Senior Thesis Proposal

Greg Tinkoff

Construction Management

Maryland Public Health Laboratories

January 13, 2013

Executive Summary

The Thesis Proposal is intended to present topics for analysis that try to solve and enhance the construction process of a given project. These topics will be investigated, providing research, analyses, and evaluation that will comprise a final thesis. Analysis topics are derived from the Maryland Public Health Laboratories project that is currently being constructed in Baltimore, Maryland. This 225,000 S.F. facility is designed to contain office and laboratory spaces for the Maryland Department of Health & Mental Hygiene. HDR Architecture Inc., Jacobs Construction Services, and Turner Construction Company are those responsible for the design and construction of the $111.4 million project that is expected to be complete in the spring of 2014. The project has faced many setbacks in cost and schedule due to unforeseen conditions and natural causes. Because of these setbacks topics for analysis were chosen to help mitigate the problems in hopes of, upon research and investigation, reducing construction costs and accelerating schedule. These technical analysis topics include, modularized and precast systems, greater use of BIM, application of a dewatering system, and additional sustainable designs for the building.

The first topic presented is the implementation of precast structural members. The Maryland Public Laboratories building is designed using a concrete structural system, which allows the use of precast concrete members. With the use of precast members it is believed that the project would accelerate its project schedule as these members can be produced to quality before installation. This also will allow work frontiers to open allowing subcontractors of differing trades the opportunity to begin work before their schedule dates. Research on the idea would investigate logistical issues, installation issues, costs and schedule impacts must be considered before establishing a feasibility analysis. It's believed that using precast concrete structural members will allow for schedule acceleration, easing the time loss suffered on the project, and potential project cost savings.

On the Maryland Public Laboratories project the use of BIM was and still is very minimal. Applying BIM to other aspects of design and construction on the project will allow for opportunities for schedule acceleration, quality increase, and costs savings. The model that was used for BIM could be used to create virtual mock-ups for the building's façade system. To successfully analyze virtual mock-ups, interviews with industry professionals and virtual mock-up case studies will provide the necessary information regarding the topic. Overhead costs associated with producing these models, experienced benefits in the form of cost savings and performance efficiency will be analyzed to create an overall feasibility analysis for the topic.

A major issue that came about during the beginning of the project was an unforeseen high water table experienced while excavating. This high water table required the need for dewatering pumps and setback the project approximately 2 months due to flooding in excavated areas. The application of a dewatering system prior to excavation could have prevented the 2-month setback with little additional project cost. As the Maryland Public Health Laboratories project is set in a previously developed area the use of a Cut-Off Wall dewatering system seems the most appropriate. Deep well and dewatering systems will be placed around the site perimeter, adjacent to the proposed slurry wall or originally design pile sheeting. This will allow for water to be pumped out of the excavation area, allowing for teams to work within the space without

experiencing flooding. Cost analysis, schedule impact, and logistical plans must be provided to understand the appropriateness of the proposed dewatering system. A final feasibility study will demonstrate if this is an adequate solution to the unforeseen high water table faced on the project.

The last topic for analysis is the application use of more sustainable features to help the project reach LEED Gold certification, a current goal of project teams and the owner. It has been mandated by both the state of Maryland and city of Baltimore that the project earns at least a LEED Silver Certification. Upon sustainable consulting it has been noted that the project is 3 credits away from achieving the Gold standard. Developing a system that will reuse water runoff and domestic water will be investigated and implemented on the project. This system will potentially reduce water consumption and water runoff; allow the project to achieve the LEED credits that have been missed in the water efficiency category. Cost savings and installation cost analyses will be performed to understand the feasibility of the design. In addition coordination and sequencing issues will be examined to understand the constructability challenges associated with implementing such a system.

The intention of the proposal is to introduce areas of research on a specific project that will be used to create a final thesis. The Maryland Public Health Laboratories is the building that will be investigated to establish a final thesis. The proposal is the beginning of the process of implementing strategic ideas to better the current construction project, producing project cost savings and schedule acceleration. It will demonstrate the how individuals within the industry decide and execute plans meet specific goals of a given project.

TABLE OF CONTENTS

Project Background

The Maryland Public Health Laboratories project is a construction project located in Baltimore, MD. The Maryland Department of Health and Mental Hygiene had required the construction a new 225,000 gross square feet fit-up laboratory building that will be located on the Johns Hopkins' Science & Technology Campus in East Baltimore. The $111.4 million building project was awarded to HDR Architecture Inc. as the designers of both the building aesthetic and engineering design. Jacobs Construction Services was awarded the role as project manager on the job with Turner Construction Company as the general contractor. The new edition to the reviving community of East Baltimore began construction on December 19, 2011 and has been expected to reach project completion on April 19, 2004.

