Technical Report 1

8621 Georgia Avenue
Silver Springs, Maryland

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Executive Summary

The building at 8621 Georgia Avenue is proposed to be built on an existing 0.69 acre parking lot located in the downtown business district of Silver Springs, Maryland. The 17 story, 347,000 ft^2 project will create more downtown multi-family housing and parking for the booming region. The project has recently finished the permit phase of development and is nearly the start of construction.

The building will be the tallest of the surrounding buildings and will be clearly visible along specific urban view corridors and pedestrian heavy areas. Therefore, detailed focus was cast on the architectural impact of the form of the glass curtain wall clad building in these locations. Being the tallest building in the area came along with the challenges of remaining under the zoning height restriction of the area. Efforts were made to decrease the floor to floor height by using post tensioning in order to squeeze the most amount of floors into the building.

The first four stories used for parking, retail, and café have flat plate concrete slab floors with minimal use of concrete drop pads and beams when necessary. The 5th through 17th floor utilizes post-tensioned concrete flat plate slabs with spans varying from 15’-10” to 24’-0” throughout these 12 floors of apartments. The variation in column locations and the use of transfer girders were eliminated due to strategic placing of columns in a regular grid that was appropriate for both the parking garage and the apartments.

The building was designed considering live loads, gravity loads, snow loads, wind loads, seismic loads, and lateral loads. The lateral force resisting system in the building is primarily made up of shear walls around the two stair towers of the structure.

The design for this building was governed by the International Building Code 2012 as well as the ‘Minimum Design Loads for Buildings and Other Structures” (ASCE 7-10). These codes reference other standards that were integral in the design process and include ACI318-11 and parts 1-5 of the ACI Manual of Standard Practice, PTI’s “Post Tensioning Manual, 6th Edition, the “Manual of Standard Practice” from CRSI, and AISC’s Steel Construction Manual, 14th Edition.

This report will cover all of these details and many more, in greater detail.

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Purpose and Scope

The purpose of this technical report is to describe the existing conditions of the 8621 Georgia Avenue building with a focus on the structural systems and components. Specific areas of concentrations will include descriptions of the floor framing, gravity system, lateral system, foundation system, joints, and load paths through the structure. The loads and codes that were used in the building's design will also be discussed. By this end of this report I should have a greater understanding of the building, how the systems work together, and future challenges for forthcoming technical reports.

Building Overview

The building at 8621 Georgia Avenue is owned by FP Wilco, LLC. in the downtown business district of Silver Springs, Maryland. The new 17 story, 347,000 ft^2 building will provide 4 floors of parking and 13 floors of apartments reaching a height of 161 ft. tall for the residence and workers in the area. As of the 50% permit drawings, the project is anticipated to cost $52 million dollars.

Picture 1: Rendered image from Southwest. Image courtesy of Holbert Apple Associates.

Great efforts were made in the design process to earn a LEED Silver rating for the building. 8621 Georgia Avenue is very transportationally sustainable with the location of the building is within a half block of the nearest metro stop and includes parking amenities for bicyclists. Water drainage issues were also strongly considered for this urban, non-pervious site downtown. The green roof helps reduce the carbon footprint of the building while simultaneously dealing with a significant portion of the water run-off.

The first floor has a dual function as the space serves both the private residents of the building as well as the public. The program on the first floor includes a Cyber Café, Fitness room, apartment lobby, and parking spaces (including bicycle and ADA parking). All of these areas, except the parking garage, are double height ceilings and are accessible from the street.

The parking garage portion of the structure continues up from the ground to the 4th floor and includes a total of 197 spaces. These first four floors are the only portion of the building that maintains its rectangular footprint. Starting at the 5th floor, above the parking garage, the form of the building takes on a U-shape with a green roof with box planters in the center of the 'U'.

Floors 5 through 16 are occupied with 292 multi-family apartments of varying sizes with accessible balconies. The upper residential floors are serviced by two stair towers and three elevators. The typical floor plan for the apartments is repeated until the penthouses on the 16th floor. The rooftop of the building is adorned with a pool, bathhouse, club, and rooftop garden terrace.

The façade of the building is comprised of precast concrete panels, a glass curtain wall system, and a masonry veneer. The precast concrete panels only occur at the levels of the parking garages. The apartment levels feature a prefinished aluminum panel curtain wall system as well as a masonry veneer on the west elevation. The details of how these façade elements are tied into the structure will be discussed later in this report.

Structural Overview

Brief Structural Description

Similarly to the surrounding structures, 8621 Georgia Avenue is made of primarily concrete. The foundation of the structure is supported by concrete columns and piers along with spread footings, strip footings, and foundation walls. The shear wall core located by the stair towers and elevator towers spans the entire height of the building and is responsible for resisting the majority of the lateral loads. The first four floors utilize mildly reinforced flat plate concrete slabs for the floors of the parking garage. The use of drop panels and beams was only used in situations where they were absolutely necessary to meet the design parameters. The 5 floor and above utilizes post-tensioned flat plate concrete slabs. This design choice to use post-tensioning was made to maximize floor to floor heights amidst the stringent zoning height ordinance.

A brief summary of the structural materials used in the project are given below.

Concrete		
Use	Strength (psi)	Weight (pcf)
Footings	3000	145
Foundation Walls	4000	145
Shear Walls	5000	145
Columns	5000-7000	145
Interior SOG	3500	145
Exterior SOG	4500	145
Reinforced Slabs / Beams	5000	145
Parking Structure	5000	145

Reinforcement	
Use	Grade
Deformed Reinforcing bars	ASTM A615, Grade 60
Weldable deformed reinforcing bars	ASTM A706
WWF	ASTM A185
7-wire Low Relaxation Prestressing	ASTM A416, Grade 270
Full Mechanical Connection	DYWIGAG, Lenton Or equivalent meeting ACI 318-12.14.3

Figure 1: Concrete and reinforcements materials and specifications.

Steel		
Use		**Grade**
Wide Flange		ASTM A992
Structural Shapes and Plates		ASTM A36
Structural Pipe		ASTM A53, Grade B, Fy=35ksi
HSS		A500, Grade B, Fy=46ksi
Cold-Formed Steel		ASTM A653 (G-60 Galv.)
	<43 mils	Fy=33 ksi
	>54 mils	Fy=50 ksi
Fasteners		
Use		**Grade**
High Strength Bolts		ASTM A325
Anchor Rods		ASTM F1554, Grade 36
Threaded Rods		ASTM A36
Shear Studs		ASTM A108

Figure 2: Fasteners and Steel materials and specifications.

Foundation System

A geotechnical study was done on the site by Schnabel Engineering Consultants, Inc. who was able to provide useful recommendations for the foundation to the design team and structural engineer. Spread footing and column footings were advocated as good choices for the foundation system. The column footings were recommended to be design to 8,000psf while the wall footings were suggested to be 6,000 psf.

The proximity of the water table to the depth of the foundation was a principal concern in their geotechnical evaluation. The groundwater table will only be approximately 5ft. below the lowest level (electrical cellar). This observation of the site called for sub-drainage materials adjacent to the foundation walls which will be bearing soil pressure.

