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INTRAMURAL BUILDING ADDITION AND RENOVATION-PHASE I

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TECHNICAL REPORT III

EXECUTIVE SUMMARY

The purpose of Technical Report 3 is to analyze areas of the Intramural Building Addition and Renovation project which are appropriate for further research and evaluation. This report consists of evaluation of acceleration scenarios and value engineering, as well as a discussion on critical industry issues and feedback ideas for possible research topics.

In previous technical reports, the schedule has been studied and analyzed to further understand the project's flow of work. This section is divided in two main parts, the critical path risks and schedule acceleration scenarios. The project's critical path can expose several opportunities to delay and accelerate the schedule, which have been identified. Due to natural events and availability of materials, the site work, superstructure and building enclosure phases of the Intramural Building possess major potential for delay, while the right site work start and the possibility to unitize the curtain wall glazing system create the opportunity to accelerate the schedule.

Value engineering is a crucial tool for exploring possible changes that can positively affect the project's final cost, schedule, and quality while meeting the owner's needs. Maintaining the value of the project to the owner is the goal of value engineering, and should be implemented in a cautious manner. Potential schedule and cost savings can be encountered in the roofing system of the Intramural Building new addition. The reasoning behind why value engineering gets approved or rejected has been identified in this report.

The 22nd annual PACE roundtable meeting was held this year at the Pennsylvania State University. It provided the opportunity for industry professionals and 5th year students to meet and discuss current industry problems. Two break sessions focused on the assembling of effective cross functional teams and phasing on retrofit projects. Several takeaways from these sessions related directly to the Intramural Building project, revealing areas of research.

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Schedule Acceleration Scenarios

The Intramural Building Addition and Renovation construction schedule start date is set at January 31, 2013, and it is scheduled to finish on February 12, 2014. This translates to total project duration of approximately eleven months or 247 working days. Table 1 is referenced from Technical Report II and it gives an overall view of the project schedule. This section will discuss the main construction sequences that define the critical path of the project while stating the main risks associated with meeting the project completion date. In addition, schedule acceleration ideas and methods will be discussed.

Phase	Start Date	Finish Date	Duration (Days)
Construction	31-Jan-13	17-Jan-14	247
Notice To Proceed	31-Jan-13	31-Jan-13	0
Site Work	12-Feb-13	2-Oct-13	164
Substructure	28-Feb-13	16-Aug-13	120
Steel Erection Start	20-May-13	20-May-13	0
Superstructure	20-May-13	11-Oct-13	102
Building Enclosure	10-Jul-13	26-Nov-13	99
Building Watertight	26-Nov-13	26-Nov-13	0
MEP & Interiors	10-Jul-13	17-Jan-14	135
Exterior Finishes	5-Dec-13	27-Dec-13	16
Costumer Move-In	12-Feb-14	12-Feb-14	0

Table 1: Schedule Overview

Critical Path

One of the many goals for the Pennsylvania State University is to have the Intramural Building completed and fully functional for students, by half way through the 2014 spring semester. In order to deliver this project on time, and tie in together with the future building phases (2 and 3), careful attention needs to be paid to the critical path of the project. The critical path activities of this project mainly related to the new addition rather than the renovation part, due to the magnitude of the project. Figure 1 details the components of the major critical path activities and directly relates to the durations depicted in table 1. Site work, Superstructure and the Building Enclosure duration represent how critical the completion of these activities is.

Site Work

As previously mentioned in Technical Reports 1 and 2, soil modification and improvements were required to construct the new addition for the Intramural Building. The soil underwent Limited Mobility Displacement Grouting, which improved the soil to prevent settlement and the probabilities of experiencing sink holes. Identifying problems with the soils early benefited the project team in preventing the construction of a new building in unstable grounds. It also affected the project schedule, delaying the construction of the building. The estimated duration for the soil improvement was of 14 days. Due to weather impact and material availability, the actual duration of the soil improvement double the expected, delaying the schedule by 14 days. It is important to put

emphasis on all activities, but critical path activities should be performed in a careful manner, to prevent project delays. The impact of this delay is the potential of delivering the building late.

Enclosure

The building enclosure is part of the critical path because of its importance to make the building watertight. The work sequence began with the installation of the exterior metal studs and the placement of the red brick façade. The completion of the brick led to installation of the curtain wall and metal panel mullions, as well as the selective demolition of the existing Intramural Building's South Wall. The final installation of metal wall panels, curtain wall glazing, and roofing system finalizes the building enclosure, achieving a fully sealed building. Building enclosure falls under the critical path of the project because of its importance as both an architectural feature and functionality. Having a fully sealed building means the ability to use temporary heating/cooling, prevent weather hazards, and protect equipment. It imperative to note the enclosure activities are all interlaced and participate equally in the critical path.

