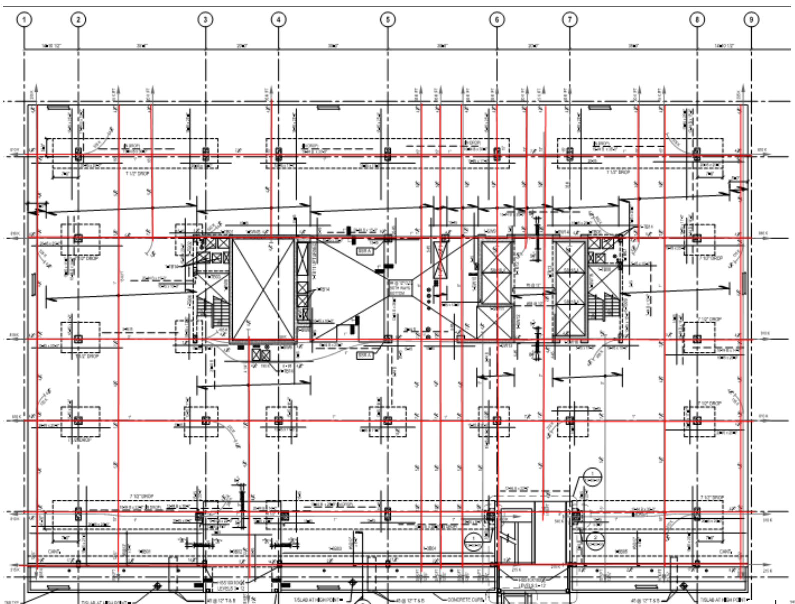


Figure 4: A typical floor plan with emphasis on the post tensioned cables.

3.3 Openings in the Slab

The main ways to traverse the buildings are through elevators, stairwells and bridges. These areas create openings in the structural slab of the building that have an impact on the load path of the slabs. There are 6 elevators in the same area that are approximately 500 square feet and a service elevator that is approximately 550 square feet. Stairwells can be found next to both the garage intake (service) and public elevators. 42' long bridges span the gap between One and Two City Center. A typical plan of these openings can be seen in figure 5.

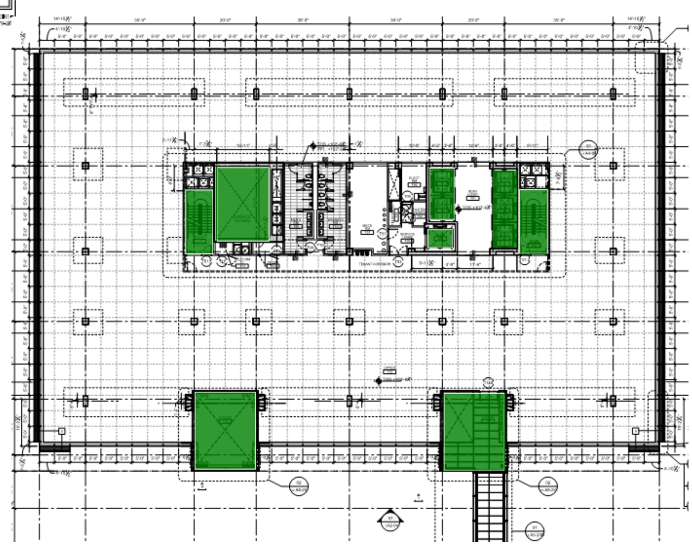


Figure 5: A typical floor plan showing the opening in the slab in green.

3.4 Stairwells

A sizable amount of the buildings openings comes from stair wells. The stairwells typically have 2 flights in between floors. These stairs are made of 3000 psi concrete and contain steel reinforcement depending on the stair span and thickness. This reinforcement schedule can be seen in figure 9. The stairwells are supported by concrete beams, shown in blue on figure 10. These beams transfer the load from the stairs into the columns. A typical elevation shown in figure 11 details the structure of the stairs throughout the building. What isn't shown in figure 11 is that the stairs are also supported by the elevator cores or shear walls.

STAIR REINFORCING SCHEDULE		
STAIR (& LANDING FOR DOUBLE RUN) SPAN 'L'	SLAB THICKNESS 't'	REINFORCING
L ≤ 10	6"	#4@10"
10 < L ≤ 12	7"	#5@12"
12 < L ≤ 14	7"	#5@9"
14 < L ≤ 16	7"	#5@7"
16 < L ≤ 18	8"	#5@6"
18 < L ≤ 20	8"	#6@7"
20 < L ≤ 22	8"	#6@6"

Figure 9:

6 STAIR THICKNESS AND REINFORCING SCHEDULE

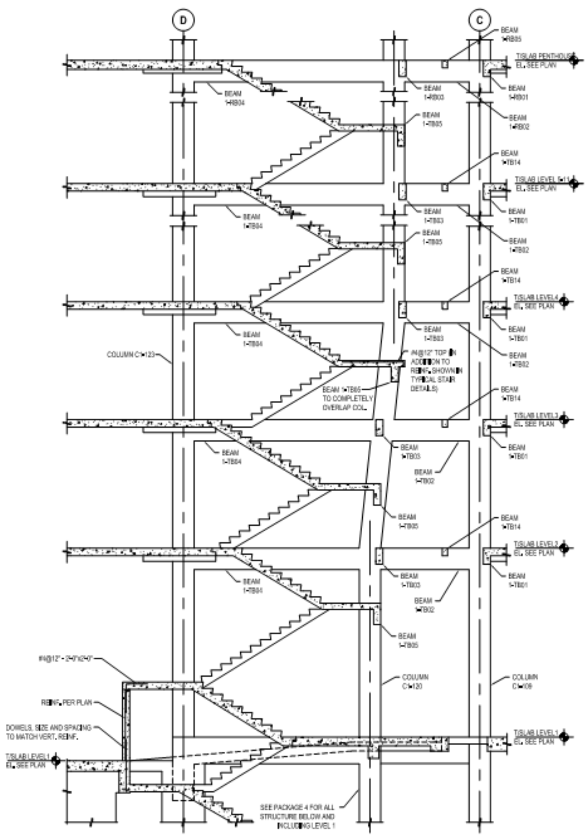


Figure 11: A typical stair section that shows the columns and beams that support the stairs.

