



# PROPOSAL

## 1776 Wilson Boulevard

Arlington Virginia

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Structural Option

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## Executive Summary

The purpose of this proposal was to identify or design a problem, propose a solution to the problem, and then develop a schedule to create a time frame for when the problem can be solved. Various tasks are created to help break down the scope of work that needs to be done. The problem revolves around 1776 Wilson Boulevard, a class A office building located in Arlington Virginia. This building consists of a high strength, post-tensioned concrete structure with concrete moment frames and shear walls serving as the lateral force resisting systems. 1776 Wilson will stand five stories tall with three and a half levels of below grade parking; retail space will be located on the ground level. Currently under construction, this building will be approximately 249,000 SF when completed and has a lump sum construction contract value of 63.5 million dollars.

Since there are only minor changes that could possibly improve the building's design it was decided to create a situation where the building would be moved from Virginia to the Central District of the Oakland/San Francisco metropolitan area in California. An alternate structural system will be designed with steel moment frames. The main purpose behind this decision was to create higher lateral loads on the structure and then to compare the designed system as well as a steel alternative. A proposal considering an alternate lateral force resisting system will be challenging and offer a great learning opportunity in design and analysis of these types of systems.

Since new lateral loads will be calculated, the current concrete system will be redesigned before the steel alternative is designed. After this is accomplished, different layouts for shear walls and braced frames will be created in order to find the most efficient system. RAM will be used to model both structures and to help efficiently size gravity members. After the design and analysis is completed the two systems will be compared.

The first breadth topic covered will be a construction management breadth. This will focus on creating a schedule for each of the systems as well as cost estimates. These new schedules will lead to new critical paths. Upon completion, these schedules and cost estimates can then be compared to not only each other, but to the actual schedule and costs for the project. Beyond comparing the two systems, the results will also show the kind of impacts that can be caused due to taking a design for a building and moving it to a new location.

Sustainability will be the focus of the second breadth topic. Due to an interest in sustainability, it was preferred to incorporate green building ideas into this proposal. However, 1776 Wilson is designed to be LEED Platinum, the highest LEED rating you can achieve. Due to this, an analysis will be carried out that looks at all the sustainable features included in the design and how they will be impacted by the location change. This will encompass the new site location, the climate, and overall energy usage. At the conclusion of this research and analysis, comparisons will be made on the energy efficiency of both buildings and the differences will be reported.

## Introduction

Located in the Rosslyn/Ballston corridor of Arlington Virginia, 1776 Wilson Boulevard will be a Class A office building with retail space and three and a half levels of below grade parking. Currently under construction, the building is to be built on a previously contaminated brownfield site that has been redeveloped. Scheduled to be finished in August of 2012, 1776 Wilson will contain approximately 249,000 SF. The lump sum construction contract is valued at 63.5 million dollars.



Fig. 1 Lobby Rendering

Designed by RTKL Associates, all 26,000 SF of retail space will be located on the ground floor and the upper four floors will contain 108,000 SF of flexible office space perfect for a building that is currently up for lease and the future tenants are currently unknown. 1776 Wilson will also include a three and half level parking garage which will be able to accommodate over 200 cars. The retail space will have a high ceiling making tenant mezzanines possible. Most of the mechanical equipment will be located in a penthouse on top

of the building. Besides the flexible office space, one of the most important interior aspects of the building is the luminous lobby that complements the generous amount of day lighting the building will receive. 1776 Wilson will also provide downtown convenience, located within walking distance of two Metro stations; several retail outlets and restaurants are within close proximity of the site.

1776 Wilson Boulevard also goes beyond the norm for sustainability; the project is designed to be LEED Platinum. The numerous green features include a 17,000 SF green roof, photovoltaic solar panels on the roof, and an incentive program aimed at educating tenants on the sustainability features of the building.



Fig. 2 Green Roof Rendering

Arlington County's C-0-2.5 zoning district includes the site of the finished building; this area generally designates commercial office buildings, hotels, and apartments. The upper floors will be considered separate mixed use occupancy while the parking levels are non-separated mixed use in accordance with building code. A generous amount of glazing helps create a well and naturally lit interior. Typical one inch thick windows with a U value ranging from 0.26 to 0.28 decorate the façades along with aluminum framed curtain walls. The rest of the façade features precast concrete and masonry panels. The roof consists of a combination of 10 and 12 inch thick post-tensioned slabs with roof pavers. The PV solar panels will add 6.6 to 6.8 psf to the roof dead load. In addition to the roof pavers, the roof will be insulated and covered by garden covering. Where roof pavers and garden covering are absent, elastomeric cementitious topped insulation is used.

