Rockville Metro Plaza II

121 Rockville Pike
Rockville, Maryland

Proposal

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Executive Summary

The purpose of this proposal is to define an element of Rockville Metro Plaza II which may be used as a point of research. This document will establish the means and methods through which this research will be conducted.

For this investigation, the focus will be a redesign of Rockville Metro Plaza II's structural system from concrete to steel. In *Technical Assignment III*, it was found that a steel system would be a viable alternative to the current one-way slab system. Composite deck and composite steel beams have been chosen to frame the floor. For the lateral system, braced frames and moment frames will be considered as alternatives. Typical connections will also be developed.

This amendment to the structure will inevitably impact many other features of the building's design and construction. Therefore, two breadths will be studied in order to see the effect of this redesign. The first will study the cost and scheduling issues that may arise. The second will assess the architectural ramifications of the new structural system.

Architectural Rendering of RMP II

Introduction

Rockville Pike Entrance

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.

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

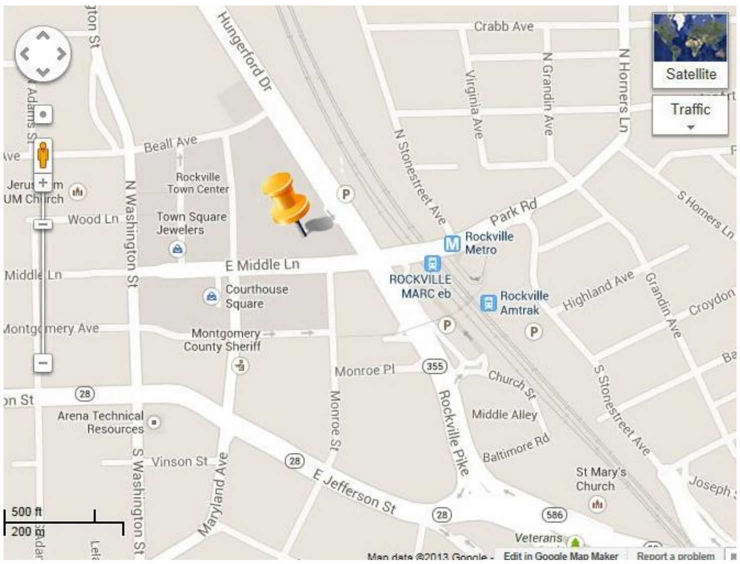
The main pedestrian entrance for the office area is located at grade along Rockville Pike as seen in Figure 1 to the left. Two retail spaces will flank this entry; their door's located adjacently. The parking levels are accessed via the ramp located on the east side of Phase I. Once completed, the parking 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 its Platinum LEED certification. The building serves as a model, revitalizing its neighborhood economically, visually, and spiritually.

Figure 2: Rockville Town Square Obelisk

Site Location

Rockville Metro Plaza II is located in Rockville, Maryland, just 20 miles northwest of the heart of Washington D.C. The site sits prominently on Rockville Pike which is one of the main routes through the area. Across from the lot is the Rockville Metro stop. With such close proximity to these passage ways, this site boasts a transportation convenience for both employees and visitors alike.



The bustling Rockville area is primarily occupied by businesses, retail, restaurants, and high rise apartments. It is an ever expanding and reawakening locale, as new construction projects continually rejuvenate the lively scene. Upon visiting the area, it can be quite evident why Choice Hotels would decide to make MET II the site of their new North American Headquarters.

Figure 3: Map of Site Location – From “maps.google.com”

The new construction of MET II would be an addition to the current Rockville Metro Plaza I to the Northwest. This posed a complication during construction, for impact on MET I’s daily function had to be minimized as much as possible. Excavation of the addition would be required to yield to the existing structure as well.

