Architectural Engineering 2013 Senior Thesis

Final Proposal for Spring Thesis Project

FOR

BLOCK 12

DEVELOPED BY

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BLOCK 12

ROCKVILLE, MD

Advisor: Dr. Dubler

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SECTION A: EXECUTIVE SUMMARY

This report will identify three analysis topics and one critical industry research topic. The construction challenges for Block 12 will be identified, along with potential solutions. The potential solutions will further be examined as a thesis investigation. Potential breaths within the analysis topics will also be stated, which include a structural and mechanical breadth. A proposed schedule for achieving the thesis investigation tasks will also be presented in a Gantt chart.

Block 12 is part of a new community development in the heart of Rockville, MD. The developer, Federal Realty Investment Trust, will own, operate, and manage the newly constructed building, which is intended to achieve LEED certified status. Within the structure's four total floors and two sublevels, various usage types will be incorporated. A parking garage will provide 163 spaces over 72,266 square feet spanning over 2 levels. In various locations across two levels, retail space will occupy 44,254 square feet and consist of 13 individual retail spaces. The residential space makes up 175,284 square feet of the building and includes 174 units, a fitness center for the tenants, and an outdoor courtyard with a swimming pool.

The existing conditions of Block 12 are ideal. Block 12 sits at on a large open commercial lot. Existing stores include Starbucks, Bank of America, AC Moor, Chipotle, and Bally Total Fitness among others. As part of phase 1 of the overall project, Bally Total Fitness will be under demolition. The existing building does not affect Block 12's construction progress, but it does affect Block 10 and 11, which are the other 2 buildings being built adjacent. Utilities are readily accessible, but due to the high occupancy demands of the overall project, most of the utilities will have to be upsized. Construction traffic flow is of a concern due to the high car flow and accessibility issues on the two primary roads. Based on the geotechnical reports, Block 12 sits above 3 feet of the water level, facilitated with the drainage concerns during excavation.

The project schedule has a critical finish date of May 2014. Federal Realty Investment Trust plans on leasing the apartments to recent college graduates, who are seeking a place to live after having accepted a job near the densely populated DC/Northern Virginia Area. The project is fast paced, with a construction schedule lasting only 20 months. This was achieved through prefabricating wood framing into sections. The production rate was increased by systematically managing workflow and through effectively splitting the building into four sections as seen on Figure 1.2. The project had a 5 day delay due to Hurricane Sandy hitting the job site. The effect was mitigated by proactively planning accumulated water deposits within the excavation. The only activity in the schedule that lies on the critical path is close-out, which also marks the period of most workforce demand.

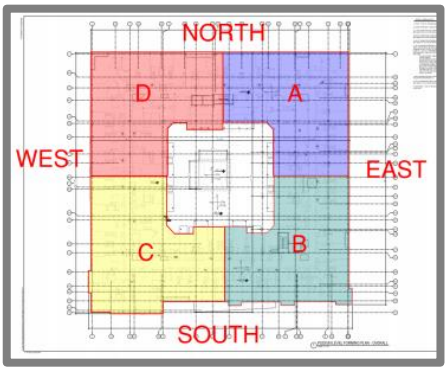


Figure 1.2: Wood framing sequence

The wood frame building sits on spread footing set 3 feet below the slab on grade level with two post tensioned concrete slabs. The cast-in-place concrete was pumped and poured using concrete barrels, to reach the building's extremes. The residential units will be heated by split system heat pumps and cooled with a cooling system. The mechanical equipment will primarily be located on the roof, including 2 RTU's. The parking garage will circulate air with 3

exhaust fans, which will be activated with CO_2 sensors. Active fire protection measures are taken by 2hr fire rated shafts and fire rated I-beams. Passive fire protection measures are additionally taken by a wet pipe system in the stairs & residential areas and a dry pipe system in the garage & retail slabs. The electrical system is a 3 phase 480/277V low voltage fed from one location to electrical closets on each level. The building will contain 1 diesel 250 KW generator for emergency power outages with an auto start specification of 10 seconds max and minimum fuel storage of 24 hours at rated load. Load bearing concrete masonry walls will house the stair shafts. The exterior retail space façade will primarily be composed of curtain walls, to be designed, furnished, and installed by the subcontractor. The systems to support excavation walls were steel soldier piles and wood lagging boards with tiebacks on the north, south, and east. The west side was laid back to facilitate truck flow traffic inside the excavation. Temporary pumps were used only used during excavation, due to the building sitting on 3 feet above the water line.

