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Executive Summary

Through this thesis proposal, four analyses will focus on specific challenges to Health Sciences Facility III and how to better improve the construction process. HSF III is a ten story lab and research facility for the University of Maryland Baltimore campus. The project is slated to complete in September of 2017.

Analysis 1: Design of Shoring System

Dewatering on the project was a particular challenge, which was not helped by the pile and lagging support of excavation system. The project needs soil that is dry enough to both achieve bearing capacity for the mud mat and install the waterproofing membrane. This analysis will look at a different shoring system and how that affects the dewatering efforts as well as how it provides value to the project.

Analysis 2: Industry Research: Intrinsic Motivations

From the PACE roundtable, this critical industry research will revolve around defining elements that motivate people to do work, both external and intrinsic measures. Motivation is a major driver toward production rates and how a person performs on their job. Through this research, the hope is to gain a better understanding of those motivators and how to tap into the motivations of successful projects or people and translate that to and entire project.

Analysis 3: Tower Crane Optimization

There will be a point in the project where the tower crane will exceed its peak usage. To investigate this challenge, this analysis will assess the sequencing of the project and how the tower crane and other equipment can best be used on the project for the best value.

Analysis 4: Resource Leveling for Cash Flow

Another challenge on this project involves cash flow. With the project spanning several years, there is only a certain amount of funding given to the project each fiscal year. This analysis will look at the mechanical trade and how its interior work can flatten the manpower curve and help with the distribution of funds on the project.

Analysis 1: Design of Shoring System

Background Research

During the excavation phase of HSF III, problems arose with the high water table in the last few feet of excavation to plan bottom. The current pile and lagging shoring method allowed water and mud to ooze from the walls and seep up from the ground. This was problematic to the project because the soil needed adequate bearing to pour the mud mat and the waterproofing required a dry surface during application. The mud that was coming through the walls was a great concern because it caused the shafts between the piles to slowly empty, creating voids behind the lagging. At first, the cranes and other heavy machinery were directed to stay at least ten feet away from the walls as a safety precaution. There were a few occasions where sinkholes formed on the north side between the lagging and the construction fence. This was solved by pouring concrete in the hole to prevent more mud and water from entering the hole. The concrete was of concern because the scope of this project included some utility work later in the project in that same corner where the sinkholes occurred, making it potentially more difficult to perform the work at a later date.

The dewatering system kept the water table down significantly, but not enough for the bottom of the hole to stay dry. The original documents did not call for any gravel under or surrounding the mat slab and foundation walls, but after several attempts to keep the site dry, gravel was used in some areas of the site to keep the water at bay for the mud mat to be poured. This issue caused delays in the completion of excavation as well as the beginning of the foundation work. Because of this, the first analysis will focus on exploring other shoring methods that could better keep water out.

Potential Solutions

Three systems will be evaluated for this analysis: the current system as well as two alternates. They will be assessed based on the time it takes to install, the overall cost of the system and the cost of dewatering systems that need to supplement each option. The two alternative systems to investigate will be the sheet piles and slurry walls against the current system of piles and lagging. A decision will be made as to which system provides the best value to the project based on the above criteria.

The first system assessed will be sheet piles. Compared to the second system, some advantages to this system include the availability of the product, the cost of the system, and the time of installation. One thing to consider is how the installation of the steel would affect the neighboring structures around it. Also, the soil type will be a big contributor to the amount of effort and time it will take to install. The second system to investigate is a slurry wall. Slurry walls are popular in areas with high water tables, but they take a long time to install and are generally the most expensive type of shoring. Because they also act as foundation walls, this might prove to be a small advantage to the project.

Execution

The following list includes the steps that will be taken to perform this analysis.

1. Research the cost and installation time of the pile and lagging system. Estimate an approximate value for the dewatering system.
2. Research the two alternative systems and evaluate the advantages/disadvantages of both.
3. Design the alternative system and perform any studies that seem necessary for the design.
4. Recommend the most appropriate system for the project.

