Washington DC Area

Multi-Use High Rise

Final Proposal

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EXECUTIVE SUMMARY

This purpose of the Senior Thesis Proposal is to provide the background information regarding the Multi-Use High Rise project, followed by an identification and overview of the four research areas being analyzed. The further analysis will be taken place over the duration of the spring, 2014 semester at Penn State University. For each analysis topic, the problem and goal are clearly defined. Each analysis includes substantial research, methodology, resources and tools, and potential solutions and outcomes are discussed. The first area of analysis takes the issue of paper construction documents and implements mobile technology to save costs and schedule delays. The second area of analysis focuses on the similar kitchen and bathroom units, recognizing the wasted time and similarity of constructing each individual unit, and utilizing modularization to save time, space and money. The third area of analysis focuses on the enormous cost of the current structural system and implements Infinity structures to reduce costs. The final area of analysis notices an insignificant sustainability representation of the project and will implement further sustainable design features in hopes to raise the current LEED rating. A structural and mechanical breadth is also created within the detailed analysis. A weight matrix will be provided, showing the weight distribution of investigative focus for each analysis in critical issues research, value engineering analysis, constructability review, and schedule reduction proposal. Finally, a proposed schedule of the spring semester will show the progress of each analysis throughout the semester.

Project Background

The Multi-Use High Rise is a two-building, multiple-use building project being constructed in the Washington DC area. Estimated at roughly $44 million dollars, this project spans over 200,000 square feet of total area. The project consists of a two-story underground parking garage, and two buildings named Building 1 and Building 2. Building 1 is a 10 story structure, utilizing three retail areas on the ground floor, with 145 apartments spanning the remaining 9 stories. Building 2 is a six story apartment complex housing 42 apartment units. The project is set to last slightly over 24 months, from July, 2012 until July, 2014. Being a design-bid-build delivery method, the owner, USAA Real Estate, contacted ZOM Mid-Atlantic for architecture purposes and Donohoe Construction Company for construction efforts. The contract is set for a guarantee maximum price, which comes in right around $44 million.

The structural system for the Multi-Use High Rise is primarily made up of cast-in-place concrete. The foundation is found on level P2, using concrete footings and slab on grade. The remainder of both buildings, level's P1 to the roof, consists of cast-in-place concrete columns, beams, and slabs. Cast-in-place concrete minimum ultimate compressive strength for footings, slabs-on-grade, and foundation walls are 4000 PSI, while framed slabs and beams are 5000 PSI. Slabs poured on grade will be a minimum of 5 inches thick, poured over a vapor barrier and 6 inches of washed crushed stone.

In the Multi-Use High Rise project a dry-pipe sprinkler system is used, using a 1250 GPM, 100 HP, 488V 3phase fire pump. This fire pump is powered by the 300kW/375KVA diesel engine driven emergency generator. Both black steel and CPVC piping is used for the fire suppression water in this system. Sprinklers are provided in all areas of both Building 1 and Building 2.

The mechanical system for the Multi-Use High Rise is also a very complex system due to the complexity of the project. A 100% Outside Air Rooftop system is utilized for both Building 1 and Building 2 in heating and air conditioning. With this, both buildings use 1.5 ton split system heat pumps with cooling capacities of 18,000 BTU/H and heating capacities of 19,000 BTU/H. Several other mechanical equipment is used to make up the overall system, like fan heaters, including unit and fan wall heaters, air flow regulators, and through-the-wall units. The exhaust fans used in this system include ceiling mounted, direct driven centrifugal and belt driven centrifugal. This project also has specific building envelope requirements for roof R value, exterior above grade walls, floors over outdoor/unconditioned space, slab/below grade walls, and glazing.

