

# Thesis Proposal Revision I



Rendering courtesy of DAVIS

## The Office Building

Brett Miller

Dr. Gannon | Construction

1/15/2014

## Executive Summary

The Office Building is a nine story core and shell project with three levels of underground parking beneath. The first story is devoted to retail space while floors two through nine will be leased for office space. The project team is pursuing LEED Gold for the building. To help with this, a green roof has been designed, along with a fitness center and more.

Before construction could start, demolition work was required on a previously existing building. Due to a delay in the release of the raze permit, the demolition process delayed the schedule by 5 months right from the beginning. The excavation process only complicated the project; by the time this process was done, the owner obtained a substantial bill for the unforeseen obstacles. With the project off schedule and over budget, investigations began on how to make up the construction duration and costs. The objective of this thesis is to address and diminish these issues through four areas of analysis.

The first analysis will address the feasibility of replacing the Cast-In-Place concrete with Shotcrete. The extreme support of excavation requires a considerable amount of work for the cast-in-place option. It is believed the use of Shotcrete will not only reduce the overall cost of the project, but also accelerate the schedule. Through this depth, a structural breadth will be performed to determine the structural loads on the foundation walls and whether the Shotcrete can withstand such loads.

The second analysis will look at the below ground walls on the west side of the site. Due to the close proximity of the neighboring foundation, a support wall had to be installed to prevent any overturning. The original contract documents call for a secant wall to be installed. This depth will analyze the opportunities a slurry wall may hold. The slurry wall and secant wall will be compared against each other for both schedule and cost. Critical issue research will also fall under this analysis for a better understanding of support walls.

The third analysis will focus on prefabrication and the role it plays on schedule acceleration and quality. Finished drywall corners will be the extent of the prefabrication. This schedule acceleration will help make up for some time lost while the raze permit was delayed.

The final analysis will look at saving the owner some money that was lost to the underground obstructions. It will be researched whether aluminum wiring or aluminum busway can be substituted in for some of the copper wiring. This will aid in the material costs as well as the labor costs. In order to properly compare the aluminum substitutes to the copper wiring, an electrical breadth will be performed to size the busway.

Through these analyses, it is expected that the alternative solutions will help reduce the cost, accelerate the schedule, all while keeping the owners desire of high end quality.

**Contents**

Executive Summary ..... i

Contents ..... ii

Project Background..... 1

Technical Analysis Descriptions..... 2

    Analysis 1 | Foundation Walls ..... 2

    Analysis 2 | Neighboring Foundation Support Wall..... 4

    Analysis 3 | Prefabricated Induced Schedule Acceleration ..... 6

    Analysis 4 | Value Engineering..... 8

Conclusions..... 9

Appendix A: Breadth Topics ..... 10

Appendix B: Analysis Weight Matrix ..... 10

Appendix C: Progress Schedule..... 10

## Project Background

MidAtlantic Realty Partners, LLC has contracted James G Davis Construction Corporation to construct a new nine story office building in the Washington, D.C. metropolitan area. This nine-story, 108,000 SF building is designed by Gensler and currently has an undetermined tenant and is pursuing a certification of LEED Gold. The \$30.5 million GMP contract for DAVIS was given a 22 month duration with a date of completion of March 23, 2015.

In addition to the nine stories above ground, The Office Building contains a three level underground concrete parking garage. A combination of a five and a half foot mat slab and



**Figure 1. Rendering NE Corner** | Courtesy of DAVIS

micro piles supports the cast-in-place (CIP) concrete structure. The rooftop penthouse is constructed of braced structural steel frames with metal decking. The top of the building features a green roof along with a rooftop terrace. The building will be enclosed by a glass and insulated metal panel curtain wall, as shown in figure 1, while the lobby will have an interior decorative glazed feature wall.

Before The Office Building could be constructed, a nine story steel structure had to be demolished. During the demolition process the abatement of asbestos was required. Due to the continual discovery of additional asbestos, the raze permit, required for the demolition of the structural steel, was delayed by five months which ultimately pushed back the construction schedule. This created an opportunity for schedule acceleration and cost reducing scenarios to be analyzed and implemented on the project.

