Northeastern Pennsylvania Office Building

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Executive Summary

This proposal is intended to be a detailed outline that will guide research on the Northeastern Pennsylvania Office Building project. The four main analyses encompassed in this proposal include critical industry research, value engineering, constructability reviews, and schedule reduction and/or acceleration pertaining to the following four analysis areas:

Analysis 1: Replacing the Pre-Engineered Metal Building

Due to delays in the project schedule caused by the PEMB, an analysis will be performed to assess the effects on the schedule and project cost if the building's structural system were to be changed. A preliminary analysis of three building systems will be used to determine the most suitable candidate. Further analysis will be performed to compare the alternate system to the PEMB.

Analysis 2: Design-Build Phase 2 & 3

Since the project team is familiar with the work being designed and constructed on Phase 1, a design-build approach could be used on similar buildings, Phases 2 & 3. A design-build project is expected to accelerate and reduce the project schedule.

Analysis 3: Horizontal Expansion vs. Vertical Expansion

The owner has shown interest in doubling the amount of occupants in the office building. This analysis will be performed to outline why a horizontal expansion would be preferred over a vertical expansion. Along with the owner's obligations being highly considered, the costs and schedules of each option will be compared.

Analysis 4: Geothermal System

A geothermal system could be installed to warm the slab of the shop building in the colder months of the year and cool the slab in the warmer months. It would reduce the amount of gas-fired heaters used in the shop building, and would therefore reduce the amount of fuel consumed to heat the space.

Table of Contents

Project Background

The Northeastern Pennsylvania Office Building is Phase 1 of a 5 phase project on the outskirts of a rural community in Northeastern Pennsylvania. The project consists of two single-story buildings on a nineteen acre project site. Security fencing will surround the site to enclose a gravel laydown yard where the owner will store materials and equipment after project completion. The office building is approximately 11,500 square feet and the shop building is about 14,700 square feet. Together, these buildings are scheduled to be constructed from June 2011 until about March 2012 and cost about $5.4 million.

Both buildings are pre-engineered metal buildings (PEMB) set on concrete pier foundations. The floor systems for both buildings are concrete slabs-on-grade with concrete grade beams. Ten gas furnaces distribute warm air throughout the office building, while the shop building uses a combined system of twelve gas-fired heaters and three large, ceiling-mounted fans to warm the space.

Analysis 1: Replacing the Pre-Engineered Metal Building

Issue

The pre-engineered metal building system used for both buildings have not only caused problems in the field with coordination, but it has delayed the project schedule. The general contractor on the project has expressed displeasure with the subcontractor that has been hired to design, fabricate, and install the PEMB for this project.

Scheduled line items that are specific to the PEMB (reactions and fabrication) have delayed the entire project schedule approximately two weeks. Delays have occurred because of miscommunications and a lack of effort by the PEMB subcontractor. Since the general contractor is capable of erecting steel structures and precast concrete structures and can construct cast-in-place concrete structures, these structural systems will be analyzed to determine, if the PEMB were to be replaced, which system would be most appropriate for this project. Criteria that will determine the appropriateness of each system will include cost, schedule impact, and seasonal and regional constructability issues.

Methodology

The first area of analysis that must be performed would be to calculate the costs and schedule impact of the pre-engineered metal building. This will include all costs associated with fabricating and installing the PEMB, as well as the costs endured by the general contractor for not completing the project on schedule. This will provide a baseline for comparison with other structural systems.

The next area of analysis will be finding a suitable replacement system. Systems that will be evaluated include a standard steel structure, tilt-up precast panels, and a cast-in-place concrete structure. Structural systems that are not suitable based on seasonal and/or regional constructability will be removed from consideration. For the remaining structural systems, schedule durations and cost data will be gathered to define the best system to replace the PEMB. An accompanying structural analysis (Appendix A) will be performed to determine member sizes for more accurate cost estimation.

Expected Results

This analysis will not only highlight the negative impacts of the PEMB, but it will also suggest an alternate system. Although a PEMB is generally considered appropriate for a project such as this, an alternate system is expected to be less expensive and have a shorter construction duration because of the PEMB delays experienced on this project.

