

AE Senior Thesis

# Phoenixville Area Middle School: Final Proposal

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## Executive Summary

This proposal contains areas of focus that will be researched throughout the following semester. Each of these areas was selected based on the conditions of the project, including such factors as location, delivery method, and design. The common themes that are the basis of the research to be conducted in these areas include: Critical Industry Issue Research, Value Engineering Analysis, Constructability Reviews, and Schedule Acceleration Scenarios. The proposed changes and future findings associated with them are not a negative reflection on the project teams' efforts on this job. They are simply a way to examine current issues and ideas by applying them to a project under construction.

### Alternative Delivery Method

The multiple prime, design-bid-build system typical of state funded projects is seeing a decline in use in recent projects. The rise of BIM and sustainable systems has given rise to an integrated design-build approach to project organization. This research will identify why exemption from the Separations Act was pursued, what requirements are necessary, and approximate the benefits of design-build.

### Alternative Heat Pump System

The current mechanical system uses water source heat pumps. This was identified in the value engineering process as a place that could achieve higher total value with a more efficient system in place. Geothermal heat pumps will be examined in this section, along with cost, schedule, and constructability concerns. LEED rating will also be addressed in this section, as a cost analysis involving government compensation for silver rated buildings will be conducted.

### Macro BIM Application

BIM use for design analysis will be identified for its potential benefits. An approximation of the benefits of Macro BIM in early planning will be presented.

### Precast Exterior Walls

A precast façade system will be analyzed for the reduction in overall project schedule

### Mechanical Breadth – Geothermal Heat Pump Analysis

The energy performance of geothermal heat pumps will be examined compared to the current water source heat pump system.

### Structural Breadth – Strip Footing Redesign

The strip footings will be redesigned to accommodate for the precast wall panel load.

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## Technical Analysis 1: Alternative Delivery Method

### Problem Identification

As required by the Pennsylvania Separations Act, the Phoenixville Area Middle School employs a multiple prime design-bid-build delivery method. An agency construction manager acts as the owner representative, and seven prime contracts were issued rather than the minimum four. While historically this system has been seen as a way to limit construction costs with lower contractor fees, the law mandating multiple prime contracting has recently been criticized for the fiscal and administrative burden it places on the owner. A growing trend within the construction industry is the use of a more integrated delivery method, utilizing a design-build approach. The benefits of this system stem from the increase in communication and involvement of all project team members. While some state funded projects have petitioned the government to utilize this method, it is unclear exactly what drives project teams to do this.

### Background Research Performed

As technology and sustainable building systems have played a larger role in the design and construction of buildings, the integrated structure for delivering projects has become increasingly common. The reasons for using this system do not typically include lower construction costs; the benefits are in the quality of design and the long term use of the building. Despite the law concerning multiple prime contracting, school districts can apply for exemption from this requirement. In doing so, they can choose a delivery method they determine to be the most cost effective.

This research will examine exactly what reasons lead owners to pursue exemption. The individuals that have pushed for this on past state projects will be interviewed. The reasons they chose to do so will help in determining why certain projects feel it is necessary to use an integrated approach. By examining litigation concerning the Separations Act, the requirements for exemption will be identified. An approximation will then be worked towards to determine the differences one delivery method has over the other. This will be done with data of past projects to give a rough estimate of the differences. The shifting of risk, responsibility, and communication amongst members of the project team that comes with the integrated approach will be identified.

### Potential Solutions

The reasoning and methods of getting around the Separations Act will be examined to show why an integrated delivery method is pursued for certain projects. The general differences in overall

project quality in both the construction and occupancy periods will be approximated. Using this information, the application of an integrated delivery method on the Phoenixville Area Middle School will be analyzed for its feasibility.

### **Analysis and Research Methods**

Other recently constructed projects that have successfully used this design-build system will be studied to identify a successful organization structure. The individuals who pushed for exemption will be interviewed to see why they chose to do what they did. The litigation surrounding the Pennsylvania Separations Act will be research to determine the requirements of exemption. The laws of other states concerning state funded projects will be contrasted to those of Pennsylvania.

### **Expected Outcome**

The anticipated outcome of this analysis area is that integrated delivery methods provide better total value to projects. The changing technologies within buildings may have made the Pennsylvania Separations Act detrimental to projects. Assuming this project has all requirements needed for exemption, the application of an integrated approach will be appropriate for the project.

## Technical Analysis 2: Alternative Heat Pump System

### Problem Identification

An energy efficient design was a focus of the owner and project team from the early planning stages of the project. As an educational institution, the school district felt responsible to set the right example for the students they educate and the community they serve. Economics was the other major driving force with the past and projected spikes in energy costs. Typically budget constraints are a limiting factor in school projects, making upfront costs a more significant concern. The school district declined the option to achieve LEED Certification largely based on this issue. However, state funded projects are eligible to receive compensation for LEED Silver certification, and this project was right at the minimum of points for this rating on the scorecard.

