Executive Summary

This thesis proposal identifies four areas of technical analysis. These areas primarily concern themselves with improving the schedule and construction means and methods. Along with the four areas of technical analysis comes two architectural engineering breadths; one being a structural breadth and the other an architectural breadth.

Analysis 1 | Community Rink Sequence off Critical Path

Removing the community rink off the critical path should benefit the construction means and methods. It will allow the project team to focus their time, labor and resources on the main rink which is necessary to ensure finishes can start appropriately on time. In order for this to be possible a structural breadth must be done to redistribute the weight of the mechanical equipment off the community rink trusses and onto some other system.

Analysis 2 | Entire Building Sequence

Such is the case in many sports facilities, schedule is critical. It is expected that the first scheduled home hockey game will be able to kick-off on time in the new ice arena. Therefore, determining the most adequate way to sequence the building is extremely important. Thusly, it is my intention to determine potential ways that the building could be more adequately sequenced to potentially improve schedule and crane exit paths.

Analysis 3 | Prefabricated Brick Façade

The enclosure is always something critical to a project. On the Pegula Ice Arena there are prefabricated metal wall panels to help enclose the building to allow finish work to be installed. It is my intention to take this one step further and to prefabricate brick as part of the system in certain areas to remove safety hazards and improve schedule. There will also be an architectural breadth associated with this to ensure aesthetics are maintained along the newly created joints.

Analysis 4 | Geotechnical Investigation

Prior to construction, a geotechnical investigation was performed using bring samples and ground penetrating radar. However, misleading information was given as part of this report, specifically concerning the ground penetrating radar. It is my intention to investigate different methods and equipment concerning geotechnical investigations and determine the most beneficial scenario.

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Technical Analysis Descriptions

Analysis 1 | Community Rink Sequence off of Critical Path

Problem Identification

In discussions with the protect team at Pegula one of the frustrating parts during construction was that they had maintain the community rink on the critical path during the structural sequencing of the building. The reason this was a nuance to the project team is that the finish work to follow is very minimal in comparison to the finish work throughout the rest of the building. Therefore, had the team been able to focus their attention and efforts to support the main rink and later followed with the community rink, there could be potential schedule acceleration and cost implications associated with this.

Background Research

Technical Report 2 consisted of a scheduling analysis. In this portion an entire schedule was required which detailed the entire building and its sequences. During this process the building was broken down into four quadrants and subsequently scheduled in a counterclockwise fashion. The schedule had to sequence the structural systems in a way which that included the community rink with the structural sequencing of the rest of the building. This was due to some of the air handling units and other mechanical equipment being located slightly over the community rink roof. Therefore, the roof joists had to be up, which meant the columns/beams needed to be in place as well as the foundation wall. Before backfill could occur along this foundation wall the slab on grade needed to be in place which meant all the underground work needed to be in place. Therefore, all work sequences needed to be done the same way as the rest of the building simply to support the AHUs and mechanical equipment on the roof

Potential Solutions

1. Sequence the work to remove the community rink off the critical path in hopes of accelerating the schedule. (Will require a structural breadth.)
2. Potentially relocate mechanical equipment on roof to support overall schedule acceleration.
3. Potentially reduce crane time to positively impact the cost.

Methodology

1. Retrieve the most up to date schedule from Mortenson Construction.
2. Schedule the building to remove the community rink off the critical path.
3. Ensure mechanical room equipment can still help support temporary heating throughout the building.
4. Perform structural breadth to support the mechanical equipment.
5. Perform any cost implications from more structural steel to decreased crane time.

Resource & Tools

1. Scheduling Industry Professionals
2. Architectural Engineering Faculty: Construction Management & Structural
3. Mortenson Construction Project Team
4. Primavera and/or Microsoft Project

Expected Outcome

With a scheduling analysis and new structural design implemented it is believed that there will be a noticeable scheduling acceleration to the project. It will also help provide more time to work sequences located within the community rink portion of the building. The mechanical room is of particular importance and had much underground work involved which took a lot of time and effort. Finally, there will be an increase in cost of material but there could potentially be increased efficiency and decreased use of crane which could influence the cost positively.