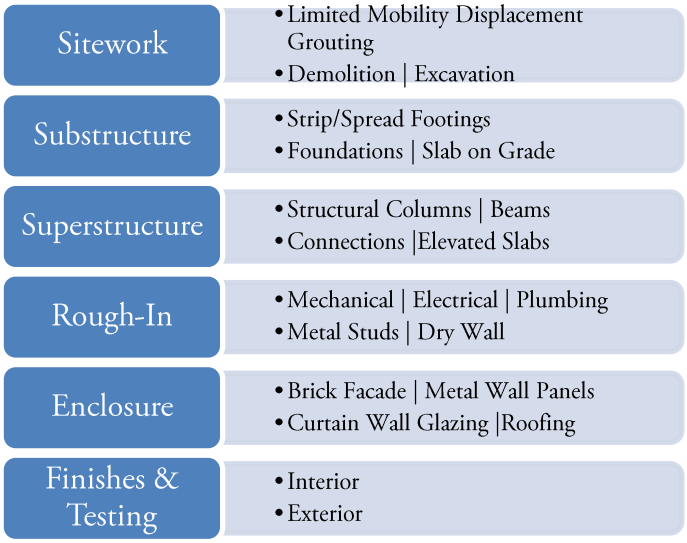


Figure 1: Critical Path Description

Superstructure

The erection of the new addition's structure plays an important role in the critical path of the project. Once the project is fully designed, the steel subcontractor is responsible for preparing shop drawings for the fabrication of members, which when finished get transported to the construction site for erection. This is a very lengthy and stressful process which requires several approvals and the most critical: time. Any delay in the process will create a problem for the project, for example an overdue discrepancy explanation on connections. If any delays occur, there is the possibility of accelerating the fabrication of steel for a price, given that the budget allows. This entire time frame is on the critical path because no other activities related to the addition can occur on-site until the phase is completed.

Risks to Completion

Enclosure

The biggest risk to the project completion date is probably the building enclosure. As previously stated, it is crucial to have a fully enclosed and sealed building to progress with the remaining interior critical activities. The installation of the brick façade on the new addition was followed with a partial demolition of the existing building's south wall. Even though the demolished portion of the existing building is covered, there is still potential to loose heat, therefore making the existing occupied building uncomfortable. The project schedule took into account the area's weather fluctuations, and projected to finish the building enclosure before the State College harsh winter days. Previous delays on critical activities and on the building enclosure lead to an existing occupied building with undesired working conditions. The risk associated with this critical path event not only applies to time, but also the owner and building occupants.

Figure 2: Existing S. Wall Demolition
Courtesy of Mortenson Construction

Schedule Acceleration

The main objective of a project team, construction management and/or contractual teams is to decrease or control the costs of a project while at the same time eliminating time spent constructing and maintaining or increasing the quality of the building. Upon encountering natural weather events and unforeseen conditions, additional time is added to a project schedule. Project teams strategize and plan out scenarios for project acceleration to meet the owner expectations and goals. The methods applied by Mortenson Construction are the typical overtime work enforcement and doubling the crew size to accelerate the schedule. Typical working hours for this project is 40 hours a week throughout a 5 day period, with optional Saturdays if schedule allows (football weekends).

Potential Acceleration

There are several areas for potential acceleration in this project. The schedule items discussed above offer the possibility to turn over the project on time, meeting the owner's needs. Identifying problems before they develop or in their early stages, and allocating resources to solve them. To overcome the loss of time in the site work phase, there is a possibility of doubling the staff and the equipment to perform the injection of grout into the soil for improvements. The only conflict applies to weather conditions; since the project started during winter, grouting during cold and humid weather isn't favorable. The option of using admixtures for the grout can come into place, to help the grout cure properly and during extreme conditions.

Another method of accelerating the schedule is the proposal of unitizing the curtain wall system to reduce on-site labor time. Instead of installing a stick built curtain wall system (Figure 3), that is with mullion framing and glazing panels, the possibility of a unitized system would comprise of prefabricated panel sections which can be delivered to the site and installed with ease. As previously stated, making the building watertight is crucial to perform interior work. A large portion of the building's exterior façade has a curtain wall glazing system, and keeping the stick built system to deliver could delay the interior finishes. The only concern with this alternate system, is the availability of prefabricate operational unitized glazing systems, to pursue natural ventilation requirements for LEED accreditation.

