Thesis Proposal

Spring Thesis Proposal Document

This report is a proposal for the analyses that will take place in the Spring of 2014.

12/16/2013 | Jeffrey Martin | Advisor –Dr. Robert Leicht | Atrium Medical

[Executive Summary]

As Atrium Medical Corporation's new facility is being constructed; areas of possible improvement to this project have begun to open up. Through a detailed study and analysis, these areas will be explored to determine any construction related benefits for this building. This proposal is being developed to describe the four depth analyses and two breadth studies that will occur over the Spring 2014 semester. These analyses and studies will be conducted to propose possible solutions that may improve construction or provide benefits for the owner.

The first analysis will delve into the redesign of the structural system. In order to redesign the structure in a way that would add construction benefits to the project, prefabricated systems were taken into consideration. The prefabricated systems will be designed in the form of precast structural concrete and modular structural steel sections. These systems should be able to provide a cost savings and/or an accelerated schedule for this project.

Analysis Option 2 consists primarily of the creation of a short interval production schedule. This schedule, also known as SIPS, will focus on specific construction tasks that have high repetition. Because of this, the prefabricated systems proposed in Analysis Option 1 will serve as the basis for this analysis, as they include tasks of high repetition. Along with a SIP schedule, a 4D Model will be developed to help visualize the construction of this projects steel structure.

Analysis Option 3 dives into a value engineering approach to determine the best possible geothermal system that could be imposed as an alternative to the existing HVAC system. A single geothermal heat pump will be determined with three possible feeding options; horizontal wells, vertical wells and an open loop field in a water basin. These systems will all be compared to determine the most cost beneficial and efficient one.

The final analysis is designed to look into different ways that safety precautions can be implemented into the design phase of this project. This analysis will primarily focus on safety issues concerned with the installation of the structural system. A series of guidelines will be formed from this analysis to depict the best way to install and connect all troublesome areas of the structural steel system. These guidelines will be universal and will be able to be used on future projects as well.

Along with the four analyses being conducted, two breadth studies will be performed to analyze the building in terms of mechanical and structural methods. The structural breadth will focus on the analysis needed to re design the building structure out of precast concrete. The type of system along with the dimensions of individual members will be computed and derived for use in Analysis Option 1. The mechanical breadth will focus on determining the heating and cooling demand loads necessary for sizing the geothermal heat pump for Analysis Option 3.

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[Project Background Information]

Atrium Medical Corporation, with its 450 employees, had the intentions of combining all of their trades into one large facility, where each division of Atrium Medical can come together to develop and distribute their company's products. It was at 40 Continental Boulevard in Merrimack, New Hampshire that Atrium Medical saw inspiration to build on an already inhabited site.

Figure 1: Atrium Medical Logo Courtesy of Atrium Medical Corporation.

The two million square foot site was preoccupied by a two story, 100,000 square foot building, originally owned by Fidelity Investments. Atrium Medical purchased this property with a budget of $17 Million, having the intentions of expanding the two story building, seen in Figure 2, by adding a single story 101,200 square foot addition. The construction of this project involves the full erection of the addition from the ground up and the renovation of the existing two story building. These two buildings will be used to house the various divisions of Atrium Medical, such as; Manufacturing, Warehousing/Storage, Research & Development, Engineering Shops and Business Offices. In order to carry out this work, Atrium Medical has chosen Hutter Construction as the CM Firm on the project under a GMP. In addition to hiring a construction firm, Atrium Medical also chose Lavallee Brensinger Architects as the designer for the architectural and structural aspects of this project.

The structural system of this building is composed of cast in place concrete foundations in the form of strip and spread footings, piers and foundation walls. On top of the concrete piers, steel columns are mounted to support the complete steel superstructure. The roof of this building is comprised of primary structural wide flange beams laid out in a grid, with k-series joists spanning between steel members.