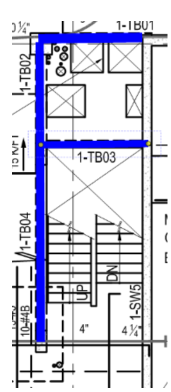
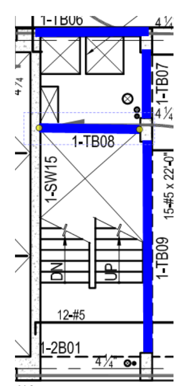


Figure 10: Plan view of two stairwells with the beams supporting them shown in blue.



3.5 Shear Walls

The elevator cores also act as shear walls taking the lateral loads of the building. The compressive strength of the shear walls follows the compressive strength of the columns. That said it varies by floor, see figure 8 for compressive strength details. The shear walls that surround the elevator shafts have a typical thickness of either 10” or 12” depending on their orientation. This is likely due to the lateral loads from one direction being greater than another. The reinforcement of the shear walls is are either #4 or #5 bars spaced 12” running both horizontally and vertically. Some shear walls change geometry near the bottom floors and become longer as seen in figure 13. This change in geometry could be due to the need to resist more shear at the base of the building. The location of the shear walls are shown on plan in figure 12.1. Their configuration is most likely so that the center of mass and center of rigidity are not far apart. This will create a smaller eccentricity and make the building more effective at resisting lateral loads.

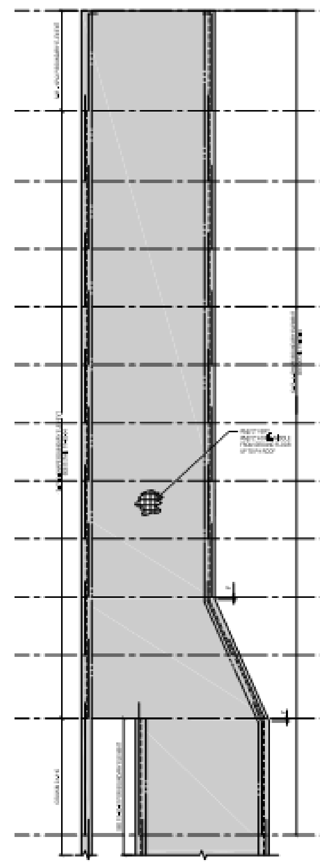


Figure 13: An elevation of a shear wall that widens at the lower levels

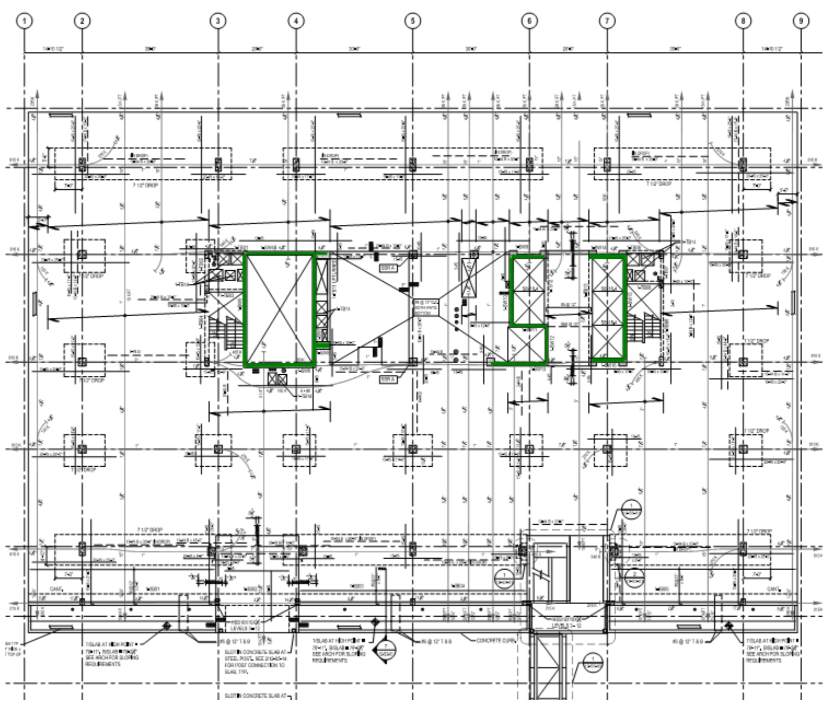


Figure 12.1: A plan view of the shear walls shown in green

3.6 Drop Panels

On every above grade floor with a post tensioned slab system there are drop panels around several columns. The dimensions width and length of these drop panels are, unless otherwise noted, dependent on the column to column span. It is detailed that the panels will be a length of L/6 where L is the center to center measurement of the columns. To ensure that punching shear does not occur the drop panels' length cannot be less than 2' on each side. The minimum extended depth from the slab is the thickness of the slab denoted as h divided by 4 (h/4). The typical reinforcement at each column location is 15 to 25 #5 bars placed each way. Figures 6 and 7 show a typical drop panel detail and where they are in plan.