## Technical Analysis Descriptions

### Analysis 1 | Foundation Walls

#### Opportunity Identification

Because of The Office building's existing conditions, common support of excavation (SOE) techniques were replaced by a more challenging system, as shown in figure 2. In normal practice, tiebacks are used to provide horizontal resistance for the wood lagged retaining walls. In the case of The Office Building, a system comprised of wales and bracing keep the wood lagged walls from caving into the site, but this created many obstacles inside the excavation. To keep the cross bracing in place, the system is tied into every soldier pile, (located about every 7.5 feet), by a wide flange. These wide flange tie-ins create many obstructions on the site that need to be worked around. When the time comes to cast the concrete foundation walls, every cross bracing connection to a pile will need to be formed around. Once the foundation walls are to strength and the cross bracing can be removed, the remaining holes will require grout to fill them in.



**Figure 2. SOE System** | Courtesy of DAVIS

#### Background Research

Because of the site constraints, it would be impossible to change the SOE for the project. What this ultimately means is that there is no way of eliminating the tie-ins at each pile. Without this as an option, it would appear that to eliminate this problem the amount of formwork would need to be reduced. It came to my attention, after speaking with industry professionals at the PACE roundtable, that Shotcrete may be an adequate substitute based on its lack of required formwork. Shotcrete is distributed through a hose and pneumatically projected at a high velocity onto a surface. This distribution process will eliminate most of the formwork required for the foundation walls. It must be remembered that anytime formwork is used, it takes time and manpower to erect the forms but also to take them down. For this reason, anytime the amount of formwork can be reduced, the schedule and budget both benefit.

## Potential Solutions

The conclusion of this analysis could bring up the following as possible solutions, the substitution of Shotcrete in place of cast-in-place concrete will:

- produce an acceleration in the schedule and a reduction in cost
- produce an acceleration in the schedule but not affect the cost
- produce an acceleration in the schedule but increase the cost
- delay the schedule but produce a reduction in cost
- delay the schedule and will not affect the cost
- delay the schedule and increase the cost

## Methodology

For this analysis to be performed, the following steps will need to be taken:

- Acquire construction drawings, shop drawings, and any 3D models from DAVIS.
- Calculate volume of concrete required for the foundation walls.
- Talk to DAVIS to get the average cost of materials, labor, and equipment for the concrete walls.
- Figure out the number of pile tie-ins and the size of the required formed out box.
- Calculate the total cost of materials, labor, and equipment for the walls including forming each box.
- Using contacts at McClone Construction Company and at Granzow Structural Engineers, it will be found out if the same volume will be needed for the Shotcrete and what the average price is for materials, labor, and equipment for Shotcrete.
- While talking with all of my contacts, I will find out what their expected labor hours would be for both CIP concrete and Shotcrete for a more accurate answer than RS Means could supply.
- Calculate the total durations for both cases from the number acquired.
- Evaluate the cost and duration numbers that were calculated and compare the two cases.

## Expected Outcome

It is believed that any increase in material cost will be less than the decrease in labor cost. Also, the pneumatically projected Shotcrete should be placed faster and cure fast than the alternative. For these reasons, the substitution of Shotcrete for the CIP concrete will produce an acceleration in the schedule as well as decrease the cost.

## Analysis 2 | Neighboring Foundation Support Wall

### **Opportunity Identification**

One of the site constraints with this project is the proximity of the neighboring foundation to the excavated hole. With The Office Building having three levels of underground parking, the need arose for supporting the neighboring foundation. The original design for this support was a wall formed by secant piles. This is a tedious process that pushed back an already delayed schedule.

### **Background Research**

Creating a secant wall is an intricate process of drilling and pouring female piles and coming back a few days later to drill and pour the male piles; one that requires much back and forth positioning of the drilling rig. While drilling the male piles, much of the female piles is being drilled out, this is a wasteful technique. For any acceleration in the schedule, a less troublesome process should be chosen.

Before a different process is chosen, it must be understood why the designers chose a secant wall. The neighboring foundation was found to be two feet over for where they expected it to be, onto the site. Because of this, then support wall had to be redesigned. The design conditions were that the wall could not deflect more than  $\frac{1}{4}$  inch and the wall had to be watertight. The neighboring building is a historic building and it was not clear whether the building sat on wood piles. If the wall was not watertight when The Office Building's project team turned on the dewatering system to keep the excavation dry, any wood piles under the neighboring building would dry up and fail.