Analysis 2 | Entire Building Sequence

Problem Identification

This project has a hard finish date. This is because this project is for Division 1 Hockey. Therefore, the building has to be ready to open by at least October 11th, 2013. The project team is moving as fast as possible but there is not going to be a ton of time at the end of the project for the building facility operator to ensure all systems work as intended prior to the opening game. As one can image, in an ice arena this could certainly cause problems. This all is simply stated to imply that the faster the building could be built, the better chance the building has to be properly commissioned prior to October 11th, 2013.

Background Research

Stated again, it was in technical report 2 where a detailed project schedule was created and analyzed. Also, having worked there over the summer it was never truly understood why the project team started their critical path at the location they did. As previous technical reports have stated the sequenced work all started in the center of the building along project south. In discussions with the project team in November, I was informed that part of the driving start point was the foundation wall which raps around three sides of the building. Therefore, it was necessary for the crane to exit the building along the south side but besides that there were no critical driving factors for starting work there.

The other item of research is that originally the project team had planned to remove the crane from the building using the same access point (into the main rink) the scoreboard and ice slab installers are going to use, however shortly before construction the crane exit plan was determined as inadequate and there was a last second decision, of sorts, to add an additional crane exit. With the schedule being a concern and the crane exit being something of an issue it seems as if something could be done to assist in these areas.

Potential Solutions

1. Sequence the start point at a different location to enhance the schedule and allow for easier crane exiting.
2. Determine a way to exit the crane along the same path as the scoreboard and ice slab installers plan to use.
3. Potentially reduce crane time to positively impact the cost.

Methodology

1. Retrieve the most up to date schedule from Mortenson Construction.
2. Sequence the building with a new start location.
3. Determine a method to allow crane and scoreboard / ice slab systems a similar access point.
4. Breakdown any schedule savings.
5. Perform potential cost implication analysis.
6. Consider relocating AHU's to expedite some of sequence 3 (reference thesis proposal).

Resource & Tools

1. Scheduling Industry Professionals
2. Architectural Engineering Faculty: Construction Management
3. Mortenson Construction Project Team
4. Crane Professionals
5. Primavera and/or Microsoft Project

Expected Outcome

With a detailed look at the new schedule it seems as if there can be noticeable time saved by the new sequence of operations. At bare minimum it will provide with a better crane exit strategy. Another reason for experimenting with the new starting point was to allow the crane to place the trusses and just back out. It was interesting, when the trusses started their erection was contingent on weather conditions. The day the second to last one was supposed to be erected, hurricane Sandy was a day away from hitting and the work stopped. It put a significant delay on the project which could be the baseline for when the last truss would need to be erected by.

Analysis 3 | Prefabricated Brick Façade

Problem Identification

This project is utilizing metal wall panels that extend the length of the wall vertically. Part of the reason these metal wall panels were utilized was to help the building become enclosed before winter. The purpose of this is to start some of the finishes to ensure they can be finished before substantial completion.

With some of the injuries incurred on site and the schedule being as tight as it is I thought it would be advantageous to try and remove as many hazards and possibly give some breathing room for the schedule.

Background Research

In technical report 3 a value engineering analysis was done. Located here is a section detailing the prefabricating metal wall panels. As stated above, these panels can extend the height of the building. They are around ten feet wide and were largely value engineered to ensure the building could be enclosed to help support finish work.

Later in discussions with the project team, Heidi Brown, project manager, relayed a similar message as the one above. When asked if there was ever consideration to attach brick to the panels it was implied that attaching brick to metal studs is not done, or at least that she has never seen it done. This was part of the interest in exploring this topic; to see if a brick façade could be attached, all as one system, to the metal wall panels.

After this meeting the PACE Roundtable was attended, where prefabrication was a topic of interest. There were breakout sessions attended, where prefabrication was discussed at length, but the individual breakdowns were of most interest. Here, I sat down with Jeffrey Angstadt, of Foreman Program and Construction Managers, who discussed possible contacts that I could get in touch with regarding prefabricated facades. Moving forward Mr. Angstadt and his contacts should be of value.

