THE PENNSYLVANIA STATE UNIVERSITY:
INTRAMURAL BUILDING PHASE III

SPRING PROPOSAL REPORT

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EXECUTIVE SUMMARY

The AE program at Penn State is one of the top programs in the country. The program prides itself with adequately preparing their students to enter the workforce and make an impact, right after college. Throughout the fifth year, AEs embark in a senior project. The project allows a student to take a construction project and fully analyze it. The fall semester consists of three technical reports which require the student to fully understand their building. They will be tasked in working with project managers and project engineers to iron out any details about the project. Each report will focus on slightly different topics, and will be proceeded by a final presentation before graduation.

Before the end of the fall semester, each student will produce a proposal, which features three opportunities to improve some aspect of their project, and 1 research topic. Each of the four analysis will be developed further in the spring semester, and compiled into a final report and final presentation that will be given in the spring. The four analysis that are explained in this report include an alternate roof system life cycle analysis, façade acceleration using varying framing structures, redesign of the mechanical system, and finally a construction industry and IPD project analysis.

ANALYSIS SUMMARIES

ANALYSIS 1: ROOFING SYSTEM LIFE CYCLE ANALYSIS

The roofing system used for Phase 3 was designed to match the existing building. There are several options of roof types that can either accelerate the schedule, or provide a lower life cycle cost over the life of the building. This analysis will focus on selecting the best option to provide protection for the IM building while also being the most efficient system

ANALYSIS 2: ALTERNATE FAÇADE FRAMING ANALYSIS

The framing used on Phase 3 is steel studs to back up the brick veneer. The enclosure is on the critical path. By substituting in different wall framing techniques, the schedule may allow for interior work to begin sooner, decreasing the construction duration on the project. Varying R values from the framing types also could provide better insulation and better mechanical performance overall.

ANALYSIS 3: ALTERNATE MECHANICAL SYSTEM ANALYSIS

The current mechanical system was designed to be LEED certified. This led to construction headaches and unnecessary money spent on an expensive system. Designing the system to better provide for the space could yield an acceleration of the schedule as well as savings to Penn State. The analysis will set out to correctly decide on a system that suites the needs of the space by looking at the occupancy and size of the space. The delays from the system caused hiccups in the project schedule and caused delays. By examining different construction durations of systems, these schedule issues could be avoided.

ANALYSIS 4: INDUSTRY AND IPD PROJECTS

A negative stigma seems to be present from subcontractors and their involvement in integrated project delivery. They worry about profits, and are sometimes not able to provide the tools and personnel needed to work on an IPD project. Research will dive into what is the preferred method of delivery and why this is true for each party involved on construction projects. The research will also set out to compare IPD projects versus non IPD project to compare savings and rewards to the parties involved.

PROJECT SUMMARY

The Intramural Building at Penn State has been a staple of the university for years. The original building is located on the corner of University Drive and Curtin Road. From the IM Building many of Penn State's most well-known structures can be seen. These include Pegula Ice Arena, the Bryce Jordan Center, and Beaver Stadium. To ensure that the IM building is keeping up with the ever-growing athletic community and student body, three phases of additions were planned. This report will focus on the third addition of the building.

The third addition to the IM Building at Penn State began construction in August of 2016 and is set to be completed by the start of the fall 2017 semester. The building addition will add approximately 62,000-square feet to the existing Intramural Building which will include an indoor turf field and a rock climbing wall. The addition will continue to add prestige to the IM building, making it the top gym at Penn State. The building will consist of a brick veneer façade, along with curtain wall and storefront systems. The addition will also include upgrades to the current electrical system and mechanical system. The mechanical system is unique and is referred to as a hybrid ventilation system. The addition will allow for 100 percent outside air to be brought in through movable windows. This will only occur at a specified temperature and humidity level. The roofing system is a modified bitumen, and will match the existing roofing systems of the building. Mortenson is the general contractor of the project, and has been the gc for all three phases of the IM building. Mortenson is also credited with being the gc for the Pegula Ice Arena. The rendering shown below is courtesy of Mortenson Construction.

PHOTO COURTESY OF MORTENSON CONSTRUCTION

ANALYSIS 1: ROOFING SYSTEM LIFE CYCLE ANALYSIS

OPPORTUNITY:

Having worked in the field for a roofing subcontractor, I wanted to analyze the roofing system for IM Phase 3. The roof that is currently being used is modified bitumen. This roofing system consists of a layer of insulation followed by a base sheet, which then the roofing material is attached to. The design of this roofing system was chosen as it is the type of roofing used for the existing building. Bitumen, or torch on roofing, is a type of roof that comes in pieces of 3 feet by about 20 feet, or 60 square feet. Each roll is "welded" to the base board by heating the material until it fuses with the board. This type of roofing often blisters and requires the installation to heat the rolls to the right temperature and apply the right pressure. I believe that other types of roofing could be a lower initial cost and accelerate the schedule, or could provide a longer warranty for the roof.

