

AE 481W

## Thesis Proposal



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**EXECUTIVE SUMMARY**

This report is a proposal for the analyses to be performed next semester concerning construction management issues related to Building 1 at Bakery Square, located in Pittsburgh, PA. The technical analyses are written based on four areas of study that include; critical issue research, value engineering, constructability review, and schedule reduction/ acceleration. An integration of breadth study and graduate level work is also included in this proposal to emphasize the extent of knowledge required for architectural engineers.

Proposed topics include analyses of an alternative pile cap design, standardization of the steel system, relocation of mechanical equipment, and implementation of production management tools. These topics are discussed in further detail below.

The alternative pile cap design will focus on the areas of constructability review and schedule reduction. This will be accomplished by redesigning a specified triangular pile cap into a more efficiently constructed rectangular pile cap.

Analysis of standardizing the steel system focuses on value engineering and constructability review. A redesign of the mezzanine level floor will be performed to use common member sizes in a repetitive fashion to decrease the coordination efforts required for erection.

Relocation of mechanical equipment will be analyzed as a value engineering topic to help improve the aesthetics and energy performance of the building. This will also be used to achieve one area of the required breadth studies.

Analysis of production management tools will be used as a research topic for critical industry issues as well as a schedule reduction topic. Efforts will be taken with the analysis to study the effect these tools have against construction inefficiencies. Research for this topic will be accomplished through literature reviews, interviews, and possible experimentations.

Two breadth topics must be included in the analysis of these topics to showcase knowledge of system integration. A structural breadth study will be required for the redesign of the pile cap in the first technical analysis. This will involve determining structural loads and designing the footing accordingly. A mechanical breadth study will be used to study the effects of relocating mechanical equipment. This process will involve performing energy load calculations and resizing the equipment as necessary.

Graduate level knowledge must also be displayed in one of the technical analyses. An investigation of production management tools will be used to meet this requirement and will be based on information learned in AE 570, Production Management in Construction.

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**ANALYSIS DESCRIPTIONS:****Analysis 1: Analysis of Pile Cap Alternative**

After initial evaluation of the foundation system, it has become evident that the design of certain pile caps is an area for possible improvement. Almost a third of the pile caps for Building 1 are designed to be formed in a triangular shape above three cast-in-place auger piles. The irregular shape is believed to be more labor intensive and therefore more costly than a traditional square or rectangular shaped pile cap. For the first technical analysis, the triangular pile cap will be evaluated and redesigned to a rectangular shaped pile cap.

This analysis will focus on a constructability review to help improve the productivity of pile cap construction and also seek to prove that schedule acceleration can be achieved by using a less labor intensive system. By using a rectangular foot print, odd angles could be eliminated and the pile cap could be constructed more efficiently. Forming the pile caps would also become easier due to the use of right angles and could be constructed with greater productivity.

The required steps to complete the technical analysis include:

1. Perform a takeoff for the triangular pile caps.
2. Analyze the required structural loads, and accordingly redesign the pile caps to the suggested rectangular shape. Knowledge from CE 397A, Geotechnical Engineering, will be used to size the reinforcement required for the pile cap.
3. Perform a takeoff for the new design.
4. Investigate the productivity rates for each type of pile cap. This will be achieved through discussions with the project engineers, foreman, and laborers on site. Documented reference sources will also be used to find common productivity rates.
5. Combine the data gathered from the takeoff and productivity rate investigation, and determine what the overall cost of construction is for each type of pile cap.
6. Compare schedule and cost differences between the two systems.

After investigation through technical analysis, it should be proven that the productivity of constructing rectangular pile caps will be higher than the productivity of constructing the current triangular design. This in turn should also decrease the overall cost of constructing the pile caps by realizing cost savings in labor hours. The reduction of labor costs due to more efficient forming methods should ultimately outweigh the cost of extra material.