The building will host occupants of the Maryland Department of Health and Mental Hygiene offering quality office and laboratory space to conduct innovative work. The concrete structural system allows for little vibration emission throughout the building, favorable for work performed by its occupants. An intricate building envelope system is applied on the project as curtain wall assemblies, metal panels, and brick facades are collectively used to create a progressive look to the building. Sustainability features such as green roofs, economizers, and maximized daylight energy consumption define the owner's efforts to express sustainability to occupants and the community.

The goal of the project is to build a facility that is harmonious to its surrounding environment and that promotes flexibility, functionality, and collaboration among occupants of the finished project. The state of Maryland and the city of Baltimore have mandated that the project achieve a LEED certification of Silver as this building should be an expression of environmental sustainability in the community. Because of the nature of the building the owner, designer, and construction professionals have strived to create a building that publicly depicts the importance of science of public health. The Maryland Public Health Laboratories will be an icon, Baltimore's effort in the revival of this area of the city as its progressive expression reflects across the community.

Technical Analysis #1: Modularized Units &Precast Structural Members

Problem Identification

Prior to erection of the building's structural system, the Maryland Public Health Laboratories project experienced significant time losses to the schedule. These unforeseen conditions have led to a great amount of money tacked onto the project budget as additional time has been counteracted with added manpower. It is imperative to find procedures or construction techniques that would absolve the time loss. To do so investigations within areas of building design and construction will exploit the possibilities.

The general design of this building is a rectangular building consisting of 6 stories and is constructed using cast in place concrete. Introducing a precast concrete design in the early stages of construction is an idea that could greatly reduce the schedule of the project, which would have mitigated the loss of time and money currently suffered on the project.

Research Objectives

The idea for this research analysis was produced after attending and listening to the topic of modularization and precast units in construction at the PACE Roundtable conference. I was chosen as a critical industry issue because this type of construction is proving to very imminent in today's industry, as owners and contractors want to produce buildings with extremely shortened schedules. There are various ways to implement precast and modularized construction within a project. The most logical method for the Maryland Public Health Laboratories is to use a precast structural system as the linear and mostly rectangular shape of the building allows for ability to create pieces that can easily build together. This eliminates costs for onsite formwork and reduces scaffolding needed to build cast in place concrete units. Also, the ability to sequence the erection of these pieces becomes easier and due to the fact they are pre-casted, work fronts become accessible earlier in the project schedule.

To properly analyze this topic of research there are numerous areas that must be considered. A breakdown of the building's structural design, using both project design documents and column/beam schedules, must be conducted to acquire the information need to produce member sizes and quantities. Research regarding crane sizing is necessary, as the crane used to pick and install these pieces must counteract the weight of each member. Logistical research will provide information regarding the delivery process and installation of the members. Sequencing of the structural members will remain similar to sequencing of the cast in place concrete. Cost and scheduling impacts is the final area of research that will prove the feasibility of the study and indicate if the use of a precast structural system will reduce the project schedule.

To obtain the necessary information within each area of the analysis discussions from industry professionals will be conducted. Online research will help establish the best way to execute a precast concrete structural system on the given project. The phases from procurement to installation will be scrutinized throughout the entirety of the analysis to properly establish the feasibility of such an idea.

Application Methodology

Specific steps must be performed to conduct a sufficient investigation of this technical analysis. These steps include:

- Research the implementation of modularized and precast units in construction and how projects have benefitted using them.
- Conduct interviews with project teams and professionals who have applied modularization and precast systems within their projects to better understand why it is used and when to use this form of construction.
- Speak to prefabrication and precast vendors to understand the quality, costs, and schedule associated with modularization and precast units.
- Analyze costs effects and compare to originally plan of construction to understand cost feasibility of using modularization and precast systems.
- Establish implementation plans, delivery analysis, and logistical plans to better understand how these aspects affect the project and guide the determination whether to use these methods for construction.
- Establish true value and feasibility of using modularization and precast structural system on the current project.

Project Resources and Tools

To perform accurate analysis regarding the feasibility of the use of modularized and precast systems within the Maryland Public Health Laboratories Project these following resources will be used:

- Project Owner, Maryland Department of Health and Mental Hygiene
- Project Designer, HDR Architecture
- Project Manager, Jacobs Construction Services
- General Contractor, Turner Construction Company
- Precast concrete vendors
- Penn State Architectural Engineering Faculty
- Project Drawings
- Case Studies
- Research applicable literature

Potential Solutions

After all research has been gather regarding project logistics, costs comparisons, and strategies of application and a feasibility studies are conducting, there are several viable solutions that can occur.

1. The implementation of precast structural system can be used on the project, both feasible strategies that will reduce project schedule.

2. Certain aspects of the system will use precast, not the system in its entirety.

3. The idea of precast systems proves infeasible and is discarded from the project.

Expected Outcome

Precast members can significantly reduce the project schedule. It allows for crucial project pieces to be assembled without affecting current work process and can be done before the pieces are needed to be placed. There are costs associated with this type of construction as additional delivery expenditures, crane size increase costs, hoisting costs, and maintenance costs collectively add to the total cost of precast systems. To counteract these costs these systems eliminate the amount of crews necessary to implement this members and units, and change orders are eliminated if stick built material is improperly installed. Precast members are expected to resolve the effects of experience schedule prolonging incidents with little to no additional cost to the owner.