BACKGROUND:

Having experience in this type of roofing, I believe that many issues could come from using this type of roofing, as well as the installation time and cost could all be examined. I have worked on repairing and replacing each type of roof, and believe that a different type could be utilized to ensure the safety of the building. Penn State is putting a lot of money into the IM Building and a leak could cause a lot of damage to electrical equipment, as well as the high end finishes inside of the building. The type of roofing being used now has a larger chance of leaking if conditions are not met. Very careful application of the materials must be used. The roofing will be done in the winter months, meaning delays and weather issues could occur. Other issues also occur with the roofing crews, and their attention to details. Other options are faster for installing, and provide less issues with weather.

SOLUTIONS:

To analyze the possible solutions, I will first compare bitumen roofing to 3 other roofing systems that I have experience with, and systems that offer different variables compared to bitumen. The three other roofing systems I will examine include EDPM (black rubber roofing), TPO (white rubber roofing material), and hot asphalt roofing. Each roofing system has its pros and cons. To determine the best outcome for Penn State, and for the general contractor I will use a life cycle comparison for each type of roof. The life cycle will take place over a set amount of time (30 years) and will look at how often repairs are for each type of roof. A look at the insulation needed for each type will also increase the thermal efficiency of the building.

METHOD:

So, the first step I will take is to develop the new construction cost for each system. By using the square footage, and my experience, I can estimate the cost to install the roofing system. I can also reach out to my previous employer to assist in this process. I will need to not only look at the material cost, but also establish the duration of each type and estimate the labor needed for the system. Each system also will require different types of equipment which will also change costs. The next step I will use is to look at repair costs, and ease of repairs for each type of roof. Certain roofs experience many more problems than others, and require repairs more frequently. By using the cost of a repair and the rate of repair I will be able begin developing a life cycle cost for each type of roof. Finally, I will do some research in different manufacturers and company specs to determine the lifespan of certain types of roofs. Once I have all the information necessary I will be able to determine the life cycle cost of each roofing type.

OUTCOME:

The expected outcome will be to change the roofing system. The best option would be the use of an asphalt roof. This type of roofing ensures Penn State the longest warranty and the most protection for the addition. The space below houses very important and expensive equipment and roofing types such as the EDPM and TPO, are very fragile and puncture easily. The pros of using EDPM or TPO are the install times. Large areas of roofing can be completed in relatively short times. These types of roofs are also very simple to repair. The outcome of the roof will be to protect the building for a longer time and will be a lower overall cost when the life cycle is completed.

ANALYSIS 2: ALTERNATE FAÇADE FRAMING ANALYSIS

OPPORTUNITY:

IM Phase 3, to match the façade of the existing building, utilized steel studs as the backing to support the full brick veneer. The exterior of the enclosure is one of the longest activities on the schedule and resides on the critical path. The exterior enclosure also must provide an adequate R value and enough thermal protection for the building during winter months. An opportunity to increase the R value of the entire assembly, as well as possibly accelerate the schedule, is to look at alternate designs for the wall system. The exterior enclosure is a prerequisite for many of the interior activities, and an acceleration of this activity would yield a smaller construction period. Without the exterior enclosure being completed on time, the interior activities will be delayed. The time of the construction of the brick work and façade also coincides with the winter months. Weather delays could easily push back the enclosure and steps would need to be taken to ensure the schedule would stay on pace. Penn State has enacted a strict schedule on the project and this will mean an alternate wall framing method could utilize prefabrication. Having the steel studs and framing systems constructed offsite could positively affect the schedule.

BACKGROUND:

Many ideas about modularization were discussed at the PACE round table. The idea came up in just about every breakout session, and sparked my interest for the possibilities on a project like IM Phase 3. Brick can sometimes come in panels, and although are much faster to install, they take away from aesthetics of the project, as well as pose other issues. I don't believe Penn State would approve the use of a brick veneer panel to be manufactured off site due to the aesthetics of the new pieces. Although modularization would not be able to be used on the brick, by implementing ways to prefabricate the wall framing system, modularization may be able to be used. Steel stud framing is generally one of the quickest methods of wall framing, and the one way to accelerate this already fast construction, is to prefabricate panels. There are different levels of prefabrication for the steel system each with its own benefits. Sizes, as well as what all is included could all be analyzed to allow for the greatest benefit to the schedule.