## Site Conditions

The site is essentially rectangular with approximate dimensions of 275 feet in the North to South direction and 125 to 200 feet in the East to West direction. This provides a total foot print area of approximately 45,500 SF. The existing site grades slope slightly from the North to the South. The surrounding area includes both residential and commercial buildings; the site itself was occupied by one to two story buildings before the project began.

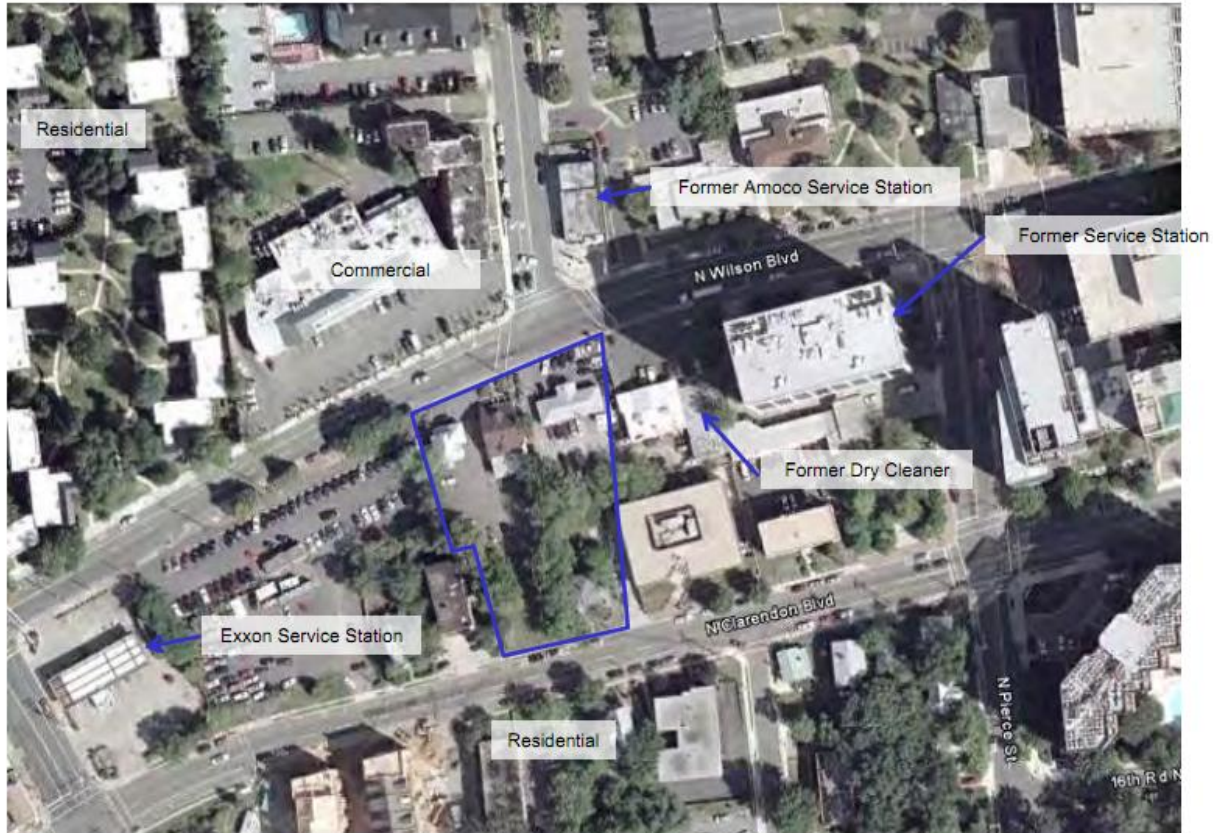


Fig. 3 Aerial View of Site

The results found in the geotechnical report for the project were based on nine soil borings. Ground cover at the site was variable and consisted of one of the following:

- 1-3 inches of asphalt with 1-21 inches of gravel below
- 2 inches of gravel
- 4 to 6 inches of top soil

Below the ground cover, a geotechnical report provided by ECS Mid-Atlantic done on the site divided the soil into three strata:

Stratum	Name	Description
I	Fill/Possible Fill	17-36 feet below site grades consisting of various amounts of sand, gravel, and clay
II	Natural Alluvial/Marine Solids	28-52 feet below site grades and under stratum 1, this stratum consists of poorly graded sand, clayey sand, and low plasticity clay with varying gravel content
III	Residual Soils/Weathered Rock	Below stratum 2 and consists of Micaceous silty sand with rock fragments.