The electrical system for the Multi-Use High Rise is a severely complex system composed of multiple panel boards and switchboards that are required to feed each floor and unit separately, as well as the retail space. The main distribution is made up of three separate

distribution panels. Switchboard 1 is a 2,500A 277/480V switchboard, switchboard 2 is a 3000A 120/208V switchboard, and switchboard 3 is a 1600A 120/208V switchboard. The lighting for the Multi-Use High rise utilizes a total of 78 different lighting fixtures throughout both Building A and Building B. The main types of lighting fixtures throughout the buildings included recessed fluorescent T5, recessed fluorescent T* and LED down lights. There is significant day lighting taken into effect during design of each building. Large windows and open areas make these possible, leaving very few fixtures to be visible. The lighting design also implemented photo sensors around the buildings to reduce energy consumption, whenever there are no occupants or there is enough daylight in the space.

This project is also within reach of a LEED Certification; given the planned sustainable design criteria are met.

ANALYSIS 1: MOBILE TECHNOLOGY INTEGRATION

Problem Identification

Paper construction drawings cost the project management team roughly $30,000 in general conditions costs, not to mention the $500 monthly printer/copier costs. This project's complexity has caused a significant amount of change orders and alterations to the drawings throughout the duration of the project. The drawings are created virtually, and kept on an easily accessible file. This topic will analyze the integration of virtual drawing stations and providing tablets throughout the jobsite, instead of paper copies. This analysis will show how changing the construction drawings from paper to virtual will help prevent problematic areas and reduce delay in construction while saving cost and time.

Research

The goal of this research is to analyze how integrating mobile technology will reduce the delay of construction efforts, minimize errors throughout the construction process, and save the project team time and money. In order to initiate the research analysis, there has to be background research done on the complexity and cost of paper construction documents. There also has to be research done on how mobile technology allows construction efforts to be performed simpler, reducing the risk of cost and time setbacks.

Methodology

- Research about paper construction documents and the areas at which they have become a burden to the construction process
- Research and ask the construction management team ways these problematic areas have been resolved and how they could have been acted upon better and faster if the construction documents were accessible virtually
- Interview the project manager and get further details about the changes to the construction document and how they have affected construction
- Discuss with the project manager their personal expertise with mobile technology, if mobile technology could have prevented the problematic areas and why it hasn't been established
- Find industry professionals who have valuable experience using mobile technology and discuss ways to integrate it in the project
- Compile all information gathered and show how mobile technology would be the better alternative to paper construction drawings

Resources and Tools

- Donohoe Construction project team – Project Manager and Project Executive
- Owner representatives

- Penn State University Architectural Engineering faculty
- Industry professionals with experience in mobile technology
- Project change orders, detailed schedule and estimate
- Applicable and reputable resources about mobile technology impacting construction activities and costs

Potential Solutions

After successful completion of analyzing the integration of mobile technology in the Multi-Use High Rise project, the overall flow of construction will potentially lead to greater efficiency. The research will show areas where mobile technology could have pointed out flaws in the construction drawings and prevented set-backs in both schedule and cost due to drawing changes. This research will show the resulting effect of the project schedule and overall construction costs. The expected outcomes of this research can potentially result in greater efficiency during the entire construction process.

Expected Outcome

- Schedule analysis discussing how mobile technology causes a reduction in change orders required throughout construction positively affect the duration of activities
- Cost analysis that will discuss the cost savings associated with both general conditions costs and general construction costs from reduced change orders

ANALYSIS 2: MODULARIZATION WITHIN UNITS

Problem Identification

It takes roughly one month to complete the kitchen and bathroom for the apartment units per floor. For every single bathroom and kitchen in both buildings of the Multi-Use High Rise project, time is taken to rough-in the MEP, trim out the MEP, install individual fixtures and equipment, and the application of finishing features. Being a project consisting of mostly apartment units, the bathrooms and kitchens in each unit will match from floor to floor, which greatly increases the duration of each floor. If both the bathroom and kitchen of each unit is modularized, being constructed to the finished level from an outside source, it can simply be placed into each unit when the time comes. This topic will analyze kitchen and bathroom modularization and the effects it has with construction duration and space utilization on a complex job site. This analysis will show how modularization can reduce the construction management team a great deal of time when completing each floor unit, and how it frees up space on a cluttered site.

