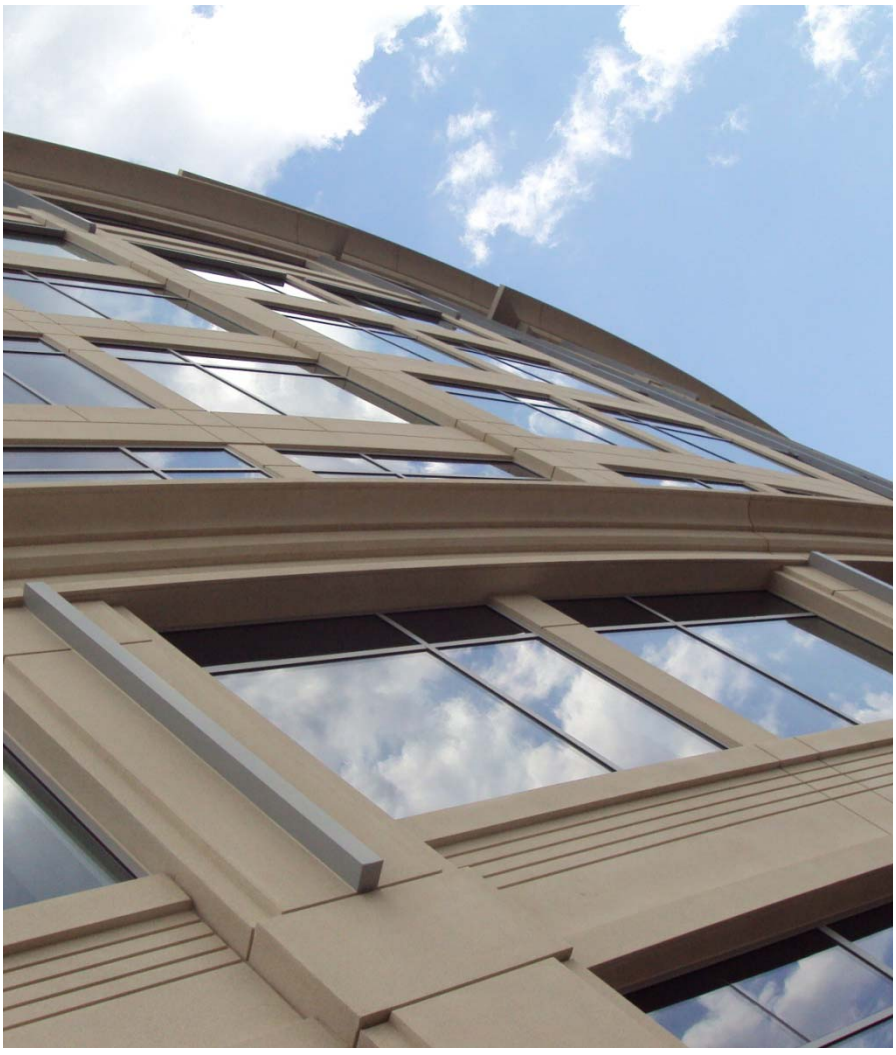
Park Potomac Office Building "E"

Thesis Proposal

Potomac, MD



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Executive Summary

The purpose of this report is to present and explain the proposed thesis investigation for Park Potomac Office Building "E". Office Building "E" is a seven story, roughly 100 feet tall office building located in Potomac, MD. The seven office levels are each roughly 25,000 square feet and sit on top of two large levels of mostly underground parking. The structure is made up of post- tensioned concrete, which is used not only to transfer gravity loads, but to resist lateral loads as well.

The floor plan, as designed, successfully minimizes the number of columns obstructing the rental spaces. This is an important consideration when designing rental spaces. To obtain this feature, long spans up to 45' were required. This was completed successfully using post-tensioned concrete, which achieved the long spans, as well as minimized deflections. However, the concrete structure produced a large building self weight, requiring the use of large mat foundations to transfer the large gravity load to the soil.

A lighter steel composite system is a possible alternative to the current design. As explored in previous reports, a composite steel system could result in significant savings from the downsizing of structural members including columns and the current mat foundations beneath the office levels.

The proposed steel system would require a complete redesign of the lateral and gravity systems, which will be completed using RAM Structural System and ETABS. After the completion of the design and the verification of all requirements, detailed cost and scheduling concerns will be addressed and compared.