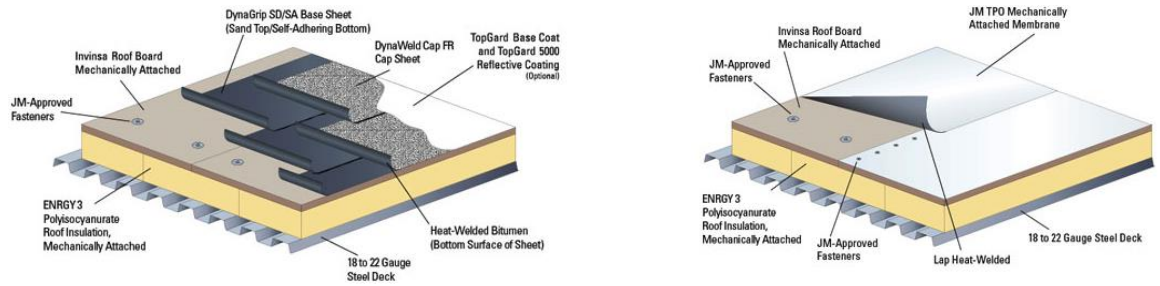
Figure 3: Stick Built Glazing System
Rendered by Gonzalo Lav

Value Engineering

Performing value engineering is a useful resource for a project team. Not only does it look into the goals of the client/owner but also identifies areas where the project itself can be enhanced to better tailor these goals. Value engineering is often seen as a tool that will decrease the cost of a building. Nevertheless, all aspects of the owner's needs, including schedule of the project, quality of the building, and the total costs are assessed for the better good of the building, and satisfaction of the owner and future occupants.

Roofing Type

One of the value engineering ideas considered and applied is the use of a TPO roofing rather than SBS systems. Thermoplastic Polyolefin (TPO) single ply roofing membranes are typically used in low slope roofs and are very durable, over 30 years. TPO roofing is heat reflective and possesses energy efficient properties (carbon footprint) mainly because of the light material color. Not only TPO roofing systems are durable, but also very easy to install and is a very economical system, as seen in Figure 4. SBS systems, is a type of modified bitumen roofing which falls under the category of asphalt roof system. SBS systems, compared to TPO, are applied in 2 to 3 ply layers; this increases the ability to withstand penetrations within the roofing system, but is labor intensive and lengthens the schedule. The potential savings in this switch is of $125,000, with schedule reductions.



SBS TPO

Figure 4: SBS vs TPO
Courtesy of Google Images

Mirrors

The new addition of the intramural building will incorporate areas with mirrors, located mainly in the large multipurpose rooms. These rooms will be used for activities such as ballroom dancing, yoga, and even fitness courses. The proposed scope of work was the use of tempered mirrors, which are more resistant to impacts. Instead, standard mirror with safety backing was analyzed to be more cost efficient, and have similar characteristics. Even though these are not as resistant to breaking, they do diminish the potential of injury on impact from fragments. The cost savings for this change is of $23,000.

Security Upgrades

In regards to improving the security on campus due to the recent school incidents, the Pennsylvania State University demanded the installation of efficient, high technological security devices in both the existing and new addition buildings (Figure 5). Even though these increase the construction costs of the project, it ensures that the client is obtaining high quality security systems to keep the building and its occupants safe from any sort of danger or conflict.

Figure 5: Fixed and Pan Tilt Security Camera

Scope Cuts

The majority of approved value engineering ideas come from changes in the scope, which decrease substantially costs and the actual duration of performing those activities. Some of these scope changes are the following:

- Remove the addition of a new locker room from scope of work – this will open up the opportunity to utilize the existing main locker room, and save both the costs and labor durations of building a new locker room.
- Instead of installing a new hot water system, it was proposed to reroute the existing system to feed into the new addition.
- Take out the fin tube radiation system proposed for the new addition fitness loft area. Opens the possibility of using air forced ventilation to heat and cool the area. Installation costs and durations are reduced.
- Elimination of secondary pumps for the hot water system while installing variable primary pumps with bypass. This potentially reduces the costs of equipment and installation times.

Value Engineering not Implemented

The value engineering process is usually tailored to the owner's needs and improving the overall quality of the project. Unfortunately not all value engineering ideas make the approval list because of either the complexity, or not meeting the expectations of the client's goals and needs, regardless of the desired cost savings. The proposal of deleting the scope of the natural ventilation system threatened the opportunity to have a more sustainable building as well as the loosing LEED accreditation. The intention of utilizing higher quality flooring material for fitness spaces was not appealing to the client because of the cost implications. The proposition of changing toilet partitions from ceiling hung to floor mounted, to prevent the additional labor and costs of materials to support from ceiling. Regardless of the time and cost implications on this value engineering, Pennsylvania State University requires toilet partitions to be hung from the ceiling, therefore rejecting this idea.