Research

The goal of this research is to analyze how modularizing the kitchen and bathroom of apartment units can reduce the duration of the project. Another goal of this research is to analyze how modularizing the kitchen and bathroom of apartment units can increase space on the jobsite. In order to initiate the research analysis, background research must be performed to explain the principle of modularization and how it can be done regarding individual kitchens and bathrooms. Background research regarding time, space utilization, and ease of transportation of modularized units must also be performed.

Methodology

- Research different techniques and the process of modularization
- Research the efficiency, ease of practice, and feasibility of modularizing individual bathroom and kitchen units
- Contact the project manager and discuss the current kitchen and bathroom schedule situation and the construction teams thoughts on modularization
- Evaluate the constructability issues, and potential time and cost savings
- Evaluate the current site plan during the interior and finishes phase and how modularized units on the job site can potentially increase useful space
- Compile all information and determine modularization will save the construction team time and space on the jobsite

Resources and Tools

- Donohoe Construction project team – Project Manager and Project Executive

- Owner representatives
- Penn State University Architectural Engineering faculty
- Modularization facilities
- Key industry members with experience using modularization
- Applicable and reputable resources about modularization impacting construction schedule and costs

Potential Solutions

Following substantial analysis of modularizing bathroom and kitchen units, the time it takes to complete the interior and finishes of the kitchens and bathrooms of each unit will be greatly reduced. The analysis will also show how modularized units on the jobsite will clear useful space allowing for a less cluttered site layout.

Expected Outcome

- Detailed analysis will show modularization can be done off-site, transported and stored onsite in an organized matter
- Analysis will also show the time it takes to install each bathroom and kitchen will greatly be decreased on a floor to floor basis, positively impacting the project schedule
- An analysis of the site layout will show how modularized units clear space on the job site during the interiors and finishes phase

Critical Industry Issue

Problem Statement

Modularization, in the construction industry, is a growing technology taking place in the construction industry that has been proven to improve productivity in construction. Impacting areas include project schedule, costs, safety, quality and waste reduction, proving modularization to be a useful tool to construction managers across the nation. Interest about modularization becomes relevant due to the Pace Roundtable, where industry professionals only had positive remarks to say. The issue in this industry isn't within the process of modularization, but the lack of use of modularization throughout the construction world. Modularization should be used more frequently on projects of all sizes.

Research Goal

When conducting research regarding modularization in the construction industry, my goal is to prove how beneficial this technique will be. The audience in which this becomes pertinent towards will be construction management companies, those who make the decision to use modularization or not. Owners in the construction industry will also deem this beneficial. After

research, it will be proven to these industry members that modularization benefits everybody saving time, money, and project quality.

Research Steps

- Review PACE Roundtable notes regarding modularization
- Read and interpret the text *Prefabrication and Modularization: Productivity in the Construction Industry*, by McGraw Hill Construction
- Interview industry professionals with significant background in modularization
- Evaluate the project schedule, costs, safety, quality, and waste reduction of other projects that utilized modularization
- Combine all research information and propose the benefits of modularization

Sources

- Donohoe Construction project team – Project Manager and Project Executive
- Owner representatives
- Penn State University Architectural Engineering faculty
- Modular design facilities
- Key industry members with experience in modularization
- *Prefabrication and Modularization: Productivity in the Construction Industry*, by McGraw Hill Construction

Data Collection Tools

- Survey and interview questions to industry professionals based on the positive impacts of project schedule, costs, safety, quality, and waste reduction through the modularization process
- Survey and interview questions to industry professionals based on the negative impacts of modularization in the construction industry
- Survey and interview questions to owners regarding the familiarization and use of modularization

ANALYSIS 3: ALTERNATIVE STRUCTURAL SYSTEMS

Problem Identification

After compiling costs for formwork, reinforcing, and concrete, the total cost of the structural system totals to $7,666,552.44, this is roughly 15% of total construction costs. The structural system is a significant portion of the project, which is responsible for much of the costs. This topic will focus on changing the current concrete structural system to a mixed system using both concrete and an infinity structure. This analysis will show the cost savings in mixing the infinity system with the current system being used. This analysis will also show how integrating the infinity system will allow for greener construction.

