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Technical Assignment Three

Penn State AE Senior Thesis

Office Building - G

Eastern USA

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EXECUTIVE SUMMARY

Technical Assignment Three is an investigation of areas that could be used for research, alternative methods, value engineering, and schedule comparison on the new Office Building-G project. This project includes a brand new 14 story, 380,100 SF office building along with a four level underground parking garage that totals around 269,000 SF. The building features a glass curtain wall along the southern elevation with the rest being made up of architectural precast concrete with punched out glazing. The largest challenge associated with the project is the adjacent metro station to the west of the project site. Special attention has to be taken into account with the metro station as well as the pedestrians that will pass the site daily to use the metro to commute to and from work.

Constructability challenges associated on this project include the proximity to the adjacent metro station, two residential buildings located to the north of the project site, and the location of the project being between the metro station and the parking garage where metro users park. Each challenge had to be carefully studied in order to produce the best solution to each problem as possible. The critical path of the project depends on mock-up testing, particularly water performance of the exterior building system. A big problem the project team faced early on was the owner's change from the original façade to a blast façade. The team had to abandon their original exterior design and start over. Schedule acceleration scenarios that the team is thinking about implementing include working longer hours and making up time during the structural phase of the project. Value engineering topics were not obtained due to owner restrictions on the project site and thus were not able to be disclosed. A change order that has taken place already is a $60,000 change order for "puddling" of concrete.

From the information obtained through the analysis of constructability challenges, schedule acceleration scenarios and value engineering topics along with the interview with Carlos Flores and Jordan Short from Turner Construction, several areas were identified that could potentially be problematic to the construction of the project. These areas are discussed within the four technical analysis methods that include the use of a tieback system, elimination of site congestion, the use of photovoltaic glass in the curtain wall, and a comparison between the original architectural precast façade and the blast façade. Each will disclose knowledge of possible research topics to be used for the thesis proposal.

TABLE OF CONTENTS

A. Constructability Challenges

The new Office Building-G is a 14 story, 380,100 SF office building along with a four level underground parking garage that totals around 269,000 SF. The building features a glass curtain wall along the southern elevation with the rest being made up of architectural precast concrete with punched out glazing. LEED Silver status is projected for the project with the usage of green and white roofs, water reuse/ reduction techniques and the use of recycled materials to name a few key aspects. The project is scheduled to be completed September 12, 2012. The project team on the new Office Building-G has some challenges that will need to be addressed before and during construction. The main challenge is the close proximity to the adjacent metro station. Along with that the team also has to take into account two residential buildings to the north of the project site and also the parking garage to the west of the site.

1. The Proximity to the Adjacent Metro Station

The main concern that the team faced prior to construction was the adjacent metro station. The station is located to the immediate west of the project site as shown in figure 1 below. This posed a major concern and was something the team took into account from day 1 of planning. The team had to comply with the metro's adjacent construction design manual. The metro's tunnel is in close proximity to the site which makes it sensitive to changes in loading due to the compressible nature of the residual soil supporting the tunnel. Also, the tunnel is located only a few feet below ground level and from the geotechnical report completed, it was determined that the tunnel was most likely constructed using sloped elevations. From this information, it was determined that sheeting and shoring most likely did not exist for the tunnel structure. In accordance with the metro's adjacent construction design manual, it was also determined that the project site is within the "zone of influence," which calls for special precautions to be made that include tiebacks beneath the track and tunnel. The project team decided not to use a tieback system, but instead a raker system to account for the adjacent metro's tunnel during excavation. The reason that a raker system was used instead of a tieback system was because the raker system allowed for a longer time of use during sheeting and shoring operations. Before the project team was allowed to go forth with the raker system, approval was needed from both the owner's engineers and the adjacent metro station's engineers as well.