SOLUTION:

Several options will be explored. As previously stated, the current system is metal studs. Several solutions will be analyzed. The first will be the original system and its current duration and cost. Next a prefabricated piece will be analyzed. Next a piece will be analyzed again but will be a larger size than the previous. Finally, a panel which as more of the wall assembly will be included and then also compared with a larger version. The two latter options will include drywall and installation already included on the interior side, as well as other possible materials. Each will be analyzed to compare cost vs installation time for the framing.

METHOD:

The first step into comparing the systems is to compare the upfront costs. Because each option will be slightly different, each will consist of a different upfront cost. Prefabrication pieces will cost more per square foot upfront, but will yield lower labor hours for installation.

Once the materials cost is analyzed the labor hours will then be analyzed. Each option will vary in installation time as well, and a detailed breakdown of each option will be developed. Finally, several other variables will be looked at including shipping, site storage, and other site utilization issues. After looking at each option in depth, a conclusion will be made.

EXPECTED OUTCOME:

The expected outcome will be to utilize large prefabricated panels, without the added wall materials. The larger pieces will allow installation to be very quick, and accelerate the process. As the studs and framing are being completed work can begin on both sides of the studs. This process will accelerate the schedule and make sure that the project is not delayed. Some issues may come up in terms of shipping and how the panels will be able to be installed on site. These issues will be looked at in depth and compared to the other systems to make sure the correct option is chosen.

ANALYSIS 3: ALTERNATE MECHANICAL SYSTEM ANALYSIS

OPPORTUNITY:

LEED is a grading system used to determine how green a building, or project is. Although many buildings utilize the LEED ratings, it is beginning to be discontinued. Phase 3 is a LEED Silver project and utilizes a hybrid ventilation system. The system uses 100 percent outside air when the temperature and humidity meet certain levels. An opportunity exists to use a different system in place of this system. The current mechanical system is great in theory, but State College weather patterns don't allow for the outside air to be used very frequently. This makes the expensive system almost useless, and is something that could be designed out of the building.

BACKGROUND:

The background of this opportunity comes from the project manager and the design of the mechanical system. The addition was designed to be LEED Silver. This was because the existing building is also designed to be LEED Silver. Many owners are straying away from LEED as it costs the project more money, and doesn't always produce a more efficient building. Owners are beginning to move to alternative scoring systems for renewable buildings. Penn State is beginning to implement this strategy, as well. The addition comes before Penn State stopped designing to LEED standards. The mechanical system of the space is one of the areas most affected by LEED on the project. The system is overdesigned and impractical. Penn State will want to save as much money as possible, and if the system is able to be value engineered out, than they would want to proceed with the VE option.

SOLUTION:

To take a step back choose a mechanical system that works for the Phase 3 space. By utilizing square footage numbers, and the type of space, a recommendation for the type of system can be examined and studied. The goal is to examine 2 other mechanical systems that will provide the necessary requirements given by the architect and Penn State. The design of the mechanical systems will not factor in LEED. The systems will also be chosen based on existing components from the original building in hopes of accelerating the construction schedule for the entire project.

METHOD:

From this information, several options (2-3) of systems will be examined. An upfront cost analysis will be determined, first. This analysis will include an estimate of the total system in terms of materials alone. Next, construction durations will be found for these systems for each possible system. By factoring in installation time, work hours can be calculated, and an upfront cost of each system can be found. Next, varying factor will be examined including lead time needed for each system, life cycle costs, and finally any issues with shipping or installation on site, and finally a look at possible added coordination between other trades will be looked at. Each of these factors will be examined and the best system will be chosen for IM Phase 3.

EXPECTED OUTCOME:

A new mechanical system will be used which is designed for the space, and not dependent on earning a LEED score. The system will serve the space and will be under budget and require less construction time. Penn State will not be forced to spend money on items they do not need, and are overdesigned. The schedule acceleration will also save the general contractor and Penn State money. The system may also allow for a more coordinated effort between trades and accelerate other trades as well, only contributing to the acceleration of the entire project.

ANALYSIS 4: INDUSTRY AND IPD PROJECTS

OPPORTUNITY:

Integrated project delivery projects are a type of project which allows project teams to be involved very early in the design of the project. It allows subcontractors and contractors to help architects and designers work out details. The ideal of using IPD projects came about from discussing modularization on a large scale at the PACE Roundtable. An opportunity exists to help educate subcontractors on the benefits to being involved in IPD projects and helping increase the overall use of them in the construction field.

BACKGROUND:

From industry experience, as well as having spoken to several industry members about IPD projects, there seems to be a lot of negative stigma about IPD coming from the subcontractors. A lot of subcontractors are not willing to, or are unable to participate in IPD projects for several reasons. One of the main reasons is profit sharing. They are not able to apply their own fees and may think they will not make as much money on the project. IPD projects also require a lot of early involvement in projects. Subcontractors are often tied up on projects and are not willing to put in time into an IPD and would prefer to bid on the projects, as they get paid for their involvement. A lot of the subcontractors also are not up to date on current technology and the time needed to train their employees is not seen as an appropriate use of resources.