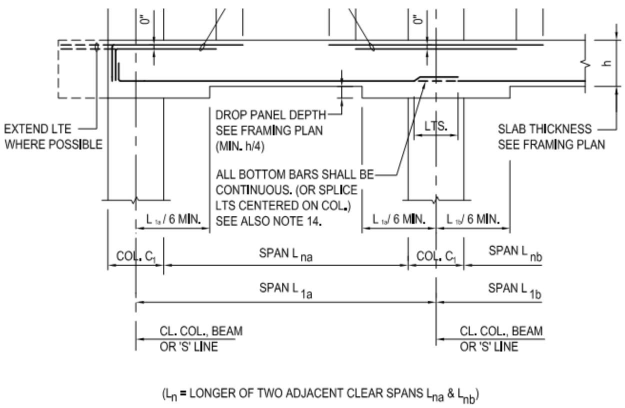


Figure 6:
3 TYPICAL DETAIL AT COLUMN STRIP WITH DROP PANELS

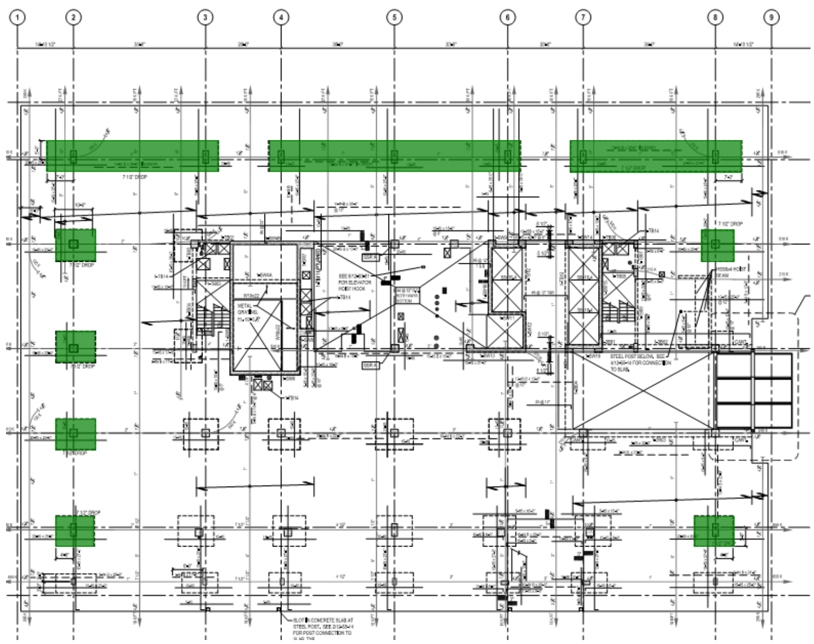


Figure 7: A floor plan showing the location and outline of drop panels.

3.7 Columns

There are typically 45 columns on each floor. These Columns vary in both compressive strength, size and height throughout the building. Typical steel reinforcing along the length of the column is 8 #8 bars. The compressive strength of the columns decreases as the building gets taller as seen in figure 8. Column ties are based off of the size of the vertical bars. Figure 14 shows the different spacing of horizontal reinforcement depending on what the vertical reinforcement is. Figure 15 details sections of columns and shows the typical layout of reinforcement.

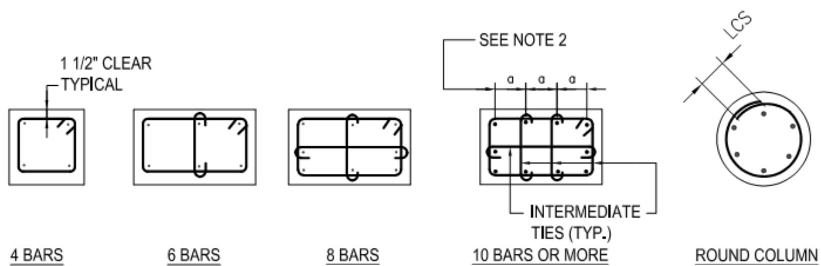


Figure 14: Specified column ties based on the vertical reinforcement.

MAX. SPACING "S" OF COL. TIES	
VERTICAL BAR SIZE	TIE SIZE & SPACING*
#5	#3 @ 10"*
#6	#3 @ 12"*
#7	#3 @ 14"*
#8	#3 @ 16"*
#9	#3 @ 18"*
#10	#3 @ 18"*
#11	#4 @ 18"*

* TIE SPACING NOT TO EXCEED LEAST COLUMN DIMENSION

NOTES:

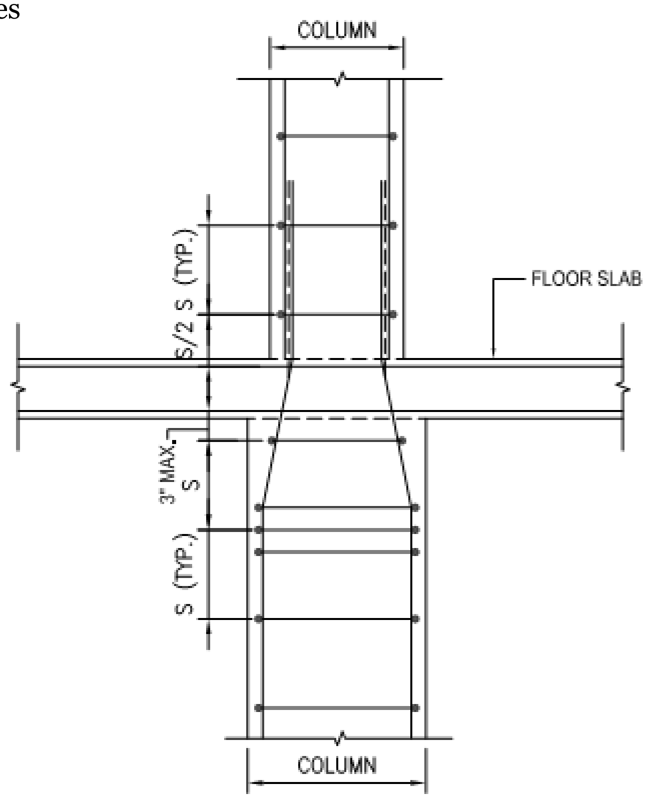


Figure 15: Sections of different columns showing the layout of reinforcement.

