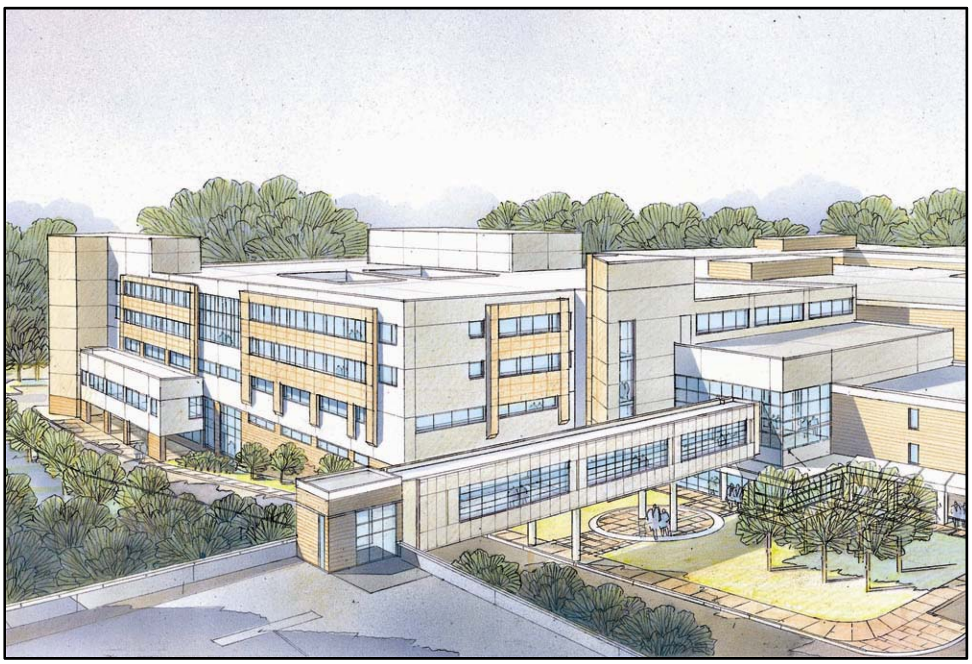
THE PENNSYLVANIA STATE UNIVERSITY
DEPARTMENT OF ARCHITECTURAL ENGINEERING

AE Fifth Year Senior Thesis

Thesis Proposal:



Unknown Hospital Expansion – Anytown, USA

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Table of Contents

Executive Summary

The construction management senior thesis proposal specifically outlines the remaining work that will be performed for the senior thesis capstone. This proposal will elaborate on some of the critical issues discussed in technical report #3. In total, there will be 4 analyses chosen to come up with alternative systems to improve upon the design or construction of the building. One of the four analyses chosen will be concerned with a current critical industry issue. There will also be included 2 breadth studies conducted within one of the four analyses that demonstrates depth of knowledge in Architectural Engineering. A weight matrix and schedule is included to show the durations of the analyses.

<u>Analysis 1: EIFS Construction vs. Precast Panel Systems</u>
The current building design utilizes a water managing EIFS system. During the construction of the building façade, there were constructability issues of the system. Along with these issues, weather became an important factor because construction was during the cold winter months. These factors could impact the project cost and schedule. A study will be performed to see whether switching to precast panels could save time and money through ease of construction and higher productivity rates. This analysis will include both structural and mechanical breadth topics due to the new loading of the building envelope for both the gravity and thermal loads of the façade.

<u>Analysis 2: 3D MEP Coordination</u>
The current method for managing MEP coordination for this project was using 2D CAD files. Coordination of Hospitals with 2D CAD can lead to unfound clashes and costly change orders in the field due to the high complexity of the systems in these buildings. This study will research the steps to integrate 3D MEP coordination into a project, and prepare a 3D model for coordination purposes to see whether using 3D MEP coordination could produce cost or schedule savings on the project.

