800 NORTH GLEBE

Arlington, VA

Thesis Proposal

Ryan Johnson

Structural Option

Advisor: Dr. Linda Hanagan

December 11, 2009

Table of Contents

Executive Summary

800 North Glebe offers class-A mixed-use office space and one level of public space located in the newly modified business district of Arlington, Virginia. The overall height of the building is 153’-9” with the ground level as a retail gathering space and nine upper levels of open plan office space with 9’-0” floor-to-ceiling heights. Vertical transportation of stairways and elevators bring you from the three below grade garage, levels to the large open retail and gathering space. Column spacing of 30’ x 46’ allows for 30,000 square foot floor plates and building setbacks are located at levels four, six, and eight to aesthetically vary the building and offer different office layouts.

The current structural system was reviewed, alternative floor slab were examined and the lateral system was studied so as to propose an alternative structural design. This new proposal will include a structural depth of changing the existing floor slab to a two-way post-tensioned system, a construction management breadth studying the effects schedule and cost changes to the project and an architectural design breadth due to the new column grid layout impacts and a façade analysis.

A post-tensioned slab system will allow for uniformity of slab type and thickness amount all spaces used throughout the entire superstructure. The current system includes two separate systems with four different slab thicknesses. To implement an effective two-way post-tensioned slab, a new column grid will need to be designed. The effects of an increased number of columns with help with building torsion but will also require transfer girders in the garage to distribute load around parking thruways. Foundations will need to be redesigned because of the forces being redistributed as well.

Due to the use of a singular slab system, the number of different concrete trades will be reduced. However, more specialized post-tensioned laborers and equipment are going to be needed. The changes this will have on the construction management will affect the scheduling, site logistics and project cost. The economical impact will be analyzed to determine if the changes are a feasible alternative.

Increasing the number of columns per level will alter the way floor can be laid out. The current plans will be studied to determine the desired number of offices and alternatives will be configured to best meet the needs of the client while complying with code. The curtail wall system will also be analyzed for thermal and moisture protection, along with the connections to the slab will be considered.

Introduction

Located in downtown Arlington, VA, 800 North Glebe offers class-A mixed-use office space and one level of public space. Three levels of below grade parking are shared between 800 N. Glebe and 900 N. Glebe, Virginia Tech's new research building. Vertical transportation of stairways and elevators bring you from the garage to the large open retail and gathering space. Levels two through ten provide open plan office space. Column spacing of 30' x 46' allows for 30,000 square foot floor plates with 9'-0" floor-to-ceiling heights. Building setbacks are located at levels four, six, and eight to aesthetically vary the building and offer different office layouts as seen in figures 1 through 4.