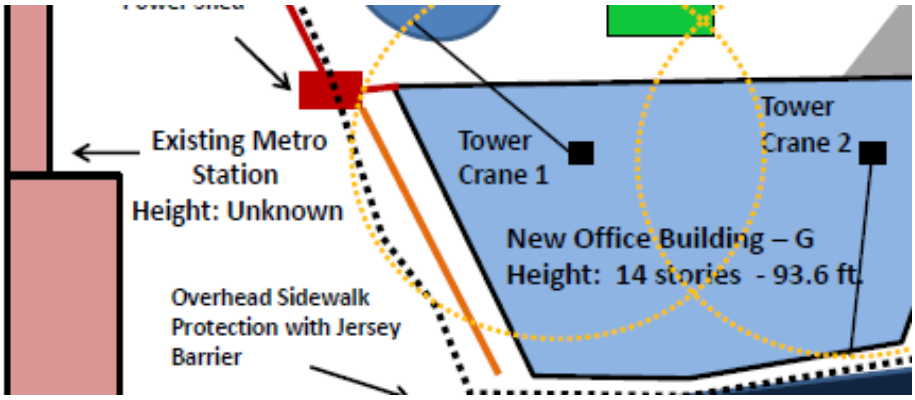

Figure 1
NOTE: Orange line represents Raker System

2. Two Residential Buildings to the North

The second constructability challenge the project team is facing on the new Office Building-G site is the two residential buildings to the north of the project. This challenge is not so much the proximity of the buildings to the site, but more so deals with the entrance to the site sharing the same roadway as these two buildings. The project team wants to keep the roadway clean at all times. With all the material deliveries being made to the site, this was a special circumstance that needed to be accounted for. In order to keep the roads clean, after each delivery, the team will immediately clean the rubble or debris that falls off the material delivery truck onto the road. This will eliminate any dispute between the residential building tenants and the project owners. While the project is going on, the team wants to make sure they account for any changes that they make to the daily routine of the people who are in the surrounding area of the project. Below, figure 2 is a close-up of the site entrance and the residential buildings.

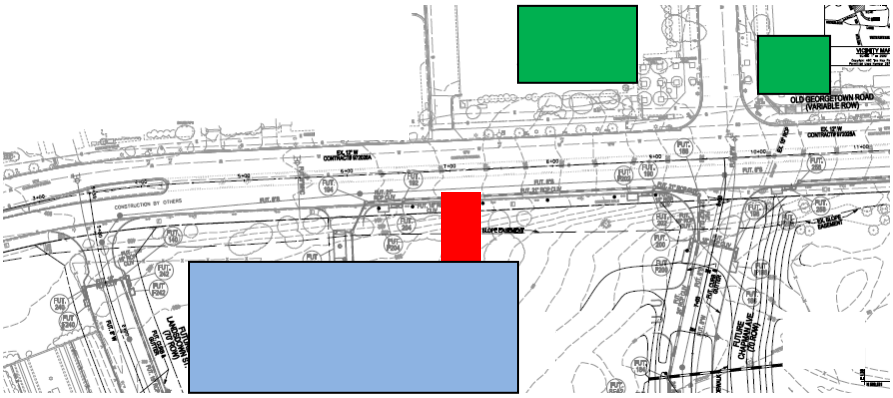

Figure 2
NOTE: Project Site: BLUE, Site Entrance: RED, Residential Buildings: GREEN

3. Parking Garage to the East of the Project Site

The third constructability challenge on the new Office Building- site is the location of the site being between the metro station and a parking garage where pedestrians who use the metro park daily. During construction, part of the sidewalk that the pedestrians would normally use is to be taken out. The project team plans to use a temporary sidewalk along the construction site for the pedestrians to use daily to walk from the parking garage to the metro station. Also, along the project site, a covered walkway will be used over that section of the sidewalk. The covered section will account for any debris that may fall or come from the site and will provide protection to the pedestrians during their daily walk to the metro station. Below, figure 3 shows the path from the garage to the metro station and also the covered sidewalk section along the project site.