The patented system by SCA Consulting Engineers, Inc. was incorporated for faster production time installing drywall. Full sheets of drywall can be placed and drilled in place, compared to traditionally trimming the drywall to fit properly. Zip system sheathing and tape was used as a moisture resistant barrier to enclose the building and reduce air leakage. This system discards the need for house wrap and felt typically required. The owner is seeking LEED Accreditation through implementing a green roof, a waste management plan, and an indoor air quality management plan.

The project delivery system is a traditional Design-Bid-Build project delivery system with the CM at risk providing a GMP. This was the chosen method due to the owner feeling comfortable with the delivery method and by previous project's success. The owner settled on a price with the general contractor, The Whiting-Turner Construction Company, through a negotiation. The owner's representative is compensated through a cost by fee basis, while the architects, engineers, and subcontractor's contract types are lump sums. It is worth noting, even though the architect and construction manager do not have a contract, they have a strong communication for the success of this project. The construction contract terms are typical AIA language stating explicitly each party's responsibilities. The schedule to abide is attached and the consequences for delay or non-compliance are stated. The contractor was selected based on a good relationship with the owner.

Block 12 is one of three buildings under construction at the same time, with a team dedicated to site work, due to the heavy site work involvement. Ted Border is the Vice President overseeing all the work performed throughout the overall project. Adam Haubert is the Sr. Project Manager primarily in charge of scheduling. Luther Hildreth is the Senior Superintendent making sure everything runs smoothly in the field. Site work and Block 12 are structured similarly with a project engineer being under a superintendent under a project manager.

Federal Realty Investment Trust is a large realty investment trust, which focuses on development and redevelopment. They typically own, operate, and manage their buildings. Federal Realty is a privately funded company who focuses on obtaining a quality building at a feasible cost.

SECTION B: BLOCK 12 CONSTRUCTION CHALLENGES

Block 12 is faced with a wide variety of challenges during the construction process. Federal Realty is primarily concerned with maintaining cost, while still providing quality. One of their major concerns includes avoiding budget overruns, which primarily occur due to design decision delays during construction. Another concern is completing the job with a quick turnover date, with an earlier and faster delivery schedule being preferred. The owner is also concerned with maintaining the cost of construction low, thus keeping the parties building the work at a tight profit margin. Additionally, the owner is also concerned with the building's energy efficiency. As shown in figure 2.1, the Block 12 analysis topic map is shown displaying the interconnections between the construction problems in Block 12 and the potential analysis topics that will be further examined.

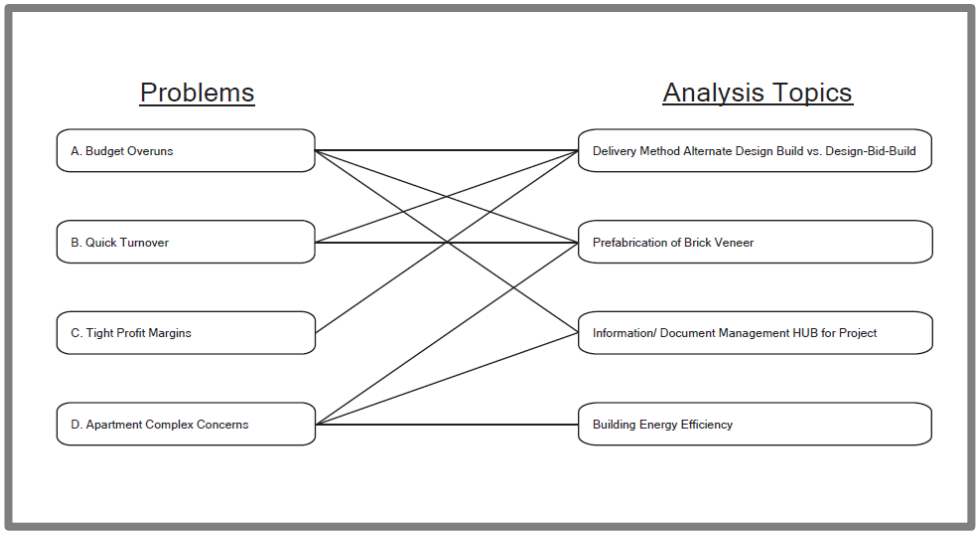


Figure 2.1: Block 12 analysis topics map.