The building's façade will be analyzed and redesigned to resist blast loading. Other façade issues will be addressed in this analysis as well; including thermal, acoustical and lighting effects. Additionally, several typical steel connections will be investigated and designed for the proposed steel system.

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Introduction

Park Potomac Office Building "E" is located prominently off I-270 at Seven Locks and Montrose Roads. It is just one of several planned office buildings that are part of an "urban village" which mixes stunning town homes, Class A office space, and a wide range of amenities including dining and shopping.

Office Building "E" is a central part of the Park Potomac Master Plan. Its central location, at the end of Cadbury Avenue, makes it a focal point for this small community (Figure 1). It also puts it right at the main courtyard that will be a retail gathering point as well.

Figure 1: View from Cadbury Ave.

Material Strength Summary

Concrete:

Footings	3000 psi
Foundation Walls	4000 psi
Columns	Varies
Slab-on-Grade	3500 psi
Reinforced Slabs & Beams	5000 psi
Parking Structure	5000 psi
P.T. Concrete	5000 psi

Structural Steel:

Wide Flanges & Tees	ASTM A992, Fy = 50 ksi
Square/Rectangular Hollow Shapes	ASTM A500, Grade B, Fy = 46 ksi

Masonry:

Compressive Strength	1500 psi

Codes & Design Standards

Original Design:

a. "The International Building Code – 2003", International Code Council

b. "Minimum Design Loads for Buildings and Other Structures" (ASCE7-02), American Society of Civil Engineers

c. "Building Code Requirements for Structural Concrete, ACE 318-02", American Concrete Institute

d. " ACI Manual of Concrete Practice- Parts 1 Through 5", American Concrete Institute

e. "Manual of Standard Practice", Concrete Reinforcing Steel Institute

f. "Post Tensioning Manual", Post Tensioning Institute

g. "Manual of Steel Construction- Allowable Stress Design", Ninth Edition, 1989, American Institute of Steel Construction (Including specifications for structural steel buildings, specifications for structural joints using ASTM A325 of A490 bolts and AISC Code of Standard Practice)

Substituted for thesis analysis:

a. "The International Building Code – 2006", International Code Council

b. "Minimum Design Loads for Buildings and Other Structures" (ASCE7-05), American Society of Civil Engineers

c. "Building Code Requirements for Structural Concrete, ACI 318-08", American Concrete Institute

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Existing Structural System

Foundations:

Park Potomac Office Building "E" consists of a seven story office building (Approx. 100' high) that sits above two levels of underground parking. The parking structure levels have a footprint of over 103,000 sq. ft. This is much larger than the office structure, which has a footprint of just more than 25,000 sq. ft.

This relationship has a large impact on the design of the foundation as well. The net allowable bearing pressures for the site are 4000 psi for undisturbed soil and 3,000 psi for foundations place on compacted structural fill. Over 150 spread footings are used throughout the project (Figure 2). All footings are 3000 psi concrete, and foundation walls are 4000 psi concrete. Spread footings, mostly ranging from 10' x 10' to 12' x 12', are used beneath the two levels of parking with no office building above. The majority of these footings are between 28" and 34" deep.

Larger mat footings are used in the center of the project, taking load from the two parking levels and also from the office building above. These larger foundations are up to 52' x 64' in size and can be up to 62" deep.

