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TECHNICAL ASSIGNMENT THREE

PENN STATE SENIOR THESES

UNIVERSITY SCIENCES BUILDING

NORTHEASTERN U.S.

PENNSTATE 1855

Turner

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CONSTRUCTION MANAGEMENT

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TECHNICAL ASSIGNMENT THREE

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EXECUTIVE SUMMARY

Technical Assignment Three is intended to identify areas of the project that are good candidates for research, alternative methods, value engineering, and schedule compression. This report will discuss a variety of constructability challenges, different schedule acceleration scenarios, and a list of proposed value engineering topics associated with construction of the University Sciences Building. All of these criteria were discussed on a site visit with the Turner staff.

The major constructability challenges identified for this facility include the discovery of a contaminated site, a change in the main stair feature late in the project, and having to deal with a congested work site on a daily basis. All of these challenges are unique, and impact the job in different ways. A contaminated site is a differing site condition that causes delays to the foundation and excavation work on site. Changing main building features late in the project can directly affect the timing and scheduling of finishes throughout the entire building. Furthermore, congested work sites can have a huge impact on the overall logistics of the building, often determining what systems can be used and how they can be completed.

Critical paths are important to understand and plan for on any project. The critical path for the University Sciences Building runs from foundations, to superstructure, to building enclosure, and ends with operable MEP systems. Of these, the enclosure of the building provides the most risk to the project schedule. Without a controlled environment, the interior finishes cannot begin. If delays do occur, Turner plans on making up time with flooring and painting by means of “shift differential” and overtime work.

A list of both approved and rejected value engineering items are broken down in this report, totaling roughly $750,000.00 in savings for the owner/CM. All of these proposed items are not intended or foreseen to detract from the overall quality or functionality of the building.

Several of the identified problems that can be analyzed in further detail include different sustainable techniques/energy efficiency methods, the implementation of BIM, change in the sequencing or systems used for the building enclosure, and the simplification of the building’s structure. These challenges may provide a good foundation for the thesis proposal.

TABLE OF CONTENTS

CONSTRUCTABILITY CHALLENGES

Contaminated Site

The site for the University Sciences Building was a challenge from the very start of the project. Turner found the underground site conditions to be contaminated upon their arrival. This contamination was unexpected, and no mention of it could be found in the Geotechnical Report. The specific composition of the contaminated matter is unknown, but this was a major obstacle for the project's initial success. Turner was tasked with removal of all contaminated soils, and replacing them with clean soils from the surrounding area. Contaminated soils are just one of the many items that can fall under the Differing Site Conditions Clause within the contract. Compensation was received for the direct material costs by the owner, but lost labor time and delays in the schedule are something that can not be accounted for in this particular situation. The university requires the facility to be operational by the start of next year's fall semester, and extra time can not be afforded by the owner.

By working overtime shifts during the foundations and concrete structure, Turner was able to mitigate this lost time. More specifically, both the simplicity of the foundations, using drilled caissons and grade beams, along with the use of filigree precast slabs for the superstructure, helped mitigate the lost time with high productivity levels from the corresponding crafts. This challenge was an initial set-back, but after making up the lost time, the project has not seen any other major delays in schedule.

Figure 1: Overview of the Site

Change In Main Stair Feature

One issue that is currently presenting a challenge for the Turner team is the late design change to the main staircase located in the atrium space within the building. The owner elected to change from a “straight” (typical rectangular shape shown in *Figure 3*) stair to a “spiral” stair design (shown in *Figure 2*). This ongoing challenge will directly affect the finishes in the atrium space.

Figure 2: Interior Render Showing the Spiral Stair Feature

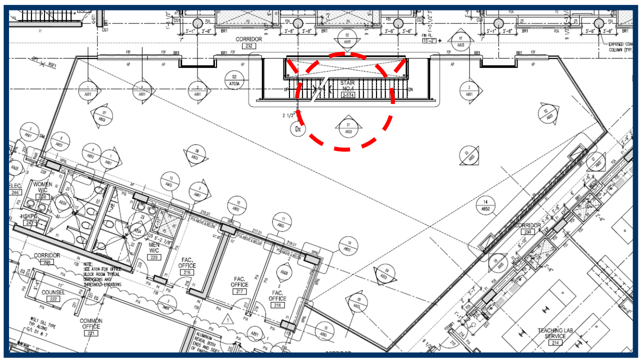

Figure 3: Plan View Showing the Original Stair Design

With this change in design, and with the extensive amount of scaffolding located in the atrium space (shown in *Figures 4 and 5*), you can imagine how this change can interfere with scaffolding supports and how the new staircase will need to be installed.