Technical Analysis #2: Virtual Mock-ups for Building Façade Systems

Problem Identification

Throughout the durations of the Maryland Public Health Laboratories project there have been a significant amount of change orders and schedule set-backs due lack of quality and error in construction. This is predominately due to the subcontractor confusion with the design documents. There are certain details that are vague or difficult to read within the drawings that have caused subcontractors to perform work incorrectly.

Incorrect work predominantly occurred during the foundation construction of the building. There were several areas where waterproofing along foundation walls were absent or installed incorrectly. This created issues amongst general contractor, Turner, and management team, Jacobs, as they discussed the implications and consequences for not having waterproofing in originally designed for spaces.

Along with waterproofing, small contracting groups who are unfamiliar to the magnitude and complexity of the building design have installed materials incorrectly. These companies, typically WBE and MBE, have been awarded the plumbing contracts and have installed P-traps and waste lines at incorrect depths within the foundation. This has caused for change orders and cutting these pieces from the concrete. Re-installation has occurred creating additional time and money to the project.

As the one of the most complex phases of the project is the building envelope construction, it would be beneficial if there were visual aid in the design. This phase is complex due to the use of four different façade systems used within the design. These include curtain wall, storefront glass, metal paneling, and a brick veneer. Virtual Mock-ups of connections of these specific façade systems to the structural design and to one another will help clarity of the design. Confusion in the design documents will be reduced as subcontractors can view these connections with a third dimensional perception.

Research Objectives

In order to properly research this topic and establish an all-around feasibility analysis there are many aspects to consider. A general understanding of virtual mock-ups must be researched and how they are beneficial to projects will be established. Costs associated with the creation of virtual mock ups will be compared to the produced benefits. Also, the research regarding the increase in quality, safety, and other indirect aspects will demonstrate the

This information will be provided mostly by industry professionals. Industry professionals will be able to provide their experiences with virtual models and what benefits they've noticed on their respective projects. They can also give their opinion whether virtual mock-ups would be beneficial on the Maryland Public Laboratories project, given the circumstances and design details.

The benefits and savings associated with virtual mock-ups tend to be qualitative so case studies will help provide a general idea for what to expect using this type of technology on the project. These case studies will provide virtual mock-ups that were implemented on projects of similar sizes and for systems of equal degree of complexity. These case studies are provided through company websites such as Mortenson Construction, and will provide reasoning why companies chose to use this models and direct benefits experienced during the project.

Application Methodology

To effectively research the analysis topic of the implementation of a precast concrete structural system, the following steps must be taken:

- Research case studies that have implement similar technology to understand associated costs and benefits.
- Conduct three interviews with industry professionals who have been a part of project that have used virtual mock-ups are have witnessed virtual mock-ups amongst their respective companies.
- Establish pros and cons list to preliminarily investigate feasibility of the use of virtual mock-ups.
- Calculate a typical overhead charge for the additional time spent to create virtual mock-ups for the curtain wall system of the building envelope
- Compare established overhead to researched cost savings associated with other projects. Use current change order costs added to the Maryland Public Laboratories project to create an overall cost analysis.
- Create a general schedule impact analysis by using research date from industry professional's experience and cases studies that have used virtual mock-ups.
- Schedule impact analysis will indicate the dates when the beginning of the construction of precast concrete member will occur and when installation will occur in the overall schedule.
- Lastly, an overall feasibility analysis will be conducted, considering all aspects that are involved with virtual mock-ups of the building envelope used on this project.

Project Resources and Tools

In order to gather all the necessary information to conduct a feasibility study whether BIM would benefit the project, several sources must be used, such as:

- Owner and their expectation of virtual mock-ups use on a project, as well as their willingness to use BIM in alternative ways.
- Project Manager, Jacobs Construction Services
- General Contractor, Turner Construction Company
- Construction professionals who've implemented BIM in ways similar to those stated above – talk to BIM professionals of the companies.
- Research case studies involving virtual mock-ups use in these aspects of construction.
- Penn State Architectural Engineering Faculty – discuss Dr. Messner the appropriateness of BIM in the areas indicated.
- Research applicable literature

Potential Solutions

Once all information is obtained and analyses, research, and feasibility studies are conducted the use of virtual mock-ups for the building envelope system on the Maryland Public Laboratories project there are several possible solutions that can be produced.

1. Using virtual mock-ups for building façade systems will significantly reduce the amount of change orders associated with the project. This in turns will decrease the overall project cost. Schedule will significantly be reduced as work efficiency on the building envelope will increase. Lastly, the quality of the product will significantly improve, as

virtual mock-ups provided extremely detailed explanations of how work should be performed.

2. Virtual mock-ups will only be able to improve certain aspect of the building envelope construction. Either schedule savings, cost savings, or quality improvement will occur. The project won't experience any other benefits from applying this models.