Potential Solutions

1. Determine the way in which a brick façade can be attached to a metal wall panel as one system.

2. Potentially develop an original engineered system with a brick façade attached to the metal wall panels.
3. Engineer a brick façade embedded into concrete.

Methodology

1. Get in touch with Mr. Angstadt and any possible contacts he may have.
2. Research prefabricated metal wall panels and determine the viability of attaching brick to the system before being hung.
3. Potentially engineer a possible solution to attaching brick to the metal wall panels.
4. Engineer a brick façade that is embedded into concrete that is to be hung in similar fashion to the metal wall panels.
5. Perform a cost comparison of the two solutions.
6. Determine schedule impacts associated with brick façade.
7. Determine logistical challenges in moving and hanging each of these systems.
8. Perform breadth analysis for architectural joints and potential structural design.

Resource & Tools

1. Jeffrey Angstadt from the PACE Round Table
2. Prefabrication Industry Professionals
3. Architectural Engineering Faculty: Construction Management
4. Mortenson Construction Project Team
5. Revit and/or Google SketchUp

Expected Outcome

This will probably be the most comprehensive depth out of the four. This is simply because of the vast amount of engineering that will have to be done in order to argue this system as a potential successful approach to the project.

Ultimately, it is believed that there will be many benefits to performing this depth. It will certainly save schedule in terms of the brick contractor, which will at bare minimum free up space for the rest of the project. It will also absolutely remove a safety hazard from this project considering the brick layers will not be doing work during hazardous winter weather. The two issues that have the potential to be detrimental to the project are the joints that will be created by the bricks and potential high costs associated with performing either of the systems presented.

Analysis 3 | Geotechnical Investigation

Problem Identification

As typical, before construction began, a geotechnical investigation was performed. This report was performed using a combination of boring samples as well as ground penetrating radar. The areas of the site that utilized the bore samples proved fairly true. However, the areas of the site where ground penetrating radar was used came out very misleading. This led the project team to believe one thing which became untrue once construction began. Therefore, it is of interest to research different types of geotechnical analysis and determine which one is the best and most efficient.

Background Research

This was not researched as part of any of my technical reports. However, it was something that the Pegula project team has discussed multiple times and would be of great interest to explore further. Essentially, the eastern portion of the building, along University Drive, was analyzed using boring samples. The rest of the buildings ground conditions was utilized using ground penetrating radar.

Once construction began the areas in which boring was done proved fairly accurate, whereas, the areas which utilized ground penetrating radar proved extremely misleading. Ultimately, the micropiles needed to be deeper than expected and where strip footing rested massive amounts of lean fill was required. At face value, it appears as if ground penetrating radar is entirely a waste of money and that companies should always bore. However, it is my intention to research the different types of geotechnical analysis equipment and determine which of them is the best.

Potential Solutions

1. Research the different forms of equipment and methods that can be used in a geotechnical analysis.

Methodology

1. Obtain the geotechnical report from Mortenson Construction
2. Obtain any additional information that supports the ground conditions.

3. Determine the original vs. actual amount of additional concrete required to adequately compensate for the inaccurate technical analysis the ground penetrating radar portrayed.
4. Perform an accuracy analysis of all the available methods and equipment.
5. Perform a cost analysis of the different systems
6. Determine which one is the best method/equipment.

Resource & Tools

1. Geotechnical Industry Professionals
2. Geotechnical Report
3. Architectural Engineering Faculty: Construction Management
4. Mortenson Construction Project Team

Expected Outcome

It is fully expected that boring is most likely going to be the most effective. However, boring is an expensive method that can take some time. It also serves only as a projection of the site since each bore is spaced out to a certain degree. Other equipment, such as ground penetrating radar, can survey the entire site and has the potential to function as a 3 dimensional software to give the project team a better understanding of the site. Therefore, there may be hidden benefits to the ground penetrating radar and other methods that boring simply does not have.

Spring Thesis Objectives

Analysis Weight Matrix

A weighted matrix was developed in Table 1 to help give an understanding of how time and resources will be allocated during the spring semester. The four depths and their respective breadths are broken down into Industry Research, Value Engineering, Constructability Review, and Schedule Reduction. These four sections detail the type of work that will be conducted during the spring semester.