3.8 Foundation/Garage

The columns detailed above come to rest on shallow isolated concrete footings. These footings are several levels below grade. This is because there are five levels of below grade parking underneath One and Two City Center. The decision to include the garage as a part of the building analysis has yet to be made. Therefor the existing structure below grade will be shortly summarized due to how separate the building and garage structures are.

The structure of the parking garage consists of a 10" concrete slab with drop panels extending L/6 distance from the columns and 6" in depth similar to the above grade floors. Normal weight concrete is specified with a compressive strength of 5000 psi. The expansion joints for the garage vary in location and are typically 2" in thickness. The main reinforcing steel used in the garage slabs are #6 bars both ways with a minimum cover distance of 2" on top and 1" on bottom. The amount of #6 bars depends on the location and the column.

The columns, at the same location as the columns above grade, have a compressive strength of 8000 psi. These columns are supported by concrete footings and Mat slabs. The concrete footings have a compressive strength of 4000 psi and are typically 60" deep. There is no typical size of footing but the average size is 15' x 15. Typically 28 or 30 #10 bars run both ways to support the footing for shear, bending, temperature and shrinkage. Columns are also supported by Mat slabs which like the footings have a compressive strength of 4000 psi. Shown in figure 16 are the locations of the Matt slabs underneath One City Center.

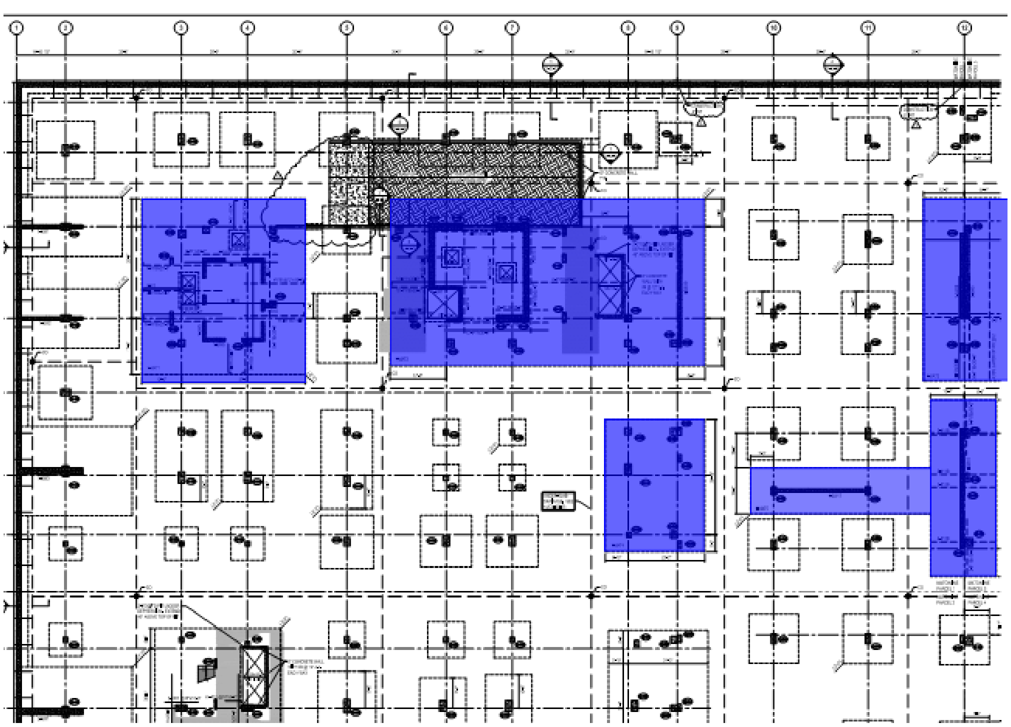


Figure 16: A plan view of the Mat slabs beneath One City Center.

3.9 Roof

The roofs of One and Two city center are under different zoning regulations than the rest of the building allowing them to exceed the 130' maximum height. Three levels make up the roof component, the penthouse the penthouse mezzanine and the penthouse roof. The penthouse level is similar to the lower 11 floors in that it is post tensioned concrete. Structural steel framing is used for the penthouse mezzanine and the penthouse roof. Both the penthouse mezzanine and roof are approximately 8,00 square feet. W10's are used as beams for the roof while w14's are used as girders to support them. Supporting the glass wall on the roof are a series of HSS members. Shown in figure 17 are beams drawn in red, girders in blue and HSS members in green.