<u>Analysis 3: Virtual Mock-ups</u>
During the design development stages of the construction process, the construction team used Evidenced Based Design to help create the layout of the OR and typical Patient rooms. This was done by creating full mock-ups of these rooms and performing walkthroughs from all members of the project team. This method to creating a suitable design is a very expensive and time consuming process. This analysis will invested whether using virtual mock-ups in place of actual construction could save both cost and schedule for the Owner of the Hospital.

<u>Analysis 4: Future Building Expansion & Healthcare Financing</u>
An important issue facing the construction industry today in the healthcare and pharmaceutical sector is the financing for these projects. Many times the ability to find financing directly affects the size and scope of the project. On the Unknown Hospital Expansion, the building was designed for the possibility of expansion on the roof of the building for the future needs of the hospital. A study will be performed to compare the added cost associated with constructing the future addition at the time of construction rather than in the future. Methods of financing for this added cost in this economic drought will also be performed.

Introduction & Background Information

The Unknown Hospital Expansion is a 281,000 SF addition to Unknown Hospital. This addition is 5 stories tall with a penthouse roof, and includes a unique three story arrival lobby space. Construction of the project began in March 2007, and has a 27 month duration. The Owner of the hospital has spent roughly $[redacted] for the hospital addition, a new parking garage, and various other improvements on the Hospital campus.

A new Emergency and MRI Department comprises of the ground floor of the hospital. The first floor consists of 14 new operating rooms for the Hospital's surgical department. The second floor inhabits the mechanical and electrical systems of the new hospital, along with space for the maintenance department. Roughly one third of the second floor is left inhabited for future fit-out plans. Both the third and fourth floors are comprised of single patient rooms totaling 126 private rooms with 2 exterior courtyards at the center of the building. These courtyard spaces will be open for the visitors and patients of the hospital, to give a lively outdoor feeling. The hospital addition also contains a unique Arrivals space as the new entrance to the hospital. This space is a 3 story atrium space connecting the existing hospital and the new hospital expansion. A bridge vestibule connects the new parking garage to the hospital at this space, along with elevators and escalators to transport visitors and patients throughout the hospital.

The structural system of the building is steel framing on spread footings. Typical floor height is 13' and 14', and the typical floor system of the elevated slabs is either 5 ½" or 7 ½" concrete on metal decking. The exterior façade is predominantly an EIFS system with metal stud back-up, along with face brick with CMU backup. Punched windows and curtain wall glazing help create a unique design with adequate day lighting.

The overall theme for this Architectural Engineering senior thesis is to improve upon the needs and quality of the Unknown Hospital Expansion without impacting the cost or schedule of the project by implementing new technologies to the design. This will be done by implementing new materials and construction styles to provide cost and schedule savings. Also, new technologies using computer aided 3-D design will also help with the construction of the different assemblies within the building.

Analysis #1: EIFS Construction vs. Precast Panel Systems

Problem Statement

During the value engineering phase of the project, Exterior Insulating Finish System (EIFS) was chosen to be the predominant façade type used on the project. When construction began on the building façade around November 2007, there were constructability issues of the EIFS system. Along with these issues, weather became an important factor because the construction of this system fell during the cold winter months. These complexities with the EIFS could have caused delays to the project schedule, which would impact the project cost.

Goal

The goal of this technical analysis is to prove that an alternate system, such as precast brick panels, could be a more effective system to use for the current design of the building, and replacing this system would not affect the overall budget of the project. This analysis will look at constructability considerations, along with cost and schedule impact between the 2 systems.

Analysis Steps

1. Compile all information that corresponds to the current EIFS system. This information will include the original budget, schedule, and any issues with the EIFS System.
2. Obtain information about Precast Brick Panels and EIFS systems from various manufacturers and subcontractors.
3. Compile and compare the information for the two systems.
4. Produce a redesign of the exterior façade using Precast Brick Panels.
5. Analyze the structural and support system for the Precast Brick Panels, and modify original structural design if needed.
6. Analyze the mechanical system implications with the use of Precast Brick Panels.
7. Create a schedule and budget for the alternate façade.
8. Compare the constructability, costs, and durations of the Precast Brick Panels to the EIFS system.