Analysis 2: Design-Build Phase 2 & 3

Issue

The Northeastern Pennsylvania Office Building is Phase 1 of a five phase project. It was delivered as a standard design-bid-build project. A preselected list of contractors was chosen by the owner to submit bids for this project. With an almost complete set of drawings and specifications, the contractors analyzed the scope of work and submitted their bid. The winning contractor then sent out the project documents to subcontractors for bids. Once all of the subcontractors were chosen, the project began construction.

Although the timeframe of design is not known at this point in time, the drawings and specifications were issued April 2011. This means there was a three month delay between the contractors receiving the project documents and the start of construction. Since Phase 2 and Phase 3 of this project are nearly identical buildings, they could be delivered as design-build projects with the Phase 1 project team to reduce the schedule and costs of these later phases.

Methodology

It is important to first understand the timeframe involved with the design-bid-build process used in Phase 1. The design aspect is unknown at this time, but the bidding stage lasted about three months and the building's construction is approximated to last nine months. With this base timeline known, design-build projects that are similar in size and cost can be investigated to determine the approximate schedule length of this type of building when using a design-build approach. The change in schedule can be extrapolated to determine an approximation of cost additions/savings due to an altered project schedule.

Expected Results

Cost additions/savings that will be derived will be directly associated with the changes in project schedule. Since the design-build process is generally shorter than the design-bid-build process, it is expected that there will be cost savings involved if the later project phases are delivered as design-build projects.

Analysis 3: Horizontal Expansion vs. Vertical Expansion

Issue

The office building portion of the Northeastern Pennsylvania Office Building is currently designed to provide work space for about 50 employees. The owner now believes that they will need to double the office space available to accommodate around 100 employees. The two options for an expansion of this size are to expand horizontally or vertically. It is assumed that the original Phase 1 construction has been completed and employees are currently occupying the office and shop buildings. It will also be assumed that the underground utilities are capable of handling the additional load from the expansion, whether it is horizontal or vertical. All other project aspects were designed to accommodate the original office building size. The primary function of this analysis is to outline and justify the benefits of a horizontal expansion when compared to a vertical expansion for this particular project.

A horizontal expansion will result in less area in the gravel laydown yard due to the larger building footprint and the addition of a second parking lot. However, the majority of the original office building could be occupied while the additional office building is constructed nearby. In order to access the original underground utilities, additional gravel yard will be unusable for the owner. Also, while the additional building's utilities are being connected to the original buildings utilities lines, the original building's utilities may not be usable.

A vertical expansion would require an almost entire building redesign due to the larger loads demanded from the building systems. Also, the office building would have to be entirely vacated while construction is being performed in and above the space. The primary advantage to a vertical expansion would be the retaining of the entire gravel laydown yard.

Methodology

After developing a list of positive and negative impacts on the project for both a horizontal and vertical expansion, an interview with the owner will help determine the priority of which impacts are most and least important to the client. This is will help decipher whether the benefits of a horizontal expansion exceed the benefits of a vertical expansion.

Using information obtained by researching other vertical expansion projects, generalized cost and schedule information can be applied to the current project data to

determine the impact of a vertical expansion. This can be compared to the approximated cost and schedule impacts derived from the current project data for a horizontal expansion.

Finally, three-dimensional models of the site with a vertical expansion and a horizontal expansion could be created to help the owner visualize and compare the aesthetic differences between the two options.

Expected Results

It is expected, since this analysis is intended to emphasize why a horizontal expansion is preferred, that the results of this analysis will show that a horizontal expansion would be preferable when compared to a vertical expansion. Although the cost of constructing a completely separate building may exceed the cost of reinforcing the original building and expanding vertically, it is likely that the owner would prefer to have the office building continuously occupied because it may cover the higher cost. Also, the duration of vacancy would be strictly dependent on the duration of the vertical expansion. However, with a horizontal expansion, this vacancy duration is not dependent on any other factors aside from usability of the underground utilities.

Analysis 4: Geothermal System

Issue

The shop building of the Northeastern Pennsylvania Office Building currently utilizes twelve gas-fired heaters that are mounted above each truck entrance to warm the space. Three large ceiling-mounted fans are used to force the warm air down so that the heat does not raise and remain at the top of the building. This system for warming the space is not very energy efficient since energy is used to by the gas-fired heaters and also by the ceiling-mounted fans.