After discussions at the PACE roundtable and further discussions with the project team at DAVIS, it was decided that a slurry wall would be looked into to replace the secant wall in order to reduce schedule time.

### **Potential Solutions**

While this analysis looks at both schedule and cost, the possible results follow, The alternative to the secant wall will:

- accelerate the schedule and reduce cost
- accelerate the schedule but increase the cost
- not accelerate the schedule but reduce the cost
- not accelerate the schedule and will increase the cost

### **Methodology**

In order to complete this analysis, construction documents will be obtained to determine the size of the redesigned secant wall, and from these documents, the cost for labor, material, and

equipment will be calculated. After discussions with references at DAVIS, Granzow Structural Engineers, and Berkel and Company Contractors, duration times needed for the secant wall will be calculated. I will then talk to associates at Balfour Beatty to obtain average duration times and cost information for slurry walls. With all of the preliminary data collected, total costs and durations will be calculated, for both the secant wall and slurry wall, and be compared.

### **Expected Outcome**

After this analysis, it is expected that the construction of the slurry wall will have a shorter duration due to the use of different equipment. It is believed that, even without the wasted concrete, the slurry wall will be slightly more expensive than the secant wall. In the end, this analysis will show how much schedule acceleration is truly worth.

### **Critical Industry Research**

In today's cities, buildings are growing deeper and closer to their neighbors, which is increasing the demand of more intense underground support systems. As the number of "deep buildings" increases, so does the complexity of the next construction project. Although it may seem years away, the use of tie-backs for lagging excavations may be waning. When the space for these tie-backs is gone, are we as an industry going to be in a state of confusion, or are we going to have enough experience from past jobs to plow through the problem? For the industry to not have a problem when this situation arises, there is some critical research that must be done. After many discussions with professionals in the industry, there does not seem to be many people know much about systems like secant walls and slurry walls. The research in this thesis will seek to provide insight on how to support a neighboring building for collapsing onto your site during construction and after. If the research turns out to be positive, we could see more of these technologies arise with less complications or oppositions.

## Analysis 3 | Prefabricated Induced Schedule Acceleration

### **Opportunity Identification**

As mentioned above in the project background, before the construction of The Office Building could begin, a nine story steel building had to be demolished. During the demolition process, the general contractor found more and more asbestos. These finds kept pushing back the release of the raze permit which would allow for the demolition of the structural steel. By the time all the asbestos had been abated and the utilities were capped, the raze permit was received five months behind schedule.

### **Background Research**

A common solution to schedule acceleration is prefabrication. Although the overall work may not have a shorter duration, the amount of time spent on site is greatly reduced. Through the prefabrication process, most of the work is done in a prefabrication factory. This gives the drywall a longer lead time before it is trucked to the project site upon installation.

The more conventional prefabrication relates to MEP systems, but due to the lack of uniformity in the mechanical, electrical, and plumbing systems, this would be an infeasible option. For this reason, prefabricated drywall corners will be investigated. In the process of prefabricating the drywall corners, a sheet of drywall has two 45° cuts that don't go through the paper. A metal spline is then added for support and the drywall is folded onto itself to form a perfect 90° corner. The paper is continuously wrapped around the corner eliminating the need for joint compound and tape. The 45° angel cuts produce a 90° corner that can rarely be produced by joining two pieces of drywall in the field.

### **Potential Solutions**

This analysis looks at both schedule and cost so the potential solutions are as follows, the implementation of prefabricated drywall corners will:

- accelerate the schedule and reduce cost
- delay the schedule but still reduce cost
- accelerate the schedule but increase the cost
- delay the schedule and increase the cost

## **Methodology**

For this analysis to be performed, the following steps will need to be taken:

- Obtain construction drawings and shop drawings from DAVIS and Performance Contracting Inc.
- Create a take-off of all drywall corners.
- Obtain material and labor costs, as well as labor hours, for both, traditional drywall corners and prefabricated drywall corners.
- Calculate costs and durations for both processes.
- Compare the costs and the schedule of each procedure.