Expected Outcome

Through this analysis, it is expected that the Precast Brick Panels will the best viable solution for the design of the Hospital's façade. Even though the initial cost of the precast panels will be higher than EIFS, there will be large savings in schedule and general conditions when using the precast facade. The precast panels will affect the structural system with heavier design loads, and also impact the mechanical system with a better R-value and lowering the design loads. Through the comparison of the two systems, hopefully it will show that the Precast Brick system is the viable alternative solution for the building façade.

Analysis #2: 3D MEP Coordination

Problem Statement

MEP coordination is a very extensive process in a healthcare facility. With all the systems that are in the walls and ceiling plenum space, an exorbitant amount of coordination is needed to minimize the amount of construction conflicts on site. The practice of using 2-D coordination for these types of buildings can lead to unfound clashes and costly change orders in the field. Redesigns of these systems also have heavy schedule impacts due to time for design changes, re-fabrication, and installation.

Goal

The goal of this technical analysis is to see whether using 3D MEP Coordination would have been a cost effective tool for the construction of the Unknown Hospital Expansion. Through the use of 3D MEP coordination and clash detection software, it is hoped to find savings in both schedule and cost. This process also could have the potential for quicker fabrication and installation of some of the systems involved in the coordination process.

Analysis Steps

1. Investigate cost and schedule implications of using 2D coordination on the Unknown Hospital Expansion.
2. Evaluate the steps involved in integrating 3D MEP coordination into a large construction project.
3. Find the cost associated with starting a 3D MEP coordination program for both construction management companies and subcontractors, including software, training, and other tools.
4. Use a sample area (one typical floor) of the hospital expansion to perform both 2D and 3D MEP coordination.
5. Evaluate the two coordination processes for both cost and schedule implications.

Expected Outcome

Through this analysis, it is expected that using 3D MEP coordination will typically take a longer time to run MEP coordination in the beginning of the coordination process. This is due to the time it takes to model these systems and inexperience of most companies with this process. The use of 3D MEP coordination should be substantially quicken towards the second half of the building coordination process. This should lead to an overall savings in schedule. Ideally, this process will also show the great potential for cost savings by finding clashes early in the coordination process, preventing costly change orders. This software also has the potential to find errors in design early in the project, limiting the number of RFI's, and delays due to design revisions.

Analysis #3: Virtual Mock-ups

Problem Statement

During the design development stages of the construction process, the Hospital, design team, Construction Manager, hospital insurance company, and risk management team used Evidenced Based Design to help create the layout of the OR rooms and typical Patient rooms of the new hospital. Evidence Based Design is the process of basing decisions of the building design on credible research to achieve the best possible solution. This was done by constructing full mock-ups of these rooms and performing walkthroughs from all members of the project team. This method to creating a suitable design is a very expensive and time consuming process.

Goal

The goal of this technical analysis is to see whether using Virtual Mock-Ups as one of the steps in the Evidence Based Design process would be more effective than constructing full mock-ups in an empty, open space. Optimally, this research would show that using virtual mock-ups will save money in the cost of materials and construction, along with savings in schedule in the early design phases of the project.

Analysis Steps

1. Investigate the original cost and schedule associated with typical Evidence Based Design with the use of constructing full mock-ups.
2. Conduct research in the field of Virtual Mock-ups. Determine the standard practice of how the VR mock-ups are constructed, the cost associated with designing a virtual mock-up, and the time it takes to build a virtual mock-up.
3. Construct a Virtual Mock-up of typical rooms in the Hospital using 3D software.
4. Compare Virtual Mock-up created to the actual Mock-ups produced during design development stages through interviews with project members that participated in mock-up walkthroughs.
5. Compare cost and schedule between the two systems.

