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1000 CONNECTICUT AVENUE

Washington DC

Thesis Proposal

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Executive Summary

1000 Connecticut Avenue is a 12 story, 565, 000 GSF commercial office building located at the corner of K Street and Connecticut Avenue in Washington D.C. The building is used primarily for office space, but also contains retail space on the first level, commercial office space on levels 3-12, a roof-top terrace with a green roof, and four levels of underground parking.

For educational purposes and goals, the structural depth for this thesis will be to re-locate 1000 Connecticut Avenue to Arlington, VA and re-designing the structural system by changing the existing system material from concrete to steel. The new gravity floor system will be comprised of a composite beam/girder system with composite deck. The new lateral system will be comprised of moment and braced frames. Since the building is located in Washington DC, the current design is limited by a zoning height restriction of 130 ft. To use the new steel framing system in Washington DC, the system will have to be designed as 11 stories in order to stay within the height limit. For this reason, 1000 Connecticut Avenue will be re-located to an area that does not have a height limitation. Re-locating the building to Arlington, VA will enable the new system to be designed as 12 stories without having to take into consideration a height limit. Further, a uniform framing layout will be created for the new system by re-locating and removing existing columns to create wider bays and the system will be designed for higher floor-to-floor heights in order to maintain high floor-to-ceiling heights.

In addition, two breadth studies will be conducted. These breadths will include a study of the new structural system's impact on construction and the existing building's acoustics and lighting. The first breadth studied will be construction impact. In this breadth, the new system will be analyzed for total cost, construction schedule and LEED certification since the new system is comprised of a different material. Also, since the structural system will be designed for wider bays and higher floor-to-ceiling heights, the owner will be able to charge higher rent and therefore the annual revenue obtained with the use of the new structural system will be compared to the revenue obtained by the existing structural system. The second breadth studied will be acoustics and lighting impact. Since the new structural system material will be changed from concrete to steel an acoustic breadth will be conducted by determining the sound transmission class (STC) and noise reduction (NR) values for both the new and existing system. These values will be used to help determine which sound treatments will be necessary to use for the office spaces in the new structural system to reduce sound transmission and increase privacy. Further, the floor-to-ceiling height for the new system will be greater than the floor-to-ceiling height of the existing system; therefore the lighting illuminance on the work plane surfaces in the space will be affected. As a result a lighting breadth will be conducted by calculating the illuminance of the existing lighting system and comparing this value to the target illuminance of the space. If the calculated illuminance value is not within ± 10 percent of the target illuminance, a new lighting system will be designed for the typical office space. The new space with lighting will be depicted through renderings.

The new structural system will be compared to the existing structural system based on 5 criteria: overall building cost; construction schedule; LEED certification; bay sizes and floor-to-ceiling heights; and annual revenue.

Introduction

1000 Connecticut Avenue, NW Office Building is a new 12 story office building located at the northwest intersection of K Street and Connecticut Avenue in Washington DC, as can be seen in Figure 1. The 1000 Connecticut Avenue Office building is designed to achieve LEED Gold certification upon completion. Despite being used primarily for office space, the building is comprised of mix occupancies, which include: office space, a gymnasium, retail, and parking garages. The structure has 4 levels of underground parking. The building's total square footage is 555,000 SF with 370,000 SF above grade and 185,000 SF below grade.

Figure 1 Building Site

To create a new Washington landmark, the building is designed to complement surrounding institutions by blending both traditional and modern materials. The facade consists of a glass, stainless steel and stone panel curtain wall system. Exterior and interior aluminum and glass storefront windows and doors are on the ground level. The lobby and retail space are located on the 1st level, which has a 12'-6 1/2" floor-to-floor story height. A canopy facing K Street brings attention to the main lobby entrance, as can be seen in Figure 2.

Figure 2 Main Lobby Entrance facing K Street (left) and perspective of curtain wall system (right)

Beyond the main entrance is a two story intricate lobby space with carrera marble and Chelmsford granite flooring, aluminum spline panels integrated with glass fiber reinforced gypsum (GFRG) ceiling tiles and European white oak wood screens, as can be seen in Figure 3.

Figure 3 Perspective of lobby

The retail space is broken down into several retail stores facing K Street and Connecticut Avenue. These retail stores are housed behind storefront glass to enable display of merchandise to potential customers. The 2nd-12th levels have 10’-7 ½” floor-to-floor story heights. Housed on the typical levels (3rd-12th) is the office space. A combination of tall story heights and a continuous floor to ceiling glass façade enables natural daylight to enter the building space as well as provides scenery to the Washington monuments, Farragut Park , and the White House, as can be seen in Figure 4.

Figure 4 Perspective of typical office with floor-to-ceiling windows that supply views to the city

In addition, located on the penthouse level is a roof-top terrace with a green roof and a mechanical penthouse, as can be seen in Figure 5.

Figure 5 Perspective of green roof on roof-top terrace and mechanical penthouse

Housed on the basement levels (B1-B4) are underground parking and a fitness center. A total of 253 parking spaces are provided; level B1 has 19 parking spaces; level B2 has 74 parking spaces; level B3 has 78 parking spaces; level B4 has 82 parking spaces. In addition, the fitness center is located on level B1.

Structural Overview

1000 Connecticut Avenue Office Building's structural system is comprised of a reinforced concrete flat slab floor system with drop panels and a bay spacing of approximately 30 feet by 30 feet. The slab and columns combined perform as a reinforced concrete moment frame. The substructure and superstructure floor systems are both comprised of an 8" thick two-way system with #5 reinforcing bars spaced 12" on center in both the column and middle strips and 8" thick drop panels. The below grade parking garage ramp is comprised of a 14" thick slab with #5 reinforcing bars provided both top and bottom with a spacing of 12" on center.

Foundation

ECS Mid-Atlantic, LLC performed a geotechnical analysis of the building's site soil conditions as well as provided recommendations for the foundation. A total of five borings were observed in the geotechnical analysis. It was determined that a majority of the site's existing fill consists of a mixture of silt, sand, gravel, and wood. The natural soils consisted of sandy silt, sand with silt, clayey gravel, silty gravel, and silty sand. The soil varies from loose to extremely dense in relative density. Based on the samples recovered from the rock coring operations, the rock is classified as completely to moderately weathered, thinly bedded, and hard to very hard gneiss.

At the time of the study, the groundwater was recorded at a boring depth of 7.5 feet below the existing ground surface. The shallow water table is located at an elevation of 35 to 38 feet in the vicinity of the site.

1000 Connecticut Avenue, NW Office Building is supported by a shallow foundation consisting of column footings and strap beams, as can be seen in Figure 6. The typical column footing sizes are 4'-0" x 4'-0", 5'-0" x 5'-0", and 4'-0" x 8'-0".