SECTION C: ANALYSIS TOPIC 1

Delivery Method Alternate Design Build vs. Design-Bid-Build

Problem

A challenge encountered in Block 12 was the delivery method implemented, which was a traditional Design-Bid-Build delivery system. This delivery system works, but has the potential to create budget overruns due to design decision delays during construction, which ultimately delay the construction schedule, and restrict the building parties to a tight profit margin. All these issues face a challenge to the successful completion of the construction of Block 12.

Background Research

There are several benefits in the design-bid-build project delivery system, one of them being the familiarity of the system among the various different trades. The owner has considerably more control over the project and the cost of the project is defined at the outset with a low bid. The negative aspects of this delivery system is when bids come in over budget, considerable time is lost trying to resolve this issue. Additionally there are no constructability reviews, which typically create issues down the road. Another negative is the fact that the books are closed, which allows profitability to be the goal of the GC/CM, rather than quality.

The design build delivery system offers great benefits, such as providing a single point of contact to resolve any issues that may potentially occur during construction. There is no adversarial relationship between the Architect and the Contractor, since they are the same entity. The downside to this is that the checks and balances are lost between the Architect and the Contractor, since they are the same entity. This delivery method also requires the construction program to be clearly defined by the owner prior to starting construction. Also, the design build delivery system required the owner to have and extensive experience in construction.

Potential Solution

The delivery system proposed is a Design Build approach in which the contractor is offered both the designer and construction services. This delivery approach assigns the contractual responsibility to a single source while mitigating the owner's risk and reducing the delivery schedule. This seems like a viable solution to solve the current issue Block 12 is facing in construction.

Steps that will be Performed to Achieve Technical Analysis/ Research

To validate the advantages of a Design Build delivery Method for Block 12, several steps will be taken. The project delivery method selection will be performed based on the owner's project objectives. The advantages of a Design Build approach will be compared to that of a Design Build delivery system. A schedule analysis will be performed to compare the schedule impact of completing the project utilizing such delivery system.

Expected Outcome

Design Build will be the preferred delivery system due to its ability to provide a higher quality finish without affecting the project delivery schedule. The delivery schedule will be shorter than that of the traditional Design-Bid-Build Delivery Method.

SECTION D: ANALYSIS TOPIC 2

Prefabrication of Brick Veneer

Problem

Federal Realty is concerned with maintaining the building on the set schedule. The delivery time for them is very important. Currently Block 12 is 1 month behind schedule. To get the project back on schedule, the already staggered schedule should be accelerated through accelerating an activity, which lies, on the critical path. The brick veneer is an activity, which lies on the critical path and had the potential to be accelerated due to its repetitive nature.

Potential Solution

Prefabricating the brick veneer will accelerate the schedule. More coordination will be required upfront, but a quicker installation time can be achieved along with the associated higher quality finish installation and general condition savings. Also, less waste in the construction site occurs due to prefabrication of the brick veneer and a safer installation process for the laborers occurs.

Steps that will be Performed to Achieve Technical Analysis/ Research

The steps that will be performed to prefabricate the brick veneer, will be to initially design the prefabricated brick veneer units. The brick façade will be identified and divided into repeatable units. The transportation logistics plan will be created to ensure the prefabricated brick veneers can be brought on site. The correct installation process for the units will be created. A cost and schedule impact analysis will also be performed to project the benefits of prefabricating the brick veneer.

Structural Breadth

To successfully analyze this system, a structural analysis of the prefabricated brick veneer will need to be performed in order to ensure the unit can resists its own weight during transportation, during, and after installation. The anchors and installation bolts will need to be examined to meet the lateral wind forces required by code. Additionally the expansion joints will be examined to ensure the brick veneer does not crack or fail post installation.