Since this project has a large site in a rural area, a geothermal system could be utilized to warm the shop building's concrete slab-on-grade while reducing the energy consumption. In addition to normal heating load requirements, the slab will be experiencing cold temperatures from the ice and snow dropped by trucks making deliveries to the shop building. The geothermal system will not only help melt this snow and ice throughout conduction, but it will also passively radiate heat in an upwards direction to warm the shop space.

Methodology

Primary research will need to be conducted to become familiar with geothermal systems and to help decide which system is most appropriate for this particular project. Once a system has been chosen for further analysis, a mechanical analysis (Appendix A) will be performed to determine the size and cost of the geothermal system. Also, based on the size of the system, a duration will be determined to install the system and will be inserted into the project schedule to determine if the installation of a geothermal system would impact the project schedule in a negative way. Finally, a cost analysis will be performed to determine the payback period for the initial installation costs for the geothermal system.

Expected Results

Although some of the gas-fired heaters and ceiling fans may still be needed for additional warmth, the energy consumption within the shop building will be reduced due to the implementation of a geothermal system. Although the initial costs and schedule impacts may be high, the payback of a system such as this is anticipated to be beneficial. Also, since the shop building does not currently have any cooling in the warmer months, this system provides passive cooling if run during the warm months of the year.

Weight Matrix

Description	Research	Value Eng.	Const. Rev.	Sched. Red.	Total
Analysis 1		10%	10%	10%	*30%*
Analysis 2				10%	*10%*
Analysis 3		10%	20%	10%	*40%*
Analysis 4	10%	10%			*20%*
Total	*10%*	*30%*	*30%*	*30%*	**100%**

Conclusion

This proposal is intended to analyze critical industry research, value engineering, constructability reviews, and schedule reduction and/or acceleration pertaining to four separate areas of analyses with regards to the Northeastern Pennsylvania Office Building. These four areas of analysis include replacing the pre-engineered metal building, using a design-build delivery system for later building phases, verifying why a horizontal expansion is preferred when compared to a vertical expansion of the office building, and installing a geothermal system to warm the concrete slab in the shop building.

Appendix A: Breadth Studies

Structural (Replacing the Pre-Engineered Metal Building)

The structural system that is determined to be the most appropriate replacement for the pre-engineered metal building will require a basic structural analysis to help determine the shape and sizes of different structural members. The shape and size of a structural member will affect both the cost and the construction duration for the building's duration.