School buildings generally are in use for fifty years, creating a promising opportunity for long term savings potential. Given the cold climate of Eastern Pennsylvania throughout the school year, heating represents a large portion of the building's energy consumption. The Phoenixville Area Middle School was designed with a mechanical system incorporating water source heat pumps. This design is a relatively efficient system, but it does not necessarily guarantee the best value for the school district over the life cycle of the building. By substituting in higher efficiency heat pumps into the system, the school district potentially can save enough on energy costs long term to justify increases in construction costs. Along with energy cost savings, the government compensation would be an added offset to the costs of this system. The additional efficiency would mean a higher overall reduction in consumption, scoring more points on the LEED scorecard and ensuring a silver rating. This area will include a breadth study on the energy use of each system.

### Background Research Performed

A discussion at the PACE Roundtable Conference was based around energy management in buildings. A key point from this discussion was the importance of life cycle analysis in design. During the value engineering process on the middle school the mechanical system was targeted. The agency construction manager on the project, Reynolds Construction Management, believed that geothermal heat pumps were a better option than the water source. However, the school district wanted to lower construction costs, and rejected this option.

## Potential Solutions

As previously described, this research will be used to determine the short and long term costs of the geothermal heat pumps compared to the currently designed water source. This will then be used to determine if this alternative makes sense economically. Ultimately, the possible outcomes will be that the long term payback makes the new system a better alternative, or that the current system is a better value. LEED silver compensation will also be included. The geothermal system will be evaluated both as with and without this compensation.

## Analysis and Research Methods

A breadth study on the efficiency of the geothermal and water source heat pumps will calculate energy consumption differences of each system. The results will be used a part of this analysis. The methods of research for this portion are organized below by the different parts of this topic.

### *Cost Analysis*

Assuming a fifty year building life cycle, the current and projected cost of energy will be used to calculate an approximate value for long term costs. Energy costs will be research based on the current and projected rates determined by expert analysis. Costs on construction will be done through research of past projects and consultation of mechanical contractors.

### *Construction Concerns*

The changes in schedule, logistics, and sequencing of the proposed system will be researched by consulting mechanical contractors. Both the contractor for the project and contacts made at PACE Roundtable will be utilized for their expertise.

### *LEED Certification*

The LEED points will be identified by examining the scorecard requirements and consulting with the construction manager on the project. Using the feasibility study done by the project team and including the changes in heat pump design, the compensation will be determined and used in the cost comparison. Additional efforts required by the project team will be addressed in the construction concerns portion.

## Expected Outcome

The geothermal heat pump system is expected to provide better total value than the existing design. The construction manager thought this was the better choice during the planning period of the project despite the school district's decision. The additional efficiency of the system will make LEED silver certification attainable, and the associated compensation and long term savings will make this decision an economically feasible choice.

## Technical Analysis 3: Macro BIM

### Problem Identification

The implementation of modeling software was limited on the Phoenixville Area Middle School. According to the architectural firm, Gilbert Architects, the only areas it was used was for the architectural and structural design. This was then used for school board presentations, facility manager communication, and creating construction documents. Multiple prime contracting structures make building information modeling (BIM) difficult to utilize since it is unclear who is responsible for leading and coordinating the process. The design of the middle school itself does not present extreme logistical or sequencing issues that would require model use for planning. However, opportunities exist on the project for BIM use to improve the processes involved with the design and construction process.

### Background Research Performed

Modeling software is versatile in its application to a variety of trades and processes. These are listed in the BIM Execution Guide created by Penn State University. While all of these uses do not apply to this project, certain areas have potential for improving the overall quality of the final product. The complete list is listed below:

<b>Building Maintenance Scheduling</b>	<b>Design Authoring</b>
<b>Building Systems Analysis</b>	<b>Engineering Analysis</b>
<b>Asset Management</b>	<b>Sustainability Evaluation (LEED)</b>
<b>Space Management and Tracking</b>	<b>Code Validation</b>
<b>Disaster Planning</b>	<b>Design Reviews</b>
<b>Record Modeling</b>	<b>Programming</b>
<b>Site Utilization Planning</b>	<b>Site Analysis</b>
<b>Construction System Design</b>	<b>Phase Planning (4D Modeling)</b>
<b>Digital Fabrication</b>	<b>Cost Estimation</b>
<b>3D Control and Planning (Digital Layout)</b>	<b>Existing Conditions Modeling</b>
<b>3D Coordination</b>	

The potential areas of application that have potential to bring positive results to this project are those regarding design analysis and energy performance. Building systems analysis with regard to the mechanical system would have provided a better means of comparison in the value



engineering process. The value engineering process as a whole could have benefited from the use of modeling software.

### **Potential Solutions**

The use of modeling software for the previously listed areas could prove to be valuable in providing extra detail and data. Positive impacts such as increased building system efficiency and rapid design comparison could mean better value for the owner. Even with a multiple prime delivery method, Macro BIM could have been utilized by the construction manager to aid in the value engineering process.