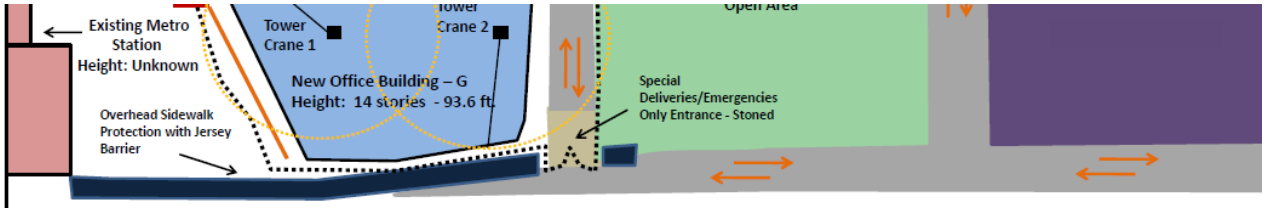

Figure 3
NOTE: Parking Garage in PURPLE

B. Schedule Acceleration Scenarios

Project Critical Path

The critical path on the new Office Building-G runs through the mock-up testing. In particular, mock-up testing dealing with the water performance on the exterior building system is what will be driving the critical path on the project. The reason that the mock-up testing will drive the critical path is because before any material is released to the project site, mock-up approval must be made. If material is brought to the site and no mock-up testing approval was made for that material, that building component will need to be scraped and started over.

The timeline for each building material is similar throughout. Each begins by first signing a contract for that particular material. Then, the subcontractor for that component is signed. From there, mock-up testing is performed off site for that particular material. Once the material passes the mock-up test and approval is given, the material can then be released for transportation to the new Office Building-G site. It is critical that each material follows this timeline to ensure the quality of the material through the testing. Approval, again, is a necessity and needed in order to keep the project on schedule.

Changes that Effected the Schedule

Currently, the project is in the early stages of construction and have not encountered many problems that could affect the current schedule. The one problem that the team did run into was a change from the original facade to a blast facade. The blast facade was the owner's contractual alternate and the decision to switch to it was made by the owner recently. In order to account for this, the project team is currently considering options to take and at this time did not have a concrete solution. One idea is to make up time lost during the finishes of the building. This is a viable solution, however the team feels that if this solution is used, the quality of the finishes would suffer and because of that do not want to commit to it until all other solutions are reviewed.

Acceleration Techniques

The project team is constantly looking into ways to accelerate the project just in case other complications occur, such as weather which always needs to be carefully monitored. They think that if they need to make up time that during the structural phase would be one time that they could use. Also, they could have the subcontractors work longer hours if needed, especially the precast and glass/glazing subcontractors. If delays do occur, the team wants to keep those delays concentrated into that particular trade, and not interrupt the other tasks being performed on the site. The team wants to try to stick to the critical path as much as they could, but they acknowledge that problems do occur and that is why they have taken into account ways that they feel they would be able to make up those delays and not jeopardize extending the current project completion date.

In order to have these acceleration techniques work, the team will have to work longer hours per day. Also, if there is a cost to keep to the schedule, the team feels that spending the money at that time would be cheaper than paying any liquidated damages at the end of the project. The team wants to try to make up as much work as possible in the office and stay away from making it up in the field as much as possible. They feel that if they push any extra work to the field that it will take away from the quality of work and they will try to stay away from that. If they keep to the schedule that they currently have in place, the team is confident that the project will run smoothly from start to finish and the building will be turned over to the owner on the current completion date, September 12, 2012.

C. Value Engineering Topics

Value Engineering is looked at on almost every construction project done throughout the world. Some refer to it rather as cost savings because that is the main goal of value engineering, to save money. Most commonly, value engineering looks at a particular product and checks to see if that product can be substituted for a similar one of lesser value but the same quality and performance. Sometimes the product in question will be substituted to try to improve that products performance, but may cost more than the original designed product. More often, value engineering will look to save money rather than spend more.