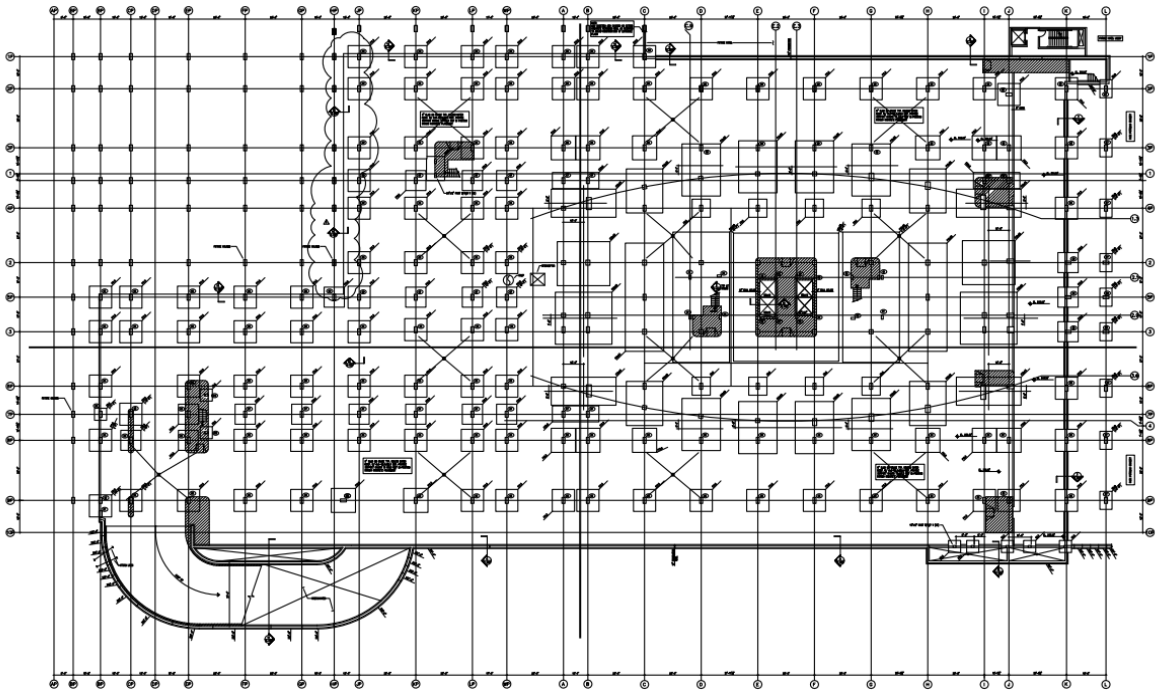

Figure 2: Foundation Plan

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Floor System:

The slab on grade at the P2 Parking Level is a 5" thick, 3500 psi concrete slab. It is reinforced with 6x6 – W2.0 x W2.0 welded wire fabric. All other slabs contain 5000psi concrete. Two-way flat slabs are used at the P1 Parking level and the Plaza/First Floor Level as well. The slab is 8" thick at the P1 Level and 12" thick at the Plaza/First Floor Level. These slabs are reinforced as needed to resist negative moment at the columns and positive moments at midspan. Post-tensioning is not used on the parking levels. Tying a post-tensioned slab into foundation walls or other fixed structure does not allow the post-tensioned slab to shrink when stressed. This would result in cracking of the slab if post-tensioning was used below grade. Using this method for the parking garage would also lead to difficulty in stressing the tendons as well. The designers of Office Building "E" use mild reinforcing below grade, and post-tensioning for the slabs above grade.

Above the Plaza Level, Office Building "E" has seven levels of office floors. These floors are 7" thick post-tensioned slabs. The post-tensioning cables induce forces in the slab ranging from 12.5 k/ft up to 35 k/ft. The post-tensioning system uses grouped tendons in the 20" beams in the E-W direction, and a one way slab with uniform tendon layout in the N-S direction. This design allows for ease of construction when laying out the tendons. The post-tensioned slab also allows for cantilevers that exist at the North and South ends of the structure. The load from a 12' cantilever on each end is taken by the uniformly spaced tendons that run through the slab.

Post-tensioning is key to achieving several main goals on this project. The first main goal is that it allows for large spans in the floor layout. The design of this project requires that columns be placed around the exterior walls of the building and the interior core as well. This requires the beams and slab to span long distances over the floor. Post-tensioning achieves these span requirements while maintaining a slab thickness of just 7 inches. Deflection over these spans is controlled effectively, while cracking is reduced as well.

Several steel shapes are utilized on the second floor slab to frame out the canopies above the East and West building entrances. This framing consists of TS5x2 shapes that are welded to ¾" plates and hung from the bottom of the slab by L4x4 angles. Steel shapes (W8x10) are also utilized as elevator rail supports throughout all floors.