Research

The goal of this research is to analyze how integrating the Infinity system in the current concrete structural system will reduce construction costs and increase sustainability. In order to initiate the research analysis, background research regarding Infinity structures is required and how it compares to concrete construction. Additionally, integrating the infinity system will lead to a structural breadth, analyzing the influence of performance and overall functionality of the structure.

Methodology

- Research the background of the Infinity Structural System
- Research specific examples of mixing concrete construction with Infinity structures
- Compare complete concrete structural system to the concrete and infinity integration structural system
- Interview the project manager to discuss the current structural system and constructability issue regarding it
- Contact industry professionals regarding the use of an Infinity structural system
- Evaluate the constructability issues, potential time and cost savings, and feasibility of the new integrated structural system
- Compile all information and determine a new structural system, mixing concrete and Infinity structures will save the construction costs

Resources and Tools

- Donohoe Construction project team – Project Manager and Project Executive
- Owner representatives
- Penn State University Architectural Engineering faculty
- Modularization facilities
- Key industry members with experience using Infinity structures

- Applicable and reputable resources about Infinity structural systems impacting construction schedule and costs

Potential Solutions

Following substantial analysis of integrating Infinity structures to the current concrete structural system, the overall construction costs will be reduced. The analysis will show no change in structural integrity of either building, nor will any interior units or features be altered. The new system will provide a more sustainable and greener structural system.

Expected Outcome

- Detailed analysis will show integrating the Infinity structures will reduce construction costs
- Analysis will also show how the new structural system will allow for a more sustainable system, gaining points in the project's overall LEED credibility.

ANALYSIS 4: GREATER IMPLEMENTATION OF SUSTAINABLE DESIGN

Problem Identification

The project is currently on tract to barely receive a LEED Credible achievement. There are only a few specific sustainability features implemented throughout design, causing the project to be less sustainable than it has the ability to be. A greener building allows the owner to save significant, unthinkable costs in the long run. This topic will focus on a greater implementation of sustainable design, when designing the Multi-Use High Rise. This analysis will give detail to specific ways a more sustainable design can be implemented to this project. This analysis will include a restructured LEED evaluation, a cost and schedule comparison following the design implementations.

Research

The goal of this research is to analyze specific sustainable design features that can be implemented to the project that will be effective for the owner. Another goal of this research is to see how the sustainable design implementations will increase the LEED rating of the project, following another LEED evaluation. Additionally, a grey-water recapture system will be implementing, leading to a mechanical breadth, analyzing the influence and usefulness of the system.

Methodology

- Research sustainable design techniques, pertinent to the Washington DC area
- Research grey-water recapture,
- Analyze the current sustainable design features and how more techniques can be implemented
- Contact the project manager and discuss the current sustainability and LEED rating of the project
- Evaluate the constructability issues, and potential time and cost savings
- Evaluate the current LEED rating and perform another LEED evaluation following design implementation
- Compile all information and determine a greater implementation of sustainable design will be beneficial to the owner and increase the projects LEED rating

Resources and Tools

- Donohoe Construction project team – Project Manager and Project Executive
- Owner representatives
- Penn State University Architectural Engineering faculty
- Sustainable design facilities
- Key industry members with experience in sustainability

- LEED resources
- Applicable and reputable resources about sustainable design impact on owner costs, construction schedule and costs

Potential Solutions

After completing extensive analysis of implementing greater sustainable design, the LEED rating and overall sustainability of the Multi-Use High Rise project will be increased. The overall owner costs will also decrease, giving owner satisfaction.

Expected Outcome

- Following the implementation of sustainable design features, a LEED evaluation will be conducted showing an increase in the projects LEED rating will be increased
- Analysis will also show the cost and schedule changes of implementing more sustainable design features to the project
- Analysis will show a decrease in owner turnover costs and overall satisfaction

SPRING THESIS OBJECTIVES

Analysis Weight Matrix

A weighted matrix was developed in *Table 1* to give further understanding of the allocation of time and resourced during the spring semester. The four analysis depths and their respective breadths are broken down into four topics of focus: *Industry Research, Value Engineering, Constructability Review, and Schedule Reduction.* These four sections detail the type of work being performed during the spring semester.

