Technical Report II

Rendering courtesy of DAVIS

The Office Building

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Executive Summary

This technical report analyzes key features of The Office Building that affect the project execution. A detailed schedule, detailed structural estimate, MEP assembly estimate, general conditions estimate, site layout plans, constructability challenges, and a building information modeling use evaluation are all investigated in the document.

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. The building contains 108 gross square feet and has a construction cost of $30 million.

The project was started on June 11, 2012, with construction starting on September 17, 2012. The project is scheduled to be completed by February 10, 2015, giving it a 22 month duration.

The building is mainly a concrete structure. The costs of concrete, steel reinforcing, and structural steel are $6,430,259, $601,539, and $84,850 respectively. This gives a total structural cost of $7,116,648. The assembly estimate had a breakdown of $510,626 for the plumbing system, $1,224,720 for the mechanical system, $734,994 for the fire protection system, and $3,465,060 for the electrical system giving a total of $5,935,400. The general conditions cost of the project came out to be $3,021,793.

The site layout planning is comprised of early excavation, structural placement, and façade installation, and will go into depth of how each phase changes the project site.

The constructability challenges listed are: the urban environment, SOE interference, and moisture control. This report will dive into each of these topics separately and discuss the problem and solution.

The building information modeling use evaluation will explain how BIM could be used on the project and why. The uses will then be compared to what is in use on the project.

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Detailed Project Schedule

*Refer to Appendix A for full detailed project schedule

The detailed schedule for this project consists of ten major phases as shown in table 1 below. Many phases overlap to achieve an efficient timetable for construction. As the last row in table 1 shows, the entire project lasted 687 days; the equivalent of 22 months.

Project Schedule Summary			
Phase	Start Date	Finish Date	Duration
Preconstruction	6/11/2012	11/25/2013	373
Permenent Power	4/4/2013	7/31/2014	341
Demolition	9/17/2012	3/29/2013	137
Excavation	4/3/2013	8/15/2013	95
Structure	8/9/2013	6/6/2014	213
Façade & Roofing	2/18/2014	10/15/2014	172
Core & Shell MEP/Finishes	12/23/2013	11/12/2014	232
Sitework	6/23/2014	11/14/2014	105
Commissioning	7/8/2014	11/20/2014	98
Final Inspections/Turnover	10/16/2014	2/10/2015	84
Total Project	6/11/2012	2/10/2015	687

Table 1. Schedule Phase Summary

Preconstruction

Issuing of the construction documents occurred on June 11, 2012 and work began on existing tenant move outs, along with investigating hazmat issues. Seismograph monitoring was installed on adjacent buildings to measure deflection during construction. This installation occurred throughout November of 2012 during the releases phase of the preconstruction process. The longest section within the preconstruction phase is the procurement. This stage is crucial to ensure quality in the products before they arrive on site, and ensure they arrive on time. Because the schedule was so important to the owner, the team was still in the GMP Development when the notice to proceed came in on September 17, 2012.

Construction

Though not appearing until later in the schedule, permanent power is a vital item to point out to the owner. For this reason, it rests towards the top of the schedule.

With the notice to proceed, work was able to start on the demolition of the existing structure. The demolition started on September 17, 2012 and wrapped up on March 29, 2013. Overall this segment lasted 137 days and involved the abatement of asbestos.

Once the existing build was demolished, the crew could get to work excavating the soon to be parking garage. The use of cross braces (as seen in figure 1) posed some delays in the excavation. For this reason, the excavation stage lasted 95 days, starting on April 3, 2013 and ending on August 15, 2013.

With the wrap up of excavation in August, the structural phase was able to begin with the construction of the mat slab (as seen in figure 1). Between the substructure and the superstructure, the entire phase will last a total of 213 days. To shorten the schedule length, the next phase will start at the same time as the structure on level 7 on February 18, 2014.

Figure 1. Installation of Mat Slab

With the façade starting on the 18th of February, the north and east elevations of the building will be completed on July 31, 2014. With the air barrier on the south and west elevations, July 31, 2014 is also the date of the weathertight milestone. The main roof will be installed by July 26, 2014 to make this possibly with final details on the roof finishing on October 15, 2014.

Once the building is weathertight, the crews can get to work on the interior. The crews will work their way up through the building, before heading back to the lobby, following one behind the other to keep a compressed schedule. The finishes will start on level P3 on December 13, 2013, and end 232 days later in the main lobby on the ground level on November 12, 2014.

While crews are at work on the interiors, another crew will be working on the site work doing sculpting the land and installing hardscape finishes and site pavers.This work will be going on for the 105 days between June 23 and November 14, 2014.

When the interior finishes are far enough ahead, the commissioning may begin on July 8, 2014. This process will take 98 days until its finish on November 20, 2014.