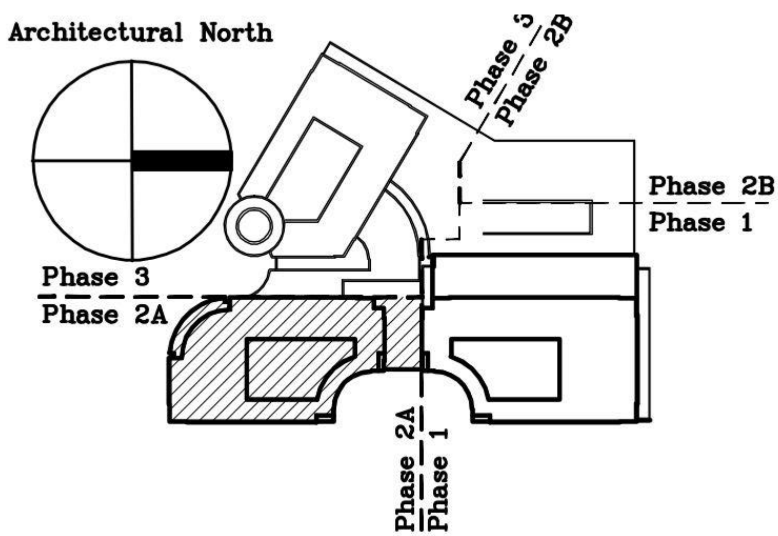


Figure 4: Map of Building Relations – by WDG Arch.

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 5 below 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.

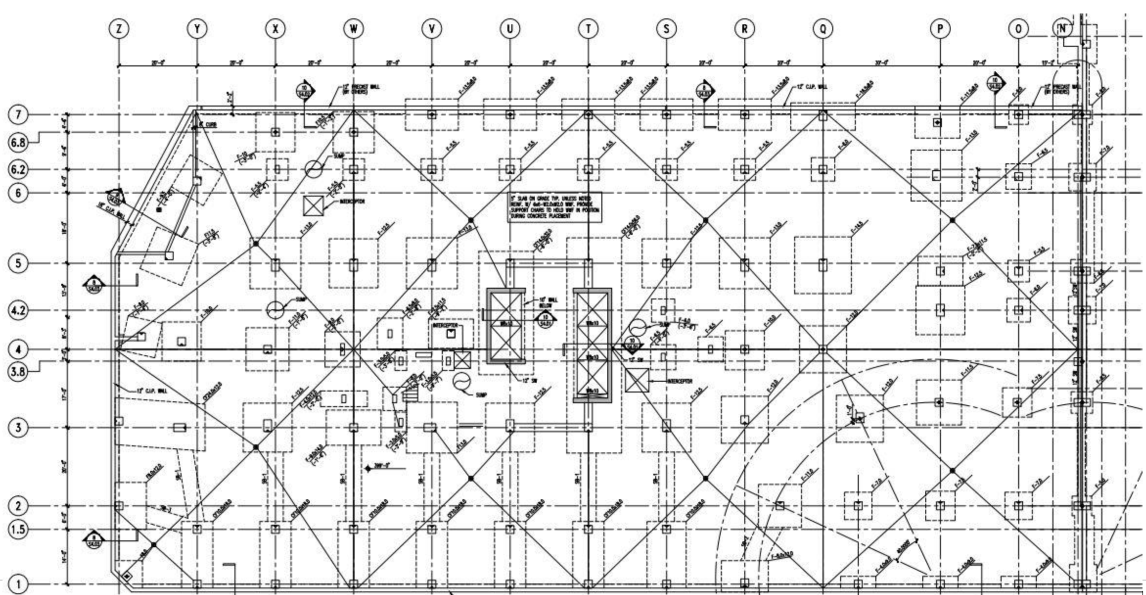


Figure 5: Foundation Plan (refer to Appendix for Enlarged Image)

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).

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 6). 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.