Table 1 Soil Stratums

It was also known that this particular area has high groundwater flow. The ground water is to be controlled by a dewatering system that will need to be put in place during below grade construction.

1776 Wilson falls into Arlington’s C-0-2.5 zoning district. This district is used for office buildings, commercial uses including retail, as well as hotels and apartments. The ratio of maximum office and/or commercial floor area to site area is 2.5:1. No office building is to exceed 12 stories, excluding penthouse spaces, by site plan approval. All penthouses are limited to one floor. Each plot is to have a minimum average width of 100 feet and a minimum area of 20,000 square feet.

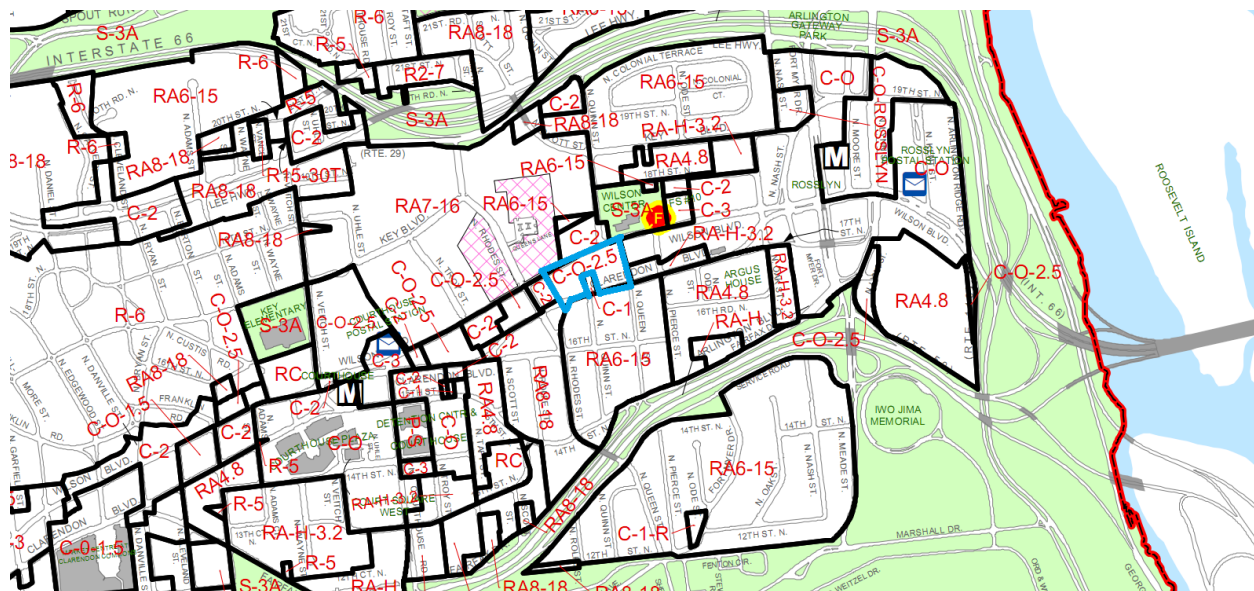


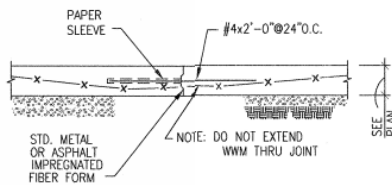
Fig. 4 Zoning Map for Arlington - The blue outline marks the district where 1776 Wilson is to be located

## Structural System Overview

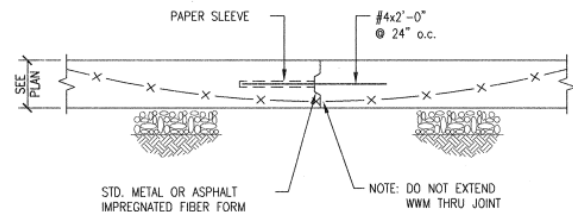
### Foundation

The geotechnical report called for a shallow foundation system on the stratum one and two soils with a designed bearing capacity of 10,000 psf. The shallow system will consist of a 4 inch thick slab on grade with 6" x 6" - 8/8 W.W.F. lap mesh 6 inches in all directions and concrete footings. The slab is placed over 10 mil polyethylene and 6 inches of washed gravel. Control joints are located at 20 feet on center for all exterior slabs. Interior slabs are to be placed in 600 SF panels with control joints placed 30 feet on center. The interior slabs are also to be laid over a layer of vapor barrier which is placed on top of 6 inches of washed gravel. Groundwater on the site must be at least two feet below the foundation subgrade level. Since the soils in the area are soft and sensitive, precautions will need to be taken to ensure equipment doesn't sink into the soil so that movement is prevented.

