Buckhorn Medical Office Building

Senior Thesis

Final Proposal

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Executive Summary

The Buckhorn Medical Office Building was built by Alexander Building Construction and was recently completed in November 2009. The total cost of construction was approximately $11.7 million over a timeline just under two (2) years.

The existing curtainwall system for the building is an aluminum metal panel system that wraps around the entire building. The construction team ran into problems early on in the project with getting submittals approved and then getting materials on-site. The first analysis of my senior thesis project is to re-design the exterior system using a pre-cast concrete panel system. I will investigate the architectural aspects as well as the structural implications of using pre-cast panels versus aluminum. I will also investigate the schedule and sequencing implications through the use of a 4D model.

The second analysis I have chosen for my thesis involves replacing the existing HVAC system with a geothermal heat pump system. This idea was originally proposed as a value engineering idea, but was turned down due to high initial costs. I will re-evaluate this mechanical system through the use of the current mechanical Revit model. I have also chosen to research solar PV panels and how the Buckhorn Office Building can benefit from their sustainability. I plan to research initial costs, lifecycle costs, and rate of return of the panels. I will use the Revit model to perform solar studies to maximize the solar gains.

The third analysis involves estimating and how BIM can be effectively used to increase productivity and efficiency. I will use various methods of performing quantity takeoffs and estimates to compare accuracy of numbers as well as efficiency of time use. I will also use the BIM model to analyze lifecycle costs of the proposed value engineering ideas.

My last analysis will focus on constructability, scheduling, and sequencing of the project using the BIM model. I will incorporate 4D models from the re-designed structural sequencing and re-designed pre-cast panel erection to build a 4D model for the entire project that will enable the superintendent to more effectively manage the construction site as well as create look-ahead schedules for subcontractors.

Technical Analysis Descriptions

Re-developing the Curtainwall System

The architect for the Buckhorn Medical Office Building proposed a design that clad the entire exterior with various types of aluminum metal panels. Throughout the project, there were delays due to manufacturer problems which lead to a delay in the overall schedule. The owner and architect chose the aluminum panel system due to its low maintenance and long life cycle; however, the aluminum panel system was very expensive and resulted in delays to the overall project schedule.

For this analysis, I am proposing a change from an aluminum panel system to a pre-cast concrete panel system. I believe that the current concrete casting technology could be very beneficial to the project for several reasons. There is a cost association where the pre-cast system would be significantly less than the cost of the existing aluminum panel system. The pre-cast system would also be equally as durable with minimal maintenance required. Architecturally, the pre-cast panels could be cast in a way to emulate the current design of the exterior façade, while providing a sizable cost savings.

To prove that this would be both a cost-effective and schedule-effective change, I will use the existing Revit model to compare the two schedule sequencing scenarios of metal panels versus pre-cast. Because the metal panels were the last item to be completed on the Buckhorn project, they directly impacted the date of final completion. I will first research the pre-cast construction panel process and evaluate the feasibility of using pre-cast panels in the Bloomsburg area. I will have to locate the nearest manufacturers, evaluate cost, and determine construction durations associated with pre-cast. I will analyze the implementation of pre-cast panels using 4D scheduling techniques in Autodesk Navisworks. I will effectively show the schedule acceleration scenarios possible with the new exterior enclosure system and how those schedule accelerations will lead to an overall cost savings.

Because I am modifying the exterior enclosure of the building, I will need to redevelop the structural system. As a structural breadth, I will examine how the increased weight of the pre-cast panel system will affect the existing structural steel and foundation system. I will re-design the structural Revit model to reflect these changes. I will also examine the schedule implications a structural re-design will have on the project, and show how these changes should be handled through a new 4D structural sequence model.

Sustainable Mechanical Systems and Value Engineering

One of the original value engineering ideas was to create a sustainable HVAC system using a geothermal system. This was initially found to have a higher initial cost, but have a lower operating cost and an overall cheaper lifecycle cost. For my mechanical breadth, I will investigate the costs associated with installing a geothermal system over the current HVAC system. To do this, I will analyze the current mechanical Revit model and examine where I will need to make changes in piping and controls, as well as how to develop the underground system based on the existing Revit site model. Because a geothermal system was initially considered during the value engineering process, I will assume that a geothermal system will be capable of handling the cooling and heating loads for the building. I will also have to re-examine the geotechnical report to ensure that existing site conditions will allow for the use of a geothermal system. The price of the lifecycle cost of the geothermal system will be done in a later analysis. The location of the geothermal wells on site will also be an essential consideration, and I will use Revit to display placement and coordination.