Expected Outcome

After the conclusion of this analysis, it is expected that an alternative system will be of better value than the existing support of excavation method. Although the cost of installation in either case will most likely be higher than the current method, it potentially might make up for itself in the time to install and the removal of delays to start the next phase of the project. It may be most valuable to implement a hybrid system, where the pile and lagging is used on the faces that did not encounter many issues with the water. It would also be advantageous to use pile and lagging in areas where the utilities enter into the wall. This will be evaluated in this analysis.

Analysis 2: Industry Research – Intrinsic Motivations

Background Research

At the PACE roundtable, the most interesting topics were related to innovative design and incentivizing team performance. The first breakout session was about innovative design. The discussion took a different direction that originally anticipated. It was focused more on how innovation is born and the drivers behind innovation. The second breakout session discussed many types of incentives that contribute to team performance. Among those listed included organizational culture, peer pressure, recognition, personal price and potential for repeat work. Motivations to perform well differ between people, which allow for various methods to have different degrees of success on projects. It was mentioned that out of this topic one area of research could be to monitor owner engagement and how it affects success. With an owner that likes to be involved in every small decision, there is potential to research this topic on HSF. The motivations of people are interesting areas to study how it affects communication and success on a project. With a lab and research facility that requires a lot of communication between trades, this could be an interesting thing to study.

These two topics are closely related to how motivation drives performance and innovation. The research topic that sounds the most intriguing to pursue is identifying intrinsic motivators and how that affects success. Projects where the laborers are not satisfied with their work tend to be less productive, which leads to a poor use of resources. On the other hand, projects that are able to rally behind a common mission and feel a sense of pride in their work promote the best environments for innovation and production.

Research Goals

Looking at the motivations behind performance, there are a few items that are of particular interest.

1. Measure how much external or intrinsic motivators affect the performance on a project.
2. Understand how much value that project teams place in promoting motivation on a project.
3. Study how motivation changes with varying roles on a project.
4. Evaluate the main drivers to motivation and what parties hold the most responsibility to promote motivation.

Execution

The audience of this research area will be various parties on a project, from the laborers to the owner representative. This variety in audience will hopefully show a range of perception related to motivation and how that drives project performance. Through interviews of project teams, hopefully the data gathered will help with understanding how people are currently motivated to perform work. From there, literature review on ways to motivate people to perform work will be intended to find solutions to increase performance on a project.

Research Questions

The list of questions below for the survey is by no means exhaustive, but they do provide a general idea of the path that this research is intended to take.

1. To what degree do you feel responsible to motivate other people to work?
2. To what degree are you satisfied with your work?
3. How often do you receive incentives to reach a certain level of performance?
4. What things drive your motivation to perform work? (family, mission statement of the project, personal improvement etc.)
5. What suggestions do you have that would help you be more motivated to do your job?

Analysis 3: Tower Crane Optimization

Background Research

The project team mentioned that there are multiple points during the installation of the exterior façade that the tower crane will be at its peak usage. This will call for two shifts to stay on schedule and best utilize the tower crane. All of the facades will be erected at the same time and many trades need use of the tower crane, making the optimization of the tower crane's usage crucial to the success of the project. Because there is no interest in accelerating the schedule, this analysis will focus on how the re-sequencing of the exterior façade will affect the project schedule and the overall construction cost. The curtain wall and the precast will be the two major trades bargaining for crane usage throughout their time on site, and they each have a substantial amount of work that spans all of the floors.

When the first two floors of the façade begin, the structure is still being poured on the upper floors. This overlap means the façade needs to be aware of the pathway that the crane is taking to transport concrete up to the top floors. The concrete has a high chance of spilling out of the bucket and could potentially damage the façade, specifically the storefront windows on the second floor.

One important element to consider in this is how the interior trades are affected by this façade re-sequencing. If it is drawn out too long, then there will be potential delays in the interior work which will not benefit the project. 4D modeling such as Synchro will be used to help visualize and understand this relationship between the structure, exterior façade contractors, and interior trades.

Potential Solutions

With the tower crane as the element that limits production on the project, the following potential solutions will address how to best use the tower crane. Overall, the design variables that will help make the decision include the tower crane, the manpower, and the cost of installation.