## **Analysis 2: Standardizing Steel System**

Another area of interest for technical analysis is the standardization of the structural steel used for the mezzanine level of the fitness center. An important lesson learned in AE 404, Building Structural Systems, is that structural steel systems should use common member sizes whenever possible. Member sizes should be repeated as often as possible also in order to eliminate confusion and reduce the amount of coordination required for steel erection.

By standardizing the structural steel system to common member sizes, the schedule and cost of the structure can both be improved. There are multiple reasons why this change can have such an effect. One reason is that common member sizes are produced more frequently throughout a steel mill's production cycle. This in turn means that there are more of these members available to purchase; therefore reducing the demand and cost for these items. It is also easier to coordinate the procurement of a beam that is produced four times a year as opposed to one that is produced only once a year.

Onsite coordination of the steel becomes less complex when the same member sizes are used more often. Although there may be a cost savings associated with sizing each member individually, there is negligible benefit gained. Standard incremental increases in beam size should be used instead, which causes a decrease in the coordination necessary for construction. Schedule delays can also be avoided when a structure is designed to use repetitive beam sizes because a larger stockpile of those members can exist. If each beam is a different size, then the erection schedule is dependent on the delivery of each individual piece, but an onsite stockpile of repetitive member sizes can be used to prevent this from happening.

To complete the analysis of standardizing the steel system, the following steps will be used:

1. Perform an in-depth analysis of the existing structural system. Included in this analysis are the existing steel and precast concrete systems. This phase of the process can be broken into several sections as well.
  - a. Determine the loading restraints for the precast structure by speaking with the subcontractor, Sidley Precast Group.
  - b. Calculate the deadweight of the existing steel mezzanine through a structural steel takeoff.
  - c. Determine the loading requirements for the structural steel with knowledge gained from AE 404 and speaking with Astorino, the architect and structural engineer.
2. Standardize the steel members used for the mezzanine level by using repetitive common member sizes. The common size members will be determined by using the

Structural Steel Designer's Handbook. Steel members will then be resized to match those sizes and repetition will be incorporated into the design. Load checks will be required to ensure that the steel system can be integrated into the precast structure successfully.

3. Compare the schedule and cost of the two steel structure designs. This comparison will include material and coordination costs associated with each system as well as the schedule impacts that will be realized through redesign. Schedule impacts and coordination costs will be found through discussion with the structural steel subcontractor and the general contractor.

Expectations outcomes from the analysis include proof that the steel structure will be cheaper to erect when member designation is standardized. This should occur because common sized steel pieces will be cheaper to procure, the complexity of the erection sequence will be reduced, and the time required for the steel erection will be shorter.

### **Analysis 3: Relocation of Mechanical Equipment**

Energy performance is an important feature to be considered for any well designed building in today's world. Locating the mechanical equipment in the proper area of the building can aid in the quest for greater efficiency. For the third technical analysis, an investigation of moving the mechanical equipment to a more desired location will be performed. By relocating the rooftop units, for the retail spaces, to the rear of the building shorter duct runs could be used. This action would also eliminate the need for mechanical shafts to run through the fitness center, which in turn provides more useable floor space for Urban Active. The removal of these shafts, which were located against the exterior walls of the south façade, would allow more direct sunlight to enter the fitness center space. In turn this could improve the energy efficiency of the fitness center as well.

The following steps will be taken to successfully implement this technical analysis:

1. Perform lighting and energy analyses for current design of the retail spaces and fitness center through the use of computer modeling software such as IES.
2. Move the mechanical system to a more appropriate location, and check the new design against code.
3. Perform lighting and energy analyses for the retail spaces and fitness center to determine how these spaces are affected by the relocation of the mechanical equipment and the removal of the mechanical shafts from the south façade.

4. Resize the equipment if necessary and determine any new costs associated with these changes.
5. Evaluate the changes through a cost comparison that includes the initial equipment and installation costs as well as any operating costs.
6. Determine if the owner is pleased with the overall effect of removing the mechanical shafts from the fitness center through a short interview process.