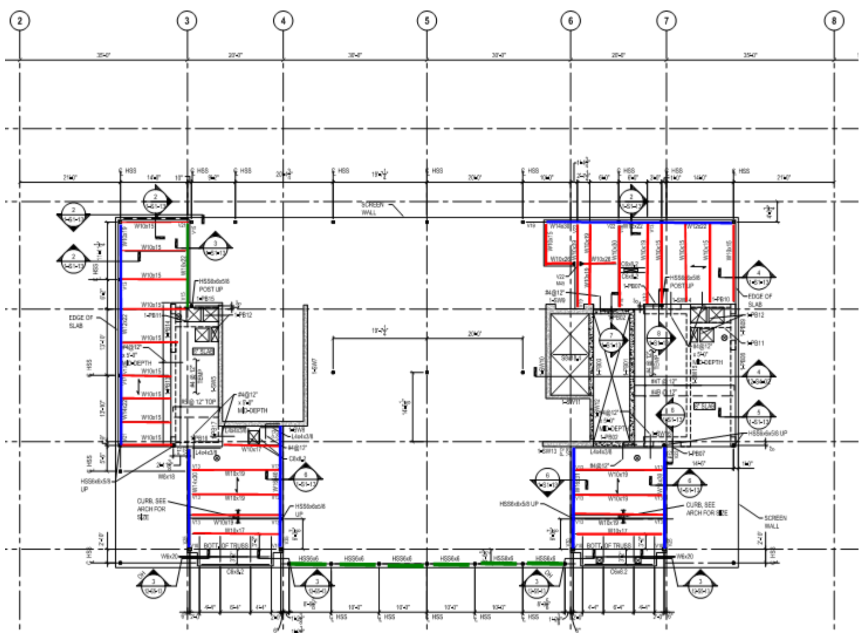
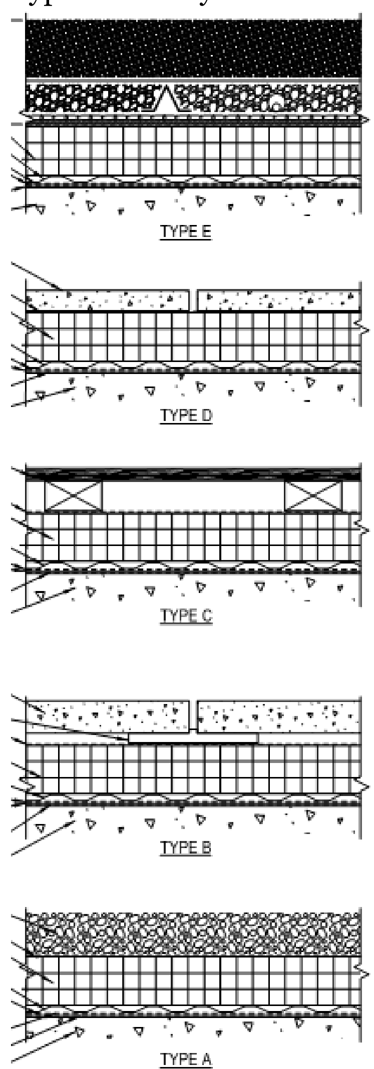


Figure 17: A plan view of the structural steel of the penthouse mezzanine.

Figure 18: The five different types of roof systems.



The roof membrane consists of five different construction types as shown in figure 18. All roof construction types have hot fluid applied asphalt as the waterproofing layer with 3" polystyrene insulation board topped with a filter fabric. The discrepancies between the roof types is what lays on top of the filter fabric. The various types of roofing have a topping of either stones, concrete pavers, wood decking or topsoil.

3.10 Bridge

One of the noteworthy architectural and structural aspects of One and Two City Center is that there are a series of bridges than span 25' between the two buildings. The bridges occur every other level starting at level 3 and ending at level 11. Every other bridge changes gridlines thus creating a pattern similar to that in figure 19. The structure of the bridges is 3.25" lightweight concrete on 2"18 gauge composite steel deck. This deck is supported by double steel angles as shown in figure 20.

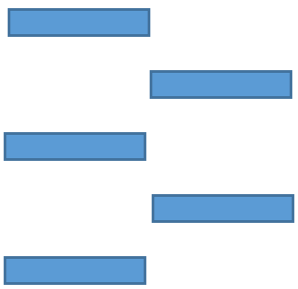


Figure 19: Simplified section of what the bridge configuration looks like.