Expected Outcome

The prefabricated brick veneer will add an initial higher cost, but the time saved during installation will more than compensate the initial higher premium. Through prefabrication, a higher quality finish will be delivered, with the added benefits of less waste and a higher safety control. Prefabricating the brick veneer will reduce the cost of the brick façade and accelerate the much needed schedule acceleration of 1 month.

SECTION E: ANALYSIS TOPIC 3

Building Energy Efficiency

Problem

The owner has apartment building concerns, which are based on the building's energy efficiency. The building is set to achieve a green certification upon completion. To maintain the building operation costs and provide energy efficiency, certain systems will be examined to calculate the optimal system to save on the building operation costs.

Background Research

There are several potential solutions that will help the building reduce its operations costs, these include implementing a building automation system, a photovoltaic system, a radiant flooring system, or an enthalpy wheel. All these option are viable solutions, but

The incorporation of a photovoltaic system and a radiant flooring system are great alternatives to reduce the building's energy consumption. The photovoltaic system is a great option for a building with space and accessibility to direct sunlight. Based on the site conditions of Block 12, the mechanical system will be placed on the roof, meaning there is little to no real state left for setting enough photovoltaic panels to achieve substantial benefits. If the photovoltaic were to be utilized for Block 12, additional structural reinforcement will be needed to support the additional load. The photovoltaic panel's cost would also have to account for the maintenance cost required to maintain the panels clean and able to absorb sunlight's energy.

Radiant flooring is a great system to directly and efficiently heat a living space. To install this system in Block 12 will require additional cost for the additional units to heat the fluid as well as for the closed system of pipes under the floor. The system will also impact the schedule, due to its more intensive installation requirements. Another factor is the fact that a radiant flooring system heats a living space over time and not "on demand", as do traditional air systems.

Potential Solution

Upon closer examination, the addition of a building automation system and the addition of an enthalpy wheel seem like alternatives, which will not significantly impact the construction cost and schedule. Adding building automation controls to each residential units, to help track and reduce their energy consumption with respect to lighting, receptacle, and heating loads will add an initial cost. With this control system, the residents will reduce their energy consumption, thus produce less strain and wear on the systems, allowing the systems to last longer with less maintenance.

The incorporation of the heat recovery system in the mechanical system will help with preconditioning the air into the system. This exchange of heat will save on energy that would have otherwise been utilized to preheat the air. An energy recover wheel is offers great benefits to increasing the building's energy efficiency. Each system has its positives and negatives. To

achieve the optimal results, a building automation control system and an enthalpy wheel should be incorporated.

Steps that will be Performed to Achieve Technical Analysis/ Research

To achieve this technical analysis, the building automation control system layout will be designed for a typical residential unit. The projected energy savings will be created based on current case studies of a similar project type and scale. The life-cycle cost of the BA control system will be projected. Also, the impact of adding the building automation system will be analyzed on the construction's cost and schedule.

Mechanical Breadth

The benefits of a heat recovery system will be demonstrated. An efficient enthalpy wheel will be designed for the retail level of this facility. The building's energy cost savings with the addition of an enthalpy wheel will be examined.

Expected Outcome

The building energy efficiency items proposed, the building automation controls and enthalpy wheel would save a substantial amount of money on the building's energy consumption. This implementation will save on the building's operations cost, due to less demand, thus less maintenance, will be required to the building.

SECTION F: CRITICAL INDUSTRY RESEARCH TOPIC

Information/ Document Management HUB for Project

Problem Statement

During the construction process of Block 12, there have been several design changes and multiple updates to the drawings. Maintaining multiple drawing and documents updated among the various different trades presents a challenge in itself. This process is very iterative and costly. Currently the construction manager is managing the drawings manually and keeping record of the drawings on record in a "History Set."

Background Research

The Partnership for Achieving Construction Excellence (PACE) holds a conference every year in early November to discuss current issues and brainstorm how to best address critical industry issues. The 22nd Annual PACE Roundtable conference highlighted the three major themes of sustainability, information technology, and integrated processes. The integrated processes topic was interesting, due to Block 12 containing prefabricated wood trusses. Most of the discussions in the roundtable were primarily based on collaboration and system information exchange. Their main discussions primarily focused on information exchange standards and systems integration.

