Rockville Metro Plaza II

121 Rockville Pike
Rockville, Maryland

Technical Report I

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Introduction

The following report introduces the existing physical conditions of Rockville Metro Plaza II. The architecture and basic structural loading concepts are assessed in this review.

This document begins with a reflection on the architectural characteristics of the building: the building's configuration of spaces in addition to the building's primary façade elements. The location and accessibility of the site will also be in consideration. The purpose of this section is to gain a familiarity with Rockville Metro Plaza II in general as well as to gain an understanding for the underlying theories of its architectural design.

Moving on, the structural systems will become the focus of the document. An overview of the structural system will be broken down into the following components: Foundations, Floor Systems, Column System, Lateral System, and Roof System. These sections will review the basic purpose as well as typical size of each component. The function of this portion of the document is to provide a cursory introduction to the structural system of Rockville Metro Plaza II. From this, an understanding as to the interaction of these systems will inherently be developed.

The third portion of the report will assess the gravity loading on the structure. Specifically, Dead Load, Live Load, and Snow Load will be considered. The document will discuss appropriate design values as well as the sources that were used to acquire them. This section will develop an understanding as to the sources and definitions of gravity loads that are present on the structure.

The final portion of this document will consider the main lateral loads acting on the structure. Specifically, Wind Load, Seismic Load, and Lateral Soil Loads will be considered. The document will discuss the methods used to determine these loads as well as how these loads are applied to the structure. A discussion of how the structure resists these loads will also be included. This section will develop an understanding regarding the sources and definitions of lateral loads that are present on the structure.

Architectural Rendering of RMP II

Executive Summary

Rockville Metro II is the second part of a three phase project that will aid in revitalizing its community. The building is planned to bring new retail venues and Class A office space to the Rockville, MD area. In September of 2011, construction began on this ten story structure.


Rockville Pike Entrance

The structure was planned to have three levels of below grade parking. An initial geotechnical report concluded that the soil at this level would be adequate to support the structure on concrete footings alone. The only concern found was that the water level could exceed this elevation. Thus damp-proofing measures were taken in the design.

The entire structural system is built using cast-in-place concrete. The lower levels of the structure (parking and retail levels) use flat plate, two-way slabs with mild reinforcing to support the floors. Columns which bear these levels incorporate drop caps for added flexural strength, deflection control, and better resistance to punching shear forces. The upper levels of the structure (the office spaces) also use a flat plate slab with mild reinforcing to support the floors. However, in order to facilitate a more flexible office space, larger column-to-column spans (40 feet) were designed. This required additional support of the slabs. To achieve this, wide, shallow post tensioned beams were added to the design. These aided in the control of deflection as well as reduced the potential for cracking. All live loading was determined using ASCE 7 as a guide.

To respond to the potential for lateral loads on the structure such as seismic and wind, concrete shear walls were incorporated into the structural design. These walls were placed near the center of the structure about the elevator core. These walls were designed to be 12” thick with rebar reinforcing. ASCE 7 also aided in determining the loading conditions for these elements. The roof of the structure is specified as a green roof. MET II is set to achieve a LEED rating of Platinum, and the green roof is one of the attributes that will aid in this achievement.

In April of 2013, construction on MET II concluded, and MET II became the National Headquarters for Choice Hotels. The following report will describe the structural systems of MET II in more depth. The structure will be analyzed as originally designed and built. Cagley and Associates is responsible for the original design the structural system of MET II and has provided all structural drawings for this report.

Architectural Introduction

Rockville Metro Plaza II is the second part of a three phase development that will bring retail venues and Class A office space to the Rockville area. Located in Rockville, Maryland, the site is situated on the corner of Rockville Pike and East Middle Lane, just one block from the Rockville Metro Station and less than a mile from I-270. MET II is a ten story office structure with three levels of underground parking and street-level retail space.

Figure 1: Exterior View from Across Rockville Pike

The main pedestrian entrance for the office area is located at grade along Rockville Pike as seen in Figure 1 to the left. Two retail spaces will flank this entry; their door's located adjacently. The parking levels are accessed via the ramp located on the east side of Phase I. Once completed, the parking areas of MET II will simply be an extension of this garage. Parking will occupy the three below grade levels of MET II as well as the first elevated level. The remaining eight levels of the structure will be occupied by office tenants. Choice Hotels is set to make this building their North American Headquarters and will thus inhabit a large majority of this building. Topping the structure will be the mechanical penthouse which will house MET II's cooling towers, generator, etc.

The structure is enclosed by a blanket of architectural precast concrete panels, masonry, and glazing. On the lower levels, a chevron shape ornaments the precast panels and finer stone accents the building. Sustainable attributes such as green roofs and energy-wise mechanical systems elevate the structure to it's Platinum LEED certification. The building serves as a model, revitalizing its neighborhood economically, visually, and spiritually.

Figure 2: Rockville Town Square Obelisk

Structural Systems Overview

Foundations

The foundation of MET II is comprised of concrete footings and strap beams. The depths, sizes, and reinforcing of footings vary greatly and are dependent upon the column load which it is supporting/distributing. All footings and strap beams were poured using 3000 psi concrete. A net allowable bearing pressure of 10,000 psf was used to design the foundations which are to be placed on undisturbed soil at foundation level. Strap beams had to be used in certain sections where the footing could not be placed centered under the column (e.g. property line abutment). The strap beam helps to distribute the weight of the eccentrically loaded column to adjacent footings and thus aids in resisting overturning. See Figure 3 below and in Figure 13 of the Appendix for illustrations of the foundation design.

Based on the geotechnical study conducted by Specialized Engineering, it was determined that at the proposed foundation level of this site, the soil was comprised mainly of decomposed and weathered rock. Their Subsurface Exploration and Geotechnical Evaluation report concluded that concrete footings would be adequate to support the anticipated load of the structure.