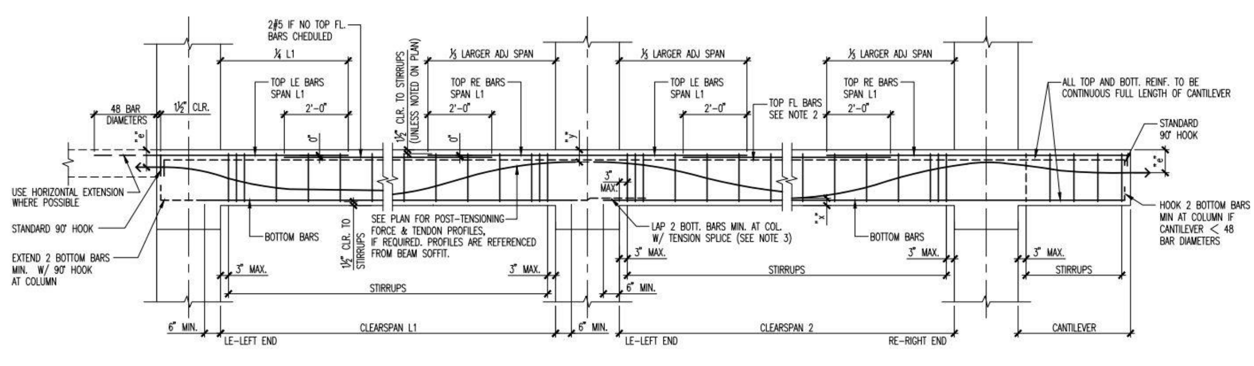


Figure 6: Post Tension Beam Detail Elevation

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.

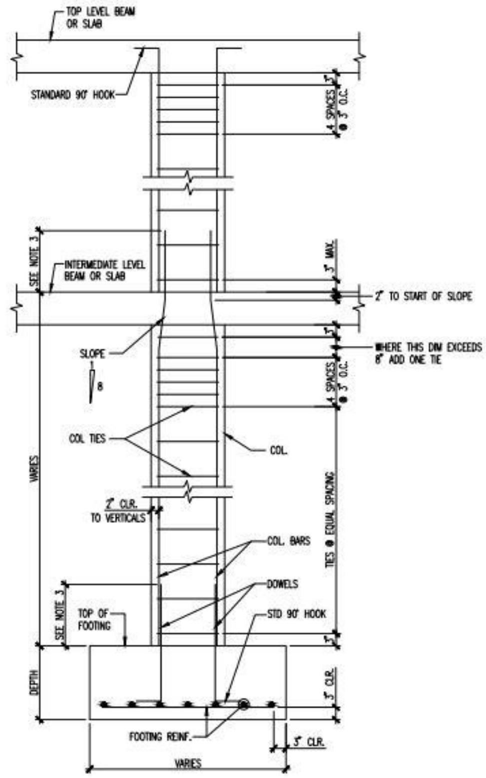


Figure 7: Column Detail Elevation

The office portion of the structure achieves a fairly repetitive column layout (see the appendix for floor plan illustrations). However, the exterior column-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.

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 8 to the right.

Figure 8: 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 9 - 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.