Typical Foundation details are shown below:

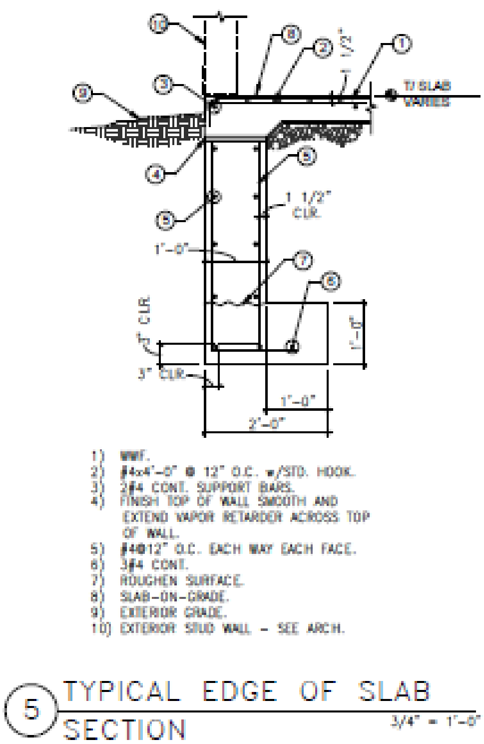

Figure 3: Typical Slab Detail. From S2.01

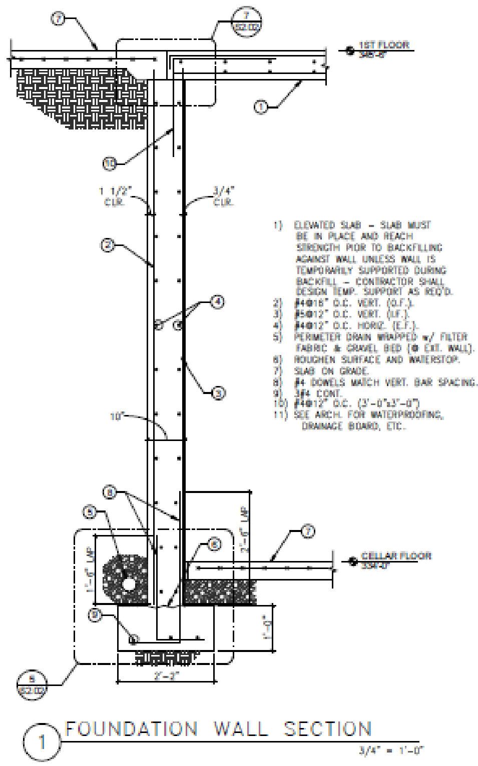

Figure 4: Typical Foundation Wall Detail. From S2.01

Only a small portion of the buildings total footprint, approximately 4,854 ft^2 goes below grade. This area is strictly for service use with electrical rooms, storage, and mechanical rooms. This level utilizes foundation walls to resist the lateral force of the soil pressures.

The geotechnical report on the soil composition of the site estimated the horizontal forces on these foundation walls to be 50 psf.

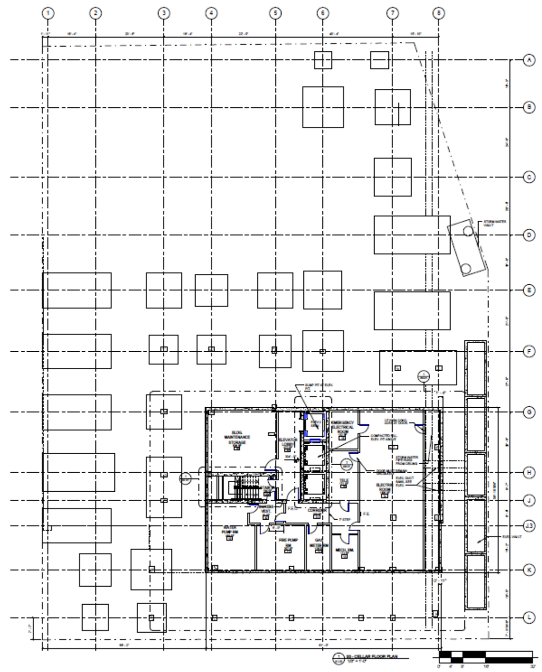

Figure 5: Cellar level floor plan

Floor System

As previously mentioned, 8621 Georgia Avenue is a concrete structure utilizing flat plate slabs throughout the building for the floor system. Drop panels are used only on the parking levels but are avoided on the apartment floors to maintain a spacious floor to floor height. The slab on grade is 8" thick mildly reinforced concrete slab and has an 18" step in elevation. In the floor system above the sub-grade cellar, a drop in the slab in required.

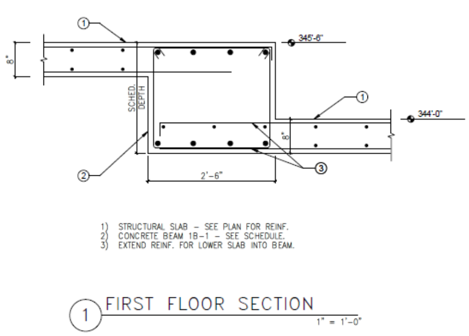

Figure 6: Typical Slab on Grade

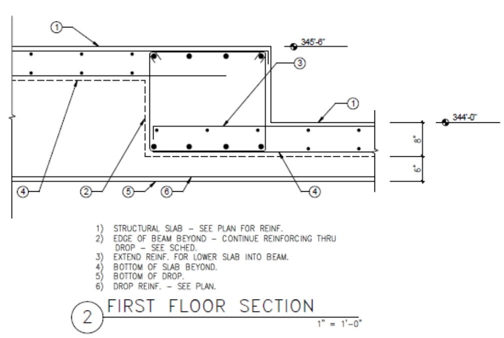

Figure 7: Slab on Grade above Cellar

Parking Garage

In the first 4 floors, as well as the first apartment level on the 5th floor, the structure will feature an 8” deep mild-reinforced cast-in-place two-way flat plate concrete slab system. The drop panels at each interior column will be 8’ x 8’ x 4” while the drop panels on the exterior columns will be 4’ x 4’ x 4”.

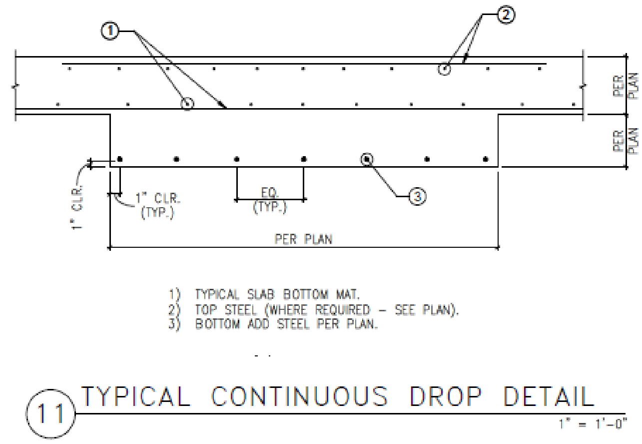

Figure 8: Typical Drop Panel

Apartments

Above the 5th floor and for the remaining floors, the structure consists of a 7.5” deep post-tensioned cast-in-place two-way flat plate concrete slab system. The use of drop panels and beams was minimized but was needed in some locations to control long-term slab deflections for longer spans. The post-tensioning system will be discussed in greater detail later in this report.