The one concern which was pointed out in the report was that ground water levels could be at or above the foundation level. In response, the foundation and its walls were designed with this in mind. A layer of granular fill was placed below the slab on grade, with drainage pipes placed throughout. These pipes direct the water to a sump pit which can expel the water when called upon. A vapor barrier lines the underside of the S.O.G. and water stops are installed at steps in the slab grade. Gravel and drains are installed similarly about the exterior foundation walls, as well as sheathing and coatings for damp-proofing.

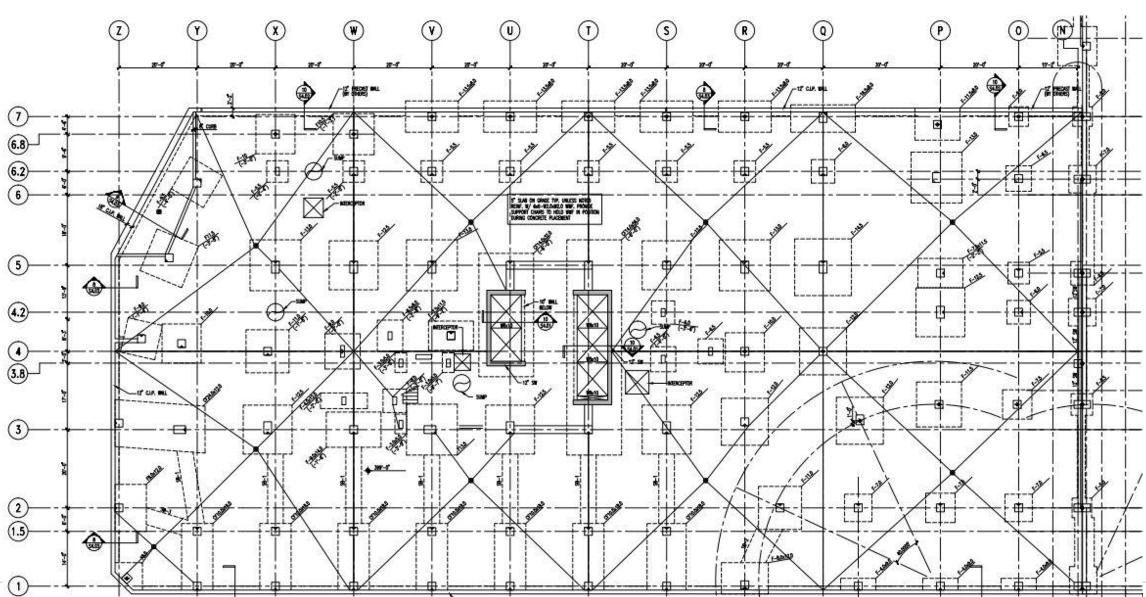

Figure 3: Foundation Plan (refer to Appendix for Enlarged Image)

Floor Systems

The structure's floor systems vary depending on the occupancy/function of the space which they are supporting as well as the distance being spanned. The concrete used for most slabs and beams was specified as 4500 psi normal weight concrete (unless noted otherwise). Refer to the Appendix for illustration of the floor systems as well as the typical bays.

Beginning at the slab on grade, we find a 5" thick concrete slab reinforced with 6x6 – W2.0 x W2.0 welded wire fabric. Two way flat slabs are employed on parking levels P2, P3, and P6. These slabs are 8" thick and use mild reinforcing which is distributed appropriately in order to resist positive midspan moment as well as negative moment created at slab-column intersections. A bottom mat is comprised of #4 bars running each way at 12" on center. The size, length, and spacing of top bars (and additional bottom bars) vary depending on loading and span distance. Drop caps are also incorporated around columns in order provide better flexural capacity, aid in deflections, and better resist punching.

The on-grade (Retail Level) level of the structure also uses only mild reinforcing in the construction of its slab. The slab thickness and elevation varies across this floor depending on the area and its use. Throughout the lobby and retail spaces, a 9" slab was found to be sufficient. However, the loading dock area and the courtyard require 10" and 12" slabs respectively. A bottom mat is comprised of #5 bars running each way at 14" on center. Once again, drop caps are used to add flexure and shear strength.

The remaining floors are designated to be office levels. These levels combine a mild-reinforced slab with post tensioned beams in order to achieve a larger slab bay (typically 40' x 20'). A bottom mat is comprised of #4 bars running each way at 12" on center. In order to achieve the large span of 40' while maintaining a relatively thin floor depth, the use of post tensioning in this design is critical (typical detail shown below in Figure 4). It allows for deflection and cracking to be controlled/reduced over these spans while the slab depth is kept to 8" thick and beams are kept to a typical 20" in depth. See Figures 15 and 18 of the Appendix for plans and typical bays.

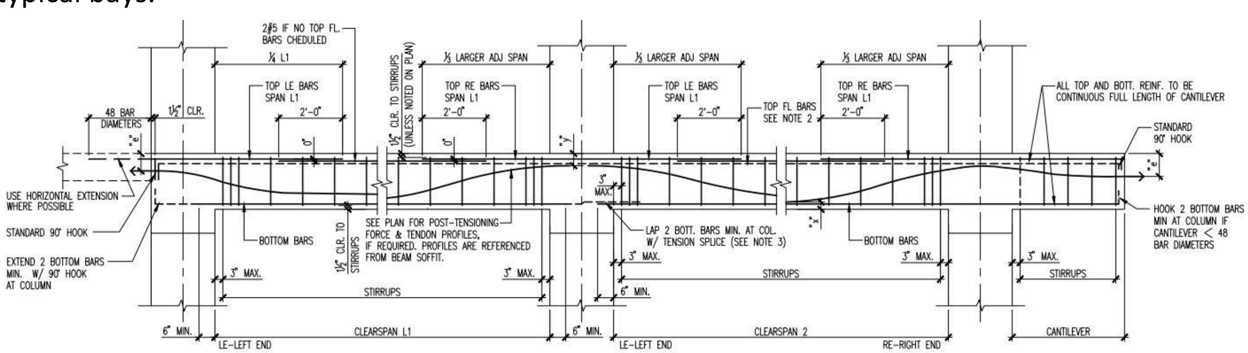

Figure 4: Post Tension Beam Detail Elevation

Column System

The structure of MET II is comprised of concrete columns. The majority of the building's columns are 24" x 24" in dimension and are reinforced with #10 and #11 rebar. The exterior of the building incorporates 30" diam. columns as architectural accents. The strength of concrete used to construct the columns is stepped down as the column rises: 5000/6000 psi ground through the 4th level, 4000 psi 5th through the 8th level, and 3000 psi 9th level and above.