There were discussions on how there should be a focus on information standards. The idea was centered around "letting designers design," so more time can be spent on design and less on documentation. This is a major concern in the industry since most projects suffer from missing information and design discrepancies. If the designers spent more time on ensuring the quality of their designs, the information exchanged to the other parties would be much more effective.

Integration among different tools and software was also discussed. This pertained to various companies utilizing different software, some even highly customizing their own in house software to suit their needs. The potential downfall to this issue is the exchange of information. Once the information is transferred, if the next party down the line does not utilize the same compatible software, the potential to utilize the information is lost. Partial lost in this process may be common, since at times not all the information may be critical, but there is a monetary issue. Work has to be redone. For example, if a mechanical contractor is given a 3D model in different software than what it utilizes to prefabricate, it is forced to redo its own model. This inefficient process not only adds time to the process, but it also adds cost. There should be a greater emphasis on communicating an exchanged model's reliability of geometry and information.

Potential Solution/ Research Goal

To remedy this information and documentation management task, a process standard will be developed. This information/ documentation management HUB for the project will be easily implemented through easily accessible software. This information HUB will not only

facilitate the access of the most updated drawings, but will also ensure the correct installation of all the building components, thus improving the quality of the project in the long run, rather than on its first cost. The documentation system will also aid in developing a punch list to assure the project is completed and to track its warranty period. The audience of this research will be all the project participants, from the laborers to the owners, whom all will be updated with the latest drawing and information updates when they occur.

Steps that will be Performed to Achieve Technical Analysis/ Research

The steps required to solve this critical industry research topic, are to develop a systematic standard that can be easily implemented on medium to large-scale projects. Interviews and questions will be asked to industry contacts from large companies, which include the Whiting-Turner Contracting Company, Forrester, Mortenson, and Barton Malow to name a few. A standard menu display and file management system structure will be developed to manage and track the information and documents. An execution plan to set the HUB in place will be established along with critical components to set and maintain the HUB will be identified. Additionally, a cost and time analysis of the HUB's implementation and maintenance cost will be projected.

Expected Outcome

The projected outcome is that the HUB is a useful tool to have on site, if it is maintained and meets all the requirements for its successful implementation. The HUB provides a useful source of information if the interface is easy to use and provides the most up to date reliable information. The implementation of tablet devices will be also play a key role to utilizing the HUB information effectively.

SECTION G: TASKS

Tasks

1. Analysis Topic 1: Delivery Method Alternate Design Build vs. Design-Bid-Build
    a. Research Design-Bid-Build vs. Design Build
    b. Project delivery method selection
    c. Pros and Cons of Design-Bid-Build vs Design Build
    d. Schedule impact of Design Build

2. Analysis Topic 2: Prefabrication of Brick Veneer
    a. Research prefabrication of brick veneer
    b. Divide Brick façade into sections for prefabrication
    c. Design prefabricated brick veneer units
    d. Transportation logistics plan
    e. Installation process guide
    f. Cost impact analysis
    g. Schedule impact analysis
    h. Structural Breadth
        i. Brick veneer unit structural analysis
            1. Transportation
            2. Installation
        ii. Anchors and installation bolts examined
            1. Lateral wind forces by code
        iii. Expansion joints thermal crack analysis

3. Analysis Topic 3: Building Energy Efficiency
    a. Building Automation system control layout
        i. Typical residential unit
            1. Lighting, receptacle, heating loads
        ii. Energy saving analysis
            1. Case studies and similar projects
        iii. Life-cycle cost analysis
        iv. Cost impact analysis
        v. Schedule impact analysis
    b. Heat Recovery unit in RTU
        i. Retail spaces
    c. Mechanical Breadth
        i. Enthalpy wheel
            1. Design and size enthalpy wheel
            2. Energy cost savings

4. HUB
    a. Interview industry contacts
    b. Identify industry acceptable software
    c. Identify hardware components
    d. Develop process standard
        i. Drawings
        ii. Shop drawings
        iii. RFI's
        iv. Change orders
        v. Punch list
    e. Create menu interface
    f. Create HUB execution plan
        i. To implement HUB
        ii. To maintain HUB
    g. Cost and Time of implementation and maintenance Analysis