### **Analysis and Research Methods**

Due to the relatively short period that modeling software has been used as a means of communication amongst team members, there is not much in terms of data that can provide quantitative research for this analysis. However, potential uses and the opinions of professionals will provide the bulk of research for this subject. Mechanical contractors, general contractors, owners and construction managers will be interviewed on a combination of the following topics:

- How BIM was applied to the previously mentioned focuses
- Requirements of all project members in terms of BIM input
- Benefits seen through use
- Problems encountered through use
- Areas that are better than others for application
- Difficulties of multiple prime BIM use

### **Expected Outcome**

The delivery method of the Phoenixville Area Middle School project may restrict the practicality of BIM on the project. However, the areas its use will be explored may prove to be useful for the project team. The use of the software may demonstrate the potential for options that are not available unless it is used on a project.

## Technical Analysis 4: Implementing a Modular Classroom Design

### Problem Identification

The classrooms of the new middle school represent a significant portion of the building space and schedule. Each one of these rooms has its own HVAC and lighting controls, casework, heat pump, and things such as finishes and glazing that require multiple trades to do work in one area. Each of these rooms is similar in design and size on the project. By creating a way to make these repetitive rooms quicker and simpler, the project can progress more quickly and the overall completion time will drop.

### Background Research Performed

Precast walls for the classroom areas would allow a rapid installation for the exterior. The time saved on enclosing these areas would allow interior work to start earlier. This drop in MEP duration for these areas would result in shorter overall project duration. The exterior façade is a constant composition of limestone and brick. The precast members would be a simple design that would not present many obstacles in field installation.

### Potential Solutions

The precast exterior walls will cut duration significantly in these areas. A quick enclosure to the classroom wings will allow the interior systems and finishes to start and finish work earlier. The resultant savings from an earlier completion date will not only potentially save money on the middle school project, it will present opportunities for the following two phases of work being done on the school campus.

### Analysis and Research Methods

Precast wall panels will be researched by examining past projects that have used them, such as the Millennium Science Center at Penn State. A design will then be developed for this project that will allow a quick erection of the enclosure. Following this, the resultant cost in extra crane time and upsizing of structural members will be determined. Sequencing will also be analyzed in terms of impact on other trades.

### Expected Outcome

The precast exterior will significantly lower project duration. The costs associated with this schedule reduction will reduce total project cost.

## Analysis Weight Matrix

The areas of analysis previously described will cover different topics critical to any proposed change to a construction project. These are research, value engineering, constructability review, and schedule reduction. The manner in which each analysis area included these core aspects is detailed in the following table.

Description	Critical Issue Research	Value Engineering	Constructability Review	Schedule Reduction	Analysis Total
<b>Project Delivery</b>	20%	-	--	-	20%
<b>Geothermal Heat Pumps</b>	-	20%	10%	-	30%
<b>BIM Application</b>	10%	10%	-	-	20%
<b>Precast Walls</b>	-	-	10%	20%	30%
<b>Core Topic Total</b>	30%	30%	20%	20%	<b>100%</b>

## Timetable

Do to the volume of research necessary for an in depth study of these areas, a well-defined schedule will be important in remaining on track to complete this work. An early estimation of the semester is provided in Appendix B.

## Conclusions

Investigating each of these areas will allow an investigation of current industry trends and changes through their application to a project under construction. The goal of this research is not to find errors and problems within the existing Phoenixville Area Middle School; the project team has done a quality job in delivery the project on schedule, on budget, and satisfactory to the owner. The point of these proposed changes is more to examine how the changes in methods and practice seen in today's construction culture can be applied to this specific project. Any findings that show an opportunity to benefit the project team in anyway can be used by them.

## Appendix A

### **Breadth Topic: System Analysis of Geothermal Heat Pump Alternative (Mechanical)**

This area will cover the difference in energy efficiency of the proposed geothermal heat pump system compared to the current water source system. This analysis is necessary for the cost comparison described in analysis area two. This study will be done to a somewhat limited extent since accuracy is not required as much as a relative comparison. In order to accomplish this, energy evaluation programs will be used with basic building geometry. The exact program to be used will be chosen based on those available to students at Penn State University. The control system and any other significant issues will be researched through consultation with established mechanical contractors.

### **Breadth Topic: Strip Footing Redesign for Precast Wall Load (Structural)**

Analysis Area 4 focuses on the design on a precast wall panel system to replace the current masonry / brick façade in place. This proposed design change would result in a loading increase on the strip footings. Once a design has been finalized for these precast walls, the design load will be determined for the footings. The exterior walls of the classroom areas have a typical design along the perimeter. This will allow a design load per unit foot to be determined, and thus a typical spread footing design for the entire exterior.

## **Appendix B**

# Richard Schimpf Spring 2012 Thesis Progress Schedule