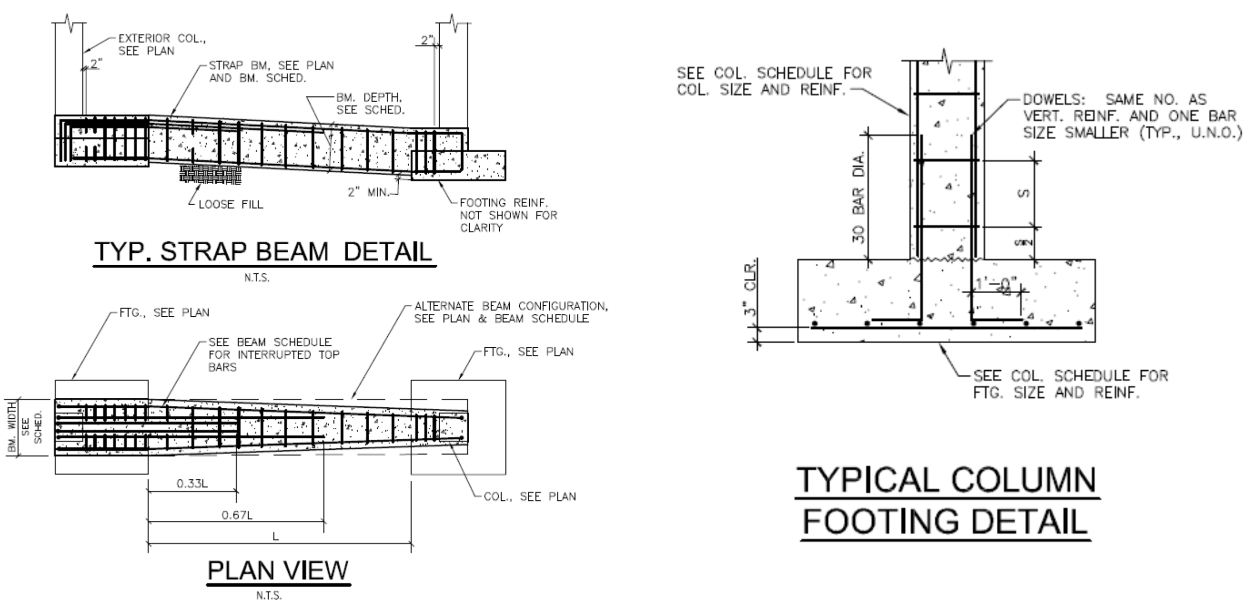


Figure 6 Details of typical strap beam and column footing

The footings bear on 50 KSF competent rock. The Strap beams (cantilever footings) are used to prevent the exterior footings from overturning by connecting the strap beam to both the exterior footing and to an adjacent interior footing. A simplified foundation plan can be seen in Figure 7.

The slab on grade is 5" thick, 5000 psi concrete with 6x6-W2.9xW2.9 wire welded fabric on a minimum 15 mil Polyethylene sheet over 6" washed crushed stone. The foundation walls consists of concrete masonry units vertically reinforced with #5 bars at 16" on center and horizontally reinforced with #4 bars at 12" on center and are subjected to a lateral load (earth pressure) of 45 PSF per foot of wall depth.