3. Virtual mock-ups is an infeasible piece of technology. The amount of time needed to create such models doesn't produce the desired outcomes. They should not be applied to the project as the project won't benefit from the virtual mock-ups for building façade systems.

Expected Outcome

It is expected that the use of virtual mock-ups in alternative aspects of the construction project will be beneficial to the entirety of the project. Virtual mock-ups for façade systems will promote efficient strategies to the design and construction of the Maryland Public Laboratories. The additional overhead costs, as well as the time allocated to continuously improve these mock-ups, updating information into them, won't supersede the cost savings and schedule reductions experienced using virtual mock-ups. It is expected that if building envelope virtual mock-ups were to be used on the given project, schedule acceleration and reduced project costs would occur.

Technical Analysis #3: Dewatering Systems

Problem Identification

One of the most significant issues that have been experienced on the Maryland Public Health Laboratories project to date was the high water table. During the excavation of the building's footprint project teams noticed that there was unexpected flooding within the excavated area. As excavation continued to proceed, flooding continued to pose as a problem as the amount of water entering the excavated area increased.

In the general region the water table in East Baltimore is at 36.5' above sea level or 30.5' deep from grade level. This number was established from research done by Jacobs Engineering. Because the building's design only reaches depths of 20' below grade the water table didn't pose as a problem for excavation.

Also, geotechnical reports were conducted for the given site based off fifteen soil test borings. These tests were conducted in random locations within the buildings footprint. After the testing was conducting, the report stated that the ground water table existed approximately at 44'-47' above sea level. This indicates that the ground water table is approximately 20'-27' below grade. The tested water table depth provided by in the geotechnical report assures that no portion of the building's design will constructed beneath the water table. This continued to provide confidence in project teams that there was no need for dewatering equipment for the project.
The actual level of the water table experienced on the project site was 45' above sea level or 18' below grade. This unforeseen high water table created significant problem for the site. The significant amount of water entering the excavation site was removed by means of dewatering pumps and lines. This equipment however was procured after the problem had occurred, causing the project to lose time and money.

There was a wellpoint plan implemented on the projects prior to excavation, as these wellpoints were to be installed around the excavation stite along the sheeting. Unfortunately, the system was suitable for removing the amount of water that existed within the excavation perimeter.

To mitigate the problem and continue with excavation, Jacobs had to obtain an approved change order of $585,000. These were individual change orders for deep wells, a french drain system, test pile program, a sump manifold, a lower wick manifold, wick drains, wick testing, additional dewatering costs and damages do to groundwater settlement were added to the total project budget. It also accounted for the cost to rent the dewatering equipment, deliver and install the equipment, and the additional manpower and shifts added to the project to make up for the lost time. The flooding that occurred delayed the project approximately 2 months, as many of the tasks were delayed. The construction of the foundation and spread footings had to be pushed back until a sufficient amount of water was removed from designated areas.
To absolve the severity of the problem that occurred on the Maryland Public Laboratories project, a dewatering system could have been implemented prior to the excavation phase. Dewatering systems eject the water within the ground of the building footprint and assure that no such problem mentioned above will occur during excavation. The use of a dewatering system on the project would relieve the excess water that would have affected the excavation.

Research Objective

To effectively implement a dewatering system on the Maryland Public Health Laboratories project preliminary research must be conducted. The essential document needed to begin the analysis is the geotechnical report. The project's geotechnical report, created by Schnabel Engineering, provides crucial information regarding soil types, ground water table depths, pressure test readings and allowable soil bearing capacities. A specific dewatering system, appropriate for the site conditions, can be chosen using the provided data. This is based mostly off soil conditions and excavation dimensions.

Once a desired system has been designated, the size of the system must be determined. Sizing of the system will allow for many plans and sub-analyses to begin. Sizing of the system will provide information regarding the type of equipment and materials needed to dewater the water beneath the building footprint. To effectively size a dewatering system, resources such as, *Construction Dewatering and Groundwater Control: New Methods and Applications, Third Editions*, will be used. Discharge flow and influence length equations will allow for an accurate design and mapping of the select system.

Once the system has been selected and sized pricing of the equipment, installation, materials, and labor will be obtained from industry professionals from both Griffin Dewatering and Mersino Dewatering. These prices will be used to establish a total dewatering system's cost for the proposed system, which in turn will be used in a cost analysis. The cost analysis will compare the costs associated with the designed system to the original system and the associated change orders.

A schedule impact analysis will also be conducted after the task duration to install, operate, and remove the designed dewatering system has been implemented into the project schedule. This will provide an understanding whether this system will impact the critical path of the project.

Lastly, a feasibility analysis will determine whether the designed system is beneficial to the Maryland Public Health Laboratories project. The goal is to eliminate all change orders and indirect costs created from the flooding issue experienced on the project by implementing a system that will effectively dewater the excavation site.