Table 1: Weighted Matrix Analysis

Analysis Description	Industry Research	Value Engineering	Constructability Review	Schedule Reduction	Total
Community Rink Sequence and Breadth	-	10%	5%	10%	25%
Entire Building Resequence	-	-	10%	20%	30%
Prefabricated Brick Façade and Breadth	-	10%	15%	5%	30%
Geotechnical Methods and Equipment	15%	-	-	-	15%

Preliminary Schedule

A proposed spring thesis schedule is attached as an appendix. It details what I will be working on throughout the semester and when I will be working through it. It includes four milestone dates. These dates are January 28, February 11, March 1, and March 25. At the end of each of these dates an expected depth is to be finished. There is some overlap in work flow and even some from depth to depth due to timing.

Proposed Thesis Semester Schedule attached in Appendix B.

Conclusion

By performing these areas of technical analysis along with the two depths I hope to prove that there were potential areas to improve the construction process of the Pegula Ice Arena located on University Park at the Pennsylvania State University. Associated with many sports facilities the substantial completion date is critical in order to ensure the season can start on time. Therefore, the bulk of my technical analysis will focus on ways to improve the schedule. That is why I chose to focus my work on sequencing the building differently as well as speeding the enclosure time. The work that is done in the spring is believed to improve the construction process and is of my opinion to offer insight into what a construction project team goes through before construction begins.

Appendix A: Breadth Topic Analysis

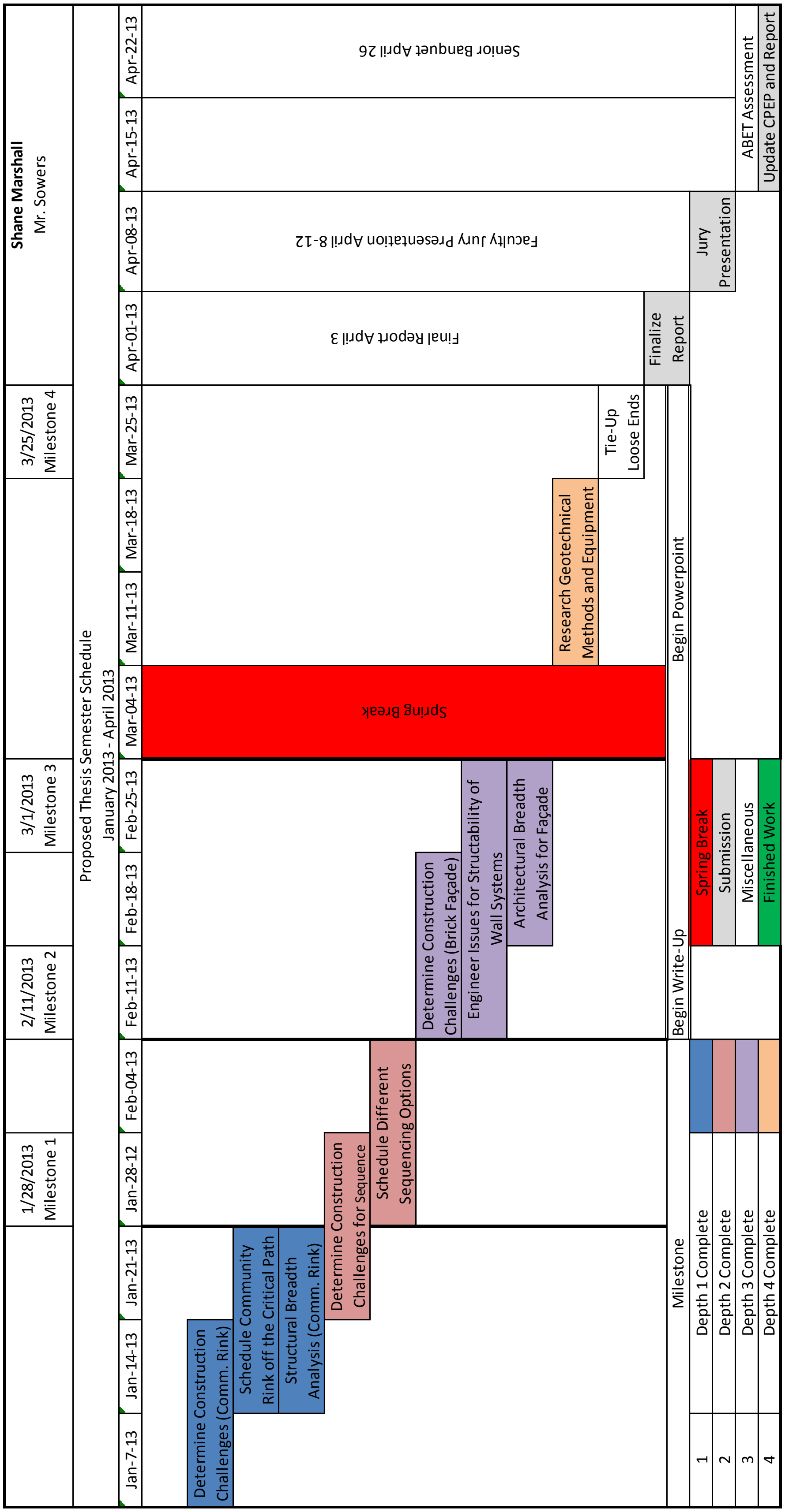
Structural Breadth | Contributes to Technical Analysis 1