Turner Construction and the project owner have agreed to a five year Guaranteed Maximum Price (GMP) contract on the new Office Building-G project. Due to the restrictions on the project, many key value engineering areas could not be disclosed. At this time, the one value engineering item that was agreed upon for the project is:

- "Puddling" with concrete - $60,000

This value engineering item was the only item that was disclosed by the project team. This particular item helped save the owner money and as was a technique that did not cause trouble with the schedule. Other items have been considered but because of the restrictions could not be disclosed. All value engineering items must be agreed upon by the owner and Turner Construction along with the particular subcontractor and engineer related to that value engineering item.

D. Problem Identification

After carefully analyzing the constructability challenges, schedule acceleration scenarios, and value engineering topics through the Project Manager interview, several items were identified as potential problematic areas on the new Office Building-G project. The following items listed may be used as research topics to pursue next semester.

Public Safety

Public safety will need to be accounted for throughout the entire construction process from start to finish. Because of the location of the new Office Building-G being between the metro station and the pedestrian parking garage, constant pedestrian traffic will be around the site, especially during the morning hours. There is a covered walkway to account for pedestrians walking near the southern part of the site, but there will also be traffic to the north of the site where residential buildings reside. Deliveries will be made at both the northern and southern entrances where pedestrians will be crossing. The project team will need to be aware of public safety at all times and make sure that the project site is secure from anyone who is not authorized to be on site. Emergency egress and vehicular traffic must be considered for all phases of the project.

Site Congestion

The new Office Building-G site is rather large, however there will be many trades going on at once throughout construction. Because the main structure is mainly concrete, a batch plant will be established between the building footprint and the office trailers. Also, an earth stock pile will be in that area along with staging and lay down areas. Two tower cranes will be used and will need to be coordinated with each other to not delay the schedule. With all of the work going on, it will be crucial to coordinate all of the trades along with both tower cranes and concrete usage.

Energy Efficiency

Office Building-G is a 14-story commercial office building with 4 levels of underground parking. These building types usually account for large amount of energy usage. Lighting, computers, security and MEP systems will require a large amount of energy and most of these systems will be running constantly. Because of the LEED Silver status the new Office Building-G plans to achieve, the energy system will be something to look into for cost savings. Energy consumption is a popular topic in the industry today and office buildings are one of the leading buildings in energy consumption usage. Looking into energy saving techniques would be a viable research topic.

Building Envelope

Because of the curtain wall system on the southern elevation and the architectural precast concrete planned as the exterior facade of the new Office Building-G, it will be critical that all materials for both systems be coordinated and delivered on time for construction. If materials

are not there when they need to be, it could jeopardize the schedule and cause delays that could potentially cause the project to not finish on time. Mock-up testing will be crucial not only to get the materials on site for the facade, but to also keep to the critical path of the schedule. If mock-up testing stalls, the whole project could stop. It will be very important that all mock-up tests for the facade are approved to get each material of the facade delivered on site and on time.

Excavation System

The new Office Building-G had the challenge of dealing with the adjacent metro station to the immediate west of the building footprint. The project team decided to use a raker system as means of support for the underground tunnel. From the geotechnical report generated, it was suggested to use a tieback system due to the fact that it was determined that sheeting and shoring probably does not exist for the tunnel structure. This is a very important issue that needed to be addressed because during excavation on the project site, vibration and soft soil in the area could cause the tunnel structure to collapse. It is imperative that the correct excavation system is used so that the tunnel will remain undisturbed during construction.

E. Technical Analysis Methods

Technical Analysis Method #1:
Use of Tieback System

Excavation support on all projects is critical to the successful completion of the project. On the new Office Building-G, excavation support is one of the primary concerns that the project team has. Due to the adjacent metro station immediately to the west of the project site, a detailed geotechnical report was needed to determine subsurface conditions on the project site and also conditions of the metros tunnel which is a few feet below ground level. A raker system was chosen by the project team to account for the tunnel structure, however I want to analyze the use of a tieback system which was originally suggested in the geotechnical report. A typical tieback system is shown in figure 4 below.