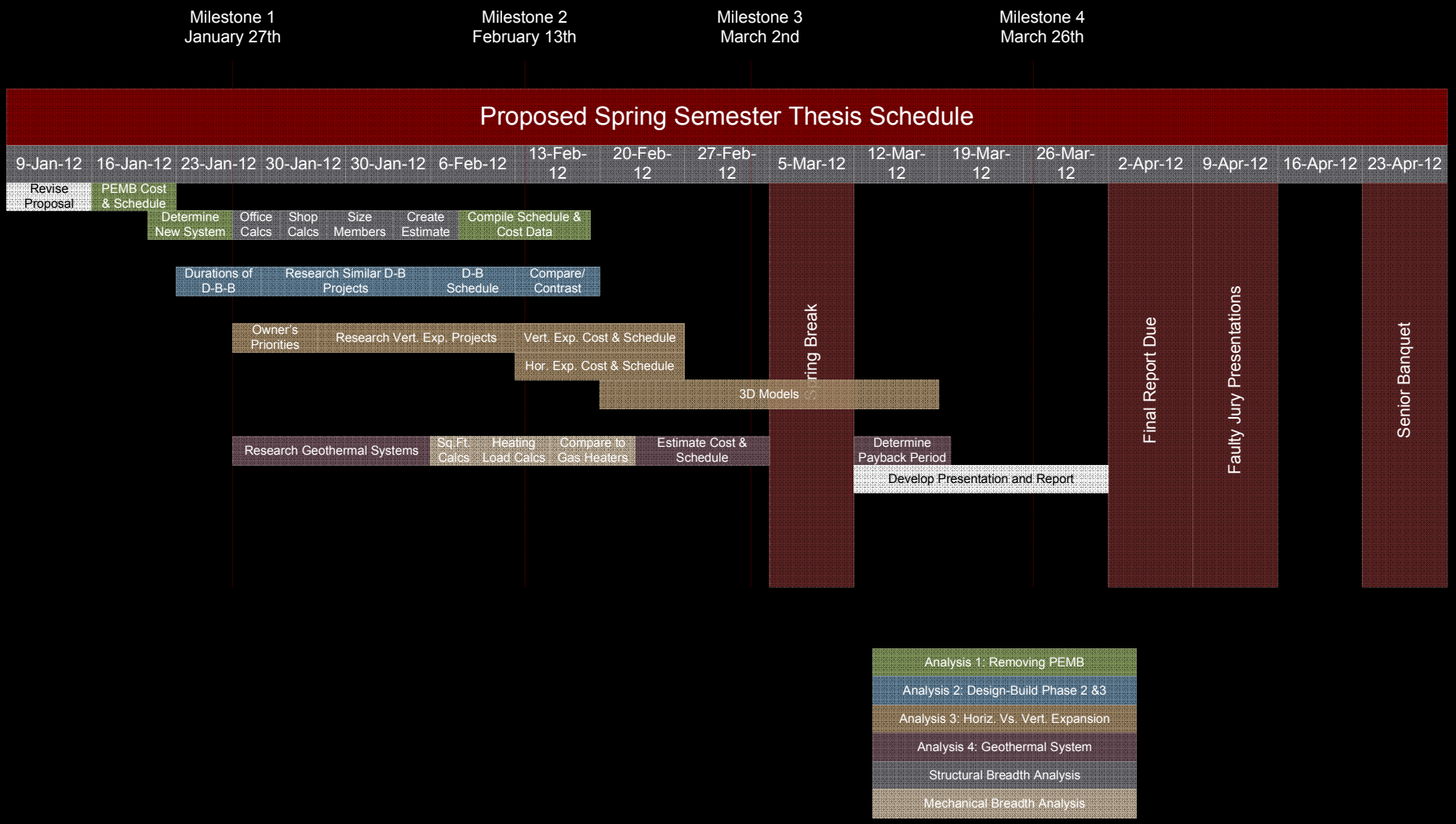
Although the shop bays are fairly consistent in size, as well as the office building bays, they are not comparable to each other. Because of this, a structural analysis will be performed for one bay of the shop building and for one bay of the office building. Loads that will be analyzed will include dead load, live load, and snow load. No seismic loads will be required because of the location of this project. The structural analysis will include spread footings, columns, and beams and girders.

Once the sizes and shapes of the structural elements in both the shop bay and the office bay are determined, they will be extrapolated to estimate the total cost of the new structural system for the project.

Mechanical (Geothermal System)

Once a specific geothermal system has been chosen for this project, square footage calculations will be found in order to determine the size of the system. These calculations will only include the shop building. Although the office building may be suitable for a geothermal system, it will not be considered for this analysis. Based on the size of the system being considered, the heating load that will be produced will be calculated. The heating load produced by the geothermal system can be used to determine how many gas-fired heaters can be removed from the shop building.

Appendix B: Proposed Thesis Semester Schedule


Milestone 1
January 27th
Milestone 2
February 13th
Milestone 3
March 2nd
Milestone 4
March 26th
Proposed Spring Semester Thesis Schedule
9-Jan-12
16-Jan-12
23-Jan-12
30-Jan-12
30-Jan-12
6-Feb-12
13-Feb-12
20-Feb-12
27-Feb-12
5-Mar-12
12-Mar-12
19-Mar-12
26-Mar-12
2-Apr-12
9-Apr-12
16-Apr-12
23-Apr-12
Revise Proposal
PEMB Cost & Schedule
Determine New System
Office Calcs
Shop Calcs
Size Members
Create Estimate
Compile Schedule & Cost Data
Durations of D-B-B
Research Similar D-B Projects
D-B Schedule
Compare/ Contrast
Owner's Priorities
Research Vert. Exp. Projects
Vert. Exp. Cost & Schedule
Hor. Exp. Cost & Schedule
3D Models
ring Break
Research Geothermal Systems
Sq Ft Calcs
Heating Load Calcs
Compare to Gas Heaters
Estimate Cost & Schedule
Determine Payback Period
Develop Presentation and Report
Final Report Due
Faulty Jury Presentations
Senior Banquet
Analysis 1: Removing PEMB
Analysis 2: Design-Build Phase 2 &3
Analysis 3: Horiz. Vs. Vert. Expansion
Analysis 4: Geothermal System
Structural Breadth Analysis
Mechanical Breadth Analysis