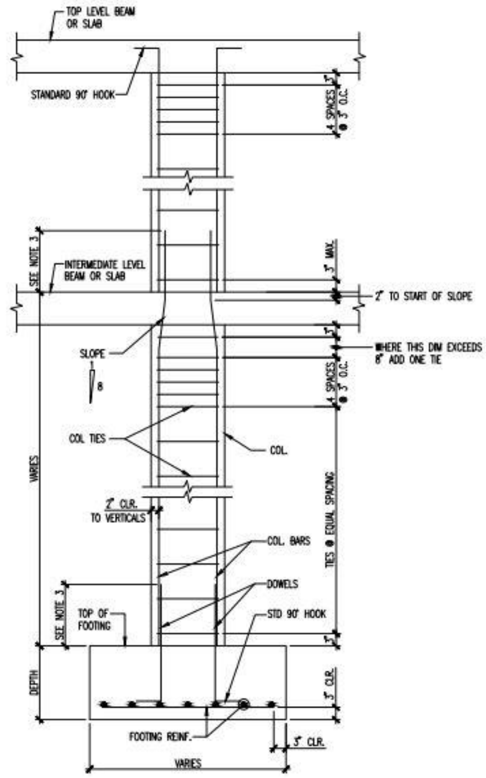

Figure 5: Column Detail Elevation

The office portion of the structure achieves a fairly repetitive column layout (see the appendix for floor plan illustrations). However, the exterior-to-interior column span on each the East and West side of the structure is 40' in length. This architecturally driven span allows tenants to have a wider, more flexible floor plan. In response to this, post tension beams are used to transfer the slab load to the columns. Within these levels, these beams are typically 48" x 20" in dimension.

Within the parking levels an extra row of columns has been added on each the east and west sides. This divides the otherwise 40' span in two (thus eliminating the need for post tension beams as seen in the upper floors). Also, most interior columns in the parking areas also incorporate drop caps for added flexural and shear capacity (refer to Figure 14 - Parking Levels in Appendix for visual depiction of locations).

In order to respond to architectural features that stood in the path of select columns, it was necessary to design some columns as sloped. On the plaza and P6 levels, interior columns are commonly sloped to accommodate the standard parking stall space in the garage levels below, as seen in figure 6 to the right.

Figure 6: Sloped Columns in Retail Space

Lateral System

Rockville Metro Plaza II uses shear walls and moment frames as the main lateral force resisting system. Lateral loads that are applied to the building are resisted by this shear wall and moment frame system as these elements transfer the force to the building's foundation.

Shear walls 12" in thickness frame the two elevator towers at the center of the structure and extend from the foundation to the roof of the structure (see figure 7 - shear wall locations are highlighted). Another 12" thick shear wall is present along part of the Northern face of the structure on the sub-grade levels. The strength of concrete used follows the same gradation as applied to the columns. As with most concrete structures, the rigid construction allows most of the building's frames to act as moment frames. This reduces the need for multiple shear walls and allows MET II to be designed with so few.

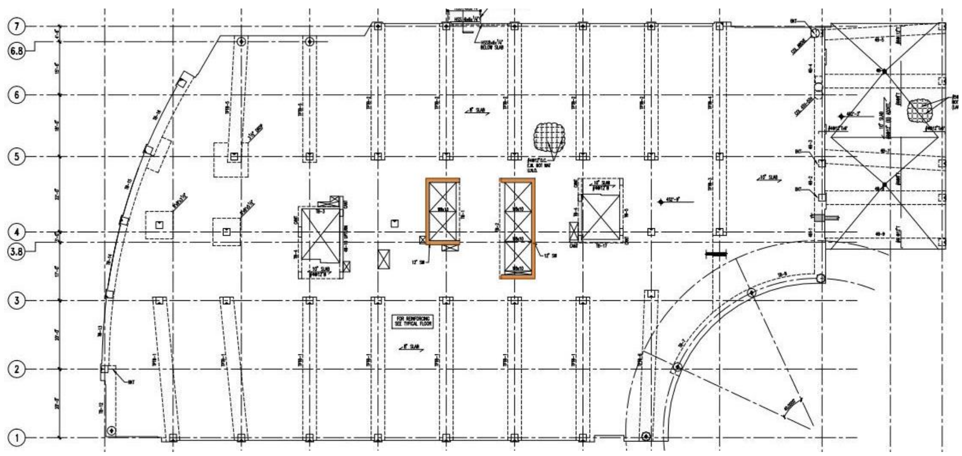

Figure 7: Shear Walls - 4th Floor

Roof System

In order to aid MET II in its pursuit of a LEED Platinum rating, a green roof system was designed as the main roofing system. The roof begins with a mildly reinforced, 8" concrete slab. A bottom mat is comprised of #4 bars running each way at 12" on center. Top bars and additional bottom bars are placed as needed. Next, a roof membrane and waterproofing layer are applied, on top of which rigid insulation is placed. A thin moisture retention mat is draped, followed by a drainage mat. Four inches of a light weight substrate soil mix is laid, in which a sedum mix is planted. Sedum is a genus of flowering plants of the family Crassulaceae and is widely used as an alternative to grass on green roofs. Refer to Figure 8 to the right and to Figure 18 in the Appendix for the green roof

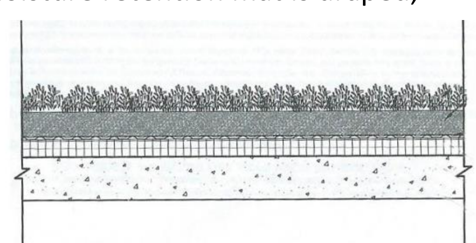

Figure 8: Green Roof Layers

composition.

