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KIMBERTON ELEMENTARY SCHOOL

EAST PIKELAND TOWNSHIP, CHESTER COUNTY, PENNSYLVANIA

THE END IS ONLY THE BEGINNING

CONSULTANT: DR. JOHN MESSNER

SERTON ELEMENTARY SCHOOL

FRIDAY DECEMBER 12TH, 2008 Revised: Tuesday January 20TH, 2009

2009 CONSTRUCTION OPTION





KIMBERTON ELEMENTARY SCHOOL

EAST PIKELAND TOWNSHIP, CHESTER COUNTY, PENNSYLVANIA



ARCHITECTURE:

- •650 students Elementary
- Two main wings: Classroom and Activities
- 30 750 SF classrooms
- •2 computer labs
- 3000 SF media center
- 650 seat auditorium/cafeteria
- 6000 SF gymnasium with full basketball and volleyball courts

BUILDING ENVELOPE:

 Masonry Veneer Exterior Split face block on first floor Green cementitious siding used. on second floor

 Asphalt shingled gabled roof on Most columns are HSS8x8x1/2 top of the classrooms, media center, gymnasium, and entry •White single-ply membrane flat roof on remainder of building

STRUCTURAL:

- Structural Steel Building
- 1.5" 20 GA composite deck with
- 2.5" of NW concrete
- Classroom live load is 40 PSF
- Spread footing support columns
- •First floor is 4" cast-in-place concrete slab with 6x6 W2.9xW2.9WWF

MECHANICAL:

- Water source heat pump
- Individual heat pumps for each classroom housed in the second <- Supply Voltage is 33KV floor mechanical room
- •6 water source heat recovery units manufactured by Des Champs housed on the roof
- Originally designed as geothermal heat pump

PROJECT TEAM:

BE

- •Owner: Phoenixville Area School District
- CONSTRUCTION MANGER: Foreman Program and Construction Managers
- ARCHITECT: Gilbert Architects
- STRUCTURAL: Baker, Ingram, & Associates
- M.E.P.: Snyder Hoffman & Associates

ELECTRICAL:

- Disturbed through building at 480/277V
- S Local Transformers step down
- to 208/120V
- Lighting uses 277V
- •125 KW Backup Generator
- 40 panel boards located throughout school

LIGHTING:

- 59 lighting types
- Classrooms use 3 32W T8 lamps
- Switching allows for 3 light levels
- The media center contains pendent and drop lights
- Gymnasium lighting is produced. by high bay fluorescents
- Cafeteria/auditorium has dimmable metal halide lights







HTTP://www.engr.psu.edu/ae/thesis/portfolios/2009/rgk5000/

Executive Summary

Thesis Proposal

Executive Summary:

To replace the aging East Pikeland elementary school, the Phoenixville Area School District decided to build a 650 student elementary school on a fallow site next to the Kimberton Fair Grounds. Because of delays due to site containments, the proposed completion date was pushed back to January 2010. The cost of construction including all fees was \$27.7 million (\$270 dollars per square foot) plus \$2 million for the site.

The site of Kimberton is complicated by the site closure plan. This project was cancelled due to contaminated groundwater underneath the proposed site. The site contained VOCs such as trichloroethylene, dichloroethylene, and vinyl chloride in aquifers 180 feet below the surface. The school board decided in June of 2008 to suspend the project and abandon the site at Kimberton. It is this cancellation that has played a critical role for a number of the analyses to be preformed during my senior thesis.

An elementary school still needs to be built for the school district. An alternate site needs to be selected for the school. It is this fact that ties this entire thesis together. Relocating this building requires the consideration of a number of factors including, building aesthetics, location on site, soil and foundation system. These analyses will include structural mechanical and architectural breadths.

The cancellation of the project gives the school district a unique opportunity to look areas of improvement in the old design. There is now a chance to add more sustainably to the project as well as value engineering the project, hopefully adding value to the project overall. A few considerations are modifying the window size for day lighting, returning the building to the originally proposed geothermal heat pump, changing the room partition type to metal stud and drywall solution, adding solar collection panels to the roof of the classroom wing of the building.