This structural breadth will require a structural redesign of the system that supports the community rink roof. The community rink roof is composed of a truss system that extends the entire length of the roof. Over part of the roof, closest to the main rink, the roof partially supports mechanical equipment located on the roof above. The intended redesign of this system will require additional roof supports that will transfer load very similarly into the columns. The largest area of concern is the uniqueness with which the structural system might need to be. The air handling units are extremely heavy and therefore cannot simply canopy similar sized beams out slightly. This is something I am going to need to discuss with one of the structural faculty members to get me started in the right direction. The other items that will be critical to this is how they relate back to construction concerns. Specifically if these connections are highly technical is there going to be extra time and effort through installation. Also, what are the additional cost impacts from the extra structural supports.

Architectural Breadth | Contributes to Technical Analysis 3

The architectural breadth will be associated with the brick façade that is going to be hung with a crane for the enclosure. The area of highest benefit is along the north and south portion of the building containing the windows which span from the main concourse through the club level. It is of interest to see whether the windows can help minimize the exposed joints that will be created through adding a prefabricated brick façade. This same principle (less is more) will be applied to the entire architectural design. Since, the goal will be to change the façade look as little as possible, it will be necessary to detail the wall. This will include architectural cuts, sections, and details; as well as, thermal and moisture related calculations proving the constructability of the newly proposed system. Finally, a virtual mockup will be utilized to help provide a visual on the façade with the new joints.

Appendix B: Spring Semester Schedule


Shane Marshall
Mr. Sowers
Proposed Thesis Semester Schedule
January 2013 - April 2013
1/28/2013
Milestone 1
2/11/2013
Milestone 2
3/1/2013
Milestone 3
3/25/2013
Milestone 4
Jan-7-13
Jan-14-13
Jan-21-13
Jan-28-12
Feb-04-13
Feb-11-13
Feb-18-13
Feb-25-13
Mar-04-13
Mar-11-13
Mar-18-13
Mar-25-13
Apr-01-13
Apr-08-13
Apr-15-13
Apr-22-13
Determine Construction Challenges (Comm. Rink)
Schedule Community Rink off the Critical Path
Structural Breadth Analysis (Comm. Rink)
Determine Construction Challenges for Sequence
Schedule Different Sequencing Options
Determine Construction Challenges (Brick Façade)
Engineer Issues for Structability of Wall Systems
Architectural Breadth Analysis for Façade
Spring Break
Research Geotechnical Methods and Equipment
Tie-Up Loose Ends
Final Report April 3
Faculty Jury Presentation April 8-12
Senior Banquet April 26
Begin Write-Up
Begin Powerpoint
Finalize Report
Jury Presentation
ABET Assessment
Update CPEP and Report
Milestone
1 Depth 1 Complete
2 Depth 2 Complete
3 Depth 3 Complete
4 Depth 4 Complete
Spring Break
Submission
Miscellaneous
Finished Work