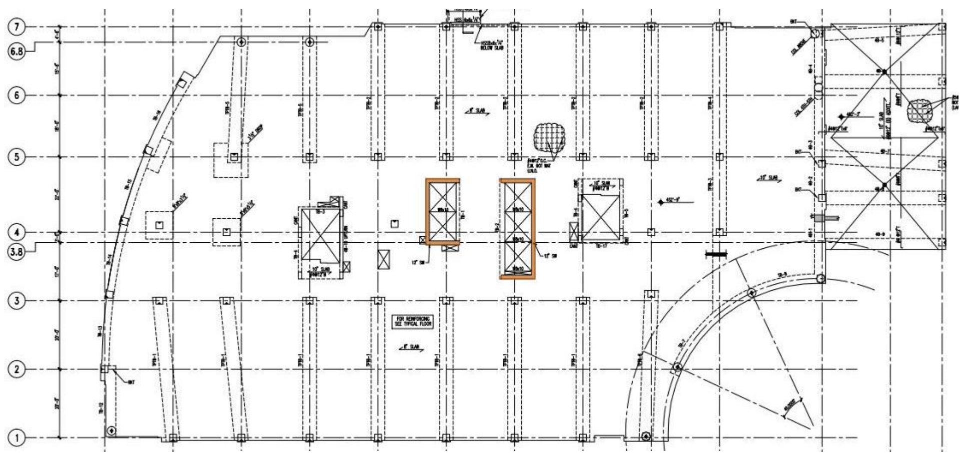


Figure 9: Shear Walls - 4th Floor

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 10 to the right for the green roof composition.

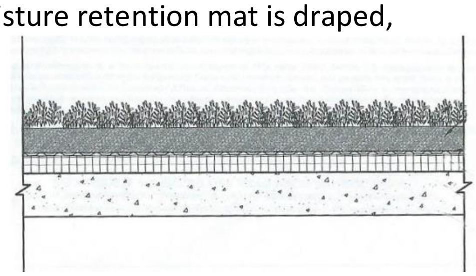


Figure 10: Green Roof Layers

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

The following documents will be referenced for the purpose of this report:

- "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 318-11",
  American Concrete Institute

- "Steel Construction Manual – 14th Edition",
  American Institute of Steel Construction

- "Vulcraft Steel Decking Catalogue",
  Vulcraft

Thesis Proposal

Problem Statement

Through past studies, the concrete structure of Rockville Metro Plaza II proved to be capable of withstanding the required design loads. The shallow floor system and long span beams create versatile rentable spaces on each level. However, the use of concrete creates a heavy structure which requires larger gravity members and foundations.

Proposed Solution

In Technical Report III, alternative floor systems were studied. Systems considered were assessed based on their ability to maintain the open floor plan as seen in the original system. Cost, fireproofing, and several other considerations were also measured in the comparison of systems. The study concluded with identifying a composite steel floor system as a viable alternative to the current concrete system.

A steel system for the office levels will likely reduce the overall weight of the structure. This may benefit the foundation of the building, resulting smaller foundation elements. Similarly, the building's gravity system may see benefits in member sizing as dead loads are reduced. This will also impact the lateral loads on the building, further reducing seismic loads. The parking levels will likely remain unchanged in the new design however.

The redesign of the structural system will also require that the lateral system be considered. The implementation of braced frames, moment frames, and/or shear walls will be investigated. Lateral forces will be recalculated and considered once again, incorporating any changes made to the structure.

Impacts that this redesigned system will have on other areas of the building will also need to be explored. One consideration is the change in floor depth due to the size of steel members. This will require coordination with MEP systems and may lead to increasing the overall building height. Additionally, the architecture of the office space will require analysis when placing lateral elements. Fireproofing steel elements will also be necessary, but will result in additional costs.

In conclusion, an entire redesign of the structural system will be completed. The alternative design will then be compared back to the original and pros and cons will be weighted to determine the feasibility of the alternative.

Breadth Topics

Cost and Schedule

Altering the main structural system of Rockville Metro Plaza II will have a significant effect on the cost and schedule of the project. The impact that this change has on the construction schedule will be assessed through calculations and comparisons. A cost analysis will also be investigated in order to determine the feasibility of the alternative system.

Architecture

The redesigned structural system will have many potential impacts on the architecture of Rockville Metro Plaza II. A deeper floor system will increase the floor to floor height of the structure. This issue will consider the routing of MEP system, local zoning requirements, and impacts regarding the façade. Additionally, the redesigned lateral force resisting system will be of significant focus. The placement of these elements must respect the interior flow of the office space as well as the intended aesthetics of the building's façade.

MAE Requirements

Knowledge gained from graduate level course work will be incorporated into the investigation, analysis, and design of work in the depth and breaths of the proposed project.