The first option is to remove the two shifts of the precast and curtain wall. The overtime of the tower crane operator would not be necessary here. This option will investigate how this affects the overall project schedule. Also, with the assumed additional cranes that will be on site when the tower crane is at its peak usage, this solution will evaluate the cost of the additional cranes and the best balance between double shifts and multiple cranes on site. The mindset behind removing the two shifts is to potentially flatten out the cash flow curve in this year, since the funding for the project comes in certain amounts every year.

Second, this analysis could investigate supplementary equipment to aid the tower crane in the erection of the façade. For example, a gantry could be used to erect the punch windows and other smaller elements, which would free up the tower crane. Also, there might be some other equipment that could erect the curtain wall or precast. This may

take the responsibility of erection off the tower crane, but the cost of the equipment and impact on the schedule and other trades will be evaluated.

Finally, the third potential solution could consider sequencing the project in sections rather than clockwise. The building is broken into four sections, the north tower, south tower, atrium, and core, seen in figure 1. They are disproportionally sized, but it might help with the tower crane production. This could free up those areas inside to perform interior work sooner in areas like the atrium or south tower. If the interior trades start earlier and with a smaller sized manpower, they might be able to better level out the fluctuations of manpower throughout the project. This will also allow the tower crane to focus on specific areas and specific trades at a time.

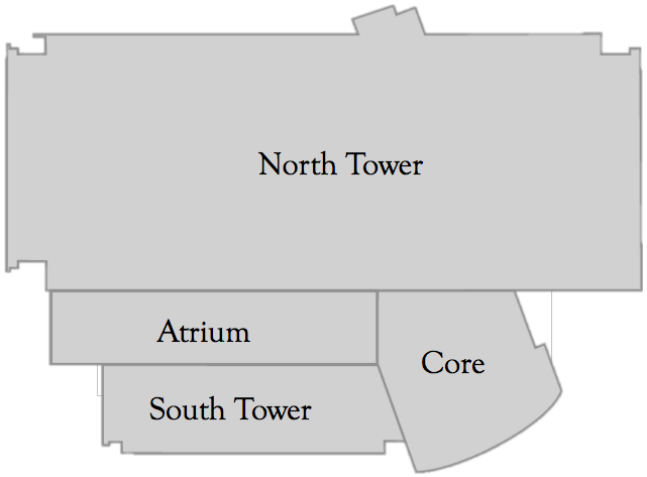

Figure 1: Breakout of HSF III

Execution

Looking at the tower crane usage, below is a list of actions that will be taken to better describe the process through this analysis.

1. Research production rates of the tower crane and trades.
2. Create a 4D model to assess the existing conditions and tower crane usage.
3. Research different equipment that can be used to aid the tower crane.
4. Create a new schedule and 4D model to optimize crane usage.
5. Evaluate the benefits and setbacks of the new schedule.
6. Study the cost impact of the re-sequenced schedule.
7. Decide on whether the new schedule provides a better value than the current system.

Expected Outcome

The current schedule will eventually require multiple cranes on site and two shifts for erection. To avoid the cost of renting a crane and the overtime of the tower crane operator, this analysis will look into the affects of using other equipment that can aid in the erection of the façade as well as drawing out the schedule to better accommodate the cash flow in that year. This analysis is expected to not affect the interior trades and will hopefully utilize the best equipment on the job to compliment the tower crane throughout its use for the façade.

Analysis 4: Resource Leveling for Cash Flow

Background Research

Cash flow is a major challenge on this project. Construction spans multiple years and the funding of this project comes in varying amounts each year. This requires a special look at how the cash is distributed throughout the project. The project delayed some purchasing of major equipment as well as the interior trades to push off major expenses into a fiscal year where a good portion of the funding will be allocated. Some trades like mechanical and electrical contractors have work for many phases of the project. For example, the mechanical trade has embeds on all of the floors that require an on-site presence during the foundation and superstructure phase. Then they begin to work in the mechanical rooms and the rough-in of their equipment. With any project, the manpower traditionally fluctuates depending on the phase of the project. This analysis will attempt to flatten that bell curve and provide a steady flow of production and manpower on the project to help aid in the cash flow of the project.