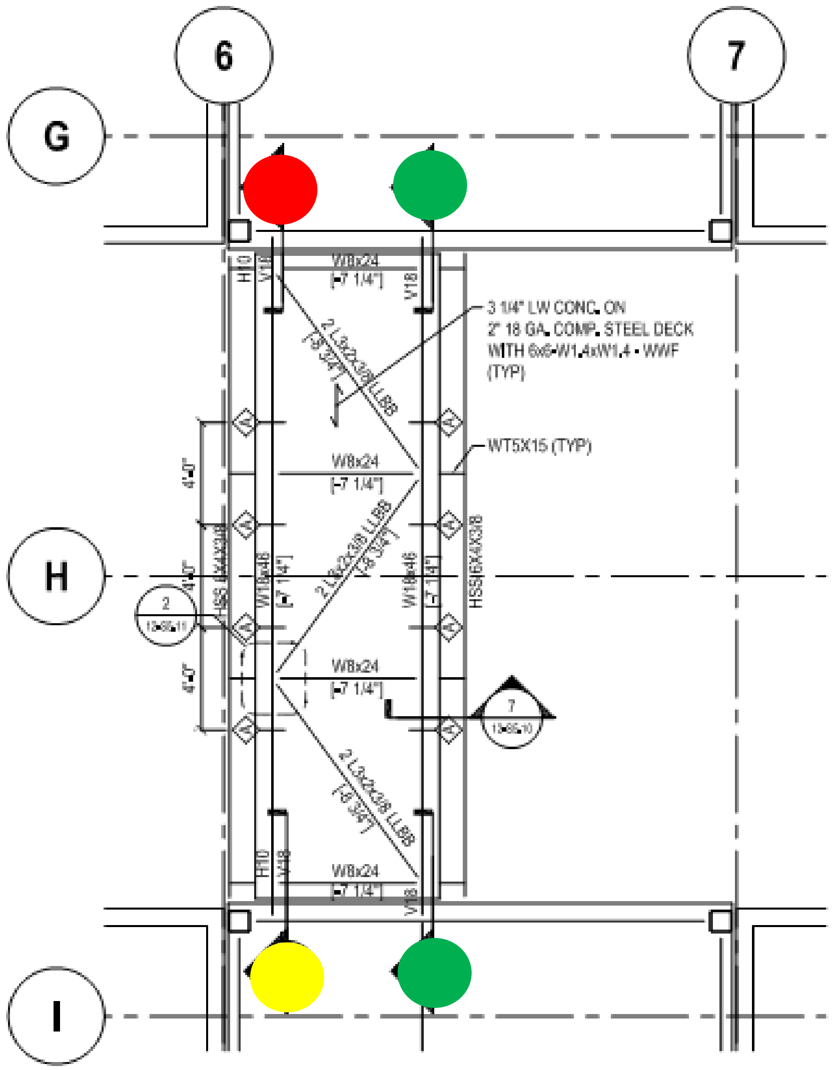
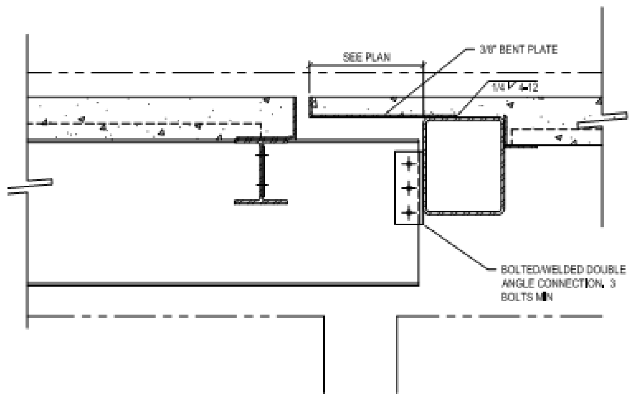


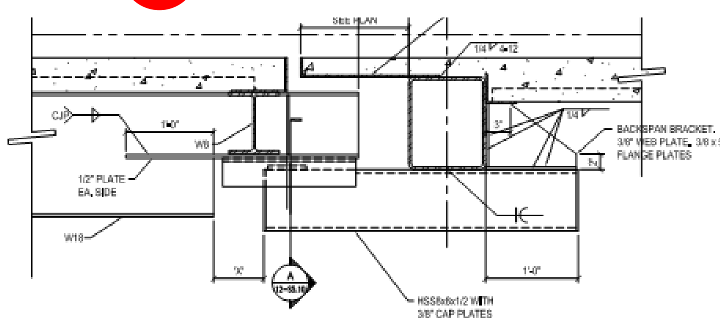
Figure 20: Bridge detail where the colored circles represent the type of connection

BRIDGE FLOOR AT LEVELS 3, 7, 11
SCALE: 1/4"=1'-0"

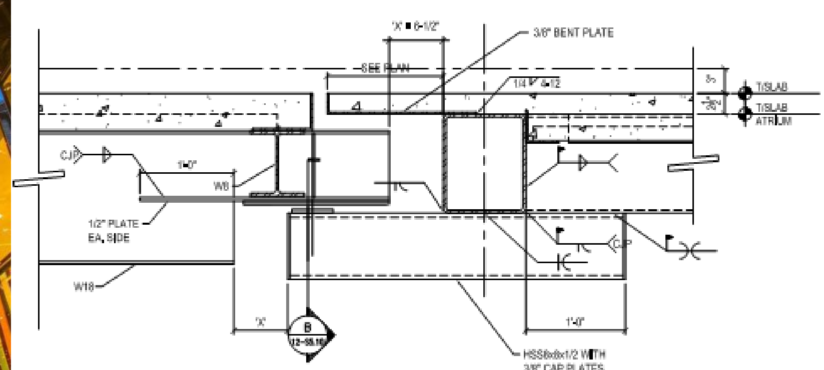
The bridge is connected to each building through pins and sliders. The various connections shown with colored circles in figure 20 represent different connections. These connections are further detailed in figure 21. Due to the nature of the connections the two building do not share any loads except for those on the bridges. The bridge does not transfer any lateral loads between the buildings.



BRIDGE FLOOR GIRDER CONNECTION AT "PIN"
SCALE: 1 1/2" = 1'-0"