Foreman Program and Construction Managers spend a number of resources on the estimation of building projects at various times during design. In the world of building information modeling there are several software products available that promise faster feedback estimate feedback as well as more accurate quantities for estimating. These different software packages should be analyzed for potential benefits. This analysis will compare new products such as Autodesk Quantity Takeoff, Innovaya, and Revit Quantity Schedules to the traditional methods of estimating ability to calculate the cost of the value engineering and sustainability ideas found in the previous analysis. Additionally adjusting the general conditions estimate and updating the overall estimate of the project will be required.

Part of this thesis is to consider the constructability of the project on a new site. For this it will be necessary to revisit technical analysis preformed during previous technical reports for the new building location. The areas that will be revisited are developing new site utilization plans, updating the schedule and detailing the proposed modifications.

Overall this thesis will incorporate the knowledge gained throughout an entire architectural engineering education at Penn State. It will focus in the areas of Critical Issue Research, Value Engineering Analysis, Constructability Review, and Schedule Reduction /Acceleration Proposal. This thesis will also consist of investigations based on graduate level studies.

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Project Background

During the summer of 2005, Phoenixville Area School District decided to hire an architect and construction manager for the construction of a new elementary school. Because of enrollment projection and to replace the aging East Pikeland elementary school, the school district decided to build a 650 student elementary school on a fallow site next to the Kimberton Fair Grounds. This school was originally proposed to be open for the 2008 school year but because of delays due to site containments, the proposed completion date was pushed back to January 2010. The school was prepared to pay \$26 million for the construction but because of delays that number was closer to \$30 million. The cost of construction including all fees was \$27.7 million (\$270 dollars per square foot) plus \$2 million for the site.

The site will have to be grub and the site closure plan will have to be completed before any major work on this site can be completed. Spread footings support the structural steel for the building. The footings for this building will be placed using traditional forming methods and pumped into place and then machine vibrated. The building's walls are made up of mostly CMU except metal studs are used in several locations. The exterior of the building contains a CMU veneer as well as cementitious siding. The mechanical system of the building is an all air system with individual water source heat pumps to heat each zone. There are also various heat recovery units, roof top units. The system is dependent on two boilers and single cooling tower. Kimberton is protected by an active automated fire extinguishing system with each sprinkler head having no more than 130ft of coverage. Fire walls separate the building in two and protect areas of vertical movement. The elementary school distributes 240/277V throughout the building and steps it down to 208/120v using 5 transformers throughout the building. The building is backed by a 125 KW generator.

The site of Kimberton is complicated by the site closure plan. The 3.85 acre area of the closure plan will be a retention pond and should not delay the construction of the building once ground is broken. The main access for construction will be from Route 113. There are no fire hydrants on site however the fire hall is on the neighboring property. Existing utilities are under Cold Stream Road and will be supplied to the elementary school via the service drive between CJ tire and Emery Oil to the mechanical room on the west side of the building. There are no buildings in the area that will interfere with construction. Overall the site is relatively open and should allow for plenty of lay down area.

The Kimberton project is being delivered with a design-bid-build method with 15 multiple prime contracts and a construction management agency overseeing. Each Contract is held by the owner (Phoenixville Area School District). The construction manager will run the day to day management of the project and the school will release the payments. Foreman Program and Construction Managers plan to staff the job with a project manager and site manager. The FPCM will act as the liaison between prime contractors, architect, and owner.

This project was cancelled due to contaminated groundwater underneath the proposed site. The site contained VOCs such as trichloroethylene, dichloroethylene, and vinyl chloride in aquifers 180 feet below the surface. The school board decided in June of 2008 to suspend the project and abandon the site at Kimberton. The school board is currently considering its options and deciding how it will proceed from this point.

Locating Building

Thesis Proposal

A. Locating Building on New Site

Where does the construction company go after the project has been cancelled? The school district still needs an elementary school for the growing population. How should the school district proceed? This thesis will focus on the steps necessary to establish a new location for the elementary school and reconfigure the building for the new site. I will consider many of the issues with relocating a building plan to a new site.