AE 530 – Computer Modeling of Building Structures - Knowledge from this course will be integral in creating effective and useful models. These models which will be created in ETABS and RAM will allow for the analysis and design of the gravity and lateral systems of the structure.

AE 534 – Analysis and Design of Steel Connections - Material from this course will be relied upon heavily as connection design will be necessary for the steel structural system redesign.

AE 538 – Earthquake Resistant Design of Buildings- Additionally, coursework from this class will be incorporated in designing the lateral system of the structure.

Figure 11: Exterior Perspective

Tasks and Tools

I. Revise Proposal
II. Design Gravity System
    i. Calculate Loading (ASCE 7-05)
    ii. Create Computer Model (RAM)
    iii. Check Design
III. Design Lateral System
    i. Calculate Loading (ASCE 7-05)
    ii. Create Computer Model (RAM/ETABS)
    iii. Check Design
IV. Design Typical Connections
    i. Determine Typical Connection Locations
    ii. Determine Loading
    iii. Design Connection (AISC Steel Manual)
V. Assess Cost/Schedule
    i. Obtain/Assess Original Project Schedule
    ii. Create Schedule for Redesign (MS Project)
    iii. Create Detailed Cost Estimate for Original Structure (R.S. Means)
    iv. Create Detailed Cost Estimate for Redesigned Structure (R.S. Means)
VI. Consider Architectural Impacts
    i. Consider Impact of Floor Depth on Overall Building Height
    ii. Assess Impact of Floor Depth on Exterior Façade of Structure
    iii. Consider Layout of Lateral System (Revit)
    iv. Determine Impact of Lateral System on Interior Office Spaces
VII. Final Report and Presentation
    i. Compare Original System to Redesigned
    ii. Write and Format Final Report
    iii. Finalize Report
    iv. Create Presentation
    v. Update Website

Schedule

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17
	1/13-1/17	1/20-1/24	1/27-1/31	2/3-2/7	2/10-2/14	2/17-2/21	2/24-2/28	3/3-3/7	3/10-3/14`	3/17-3/21	3/24-3.28	3/31-4/3	4/7-4/11	4/14-4/18	4/21-4/25	4/28-5/2	5/5-5/9
Steel Structure Design																	
Research Methods and Configurations																	
Design Gravity System																	
Create Computer Model of Structural System																	
Design Lateral System																	
Create Computer Model of Lateral System																	
Analyze and Verify Design																	
Compare Original and Redesign																	
Steel Connections Design																	
Research Possible Connection Types																	
Determine and Design Typical Connections																	
Cost/Schedule																	
Obtain/Review Original Project Schedule																	
Create Schedule for Redesign																	
Cost Estimate for Original Design																	
Cost Estimate for Redesign																	
Architecture																	
Consider Lateral System Options																	
Determine Lateral System Impacts																	
Impact of Floor Depth on Building Height																	
Impact of Floor Depth on Façade																	
Wrap-Up																	
Write/Format Report																	
Create Presentation																	
Update Website																	
									Spring Break					Presentaions			Finals

Conclusion

The proposed depth of this investigation will be to redesign the structural system of Rockville Metro Plaza II. For this endeavor, a steel system will be considered. Data from studies conducted in prior technical reports, Tech III specifically, will be drawn upon and expanded in order to select a viable solution. The loading of the structure will be reassessed and members will be designed accordingly.

An analysis of the lateral system will consider the use of steel braces and moment frames. Placement of these elements will consider the architecture of the building in order to minimize impact on this feature. The redesigned system will be modeled using Etabs and RAM and will be verified for adequacy.

A comparison of the redesigned system to the original system will display the feasibility of the result.

Furthermore, elements affected by this redesign will be considered and the impacts weighed. Specifically, the architectural features of the building (façade, building height, and office layout) as well as the cost/scheduling of building's construction will be assessed.

Exterior Perspective