Typical Bay

A typical bay size for the project varies with columns spaces ranging from approximately 16 ft. to 24 ft. in each direction. These bay sizes are consistent throughout the whole building despite the functional transition from parking to residential. The larger bays are located where the drive lane of the parking garage is. Because the same column locations are continued up the entire building height, there was not the need for sloped columns or large transfer girders. The only situations where transfer girders were needed were at the second floor due to the transition from retail/lobby space to the parking structure and also adjacent to the pool at the top of the building.

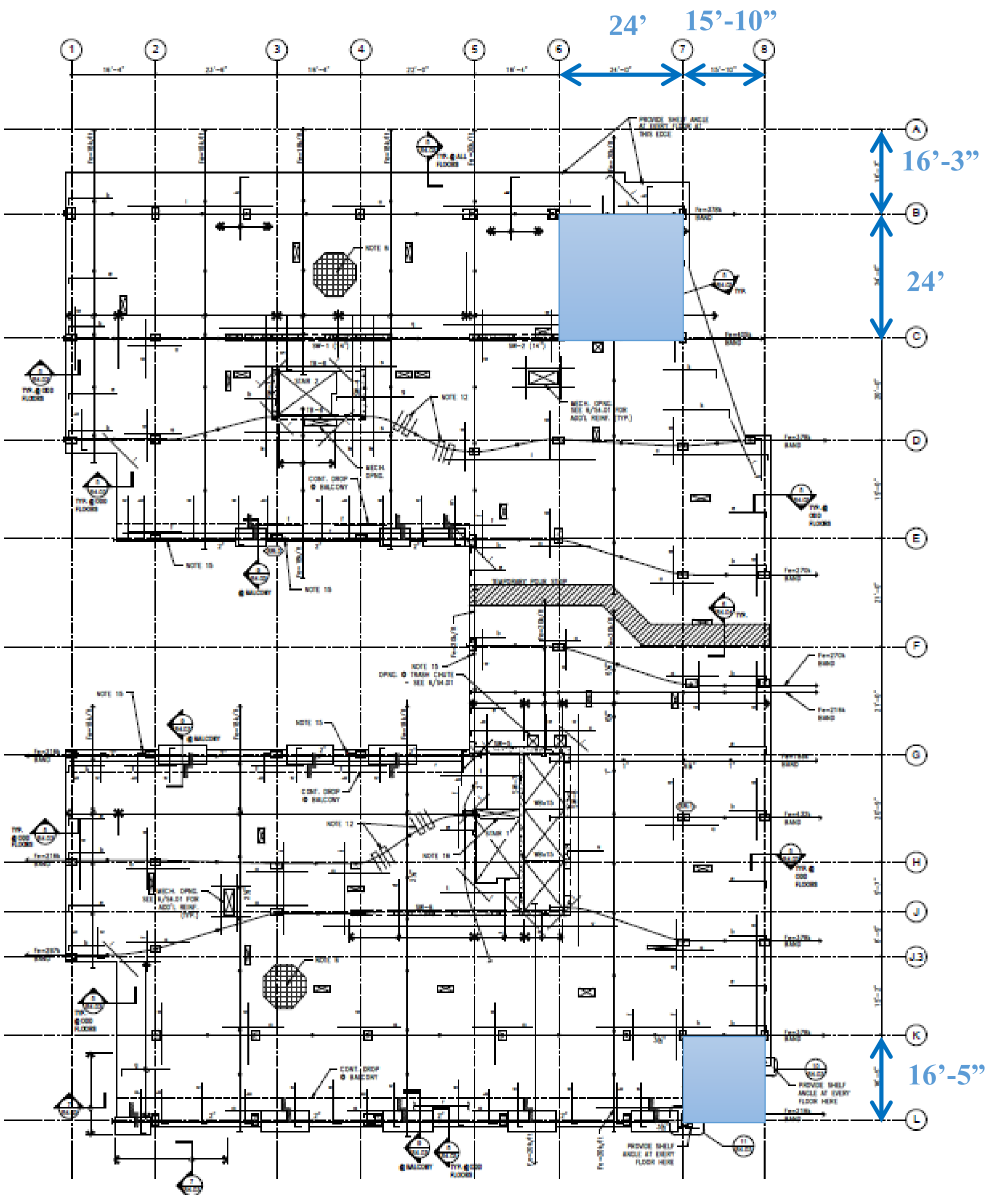

Figure 9: Typical Apartment Framing Plan

Columns

In order to accommodate the accumulated load in the lower floors, the concrete columns change in size and strength throughout the height of the building. Three different strengths of concrete are used in the columns throughout the project. The concrete strength increases in the lower floors to handle the higher axial compression loads without having to make the columns huge. This structural design decision will reap benefits by saving space in the apartment and parking garage floors.

Concrete Columns	
Location	Strength (psi)
Above 8th	5000
4th-8th	6000
Below 4th	7000

Figure 10: Concrete Columns Strengths

The column sizes generally seem to increase slightly by 2”- 4” in each dimension below the 4th floor. Although the column sizes and strengths change, the reinforcing in the columns is uniform throughout the entire height of the building.

Post Tensioning

Floors 5 through 16, which house the multi-family apartments, utilizes post-tensioning in the floor slabs. Both banded tendons and uniformly distributed tendons are used in addition to other mild steel reinforcing. The banded tendons typically run in the plan east-west direction while the uniformly distributed tendons span across the plan north-south direction.

The banded tendons vary is strength from 216 kips to 513 kips while the distributed tendons have tend to have a linear strength varying from 18 k/ft to 22 k/ft. The figure below shows the locations of these post-tensioned cables on the typical apartment framing plan.