To begin I should briefly analyze other cancellations of school projects. This can be done by researching the internet and conversing with industry ties. It would also be a good idea to survey them to see what they would have done. The next step would be to consider what approach the school is currently taking and evaluate that. I know the school district is discussing and considering purchasing a nine-hole golf course neighboring the current high school and middle school campus in Phoenixville. There are factors about this new site that should be considered before purchasing the land. This is a decision that will ultimately need to be made by the school district however understanding how the site can be redeveloped to fit there needs will greatly assist the decision making process.

The physical location of the building on the site is one of the first steps in deciding whether or not the golf course will work for constructing the elementary school. There are many things to consider before

locating the building such as existing site conditions, storm water management, site layout, solar angles, soil conditions, etc. Ultimately the goal of this particular analysis is to create a viable site plan for the existing school design that was created for the Kimberton site. The existing design will be used because the school does not want to pay for another school design however it may be possible to make improvements to the design possibly saving the school district money by having the project cancelled.

A critical step in this analysis is obtaining site plans of the golf course. It may be possible to obtain this from the school district, the golf course owner, or the Phoenixville area school district. If one is not available, create one using topographic maps of the region and Google Earth/Maps aerial photos. The golf course should then be visited and document through photos to ensure that the site plans and aerial photos are current and accurate. An existing site of the nine-hole golf course will be developed using Revit. The level of detail will be based on the precision of the information received about the site. The better information about the site obtained from the school district the better the site plan will be. The location of the building will then be based on relation to other existing schools, minimal excavation, utility services, solar considerations, etc. The existing schools need to be reflected on because the building will have to tie into the other schools infrastructure including entrance to site (most likely Gay Street). The landscaping around the site should tie into the activities field of the neighboring schools and help

Construction Option: Messner

Ralph Kreider



Locating Building

Thesis Proposal

improve those facilities. The site utilities will be understood to minimize the site disturbance caused by running the underground utilities. The school will be located to minimize excavation necessary to create a new school. Overall, the site appears to be relatively flat with rolling hills so hopefully this should not be a problem. The solar angles on the Phoenixville area should be focused on locating the building best for solar heat gain. It is more important to gain as much heat as possible because the building will mostly be used during the winter months.

An architectural breadth will be the evaluation of the current school building on the newly proposed site. To perform this evaluation, renderings of the current building on the existing golf course will be created. Next a landscape plan will be generated of the golf course keeping as much of the original topography and vegetation as possible. It is important that all of the features of the original landscape of Kimberton Elementary will be included with the new site. For example the soccer field, kickball field, playground and parking all need to be included in the new site plan. Rendering the building on the new site once the site plan is created seems to be the next step. The building's appearance should not have to change drastically due to this relocation. However it may be necessary to mirror, or change entrances based on the site. Possibly some color schemes and materials should be change in order to match the other schools.

The foundations will need to be checked to make sure that they will still work as designed. This could be considered a structural breadth. First the soil conditions of the site will need to be checked. In order to do this, geotechnical surveys of the golf course should be obtained from the school district or golf course owner. If there are no geotechnical surveys available then it may be possible that the borough would have soil reports of neighboring buildings. The school district would also have the soil reports from the building of the high school and middle school. The soil bearing capacity will then be compared to the bearing capacity of the previous Kimberton site. If the soil bearing capacity is equal or higher, the foundation can be maintained as designed. If the bearing capacity is not high enough then the foundation system will have to be redesign and it will be a structural engineer that has to perform this analysis. It would not be prudent to redesign the foundation system in this thesis because of the experience of a construction option student and their experience level.

B. Building Systems for Sustainability and Value Engineering

The cancellation of the project gives the school district a unique opportunity to discover areas to improve the old design. Not many projects have full construction documents to take a part and analyze. The project can no become more sustainable as well as hopefully adding value to the project overall. This analysis will focus on the following: studying day lighting of classrooms, returning the building to the originally proposed geothermal heat pump, changing the room partition type to metal stud and drywall solution, adding solar collection panels to the roof of classroom wing of the building.