Application Methodology

An extensive investigation of a Cut-Off Wall dewatering system must be conducted to understand the feasibility of the system if it were to be implemented on the project. Also, research on the installation process and the duration it takes this system to successfully dewater the given building perimeter area will prove the value of the system. Several aspects that should be considered and investigated regarding this system include:

- Research Cut-Off Wall dewatering systems and alternative Cut-Off Wall systems.
- Investigate how Cut-Off Wall dewatering systems are implemented during a project and how it removes water from an area.
- Investigate the duration it takes by measuring the rate specific systems remove water for a given area and apply it to the area necessary for the project.
- Consult Jacobs Engineering to better understand the implications and benefits for using this system.
- Design a logistical layout of these walls and wells to ensure maximum efficiency in the dewatering procedure and cost effectiveness.
- Analyze system equipment and installation costs and compare them to the cost associated with the efforts used on the site to eliminate the high water table issue.

- Analyze the length of the dewatering processed used by the Cut-Off Wall system and how it will impact the schedule.
- Investigate the feasibility of a Cut-Off Wall dewatering system to decide if it should be implemented on the Maryland Public Laboratories project.

Project Resources and Tools

To successfully conduct adequate research on the dewatering system, specific resource and tools will be used such as:

- Research applicable literature.
- Interviews and discussions with geotechnical contractors and geotechnical consultants.
- Discussion with Jacobs' project team.
- Slurry wall vendors
- Dewatering equipment vendors
- Penn State Architectural Engineering Faculty
- Case studies
- Project Drawings
- Project Geotechnical Report

Potential Solutions

In conclusion to a thorough investigation of the Cut-Off Wall dewatering system, costs analyses, logistical planning, and system summaries will prove that there are three potential solutions that can be implemented on the project. The three solutions include

1. The use of a Cut-Off Wall dewatering system using slurry walls as it doesn't negatively impact the schedule and will prevent the lost time suffered as the project teams experienced the unforeseen high water table. The slurry wall is used excavation supports and will be implemented during foundation construction of the project.

2. The use of a Cut-Off Wall system using the original designed H-pile and sheeting excavation support plan. Instead of using slurry walls, the H-pile and sheeting method will be used as a barrier to the high water table. The installation of deep well will remain as the source of dewatering the area intend for excavation.

3. The use of a Cut-Off Wall system is too costly and the process of installing the equipment and removing the water won't time nor cost efficient compared to dewatering using a pump systems throughout the excavation process.

Expected Outcome

The unexpectedly high water table posed as a significant schedule threat on the project, delaying construction approximately 2 months on the Maryland Public Laboratories project. A well implemented dewatering plan before the commencement of excavation could have prevented the substantial set-back in project schedule. It is expected that the use of a Cut-Off Wall dewatering system using the originally planned H-pile and sheeting excavation support system will be the most cost efficient dewatering process that will allow for excavation without the experience of water table implications. Although the H-piles and sheeting may not be as effective as a barrier to the water table compared to a slurry wall, slurry walls are more expensive and once placed in the ground they will continue to remain in place. If the slurry wall isn't a part of the structural design it is less efficient, only acting as an impervious barrier to a water table.

A dewatering system such as a Cut-Off Wall system will tack on additional costs to the total project cost, but the benefits will outweigh the lost time and money spend dewatering the flooded areas during the previous excavation of the project.

Technical Analysis #4: Further Implementation of Sustainable Design

Problem Identification

A building of the magnitude of the Maryland Public Laboratories will have a great cost associated with the design and construction. The total projected cost at the beginning of the project was estimated to be $110 million, but with the addition of change orders the total has increased to $112.5 million. This is a large sum of money provided by the owner for the construction of the new facility. Once the building has been turned over to the owner for operational use, it continues to generate costs. These costs include the energy required to power the building's operations, potable water for building occupants, and maintenance costs.
In order to make up for the cost to build the project and those associated with running the facility certain systems can be value engineered to reduce material cost, installation cost, or increase energy savings. A value engineering idea that has been mentioned on the project, but never implemented was the idea of a stormwater harvesting system used within the green roof design. The ability to use stormwater and domestic discharge water as grey water within the building, as well as reuse water consumed by the building and its occupants would create resource cost savings. This will reduce the cost of water bills and with time help to potential pay-off the cost of construction.

In addition to the cost savings associated with implementing the stormwater harvesting system, it will potentially achieve unattained LEED requirement points. The Maryland Public Laboratories project had Sustainable Deign Consulting do a preliminary LEED evaluation to provide a synopsis of the areas the building would earn points. Within the report it was indicated that four points were lost in the Water Efficiency category. The points missing points fell into the two sub-categories, Innovative Wastewater Technologies and Water Use Reduction. These two sub-categories directly relate to the value engineering topic regarding grey water systems. If the system were able to achieve these four points, the total points acquired by the Maryland Public Laboratories project would be 61 points. This would give the project a LEED Gold certification.
Both the state of Maryland and city of Baltimore have mandated this project reach a sustainable rating of LEED Silver. This requirement has been established to project a sense of innovation and progression by the building to the community. A revival program has been enacted within the East Baltimore area as the community strives to rebuild the once impoverished area. Achieving LEED Gold will not only benefit owner's through reduction in operations cost, but will exceed the community, city, and states expectations for the building. A LEED Gold facility will be a great addition to the area and serve as an icon for the public.