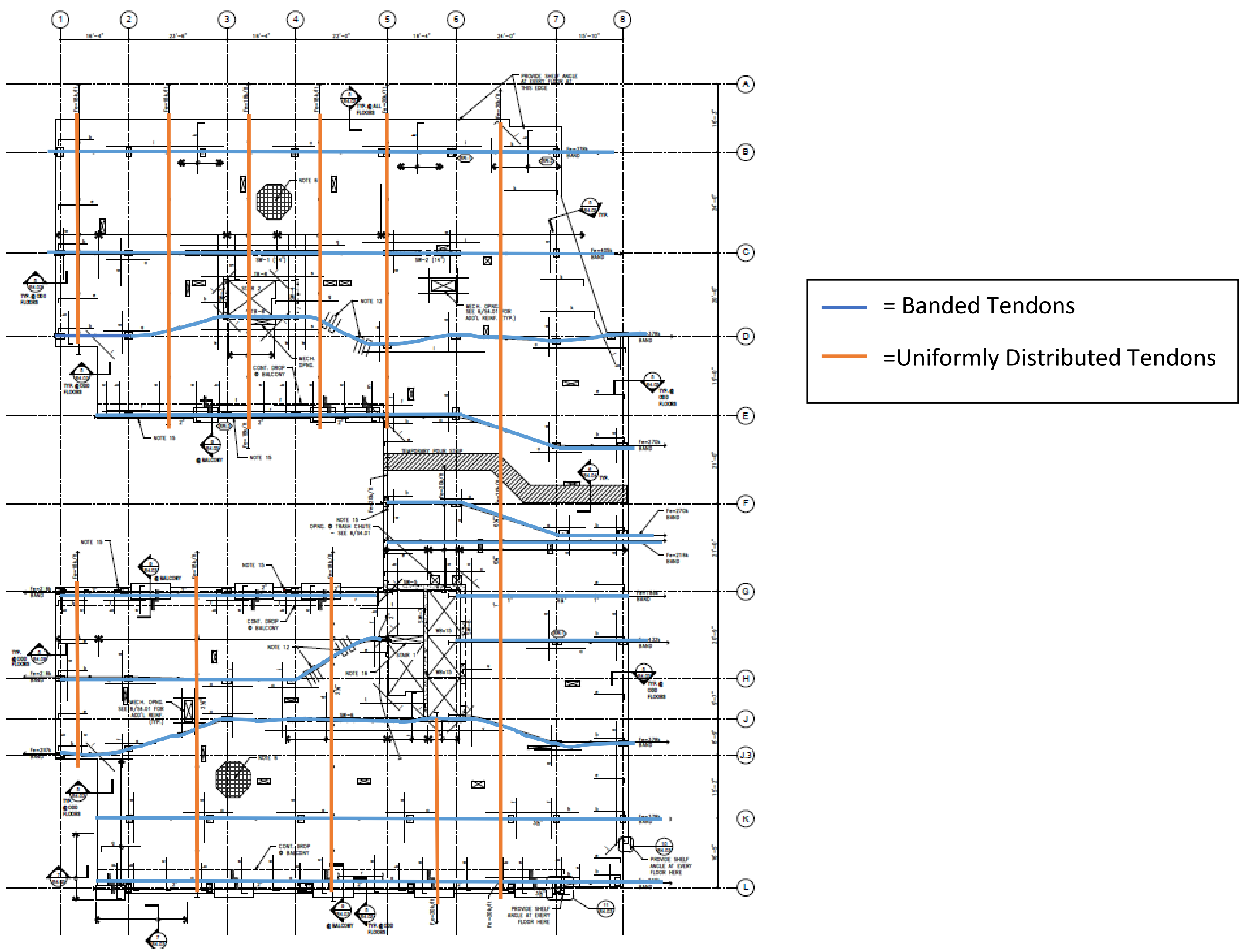

Figure 11: Typical Apartment Framing Plan

The post-tensioned strands do not span straight across the building in the center of the slab, but oscillate between the top and bottom of slab depending on its position relative to columns or any openings. The detail below shows the typical band orientation when being placed within a slab.

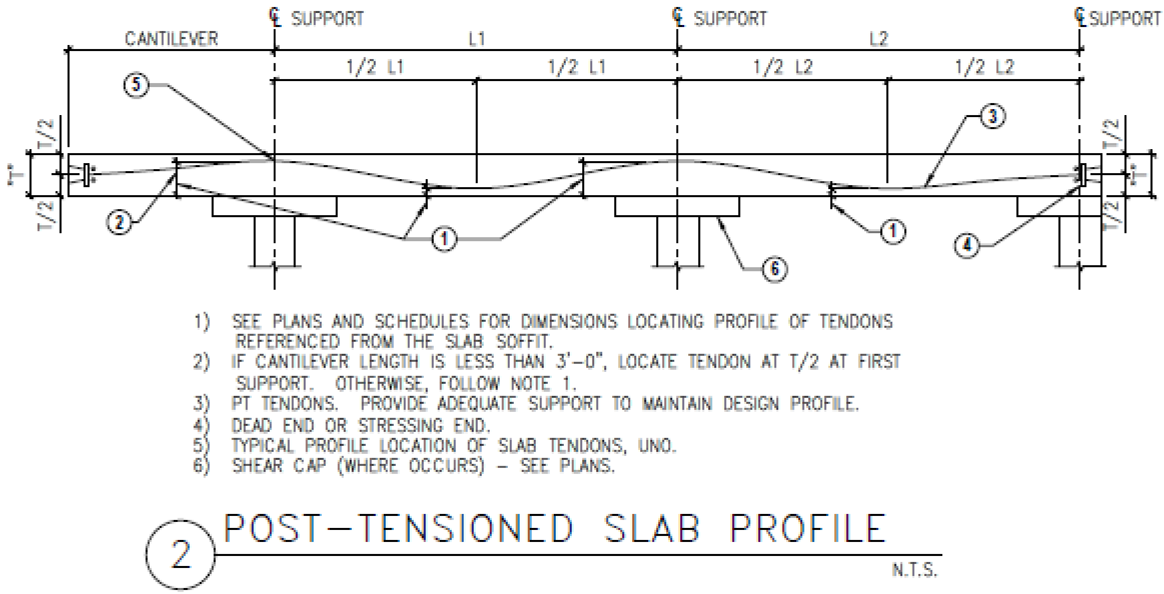

Figure 12: Typical Post-Tensioning Slab layout

Roof System

The roof area of 8621 Georgia Avenue is highlighted by having an 18' x 56' pool. The structure around the pool will consist of a mild-reinforced cast-in-place concrete slab and beam system. The pool will basically be a large concrete box filled with the appropriate waterproofing materials. An isometric view of the 16th floor pool level with a club, locker room, roof terrace, and other apartment suites is shown below.

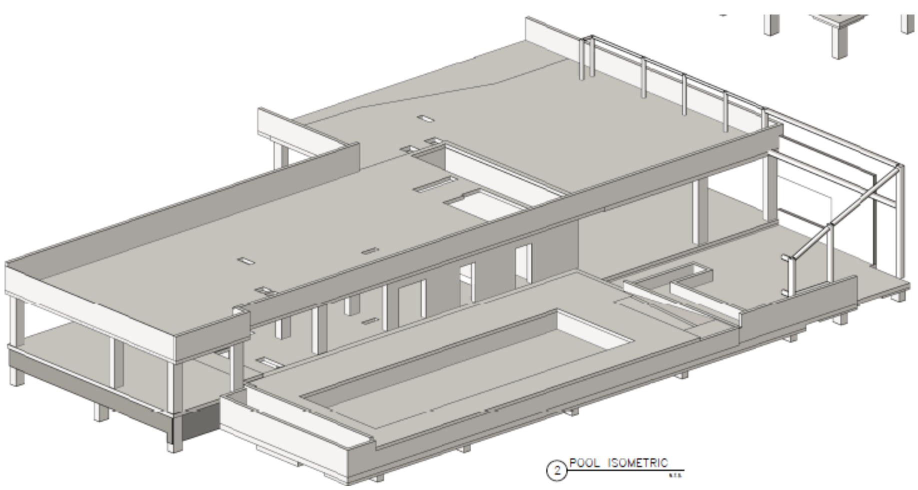

Figure 13: 16th Floor Isometric View

The roof construction is the same post-tensioned concrete two-way slab that is present in the floors below. A 1' layer of concrete topping is added to the slab then completed with a terracie finish.

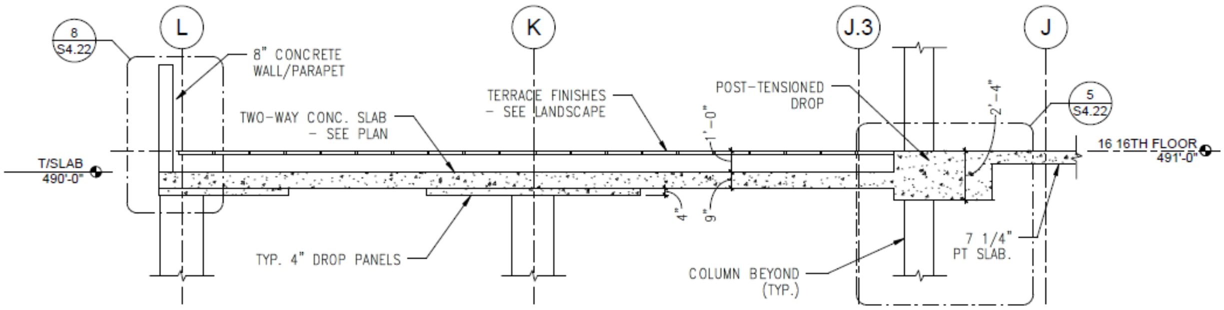

Figure 14: 16th Floor Section

Underneath the pool, the slab is depressed by 16" before additional concrete slabs and walls are built up upon it to house the pool. A section through this condition of the 16th floor slab is shown below.

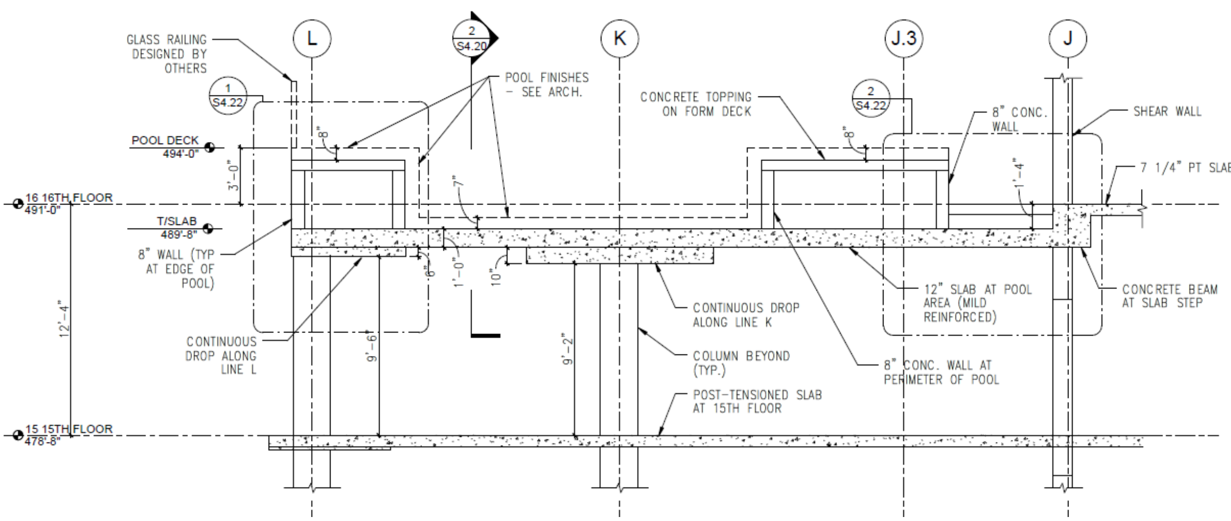

Figure 15: 16th Floor Section through Pool

Bio-Retension Area

On the fifth floor the footprint of the building plan chances and steps back into a ‘U’ shape from a rectangular form. The center of this ‘U’ is home to a bio-retension area and outdoor terraces accessible to the apartment occupants.

To deal with the massive 600 PSF superimposed dead load of the bioretension area and surrounding planters, the concrete slab is increased to 12” thick in this section of the floor plan. The drop panels on the interior columns runs continuous through the 3 columns directly supporting the bioretension area. In these locations, the total slab thickness would be 20 inches.

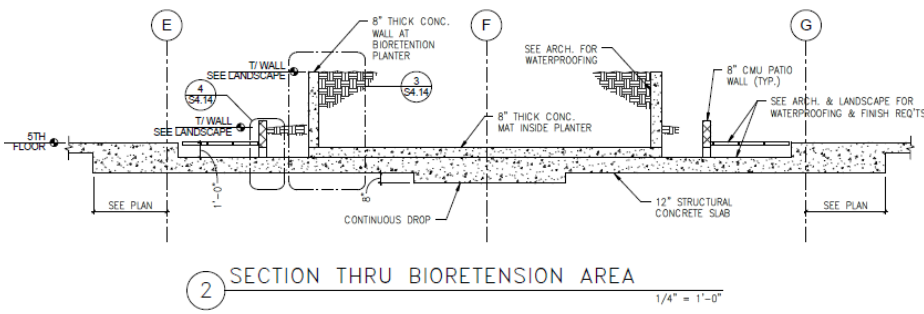

Figure 16: Shear Wall Locations

To accommodate the bio-retention area and planters, small 8” thick concrete walls resist the soil pressure from the potentially saturated beds of soils and foliage.