The day lighting of the building will be considered for the new project site. First it will become necessary to evaluate the current day lighting of classroom spaces of this building and if it can be improved upon it. A primary step is to contact the original architect and understand what standards they used to day light the classrooms. Next BIM software like IES will be used to obtain current day lighting of the building on the new site location and orientation. The window size and type will be a factor for this day lighting study. Is it correct or should be change? The heating and cooling loads will not be recalculated due to change possible change, but acknowledged that it will have to be considered before making final decision. Hopefully, day lighting can be increased while heating load will decrease. There are a number of sensor systems that could automatically adjust the room lighting based amount of daylight entering the space.

Another analysis considers what HVAC system should be used on the new site. It was originally proposed to use a geothermal heat pump to heat and cool the building but was changed due to site contamination at the Kimberton site. What is required to convert it back to geothermal heat? The mechanical engineer, Snyder Hoffman and associates, will be contacted to receive the original specs of the geothermal heat pump. Then the system will be "Reinstall" into the building and all the changes required will be made. This analysis should be rather simple because the system was almost fully design before it was changed. The price the lifecycle cost of the different system will be done in a later analysis. The location of the geothermal wells on site is also an essential consideration and would use Revit to display placement and coordination.

An alternate interior partition system will be investigated compared to the current concrete masonry unit construction. Typically schools are built with CMUs which make future changes very difficult additionally installation is a very labor intense process. This analysis compares the CMUs to a drywall on metal stud as the main partition type. The second floor of the building already uses metal studs and they could possibly be used throughout the building. The architect should be contacted to find out the reasons that they did not use the alternate systems. From there a specific product should be located that would be durable enough for an elementary school. The next step will compare and contrast the potential benefits and drawback of a metal stud system. The pricing of the system will take place in the next analysis and the schedule will be compared in the final analysis.

The current design contains a number of sloped roofs that could be ideal for solar electricity collection. In one orientation the roofs of the cafeteria and gymnasium would be ideal; in another orientation the roof of the classroom wing could be used. The first step of this sustainable consideration is ensuring the building orientation and slope of the roof is ideal for solar

Sustainability and VE

collection. Next a PV panel will be researched that is both efficient and cost effective. To assist in this, BIM tools will be used in the next analysis to compare prices of different systems. Additionally DC lighting should be considered to avoid loss of energy in the DC-to-AC conversion. It will also have a backup AC-DC converter for days when solar collection is not at peak. The energy could be used on the high school and middle school before being sold back to the grid. Therefore there would not be a need for battery storage on site. The lifecycle costs of the solar panels will be calculated using BIM tools to assist in analysis. This will determine whether or not adding solar panels would be cost effective. Additionally the LEED checklist will be completed to quickly suggest additional areas to improve design.

BIM in Estimating

Thesis Proposal

C. Re-estimate the Construction Cost using BIM in Estimating

Foreman Program and Construction Managers spend a number of resources on the estimation of building projects at various stages during design. Currently, Foreman takes off drawings and estimates using the paper drawings provided by the architect. It is a time consuming process and needs to be repeated at each stage of design. The Kimberton Elementary School project was taken off at least three separate times. Because the project was delayed all of the figures had to be adjusted for time which is not a perfect transition because different elements of the construction project changed at a different rate over the one and half years the project was delayed. Additionally the individual prices of divisions of the project are very important because of the multiple prime contracts method used on Pennsylvania school projects. It is not only necessary to know a change in the overall project cost but also the change in cost of individual project packages.

In the world of building information modeling there are several software products available that promise faster feedback estimate feedback as well as more accurate quantities for estimating. These different software packages should be analyzed for potential benefits. This analysis will compare new products such as Autodesk Quantity Takeoff, Innovaya, and Revit Quantity Schedules to the traditional methods of estimating. In this analysis the value engineering and sustainability ideas found in the previous analysis will be estimated.

The first step to this analysis is to estimate the value engineering and sustainability ideas using traditional methods. Quantities will be taken off from the construction drawing paper drawings and counted. RS Mean's books will be used to find pricing. The life cycle cost of the proposed change will then be calculated. The number of hours using traditional methods will then be recorded for later analysis.