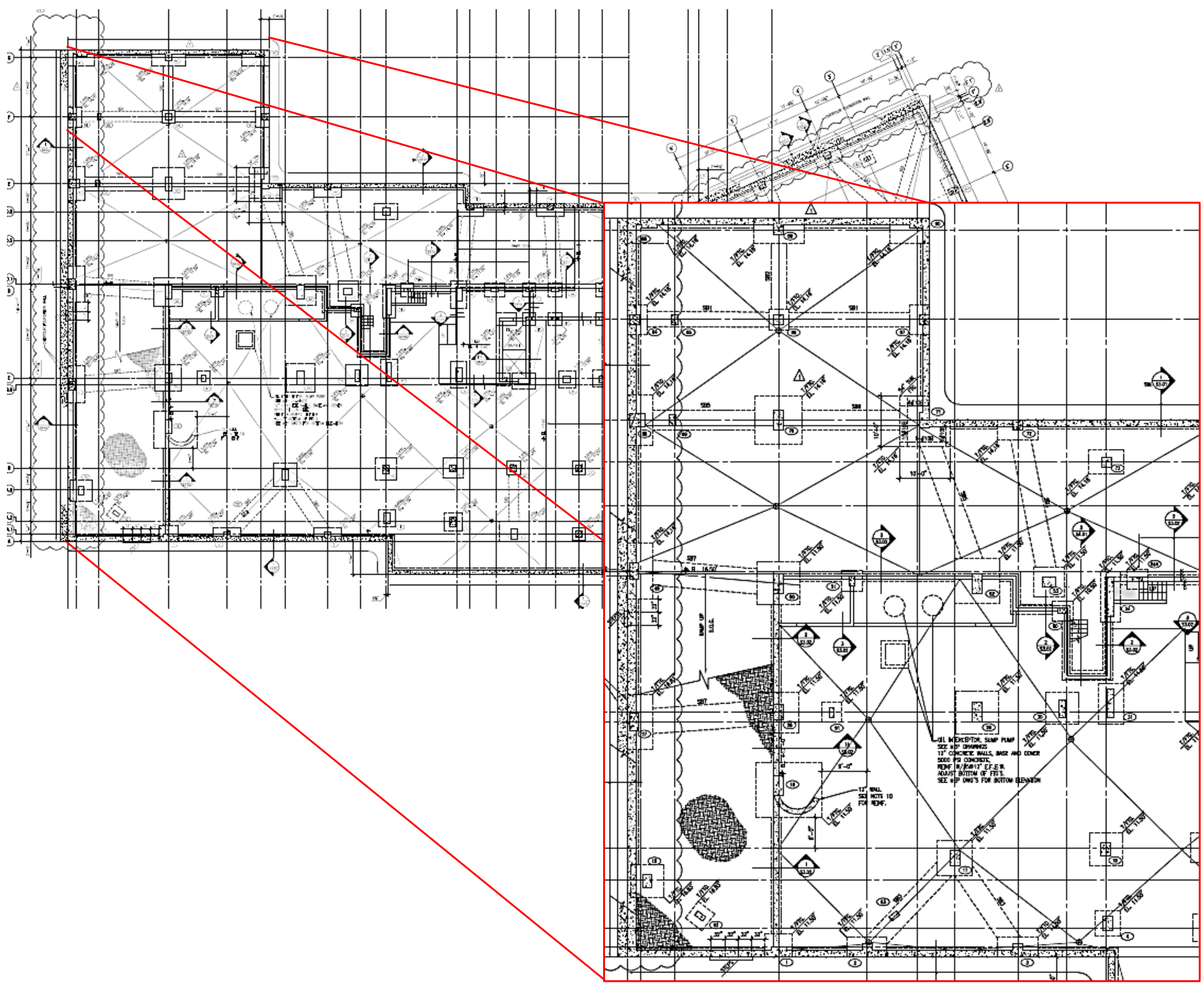


Figure 7 Foundation plan

Framing and Floor System

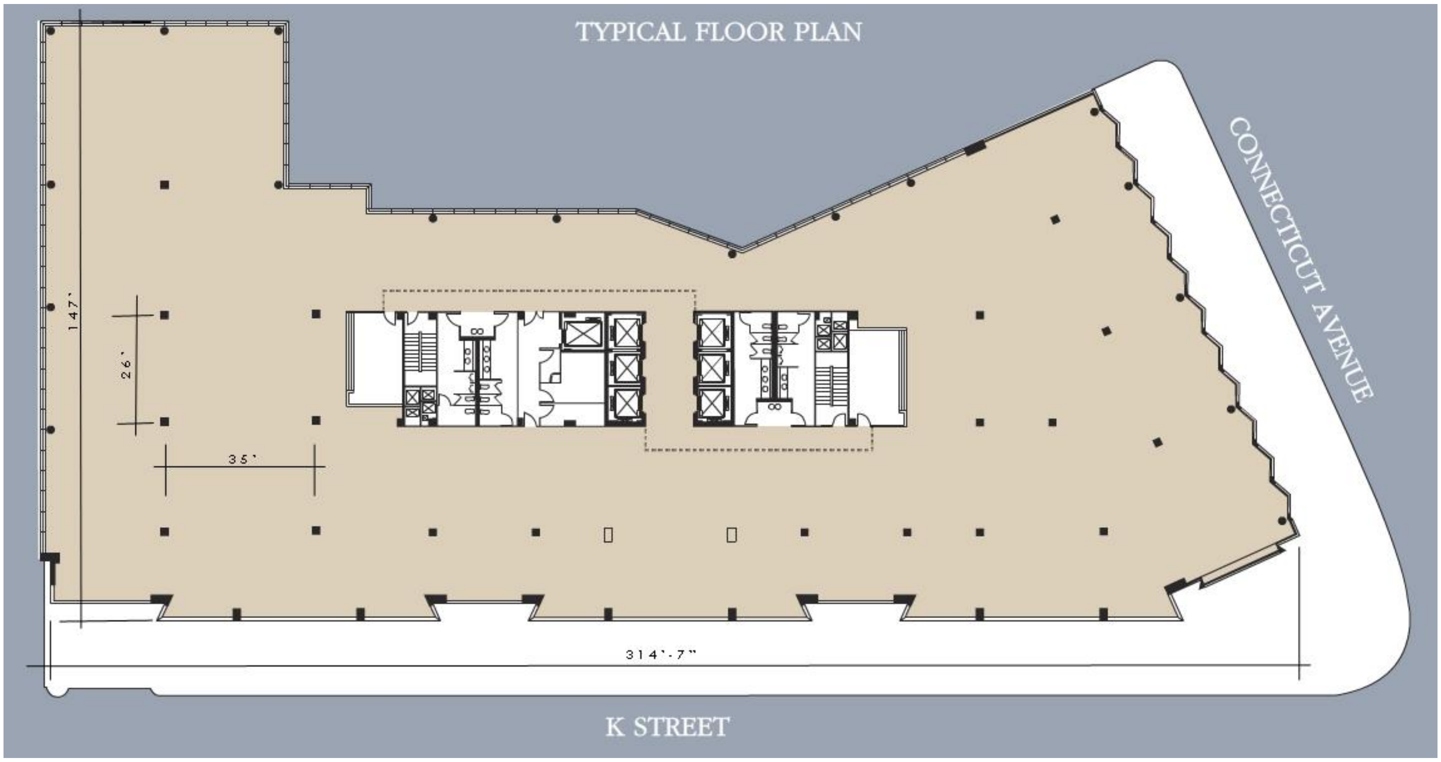
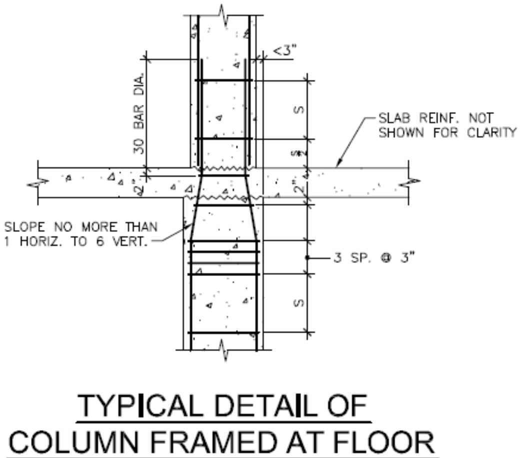


Figure 8 Floor plan displaying column locations and bays

The framing system is composed of reinforced concrete columns with an average column-to-column spacing of 30'x30', as can be seen in Figure 8. The columns have a specified concrete strength of f'c=8000 psi for columns on levels B4 to level 3, f'c=6000 psi for columns on levels 4-7, and f'c=5000 psi for columns on levels 8-mechanical penthouse. The columns are framed at the concrete floor, as can be seen in Figure 9, and the columns vary in size. The most common column sizes are 24"x24", 16"x48", and 24"x30". The column capitals are 6" thick, measured from the bottom of the drop panel, extending 6" all around the face of the column, as can be seen in Figure 10.



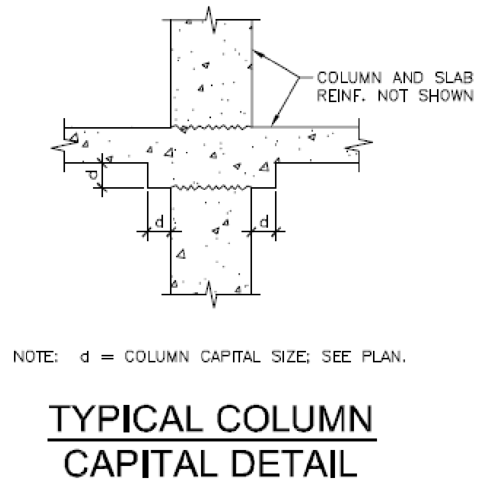


Figure 9 Typical Detail of column framed at the floor **Figure 10** Typical column capital detail

The typical floor system is comprised of an 8" thick two-way flat slab with drop panels reinforced with #5 bottom bars spaced 12" on center in both the column and middle strips, as can be seen in Figure 11.