Critical Industry Issues

PACE Roundtable Introduction

The 22nd Annual Partnership for Achieving Construction Excellence was held November 6th – 7th at the Penn Stater Conference Center Hotel. Top industry professions, Penn State Faculty, graduate and 5th year Architectural Engineering students attended this event to discuss the main topic of focus: Whole Project Delivery. In the construction industry, projects start from a napkin sketch and develop the building in a given time interval. From the start, it is critical for a successful project to have the appropriate delivery method, adequate and experienced professionals, a well-developed goal, and an involved owner. Having industry members which have experienced several projects from all different perspective points made for an interesting day of discussion. The roundtable event consisted of two breakout sessions and small group feedback sessions. The roundtable event initiated with an overview of the current research and work the University is committed to, as well as an update on the Architectural Engineering faculty members; presented by Dr. Leicht and Dr. Messner.

Following the introduction, the day continued with two industry breakout sessions. These consisted of three main groups: Sustainability, Information Technology, and Integrated Processes. Each session focused on particular topics of the categories previously stated and can be seen in Table 2. Monitored by Penn State faculty, these sessions created the opportunity for students and industry members to interact and discuss several topics along the lines of each category. The last part of the event was a small group session with an industry professional to discuss and gain feedback on the information learned throughout the day. Ensuing sections focus on the two breakout sessions attended, *Assembling Effective Cross Functional Teams* and *Owner Phasing Decision for Cost Effective Retrofits*.

	A. Sustainability	B. Information Technology	C. Integrated Process
1. Personnel	Safety – Prevention through Design	Information Management for the Workforce	Assembling Effective Cross Functional Teams
2. Integration	Owner Phasing Decision for Cost Effective Retrofits	Efficient Delivery of Facility Management Information	Criteria and Drives for Effective Multi-trade Prefabrication and Modularization

Table 2 – PACE Breakout Sessions

Breakout Session #1 – Assembling Effective Cross Functional Teams

In the first breakout session, the topic of discussion was "Assembling Effective Cross Functional Teams". Led by Gretchen Macht and Bryan Franz, the discussion began with a brainstorming session. Both students and industry professionals developed a list of key words associated with what makes up an effective team. The goal of this session was to discuss the challenges of selecting the right group of teams for a project as well as the qualities these must possess to have a successful project. It was crucial for the discussion to properly define what is a cross functional team.

Projects involve several different entities which are composed of groups. For example, in a typical design bid build project, there are three (3) main groups: Owner, Architect, and Construction Manager or General Contractor. These groups individually have assigned teams which are responsible for the project. These individual teams are built with the best selection process, with the appropriate members for the task to be accomplished. A cross functional team refers to these different individual groups work together in a multi-disciplinary level. Figure 6 represents the individual functional teams with blue arrows, while the red depicts cross functional team across the three different teams. Even though the discussion sometimes drifted from its original intent, valuable information was gained by participating and listening to the various industry professionals' experiences dealing with different teams.

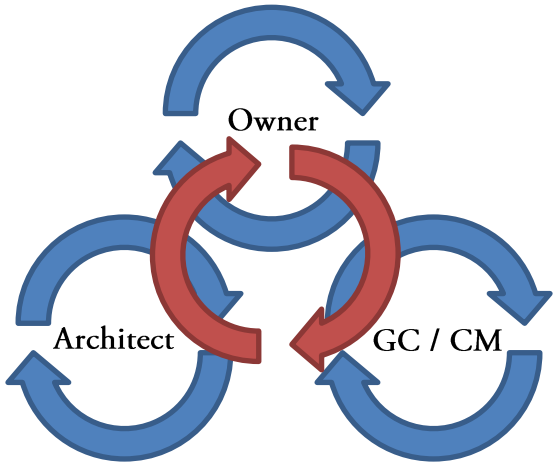


Figure 6: Cross-Functional Team

The main idea of the discussion revolved around how the team is formed and the main attributes it should have to succeed in a project. Sharing common goals, working in a collaborative manner, communicating effectively, having strong leadership and expertise were some of the most important attributes of which these cross functional teams must have to be successful. The question that was raised, related directly to how are these team selected. Even though there are several answers to this question, there only answer we could all agree on was that the selection of the team is tailored by the owner. Owners procure the best fit for their projects, including a team that meets all of the requirements and needs the owner has. Usually this process is through the best value selection.

An interesting question arose to the discussion related to how to deal with an internal team conflict. Many answered that the "conflict child" is usually easy to identify early on the project's life span. Nevertheless, many of the industry professionals mentioned that when a team member is conflictive, it is typical to suffer through the storm, which shocked many the students. Some of the solutions

presented to this conflict individual ranged from providing motivational incentives to finish work to getting rid of the individual.

