Senior Thesis Proposal

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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 modularized mechanical units and the use 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. Modularized mechanical units will be used above laboratory spaces, as these spaces prove to be the most complex areas, with the exception of the mechanical room. MEP construction within these spaces drive the critical path of the schedule towards the end of the project and is an area that could potential see time reduction if modularized mechanical spaces were implemented. For each idea, logistical issues, installation issues, costs and schedule impacts must be considered before establishing a feasibility analysis. It's believed that using both the modularized mechanical units and precast concrete 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 value engineering opportunities to be applied, easy subcontractor coordination and direction, schedule acceleration and costs savings. There are four areas where BIM could be applied to the project that would produce benefits. These are using BIM for energy modeling, as built & construction document applications, site logistic coordination, and owner turnover for operational uses. It is important to understand where BIM must be applied in a project because over using BIM can cause for unnecessary work scope for those applying BIM. Overhead cost analysis compared to cost savings seen using BIM on other project will be considered. Schedule impacts using BIM in the multiple areas of the construction and design project will also be noted. A final feasibility analyses will determine whether using BIM in a more holistic sense will prove beneficial towards the project, producing schedule acceleration and cost savings.

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. The addition of chilled beams in office and laboratory space, dual enthalpy wheels in the HVAC system, and alternative roof design that allows for rainwater harvesting will provide enough credits for the project to reach Gold certification. Re-design of the roof and HVAC systems will be necessary and will be the basis for the breadths for the Thesis. Changes to the structure and cooling loads of the building will be calculated to understand each features impact on the original building design. Schedule impacts, costs analyses, installation evaluation, and a feasibility study for each proposed sustainability feature will provide the information necessary to determine if these will collectively achieve the LEED Gold certification and produce energy cost savings, without greatly increasing project costs.

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.

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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

During the beginning phases of construction, immediate challenges were faced that caused the project schedule to suffer. These issues collectively contributed to schedule slippage as project teams have devised plans to make up for lost time increasing the amount of crews working on site and the number of days per month these crews would work. It has been approximated that hundreds of thousands of dollars would be spent to hire additional crews that would work such a great deal of overtime. Modularized units and precast structural members is an idea that would allow contractors to continuously perform quality work, potentially mitigating the problems that have affected the schedule on site.

Research Objectives

Modularization and prefabrication is a fairly new topic in the construction industry that refers to the idea of assembly systems as a whole, then delivery these units to site for installation. It's thought to be a way of significantly reducing the schedule of a project as these units can continuously be built off site, while on-site tasks are being performed. There are a couple of methods of modularization and precast may benefit the Maryland Public Laboratories. One of which is the use of precast concrete structural members.

The Maryland Public Laboratories is a cast in place concrete structural system that used the continuously use of formwork, pours, and curing to create each floor of its sub and superstructure. This process is a major part of the project critical path and by reducing it using precast concrete members could greatly reduce the schedule of the entire project, reducing the severity of the problems faced prior to the construction of the building structure. Structural members can be constructed offsite simultaneously, ensuring that they are built to appropriate quality. These members will not have to be protected from naturally damaging conditions. Also, the ability for these members to cure while prior activities are in progress opens work frontiers for alternate tasks quicker than when casted in place.

To understand whether the implementation of precast structural members would benefit the schedule and potential cost of a project extensive research on the procurement, cost and installation methods must be considered. Because these units would be rather large in comparison to the material used for a cast in place system the procurement of these members would need to be analyzed in a logistical sense. Cost analyses of creating and shipping these members to site, as well as the added crane size will need to be compared to the originally designed cast in place method. Lastly, sequencing of these pieces must be considered to assure it is feasible to build by piece instead of casting columns and floor slabs.

As this building is considerably comprised of laboratory spaces involving complex mechanical features, the use of modularized mechanical units used in plenum space above these labs could significantly reduce project schedule. Along with the cast in place superstructure construction, the installation of mechanical equipment in the laboratory space is a major aspect of the project schedule. This critical path activity predominately drives the schedule throughout the interior phase. Implementing modularized units and hoisting them into designated lab spaces will reduce the time spent stick building complex mechanically design laboratory space and will reduce potential system design clashing. Also a reduction in crew size will occur as multiple trades will not have to be present to construct the mechanical spaces above each laboratory.
To properly analyze the use of modularized mechanical units above laboratory spaces, consideration of the procurement process, the costs analysis of units compared to stick built systems, and process of

installation is crucial. Similar to precast concrete structural members, the procurement of these units must be taken into consideration, as the time of delivery and area for storage must be established. The costs comparison of creating these units off site, shipping, hoisting, installation, and maintenance of these units must be conducted to determine the feasibility of the modularized units. Lastly, strategies of inserting these units into the building, navigating throughout the building and hoisting them into place will need considered, ensuring that this process can be implemented without affecting other interior work.