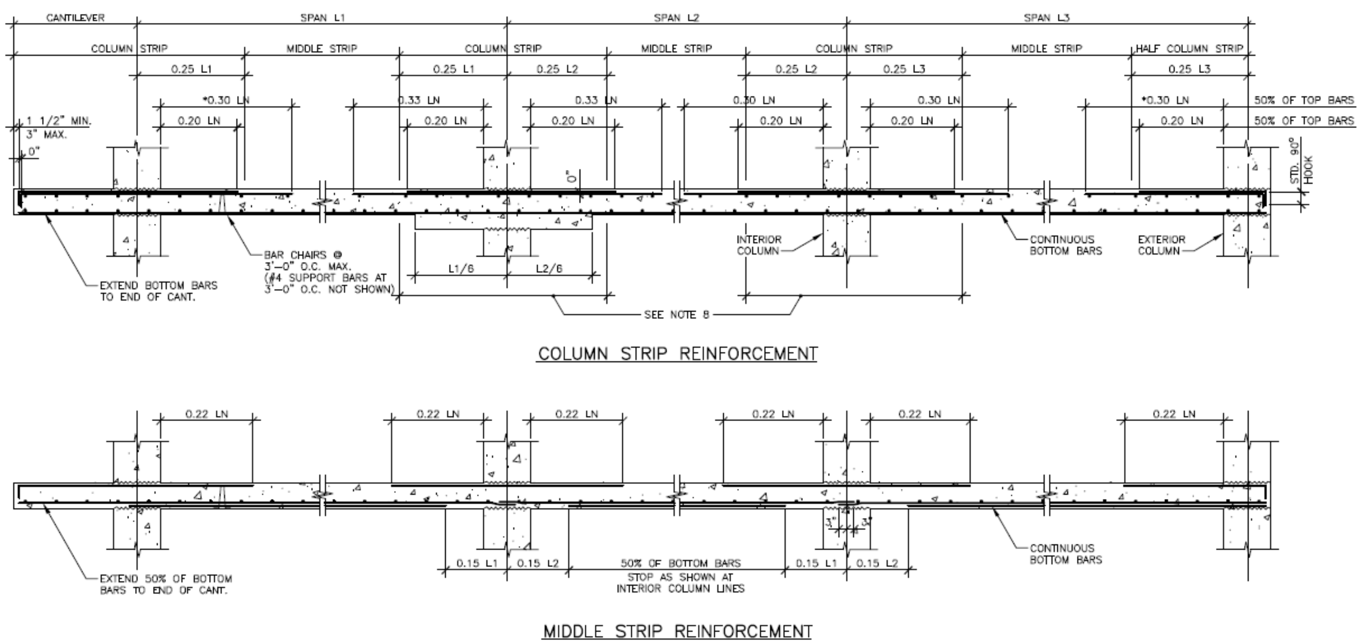


Figure 11 Typical two-way slab reinforcing detail

The individual drop panels are 8” thick, extending a distance d/6 from the centerline of the column, as can be seen in Figure 12.

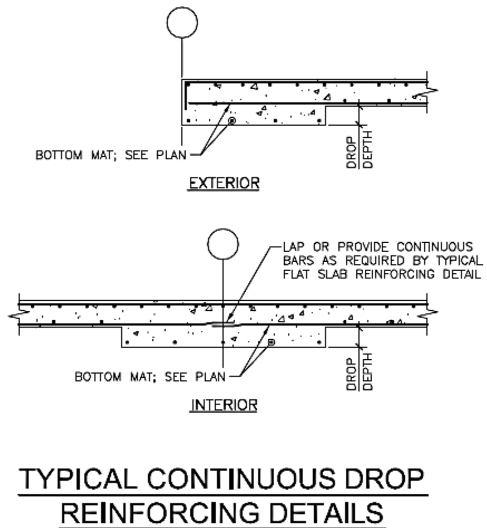


Figure 12 Typical Continuous drop panel

A 36” wide by 3 ½” deep continuous drop panel is located around the perimeter on all floor levels. Levels 3-12 are supported by four post-tension beams above the lobby area. Due to the two story lobby, there’s a large column-to-column spacing. As a result, post tension beams are used to support the slab on levels 3-12 located above the lobby. In addition, four post-tension beams support the slab on levels 3-12 that are located above the two-story parking deck, which also has a large column-to-column spacing, as can be seen in Figure 13.

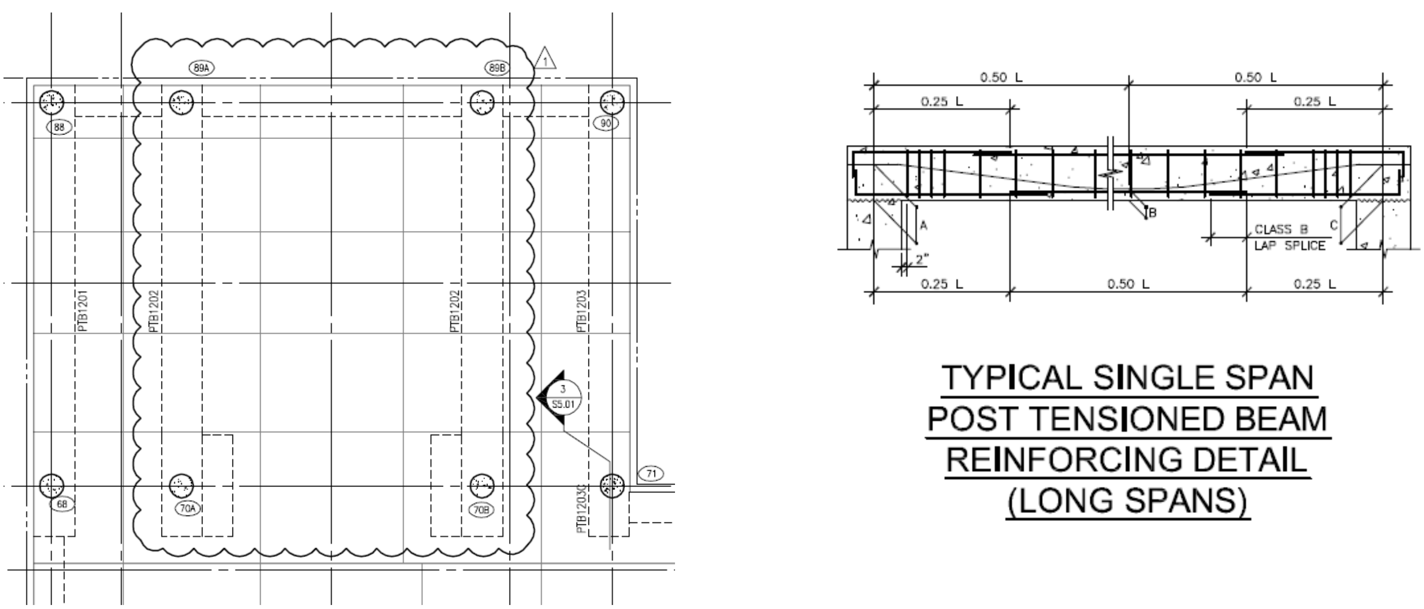


Figure 13 Plan view and typical detail of Post-tension beams supporting slab on levels above two-story loading dock

Lateral System

The lateral system is comprised of a reinforced concrete moment frame. The columns and slab are poured monolithically, thus creating a rigid connection between the elements. The curtain wall is attached to the concrete slab, which puts the slab in bending. The curtain wall transfers the lateral load to the slab. The slab then transfers the lateral load to the columns and in turn the columns transfer the load to the foundation. Transfer girders on the lower level are used to transfer the loads from the columns that do not align with the basement columns in order to transfer the load to the foundation. A depiction of how the lateral load is transferred through the system can be seen in Figure 14.

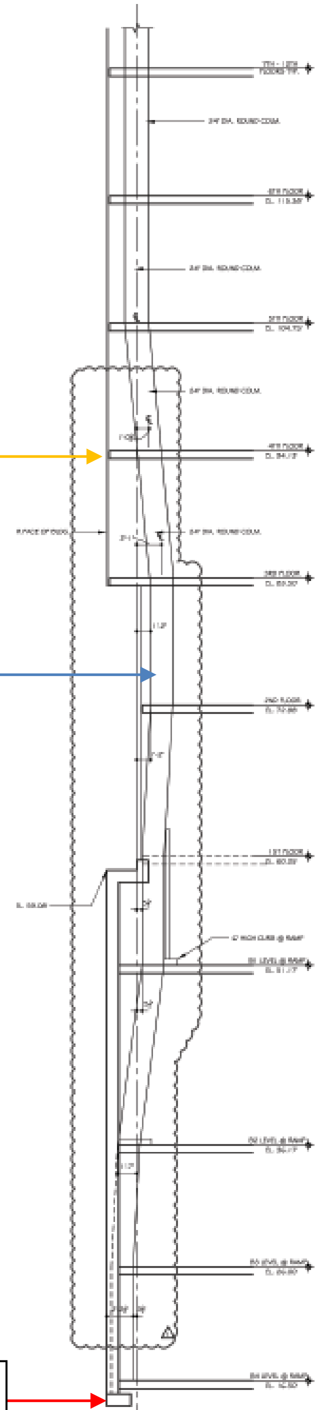


Figure 14 Lateral load path depiction

Roof System

The main roof framing system is supported by an 8”thick concrete slab with #5 bars spaced 12” on center at the bottom in the east-west direction. The slab also has 8” thick drop panels. The penthouse framing system is separated into two roofs: Elevator Machine Room roof and the high roof. The elevator machine room roof framing system is supported by 14” and 8” thick slab with #7 bars with 6” spacing on center top and bottom in the east-west direction.