By relocating the mechanical system and the mechanical shafts, energy loads should be reduced in both the retail spaces and fitness center. The lighting load inside the fitness center should be reduced because the south façade will become more open. This in turn should also affect the energy load of the space and possibly reduce the size of the mechanical equipment. Cost savings should be realized in both initial costs and lifetime operating costs.

#### **Analysis 4: Implement Production Management Tools**

Inefficiencies associated with current management and construction practices are critical issues that the construction industry is facing. Production management tools can be used by contractors to help solve these problems. By using tools taught in AE 570, Construction Management in Construction, the general contractor should be able to help mitigate these concerns. One example is a short interval production schedule (SIPS), which is an excellent tool to use for a building with repetitive features. The majority of Building 1 is a repetitive parking garage structure and would fit well with the SIPS tool.

Production management tools, such as those taught in AE 570, will be the topic of research for the final technical analysis. To successfully research this topic, case studies on this topic will be evaluated, and interviews will be performed with general contractors who have had experience with production management. Experimental implementation of such tools at Bakery Square might also be possible. All results will be documented and shared with the construction management team at Bakery Square.

The following process will be used to research production management tools:

1. Perform a literature review on information regarding the implementation of production management tools. Case studies will constitute the majority of this section. Document the lessons learned from these articles for later use to aid in the creation of the production management manual.
2. Interview construction managers, who have had used these tools in the past, to determine the associated benefits of each tool. Possible questions include:

- a. Are there certain projects where production management tools are more beneficial?
  - b. How long have you used these tools?
  - c. What steps did you take to implement these tools?
  - d. What benefits, real or perceived, are gained by using these tools?
  - e. Are there any drawbacks/ hindrances to implementing these tools?
3. Use the information gathered from the literature review and interviews to create a production management manual. This document will be a summary of the possible tools that could be used for each project. It will also include a decision tree to help the user implement the correct tool. This information is based on knowledge gained from AE 570.
  4. Present this manual to the general contractor at Bakery Square and suggest the possible implementation of tools for experimentation purposes.
    - a. Run experimental implementation of accepted tool(s) and document findings.
    - b. Incorporate information gained from experimentation in the production management manual.

Research of this topic should yield a useful production management manual that can be used by a general contractor to help manage projects. Analysis should determine that with a proper manual and implementation plan the tools will successfully aid in the management of a jobsite and increase the productivity of the workers. This should also mean that the general contractor will use these tools on future projects.

**WEIGHT MATRIX**

Description	Research	Value Engineering	Constructability Review	Schedule Reduction	Total
<b>Alternative Pile Cap</b>	----	----	10%	10%	20%
<b>Standardizing Steel System</b>	----	10%	20%	----	30%
<b>Mechanical Equipment Relocation</b>	----	20%	----	----	20%
<b>Implement Production Management Tools</b>	20%	----	----	10%	30%
<b>Total</b>	20%	30%	30%	20%	100%

- Table 1 - Weight Matrix

**CONCLUSION**

The proposed technical analyses will seek to improve the constructability, schedule, and value of Building 1 at Bakery Square. The analysis topics include pile cap design, standardizing the steel system, relocation of mechanical equipment, and the implementation of production management tools. In addition to evaluating construction management issues, structural and mechanical studies have been integrated into the proposal to highlight the breadth of knowledge expected from architectural engineers.

**APPENDIX 1 – BREADTH STUDIES**

Knowledge of system integration must be shown by including breadth topics in the analysis of Building 1. The areas of breadth that will be used include structural and mechanical knowledge. These topics have been successfully integrated into the analyses of the pile cap and the mechanical equipment.

Redesigning the pile cap to improve the constructability requires a background of structural knowledge. Information from AE 404 and CE 397A will be used to redesign the concrete pile cap. This process includes breadth studies on structural loading and the design of a concrete footing.

Relocating the mechanical equipment used to condition the retail space is based on knowledge of mechanical systems. AE 310 information will be used in order to calculate design loads and size the equipment. Additional mechanical knowledge needed for this analysis include the use of modeling software to determine operating costs of the systems.