## **Expected Outcome**

It is expected that the overall duration for the drywall will decrease by a substantial amount. As mentioned above, all of the work involved with taping the joints and applying/sanding away multiple layers of joint compound get thrown out for a corner that comes straight out of the warehouse. Although this may seem like a small task, when all of the corners are taken into account, the time savings starts to add up. Also, it is the belief that this process will put a reduction in the cost. Although there will be a cost for prefabricating these corners in a warehouse, this cost will not be as substantial as the cost savings that comes from not having to tape and mud all of the corner joints.

## Analysis 4 | Value Engineering

### **Opportunity Identification**

Although the project team understood what was buried under the previous building, there were many unforeseen obstructions during the excavation process. Due to this reason, along with the costs associated in the schedule delays, value engineering must be looked at to save the owner some money.

### **Background Research**

It is clear through the owners want to have a LEED Gold building that quality is important to the owner. It is for this reason that finishes will not be reduced to cheap materials. One area of potential lies with the electrical system. As it stands, busway is run only vertically through the building. Because of the efficiency of busway, less metal is required than that needed for copper wiring and the presence of conduit is nonexistent in the busway. For this reason, if larger horizontal wire runs were replaced with busway, the owner may stand to save some more money. Areas where this may be beneficial would be where wires run from the two switchgears to the vertical chases and from the roof top generator to the vertical chases.

### **Potential Solutions**

With cost being such a big priority of owner's, this analysis will only look at the cost aspect of the change. The replacement of the larger horizontal wiring with busway will either reduce the cost or increase the cost of the electrical system.

### **Methodology**

For this analysis to be completed, notes from previous classes as well as research from contacts at Perlectric and DAVIS will be referenced to better understand busways. The use these contacts will also be used to find a general cost for both options that is a better reflection of reality than RS Means can provide. A take-off will then need to be completed for the larger wires that will be replaced. The size of the busway and distance required will be calculated. With this information, both labor and materials costs will be calculated for both systems and compared against each other.

### **Expected Outcome**

It is believed that the busway will be a less expensive alternate system. The majority of any cost reduction would come from labor for the absence of wiring pulling. That being said, the material required for the busway is believed to also be less than that required for the large horizontal wiring.

## **Conclusions**

The four technical analyses mentioned above, along with the two breadth topics expressed in Appendix A, all focus on ways to help reduce cost and accelerate the schedule, all while keeping the high end quality the owner is striving for. Whether it is redesigning the foundation or support walls, using prefabrication technologies, or value engineering, it is expected that these analyses will produce results that would have benefited the project team and the owner of The Office Building.

## **Appendix A: Breadth Topics**

**Structural Breadth | Incorporated in Analysis 1**

The Shotcrete comprised foundation walls, as detailed in Analysis 1, provide an opportunity to apply research and analysis outside of construction management areas. To study the structural aspect of this system, load calculations will be calculated. To properly calculate these values, knowledge from both AE 308, AE 404, and CE 397A will be used along with the notes from the classes. These calculations will help to show whether the volume and strength of the CIP concrete can be applied to Shotcrete while carrying the same loads. Any change in either volume or strength will affect the cost of the process which will show in the first analysis. If any additional reinforcement is required, the change in both cost and time will be added to the price and time subtracted by the lack of formwork.

**Electrical Breadth | Incorporated in Analysis 4**

Analysis 4 looks at replacing the larger horizontally run copper wiring with aluminum wiring or busway in order to save money for the owner. In order to truly replace one system with another, the load will be determined from the existing system, and both the aluminum wiring and aluminum busway will be sized accordingly. Notes and knowledge learned from AE 311 will be used along with consultations with industry professionals to ensure an efficient system. The new design will also comply with the National Electrical Code (NEC).

## **Appendix B: Analysis Weight Matrix**

Table 1 shows a weight matrix that describes a breakdown of each analysis topic and the amount of time spent on each. The weighting related to the breadth topics has been included with the analyses they apply to.

Table 1. Weight Matrix

Description	Critical Issue Research	Value Engineering	Constructability Review	Schedule Acceleration	Total
Foundation Walls		10%	5%	10%	25%
Support Wall	15%	5%		10%	30%
Prefabrication	5%	5%	5%	5%	20%
Value Engineering		15%	10%		25%
<b>Total</b>	20%	35%	20%	25%	<b>100%</b>

## **Appendix C: Progress Schedule**