Analysis Description	Industry Research	Value Engineering	Constructability Review	Schedule Reduction	Total
Mobile Technology Implementation	-	**10%**	-	**15%**	**25%**
Modularization	**15%**	-	-	**15%**	**30%**
Alternative Structural System	-	**10%**	**15%**	-	**25%**
Sustainable Design Implementation	-	**10%**	**10%**	-	**20%**

Spring Thesis Schedule

A proposed spring thesis schedule is attached as an appendix to the document. It details the work being performed throughout the spring semester, and when time will be allotted for each area of analysis. It includes four milestone dates; January 29, 2014, February 27, 2014, March 5, 2014, and March 24, 2014. At the conclusion of each of these dates, an expected depth is to be finished. The date of final completion will be April 9, 2014 and final presentations will proceed shortly after.

Conclusion

In conclusion, the four areas of analysis have potential to greatly increase the productivity and efficiency of the Multi-Use High Rise project. Each topic was chosen based on the work provided for Technical Assignment 3, and information gathered regarding leading issues with the project. Along with this, the PACE Roundtable greatly influenced several analysis research topics, and provided insightful information towards each area.

Appendix A: Breadth Areas

Breadth Topics

The demonstration of breadth in Architectural Engineering will be accomplished in two analysis topics. The purpose of breadth analysis is to illustrate the breadth skills outside of the construction option. The first breadth topic is related to Analysis #3, integrating the Infinity structural system with the current concrete system. The second area of breadth is related to Analysis #4, implementing grey-water recapture as a sustainable design feature.

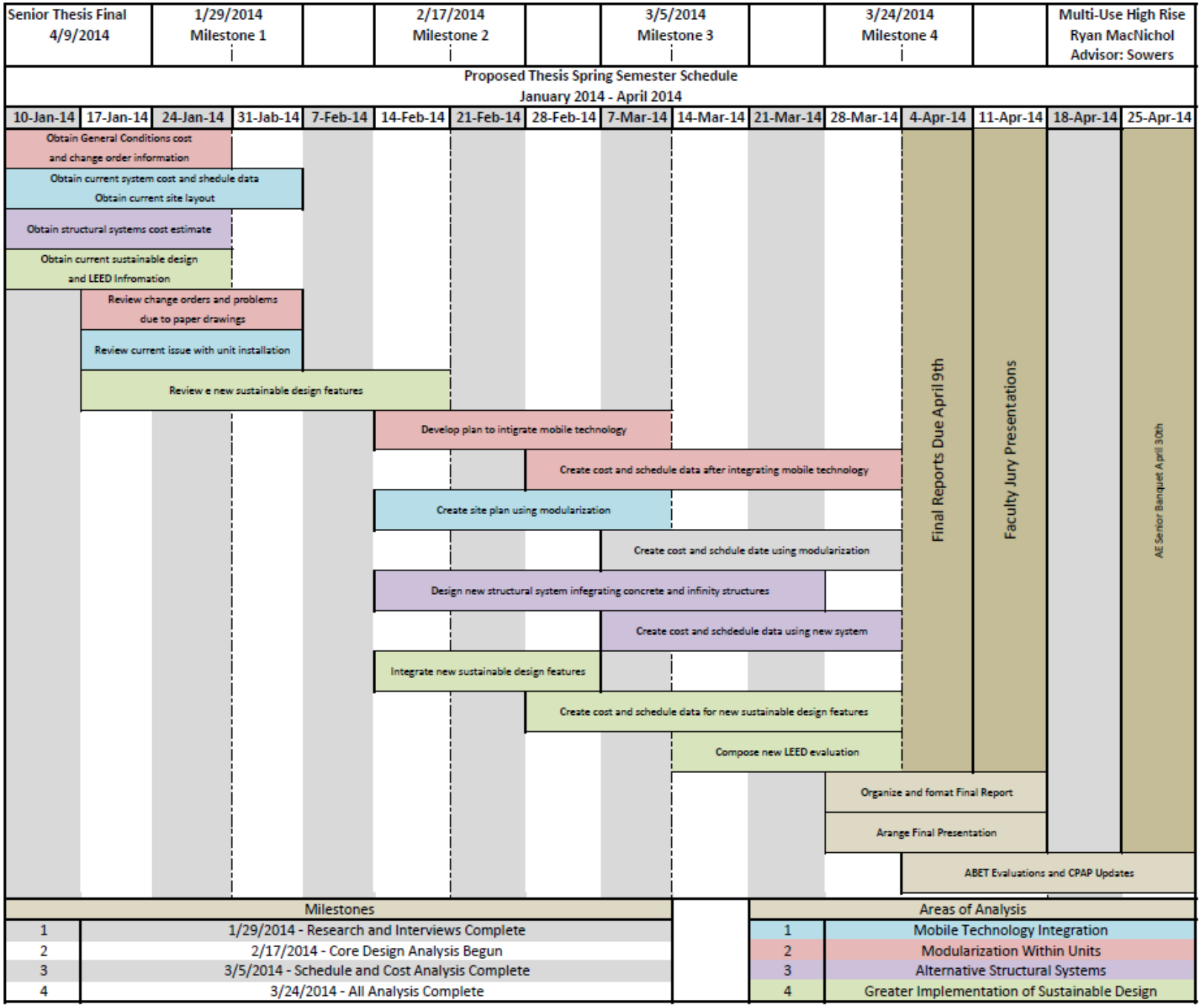
Breadth 1- Structural Breadth: Infinity Structural Integration