Expected Outcome

Through this analysis, it is expected that using virtual mock-ups in place of constructing actual mock-ups of typical rooms of the hospital is more cost effective solution. This analysis will also show there may also be schedule savings as well. A guide for use of virtual mock-ups on a construction project will be given to help members in the industry learn about, and use this tool.

Analysis #4: Future Building Expansion & Healthcare Financing

An important issue facing the construction industry today in the healthcare and pharmaceutical sector is the financing for these projects. Healthcare facilities around the nation are finding themselves with the need to invest in their facilities due to the natural aging of the buildings, new technology, competition, and consumer demand. With the cost of healthcare construction doubling since 2004 and continuing to rise, the healthcare industry is having trouble finding the revenue to expand and meets these demands.

Problem Statement

Construction financing is an extremely critical element for healthcare construction in both renovation and new construction. Many times the ability to find financing directly affects the size and scope of the project. On the Unknown Hospital Expansion, the building was designed for expansion on the roof of the building for the future needs of the hospital rather than constructing a larger building at the time of construction.

Research Goal

The goal of this technical analysis is to investigate the design/plan for the future addition on the roof of the Unknown Hospital Expansion project. This study will compare the added cost associated with constructing the future addition at the time of construction of the Unknown Hospital Expansion as compared to construction many years from now. A feasibility study will also be performed for performing this expansion on the roof of an existing hospital building.

Research Steps

1. Investigate the future plans of expansion on the Unknown Hospital Expansion project.
2. Produce an estimate for the cost of this future expansion.
3. Produce an estimate to add this future expansion to the current scope of work of the Unknown Hospital Expansion.
4. Study the feasibility of performing future construction expansion on the roof of an occupied Hospital.
5. Investigate the current status of healthcare construction financing market due to the recent economic downturn.
6. Provide techniques/options to help finance the current project to add the future expansion to the current scope of work.

Expected Outcome

The main intention to this analysis is to understand the current healthcare financing market, and to show it is more cost effective and feasible to add the future expansion to the scope of the current project rather than building in the future. The cost of expanding in the future will be much greater due to the new Archtect, Engineer, Construction Management fees and the cost of inflation. There will also be much greater risk involved building on top of an occupied Hospital space.

Weight Matrix & Timeline

Below in Table 1 is a weight matrix showing the level of involvement each analysis item will be in the thesis capstone. The core thesis investigation areas will include: Critical Issues Research, Value Engineering Analysis, Constructability Review, and Schedule Reduction / Acceleration Proposal. The totals of the subsections are along the right and the bottom of the matrix. The analysis of EIFS vs. Precast Panels contains the most time involved because both breadth studies are integrated within this study. Also included below in Figure 1 is the timetable for the research to be performed for the analyses in the thesis capstone. All research will be completed in early April in order to meet the due date of the final report.

Description	Research	Value Eng.	Const. Rev.	Schedule Reduction	Total
EIFS vs. Precast Panels	5%	10%	10%	10%	35%
3D MEP Coordination	—	—	10%	10%	20%
Virtual Mock-Ups	5%	5%	10%	—	20%
Healthcare Financing & Future Hospital Expansion	20%	—	5%	—	25%
Total	30%	15%	35%	20%	**100%**