Design Codes

As defined on page S1.00 of the construction documents, the following codes are applicable to the design and construction of MET II's structural system:

- "The International Building Code-2009",
  International Code Council

- "Minimum Design Loads for Buildings and Other Structures" (ASCE 7-05),
  American Society of Civil Engineers

- "Building Code Requirements for Structural Concrete, ACI 318-02",
  American Concrete Institute

- "ACI Manual of Concrete Practice – Parts 1 Through 5" (2002),
  American Concrete Institute

- "Post Tensioning Manual, 5th edition",
  Post Tension Institute

Load Analysis - Gravity

Dead Load

Dead loads are permanent loads on a structure. Within MET II, floor dead loads are mostly comprised of the concrete slab itself. Reinforced, normal weight concrete is used in the construction of slabs, thus a value of 150 pcf is appropriate as a design value. Superimposed floor dead loads, such as flooring or ceiling tile, contribute a smaller fraction. To achieve an accurate design value for the superimposed load, architectural drawings and specification cut sheets could be analyzed. However, the assumed value as per the structural documents is 5 psf for floors and 10 psf for roofs.

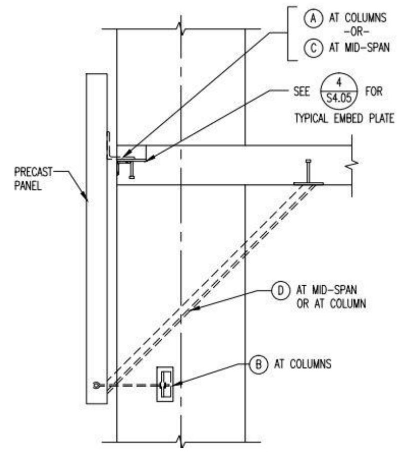

Figure 9: Precast Elevation Detail

Similarly, wall dead loads have a single large contributing component to dead loads: architectural precast concrete panels (depicted in Figure 9 to the right). Aluminum-framed glass and a cold-formed steel framed wall comprise the remainder of the wall dead load.

Live Loads

Design live loads for MET II are determined based on the function of the space being designed. Within the structure, office, parking, corridor, retail, light storage, and stair type loading definitions will most commonly be used in design. Upon comparison between design loads listed on the structural documents and those suggested in ASCE 7, it can be seen that all requirements are met. Some design loads used (mechanical and parking areas) exceeded the required load listed in ASCE 7. These increases in load are based on engineering judgment and owner specifications.

Snow Load

The roof of the structure is predominantly flat. Thus a flat roof snow load was used in designing the roof's structure. This value was determined to be 17.5 psf (reduced from a ground snow load of 25 psf). Due to the penthouse projection and roof curb, unbalanced, drifting, and sliding snow loads also had to be considered in the design. Procedures used for evaluating the flat roof snow load, drifting, etc. are defined in ASCE 7.

Load Analysis - Lateral

Wind Load

Wind forces act on the façade of a structure. Based on tributary area, the load would be distributed story wise into the floor slabs of the structure (which can be considered rigid in this model). The slab then transfers the force into the shear walls and moment frames of the structure. In turn, the load is funneled to the foundation of the structure.

In analyzing the structure for this load case, various load combination must be considered as per ASCE 7. Due to the building's geometry, wind in the East-West direction would likely provide larger loads relative to the perpendicular orientation. This can be surmised by looking at the length of each side of the structure. The east and west sides are nearly twice as long as their perpendicular counterparts, thus they will have a larger tributary area and will see a stronger force.

Wind loads for this structure were calculated using the approaches listed in ASCE 7. The basic wind speed used in design was 90 mph. This value is determined via graphics from ASCE 7 such as the one depicted in figure 10. The site importance factor and site exposure category are 1.0 and B, respectively. A net wind uplift force of 25 psf was also determined. In analyzing this system, lateral wind loads would be applied to the vertical, exterior face of the structure as per ASCE 7.