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 impanation and a feasibility studies are conducting, there are several viable solutions that can occur.

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

2. The use of one or the other option will be applicable to the project as it will mitigate schedule loss during the current project.
3. Certain aspects of each system will use precast or modularized sets, not the system in its entirety.
4. The idea of modularization and precast systems proves infeasible and is discarded from the project.

Expected Outcome

Modularization and the use of 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 modularization and 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. Modularized units and 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: Holistic Application of BIM

Problem Identification

Building Information Modeling or BIM is a tool used by project teams to greatly improve the efficiency and quality of the design and construction process. Unfortunately, BIM wasn't used to it full capacity on the Maryland Public Health Laboratories. HDR designed a preliminary BIM model only with the intentions as a visual tool for the owner. It was used to provide a 3-D image of the building so the owner would understand how the project after completion, would appear. Afterwards, it was turned over to the general contractor, Turner, who has used the model to conduct MEP coordination on the project, but not for much else. Applying BIM to alternative areas of the construction project may help reduce the number of task errors present in the field, reduce the number of change orders, improve site logistical plans, implement viable value engineering ideas, and once finished be able to be provided to the owner for operational use. This can greatly improve schedule and potentially reduce costs accumulated on the project due to negligence and change orders.

Research Objectives

The use of BIM on an array of aspects throughout can greatly benefit the construction process of the Maryland Public Health Laboratories. Because this project was mandated to achieve LEED Silver certification it was mandatory that the design team, HDR Architecture, provide an energy model of the building using BIM. If this energy model was used throughout the design process and into the construction process to implement value engineering ideas project teams could enhance sustainable features of the building, creating a more energy efficient building, exceeding the goals of the current project. By doing so would create little additional overhead cost as there is a required energy model already established that can be used within BIM for value engineering purposes. The expenditures that would be associated with such would be the soft costs of additional research and time spend manipulating the BIM module to account for energy modeling.

In addition to energy modeling, the use of detailed construction documents and as-built drawings will help subcontractors easily identify their scope of work and the procedure they must follow to perform their tasks to the expected degree of quality. There have been issues regarding subcontractor not being able to identify all equipment and materials in their scope of work due to confusion of the construction drawings. This has allowed for improper installation of materials and equipment creating additional change orders as well as time spent overviewing the mistake and discussing whether the task may proceed without consequences to the project. Implementing detailed construction documents and as-built drawings into the BIM model will allow contractors to review their scope of work prior to beginning the task so they can easily understand the materials and the procedures used to complete the task. As-built drawings will allow others to observe the deviation of the project on site compared to the original drawings and successfully construct to what has been established in the field.

Site logistical modeling would also be a key feature of BIM that would prove beneficial to this project. Because the site is located in such a congested area and the designated project space only allows for minimal staging, proper allocation of space is crucial. Updating and manipulating the BIM model to account for the staging of equipment and deliveries will assure efficiency with site logistics, preventing problems that could impede the construction process and increase site safety.

Lastly, there has been no indication that Turner plans to turn over the model to the owner for operational use after the project has been completed. It would be beneficial if operational and maintenance information was implemented into the BIM model for mechanical and electrical systems within the

building. Due to the complexity of mechanical and electrical systems within the building it would be beneficial to have a model that represented the efficiency of equipment within the building and its current status. This would allow owners to understand what equipment is currently malfunctioning, what needs to be repaired, and how to reach the specific component. It allows for buildings to be more efficient, potentially saving owners money throughout the lifecycle of the building.

Even though BIM is a tool that provides substantial benefits to a construction project it is up to the owner's discretion on whether they believe it is necessary to be used. There are additional overhead costs when implementing BIM on a project and the more uses for BIM the greater the cost. The owner must establish what is required of BIM on a project and must weigh the options whether BIM is beneficial in certain aspects of a project. Through case studies and owner/contractor/designer surveys the benefits of BIM can be recognized or disproved through the previously stated areas. Combining that with feasibility studies of added overhead costs in relation to costs savings experienced using BIM, the actual value using BIM in a holistic approach will either prove beneficial or not worth the time or effort in regards to the Maryland Health Laboratories project.