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Gravity System:

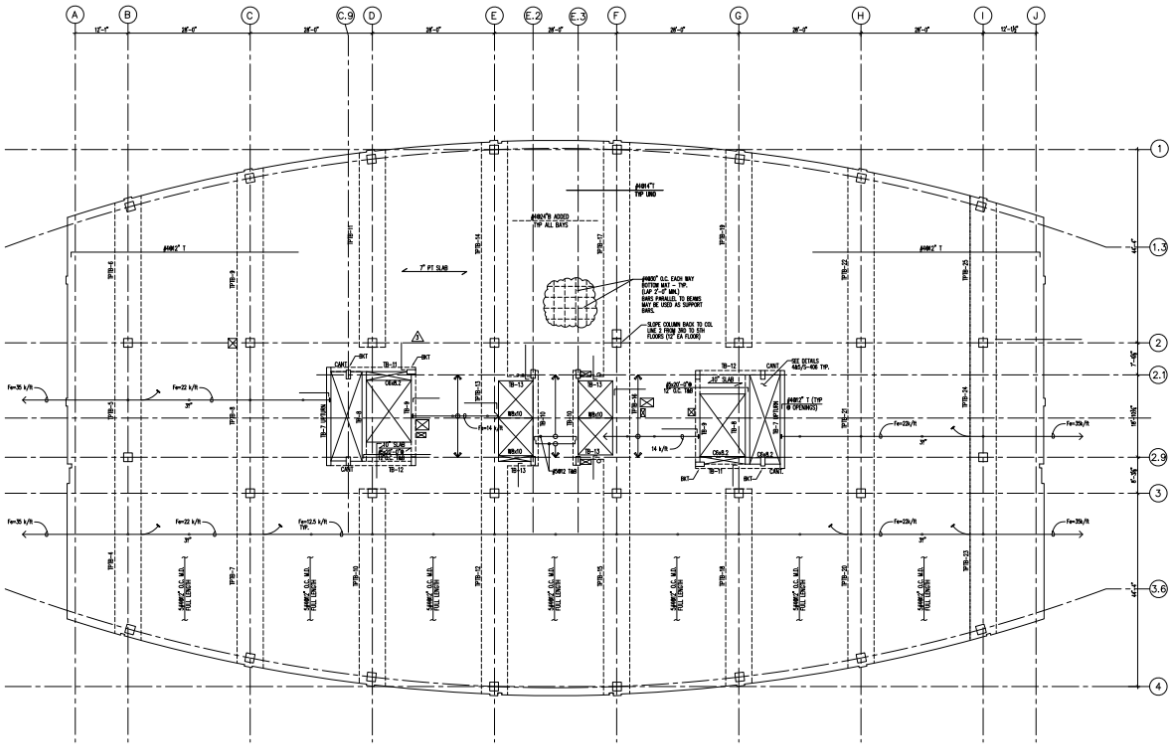

Figure 3: Typical Framing Plan

The majority of the columns in the two levels of parking are 18" x 36" columns reinforced with 10 #9 bars. These columns are typically spaced between 15' and 30' apart. Columns supporting only the two parking levels consist of 4000 psi concrete, while 6000 psi concrete is utilized where load from the office building portion above is carried. Columns in the parking levels utilize drop panels to spread the load and resist punching shear.

In the office portion of the project, a relatively repetitive column layout is achieved. Excluding the central building core, 32 columns are used to transfer the load down through all seven levels. Long span post-tensioned beams are used to transfer load from the floor to the columns. At typically 20" x 72" in size, these shallow, wide beams span in the E-W direction and continue the entire building width. In order to minimize the amount of columns in the tenant spaces and promote flexible space planning, large spans up to nearly 45' exist on each floor.

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Columns on the office levels are 24" x 24" at every level and the concrete strength is varied throughout the levels to support an increased load as required. The plaza level through the fourth floor use 5000 psi concrete, while 4000 psi concrete is used above the fourth floor.

Lateral System:

Park Potomac Office Building "E" uses concrete moment frames, as well as shear walls to resist lateral forces. In the E-W direction, the wide post-tensioned beams on each floor create a series of parallel frames that run up through all seven floors. These frames resist any lateral forces on the building in the parallel direction.

Similarly, forces in the N-S direction are resisted by concrete moment frames as well as by four shear walls. The concrete columns and the 7" slab, which is post-tensioned in the N-S direction, combine to create a frame that resists later forces in this direction as well.

The overall lateral system and load distribution of lateral forces will be described in further detail later in this report.