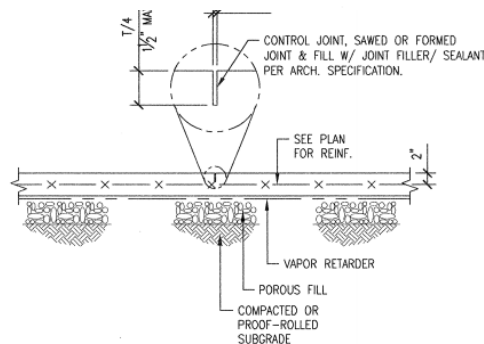
All footings are to penetrate at least one foot into undisturbed soil or compacted fill. All exterior footings must be at least 2'6" below the finished grade, this also holds true for footings in unheated spaces such as garages. The typical wall footing will be 12 inches deep and extend 6 inches past the face of the wall. Disturbed earth under footings will be replaced with 2000 psi concrete. The footings will be 4000 psi concrete and the slab on grade will be 5000 psi.



TYP CONTROL JOINT  
FOR SLAB ON GRADE



TYPICAL CONSTRUCTION JOINT  
@ SLAB ON GRADE



- NOTES:
1. LOCATE CONTROL JOINT @ EACH COLUMN CENTER LINE AND PER STRUCTURAL NOTES GUIDE LINES.
  2. SAW CUT JOINT MUST BE MADE AS SOON AS POSSIBLE AFTER THE SURFACE IS FIRM ENOUGH BUT NO LATER THAN 16 HOURS AFTER PLACEMENT.

SLAB ON GRADE  
CONTROL JOINT (CJ)

Fig. 5 Slab on Grade Control Joint

## Floor System

This project uses a high strength post tensioned concrete structure. Each floor consists of flat slabs ranging in thickness from 4" slab on grades to 12" thick reinforced concrete slabs. Some portions of the building have thicker slabs but 8-12" is the typical size. Each slab has drop panels at the column locations that are typically 8" thick, much larger than typical drop panels. Select locations have drop panels even thicker with 10" being the largest thickness found in the building. Post tensioning is put to use starting on the second floor and the column layouts create typical 30' by 30' bays with 30' by 45' bays also present. The high strength concrete used for the framing system of the building allows for these bays as well as reducing the total weight of the building, the typical strength is 6000 psi.