Design Codes

According to sheet S601, the original building was designed to comply with the following:

- 2000 International Building Code (IBC 2000)
- Building Code Requirements for Structural Concrete (ACI 318)
- Specifications for Structural Concrete (ACI 301)
- Manual of Standard Practice for Detailing Reinforced Concrete Structures (ACI 315)
- Specification for the Design, Fabrication and Erection of Structural Steel for Buildings (AISC manual), Allowable Strength Design (ASD) method

The codes that were used to complete the analyses throughout technical reports 1-3 are the following:

- ACI 318-08
- Minimum Design Loads for Building and Other Structures (ASCE 7-10)
- AISC Steel Construction Manual, 14th Edition, Load and Resistance Factor Design (LRFD) method
- Vulcraft Steel Roof and Floor Deck Catalog, 2008
- Vulcraft Composite and Non-Composite Floor Joists Catalog, 2009

Structural Materials

Table 1 below shows the several types of materials that were used for this project according to the general notes page of the structural drawings on sheet S601.

Concrete (Cast-in-Place)		
Usage	**Weight**	**Strength (psi)**
Spread Footings	Normal	4000
Strap Beams	Normal	4000
Foundation Walls	Normal	4000
Formed Slabs and Beams	Normal	5000
Columns	Normal	Varies (based on column schedule)
Concrete Toppings	Normal	5000
Slabs on Grade	Normal	5000
Pea-gravel concrete (or grout)	Normal	2500 (for filling CMU units)
All other concrete	Normal	3000
Reinforcing Steel		
Type	**Standard**	**Grade**
Deformed Reinforcing Bars	ASTM A615	60
	ASTM A775	N/A
Welded Wire Fabric	ASTM A185	N/A
Reinforcing Bar Mats	ASTM A184	N/A
Post-Tensioning (Unbonded)		
Type	**Standard**	**Strength (ksi)**
Prestressed Steel (seven wire low-relaxation or stressed relieved strand)	ASTM A416	270
Miscellaneous Steel		
Type	**Standard**	**Grade**
Structural Steel	ASTM A36	N/A
Bolts	ASTM A325	N/A
Welds	AWS	N/A

Table 1 Design materials

Problem Statement

1000 Connecticut Avenue’s structural system currently consists of a two-way flat slab floor system supported by concrete columns with an average spacing of 30ft x 30 ft. The current lateral system consists of concrete moment frames comprised of the concrete columns and two-way flat slab system. The in-depth analyses performed in technical reports 1-3 showed that the existing structural system is adequate to support the combined lateral and gravity loads and meets serviceability requirements.

For educational purposes, 1000 Connecticut Avenue NW Office Building will be re-located to Arlington, VA and re-designed as a steel frame system consisting of two lateral systems: moment frames and braced frames. The new structural system will be analyzed to determine whether:

- the overall building cost can be reduced;
- the construction schedule can be reduced;
- LEED certification will remain unchanged;
- the bay sizes and floor-to-ceiling heights can be increased;
- the annual revenue can be increased

Since the existing 12 story structure is located in Washington DC, which has a zoning building height restriction of 130 ft., in order to use the new steel system the structural system will have to be designed as 11 stories to stay within the height limit or re-located to an area that does not have a height restriction. To make a fair comparison between the two systems, the building will be re-located to Arlington, VA so that the new structural system can be designed as 12 stories.

The major design differences between the existing structural system and the proposed structural system can be seen below.

- The steel structural system will increase the structural depth and therefore to maintain a minimum floor-to-ceiling height of 8’-6” the overall building height will need to be increased. Since the building height is currently 130 ft., the building height cannot be increased with the existing 12 stories. As a result, the number of stories will have to reduce to 11 to stay within the height limitation or the building will have to be re-located.
- The current column layout is non-uniform and therefore to use the new steel structural system, a uniform framing layout will need to be created by removing and re-locating columns to create a uniform layout.
- The alternative lateral systems will be subjected to different seismic loads; therefore the seismic loads will need to be re-calculated for the new system.
- The steel system will be subjected to more vibration.
- The structural steel system is more flexible and therefore braced frames will be needed to resist lateral loads.

Proposed Solution

1000 Connecticut Avenue's structural system will be re-designed as a steel framing system. The lateral force resisting system will consist of moment frames around the perimeter of the building and eccentric braced frames located around the elevator shafts and stairwell cores. After calculating the seismic loads for the new structural system, the new lateral system will be modeled and analyzed in ETABS for both seismic and wind loads.

In technical report 2, alternative gravity floor systems were designed and compared based on the following criteria:

- Architecture (fire rating other impacts)
- Structural (foundation and lateral system impacts)
- Serviceability (maximum deflection, vibration control, and sound transmission)
- Construction (additional fire protection and schedule impact)

The composite beam/girder system with composite deck was shown to be a viable alternative. To use this alternative floor system, the building height will need to increase since the structural depth for each level will increase. 1000 Connecticut Avenue is currently 130 feet and the zoning height restriction in Washington DC is 130 ft. Therefore to use the composite steel beam/girder floor system the number of stories will need to be reduced from 12 to 11 to maintain high floor-to-ceiling heights and to remain within the restricted height limit or the building will have to be re-located. Therefore, the structural system will be designed as 12 stories by re-locating the building to Arlington, VA, which does not have a zoning height restriction. In addition, columns will be re-located to create a more uniform framing layout, certain column lines will be removed to create wider bays, and the new structural system will be designed for higher floor-to-ceiling heights.

Breadth Study I: Construction Impact

This first breadth will analyze the impact of the structural system redesign on the total building cost; construction schedule, including creating/checking new critical paths; site management of steel versus concrete; building LEED certification; and the anticipated revenue increase from the use of the new structural system. First, the current cost estimate will be compared to the cost estimate of the new structural system. Second, the new structural system construction schedule will be compared to the existing system construction schedule. Third, how the construction site will have to be managed differently for steel compared to concrete will be evaluated. Fourth, the building LEED certification with the use of the new structural system will be compared to the existing building LEED certification. Last, the revenue obtained from the new structural system with wider bays and higher floor-to-ceiling heights will be compared to the existing structural system's revenue. Wider bays and higher floor-to-ceiling heights will increase the rental value of the floor space and therefore the building owner will be able charge higher rent, which will potentially increase revenue.