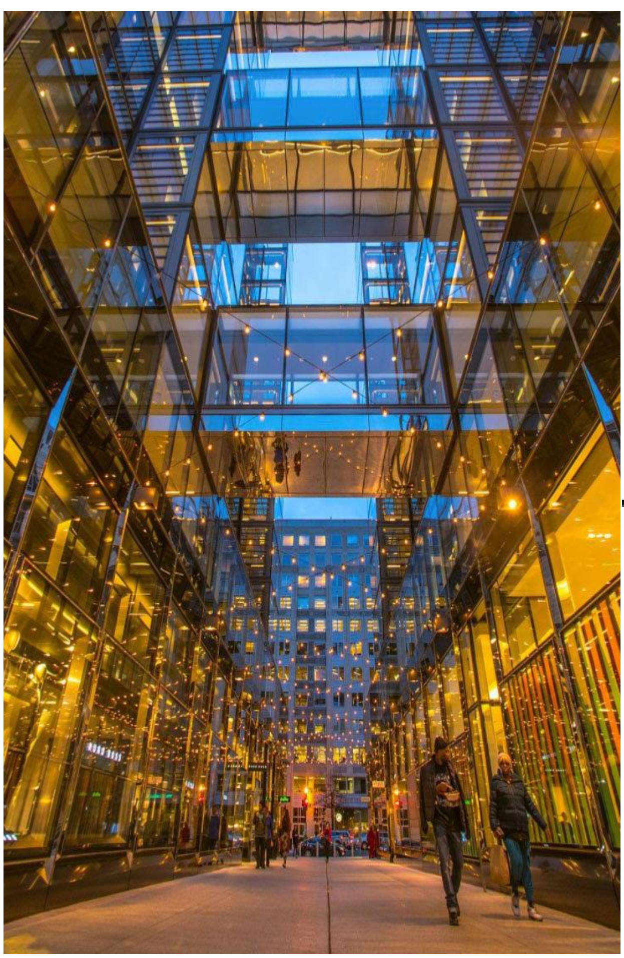
BRIDGE FLOOR GIRDER AT GUIDED SLIDING CONNECTION
SCALE: 1 1/2" = 1'-0"



BRIDGE FLOOR GIRDER AT SLIDING CONNECTION
SCALE: 1 1/2" = 1'-0"

Figure 21: Connection details for the bridges at levels 3, 7, and 11.

Figure 22: Upward view from beneath bridges.



3.11 Envelope

The façade of the building is made of a glazed aluminum curtain wall. The glass wall encases the building and is supported by connections to the slab. This connection consists of two steel angles bolted into the side of the slab as shown in figure 23.

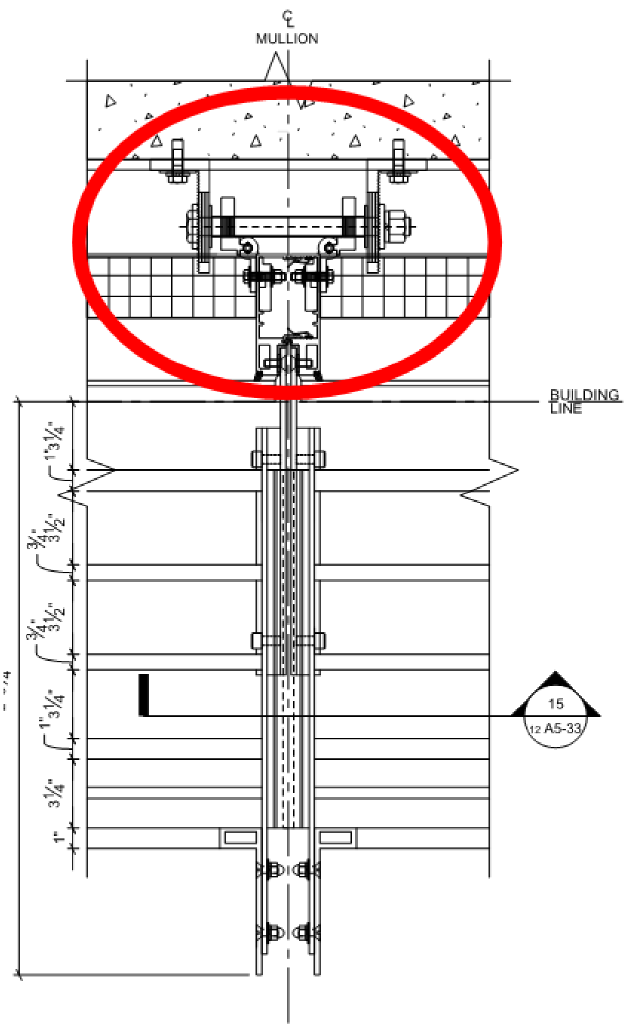


Figure 23: Plan detail of curtail wall connection to slab.

The envelope of the building also features an atrium space that extends the full height of the building. This can be seen in a general geometric model of the building shown in figure 24. The glass wall of the atrium space is supported by steel HSS members.

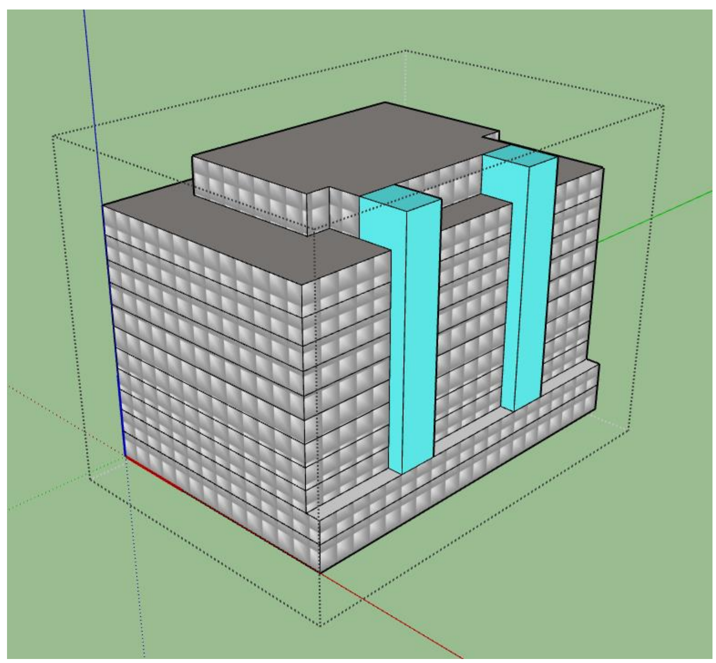


Figure 24: Geometric model of One City Center showing the atrium spaces in light blue.