Next Revit quantity schedules will be used to assist in estimating process. The estimated value will be calculated the same as traditional method except using quantities collected from the Revit model schedules rather than hand counting. The quantities are then matched to RS Means cost data and the life cycle cost of proposed changes is calculated. The number of hours using traditional methods will then be recorded for later analysis.

Innovaya will then be used to estimate proposed changes. This method to associate the cost of construction is on BIM wiki and has been developed by Penn State. It is this method that will be used to estimate the lifecycle cost of each change. The number of hours will be recorded for learning method and number of hours taken to perform estimate.

The Revit model will be used to test Autodesk Quantity Takeoff's ablity to link to a timberline database. Exploring the new software program, Autodesk Quantity Takeoff for its potential is part of the process. The use of building information modeling could eliminate a lot of the tedious work required when quantity estimating. It is also important to determine the correct method of modeling. A process for modeling should be developed so that it can be taken off properly. From that point Autodesk QTO will be used to estimate the four value engineering and sustainability ideas. The number of hours used to perform estimate and learn the software will be tracked for later analysis. The process of using Autodesk quantity takeoff well then be disseminated on the BIM Wiki.

BIM in Estimating

Next the analysis will include comparing and contrasting the different methods of BIM estimating to traditional estimating methods. The actual costs generated with each model will be compared to determine which is the most accurate. It may be possible ask a contractor to price the changes so that there is an accurate baseline. It is important to also compare time taken with each method. There will be an attempt to approximate additional time saving after process is mastered. It will also be necessary to adjust the general conditions estimate based on the time and setting and update overall estimate based on time and changes to building. The findings of this analysis is will be shared on the BIM wiki which will hopefully show that using BIM to assist in estimating in the next step in BIM implementation for a number of companies.

Constructability Analysis

Thesis Proposal

D. Constructability Analysis of new site using BIM tools

Part of this thesis is to consider the constructability of the project on a new site. For this it will be necessary to revisit technical analysis preformed during previous technical reports for the new building location.

It will necessary to develop a new site utilization plans based on the new site. Revit will be used to show the multiple phases of construction. This will ensure that the site will work easily for construction. Additionally the construction of this elementary school can not interfere with school functions at the high school and middle school.

Next the project schedule will be updated based on a change of date and different site conditions. (i.e. No site closure plan.) Creating a 4D model using Navisworks will show the schedule. The Revit model will be sectioned of into multiple Navisworks files to assist in this. Additionally, a detailed 4D model of the schedule implications based on the proposed changes will be crafted.

Ralph Kreider Construction Option: Messner

E. Conclusions

Weight Matrix

Below is the weight matrix for approximate percentages of my four analyses of my thesis project. Each percentage is based on how much of the study I feel will focus in the areas of Critical Issue Research, Value Engineering Analysis, Constructability Review, and Schedule Reduction / Acceleration Proposal. Moreover the table also illustrates the percentage total value of the overall thesis project.

Description	Research	Value Eng.	Const. Rev.	Sched. Red.	Total
Locating Building	10%	5%	10%	0%	25%
Sustainability and VE	10%	15%	5%	5%	35%
BIM in Estimating	10%	10%	0%	10%	30%
Constructability Review	0%	0%	10%	0%	10%
Total	30%	25%	25%	20%	100%

Critical Issues Research

The investigation in the use of BIM tools for construction estimating will be the primary research into issues critical to the construction industry. This use of BIM to aid in construction management process is crucial to riding the industry of much of its waste to redundant work. By performing an evaluation of an alternate site I will have to research other project cancellations. Because of the economy there are most likely a number of other schools projects that have been cancelled. It will be interest to see the steps they are taking to move forward. Finally when analyzing sustainable and value engineering ideas, new technologies will be considered that are at the forefront of our industry. A majority of this thesis will focus on research of industry issues.

Value Engineering Analysis

The goal of the ownership is to deliver a school building on time, and on budget. This thesis will be organized around the opportunities relocating the building have for value engineering and sustainability. For example, the mechanical system can be converted to geothermal. (part of a mechanical breadth) as well as consider the life cycle cost implications of adding solar panels to the building. Value engineering will be considered during my evaluation of an alternate site for the building. The analysis of interior partition system is based on the fact that it should be a less expensive product and should be able to save considerable time on the schedule. Overall, the consideration of value engineering during this thesis investigation will add value on the project.