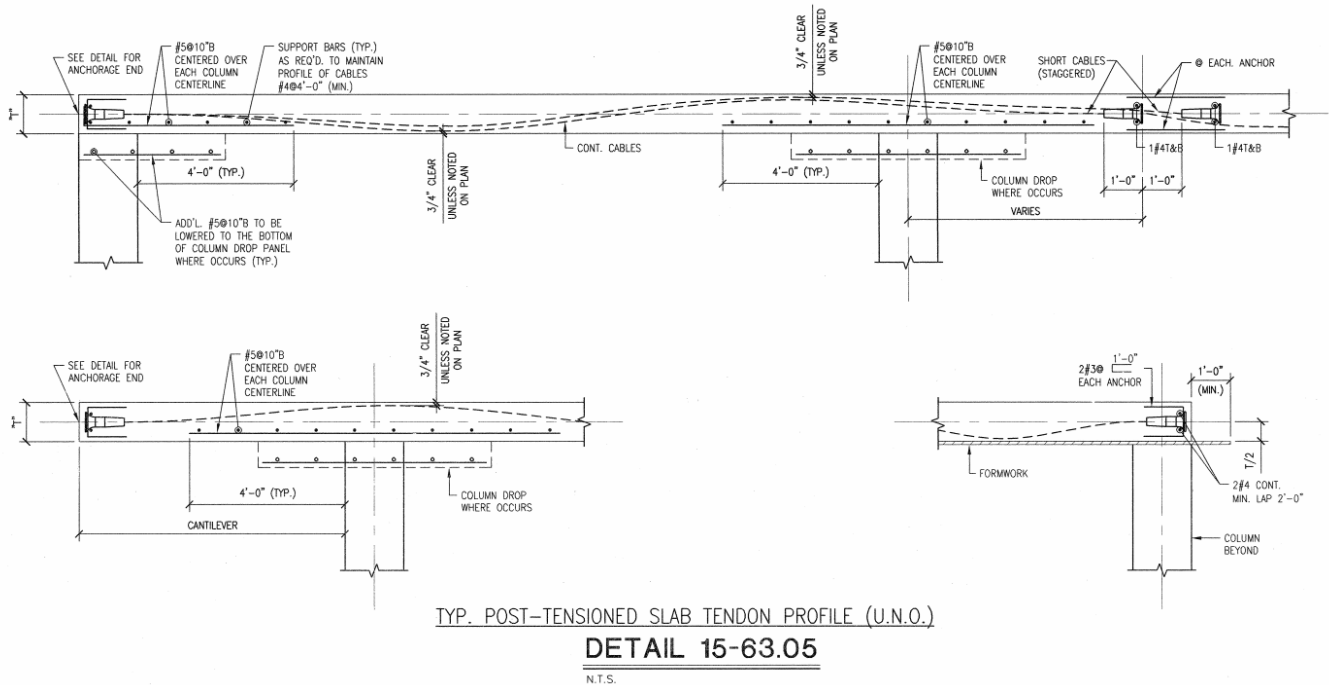


Fig. 6 Typical Post Tensioned Slab Tendon Profile

## Roof System

The roof system of 1776 Wilson consists of 8 and 10 inch thick post tensioned two way slabs. The roof area is covered by either vegetation from the green roof, roof pavers, or a concrete wearing slab. Below the roof surface consists of filter fabric which is accompanied by a deck drainage mat where there is vegetation. Four inches of roof insulation is used as well as hot rubberized asphalt for the waterproofing assembly. The roof areas will see added load due to the solar panels and racking system, these will add 6.6 to 8 psf to the roof dead load.



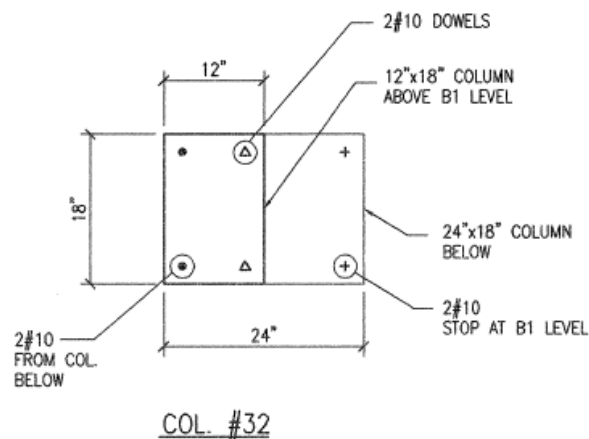
## Columns

The column layouts of 1776 Wilson are uniform and create typical 30 feet by 30 feet bays, with some 30 feet by 45 feet bays. The reinforced concrete columns on the upper floors are typically 22x22 inch columns and 12x30 inch columns; the lower levels are typically 24x24 inch columns. Reinforcement ranges from #8 to #11 bars. High strength concrete is used to keep column sizes down and to help maintain the 9' 3" ceiling heights called for in the plans and drawings, as well as a tall ground floor that provides enough room for tenant mezzanines.

Floor	Sizes	Reinforcement	Compressive Strength (ksi)
5 <sup>th</sup>	22x22, 12x30	4#10, 8#11, 4#9	Typically 5, some columns are 6
4 <sup>th</sup>	22x22, 12x30	4#10, 8#10, 4#9	Typically 5, some columns are 6
3 <sup>rd</sup>	22x22, 12x30	4#9, 4#10, 4#11, 8#10, 8#11	Typically 5, some columns are 6 and 8
2 <sup>nd</sup>	22x22, 12x30	4#10, 4#11, 8#10, 12#11, 6#9	Typically 5, some columns are 6
1 <sup>st</sup>	24x24, 12x30, 24x29 3/4*	4#11, 8#9, 8#10, 8#11, 12#11,	Typically 8, some columns are 10
Basement Levels	24x24, 12x30, 32x18, 24x18, 12x18*	4#11, 12#11, 8#11, 4#10, 6#9, 8#9	Typically 8 at the B1 level, 6 below, some columns are 10

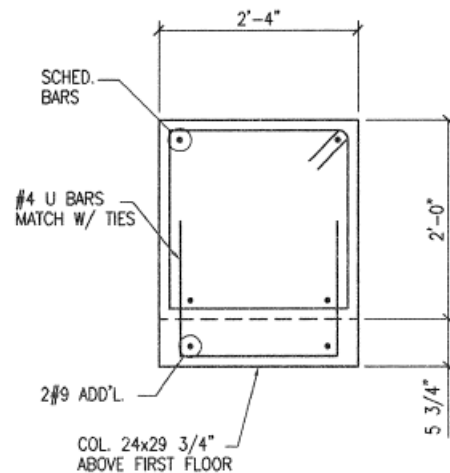
Table 2 Column Schedule Summary

\*see following details



### DETAIL 1-61.01

3/4"=1'-0"



### DETAIL 2-61.01

3/4"=1'-0"

Fig. 7 Column Details

## Lateral System

1776 Wilson Boulevard incorporates a combination of ductile reinforced concrete moment frames and reinforced concrete shear walls. The top two stories hold the ordinary moment frames while the shear walls surround the elevator shafts of the bottom three stories providing aid to the moment frames. This creates a dual system on the bottom three stories that share the lateral loads. Simplifications were made for the wind analysis done and ASCE 7-10 offers a way to calculate seismic loads for buildings with different vertical lateral force resisting systems. More information on those calculations can be found in the wind and seismic sections of this report.