4. Loads and Codes

The following load tables consist of the design loads in accordance with the District of Columbia DCRA-12 2003 and International Building Code (IBC) 2000 which in turn references ASCE 7-98. Other design codes used are ACI 318-02 and 530-2000 along with AISC-LRFD second edition. It is important to note that the structural members are not designed for any vibratory loading.

4.1 Live Loads

These loads are based on the expected occupancy load for given regions of the building. The loading of mechanical rooms was based on assumed weights of the mechanical equipment. Occupancy loads are derived from probabilities and have different safety factors applied for different loading conditions.

Live Loads	Pounds per square foot (PSF)
Office	80 psf
Ground floor, Retail, Lobbies, Stairs	100 psf
Mechanical rooms, Storage	150 psf
Terraces	100 psf

4.2 Dead Loads

Dead loads, more accurate than live loads, are commonly known material loads in the building. Mechanical dead loads, same as live loads, are assumed equipment weight. The following table does not include the self-weight of structural members rather the loads that those members would support.

Dead Loads	Pounds per square foor (PSF)
Office Floor/Partitions	20 psf
Mechanical Equipment	10 psf
Green Roof (roof)	50 psf

4.3 Snow loads

Loading caused by seasonal snow on buildings is estimated using the specified building code. The code contains maps and minimum standards to abide by for snow loading. The table below shows the variables used in calculating the roof snow load. It is specified that the calculated snow load comes from the variable below plus sliding and drift. It is also noted that the greater of the two loads, from the map (30psf) or from calculations, will govern.

Snow Factor	Value
ground snow load (Pg)	25 psf
exposure factor (Ce)	1
importance factor (I)	1
thermal factor (Ct)	1
roof snow load (Pf)	17.5 psf

4.4 Wind Loads

Wind loads, like snow loads, have their own map in the code that details a statistical wind speed in miles per hour. The winds pressure on the building is then determined from the wind speed in combination with other factors. The wind load acts on the cladding and in turn the cladding or curtain wall imposes forces on the building. It has been assumed that theses imposed wind loads from the cladding system create no moments or torsional effects on the structural members.

Wind Factor	Value
Wind speed	90 miles per hour
Importance factor	1
Exposure category	B

4.5 Seismic Loads

Loads caused by seismic conditions can place the building under a variety of loading conditions. During an earthquake the building can be pushed up pulled down or be shifted laterally. The most common condition, and thus the design condition, is lateral shift. The seismic resisting system in One and Two City Center are reinforced concrete shear walls which disperse the lateral load from the ground throughout the structure. It is important to locate the shear walls in such a manner that the buildings center of mass and center of rigidity are not far apart. If they are then the building will experience torsional twisting effects during high lateral loads. Figure 12.2 below shows the location of the shear walls and an estimated location of the buildings center of mass and center of rigidity. The procedure for determining the seismic forces on the building is the equivalent lateral force procedure. Below is a table showing the factors and results from that analysis.

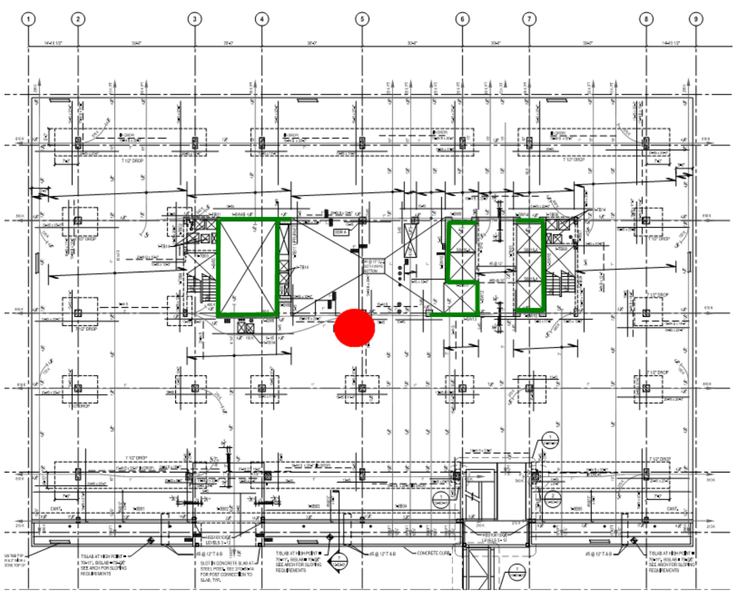


Figure 12.2: A plan view of the shear wall locations in green and an estimated location of the center of mass and rigidity in red.

Seismic Factor	Value
Use group	1
Site Class	C
Spectral response coeff	Sds=0.143 Sd1=0.071
Design Category	B
Base shear	NS-1082Kips EW-1255Kips

5. Conclusion

One and Two City Center was constructed in 2011 and is a type B mixed use building. The structural floor system uses post tensioned concrete slabs to allow for greater floor to floor height. The openings in the slab are for means of egress and for atriums. Where there are elevators and stairwells there are reinforced concrete shear walls which resist the later loads of the building. The columns support the gravity loads of the building and have drop panels typically 6” in depth surrounding the columns. Supporting these members are a combination of shallow concrete footings and mat foundations. Both of which are located four levels below grade where they also support a parking garage complex. It has yet to be decided if this garage will be included in the further technical reports. This garage system supports both One and Two City Center structures and thus both building share a foundation. Both building are also connected with a series of bridges connected with a pin and slider mechanism. Due to the nature and symmetry of the structure that both buildings have it is unlikely that both will be evaluated in the next reports.

6. Appendices

Figures