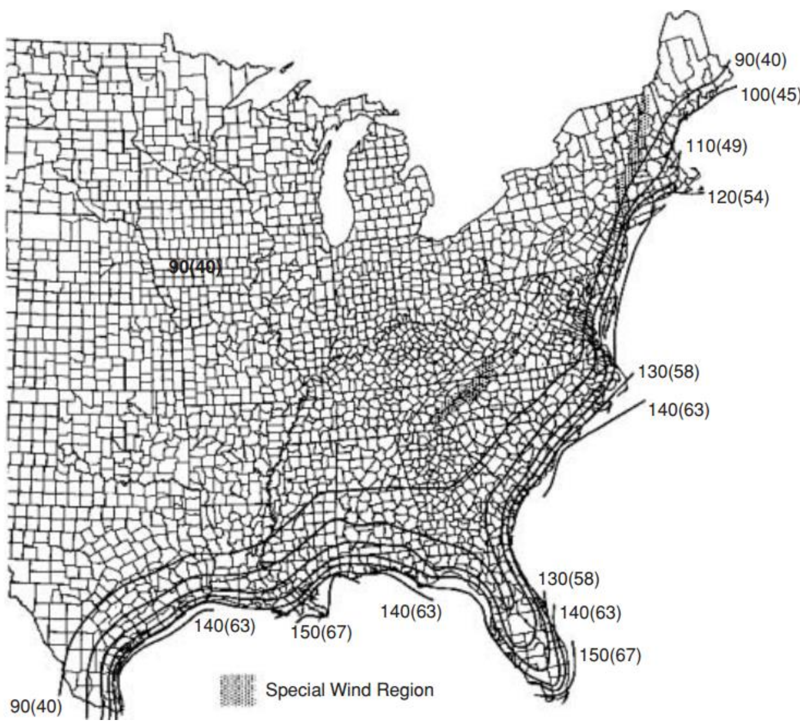

Figure 10: Basic Wind Speed Graphic from ASCE 7-05

Seismic Load

Seismic loads are those caused by the movement of the earth below the structure. This movement is an oscillatory vibration of the ground surface following a release of energy in the earth's crust. An earthquake typically has a main shock and aftershocks. Earthquakes are difficult to design against due to their secondary effects such as liquefaction, landslides, fire, etc.

ASCE 7 offers the guidelines for design against seismic loads that were used in the design of MET II. The aid allows the effects of an earthquake to be simplified into a lateral load at the base of the structure, i.e. the base shear. The base shear is calculated as a result of the relationship between the mass at each floor, the building's frequency, and a selected ground motion. Equations in ASCE 7 allow for the design ground motion to be predicted and graphed as shown in Figure 11 to the right. Once a base shear is found, the force may be distributed to slab of each level of the structure in a proportional fashion based on the weight and height of the level. Analysis procedure follows that the slab then transfers the force into the shear walls and moment frames of the structure. In turn, the load is funneled to the foundation of the structure and dispersed there.

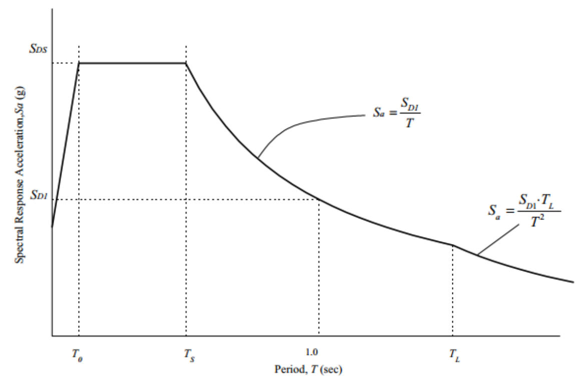

Figure 11: Design Response Spectrum graphic from ASCE 7-05

Lateral Soil Load

Lateral soil loads are considered in the design of the foundation walls. A lateral equivalent fluid pressure as determined by the geotechnical report is used for this calculation. At rest condition (braced walls), this force was determined to be 55 psf per foot of depth. For the active condition (cantilevered retaining walls), this value was determined to be 45 psf per foot of depth. These values may then be used to design the foundation walls as guided by ACI 318-02.

Conclusion

Through this study, a better understanding of Rockville Metro Plaza II's structural systems may be achieved. Beginning at the foundation, concrete footings and strap beams support the structure. From here, concrete columns rise through the building, supporting each floor. Concrete and mild reinforcing comprises the floor slabs on each level. For added support and deflection control over longer spans, post tensioned beams are incorporated on the office levels. Shear walls at the building's core as well as moment frames throughout provide lateral stability within MET II.

Figure 12: Exterior Perspective

The original design intent of the structural engineer comes into focus as methodologies and design values are studied. For a deeper understanding, the values achieved by the engineer as well as the end result could be assessed by additional analysis.