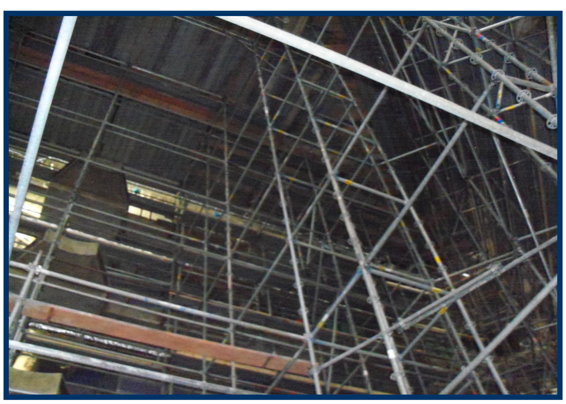

Figure 4: Scaffolding (looking up)

Figure 5: “Dance Floor” Supported by Scaffolding

To mitigate this issue, the atrium scaffold system, used to complete all of the high work in the atrium, has been designed to allow for the staircase to be brought in and erected with the scaffolding in place around and above.

Congested Site

The University Sciences Building is located in one of the largest cities in the Northeastern United States, and right in the heart of the University's campus. Turner does not have the luxury that other sites may have when it comes to things such as laydown space, material/equipment storage space, accessibility, and other challenging site logistical issues. All of these challenges are a direct result of a congested site and can alter the means or methods used to complete the project.

Limited laydown and storage space means that every delivery has to be planned out well in advance. It may have been cheaper to erect the structure using a typical crawler crane, but a tower crane made more sense for this building because it allowed for more room on-site.

Accessibility to the site is somewhat limited, making it difficult for unloading of material and timing of deliveries. Both vehicular and pedestrian traffic are a concern from a safety standpoint, requiring lane closings and overhead protection for pedestrians. Less space outside of the building typically equates to more congestion within the building.

Turner has done a great job organizing and orchestrating the movement and storage of materials on site. Everything is installed directly from the truck, or soon after the material is delivered. Lanes are closed when needed, small site trailers are only allowed for the larger trades, and electric hoists were used along the building façade to install the framing for the metal panels. There is very little congestion and construction waste both outside and within the building.

Site congestion is a major concern for any building located in the heart of a city, but no major delays or problems were spoken of when asking the Turner team. Deliveries and installation of material have been on time and without issues.

Figure 6: Aerial View of the Site

SCHEDULE ACCELERATION SCENARIOS

<u>The Critical Path of the Project Schedule</u>

Critical paths are important to understand and plan for on any project. These are the activities that have no cushion or play in the schedule. Other activities rely on the completion of tasks on the critical path, and the ones shown in *Figure 7* apply to the University Sciences Building directly.

Foundations and the completion of the building's structure are critical for the start of construction for all the other trades on the project. The enclosure of the building is still ongoing, but should be fully enclosed within the next week or two; no later than 12/15/2010 on the project schedule.

FOUNDATIONS: ***Excavation, Caissons, and Grade Beams***

↓ ↓ ↓

STRUCTURE: ***Filigree Precast, CIP Concrete, and Steel***

↓ ↓ ↓

ENCLOSURE: ***Masonry, Metal Panels, Glazing, and Roofing***

↓ ↓ ↓

OPERABLE MEP SYSTEMS: ***Heating for Finishes, Permanent Power, etc.***

Figure 7: Sequence Representing the Project's Critical Path

Biggest Risks to the Project Completion Date

The biggest risk to the project schedule is the enclosure of the building. Enclosure of the building before the harsh winter months is critical from a temporary heating standpoint. Finishes cannot begin until the temperature and moisture in the building is controlled. Any delays in this activity will delay all of the interior finishes for the facility.

Figure 8: North-East Corner of the Building

Figure 9: Window Installation

Figure 10: South-West Corner of the Building

Key Areas That Have Potential to Accelerate the Schedule If Needed

Currently, most of the MEP rough in and all of the rough in framing are complete. The areas that Turner plan to pick up the most time are in flooring and painting. Most of the flooring work and some of the painting will be done on evening hours to keep the remainder of the work on the day shift. Turner will have to pay “shift differential” for the night shift work, but determined that this method is the least costly of the various techniques for recovery that were discussed.

Shift differential refers to extra pay received by employees for working a less-than desirable shift (i.e., late nights, evenings). Shift differential pay is an integral part of each eligible employee's gross compensation and is subject to the same payroll deductions and payroll charges as regular salary or wages. The shift differential pay is added to the base hourly rate before the calculation of an overtime rate.