Figure 2: Rendering of Existing Two Story Renovation Courtesy of Lavallee Brensinger Architects

The mechanical system is being constructed utilizing a hot and cold water supply/return system that provide heated or chilled water to eight multi-zone air handling units and four single-zone roof top units. These units provide heated or chilled air to VAV control boxes throughout the various zones of the building. The electrical system and lighting system of this project will not be delved into for this proposal as they are not key areas that will be looked at during analyses.

[Analysis Option 1: Prefabrication of Structural System]

Problem Identification

The structural system designed for Atrium Medical Corporation consists of a cast-in-place concrete foundation with a steel superstructure. Currently there are no problems with any aspects of this imposed system, but there is always room for improvements. The structural system, having already been erected, took approximately 2 months to complete. The intent of this analysis is to determine a more efficient system based on cost comparisons as well as schedule acceleration tactics. Two systems will be analyzed and compared with the original design to determine any cost or scheduling benefits.

Proposed Solutions

In order to achieve any form of schedule acceleration and/or cost benefits, two prefabricated systems will need to be analyzed to determine their overall installation times as well as costs. One of the systems proposed would be to design a steel structure, similar to the original design, consisting of prefabricated braced frames and modular roofing sections that can be installed in large sections. Since this system will not differ from the original design, the total cost may actually increase from that of the original system, due to prefabrication costs. The installation time will be the primary focus and will be compared with the original system.

The other system being proposed is a precast concrete structure. This system will need to be redesigned and researched to determine the most feasible precast concrete structure to take the place of the imposed steel structure. This system will most likely utilize precast concrete columns, roof members and wall panels. This system will need to be analyzed to determine its cost benefits, as well as any acceleration to the schedule that it may propose.

Research Methods

In order to properly research these two proposed systems, many different types of prefabrication, in steel and concrete, will need to be analyzed to determine the most feasible options in both steel and concrete, for this building. Tactics from AE 475 and AE 476 will be used to accurately determine the costs and schedule impacts these systems will have.

Analysis Steps

- Determine all information regarding the current steel structure (cost, installation time, major structural components etc.)
- Research and analyze different prefabricated systems
- Determine which two systems, precast concrete and steel are most feasible and efficient for this building
- Determine the cost benefits and durations for the precast system by utilizing estimating from cost databases and labor hour's information.
- Determine the time of installation for the prefabricated steel structure by utilizing labor hour information

- Compare and contrast the differences between the three systems to determine and benefits the new proposed systems may impose.

Resources

- Dr. Leicht (AE Construction Professor, Advisor)
- Dr. Hanagan (AE Structures Professor)
- Precast Specialties Corp. (Precast Concrete Experts)
- H & H Steel Fabricators (Steel Fabrication Experts)
- Foley Buhl Roberts (Structural Engineer on the Project)

Anticipated Outcome

The intended outcome of this analysis is to hopefully obtain a structural system design that will accelerate the schedule as well as provide the owner with an equivalent or less expensive system. This analysis will provide multiple possible systems, compared and contrasted with one another, and the benefits of each system will be weighed against the others to determine the best possible design.

[Analysis Option 2: Re-Sequencing of Interiors]

Problem Identification

The project being constructed for Atrium Medical Corporation began in May of 2013 and has an intended completion in June of 2014; 13 months total duration. The owner of this project has accepted this duration and has been holding Hutter Construction to complete the project before the imposed deadline. For this analysis, a SIP schedule will be performed to aide in decreasing the overall duration of the projects schedule by cutting down on major construction tasks.

Proposed Solutions

In order to mitigate this situation and develop an accurate schedule, each of the prefabricated systems proposed in Analysis Option 1 will need to be broken down into major construction sequences. These tasks will have high repetition in installation working from one wing of the building to the other. The repetitive nature of these construction tasks will allow the development of durations that can be accurate to the minute. A 4D model will be generated to depict the construction sequencing of the buildings prefabricated systems.

Research Methods

Research for this analysis will involve finding information scheduling and previous projects. This information will be used to help not only develop a schedule for the prefabricated components on this project, but also determine any issues that may have occurred in the past that would prevent a SIP schedule from being accurately created.