Appendix

Structural Drawings

P1 Level/Foundation

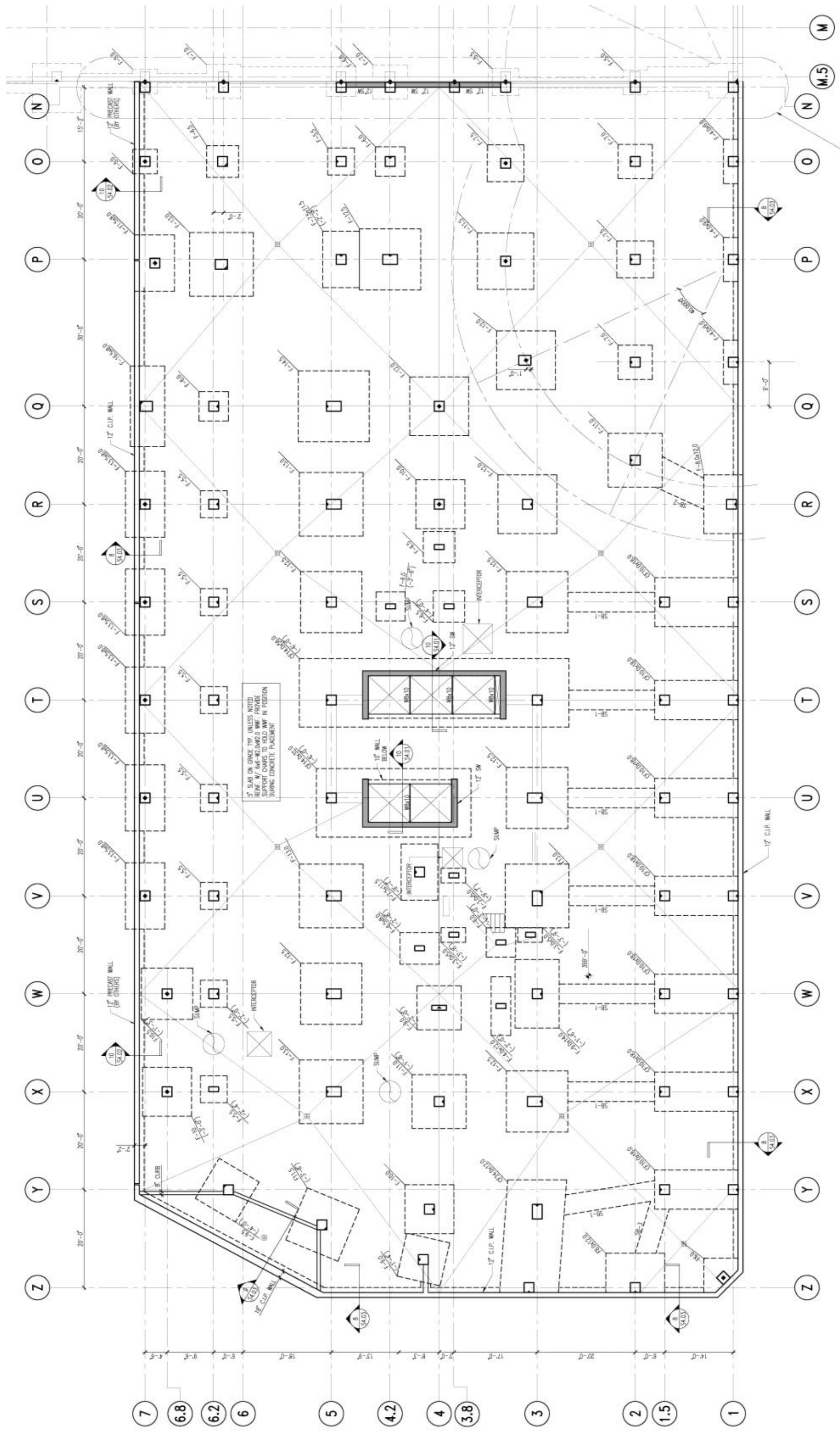

Figure 13: Foundation Plan

P2 and P3 Parking Levels

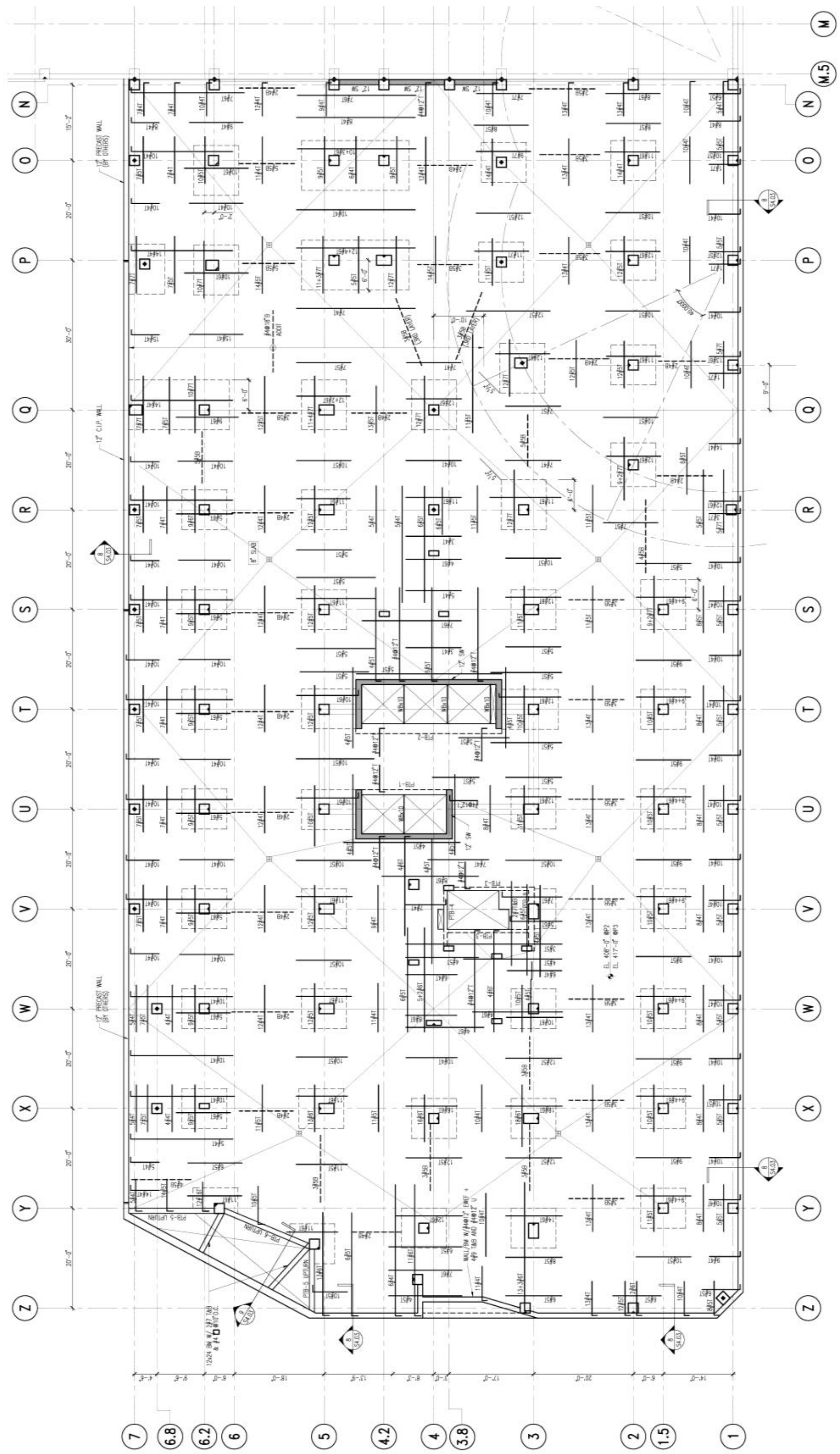

Figure 14: Parking Levels Floor Plan

Typical Floor Framing Plan

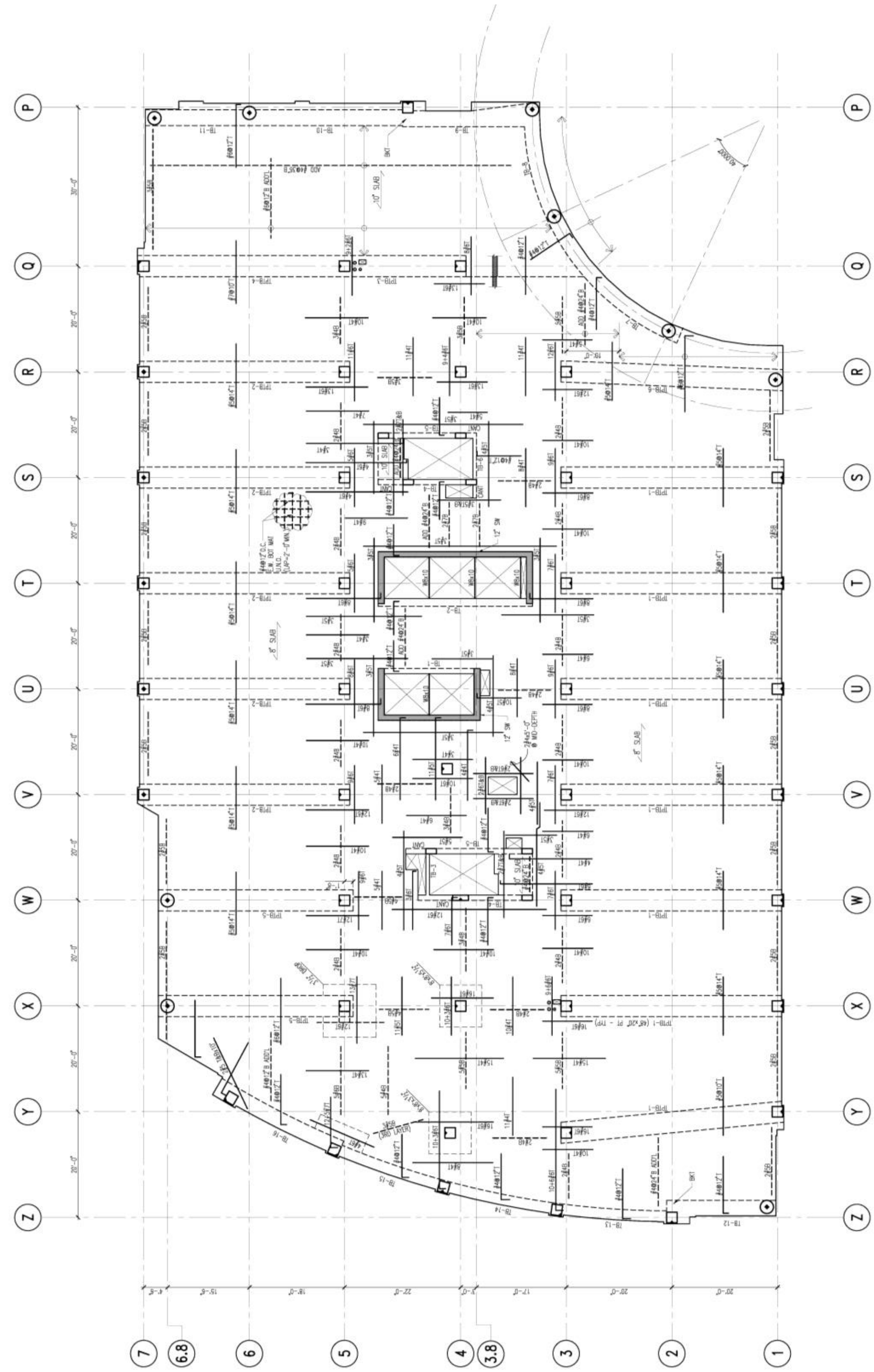