SOLUTION:

A potential solution to this problem is to educate the construction workers on IPD projects, and to understand their grievances with IPDs. By identifying what they like most about certain project delivery methods, then we can begin to apply these principles to the IPD method. Each level of the construction field will need to be analyzed including owners, architects, subs and general contractors. The bulk of the contacts and information will be based upon subcontractors. By understanding which parties are not in favor of IPD projects, they can begin to learn the potential benefits of IPD project and begin to utilize them more in the field.

METHOD:

The first thing I need to do is to gather information on IPD projects vs normal projects. I will need to establish similar sized projects and compare schedules, costs, and other key information that may point towards IPD projects being more beneficial for all parties, rather than any one party gaining a higher profit. I plan to include questions about project sizes and types for the participants to fill out. By including as many questions as possible about past projects, I will begin to understand how and where IPD could work. I will also begin by first surveying smaller subcontractors and gaging their opinions on projects. I would like to investigate which delivery methods they prefer, which ones they don't like and why. Questionnaires will be drafted which will collect the opinions of several different parties. The parties that could be included are all types of subcontractors, general contractors, architects, and even owners. In an IPD project all parties must be willing to contribute to the project and must be willing to work together. By looking at the results of several different member of each level conclusions can be draw from the information.

EXPECTED OUTCOME:

Gaging subcontractor's thoughts and feelings about project delivery methods will help general contractors work with subs, and be more efficient on projects. Subcontractors are very important and are performing the work on the project. By knowing what benefits them and what they prefer, steps can be taken to keep them happy. Worker morale is important in both quality of projects, as well as efficiency. I also think some of the other parties will not be in favor of IPD projects. The thought of not going with a low bidder, or being forced to work with a party they do not prefer may really put them off of the project.

CONCLUSION

This report has discussed four analysis based upon the information found through the first semester of senior thesis. The analysis all are based upon the construction of Phase 3 of the IM building addition. The analysis that were discussed in the report include the roof life cycle analysis, an alternate façade framing analysis, an alternate mechanical system analysis, and finally an analysis set to look at the construction industry and IPD projects. Each of these analyses will be further developed in the spring semester of senior thesis. This report has laid the cornerstone to begin working towards completing the thesis project in the spring semester

APPENDIX: BREADTH STUDIES

As part of the final presentation, each student will need to analyze a breadth outside of their option. Each of the analysis described in this report have room to develop analysis on a breadth other than construction. As the students continue to research the analysis of their building, they will begin needed to consider other breadths that have been learned throughout the curriculum. To begin preparing to look at these different breadths, a summary of two options are listed below. The student may use these breadths in the final presentation, or may find using a separate breadth for their analysis will be more beneficial. Below are the initial breadth proposals for IM Phase 3.

BREADTH PROPOSAL 1: MECHANICAL BREADTH

The first breadth proposal is the mechanical breadth which will be a main driving point of Analysis 3: Alternate Mechanical System Analysis. This analysis will focus on prescribing a new system for IM Phase 3. After completing the Analysis 3, the most efficient system for the space will be chosen based solely on construction issues such as schedule, upfront cost, and a life cycle cost. From this point, the mechanical breadth analysis will begin. I will perform a detailed take off of the space to determine any notable features such as cubic feet of space, and the R values of materials in the space. I will then need to determine the recommended CFM, temperature, and humidity levels for a gym/athletic area. Once this is determined I will be able to apply mechanical tests to ensure that the system that was chosen can perform similarly, or better than the original mechanical system. The output needed by the system will also factor into whether the system will an adequate substitute. A look at vents and space needed in the ceiling, as well as other locations may yield more changes to the design of the system, and may cause a higher overall cost based on the conditions necessary for the space.

BREADTH PROPOSAL 2: STRUCTURAL BREADTH

The second breadth proposal will come in the form of a structural breadth. Analysis 2: Alternate Façade Framing Analysis will be where the structural breadth is applied. Several options for framing will be explored by this analysis. Each different type of framing will need to be analyzed to not only support the load of the structure, but to also support the brick veneer that will be added to the framing. A detailed loading plan will need to completed as well as the spacing and design of the framing will need to be completed. They type of framing, that will be the most beneficial for the project. The exact type of framing that will be looked at will rely on the results of Analysis 2. Once the analysis is complete the structural analysis can occur. Load paths and load bearing will be analyzed from the original wall framing, and then translated into the new type of wall structure. The new system will have slightly different load bearing properties and may distribute weight into areas not previously designed for the weight. Changes may need to be made from this point to other sections of the wall as well.