Analysis Steps

- Perform a total breakdown of the project schedule to determine areas that can be resequenced
- Develop a 4D model
- Develop a re-sequenced schedule
- Compare SIP schedule to original schedule, using 4D Analysis to determine differences and any saved time.

Resources

- Professor Craig Dubler (AE Construction Professor, SIPS Experience)
- Dr. John Messner (AE Construction Professor, SIPS Knowledge)
- Hutter Construction (CM Firm on Project)

Anticipated Outcome

By analyzing sequence, the results of this analysis should conclude with an accelerated project schedule.

[Analysis Option 3: Geothermal System Implementation]

Problem Identification

Currently Atrium Medical is being fitted with an HVAC system in the form of boilers and chillers that supply heated or chilled water to eight multi-zone air handling units and four single-zone rooftop units. These then distribute heated or chilled air to VAV control boxes that supply each zone with a regulated temperature. With the system being installed in the building presently, there have been no issues. However, this analysis is being composed to develop additional geothermal system types that could be combined with the existing system. These systems will utilize value engineering to determine the most efficient system based on cost and efficiencies.

Proposed Solutions

In order to accurately perform an analysis regarding the different geothermal systems, information will need to be researched concerning the three different types of well fields that feed geothermal heat pumps with some form of refrigerant. These three well fields include; horizontal loop, vertical loop, and an open loop field within a water basin. These systems will be adequately sized to meet this buildings demand loads, which involves sizing the heat pump as well as the loop fields. Other factors will need to be taken into consideration such as excavation, drilling and installation costs. These factors will also be included in the overall system costs, which will then be compared with one another to determine the differences in costs. The efficiencies of all these systems will be compared to determine the best, viable option for implementation. In addition to the up-front installation costs, an overall lifecycle cost will be determined for each system type. This lifecycle calculation will essentially determine each systems payback period to figure out whether the systems will be beneficial throughout the lifespan of the building.

Research Methods

Information will need to be researched regarding the three types of systems. The excavation, drilling, materials, installation and equipment costs will all need to be researched in order to accurately estimate the systems costs and time required for installation.

Analysis Steps

- Determine the rough size and scope of each of the three geothermal systems, as well as pros and cons, to determine the best viable system.
- Develop a cost and time estimation for the labor, materials and equipment involved in the creation of the best option.
- Input the systems into Climate Master software to weigh the differences in system efficiencies.
- Determine the life cycle cost of each system to determine the payback periods.

Resources

- Climate Master Design Software
- Moses D.F. Ling, PE (AE Professor, Mechanical)
- Dr. Robert Leicht (AE Professor, Value Engineering)

Anticipated Outcome

By performing the necessary steps in determining the cost and time information for each system, a comparison of efficiencies can be compiled and the systems can be accurately contrasted. This contrast can be used to visualize the major differences in the up-front system costs and durations. In addition to the initial comparison, the three systems will also be broken down by lifecycle costs and will not only be compared with one another, but also the original system. These comparisons help to determine the feasibility of each system in relation to costs throughout the life of the building.

[Analysis Option 4: Safety: Prevention Through Design]

Problem Identification

Hutter Construction, the CM Firm for the project, currently has an extensive safety plan that covers both field and office staff members. All of their employees have received OSHA 10 hour training, including project managers. Also, superintendents working for Hutter each have OSHA 30 hour training to give each one the ability to properly oversee all personnel on site, in regards to their safety. This training strictly covers information regarding general safety practices that are most effective during typical construction activities. There are currently no implemented plans, created during the design of the building systems that devise ways to prevent any hazards that may occur onsite. By imposing such a plan during the design phase of the project, Hutter would be able to foresee any issues that may occur onsite during construction and hopefully prevent them.