Breadth Study II: Acoustics and Lighting Impact

By re-designing the structural system as a steel framing system an acoustic breadth will be conducted by determining the sound transmission class (STC) and noise reduction (NR) values for both the existing two-way flat slab system and the proposed composite beam/girder gravity system. In addition, since the new structural system will be designed for higher floor-to-ceiling heights, lighting illuminance applied to the work plane surfaces will be affected. As a result, a lighting breadth will be conducted by checking the illuminance of the existing lighting system and comparing the calculated value to the target illuminance of the space. If the existing lighting design does not meet the target illuminance of the space, the lighting system for a typical office will be re-designed with new lighting fixtures. The new space with higher floor-to-ceiling heights and new lighting will be represented through renderings.

MAE Course Related Study

The redesign of 1000 Connecticut Avenue will implement material from a couple of graduate level courses that are a part of the integrated Bachelor/Master of Architectural Engineering program. The new lateral system will be modeled in ETABS using knowledge gained in AE 597A (Computer Modeling). To design the typical moment, braced, and shear connections, material learned in AE 534 (Steel Connection Design) will be used.

Tasks and Tools

Structural Depth:

1. Gravity Floor System Redesign:
    a. Create a uniform column layout and wider bay widths by relocated and removing columns
    b. Specify the appropriate composite deck floor system based on the floor gravity loads
    c. Design the beams and girders for a typical floor
    d. design the gravity columns
    e. design typical shear connections

2. Design of eccentric braced frames and moment frames:
    a. Determine the most effective braced frame locations and configurations
    b. Recalculate the seismic loads
    c. Use computer modeling programs (including ETABS and SAP) to determine the required member sizes of the lateral force resisting members subjected to combined gravity and lateral loads
    d. Analyze building output to confirm design adequacy
    e. Design typical braced and moment connections

3. Discussion and comparison of the new structural system:
    a. Discuss advantages and disadvantages of the new structural system

Breadth Study 1 - Construction Impact:

1. New building cost
    a. Determine the building cost with the use of the new structural system
    b. Compare the existing building cost estimate to the new building cost estimate
2. Construction site management of steel vs. concrete
    a. Determine how the site will have be managed for constructing the new steel structural system
    b. Determine how the site has to be managed when constructing the existing concrete structural system
    c. Compare how the two materials (steel vs. concrete) have to be managed differently on site
    d. Create/check new critical paths for steel vs. concrete
3. LEED Certification
    a. Determine the LEED certification of the building system

   b. Compare to LEED certification of the new system to the existing building LEED certification
   c. If there is a difference between the ratings, determine which categories the two systems differed most based on the LEED rating system
4. Revenue comparison of steel structure vs. existing concrete structure
   a. Determine the revenue obtained from the existing structural system and layout
   b. Determine the revenue obtained from the new structural system and layout
   c. Compare the revenues for each structural system to determine which system/ layout results in a higher profit

Breadth Study 2 – Lighting and Acoustics:

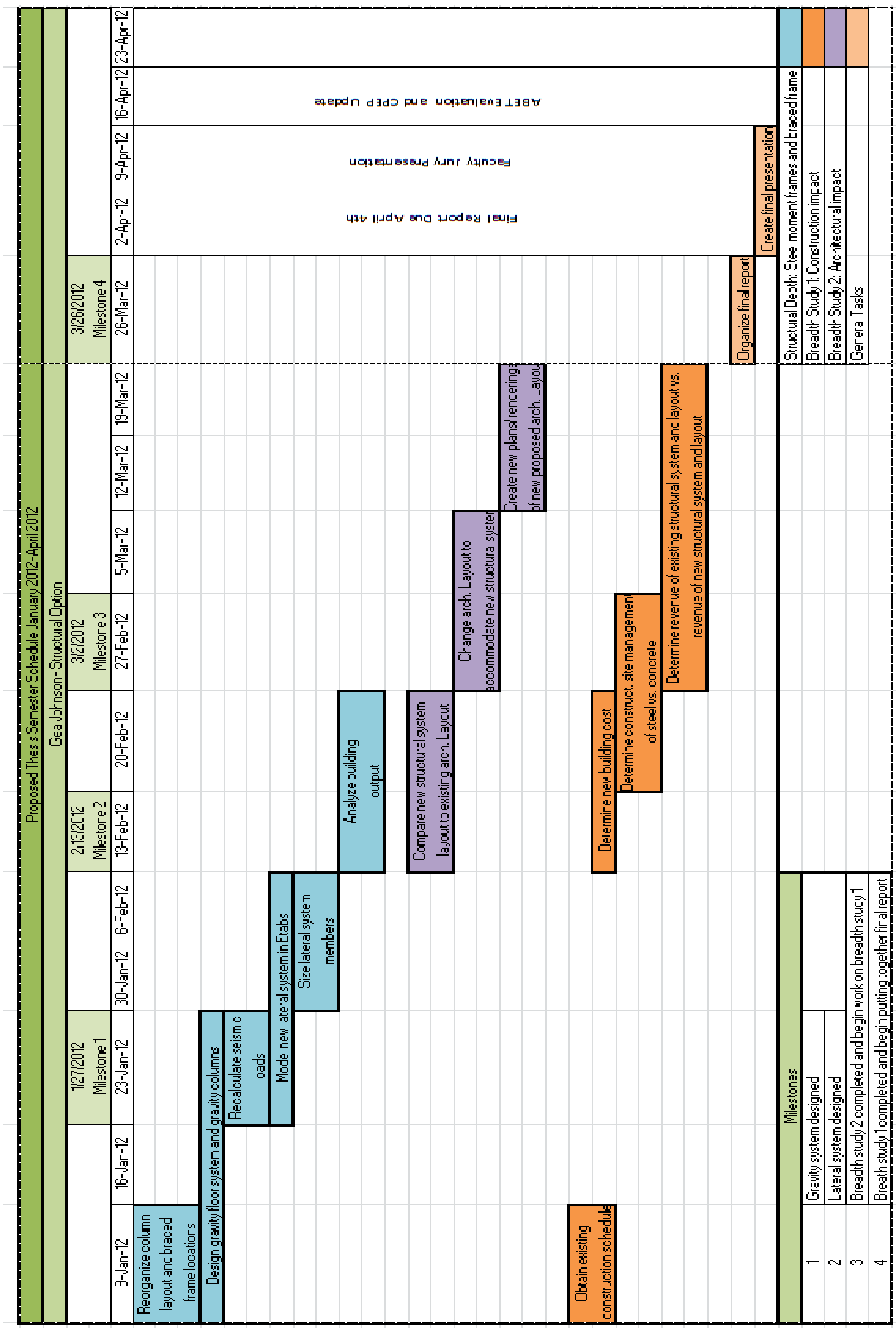
Lighting:

1. Determine the design criteria for the typical office space(i.e. tasks, target illuminance, luminaire layout, light distribution)
2. Determine the typical office space room details (i.e. length, width, height, work plane height, and room reflectance values for the ceiling, walls, doors, windows and floor)
3. Determine if the existing luminaires can be used in the new space by calculating the illuminance of the existing luminaires in the new space and comparing their illuminance value to the target illuminance for the space
4. If the existing lighting is not within ± 10% of the target illuminance, either increase/decrease the number of existing luminaires or re-design the lighting system by selecting alternative luminaires from luminaire product catalogs
5. Use AGI to complete a photometric analysis to determine the number of luminaires and layout needed to meet the target illuminance
6. Create renderings of the new space with lighting