Application Methodology

To understand the true value of BIM and the many uses of the tool on a number of aspects of a construction site several steps must be taken. These steps provide personal accounts and experiences with the use of BIM and how BIM has proved valuable in certain occasions. These steps include:

- Thorough investigation on the indicated uses of BIM and how they can benefit a project.
- Cost analyses associated with overhead costs when implementing alternative uses of BIM.
- Use cases studies and alternative research documents to investigate the use of BIM in an operational and maintenance sense and the cost benefits experienced after turning over a model to the building owner.
- Time consumption evaluations to establish the necessary time allocated to meet these BIM requirements.
- Interview owner to understand their expectations of BIM on the current project and if they would have allowed additional uses of BIM to occur.
- Interview Jacobs and Turner to fully understand the, to date uses of BIM and if they possess the ability to implement BIM in the areas previously mentioned.
- Establish a feasibility study of whether implementing BIM to a variety of aspect of construction would truly benefit the construction 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 BIM 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 BIM 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 regarding a holistic approach of BIM on the Maryland Public Laboratories project there are several possible solutions that can be produced.

1. Using BIM will benefit a project as it will reduce the cost the build and time spent building the current construction project. Value engineering using a BIM energy model will allow the implementation of energy efficient designed. Detailed construction documents and as-built drawing will prevent improper construction within the field, reducing change order costs and project delays. Site logistical modeling will improve the efficiency of laydown and deliveries of material assure that materials are readily available for use without delays the project. Turn-over of the BIM model to the owner will allow the building to function and be maintained in an energy efficient manner providing costs savings throughout the lifespan of a building.

2. Only certain aspects are positively affected by BIM, produced schedule reducing and cost saving outcomes. The other aspects are deemed unnecessary and consume too much time and effort by project teams to be viewed as beneficial.

3. The use of BIM besides for MEP coordination and a visual model is unnecessary, producing little to no benefits towards the project. The invested time maintaining and manipulating the model doesn't achieve expected benefits as it was believed to.

Expected Outcome

It is expected that the use of BIM in alternative aspects of the construction project will be beneficial to the entirety of the project. A holistic approach using BIM 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 the BIM model, updating information into it, won't supersede the cost savings and schedule reductions experienced using BIM in multiple ways. It is expected that if BIM were to be used for energy modeling, construction and as-built documentation, site logistical planning, and building operational and maintenance use schedule acceleration and reduced project costs would occur, as well as continuously cost savings through reduced building energy consumption.

Technical Analysis #3: Dewatering Systems

Problem Identification

As the project teams commenced excavations they were face with an unforeseen condition that has been the cause to major setback in the project schedule. It was noticed that the water table encountered during excavation was higher than the one reported in the geotechnical report. As excavation continued to proceed the water table became more of a problem flooding specific areas preventing foundation construction to proceed. Dewatering pumps were brought to site to alleviate the flooded excavated area as water was pumped away from the excavation perimeter. This set back the schedule approximately 2 months and added costs of construction due to the procurement of the water pumps and lines. The use of a dewatering method prior to construction may have prevented the water table issue preventing the loss of time on the project.

Research Objective

One of the most severe issues experienced on-site was the unforeseen high water table that has caused major setbacks in the project schedule, as well as accumulated additional costs. To prevent these from occurring using a Cut-Off Wall dewatering method. This type of dewatering method is used on projects that have a lot of existing conditions and structures adjacent. This is so with the Maryland Public Laboratories as the project is located in East Baltimore, a developed urban area that surrounded by roadways and buildings on all sides. Slurry walls are placed around the building perimeter that act as barriers to the water tables. Deep wells will be drilled adjacent to these walls that will consist of pump assemblies. This will allow water to be removed from the building perimeter before excavation occurs.

The use of a dewatering system prior to excavation will eliminate any potential problems facing high water tables during excavation. The implementation of this system is not used to accelerate schedule, nor reduce initial cost of construction on the project, but is used to prevent problematic incidents that have accumulated costs and has set-back the project schedule several of months. The slurry walls created also serve as excavation support so the H-pile sheeting used on the project can also be discarded.