Proposed Solutions

In order to devise a plan that essentially eliminates hazards during construction, research will need to be conducted around specific systems that pose potential hazards in construction. Some of the greatest risks in construction tend to arise during the installation of structural steel. Therefore, an analysis will be conducted regarding the preparation and install of the structural steel on this project. In addition to the aforementioned analysis, research will also be performed regarding the opportunities for precast concrete structure designed in Analysis Option 1, and a safety plan will also be designed to help prevent any issues from occurring in the field.

Research Methods

Research will be conducted in the form of determining various safety procedures involved in the prepping, installing and connecting each of the structural steel members throughout the building. Some research may be found using the NISD or National Institute of Steel Detailing. Also, research will be conducted to find safer procedures for installing and connecting precast concrete structural members.

Analysis Steps

- Research safer procedures for preparation, installation and connection of steel members
- Research safer procedures for installing and connecting precast members
- Compile analysis in the form of guidelines to depict how to properly install concrete and steel members

Resources

- Dr. Robert Leicht (AE Construction Professor, PACE Information)
- NISD (National Institute of Steel Detailing)

Anticipated Outcome

This analysis will provide a series of guidelines that will aide in the prevention of many hazards that have a possibility of occurring during construction. These guidelines will be implemented during the design phase of the project to develop a foresight to any possible hazards that may occur in the future.

Appendix A: Breadth Topics

[Breadth Topics]