Acoustics:

1. Calculate the sound transmission class (STC) and impact insulation class (IIC) for the existing two-way flat slab system and composite beam/girder gravity system
2. Determine the noise reduction (NR) and transmission loss (TL) for the new space
3. Based on the STC, IIC, NR, and TL values, determine the type of acoustical insulation and sound treatments to use for the new space

Structural Depth and Breadth Study proposed schedule



Conclusion

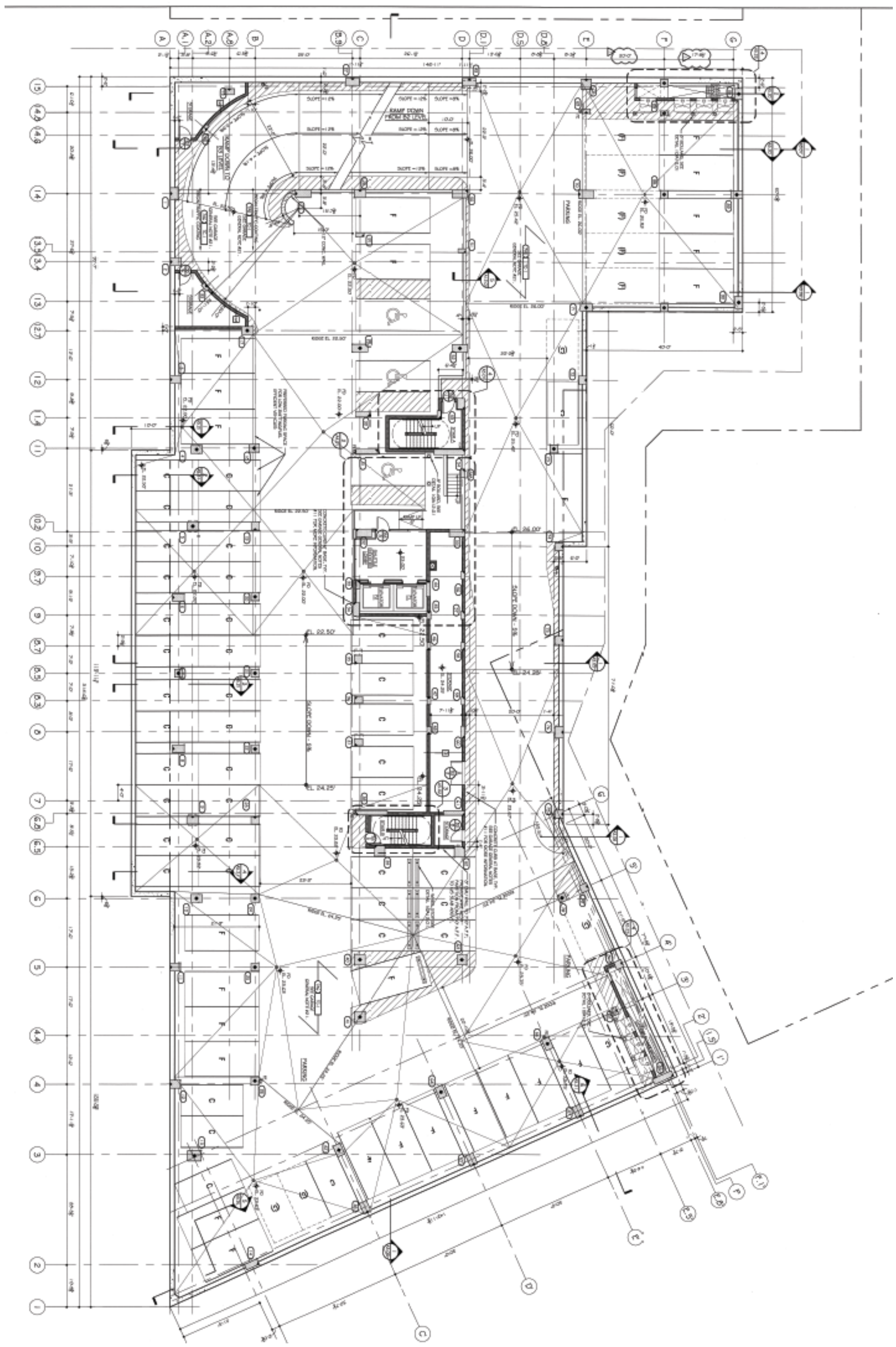
The structural depth for this thesis will be to re-locate 1000 Connecticut Avenue to Arlington, VA and re-designing the structural system by changing the system from concrete to steel. The new gravity floor system will be comprised of a composite beam/girder system with composite deck. The new lateral system will be comprised of moment frames and braced frames. Since the existing building is located in Washington DC, the design is limited by a zoning height restriction of 130 ft. The new system will have to be designed as 11 stories instead of 12 stories in order to stay within stay within the height limit. As a result, the system will be re-located to Arlington, VA, which does not have a height limitation. A uniform column layout for the new system will be created by re-locating and removing columns to create wider bays and the floor-to-floor heights of the system will increase to create higher floor-to-ceiling heights.

In addition, two breadths will be studied. These breadths will include a study of the new structural system's impact on construction and the existing building's acoustics and lighting. The first breadth studied will be construction impact. In this breadth, the new system will be analyzed for total cost, construction schedule, and construction site management. Also, since the structural system will be designed for wider bays and higher floor-to-ceiling heights, the owner will be able to charge higher rent since the rental value of the floor space will increase. Therefore the annual revenue obtained with the use of the new structural system will be compared to the revenue obtained with the use of the existing structural system. The second breadth studied will be acoustics and lighting impact. Since the new structural system material will be changed from concrete to steel an acoustic breadth will be conducted by determining the sound transmission class (STC) and noise reduction (NR) values for both the new and existing systems. These values will be used to help determine which sound treatments will be necessary to use for the office spaces in the new structural system to reduce sound transmission and increase privacy. Further, the floor-to-ceiling height for the new system will be greater than the floor-to-ceiling height of the existing system; therefore the lighting illuminance on the work plane surfaces in the space will be affected. As a result, a lighting breadth will be conducted by calculating the illuminance of the existing lighting system and comparing this value to the target illuminance of the space. If the calculated illuminance value is not within ± 10 percent of the target illuminance, a new lighting system will be designed for the typical office space. The new space with lighting will be depicted through renderings.