5. Final Report and Presentation
    a. Outline final report
    b. Outline final presentation
    c. Finalize report
    d. Prepare final presentation
    e. Practice

SECTION H: OVERALL GRADE BREAKDOWN SUGGESTION

Overall Thesis Project Grade Breakdown	
Analysis Topic 1:	20%
Analysis Topic 2:	30%
Analysis Topic 3:	25%
Critical Industry Research Topic:	25%
Total Thesis Project Grade:	**100%**

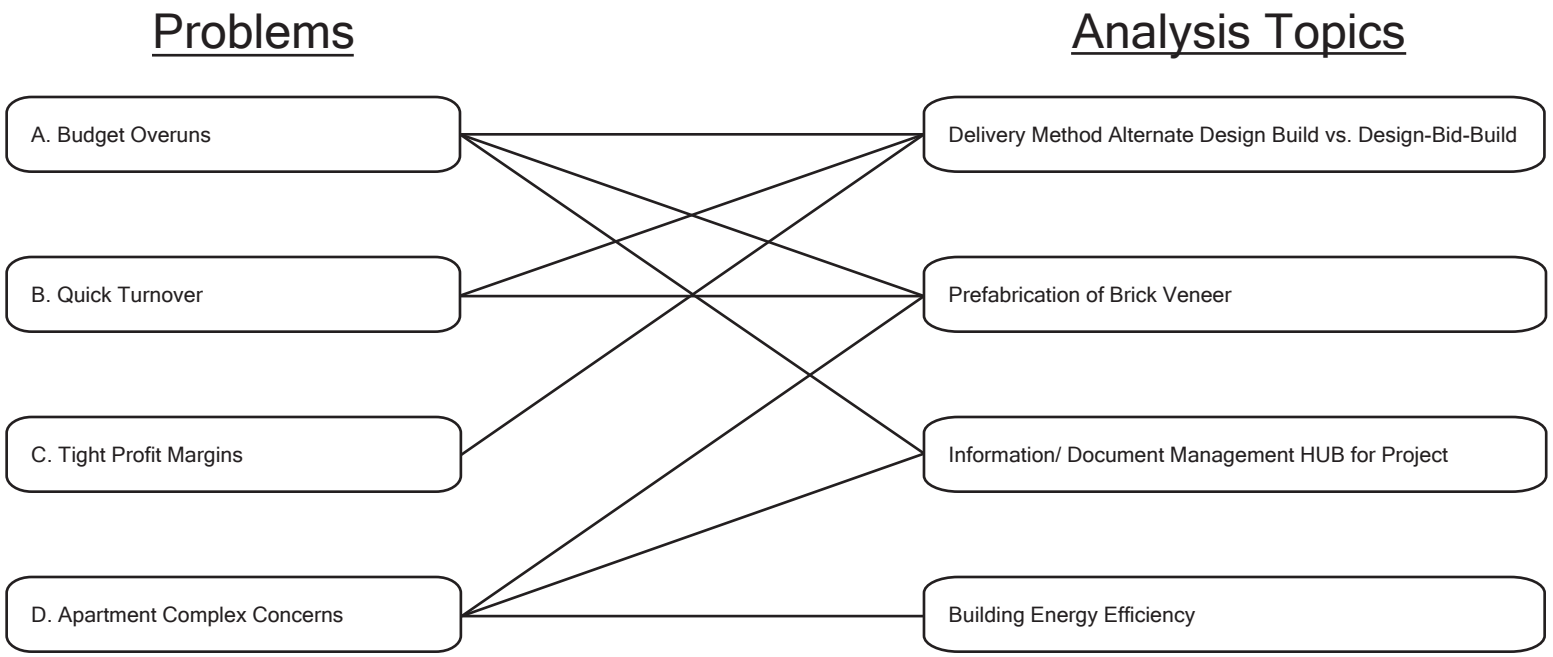
SECTION O: ATTACHMENTS

1. **Block 12 Analysis Topics Map** [FROM SECTION B]

2. **Demonstration of Breadths- Appendix I** [FROM SECTION D & E]

3. **Proposed Thesis Semester Gantt Chart Schedule** [FROM SECTION A]