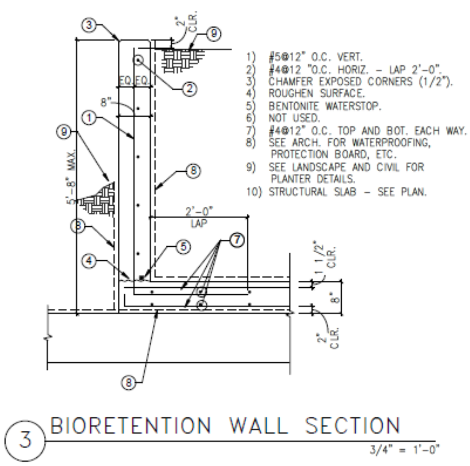

Figure 17: Bio-retension wall

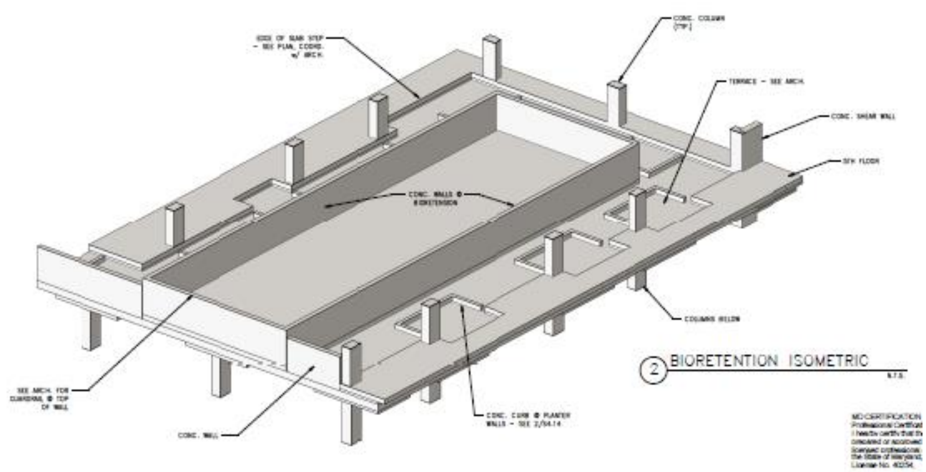

Figure 18: Bio-retension Isometric

Lateral System

The Lateral Force Resisting System (LFRS) of 8621 Georgia Avenue consists of 14 regular concrete shear walls that are 12” thick. These shear walls are concentrated around the stair and elevator towers within the building. A few concrete moment frames exist in various bays but the majority of LFRS elements are the aforementioned shear walls.

The reinforcing in each wall calls for #5’s at 12 inches on center, each way, each face. This is a fairly typical rebar arrangement for shear walls and is kept uniform across each shear wall regardless of height or location. The figure below shows the locations of the shear walls

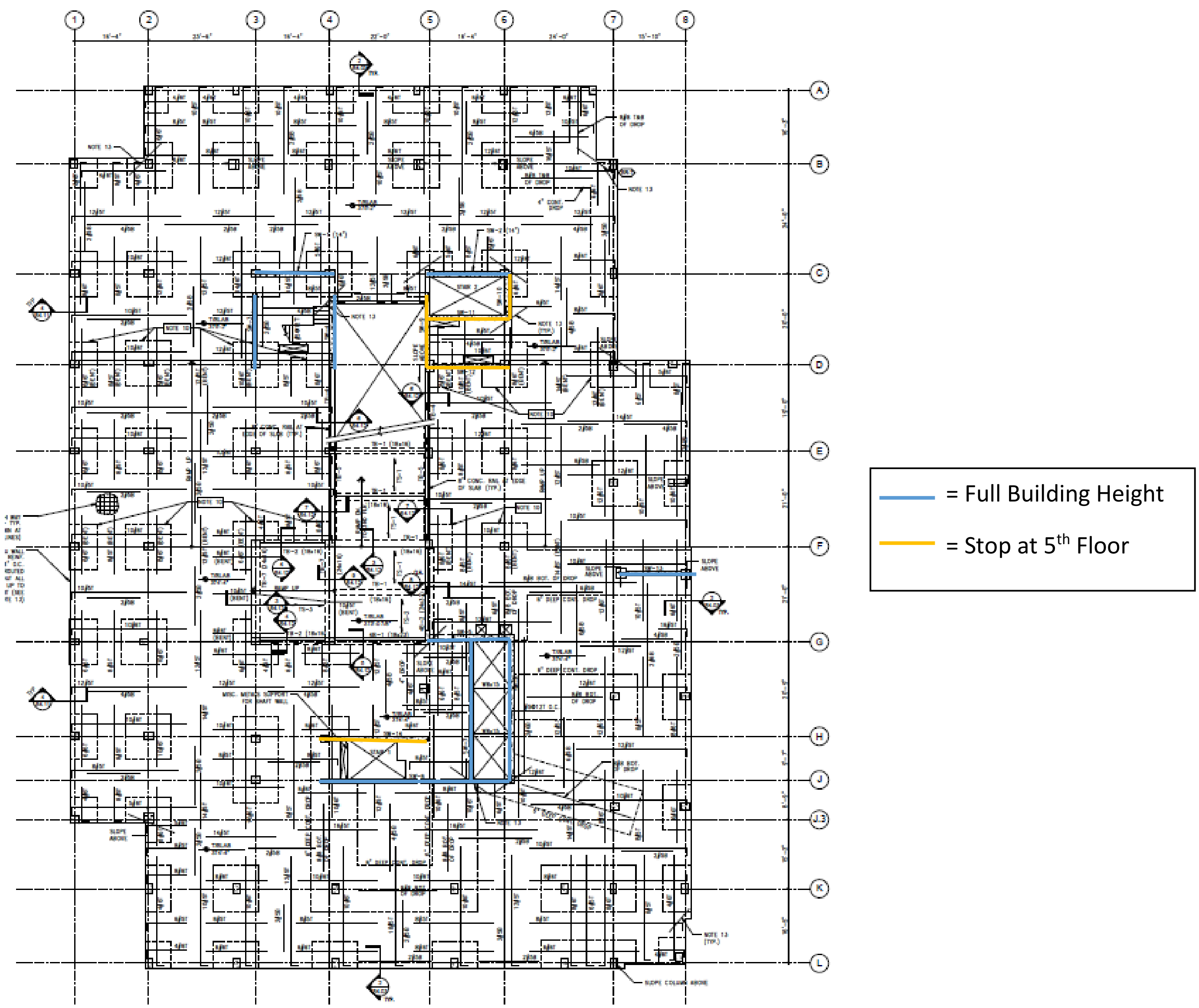

Figure 19: Shear Wall Locations

Joint Details

The following two figures show some of the typical construction joint placements for the concrete slabs and walls. The placements of the joints are to avoid excessive cracking in the concrete.