The lateral loads will be distributed by relative stiffness starting at the roof diaphragm and then travelling through the columns that make up the reinforced concrete moment frames to the floor diaphragm. The floor slabs themselves serve as the beams in the moment frames and transfer the loads to the columns on the floor below where they eventually reach the shear walls on the bottom three stories. Once the lateral loads reach the shear walls, the walls resist lateral loads and moments about their strong axis. They can also resist transferred gravity loads from tributary members of the structure. The lateral loads will be transferred through the walls to the floor diaphragm where eventually they will be dispersed into the soil once they reach the foundation.

The shear walls are located in the same spot on each of the first three floors and maintain a 12" thickness. The longer shear wall is much more rigid compared to the other two shear walls. Together, these three shear walls help lower the lateral forces that need to be resisted by the moment frames. Due to torsion, the building tends to rotate around the taller right half of the building so the shear walls are able to help decrease the movement of the left half of the structure.

## Structural Depth

1776 Wilson Boulevard is efficiently designed and there are only minor changes that could possibly improve the building. Technical report two showed that the post tensioned, high strength concrete floor system is the best option and it wouldn't be worthwhile to dedicate a significant part of this proposal to an alternative as far as floor systems are concerned. After completing technical report three, which proved to be the most challenging, it was decided that an investigation into a lateral force resisting system alternative would provide an interesting and challenging proposal with a great opportunity to learn more about this area of design and analysis. Since the currently designed building was investigated in technical report three, 1776 Wilson will be relocated to the west coast where higher seismic loads will control the design and demand changes to the structural framing.

The central district of the Oakland/San Francisco metropolitan area will be the new location of 1776 Wilson Boulevard. After researching various areas in California, this location was chosen because it relates well to the actual site in Arlington Virginia. Both areas are undergoing development projects including brownfield-redeveloped sites and both locations are in the heart of a transportation hub which is important to 1776 Wilson's LEED Platinum rating. A more detailed discussion of the new site will be included in the final report.

A redesign of the current system will be performed and then an alternative steel based design will be carried out and compared to the original. In order to prevent creating an overwhelming proposal, foundation design will not be included in the scope of work. It is noted that a new site location would require a separate geotechnical report to verify the foundation design and then changes would need to be made to accommodate the new soils the building would rest on. The proposal will require designs for floor systems to be carried out to a greater depth than technical report two but comparisons won't be analyzed as the lateral loads and resisting systems are the main aspects of the proposal.

## Structural Depth Approach

After redesigning the current system for the new lateral loads, alternatives will be chosen and investigated. The shear wall layouts will be altered to find any possible improvements and a steel moment frame system will be designed with options for braced frames or shear walls. Impacts on construction and the schedule for the project will be included in a breadth topic. The two most efficient designs will be used for the final comparison, one concrete system and one steel system.

## Structural Depth Outcome

After completing this proposal, a much better understanding will be gained on the topic of lateral loads and how to design systems to efficiently resist them, not just in terms of resisting forces but in cost, construction, and schedule impact as well.

## Breadth Topics

### Construction Management: Schedule Impacts and Cost

This breadth topic will involve the creation of alternate schedules for both the redesigned concrete system as well as the proposed alternate steel system. These schedules will then be used to compare the time it will take to construct these systems. New critical paths will be developed and specific differences in time and cost will be reported. Comparisons can also be made to the actual project schedule that states August of 2012 as the completion date for the building.

Once these schedules are completed an in depth cost analysis can be performed. Since the cost of certain items will depend on the duration of the work, it is necessary that the schedules be completed first. Once this analysis is finished, specific cost differences can be reported between the two systems and the actual structural system that is to be used. Once this breadth topic is complete, the results will not only show the differences between lateral systems in terms of cost and time but also in differences found in taking a building designed and built in the northeastern United States and moving it to the western United States.