Figure 15: Typical Office Level Plan

Main Roof/Penthouse Level Framing Plan

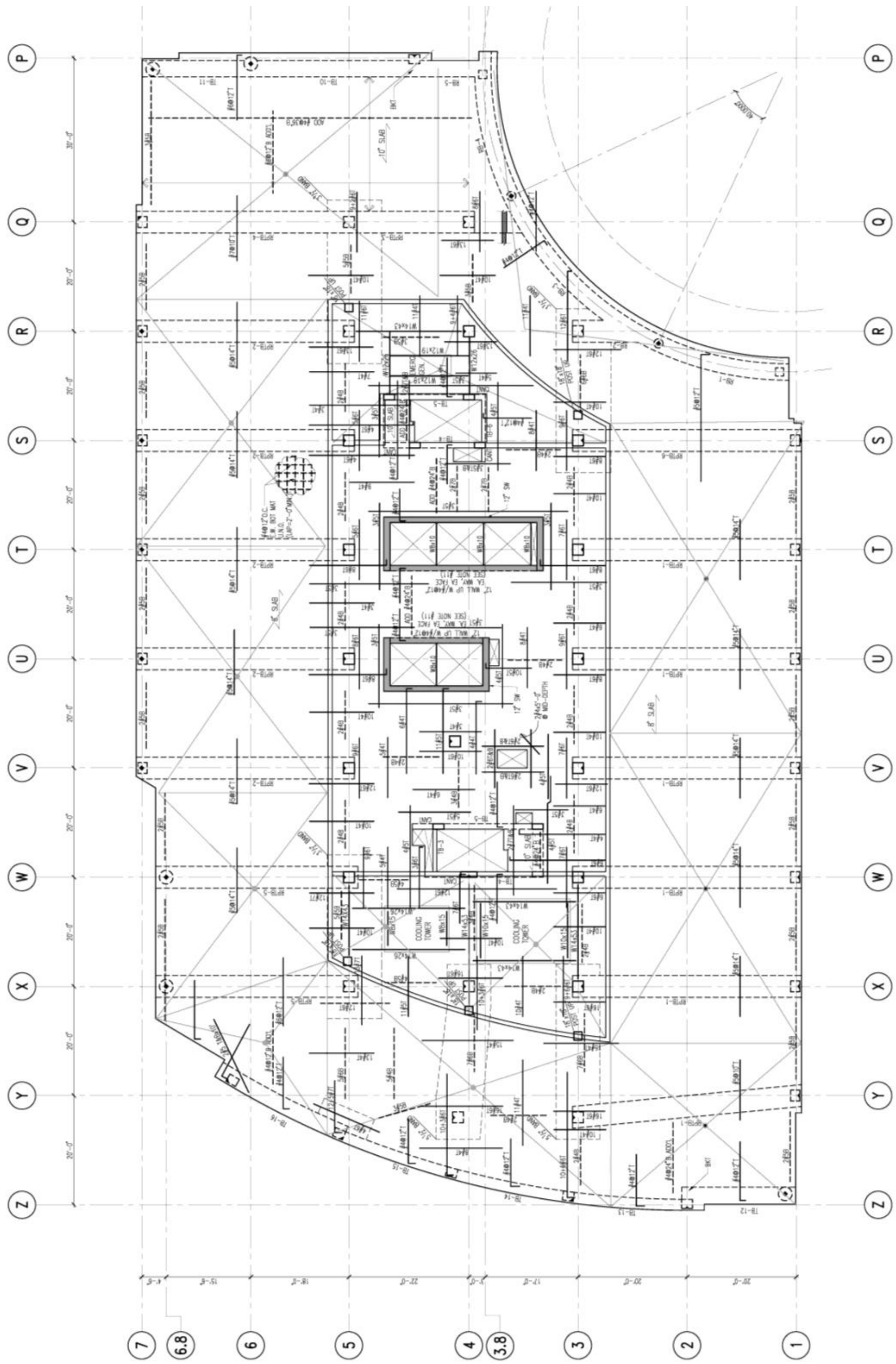

Figure 16: Main Roof/Penthouse Level Plan

Typical Bays

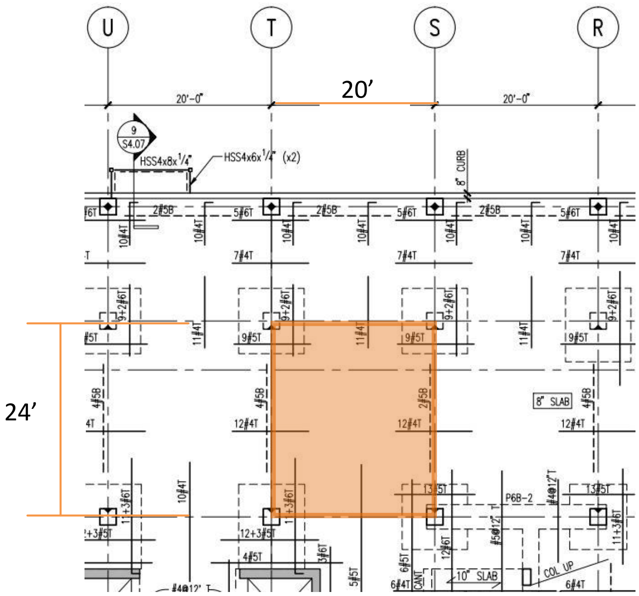

Figure 17: Typical Interior Garage Bay

-Two Way Slab, 8" thick
-Dimensions – 20' x 24'