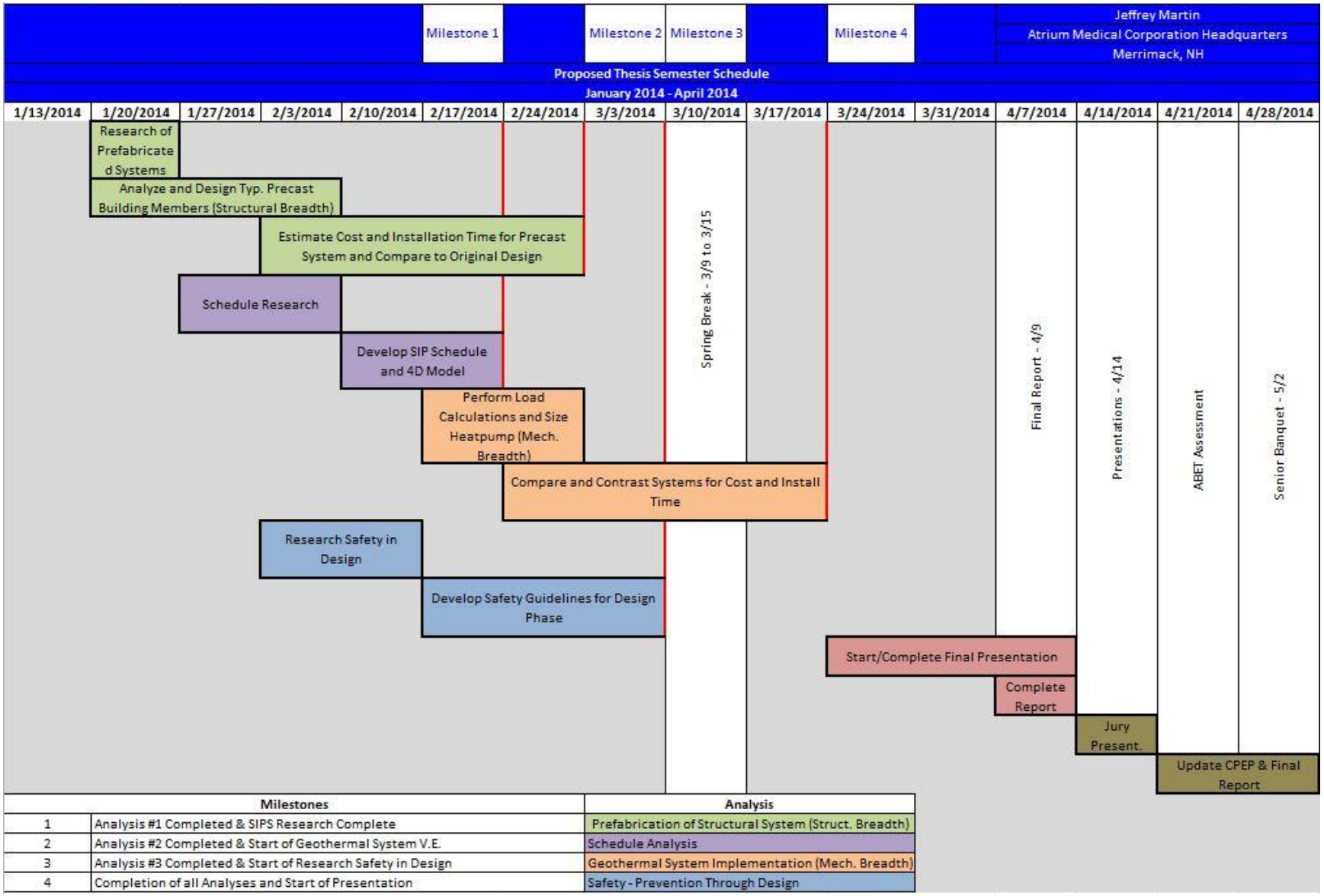
Breadth Option 1: Structural

In order to help support the study of Analysis Option 1: Prefabrication of Structural System, a breadth analysis will need to be performed. This breadth will delve into the redesign of the building's structural system. Typical members will be researched and analyzed to determine the best fit under the most intensely loaded areas. These members will be estimated and extrapolated throughout the building to assume a representative structure for the whole building. Once a simple design is found, Analysis Option 1 will look into determining a cost and installation estimate of this system, along with another prefabricated system, and compare the outcomes to original design.

Breadth Option 2: Mechanical

In order to help support the study of Analysis Option 3: Geothermal System Implementation, a breath analysis will need to be performed. This breadth will be conducted to determine the various loads needed to adequately size a geothermal heat pump. For this study, the demand loads for this building will be conducted using tactics from AE 310. These computations will provide the information necessary to size the heat pump for this project, which will be used in the value engineering method found in Analysis Option 3. Within Analysis Option 3, three types of geothermal systems will be drawn; horizontal loop, vertical loop and open loop fields. A layout will be provided for each system and a cost/installation analysis will be performed to determine the most efficient option.

Appendix B: Senior Thesis Timetable


Milestone 1
Milestone 2
Milestone 3
Milestone 4
Jeffrey Martin
Atrium Medical Corporation Headquarters
Merrimack, NH
Proposed Thesis Semester Schedule
January 2014 - April 2014
1/13/2014
1/20/2014
1/27/2014
2/3/2014
2/10/2014
2/17/2014
2/24/2014
3/3/2014
3/10/2014
3/17/2014
3/24/2014
3/31/2014
4/7/2014
4/14/2014
4/21/2014
4/28/2014
Research of Prefabricated Systems
Analyze and Design Typ. Precast Building Members (Structural Breadth)
Estimate Cost and Installation Time for Precast System and Compare to Original Design
Schedule Research
Develop SIP Schedule and 4D Model
Perform Load Calculations and Size Heatpump (Mech. Breadth)
Compare and Contrast Systems for Cost and Install Time
Research Safety in Design
Develop Safety Guidelines for Design Phase
Spring Break - 3/9 to 3/15
Final Report - 4/9
Presentations - 4/14
ABET Assessment
Senior Banquet - 5/2
Start/Complete Final Presentation
Complete Report
Jury Present.
Update CPEP & Final Report
Milestones
1 Analysis #1 Completed & SIPS Research Complete
2 Analysis #2 Completed & Start of Geothermal System V.E.
3 Analysis #3 Completed & Start of Research Safety in Design
4 Completion of all Analyses and Start of Presentation
Analysis
Prefabrication of Structural System (Struct. Breadth)
Schedule Analysis
Geothermal System Implementation (Mech. Breadth)
Safety - Prevention Through Design