The structural breadth will involve changing the current concrete structural system to an integrated system. This integrated system will include concrete construction and an Infinity structure. This will have an effect of the overall structure, reducing load that is created by the structure itself. This change in loading will require a reevaluation and redesign. This new structural system will also change the story height of the building. When choosing the Infinity structural integration, a direct cost and schedule difference will be noticed and analyzed.

Breadth 2- Mechanical Breadth: Grey-Water Recapture System

The mechanical breadth will include implementing a grey-water recapture system to the project. This system will allow the project to increase its sustainability and LEED rating, and also save the owner costs. This system will affect the mechanical system of the building, requiring a redesign to allow the recapture system to become effective. When analyzing the grey-water recapture, the change in mechanical system will alter the overall project cost and schedule, while decreasing owner costs and increasing overall satisfaction.

Appendix B: Spring Thesis Schedule


Senior Thesis Final
4/9/2014
1/29/2014
Milestone 1
2/17/2014
Milestone 2
3/5/2014
Milestone 3
3/24/2014
Milestone 4
Multi-Use High Rise
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Proposed Thesis Spring Semester Schedule
January 2014 - April 2014
10-Jan-14
17-Jan-14
24-Jan-14
31-Jab-14
7-Feb-14
14-Feb-14
21-Feb-14
28-Feb-14
7-Mar-14
14-Mar-14
21-Mar-14
28-Mar-14
4-Apr-14
11-Apr-14
18-Apr-14
25-Apr-14
Obtain General Conditions cost and change order information
Obtain current system cost and shedule data
Obtain current site layout
Obtain structural systems cost estimate
Obtain current sustainable design and LEED Infromation
Review change orders and problems due to paper drawings
Review current issue with unit installation
Review e new sustainable design features
Develop plan to intigrate mobile technology
Create cost and schedule data after integrating mobile technology
Create site plan using modularization
Create cost and schdule date using modularization
Design new structural system infegrating concrete and infinity structures
Create cost and schdedule data using new system
Integrate new sustainable design features
Create cost and schedule data for new sustainable design features
Compose new LEED evaluation
Organize and fomat Final Report
Arange Final Presentation
ABET Evaluations and CPAP Updates
Final Reports Due April 9th
Faculty Jury Presentations
AE Senior Banquet April 30th
Milestones
1 1/29/2014 - Research and Interviews Complete
2 2/17/2014 - Core Design Analysis Begun
3 3/5/2014 - Schedule and Cost Analysis Complete
4 3/24/2014 - All Analysis Complete
Areas of Analysis
1 Mobile Technology Integration
2 Modularization Within Units
3 Alternative Structural Systems
4 Greater Implementation of Sustainable Design