Potential Solution

Looking at the mechanical trade, this analysis will focus on manipulating the schedule of the mechanical contractor's interior work to better represent a steady flow of crews from one project to the next. The mechanical trade was chosen because they are on the jobsite for most of the project and they have a variety of expensive equipment and long installation durations. This lends itself to opportunities to look at the cash flow curve and how to alter it. First, a SIPS analysis of the mechanical trade will help understand how to allocate crew sizes and manpower for different types of work. With an understanding of sizes of crews and durations to complete work, these can be manipulated in a way to help with the leveling of manpower across the duration that they are on site.

Execution

Below is the method in which this analysis will be performed.

1. Research manpower and production rates of different interior tasks on a project.
2. Research the amount of funding received each year on the project.
3. Assemble the manpower information of the current schedule.
4. Create a SIPS schedule of the interior trade.
5. Assess the outcomes of this schedule, and decide whether not applying a SIPS type of schedule helps level out the resources of the project.

Expected Outcome

The use of SIPS will help understand the needs of the mechanical trade to perform the work and how to break up the job into repeatable chunks to level out the manpower curve. This is intended to give a more steady flow of cash per month which can help with the allocation of funds year to year. A predictable cash flow from a specific trade can help a project manager better understand where the purchasing of large equipment can be located. Although there is potential for the schedule to be reduced, the subsequent reduction in general conditions cost will hopefully balance this out.

Weighting Breakdown

The first analysis, as seen in table 1, is intended to put the most effort into. The final two analyses are inter-related which is why they have similar weighting. Finally, the research is the least weighted because it is the most qualitative of the analyses and will have the least amount of measurable outcomes.

Table 1: Weight Breakdown

	Industry Issue	Value Engineering	Constructability Review	Schedule	Total
Design of Shoring System	—	10	15	10	**35**
Research: Intrinsic Motivations	15	—	—	—	**15**
Tower Crane Optimization	—	—	12.5	12.5	**25**
Resource Leveling for Cash Flow	—	5	10	10	**25**
Total	**15**	**15**	**37.5**	**32.5**	**100**

Conclusion

Each analysis in this thesis is intended to research and better understand construction issues while utilizing the resources and knowledge gained through the pursuits of an architectural engineering degree. The breadths are designed to showcase the talents and knowledge of other disciplines that take this program to the next level.

All of the analyses cover a wide range of construction topics and are related to understanding value and how to improve value on the project, from the value of a product to the value of time spent performing certain tasks or using certain equipment on a job. At the completion of this thesis, it will be decided whether or not these analysis have enhanced the value of the project in any measurable way.

Breadth Studies

Analysis 1: Structural Breadth

The first analysis focused on a study of alternative support of excavation systems. A matrix will analyze the three systems with cost and schedule. To better understand the cost of the alternative system, there will be a structural analysis of both the sheet piles and the slurry wall. One bay of the support of excavation will be the main focus of design and analysis across all systems and extrapolated around the entire support of excavation. A study of the soil will help with the design of the retaining structures. This high level design will aid in the most accurate cost breakdown for the purposes of this analysis. Designing these systems are primarily intended to make a well informed decision on the best support of excavation system in an area with a high water table.

Deliverables:

- calculations for the design of the support of excavation systems
- results of soil study

Analysis 3: Architectural Breadth

The third analysis relates to manipulating the schedule for the optimization of the tower crane. One challenge on the project is the current design of the precast panels are too heavy on the north side for the tower crane to pick. This architectural breadth will look into the how to break the panels into smaller segments for the crane to lift. With the current configuration requiring another crane on site to erect some of the precast panels, this breadth will analyze how smaller panels will affect the cost and schedule of the north façade.

Deliverables

- know the maximum loads of the crane
- study of the current panel system
- study of how daylighting is affected in the space by reconfiguring these panels
- study how this affects the cost/schedule of the tower crane production