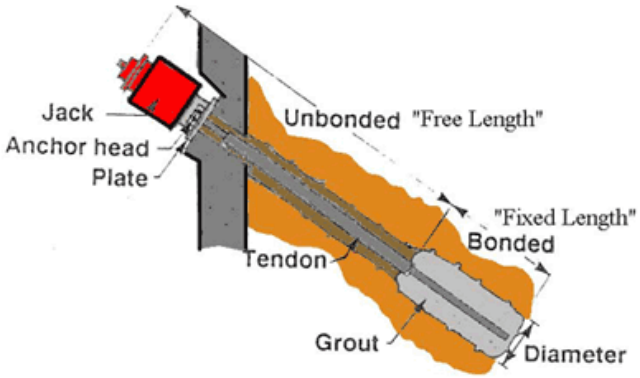

Figure 4
Typical Tieback

This analysis will include research on tieback systems and in what situations are they primarily used. Along with research on tieback systems, I plan to prepare a detailed analysis that with compare both tieback systems and raker systems. I will discuss with Turner Construction their reasoning why they choose to use a raker system instead of the suggested tieback systems. I will also look at costs of each system and also the advantages and disadvantages of each system through product websites.

Technical Analysis Method #2:
Elimination of Site Congestion

Site congestion is a potential problem that could affect the overall construction progress and cause delays that could push the project past its scheduled completion date. Currently the site is scheduled to have an on-site batch plant when the concrete phase of the project

commences. Also once the two tower cranes get on site, many trades will be going on and site congestion could become a problem with all the work being performed simultaneously.

This analysis will include an exploration of moving the batch plant off-site to utilize the space that the on-site batch plant would occupy. The site can be moved to the space near the sheeting and shoring operations or off site altogether. I will look to see how this move impacts the schedule and if it decreases the project schedule or increases it substantially. Also, a detailed analysis will look at the current project schedule, including activity durations and the tower crane pick schedule. I will look to make sure that necessary materials are scheduled to be on site when they need to be and that materials that are not needed at the time are not on the site which would cause congestion that is not needed.

Technical Analysis Method #3:
Photovoltaic's in Curtain Wall

Office Building-G is currently in line to achieve LEED Silver status upon completion, however it is always good to look for ways to reduce energy consumption. Due to the size of the building, the total energy used daily can be very high and one way to reduce consumption is by implementing photovoltaic glass in the curtain wall system. Figure 5, below, shows Rainbow Solar Inc.'s photovoltaic glass. By using this glass on the curtain wall, it could help reduce the buildings total energy consumption.

Figure 5
Rainbow Solar Inc.'s Photovoltaic Glass

The analysis of the photovoltaic glass will include a look at the change in cost if the glass window is implemented on curtain wall. This will look at the product costs, installation costs, and lifetime determination for payback from the glass. Also, a daylight analysis will also be conducted to determine an average of how much sunlight will hit the photovoltaic glass and at

what times of the year sunlight will directly hit the curtain wall. A daylight analysis will be critical to show sunlight patterns and see if the southern elevation of the building will be interrupted by shadows preventing sunlight from hitting the glass. The schedule impact and design impact will be researched by determining installation procedures from Rainbow Solar Inc.'s website. An analysis of the effect of the photovoltaic glass on the curtain wall structure can be a viable option to use as a structural breadth.

Technical Analysis Method #4:
Precast Architectural Concrete Façade vs. Blast Façade

As discussed in the schedule acceleration scenarios section, the project owner decided to change the original façade design from architectural precast concrete to a blast façade as per contractual agreements. I want to perform a comparison analysis of the precast concrete versus the blast façade. In order to accomplish this, I will look into the cost of both exterior systems by researching both systems that planned to be used. From there I will compare which system is more cost effective for use on the building, by use of each products website. Another comparison analysis would be to compare the installation methods of each system and how that will affect the length of the schedule. I will again consult each systems website and also the project's precast subcontractor for help in finding information on installation methods. Finally, I will compare the weight of each system to see if any structural impact will occur on the building due to each system. If there is an impact, that could raise or lower the cost of the entire structural package that would affect the cost of the project. This analysis will help to show which system would be more cost effective and which would have a lower installation rate, thus increasing or decreasing the schedule length.