VALUE ENGINEERING TOPICS

Key Areas of Value Engineering That Were Implemented On the Project

1. The fire stairs were allowed to be done using the fabricators standard details in lieu of custom details in the drawings.

2. Curved glass at Rotunda is being fabricated by an alternate manufacturer in Mexico in lieu of Spain.

3. EMT used in lieu of rigid conduit where noted and MC cable used in lieu of EMT where noted.

4. Separate High voltage switch, transformer, and panel were all combined into a packaged switchgear unit.

5. VCT 12"x12" is being used in lieu of sheet vinyl in all except wet labs.

Accepted VE totaled $690,000

Ideas for Value Engineering That Were Considered But Not Implemented

1. Not accepted was an alternate metal casework manufacturer for the labs.

Declined VE totaled $150,000

Correlation to the Goals of the Owner

None of the value engineering items above are an operational or quality downgrade for the owner/user. The architect was quite attached to the sheet vinyl specified, but the owner actually prefers the VCT instead of the sheet vinyl.

PROBLEM IDENTIFICATION

Along with the Contaminated Site, Change in Stair Feature, and Congested Site issues mentioned in the Constructability Challenges portion of this report, below is a list of some other problematic features that may be pursued through a detailed analysis of building systems and construction methods.

Public Safety

Since this facility rests in the heart of a major US city, safety of both the nearby vehicles and pedestrians will be critical at all times. At the same time, it is also important to maintain an efficient work site. Several measures have been installed to protect the public, while maximizing the room on site that the crafts have to work with.

Figure 11: Overhead Protection

Overhead protection, lane closures, and blocked off sidewalks with chain linked fencing help establish a working barrier between the site and the city. Tower crane movements and swinging picks over buildings/streets must be coordinated to avoid any sudden drops/failures. An emergency evacuation plan is also critical to the safety of the workers on site and should be known and followed at all times of the job.

Layout of Masonry/Exterior Windows

As seen in *Figure 12* to the right, the layout of masonry and exterior windows is what gives this building its personality. With creative design follows creative solutions. This scattered arrangement of finished requires an extreme amount of coordination and precision to ensure the proper fit and seal of the building's façade systems. This unusual arrangement makes the layout and construction of these walls a little less efficient than a patterned arrangement because no wall on any floor is completely identical. The owner may like this look, but perhaps there is another way to establish a pattern that gives off the same finished look, but with some repetition to ensure better quality and efficiency from the trades responsible for its construction.

Figure 12: Completed Portion of Exterior Façade

Exterior Skin's Water Tightness

This building is also unique in the sense that rainwater is designed to drain behind the exterior aluminum cladding instead of along the outside like most façade systems. This seems like it could provide drainage and warranty issues down the road. If the vapor barrier were to get damaged over time, leaks into the building could prove to be very costly over time. See *Figure 13* to the right for a picture of the installation process from vapor barrier, to metal framing, to hanging of the aluminum panels (right to left).

Figure 13: Progression of Exterior Finish

MEP Systems Start-Up

Currently, the Turner team is working hard to get the building enclosed, and the MEP systems up and running so that interior finishes can begin. It looks as though building enclosure may come close to the 12/15/10 deadline set on the CPM schedule, and any delays could be extremely costly in terms of delays to the overall schedule. There may be a better way to sequence the installation of these panels to avoid any possible delays. It is critical that the HVAC system start-up is on time in order to avoid any unnecessary winter protection costs (temporary heating and plastic sheeting for the openings), and to provide a climate controlled environment for the building finishes.

LEED Certification / Energy Efficiency

This is listed as a problem only in the sense that the owner has chosen not to pursue some areas of LEED that could be really beneficial to the facility. The indoor air quality portion of LEED is being met with the Biowall system that is being implemented, delivering clean recycled air to the building occupants. However, other more energy efficient solutions could be implemented to cut down on the operational costs of the building, like renewable energy or rain water collection systems.

Filigree/Biowall Systems

With the implementation of new systems comes a major learning curve. The unique implementation of a Biowall and Filigree precast slabs on this project can cause major headaches if not installed properly.

The Filigree slabs took a while to set up, but once it came time for the CIP concrete topping, the building structure quickly progressed as the system intended.

The Biowall is being left till the end of the interior finishes portion of the project because of the scaffolding that is currently in the way of its completion.