The Buckhorn Office Building is in the process of seeking a LEED Silver rating; however, few sustainable design options are currently being implemented. One consideration that I am proposing is the implementation of solar PV panels located on the roof of the building. The current roof houses four (4) small rooftop units, and there is ample space for solar PV panels. In order to make the solar panels most effective, I will conduct solar studies using the Revit model to ensure proper placement and alignment of the panels based on the geographic location of the Buckhorn Office Building. Next, a PV panel system will be researched that is both efficient and cost-effective. The lifecycle costs of the PV panel system will be analyzed in a later analysis. Additionally, the LEED checklist will be completed to quickly suggest additional areas for sustainable design.

Cost Estimating using Building Information Modeling

Alexander Building Construction spent a number of resources on the estimation of the Buckhorn Office Building project at various stages of the design process. Alexander currently uses a system where takeoffs and estimates are performed using paper drawings provided by the architect. This process is extremely time consuming because the takeoffs and estimates are performed at each stage of design. The Buckhorn Office Building was taken off at least three times through the design phases, and at least once when an addition was added at the request of the owner. Alexander also analyses projects by systems costs and by square-foot costs and these numbers had to be revised several times as well.

In the world of building information modeling, there are several software packages available to help enhance the estimation process as well provide more accurate quantities for takeoffs. These different software packages will be analyzed for their potential benefits. This analysis will use Autodesk Quantity Takeoff to compare results against 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 will be to estimate the costs of the value engineering and sustainability ideas listed above using traditional methods. Quantities will be taken off from the construction drawing paper drawings and counted by hand. *RS Means* will then be used to find pricing. The lifecycle costs of the proposed changes will then be calculated. The number of hours using traditional methods will be recorded for further analysis.

The second step will involve using Revit to produce quantity schedules. The estimated costs will be calculated using the traditional method of *RS Means*. The quantity schedules will be compared for accuracy, and the lifecycle costs of proposed changes will be calculated. The total number of hours using this hybrid method will be recorded for later analysis.

Next, the Revit model will be used in alliance with Autodesk Quantity Takeoff to link to a Timberline database. The additional time required to explore the software will be factored in to the total time spent preparing the estimate. This is important to add this training period because it simulates the process an actual company would follow when implementing new software.

Lastly, the analysis will compare the different methods of BIM estimating against traditional estimating. The actual costs generated with each model will be compared to determine which is most accurate. As well as accuracy of cost, times required to complete each estimate will be compared. It

will also be necessary to adjust the general conditions estimate based on duration of each estimate. This analysis will show how BIM can be used to produce quicker, more accurate estimates.

Constructability and Scheduling Re-evaluation Using BIM

The owner, Geisinger Health System, requested at the beginning of the project that a 3D model be turned over at the completion of the project as part of their as-built documentation. The model was not originally used for any scheduling or sequencing of the project; however, now that a model is complete, it would be beneficial to use this as a tool to more efficiently manage the site plan as well as the various complex sequences of the project.

For this analysis, I will put together a detailed 4D model of the entire site plan showing site and infrastructure development as well as spatial planning. I will also incorporate the 4D sequences of the proposed changes from my other analyses to reflect the changes I am proposing to the building. This model will yield as an effective tool for site logistics between the superintendent and the various subcontractors that require storage or laydown space. It will also serve as a tool for the superintendent to plan more effective look-ahead schedules. A 4D schedule of the entire project will accurately document the lifecycle of the project and will be used as an as-built to be turned over upon completion of the project.

Conclusions

Weight Matrix

Below is the weight matrix for approximate percentages of my four (4) analyses for my senior thesis project. Each percentage is based on how much of the analysis I feel will fall into the four categories of: Critical Issue Research, Value Engineering Analysis, Constructability Review, and Schedule Reduction/Acceleration Proposal. The table also represents the total percentage of time required to adequately fulfill the proposed analysis.