### Sustainability

Since sustainability is something the author of this proposal would like to get involved with as their career progresses, it was favorable to try and include a sustainability breadth topic in this proposal. 1776 Wilson is being designed to LEED Platinum, the highest LEED rating that can be achieved. Not all items that gain LEED points for 1776 Wilson will be changed due to a new site location so those particular items will not be included in the scope of work for this breadth topic. The more important features, such as how much energy can be saved by the photovoltaic solar panels, what changes could be made to the HVAC systems, and possible changes to the façade of the building will serve as the focal points for this study. Since the western United States is better suited for the use of solar panels, it is anticipated that more energy will be saved and the differences over the energy saved in the eastern United States will be documented.

For this proposal, all aspects of 1776 Wilson's LEED Platinum rating will be looked at in terms of what changes would need to be made when the building is moved to a different climate zone. These features will be grouped together and ordered by priority which ensures the most important features will get the most in depth analysis. Once the analysis and results are completed and organized, comparisons will be made and any changes in LEED ratings can be reported. Overall improvements or lack of improvements, in terms of energy usage, will also be reported on.

Hand calculations will be done in combination with the use of the computer program RETScreen to gather data relevant to this breadth study.

## Tasks

### Structural Depth

1. Select new site location
  - a. New site must provide a significant number of similarities to the original site in terms of zoning and nearby amenities
  - b. A brownfield site that can be redeveloped would be preferred
2. Design new steel gravity system
  - a. Determine slab/deck thickness based on loads found in structural drawings
  - b. Size columns, beams, and girders for a typical bay
  - c. Complete new RAM model to help verify and more efficiently size gravity members
3. Design steel moment frames
  - a. Recalculate lateral loads using ASCE 7-05 (due to the less complicated procedure for calculating wind loads)
  - b. Create moment frame layout
  - c. Use RAM to verify design and layout
4. Alternate shear wall/braced frame layouts
  - a. Use RAM to find most efficient shear wall layout in regards to currently designed system
  - b. Use RAM to find most efficient shear wall layout in regards to the newly designed steel moment frame system
  - c. Use RAM to find most efficient braced frame layout in regards to the newly designed steel moment frame system
5. Document results
  - a. Collect and organize results for concrete system
  - b. Collect and organize results for steel system

### Construction Management Breadth

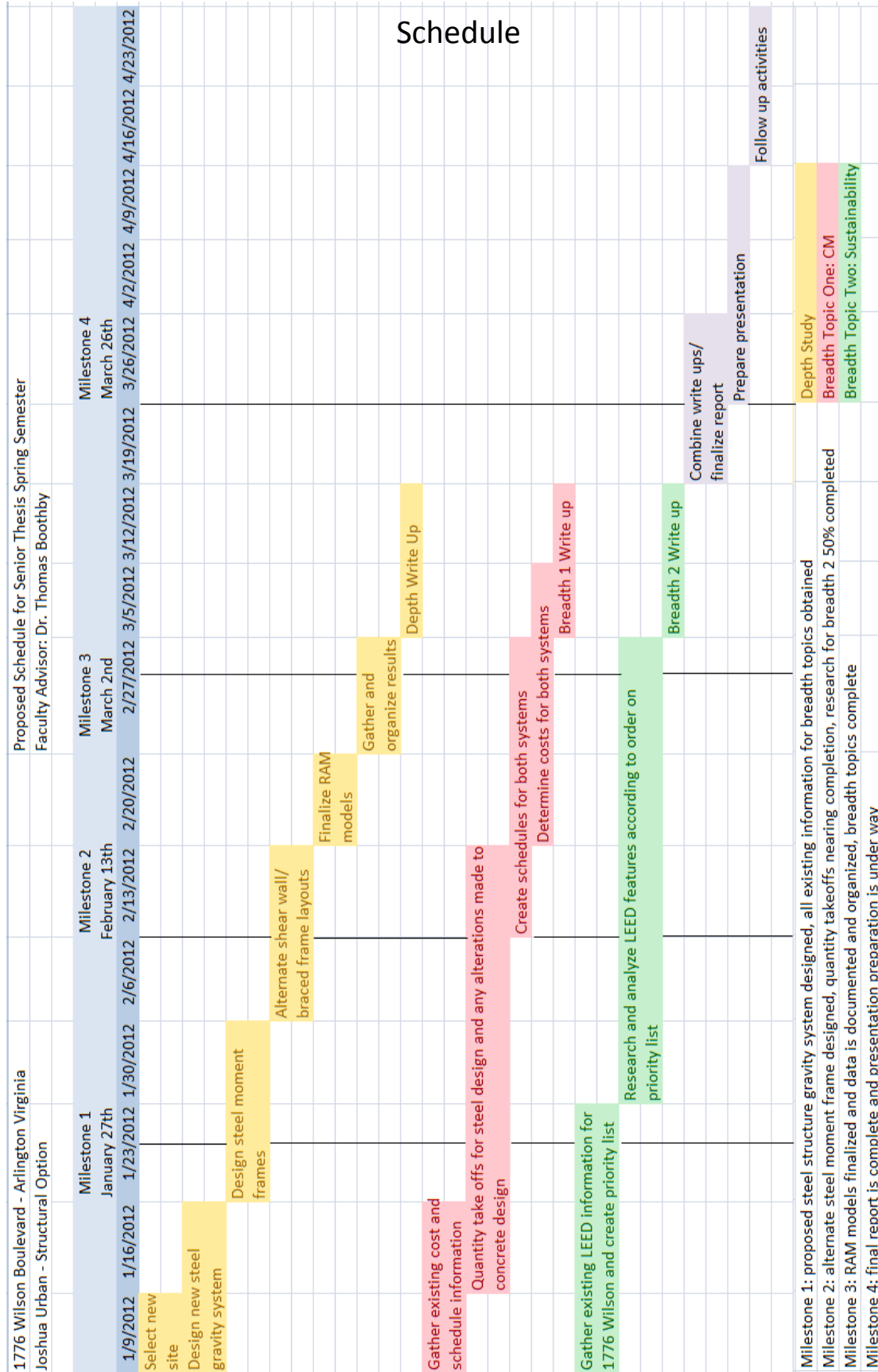
1. Take offs
  - a. Perform material take offs for a typical bay in both systems
2. Schedule Analysis
  - a. Use RS Means to determine rates for performing various aspects of work in relation to the two systems being investigated
  - b. Create a schedule for each system using MS Project
3. Create new critical paths
4. Cost Analysis
  - a. Use RS Means for cost data
  - b. Create a cost estimate for each system that includes various non structural related changes in architecture or other areas