Research Objectives

To accurately assess the feasibility of implementing a stormwater harvesting system a number of calculations, planning, costs, and schedule analyses must be conducted. Stormwater harvesting systems are designed to capture all water that can be potentially reused within the building and to reduce stormwater runoff. To begin a stormwater harvesting supply will be calculated in gallons. This will allow for accurate sizing of a cistern that is used to store the water. This can be calculated using a rainwater harvesting calculator provided by Contech.

The tank size will allow the ability to size the components, such as pumps, filters, and discharge piping involved with the system. Using the given sizes for each component, pricing for the system can calculated.

Also, the tank size will determine where in approximation to the building footprint the tank will be installed. A tank that serves structures over 100,000 S.F. will require a large area to be excavated. An evaluation of the parking lot north of the project footprint and west of the project trailer complex will be performed to determine whether this is a sufficient space to install the stormwater harvesting system.

If the desired location proves sufficient to install the system a demolition and excavation analysis will be performed. Demolition costs will be created based off HDR's proposed demolition for the Maryland Public Laboratories Project. This is due to the fact that this parking lot area was originally a part of the planned demolished portion. Excavation for the system will be researched and mapped on the site plan to demonstrate the location and depth the system will be installed. Also the size will provide a cost associated with the excavation. Lastly discharge lines will be also mapped to and from the building and indicated in the excavation plan.

Once all costs associated with designing the structure have been comprised, the value will be compared to the cost associated with the facilities water consumption. The cost savings produced by the rainwater harvesting system will be used as the basis for comparison. In addition a life cycle cost analysis will be conducted analyzing the cost savings over time and the cost associated with maintaining the system. The goal is to hopefully save enough money in the future to pay off the building project.

The total reused water will be calculated supplied by this system will be used for LEED evaluations. The quantity of water runoff conserved and re-introduced back into the building will hopefully be sufficient enough to meet point requirements in the Water Efficiency category. Sustainability consulting has determined that based on the design point lost within this category are due to the lack of innovative wastewater technologies and water use reduction.

A schedule impact and sequencing analysis will be done investigating where during the construction project this will occur and for how long. Because this type of construction occurs adjacent from the building project there should be little affect to the critical schedule and confliction of sequencing.

Lastly a feasibility study will conclude whether such a system would be beneficial to the Maryland Public Health Laboratory facility. It is the goal that a significant costs saving will be attributed to the system over time, compared to the additional upfront costs to the building's construction.

Application Methodology

To effectively research the analysis topic of stormwater harvesting, the following steps must be taken:

- Conduct preliminary interviews with Contech Engineered Solutions, Jacobs Engineering, and Turner Company to discuss system sizing and water supply/demand for the Maryland Public Health Laboratories facility.
- Use Rainwater Harvesting Calculator to efficiently size a system appropriate for the building required loads.
- Map demolition and excavation for the proposed system installation.
- Price system and calculate costs associated with the installation for a cost analysis.
- Compare costs of system and installation with potentially savings cost through current water/sewer rates for Baltimore City.
- Analyze the impacts on the schedule and determine the total duration of the installation of the system.
- Compare runoff water and grey water values to LEED credit requirements to determine if additional point will be achieved.

- Conduct an overall feasibility study for the stormwater harvesting system.

Project Resources and Tools

In order to gather the necessary information to conduct research on the implementation of these sustainable features these resources will be used:

- Research applicable literature.
- Vendor information on the product. (Contech)
- Jacobs Engineering.
- Project Owners goals and expectations
- Turner Construction company, GC
- Penn State Architectural Engineering Faculty – David Riley
- Case studies
- Project Drawings
- LEED Evaluation Report

Potential Solutions

In order for the project to achieve LEED Gold certification, project manager and owners must implement the sustainable featurs into the design to make up for the currently lost credits. These must happen without compromising schedule, the cost, or the design of the building. There are three potential solutions to this analysis that could occur:

1. The stormwater harvesting system is beneficial to the overall design of the building allow the project to achieve LEED Gold certification. They don't create significant additional initial costs to the building and doesn't negatively impact the project schedule. The building owner experiences

2. The stormwater harvesting system does add a significant cost to the project, while still being providing the ability for the building to achieve a LEED Gold certification. The system will be able to payoff itself within the next couple years.

3. The stormwater harvesting system in an infeasible system that produces significant additional costs and time to the project. The additional points needed to achieve LEED Gold certification will not be obtained. The stormwater system will pay for itself after over 10 years of operation.