Description	Research	Value Engr.	Const. Rev.	Sched. Red.	Total
Curtainwall Design	10%	10%	5%	5%	30%
Sustainability and VE	10%	10%	5%	0%	25%
Estimating with BIM	15%	10%	0%	5%	30%
Scheduling with BIM	5%	0%	10%	0%	15%
Total	40%	30%	20%	10%	100%

After evaluating my weight matrix, I believe that the two most intensive analyses will be the curtainwall redesign and the estimating and quantity takeoff using BIM software. The curtainwall redesign will involve a lot of research regarding the logistics of implementing a pre-cast system. I will have to find information regarding manufacturers available, durations and crew sizes, approximate costs of the panels as well as overhead costs such as storage of materials and crane rentals. I will also have to analyze the value of the pre-cast compared to the aluminum panels and determine the direct savings as well as indirect savings through general conditions and schedule acceleration. Lastly, I will have to assess the structural design of the building and re-evaluate the loads placed on the superstructure due to the pre-cast. Both the steel erection and the pre-cast panel installation will have to be modeled and scheduled using Revit and Navisworks.

The second analysis that will require a significant amount of time will be the analysis comparing different methods of estimating and their repercussions on accuracy of quantity and cost savings. I feel that this will involve a lot of time learning how to properly use Autodesk Quantity Takeoff as well as learning how to construct a model that can be accurately used for estimating purposes. I feel it will also take a considerable amount of time to learn Timberline estimating software and how it interacts with Autodesk Quantity Takeoff. Although these learning periods might take a considerable amount of time, it will be important to document those hours as part of the productivity study.

APPENDIX A

Breadth Studies

Architectural Breadth

The re-design of the exterior curtainwall will be a significant change in the aesthetic appeal of the building and careful consideration for design will be taken to try and emulate the aluminum panels as closely as possible. I believe that the pre-cast advantages outweigh the few aesthetic qualities the aluminum panels may have. Because the Buckhorn Office Building is a fairly basic shape, panel fabrication and design should not be a concern. Accuracy of color and texture will be paramount in achieving an aesthetic appeal approved by the architect.

Structural Breadth

With the re-design of the exterior curtainwall, there will be a significant increase in load applied to the outside edge of the building. Structural calculations and assessments will be made to ensure the steel frame will be capable of handling the added loads. With this structural re-design, the foundation support system will also be re-evaluated to ensure the spread footings and soil bearing capacities are capable of handling the added loads.

Mechanical Breadth

One of the original value engineering ideas was to use a geothermal heat pump system over a typical VAV system. It will be necessary to assess the current HVAC system and make changes to equipment and piping to ensure the geothermal system will work properly. It will also be important to evaluate the geotechnical report in order to locate the geothermal wells on the site and make sure they are up to the requirements of the system.