Throughout this discussion, integrated project delivery method was introduced in an interesting way. Steve Lee from Benchmark Construction provided an example of how a fellow coworker is performing IPD projects throughout the nation. Steve mentioned that his coworker would put together the selected construction manager or general contractor and the architect in the same room, and provide different project related scenarios as an interview process. This would be an all-day event which would show the owner how this project team interacted to solve problems, and identify concerns. This allowed the owner to have a better understanding of how his whole project team was going to function throughout the construction.

Breakout Session #2 – Owner Phasing Decisions for Cost Effective Retrofits

The second session attended was focused around the phasing of retrofit projects, which attempted to discuss the typical problems and risks encountered in projects that undergo renovations. Led by Dr. Rob Leicht, the discussion initiated with the definition of retrofitting. Retrofit and renovation projects are different. The key difference is that retrofit projects incorporate new systems into an existing building to improve the performance and efficiency.

The discussion was directed towards some of the problems encountered in retrofit/renovation projects. Interesting issues were stated, such as maintaining work flow continuous and designing strategies to minimize occupant impact. Most of these problems were directly related to the Intramural Building Renovation, and was entertaining to share the experiences learned from being on site. Many of the industry professionals shared their experiences with phased occupancy projects, which helped understand why sometimes owners refuse or choose to keep buildings operational while undergoing renovations.

The discussion later entered into describing some of the impacts, cost included, experienced by the owner during a retrofit/renovation project. It was interesting to see a wide variety of effects cost and duration related, and provided the possibility of implement a proposal for my senior capstone project: the idea of analyzing costs between phased and empty building renovation. Some of the topics discussed were related to why owners undergo phased retrofits and when to start renovation/retrofit projects.

Feedback from Industry Roundtable

The last event of the day, three students and an industry professional were grouped together to discuss student's thesis projects and develop possible areas of research for the proposals. Quaid Spearing, Russell Voigt and I were paired with Craig Dubler of the Office of Physical Plant. He is very knowledgeable of the current projects under construction at the Pennsylvania State University, which was very advantageous for me because he could provide me with key feedback, from an owner's point of view. After we all discussed the learnings from the previous two breakout sessions, we all discussed our possible research proposal ideas.

Dr. Dubler advised me to look into the reasoning behind why the Intramural Building was broken down into three phases and to analyze the costs and risks associated with building phases 1 and 2 together instead of eleven months apart. In addition to this, he told me to research what makes Rec Hall and White Building more frequently visited than the IM building through questionnaires and polls. Another research idea was related to changing the delivery method of the project. Since Craig works for the University, he recommended analyzing different delivery methods that would improve the construction efficiency. Lastly, he suggested performing a cost analysis of relocating building occupants versus the actual costs of the construction fully occupied.

APPENDIX A

Research Topics

Student Name – Gonzalo Lay

Session 1C – Assembling Effective Cross-Functional Teams - Research Ideas

1. Assembling a team together through the integrated project delivery interview method
2. Analyze the success rate of project teams in the procurement stage from similar buildings around the area. Limited to owner's permission.
3. On the owner's, contractor's, and subcontractor's side, analyze the different levels of common goals. Look into the different levels of complexity between them, what they share and not share.

Session 2A – Owner Phasing Decisions for Cost Effective Retrofits – Research Ideas

1. Create a model which can simulate rapid feasibility of time and costs for phasing retrofit projects. 5D model which shows the advantages of phasing projects.
2. Evaluating the success of "value adding" in retrofit projects. This relates to costs, quality, schedule and safety all together.
3. Retrofit mockup construction which will depict the different scenarios for occupants during construction.

APPENDIX B

Industry Feedback

Industry Member – Craig Dubler, Office of Physical Plant (OPP)

Key Feedback

- Look into adding Phase II for the second part of capstone project
- Evaluate different delivery methods to get out of the CM @ Risk and Multiple Prime deliveries preferred by Penn State
    - IPD?
    - More AE/CM/Owner interaction for better results?
- Building occupants relocation analysis, cost savings.
    - Relocation costs vs. actual costs (perspective of occupant and owner)
- What works and doesn't work in other fitness facilities
    - White Building
    - Rec Hall
    - Student questionnaire?

Suggested Resources

- Talk to building occupants
- Evaluate with different industry members other delivery methods
    - Simple to complex
- Visit OPP and discuss with any Project Coordinator
- Students who use the facilities
- Steve Lee – Benchmark Construction – IPD contact