Expected Outcome

After the consideration of the stromwater harvesting idea it has been expected that the implementation of the each will benefit the project. The building will be able to meet LEED Gold certification requirements, also while consuming less water, therefor increasing water cost savings. The use of this system will allow for run-off water to be consumed significantly reducing water consumption costs without greatly compromising the construction project as a whole. The cost this features may increase the cost of construction initially, but the owner will see paybacks with the design, meeting the great goal of an innovative and sustainable project.

Conclusion

This report is intended to propose topics for analysis for the Architectural Engineering Senior Thesis. Of the four, three focus on current industry issue that are prevalent in the industry today. The idea of prefabricated components is a process used to accelerate the schedule of a project. This would be beneficial to the Maryland Public Health Laboratories as the project has faced many set-backs in the schedule and the use precast members would allow the project to regain lost time. Using BIM in more areas of the construction process will allow more efficient coordination, reduction in cost and schedule, and more efficient building operations. BIM is used minimally in the project and could be benefitted if applied to more aspects of construction, such as virtual mock-ups for building systems, specifically the building envelope. An unforeseen high water table was the source of many set-backs in the total project schedule as preliminary dewatering techniques weren't considered prior to excavation. A look at dewatering methods can substantially alleviate the project from the time lost by the from the high water table incident. Lastly, sustainability and achieving LEED Silver was a main goal of the owner and project teams for the Maryland Public Health Laboratories. As a currently industry topic today it is crucial that building are designed as such to consume less energy and create quality indoor environmental spaces. Added stormwater harvestings system can help the project achieve LEED Gold, while producing costs benefits in the process.

Examining all topics explained will provide the necessary information to conduct analyses for a thesis. The results produced by these analyses will hopefully improve on the construction process and design of the project, bettering the industry. Enacting these strategies are hoped to improve the efficiency on the project and provide a better understand the decisions that must be made to ensure problems are solved in a cost and schedule efficient manner.

Appendix A: Proposed Thesis Breadth Topics

Breadth Topics

Mechanical Breadth (Analysis #3)

The Maryland Public Health Laboratories has experienced significant amounts of flooding during the excavation process. This has been due to an unanticipated high water table. To effectively perform a feasibility study for the dewatering system in analysis 3 a system selection, sizing, and mapping is necessary. The Powers textbook for Construction Dewatering and Groundwater Control will be used to provide all necessary equations to appropriately size a system necessary for the given project.

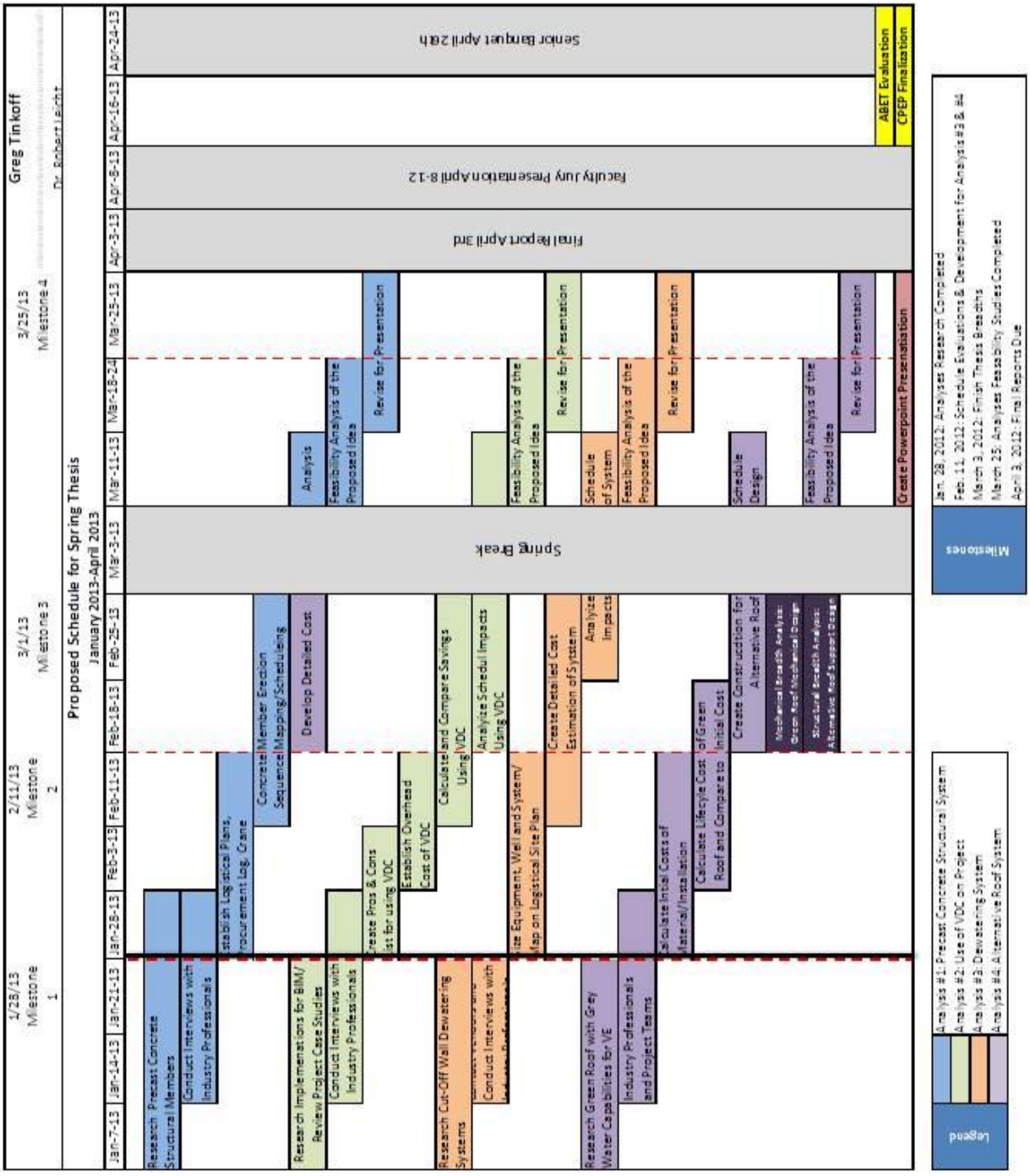
Once the system is selected and sized it will be appropriately mapped on the project site. It must be mapped as such to effectively eject enough groundwater from the site, lowering the groundwater table to an adequate level for excavation. This is also performed using equations from the mentioned text. This will allow for cost analysis, constructability evaluations, schedule impacts, and an overall feasibility study for the system.