-Bottom Mat - #4 @12" o.c. each way

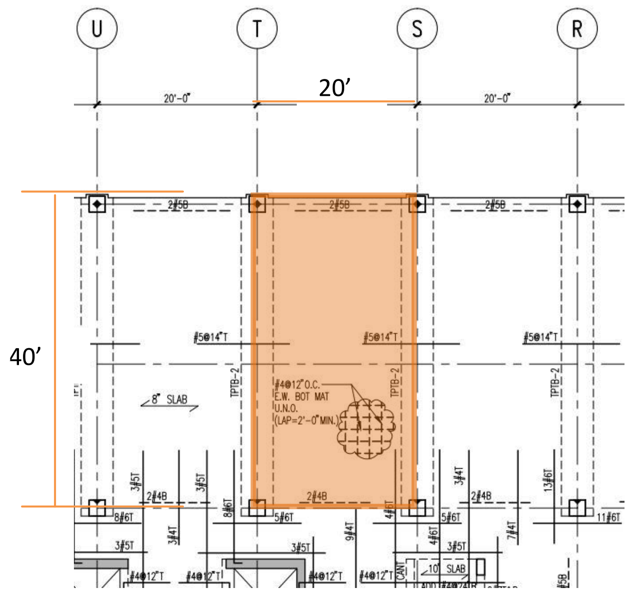

Figure 18: Typical Office Level Bay

-One Way Slab, 8" thick
-PT Beam – 48" x 20"
-Dimensions – 20' x 40'
-Bottom Mat - #4 @12" o.c. each way

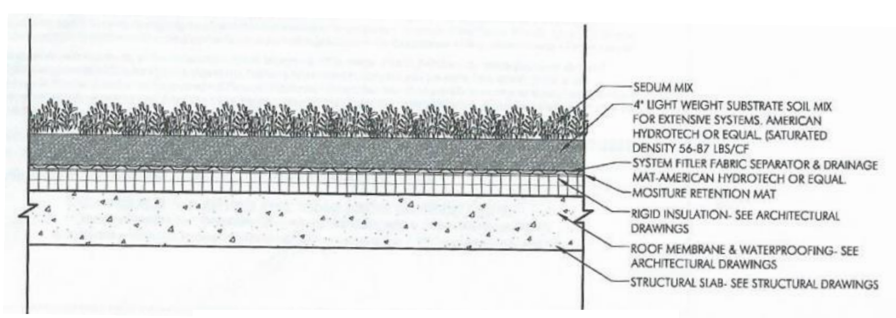

Figure 19: Green Roof Composition