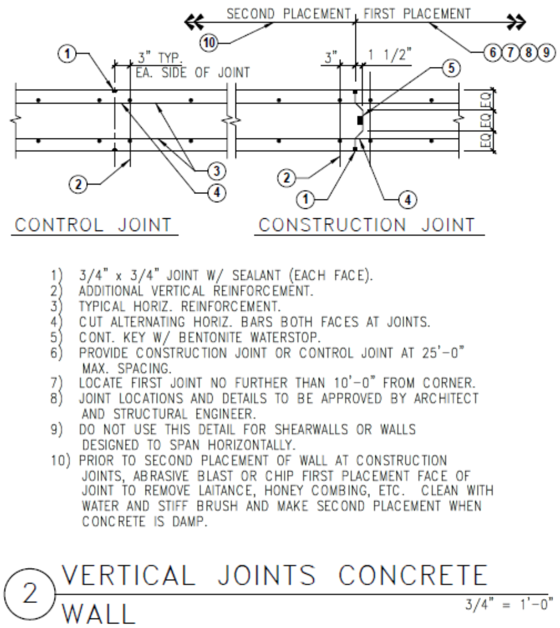

Figure 20: Concrete Vertical Joints

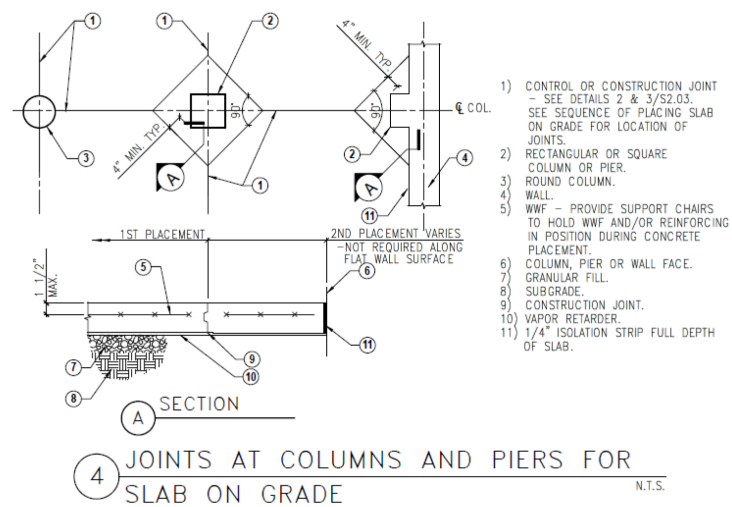

Figure 21: Slab on Grade Construction Joints

Typical Connections

In 8621 Georgia Avenue some of the typical connections involve how the façade of the building is attached to the columns and slabs. These connections are briefly discussed and shown in the following section.

Precast Panels

The precast panels line the exterior face of the building on the bottom four floors around the parking garage. The panels are attached to the slab and columns by load bearing connectors which resist loads perpendicular to the panel, like wind loads, but allows for horizontal movement.

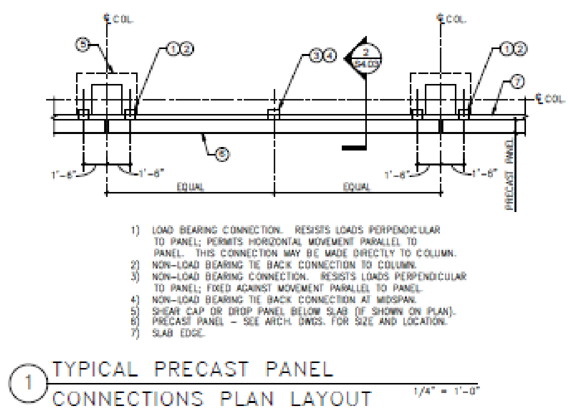

Figure 22: Precast Panel Connection

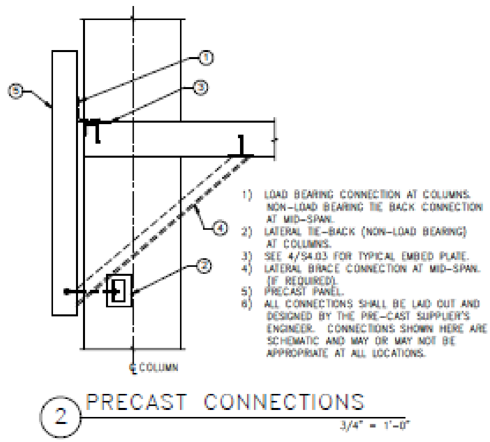

Figure 23: Precast Panel Connection, Section

The panels also utilize lateral tie backs which also connect back to the slab and column. It is through these connections that the lateral wind forces are able to be transferred to the floor diaphragms.

Curtain Wall

On the upper floors of the building above the parking garage the façade consists of a curtainwall system or a masonry veneer. The curtain wall is tied back into the slab in a very similar way that the precast panels are. The masonry veneer is supported beneath by a shelf angle that is connected into the slab by a ¾" diameter wedge insert. These shelf angles are present at each floor and support one floors height of masonry veneer.

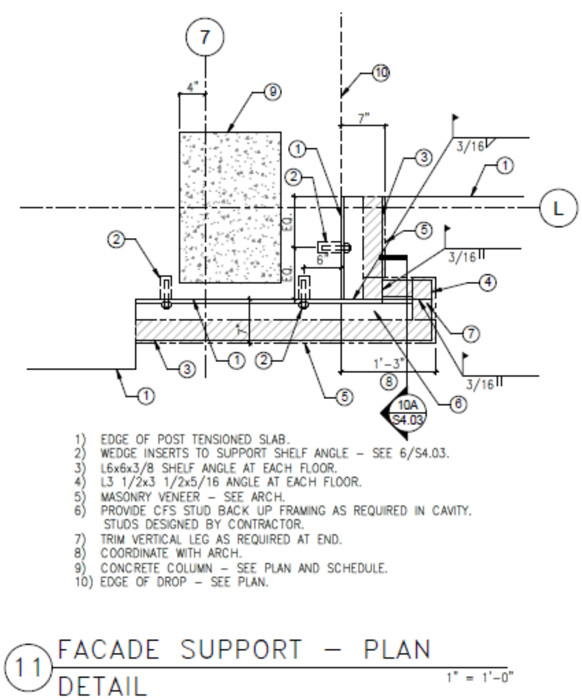

Figure 24: Façade Support

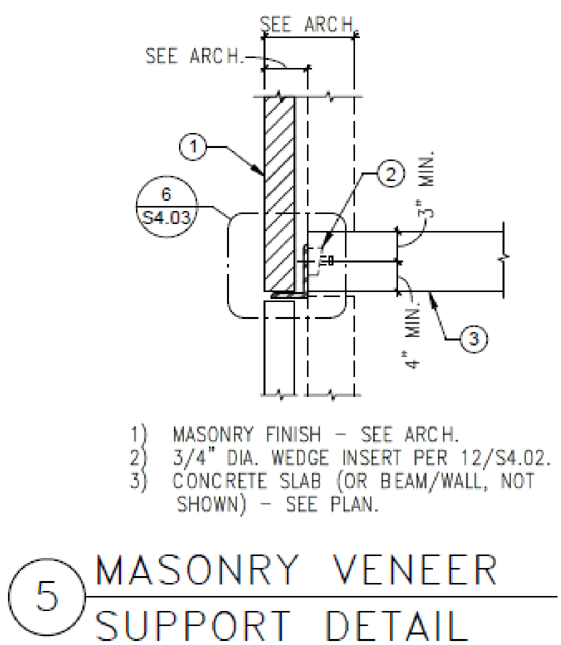

Figure 25: Masonry Veneer Detail

Design Codes and Standards

Below is given a list of all applied codes and reference standards for the structural design of the 8621 Georgia Avenue project:

- International Code Council
  - International Building Code, 2012
- American Society of Civil Engineers
  - ASCE 7-10: Minimum Design Loads for Buildings and Other Structures
- American Concrete Institute
  - ACI 318-11: Building Code Requirements for Structural Concrete
  - ACI Manual of Concrete Practice – Parts 1 through 5
- Concrete Reinforcing Steel Institute
  - Manual of Standard Practice
- Post Tensioning Institute
  - Post Tensioning Manual, 6th Edition
- American Institute of Steel Construction
  - Steel Construction Manual, 14th Edition, 2010
  - AISC 360-10: Specification for Structural Steel Buildings
- Structural Welding Code – Steel ANSI/AWS D1.1-10
- North American Specification for the Design of Cold-Formed Steel Structural Members (S100-07/SI-10)
- Metal Bar Grating Manual – 6th Edition (ANSI/NAAMM MBG 531-09)

Design Loads

The determination of the design loads for the project were found using the codes and references listed in the previous section of this report. The following section will report from where in each particular code that the design values are derived from.