Structural Breadth (Analysis #1)

There are structural considerations that are needed to be made when applying a precast structural system into a building. Breaking down a building originally designed cast in place structure is not enough to accurately investigate analysis 1. A structural analysis will investigate punching shear at an interior column, as the drop columns have been removed for precast design. This will demonstrate whether the design can possess the strength to withstand the shear load applied on the floor slab at the given column without allowing the column to puncture through the slab.

Also, the span length of hollow core planks will be performed. This will provided accurately lengths of plank design that can withstand the superimposed load at a typical floor. These loads will be calculated by the live load of the given occupancy area. Once a plank span has been chosen that can withstand this superimposed load, an accurate number of planks necessary for the design will be able to be established.

Appendix B: Senior Thesis Timetable


Greg Tinkoff
Dr. Robert Leicht
Proposed Schedule for Spring Thesis
January 2013-April 2013
1/28/13 Milestone 1
2/11/13 Milestone 2
3/1/13 Milestone 3
3/25/13 Milestone 4
Jan-7-13
Jan-14-13
Jan-21-13
Jan-28-13
Feb-3-13
Feb-11-13
Feb-18-13
Feb-25-13
Mar-3-13
Mar-11-13
Mar-18-24
Mar-25-13
Apr-3-13
Apr-8-13
Apr-16-13
Apr-24-13
Research Precast Concrete Structural Members
Conduct Interviews with Industry Professionals
Establish Logistical Plans, Procurement Log, Crane
Concrete Member Erection Sequence/Mapping/Scheduling
Research Implementations for BIM/ Review Project Case Studies
Develop Detailed Cost
Conduct Interviews with Industry Professionals
Create Pros & Cons List for using VDC
Establish Overhead Cost of VDC
Research Cut-Off Wall Dewatering Systems
Calculate and Compare Savings Using VDC
Conduct Interviews with
Analyze Schedul Impacts Using VDC
Spring Break
Size Equipment, Wall and System/ Map on Logistical Site Plan
Create Detailed Cost Estimation of System
Analyze Impacts
Research Green Roof with Grey Water Capabilities for VE
Industry Professionals and Project Teams
Calculate Intial Costs of Material/Installation
Calculate Lifecyle Cost of Green Roof and Compare to Initial Cost
Create Construction for Alternative Roof
Mechanical Breadth Analysis: Green Roof Mechanical Design
Structural Breadth Analysis: Alternative Roof Support Design
Analysis
Feasibility Analysis of the Proposed Idea
Revise for Presentation
Analysis
Feasibility Analysis of the Proposed Idea
Revise for Presentation
Schedule of System
Feasibility Analysis of the Proposed Idea
Revise for Presentation
Schedule Design
Feasibility Analysis of the Proposed Idea
Revise for Presentation
Create Powerpoint Presentation
final Report April 3rd
Faculty Jury Presentation April 8-12
Senior Banquet April 24th
ABET Evaluation
CPEP Finalization
Legend
Analysis #1: Precast Concrete Structural System
Analysis #2: Use of VDC on Project
Analysis #3: Dewatering System
Analysis #4 Alternative Roof System
Milestones
Jan. 28, 2012: Analyses Research Completed
Feb. 11, 2012: Schedule Evaluations & Development for Analyses #3 & #4
March 3, 2012: Finish Thesis Breadths
March 25: Analyses Feasability Studies Completed
April 3, 2012: Final Reports Due