Conclusions

Thesis Proposal

Constructability Review

The suggestions and modifications will lead to a more constructible building. The overall evaluation of an alternate site will incorporate many constructability challenges. First the site utilization plan will have to be completely redeveloped. The atheistic of the building will have to be considered which ties in to an architectural breadth. Furthermore, the relocation will also include reviewing the constructability and stability of the foundation on the new site. The building will be placed on the new site based its ability to be built in that location. Additionally the analysis of the building partition system will present a number of constructability questions. Choosing an alternate system like drywall on metal studs could possibly reduce site congestion but also add issues of its own. Moreover, using 4D modeling will allow the changes in constructability to be illustrated easily. Overall, this analysis will be incorporated throughout my entire thesis.

Schedule Reduction / Acceleration

The analysis of schedule reduction will most heavily be considered during the determining the affects of the sustainability and value engineering ideas have on the project schedule. The analysis of day lighting, geothermal heat pump, drywall on metal stud and PV cells on sloped roof all should be considered for the impact on the schedule. It may also be possible to decrease the schedule because the site was relocated and no longer has a closure plane. Additionally while not decreasing the project schedule, the use of BIM for estimating should reduce the number of hours spent working on the project. Reduction of the schedule will be intertwined through the entire thesis.

Incorporation of Graduate Classes

As required to complete the integrated masters here at Penn State, a number of the analyses will incorporate ideas generated during graduate course work. These studies will focus primarily on the use of building information modeling to aid in the construction process. The general understanding and the impact on industry were furthered by AE 597G course. This course taught a great deal about how each use of building information modeling will benefit a project and what steps should be taken before implementing each use in construction. BIM will be used to further illustrate each analysis that is proposed to study. This graduate level topic will tie the entire thesis together.

Final Thoughts

Overall I feel that my thesis is focused on topics that are very pertinent to the industry today and in the future. I feel that the process I develop while using building information modeling will not only benefit myself but will also benefit any individual that I come in contact with or reads my work. I hope that the answers and solutions that I find will assist greatly the Phoenixville school district with the decisions that they have to make about purchasing the site. Hopefully I can save the school board and administration some time in developing a site plan and the modification necessary to complete the elementary school project. I look forward to implementing the step necessary to complete the large number of tasks before me.

Thesis Proposal

Appendix 1 – Breadth Studies

Architectural Breadth

The evaluation of an alternate site is very architecturally intensive. First I will need to locate the building aesthetically on the site as well as the best location for environmental gain. I will need to architecturally review the building to make sure that it will fit the site in the first place. Modification may be necessary. I will also evaluate the floor plan to see if the functionality is still maintained. Additionally the site will also have to be completely redeveloped to make sure that it incorporates all the uses of the original site plan.

Mechanical Breadth

When relocating the building it may be feasible to return to the originally proposed system of geothermal heat which was changed due to site contamination. This will involve reviewing the design and making the necessary changes to use geothermal heat. I would also evaluate the life cycle cost of the system. I would also need to locate the geothermal wells on the site and make sure they are up to the requirements of the system.

Lighting/Electrical Breadth

The evaluation of the day lighting of the classrooms of elementary school will incorporate knowledge gained in the lighting electrical classes. It is important to ensure that the light levels in the room will be proper for to facilitate learning as well as utilize all of the energy of the sun. Additionally, during my evaluation of solar panels on the roof of the building, I will need to calculate the loads provided by the panels and consumed by the lighting of the building.

Structural Breadth

When evaluating the alternate site, the structural stability of the foundation will need to be confirmed because of different site soil bearing capacity. I will need to check these soil conditions and make sure the soil bearing capacity is at least as high as the original site. If it is not as high I will make the recommendation that the foundation be redesigned.

Overall, my thesis investigations will require a very well rounded breadth of architectural engineering knowledge and is not just limited to my understanding of building construction.

App 2 - Proposed Schedule

Appendix 2 - Proposed Thesis Schedule

Thesis Proposal

Below is a schedule on how the specific task required for each analysis will be completed.



Ralph Kreider