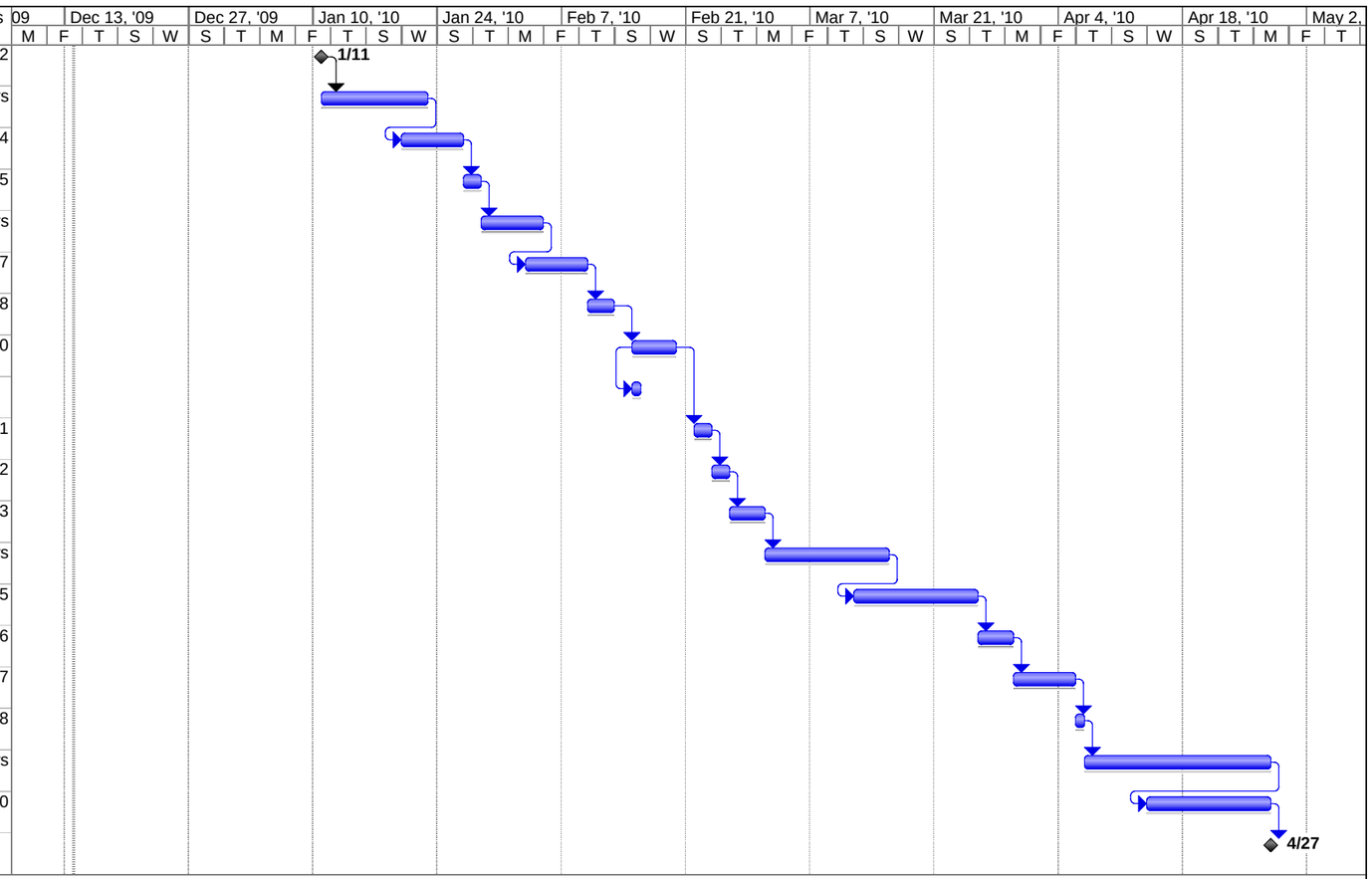
Electrical Breadth

With regards to adding sustainable design features to the Buckhorn Office Building, solar PV panels will be researched and evaluated for initial cost as well as lifecycle costs. Solar studies will be completed to ensure proper placement and adjustment for maximum solar exposure. The loads provided by the panels will also be calculated to determine the return on investment.

APPENDIX B

Proposed Schedule

ID	Task Name	Duration	Start	Finish	Predecessors	Successors
1	Start Semester	0 days	Mon 1/11/10	Mon 1/11/10		2
2	Pre-Cast System Research	10 days	Mon 1/11/10	Fri 1/22/10	1	3FS-3 days
3	Pre-Cast Value Engineering	5 days	Wed 1/20/10	Tue 1/26/10	2FS-3 days	4
4	Pre-Cast Constructability	2 days	Wed 1/27/10	Thu 1/28/10	3	5
5	Pre-Cast 4D Modeling	5 days	Fri 1/29/10	Thu 2/4/10	4	6FS-2 days
6	Pre-Cast Schedule Review	5 days	Wed 2/3/10	Tue 2/9/10	5FS-2 days	7
7	HVAC Research	3 days	Wed 2/10/10	Fri 2/12/10	6	8
8	HVAC Modeling	5 days	Mon 2/15/10	Fri 2/19/10	7	9SS,10
9	HVAC Constructability	1 day?	Mon 2/15/10	Mon 2/15/10	8SS	
10	Solar Research	2 days	Mon 2/22/10	Tue 2/23/10	8	11
11	Solar Studies	2 days	Wed 2/24/10	Thu 2/25/10	10	12
12	Solar Value Engineering	2 days	Fri 2/26/10	Mon 3/1/10	11	13
13	Cost Estimating Research	10 days	Tue 3/2/10	Mon 3/15/10	12	14FS-2 days
14	Cost Estimating Value Engineering	10 days	Fri 3/12/10	Thu 3/25/10	13FS-2 days	15
15	Cost Engineering Analysis	2 days	Fri 3/26/10	Mon 3/29/10	14	16
16	4D Scheduling Modeling	5 days	Tue 3/30/10	Mon 4/5/10	15	17
17	4D Scheduling Analysis	1 day	Tue 4/6/10	Tue 4/6/10	16	18
18	Final Written Thesis Report	15 days	Wed 4/7/10	Tue 4/27/10	17	9FS-10 days
19	Final Thesis Presentation	10 days	Wed 4/14/10	Tue 4/27/10	18FS-10 days	20
20	Complete Senior Thesis	0 days	Tue 4/27/10	Tue 4/27/10	19	



Project: Project1
Date: Mon 12/14/09

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone