AE 481W

Thesis Proposal

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Construction Management

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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, a lightweight structural system for the mezzanine level, relocation of mechanical equipment, and the use of sustainable technologies. 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 a lightweight structural system focuses on value engineering, constructability review, and schedule reduction. A redesign of the mezzanine level floor will be performed to use a more efficient system that will reduce the schedule and require less crane time.

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

Analysis of green technologies such as piezoelectric floor tiles and electrical generating bicycles will be used as a research topic for critical industry issues as well as a value engineering topic. Efforts will be taken with the analysis to study the effect these technologies have on energy usage, operating costs, and overall sustainability. Research for this topic will be accomplished through literature reviews 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 sustainable technologies will be used to meet this requirement and will be based on information learned in AE 597D, Sustainable Building Methods.

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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. Through discussions with the general contractor it became apparent that they believed the irregular shape was 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, but was not chosen because the structural engineer did not redesign the cap.

Analysis 2: Analysis of Lightweight Mezzanine Structural System

Another area of interest for technical analysis is the use of an alternative structural system for the mezzanine level of the fitness center. Instead of a bulky steel system, lightweight systems will be analyzed as possible alternatives. A lightweight structural system should prove to reduce the cost and schedule of this project, and therefore would be more appropriate for this particular application.

The schedule of the project can be reduced with an alternative structural system for the mezzanine by reducing the amount of erection time required. The primary reason for this would be an elimination of crane time, which was required for the large Wx33 beams. With a lightweight system the structural elements can be moved and positioned into place without the use of the crane. The crane can then proceed to continuously erect the precast elements without stopping to help erect the mezzanine level. This alone would cause the schedule to be reduced by four days. It is also possible to decrease the time required to erect the mezzanine because properties of the lighter weight system lend itself to more efficient erection times.

A lightweight system should reduce project costs due to fact of the ever increasing price of steel. The original design requires extremely large pieces of steel that drastically increases the price of the project since each additional pound of steel creates additional material cost. By using a lightweight system the weight of material can be reduced and therefore decrease the construction costs. The reduction of crane time as explained above will also cause a reduction in cost because the crane can be moved off site at an earlier date.

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. Investigate alternative lightweight structural systems.

3. Design the new mezzanine level with the most appropriate system available.

4. Compare the schedule and cost of the two steel structure designs. This comparison will include material and construction 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 lightweight structure will be cheaper to erect. This should occur because of reductions of material cost, crane time, and schedule length.

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 and possible redesign 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. Investigate alternative mechanical systems.

2. Move the mechanical system to a more appropriate location, and check the new design against code.

3. Evaluate the changes through a cost comparison that includes the initial equipment and installation costs as well as any operating costs.

4. 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 the space should have a more aesthetically pleasing configuring. 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: Investigate Sustainable Gym Design

Sustainability is an important design criterion that must be considered when developing any type of project. This concept has received a lot more attention recently due to increases in cost of resources, energy costs, and decreases in natural resources. The LEED rating system is the most prevalent and widely known authority for green design and gives certification points based on sustainable design criteria in site usage, water efficiency, energy and atmosphere, material and resources, indoor environmental quality, and innovation and design process.

Points associated with the innovation and design process section of LEED can be the most difficult items to achieve credit for. With that being said, innovative design points are among the most beneficial and sustainable items to incorporate into a building's design because the edge of the envelope must be pushed in order to create these innovative designs. For this reason, it is important to incorporate innovative design ideas into a project.

Physical energy that is spent by members at a fitness facility could possibly be harnessed and reused as electrical energy to reduce the amount of grid-supplied energy that building uses. Research will be performed on the various types of energy harnessing technology that can be used in a fitness facility application. Some ideas include piezoelectric floor tiles and electricity generating fitness bicycles. These and other human powered energy sources will be investigated for this analysis as well as other green design technology that could benefit the building as a whole.

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

1. Perform a literature review on information regarding human powered sustainable technology and green technology as a whole. Case studies will constitute the majority of this section. Document the lessons learned from these articles to aid others in the design of more sustainable buildings.

2. Research current sustainable technology that allows a facility to capture physical energy spent by people and reuse it as electrical energy.
   a. Research electrical generating bicycles.
   b. Research piezoelectric floor tiles.
   c. Research other human powered energy sources.

3. Run load calculations for the green technologies.
   a. Determine average power generated by each application.
   b. Determine if energy generated is equal to or greater than the energy used at the fitness facility.

4. Determine costs to implement energy harnessing technologies and cost savings during operation.

5. Research other areas of sustainable design that could be incorporated into the building project.

Research of this topic should show energy harnessing technology at a fitness facility can be used to supply a large portion of the electricity required to operate the gym. Analysis should determine that the sustainable equipment will be economically successful by reducing the operational costs of the facility. This technology should also help to reduce Bakery Square's carbon footprint and bring energy consumption closer to net zero usage which is a main goal of all sustainable design.

WEIGHT MATRIX

Description	Research	Value Engineering	Constructability Review	Schedule Reduction	Total
Alternative Pile Cap	----	----	10%	10%	20%
Lightweight Structure	----	10%	10%	10%	30%
Mechanical Equipment Relocation	----	20%	----	----	20%
Sustainable Design	20%	10%	----	----	30%
Total	20%	40%	20%	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, using a lightweight structural system for the mezzanine level, relocation of mechanical equipment, and implementation of sustainable technologies. 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 a 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.