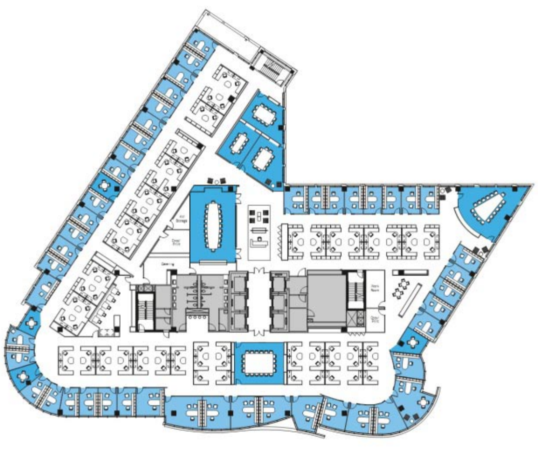


Figure 1: Floor Level 3

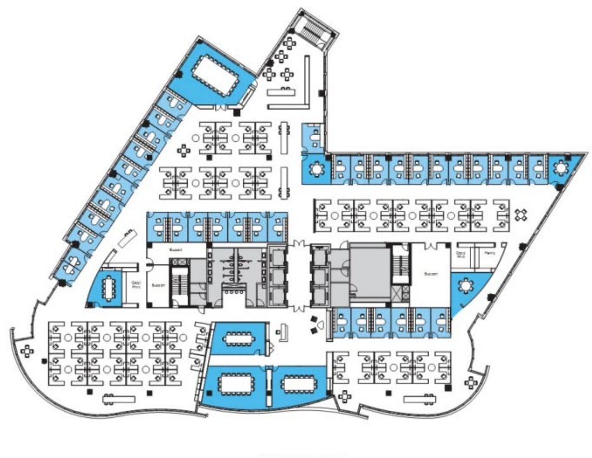


Figure 2: Floor level 5

Figure 3: Floor Level 8

Figure 4: Floor Level 10

Architectural Overview

800 North Glebe is a 10-story 316,000 square-foot mixed-use office building. Retail and public gathering spaces are located at street level in the 2-story lobby of the building. The remaining nine levels will provide class-A mixed-use offices. 800 North Glebe was designed for LEED Gold Certification by utilizing numerous strategies to minimize its carbon footprint.

Figure 3: South East Face

Innovative sustainable and responsible design practices are one of the designer's primary goals. Integration of sustainability and every day design by minimizing the carbon footprint, balancing energy, resources and feasibility all went into design on 800 North Glebe. In accordance with the U.S. Green Building Council's Leadership in Energy and Environmental Design, the owner has a goal to achieve LEED Gold Certification, which the designers fulfilled. LEED Gold Certification requires the design to attain at least 34 out of 61 possible points.

The 10-story façade, created by three sail-like sweeping glass curtain walls, accentuate the sight lines of the building. Radial lines and circles were widely used to define the crown and drum feature of level one and the sail feature of the remaining levels. Refer to figure 5,6 and 7 for visual representation of façade features.

Figure 4: Sail Feature

Retail and community spaces on the ground level offer 14'-6" ceiling heights with floor-to-ceiling glazing. Over the main building entrance, there is a diamond expression decorative composite metal canopy with a plaster soffit and sunguard ultrawhite laminated backlit glass as shown in figures 6 and 7.

Offices on the remaining levels of the structure offer 9'-0" floor-to-ceiling heights.

Figure 5: Front View

Three types of Architectural precast panels, metal cladding and glazing will adorn 800 North Glebe's façade. The large sail-like curtain wall consists of Viracon VRE 1-46 on insulated heat strengthened vision and spandrel glass with PVD finished custom color composite metal mullions. Along the street level, one will find a variety of stone, metal and glazing. These include Oconee granite with a polished finish at the base, insulated spandrel glass, precast concrete panels with a light sandblast finish and PVDF finished aluminum louvers.

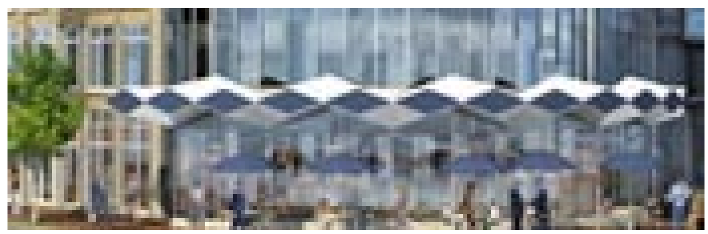


Figure 6: Canopy Over Main Entrance

Vertical bands rising up the building are made of precast concrete panels with a medium sandblast finish while horizontal bands consist of exposed aggregate finished panels. Other glazing found on the building is sunguard supernatural-68 on ultrawhite insulated glass and Viracon VRE 1-46 on insulated punch vision glass.

Protection from the elements on the roof is provided by the composite roof membrane. The composite consists of R-19 high density rigid insulation, protection board, and fully adhered 60 mil TPO membrane on top of a structural concrete slab. Where the roof system terminates at a curtain wall, fluid applied waterproofing is placed atop drainage board.

Existing System Overview

Foundation

Geotechnical studies performed by ATC Associated Inc., reported site and subsurface conditions encountered and the following information details their geotechnical recommendations for the project. Three levels of parking make up the substructure of 800 N. Glebe, at roughly thirty feet below existing grade. Groundwater levels were encountered at depths ranging from approximately 22' to 37' below the existing ground surface.

Gravel, sand, silt and clay comprise the underlain site between existing elevation and bedrock, located 35.7' to 58.8' below existing ground surfaces. The analysis indicated that spread footing foundations bearing on the dense residual soil would be feasible for a majority of the structure. Below the ground level lobby area, caissons needed to be a minimum diameter of 60" and a mat foundation would be sufficient when designed for a maximum allowable bearing pressure of 3.5 ksf.

3 ksi normal-weight concrete (NWC) is used for the foundations and interior slab on grade, the garage slab-on-grade (SOG) uses 4.5 ksi NWC and the cellar columns are composed of 4 ksi and 8 ksi. Reinforcing varies in size throughout the footings and caissons, depending on thickness. A large mat foundation is located below the shearwalls at a thickness of 6'-0".

Superstructure

A 4" thick SOG is located near the main entrance of the retail lobby. A 24" wide x 30" deep turndown, reinforced with #5s, surrounds the perimeter of the SOG. The ground level retail includes a 10" thick one-way slab with 10'-0"x10'-0"x5.5" drop panels support around the columns for punching shear resistance. Plaza slabs are 12" thick with 10'-0"x10'-0"x12" drop panels. Concrete strengths for the ground level include 3 ksi (SOG), 5 ksi (plaza slabs and framed interior slabs) and 4, 6 & 8 ksi (superstructure columns). Reinforcement for the SOG includes 6x6-10/10 welded-wire-fabric, while the one-way slab is reinforced with #5, #6 and #7s.

The remaining levels of the superstructure employ a one-way slab over post tensioned girders for the majority of the slab area which is represented as yellow in Figure 9. Girders range in size from 48" wide x 18" thick to 72" wide x 20" deep. Post tension tendons are ½" diameter with .153 square in. area low-relaxation strands with an ultimate strength of 270 ksi. A minimum of two post tension cables pass through the column reinforcement in the direction of the girder. This allows for continuous force distribution from one span to another, spanning the East/West directions. For levels two through six, two-way mildly reinforced slabs, colored cyan in Figure 9. Two-way slabs are 10.5" thick and are generally reinforced with #5 @ 10" in both directions. Drop panels in these areas are typically 10'-0"x10'-0"x7.5" to alleviate punching shear at the columns. Slabs over the 36" diameter column are 12" thick with #5 @ 12" parallel to the girder and #6 @10" perpendicular to the girders, due to the cantilever action.

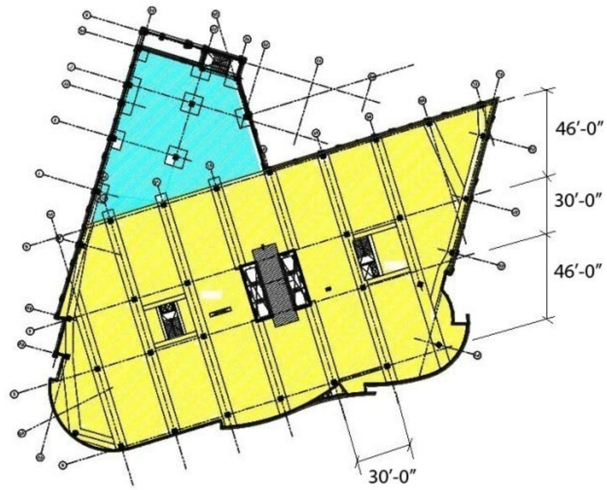


Figure 7: Slab Type Layout

Though the primary supporting material is concrete, steel shapes are used throughout the building for additional support. Elevator openings are supported by S8x18.4. HSS 6x3x1/4 were used as beams for additions support of shaft walls and W12x16s were used as elevator safety beams below the slabs. Steel allows for easy attachment of elevator rails and differential shaft openings.

Lateral System

Shear walls in the core of the building provide the entire lateral support, as designed by the engineer (Figure 8). However, since the building primarily consists of reinforced concrete columns and post-tensioned concrete beams, part of the lateral forces could be distributed through these members, as seen in Figure 9 where columns are red and beams cyan.

Two 12”thick “C” shaped walls, 31.83’ long East/West and 9.58’ long North/South per each “C”, encase the elevator banks and are reinforced with #4 horizontally and #5 vertically. From the sixth floor down, walls running North/South are specially reinforced three feet from each end with #7 and #8 rebar. All of the shear walls use concrete with a compressive strength of f'_c= 6 ksi. Building drift criteria for wind loads is L/400 or 3/8” inter-story drift at typical floors (12’-9” floor-to-floor) and for seismic loads is L/76 or 2” inter-story drift at typical floors (12’-9” floor-to-floor).

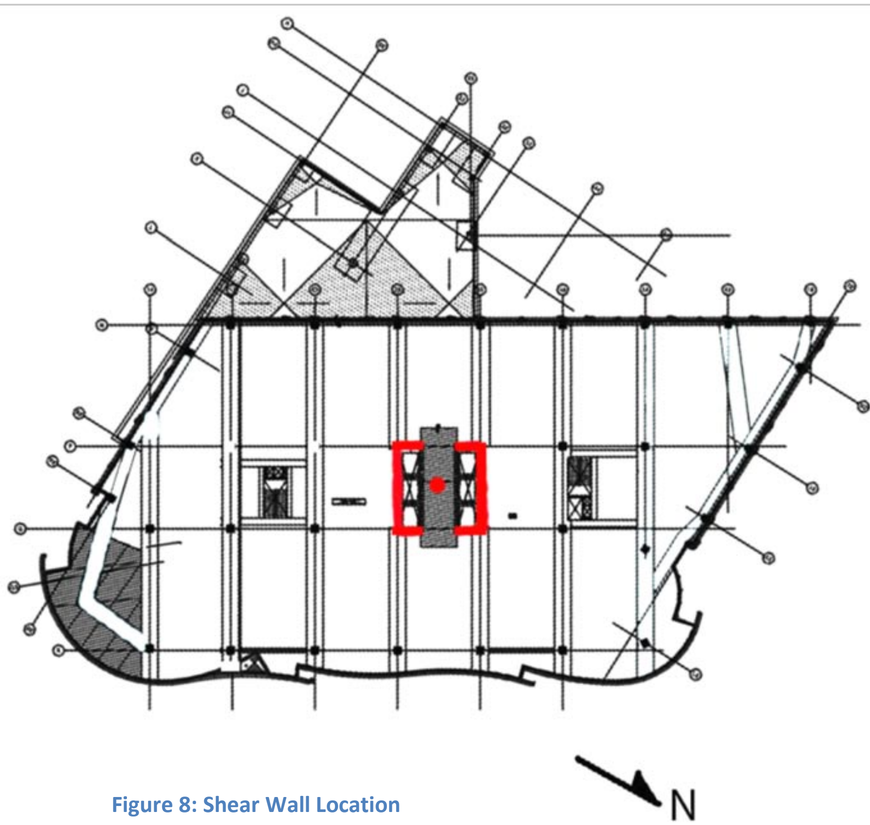


Figure 8: Shear Wall Location

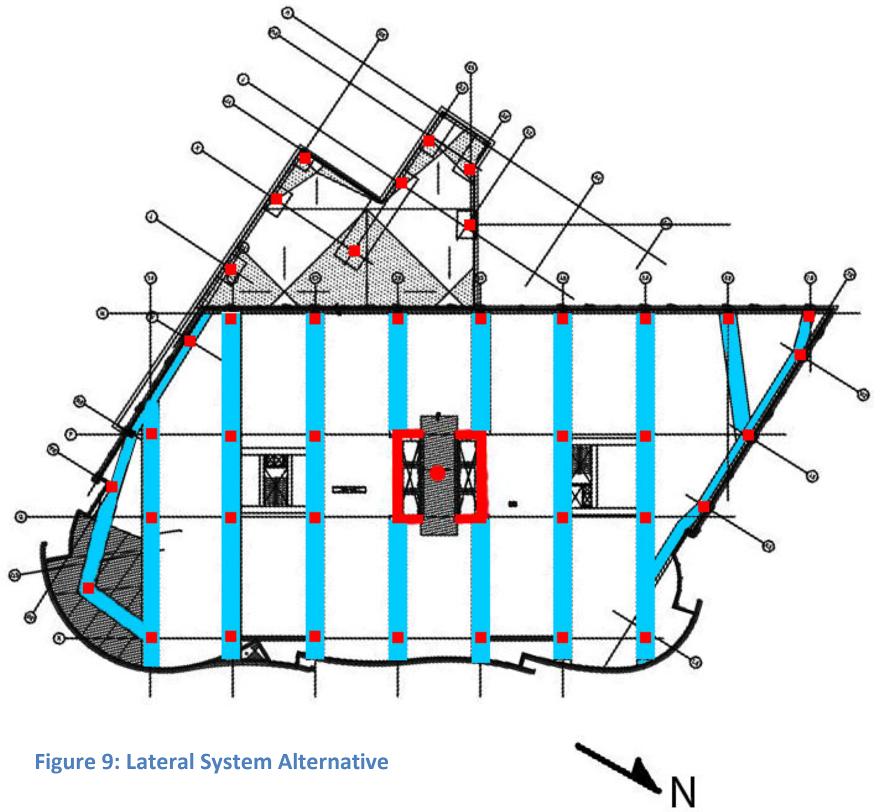


Figure 9: Lateral System Alternative

The columns throughout the building are primarily 30"x30" with 72" wide by 18" deep post-tensioned beams tying into them. Though these members were not designed to take the primary lateral force, they will transfer loads through themselves, and therefore have some affect on the lateral system. A 9" normally reinforced concrete slab transfers loads to the post-tensioned beams and act as a rigid diaphragm for the structure. Also, post-tensioned tendons surround the building slab edges to reduce slab deflection, but will also help transfer lateral forces. These are not marked above but are around the entire one-way slab perimeter.

Problem Statement

The first three technical assignments had found that current slab system and lateral structural system are capable of resisting applied loads to the building. However, because of the building shape and setbacks, two different slab systems are used throughout 800 North Glebe, where there are a total of four different slab thicknesses, using a variety of concrete strengths. Also, because of the large bay sizes, 30'x 46' typ., perimeter post-tensioned beam were added to help reduce slab edge deflections where the glass curtain wall system is attached. With this information in mind, the proposed goal is to reduce bay sizes and implement a uniform slab thickness. A new column layout may require transfer girders to distribute loads so that the parking levels are not disturbed with columns lying in the driving path.

Problem Solution

Based on the analysis performed in technical report II, to allow for a uniform slab thickness with the new column grid layout, a two-way post-tensioned floor slab system would be optimal. Since post-tensioned slabs are cast-in-place, it is possible to implement the system into 800 North Glebe with its unique curved slab edges.

The increase of columns will help to reduce the building torsion, but will require transfer girders in the garage level to distribute the forces around the garage thruways and to the foundations. The current foundations will then need to be redesigned to support the new loading pattern. Along with the increased number of columns to help reduce building torsion, a post-tensioned floor slab will act more like a rigid diaphragm and therefore contribute to the lateral load carry capacity of the structure.

Since part of the building is already a post-tensioned floor system, it can be deduced that the Arlington area has the proper contractors to complete the structure. Many large metropolises do not have experienced post-tensioned laborers, but this is not the case for Arlington. Standardizing the slabs would help to reduce the variety of concrete trades on the project.

Breadth Study I

The first breadth study will focus on scheduling and cost related to the redesign of the structural system to a two-way post-tensioned slab system. Changing the slabs to a building wide uniform system will have significant changes on the construction process. The management of the construction site would require a new schedule to allow for more post-tensioning equipment and the timing of the contractors and inspections. Microsoft Project would need to be used to allow for critical path and site logistics. In addition, scheduling impacts both the short term and long term cost of construction. Upon completion of the construction process analysis, a conclusion will be drawn with respect to cost and constructability on whether the two-way post-tensioned slab system is a viable alternative.

Breadth Study II

To accommodate for the increase in columns, the architectural floor plans will need to be altered. 800 North Glebe is a mix-use office building offering the tenants class-A space. So as to not diminish the number of offices available, interior partition walls will need to be moved around. The existing layout will be studied to determine the proper size of rentable offices and cubicles and great effort will be made to keep the same ratios. Also, care will need to given to make sure that the means of egress comply with code.

Also, by creating a uniform slab thickness, the use of perimeter post-tensioned beams may not be needed. If this is the case, the curtain wall system will need to be altered. The connections could be changed to accommodate greater movement or the weight of the system reduced. This will need to be further investigated for feasibility.

MAE Course Related Study

To fulfill MAE requirements for senior thesis, the knowledge learned through master's level courses will be implemented. Information taught in AE 597A, Computer Modeling, will be critical in analyzing the structural system of 800 North Glebe. Even though RAM Concept was not specifically taught, the concepts of meshing, diaphragms and property modifications will be used. Along with AE 597A, the information taught in AE 542, Building Enclosures, will be utilized through the determination of curtain wall systems.

Task and Tools

Structural System Depth

1. Create New Column Grid Layout
2. Post-Tensioned Floor Slab Design
    - Create RAM Concept Model
    - Determine required slab thickness
    - Evaluate cantilevered edges and other specialty areas
    - Create two-way post-tensioned tendon layout
3. Concrete Column Design
    - Determine new floor loads from task 2
    - Design columns to minimize size using PCA Column
4. Determine effects on parking garage levels
    - Design transfer girder where needed
5. Evaluate Effects on lateral system
6. Evaluate effects on foundations

Breadth Topic I (Construction Management)

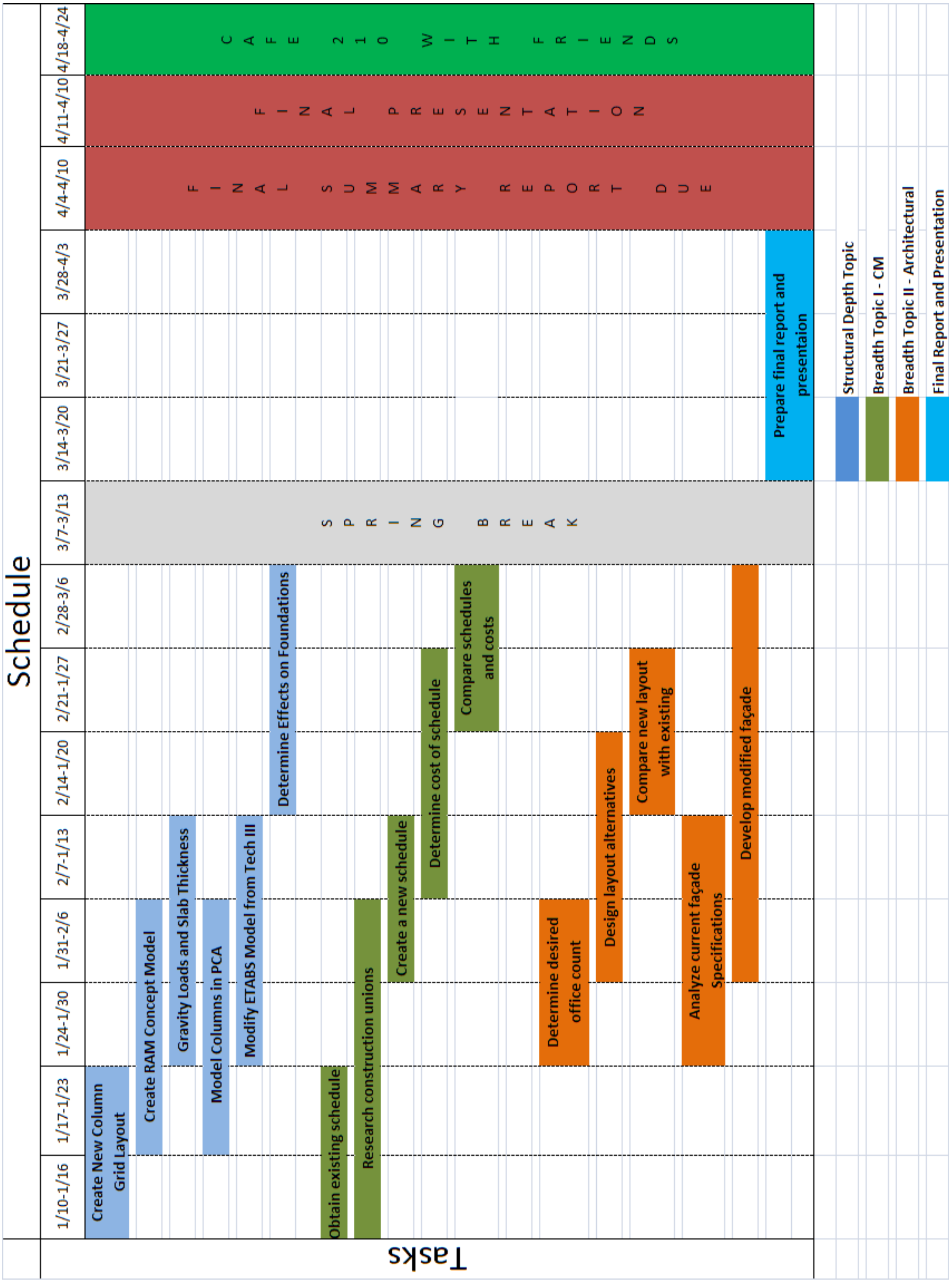
7. Obtain existing schedule and cost information for the current building design
8. Research Arlington area construction unions and optimization information
9. Create a new schedule and cost analysis based on the new structural design using R.S. Means Building Construction Cost Data
10. Compare the two schedules and cost analysis for short versus long term impacts

Breadth Topic II (Architecture Study, Building Envelope)

11. Determine the required number of office from the existing plans
12. Design possible office layout alternatives
13. Compare with existing to check if it meets the needs of the client

14. Analyze the current building façade specifications
    - Research all components in the system
    - Determine possible concerns with the system
15. Develop modified or new façade to minimize failure opportunities

Timetable


Schedule
Tasks
1/10-1/16
1/17-1/23
1/24-1/30
1/31-2/6
2/7-1/13
2/14-1/20
2/21-1/27
2/28-3/6
3/7-3/13
3/14-3/20
3/21-3/27
3/28-4/3
4/4-4/10
4/11-4/10
4/18-4/24
Create New Column Grid Layout
Create RAM Concept Model
Gravity Loads and Slab Thickness
Model Columns in PCA
Modify ETABS Model from Tech III
Determine Effects on Foundations
Obtain existing schedule
Research construction unions
Create a new schedule
Determine cost of schedule
Compare schedules and costs
Determine desired office count
Design layout alternatives
Compare new layout with existing
Analyze current façade Specifications
Develop modified façade
Prepare final report and presentaion
SPRING BREAK
FINAL SUMMARY REPORT DUE
FINAL PRESENTATION
CAFE 210 WITH FRIENDS
Structural Depth Topic
Breadth Topic I - CM
Breadth Topic II - Architectural
Final Report and Presentation