To consider the possibility of implementing a dewatering system prior to project excavation several an investigation of the process should occur as well as cost analyses. Preliminary research has led to the discovery that a Cut-Off Wall dewatering system is most suitable for this project. An investigation of the process of how the system is implemented and how it functions should be performed to give a better understanding of the system in general. The accessibility to equipment and time it takes the system successfully accomplish its task this system will prove if it is a viable solution compared to dewatering the flooded areas during excavation through the use of pumps. Cost analyses will demonstrate the feasibility of the system in comparison to the relief efforts used on the project when faced with the implication of an unforeseen high water table. There are several aspects to consider before establishing whether this system will be beneficial to the project before excavation proceeds.

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

It has been mandated by the state of Maryland, as well as the city of Baltimore, that this project achieves LEED Silver certification. The design and construction professionals have strived to meet these mandated requirements, reaching a LEED evaluated design that received 57 credits. This has score guarantees a LEED Silver certification, but only 3 addition credits will allow the project to receive a LEED certification of Gold. It has been a mission of Jacobs Construction Services and the owner to meet the Gold standard and have continued to work together to value engineer ways to do so. As the goal of the design of the building was to express innovation and sustainability it is important that this building achieve a maximum level of sustainability. Value engineering idea that will not only make the building more sustainable, but reduce construction costs and building operational cost will benefit the owner and those of the community, exceeding the expectation of the state and city.

Research Objectives

Sustainability has been a lead objective for current projects, as many owner and design professionals agree to create buildings to meet LEED specifications. The Maryland Public Health Laboratories is a project that has been designed to achieve sustainable goals by implementing innovative strategies to consume less water and energy, as well as positively impact its surrounding environment. It has currently been expected to achieve a LEED Silver certification and is on the fence of reaching a Gold certification. To achieve this certification project design and construction teams could consider the value engineering ideas of implementing chilled beam systems within office and laboratory space, along with the installation of dual enthalpy wheel in the buildings HVAC system. Also, choosing another roof design that may allow for the harvesting of storm water to be used as “grey water” within the building is another value engineering idea that will allow the project to achieve LEED Gold.

When considering the mechanical components of a chilled beams and dual enthalpy wheels it is understood that these either consume less energy to operate or recovery additional energy that would be exhausted from the building. This would allow the building to operate more efficiently, decreasing the money spent on energy consumption. Also, using these systems can potentially decrease the sizing of the HVAC system as it doesn’t require as much energy to meet specific requirements of the building facility type. Construction and scheduling methods must be evaluated regarding the two systems as there may be additional consequences or benefits resulting in the use of them. Also, cost analyses must be conducted to understand the financial impact on using these systems. Additional installation costs, reduced building operational costs, and reduction of HVAC system costs, as well as simply unit cost will be researched to understand the value associated with implementing this features in the design.

A green roof system has been currently designed to for the Maryland Public Health Laboratories. This has disallowed roof runoff to be reused and implemented with the building. If another alternate roof system was used that promoted the use of runoff storm water use within the building LEED credits can be achieved that has previously been missed and a reduction in water consumption would result in the design. Even though this seems to be viable value engineering idea, there are many considerations to be made when applying the alternative roof. Structural issues occur as the change in the design may produce a different load that could change create structural design needs. Costs comparisons of the original green roofs and a new alternative roof need to be considered to understand the feasibility of the proposed

design. Also, green roofs provide certain amount of insulation to a building and the loss of it could create additional HVAC loads within the building adding to the cost of building operations.

The use sustainable features such as chilled beams, dual enthalpy wheel, and an alternative roof design that allows for harvesting roof runoff can help the project achieve LEED Gold certification, a recent goal established by project managers and owner. But, many considerations due to affects in the current design and costs associated with the application of new sustainable features must be made before establishing the value of these features.

Application Methodology

To fully evaluate and understand the impact additional sustainable feature may have on the current Maryland Public Health Laboratories project steps must be taken. These steps will provide the research to successfully produce cost analyses of the new design in comparison to the original designs and effects each will have on other systems within the building. These steps include:

- Research chilled beams, dual recovery wheels, and alternative roof systems to understand how they function, what benefits they provide, and the costs associated with the feature.
- Interview vendors of these features for further investigation of these features.
- Investigate case studies on projects that have implemented these features and the benefits or drawbacks produced from the use of them.
- Consult Jacobs Engineering and Construction Services to understand the feasibility of using these features and additional implications associated while constructing.
- Evaluate schedule impacts of applying these sustainable features.
- Conduct costs analyses of these features using their energy savings costs, installation and product costs, and costs to construct to compare with the cost of the original design.
- Evaluate and calculate changes in structural and mechanical demands when using these features.
- Investigate the true value of these sustainable features and decide if they are worth installing.