Roof System:

The main roof system consists of a 7" to 8" structural slab. This slab varies in order to create the required roof slopes throughout. The roof contains a Penthouse/Mechanical space, as well as an elevator machine room. The penthouse roof is an 8" two way flat plate system, while the elevator machine room utilizes a 12" thick slab.

TS8x8 posts and TS 6x6 supports are used to frame a 16' tall screen-wall on the roof level to isolate the mechanical spaces from view.

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Problem Statement

The post-tensioned concrete structure used for Office Building "E" has proved sufficient to resist the required lateral and gravity loads for the structure. The shallow post-tensioned slab allows for long spans and minimizes the need for columns in the rentable spaces on all floors. However, the large building self weight creates a need for large mat foundations that have a negative impact on both the cost and schedule aspects of the project.

Proposed Solution

In Technical Report #2, several alternative floor systems were explored as possible options for use in the structure. The main emphasis of this study was to maintain the current column layout to maximize the unobstructed rentable area. This study showed that using a composite steel floor system could provide a viable alternative to the current system.

Using a steel structure for the office levels, rather than a post tensioned structure will have several major impacts resulting from the reduced building self weight. The large mat foundations currently used beneath the office building could be reduced in size, which will have significant cost and schedule impacts on the project. Additionally, the building's gravity system will not be required to carry as much load, which could result in cost savings due to a reduction in member size.

The redesign of the structural system would also require a redesign of the lateral resisting system. Braced frames, moment frames, shear walls, or a combination of the three will be explored as possible options for the new lateral system. Lateral forces will be recalculated and reconsidered for wind and seismic forces, taking into account any changes in the structure.

There will be a few negative aspects to changing the design as well, which will need to be explored in more detail. The first of which is the increased floor depth due to the steel members. This will require consideration of mechanical spaces and may result in increasing the overall building height. Additionally, fireproofing would need to be completed as well, resulting in additional costs.

A detailed study will be completed to redesign the structure and compare the overall benefits to any drawbacks to show whether or not the system is beneficial.

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Breadth Topics

MAE/BAE:

The redesign of the structure will include several topics from the Computer Modeling and Design of Steel foundations graduate courses at Penn State. ETABS will be used to complete the design of the proposed lateral system, as well as analyze the lateral force affects on the structure. Extensive lateral force analysis methods used in this course will be applied to design and analyze lateral systems. Also, after the steel structure is designed, several typical steel connections from the design will be calculated and designed by hand.

Cost and Schedule:

The first breadth topic that will be incorporated is in the field of construction management. When comparing the proposed system to the actual design, it will be important to have an accurate cost and schedule comparison. It is anticipated that the reduction of the mat foundations could have significant benefits to the project overall. Additionally, steel erection cost and time will be compared to post tensioning. Overall, this detailed analysis will be beneficial in making a final comparison.

Façade:

The second breadth topic will be an analysis and consideration of the façade of the building. A focus will be placed on designing a blast resistant façade for the enclosure for Office Building "E". Hand calculations will be performed in order to design this system. Other factors including thermal, lighting, and acoustics will also be analyzed in this study.

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Tasks and Tools

Design Steel Structure (RAM/ETABS)

- Create RAM Structural System Model to design gravity system
  - Investigate lightweight and normal weight concrete options
- Create ETABS model to design lateral system (Shear walls or Frames)
  - Complete a detailed lateral analysis of redesigned system
  - Analyze steel design and verify strength and serviceability requirements

Steel Connections (AE 534/AISC Steel Construction Manual - 13th Ed.)

- Determine typical locations to design connections
- Complete hand calculations to determine loads on connection
- Research connections to determine most constructible/economical
- Design 2-3 typical steel connections by hand calculations

Façade (AE 542)

- Obtain detailed façade information
- Investigate current façade
- Research blast design and requirements
- Complete blast design by hand calculation
- Calculate thermal and lighting loads for glass
- Compare façade design to current design

Cost/Schedule (R.S. Means Data, MS Project)

- Obtain and review project schedule from project team
- Create detailed schedule for proposed redesign
- Complete detailed cost estimate for original post-tensioned structure
- Complete detailed cost estimate for redesign

Miscellaneous

- Complete an overall comparison of both systems
- Organize and write final report
- Update website and prepare for final presentation

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Schedule