After the 30 days of final inspections from October 16, 2014 until November 26, 2014, the project will be substantially complete on November 26, 2014. 52 days after the punchlist begins on December 1, 2014, the project will be complete on February 10, 2015.

Detailed Structural Estimate

*Refer to Appendix B for full detailed structural estimate

The structural system for this building consists mainly of cast-in-place concrete with a secant wall on the west side of the building and steel members holding just the penthouse roof. The foundation is a mat slab with micro piles. Instead of finding a typical bay for the building, this estimate was broken up per floor due to inconsistencies. The components of the structure are compared in Table 2.

	Typical Floor	Estimated Building
Concrete	$358,815.73	$6,430,258.70
Rebar	$36,721.86	$601,539.04
Structural Steel	N/A	$84,849.77
Total	$395,537.59	$7,116,647.51

Table 2. Cost comparison of structure components

Concrete

The concrete for the exterior walls of the parking garage were lumped into the quantity with the first parking level concrete and the floor of the third parking level is the mat slab, therefore the three parking levels share the same floor area but have differing concrete volumes. Because of differing concrete thickness, the third through ninth floor share the same floor area, while the second through seventh floors share the same concrete volume. The main components of the material cost include:

- Concrete costs
- Formwork
- Plastic or blankets

The plastic or blankets are for the concrete slabs. A waste factor of 5% was used for all costs, giving a value of $9.43 million.

Concrete Reinforcing

The reinforcing throughout the build is much like the concrete in that it is typical for most floors but larger on others. The typical floors contain about 21 tons of rebar while the penthouse contains a couple more tons due to the heavy mechanical loads. The third parking floor has

about 79 tons of rebar because of the matt slab, as mentioned above. The cost for the rebar is simpler than the concrete in that it is just price of the steel reinforcing and the labor price for installation. The reinforcing steel also used a 5% waste factor, giving a total cost of $601 thousand.

Structural Steel

As mentioned above, the penthouse roof is the only location of structural steel. Like the rest of the building, a typical bay could not be used because of variations of steel shapes and sizes. The costs associated with the structural steel include: steel costs, labor costs, and equipment costs. Like the rest of the structure, a 5% waste factor was added to all steel costs. As Table 2 shows, the structural steel cost is much lower than that of the concrete. This is because the steel was such a small part of the building.

MEP Assembly Estimate

*Refer to Appendix C for full MEP assembly estimate

This assembly estimate focused on the main parts of the following building systems:

- Plumbing
- Mechanical
- Fire protection
- Electrical

Table 3, below, shows how these systems compare to each other in cost.

Description	Cost
Plumbing	$510,625.92
Mechanical	$1,224,720.00
Fire Protection	$734,993.74
Electrical	$3,465,060.32
Total	$5,935,399.98

Table 3. Assembly Estimate Breakdown

The pluming and fire protection costs represent typical systems for a building of this size.

The mechanical system in The Office Building is a water-to-air system which consists of cooling towers, chillers, and air handling units. This system pushes air throughout the office space on the second to ninth floors and pumps water to multiple variable-volume-air devices in the retail space on the first floor. For this system the estimated cost came in a little low, but an assembly estimate is only accurate with 10%.

The electrical system for this building consists of a switch board serving the upper half of the building and a switchboard serving the lower half of the building. There is also a diesel powered generator on the rooftop. The estimated costs seems accurate to the system in The Office Building.

General Conditions Estimate

*Refer to Appendix D for full general conditions estimate

A general conditions estimate was performed on The Office Building and the results can be seen in Appendix D. The estimate is made up of the following:

- Personnel on site
- Material required by the general contractor
- Equipment used by the general contractor to complete the project
- Insurance and bonds required for the general contractor.

For the sake of the estimate, a few positions had to be lumped together, but the outcome was still accurate. An example of this would be a layout engineer and a project engineer sharing the role of field engineer. After combining the four components of the estimate listed above, a total was calculated to be just over $3 million.

Site Layout Planning

*Refer to Appendix E for site layout drawings

The Office Building is located in the urban environment of Washington, D.C. The project site sits at the corner of a busy intersection of the city. This urban setting will put restrictions on hours of work as well as hours of deliveries.

Adjacent to the site are two nine story historic buildings as well as a transportation authority tunnel along the property line. These factors restrict the space for material storage and truck staging.

Because of these constraints, the site layout plans do not change much between phases of construction. The fence stays in its primary location throughout the construction process. Three phases to highlight will be the following:

- Early Excavation
- Structure Placement
- Façade Installation

Layout drawings for these phases can be seen in Appendix E.

Early Excavation

As seen in Appendix E, a ramp will be in place at the southeast corner for trucks to remove the soil from the site. Material storage for lagging will be located on the south side of the site along the back ally. Excavators will work in the hole excavating earth and loading trucks. Other drill rigs will be there as well to install auger cast piles and the secant piles along the west wall. Eventually the large equipment and ramp will need to come out of the hole to continue excavating down another 25 feet.