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.
- 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 sustainable features 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. All three sustainable feature designs are beneficial to the overall design of the building allow the project to achieve LEED Gold certification. They don't create additional initial costs to the building and don't negatively impact the project schedule. The building owner experiences
2. Only a couple of sustainable features are used within the total project design, while still meeting the goal of achieving LEED Gold. Remaining features proved unnecessary or actually hurt project total costs and schedule and weren't considered as an alternative.
3. All sustainable features were considered, but all weren't accepted into the design of the building. Even though they these features helped achieve LEED Gold they negatively impacted the cost and schedule and constructability factors have made these an infeasible value engineering idea.

Expected Outcome

After the consideration of all three sustainable value engineering ideas 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 energy, therefor increasing energy savings. The use of an alternative roof will allow for run-off water to be consumed significantly reducing water consumption costs without greatly compromising the insulation factor of a green roof. The cost of these 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 modularization and 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 of modularized units and 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. 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 sustainability features 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

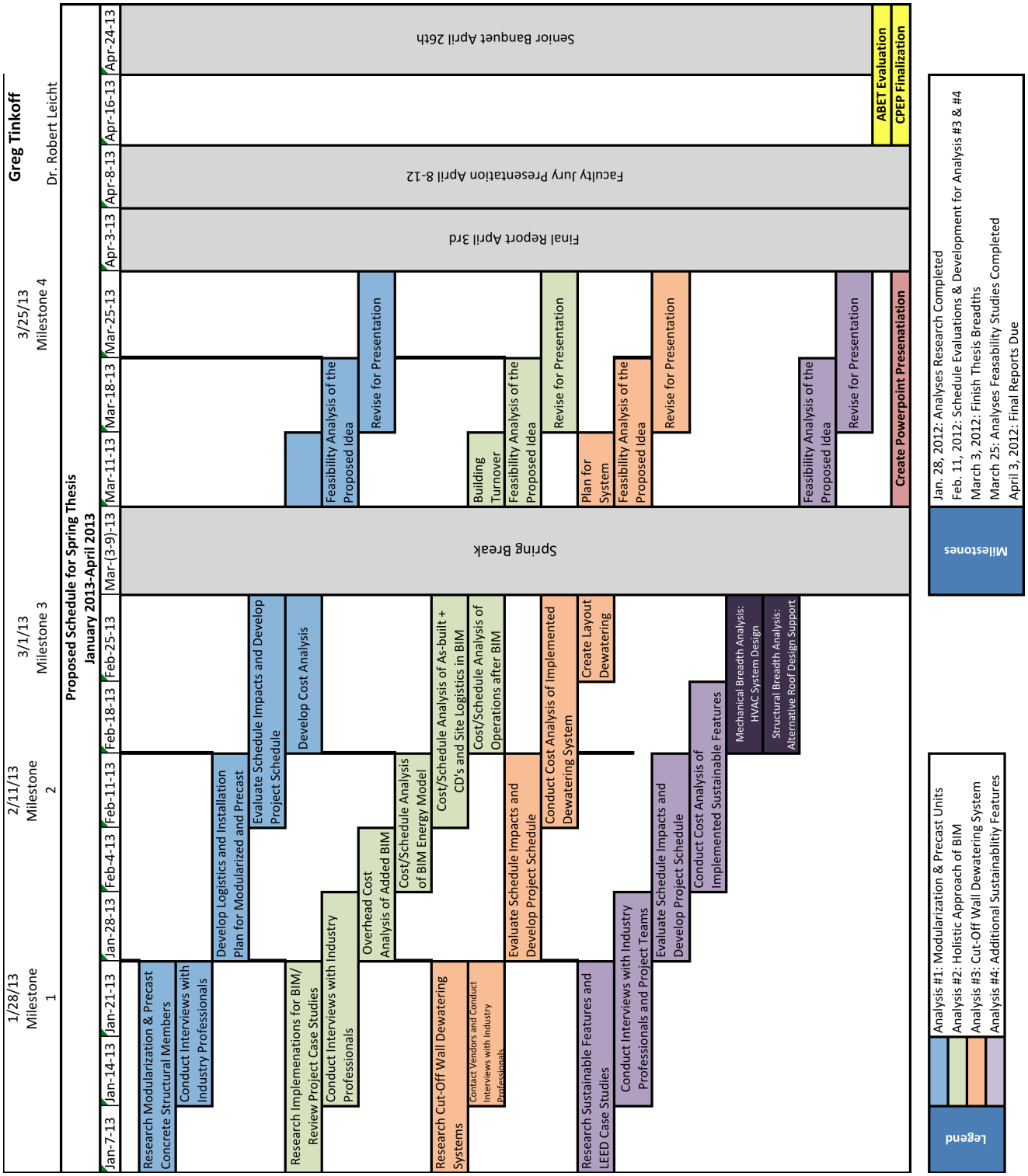
Mechanical Breadth (Analysis #4)