Not Implementing BIM

Turner has made the implementation of BIM mandatory on all of their projects. The Turner team for the University Sciences Building petitioned against using BIM for this facility because the owner was unwilling to pay anything extra to use it. However, the use of BIM is intended to save a project time and money in the end with careful planning and coordination up front. It would be interesting to see just how much time and money could have been saved on this job from the utilization and implementation of BIM.

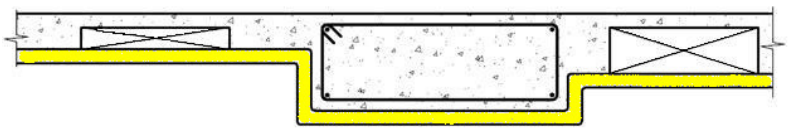

Figure 14: Section View of a Slab with Filigree Precast Concrete

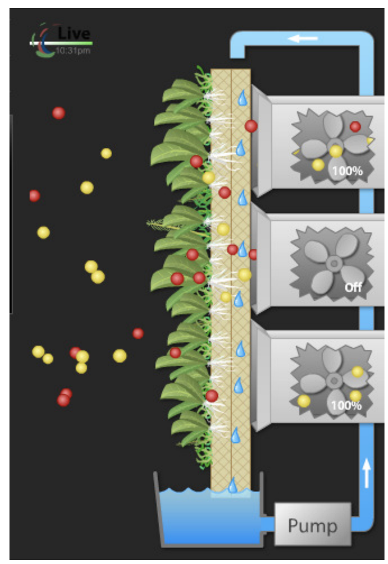

Figure 15: Diagram of a Biowall's Operating System

TECHNICAL ANALYSIS METHODS

Technical Analysis Method #1: Sustainable Techniques / Energy Efficiency

The University Sciences Building is projected to achieve LEED Gold Certification upon the completion of the project. Even though this is a solid level of accreditation, some points were skipped over that might be practical and cost beneficial to implement. Some examples include the use of solar photovoltaic panels, wind turbines, or passive heating and cooling. Other things like the use of green roofs or gray water systems could also be beneficial to the owner.

Types of Analyses Required and How to Complete Them

All sustainable analyses require a feasibility study of what it would cost to install the systems, the payback period for each, and any other non-cost related incentives to the university and its image. This study would also include the optimum arrangement and size of the suggested alternative systems. This portion may serve as the MAE breadth topic for the integrated masters program.

Technical Analysis Method #2: Implementation of BIM

Building Informational Modeling (BIM) is designed to save the construction manager and owner both time and money through upfront coordination and collaboration. It would be interesting to see how the implementation of BIM could have helped this project in particular, and what the process would look like.

Types of Analyses Required and How to Complete Them

BIM has a large variety of uses, not just clash detection and 4D modeling. It is important to determine first what uses of BIM would be of most value to the owner and the Turner team. Every project is unique, and you can spend as little or as much time as you want modeling and feeding information into that model. It is important to determine what level of detail is needed before the modeling and collaboration process begins.

Technical Analysis Method #3: Building Enclosure

Building enclosure is critical to the start and success of the building's interior finishes work. All HVAC equipment and controls must also be ready to start-up during the close-in phase of the project. This involves a lot of testing and commissioning to ensure proper functionality of the system. Building enclosure may or may not meet the 12/15/10 deadline that has been set, but it seems as though the sequencing of panels and the type of exterior façade system used could be altered to ensure interior finishes start on time.

Types of Analyses Required and How to Complete Them

This analysis includes both the changing of material and the process in which they are installed. However, it is important to maintain the same architectural look that the owner wants for the building. The rate of installation and the cost of installation, along with the overall quality of the product are important for this type of analysis. Alternatives for the non load bearing CMU or the scattered arrangement of panels may be a few of the possibilities for this analysis.

Technical Analysis Method #4: Simplification of Structural System

The structural system for the University Sciences Building is comprised of a variety of different systems. Steel, precast, and cast-in-place (CIP) concrete are all used throughout the building. There are no typical bays in the facility, and over 25 different steel beam sizes are used at the penthouse levels. The slabs themselves range from 10”-12” in thickness. A good structural breath might involve the simplification of the structural system as a whole. Why did the owner use both steel and concrete? Why not one or the other? Do the slabs really need to be that thick, or can they be reduced to 6”-8” in thickness? Is there a way to simplify the structure into typical bays for better productivity and constructability?

Types of Analyses Required and How to Complete Them

Analyses would include both structural calculations and feasibility of construction. It is important to determine material, labor, and transportation costs for the various systems. Location and availability of material/labor also play an important role in the decision making for what type of structure to chose.