National Codes

The two codes that were used in the design of the building were the IBC 2012 and ASCE 7-10. Chapters 4, 11-30 on live loads and lateral loads were used to generate the loadings for these conditions in 8621 Georgia Avenue. All of the design loads used in the project can be found on sheet S0.01

Gravity

Dead Load

The typical roof, floors, and parking areas were given an additional superimposed dead load in addition to the material self-weights. Other atypical conditions received an additional superimposed dead load based upon experience and specifications with those systems.

Superimposed Dead Loads in addition to the Self-Weight	
Structural Element	Weight (psf)
Typical Roof	30
Typical Floor	15
Parking Areas	10
Unique Conditions	
Intensive Green Roof	60
Bio-Retension Planter	600
Courtyard Planters	240

Figure 26: Superimposed Dead Load Values

Live Load

All live loads were determined using Chapter 4 of ASCE 7-10 and Chapter 16 of IBC 2012 on live loads. In accordance with IBC 2012 section 1607.02, the column, foundation, and beam live loads were able to be reduced.

Snow Load

The ground snow load for Silver Springs, Maryland is recorded as 30PSF according to Chapter 7 of ASCE 7-10. In most cases, the roof snow load can be reduced by a factor of

0.7 (assuming no other factors apply) but the Montgomery County amendments set the minimum roof snow load to 30 PSF, so there is no reduction from the ground to roof snow load

Lateral Loads

The Lateral loads for 8621 Georgia Avenue were determined using chapters 11-13 and 26-30 covering seismic and wind loading. For this project the wind load was the controlling lateral load. Similar to the gravity loads, all design loads are found on sheet S0.01.

Wind

The wind load was specifically found using chapters 26-30 from ASCE 7-10. The building is considered to be Risk Category 2 with a Wind Exposure Category C and basic wind speed of 110 MPH. Net design pressures on various parts of the enclosure are given in the table below:

Net Design Pressures	
Walls (Zone 4)	+20 PSF, -20 PSF
Walls (Zone 5)	+20 PSF, -34 PSF
Roofs (Zone 1)	-27 PSF
Roofs (Zone 2)	-44 PSF
Roofs (Zone 3)	-59 PSF

Figure 27: Net Wind Pressures

Seismic

The seismic design loads were primarily found in Chapters 11 and 12 of ASCE 7-10. Specific components and systems dealing with the architecture, mechanical, electrical, etc. also reference Chapter 13 of ASCE 7-10.

The building is a Risk Category 2 with an importance factor of 1.0 that falls in Seismic Design Category A.

Soil

The lateral soil loads on the building were the same loads recommended by the geotechnical report performed by Schnabel Engineering Consultants, Inc. The soil load was determined to have a sliding resistance of 0.35 and a net pressure of 50 PSF/ft of depth.

Load Paths

Gravity

The gravity loads from the building are those that caused by the combination loading of the dead and live loads. These loads will be resisted by the concrete floor slabs at each level. The slabs will distribute the load to the nearest columns (or shear walls) by which its' bay is bound by. The columns will then carry the load directly down the building and into the foundations and eventually, undisturbed, virgin soil.

The figure to the right gives an example of the load path in a section of the building due to gravity loads.

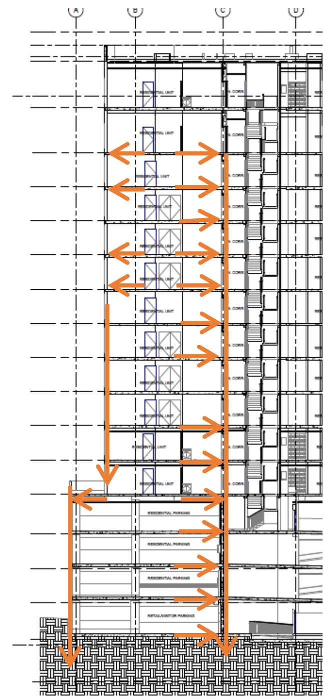

Figure 28: Gravity Load Path

Lateral

The controlling lateral load on 8621 Georgia Avenue is wind. This wind force will exert itself on the façade of the building as a positive or negative pressure distribution. The façade with distribute the force from the wind pressure to the floor slabs via the connection by which the façade is attached to the structure. This creates a horizontal force at each floor level.

This force is distributed amongst the columns and shear walls on that floor by the diaphragmatic action of the concrete slab. Because the diaphragm is comprised of concrete, and consequently can be considered a rigid diaphragm, the loads will distribute to the LFRS elements based on stiffness. The shear walls are inherently stiffer than the columns when oriented parallel to the horizontal force. Because there are multiple shear walls in each direction, they will the primary means to resisting the lateral load as opposed to the concrete columns.

Once the lateral load has been transferred from the shell, into the diaphragm, and then into the LFRS elements, these elements carry this horizontal load down through the building and into the foundation.

Conclusion

In this first of four technical reports the physical existing conditions of 8621 Georgia Avenue were investigated. The focus of this exploration was the structural system of the building. The foundation system, floor systems, gravity system, lateral system, connection details, as well as the pertinent design loads and codes were all examined to get a more comprehensive understanding of the building project.

The architecture and function of the building provides critical amenities to the area and a recognizable building to the urban landscape. The structural design of the building was driven by two primary factors: maximizing the floor to floor height under the zoning height restriction and also maintaining a structural grid that was compatible for both the parking garage and the apartments.

The gravity system for the building is comprised of mild-reinforced and post-tensioned two-way concrete flat plate slabs. The columns supporting these slabs maintain a semi-regular grid throughout the height of the building and increase in strength in the lower floors. A greater study into the behavior and analysis of post-tensioned floor slabs will be necessary for future technical reports and design assignments.

The lateral system is primarily comprised of concrete shear walls around the stair and elevator towers, most of which ascend the entire height of the building. This could pose some challenges later in the semester during the computer modeling of the lateral system of the building. Simplifying and accurately modeling these elements will be of great importance.

The design codes and standards for the project were also explored in the content of this report. Because the building is just under construction, all of these codes are still relevant and current. Therefore, in moving on with my study of 8621 Georgia Avenue I should be able to use all of the same design loads that the structural engineer used.

Overall, 8621 Georgia Avenue will be a fantastic educational exercise that will be both challenging and fun due to the project specific design parameters and having to analyze structural systems (such as post-tensioning) that I am not familiar in working with.