Table 1: Weight Matrix

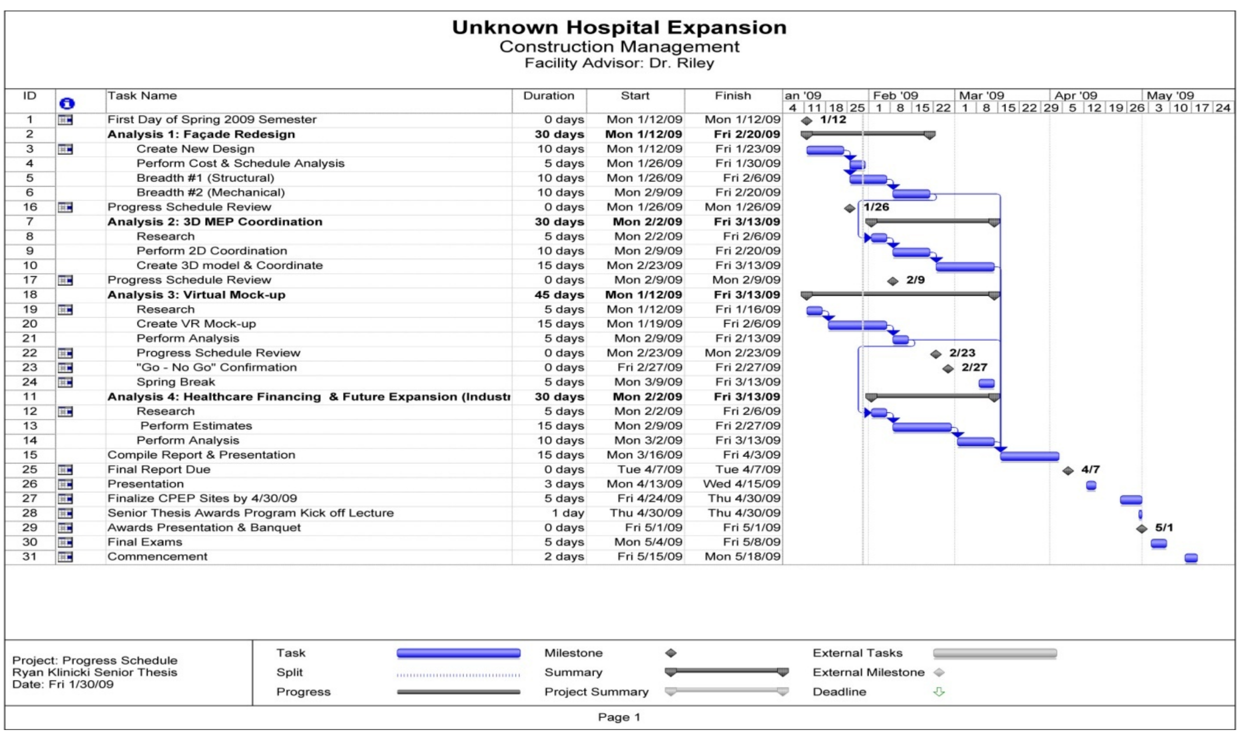

Figure 1: Thesis Timetable

Appendix A: Breadth Studies

Breath #1: Structural

The first breadth of the Unknown Hospital Expansion will be a study/redesign of the exterior members of the structural system. This breadth will be integrated with the analysis of EIFS system vs. precast panels. For this analysis, a redesign of the exterior façade will be conducted using precast brick panels. Due to the added weight of the new system, many of the members of the structural system will have to be resized to meet the new gravity loads on the building. This may be difficult to come up with an adequate design because this building was designed structurally for future expansion on the roof of the building. Many of these members are currently highly overdesigned in preparation for the future expansion. Through analysis, if the structural members need to be redesigned, members will be resized and an estimate will be performed to find the added cost, structurally, to replace the current EIFS façade with precast panels.

Breath #2: Mechanical

The second breadth topic of the Unknown Hospital Expansion will also be additional research to Analysis #1: EIFS Construction vs. Precast Panel Systems. This breadth will be a study of the mechanical system implications when changing the types of facades on the building. Precast panels typically have a larger R-value then EIFS systems due to the material type used create the panels, as well as the added thickness of the wall system. This breadth will measure the thermal loads of the two systems. Optimally, using precast panels will lower both the heating and cooling loads on the building that some of the equipment may be resized or that there could be long-term savings in monthly heating and cooling costs.