5. Document Results and Compare
  - a. Collect and organize results for the two cost estimates and schedules
  - b. Compare cost estimates and schedules, not only with each other but also with the actual cost and schedules for 1776 Wilson

### **Sustainability Breadth**

1. Create an organized document of the various sustainable features of 1776 Wilson Boulevard
  - a. Use LEED score sheet for the project to break down all the sustainable features
  - b. Group features based on what impacts could be made on them by changing the building's location
  - c. Create priority list so that most important features are changed and analyzed first
2. \*Document changes made to LEED items based on switching locations, including, but not limited to:
  - a. Efficiency of PV solar panels in the northeast and western United States
  - b. Site choice and impacts
  - c. HVAC efficiency impacts due to different climates
  - d. Area research to determine nearby amenities and features
  - e. Glass performance and impact on energy savings
  - f. Façade analysis
  - g. Green roof and heat island effects
3. Use RETScreen to model the sustainable features of 1776 Wilson
  - a. Perform hand calculations to check RETScreen results and to gather any additional information needed
4. Organize results and compare

\*the items included in task two for the sustainability breadth topic are subject to change or modifications once work on this topic begins





## Conclusion

The proposal for 1776 Wilson will focus on structural performance under tougher lateral loads, time, costs, and energy efficiency. The new location for the building will be the Central District of the Oakland/San Francisco metropolitan area where higher seismic loads will require a redesign of the high strength concrete system. Since building weight impacts seismic design the most, it is logical to propose an alternative steel system that will weigh less than its concrete counterpart. RAM will be used to help efficiently size gravity members and a steel moment frame system will be designed. To accompany the concrete and steel moment frame systems, various layouts for shear walls and braced frames will be performed to find the most efficient and effective set up to resist the recalculated lateral loads.

Once designed, new schedules will be created so that a cost analysis can be performed as well as to compare time frames for how long it will take to construct these two systems. Both the schedule and costs can be compared to the original design for Arlington, Virginia.

Finally, a sustainability depth will provide a chance to learn more about energy efficiency and a comparison between LEED Platinum buildings as designed for two very different climates. The northeastern site will be changed to the western portion of the United States and impacts on various aspects of 1776 Wilson's LEED rating will need to be analyzed so appropriate modifications can be made. Some of the energy usage areas that can be researched and compared will include HVAC equipment efficiency in a different climate, how much energy can be saved through the use of photovoltaic solar panels, and possible changes to the building's façade. Since there are many areas of sustainability that can be looked at for this depth topic, it will be important to make a priority list of all the features so they can be ranked in terms of importance and how much they are impacted by a site change. This ensures that the most important aspects will be addressed and features that don't depend on location will not be included.

\*All images courtesy of Skanska USA.