The Maryland Public Health Laboratories have been mandated to achieve a LEED Silver certification, but after sustainability consulting it has been discovered that the project is just shy of LEED Gold certification. The addition of sustainable features such as chilled beam systems, dual enthalpy wheels, and an alternative roof design will allow for the project to meet LEED Gold requirements. By implementing these features, extensive research and calculation must be provided to understand the impact each will have on the total building HVAC load. Also an alternative roof design will change the insulation from that provided by the green roof, also affecting the cooling load of spaces within the building. The change in cooling load and the new energy required to support these features must be calculated and evaluated to successfully establish the feasibility of these features and if they should be implemented in this building.

Structural Breadth (Analysis #1 & #4)

There are structural considerations that are needed to be made when applying both mechanical modularized units above laboratory spaces and an alternative roof design. In Technical Analysis #1 the idea of using modularized mechanical units were introduced. To hoist and install these units into their specific areas additional structure must be added into the overall structural design of the building. Members that will allow for this unit to be attached must be implemented. An alternative roof design may increase the total roof designed load which would cause for additional support in the roof structural system. Calculations of the total load and the structural systems current load capacity must be performed to understand whether it is necessary to provide additional support. A re-design of the structural system or additional support may be necessary to withstand added load of the proposed alternative roof design.

Appendix B: Senior Thesis Timetable


1/28/13 Milestone 1
2/11/13 Milestone 2
3/1/13 Milestone 3
3/25/13 Milestone 4
Greg Tinkoff
Dr. Robert Leicht
Proposed Schedule for Spring Thesis
January 2013-April 2013
Jan-7-13
Jan-14-13
Jan-21-13
Jan-28-13
Feb-4-13
Feb-11-13
Feb-18-13
Feb-25-13
Mar-(3-9)-13
Mar-11-13
Mar-18-13
Mar-25-13
Apr-3-13
Apr-8-13
Apr-16-13
Apr-24-13
Research Modularization & Precast Concrete Structural Members
Conduct Interviews with Industry Professionals
Develop Logistics and Installation Plan for Modularized and Precast
Evaluate Schedule Impacts and Develop Project Schedule
Research Implemenations for BIM/ Review Project Case Studies
Develop Cost Analysis
Conduct Interviews with Industry Professionals
Overhead Cost Analysis of Added BIM
Research Cut-Off Wall Dewatering Systems
Contact Vendors and Conduct Interviews with Industry Professionals
Cost/Schedule Analysis of BIM Energy Model
Cost/Schedule Analysis of As-built + CD's and Site Logistics in BIM
Evaluate Schedule Impacts and Develop Project Schedule
Cost/Schedule Analysis of Operations after BIM
Research Sustainable Features and LEED Case Studies
Conduct Cost Analysis of Implemented Dewatering System
Create Layout Dewatering
Conduct Interviews with Industry Professionals and Project Teams
Evaluate Schedule Impacts and Develop Project Schedule
Conduct Cost Analysis of Implemented Sustainable Features
Mechanical Breadth Analysis: HVAC System Design
Structural Breadth Analysis: Alternative Roof Design Support
Spring Break
Building Turnover
Feasibility Analysis of the Proposed Idea
Revise for Presentation
Plan for System
Feasibility Analysis of the Proposed Idea
Revise for Presentation
Feasibility Analysis of the Proposed Idea
Revise for Presentation
Create Powerpoint Presenatiation
Final Report April 3rd
Faculty Jury Presentation April 8-12
Senior Banquet April 26th
ABET Evaluation
CPEP Finalization
Legend
Analysis #1: Modularization & Precast Units
Analysis #2: Holistic Approach of BIM
Analysis #3: Cut-Off Wall Dewatering System
Analysis #4: Additional Sustainablitiy Features
Milestones
Jan. 28, 2012: Analyses Research Completed
Feb. 11, 2012: Schedule Evaluations & Development for Analysis #3 & #4
March 3, 2012: Finish Thesis Breadths
March 25: Analyses Feasability Studies Completed
April 3, 2012: Final Reports Due