Structural Placement

Due to the fact that the structure is mostly comprised of concrete, two locations will be provided for truck staging and pump trucks. One will be at the North end of the site and the other at the Southeast side. To fit the trucks in the staging area at the east side of the site, the portable toilets will be moved along the back ally. The general contractor's trailer will be moved to where the sub storage trailer was during the early excavation stage. The sub storage trailer will then be moved to where the general contractor's trailer was and the subcontractor office trailer will be placed on top of the storage trailer.

Façade Installation

The façade installation is to start before the completion of concrete to speed up the schedule. When this process starts up, one of the larger material storage areas will be moved into the building to make room for a rough terrain crane. The east pump truck will also be taken away due to the concrete wrapping up.

Constructability Challenges

There are many constructability challenges with The Office Building, some of which have already been mentioned. The challenges which will be highlighted include:

- The urban environment
- The support of excavation interfering with the concrete walls
- Moisture control

The Urban Environment

As mentioned in the previous section, the location of the project site produces many headaches for the team. With the location comes the lack of material staging, the need for traffic control at both truck staging locations, and delivery times. Being in the heart of city, many deliveries will not be allowed until after 10:00 AM. Another time constraint would be the start time being no earlier than 6:00 AM.

To overcome the challenges that come with the urban location, the team held some material offsite. They also employed a flagger for each gate to control traffic when trucks were arriving or departing. The team made sure that if they needed something on site in the early morning, the items were delivered the day before so they did not get held back by the 10:00 AM time constraint.

SOE Interference

Because of the close proximity to the transportation tunnel, cross bracing is required to support the excavation of the parking garage. Unfortunately, everyplace the cross bracing ties into the side of the excavation, it cuts through the exterior walls.

To contend with this problem, the team will frame a hole around every interfering piece and constructed the wall around the SOE. Once the cross bracing is uninstalled, the team will go back through and fill in the holes.

Moisture Control

With the bottom of the excavation being at sea level, ground water is a major concern. Also, the waterproofing subcontractor will not guarantee the garage to be watertight because of the secant wall. The waterproofing subcontractor's scope only guaranties the north, east, and south walls but does not include the secant wall on the west side.

To overcome the threat of water, the team will drill dewatering holes to pump ground water out of the bottom during construction and through operation. To waterproof the garage, the team decided to add a waterproof admixture to the concrete makeup of the secant wall.

Building Information Modeling Use Evaluation

*Refer to Appendix F for BIM process map

Building Information Modeling (BIM) was used on the Office Building project. The team utilized 3D coordination to run clash detection of the different trades. With the owner's needs including quality, cost, and schedule, more BIM uses could have been utilized on this project. Table 4 below shows different implementation choices for BIM uses on this project.

X	PLAN	X	DESIGN	X	CONSTRUCT	X	OPERATE
	PROGRAMMING		DESIGN AUTHORING		SITE UTILIZATION PLANNING		BUILDING MAINTENANCE SCHEDULING
X	SITE ANALYSIS		DESIGN REVIEWS		CONSTRUCTION SYSTEM DESIGN		BUILDING SYSTEM ANALYSIS
		X	3D COORDINATION	X	3D COORDINATION		ASSET MANAGEMENT
			STRUCTURAL ANALYSIS		DIGITAL FABRICATION		SPACE MANAGEMENT / TRACKING
			LIGHTING ANALYSIS		3D CONTROL AND PLANNING		DISASTER PLANNING
			ENERGY ANALYSIS		RECORD MODELING		RECORD MODELING
			MECHANICAL ANALYSIS				
			OTHER ENG. ANALYSIS				
			SUSTAINABLITY (LEED) EVALUATION				
			CODE VALIDATION				
	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)
	COST ESTIMATION	X	COST ESTIMATION	X	COST ESTIMATION		COST ESTIMATION
	EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING

Table 4. BIM Use Summary

Site Analysis

At the start of the project, there was an existing building and utilities on the proposed site. Using a model early on in the project could help show what is on site and how the demolition process should proceed, and may save time on the schedule.

3D Coordination

As was previously stated, the team implemented the use of 3D coordination to run clash detection for the different trades. This is a great way to ensure quality before anything even gets to site. This should be used in the design process as well as the construction process in the case of changes or additions to any scope of work.

Phase Planning (4D Modeling)

With all of the challenges that face the project team on The Office Building, 4D modeling is a great feature to show the progression of work as well as the placement of different materials on

the congested site. It should be used in the design phase to work out a plan of action. 4D modeling can also be used in the construction phase to ensure the schedule is maintained or even show new items when unforeseen circumstances come up.

Cost Estimation

BIM modeling is an effective tool for quantity takeoffs in the estimation phase of the design process. The cost estimation aspect of BIM can also be applied during the construction process to ensure accuracy in the budgets.