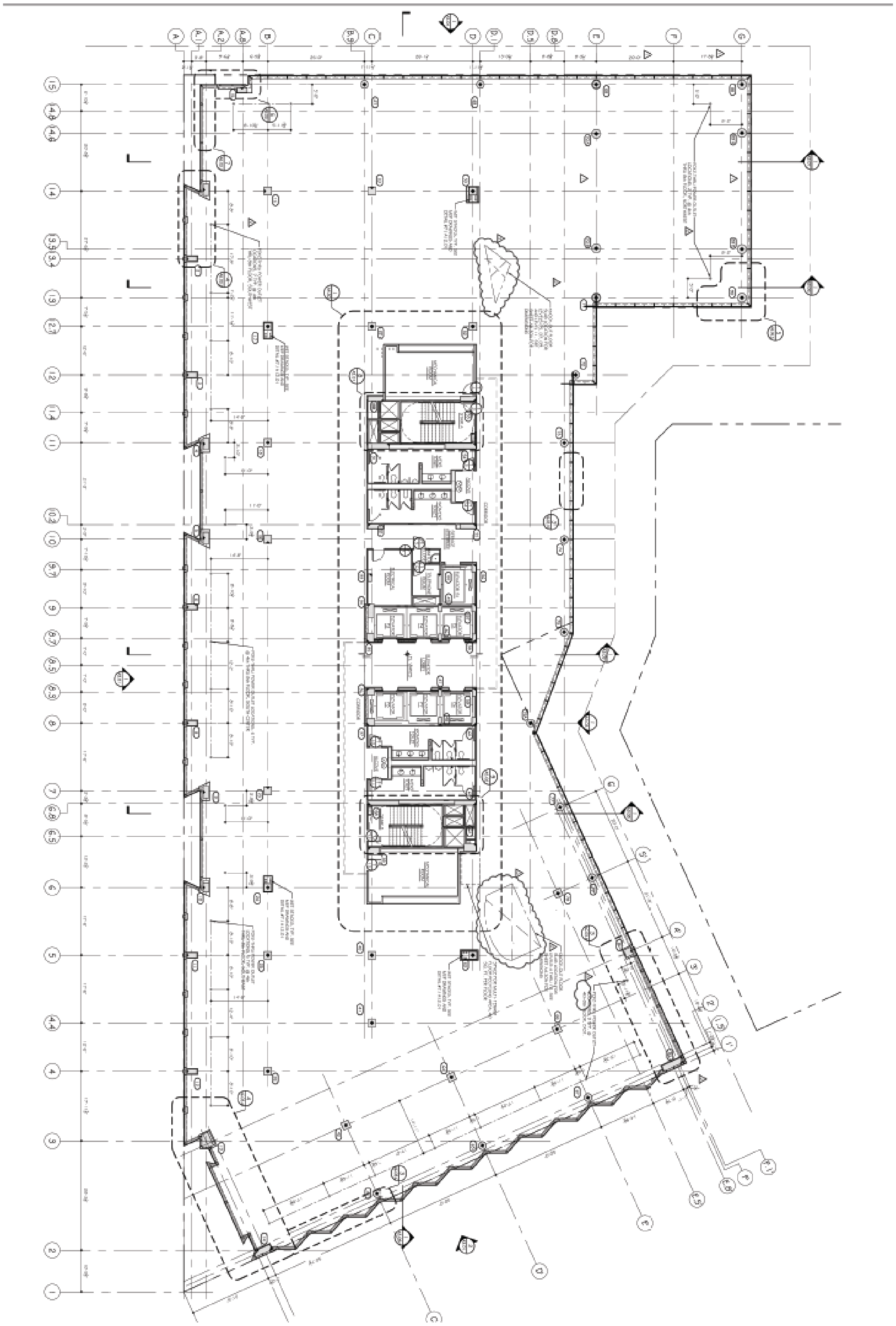
The new structural system will be compared to the existing structural system based on 5 criteria:

- overall building cost
- construction schedule
- LEED certification
- bay sizes and floor-to-ceiling heights
- annual revenue

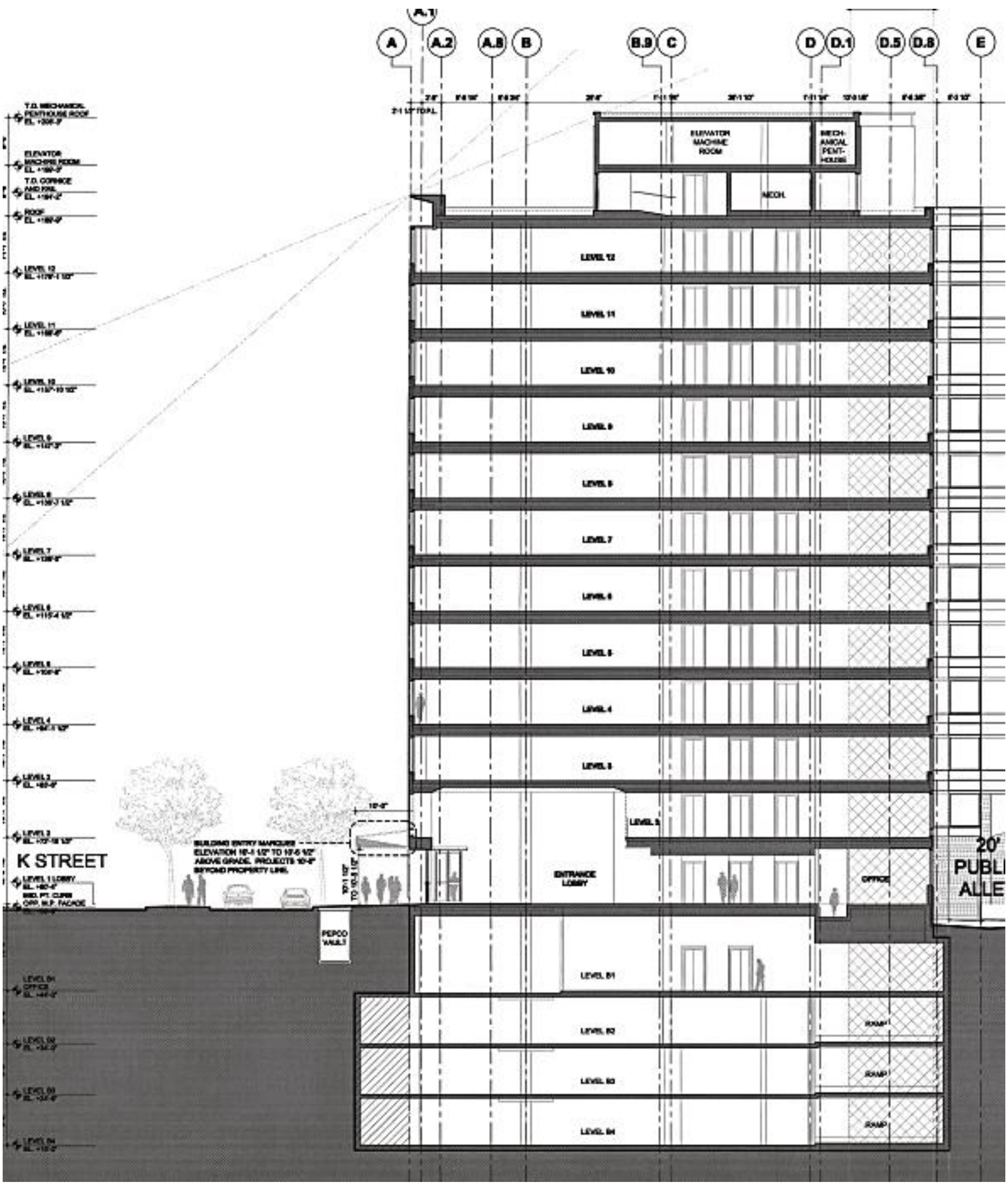
Appendix A: Typical Floor Plans



Typical underground parking plan rotated 90 degrees CW



Typical Floor plan oriented 90 degrees CW



Building Section