Block 12 Analysis Topics Map



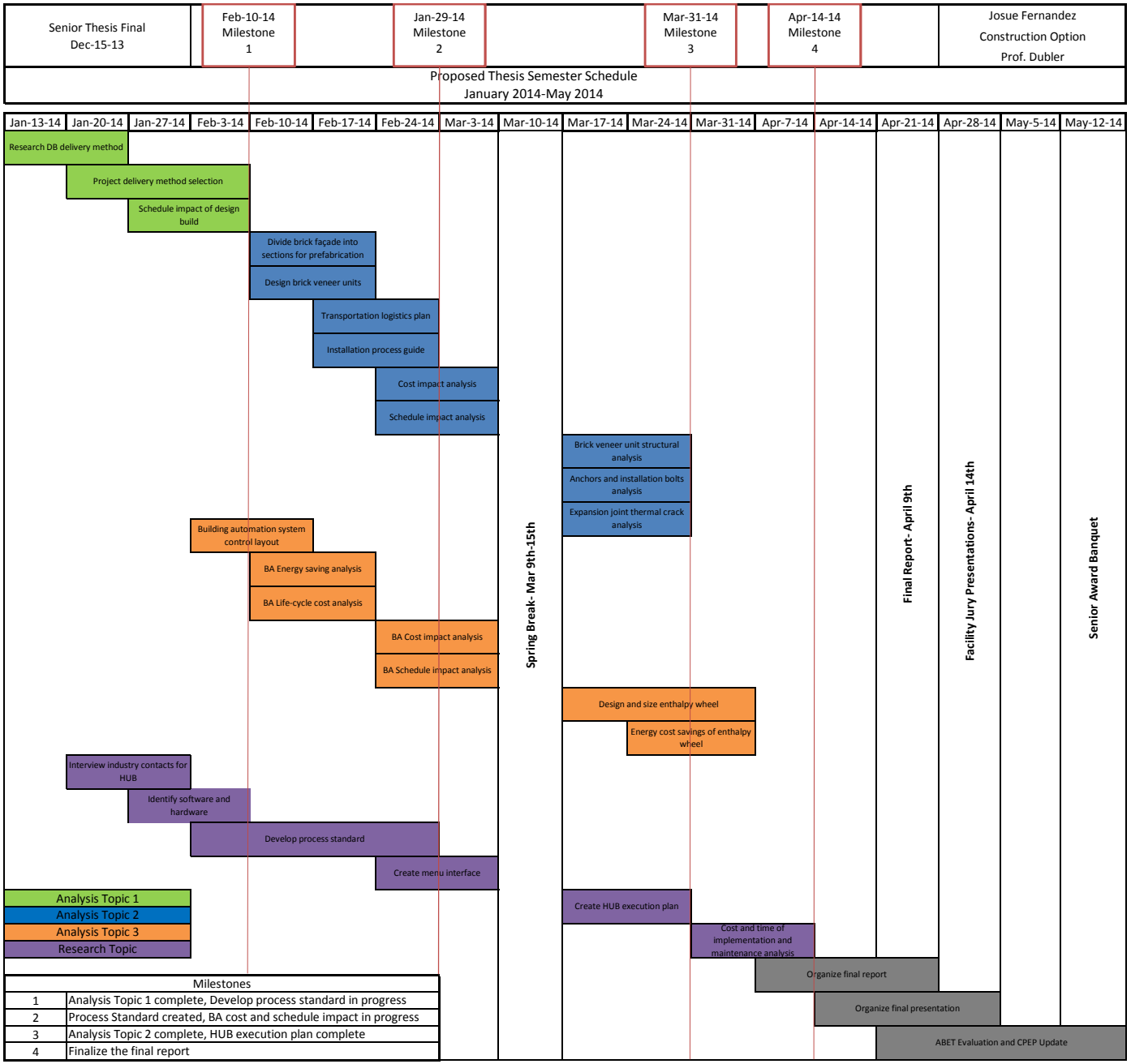
Demonstration of Breadths- Appendix I

Structural Breadth

To successfully analyze this prefabricated brick veneer, a structural analysis will need to be performed in order to ensure the unit can resists its own weight during transportation, during, and after installation. The anchors and installation bolts will need to be examined to meet the lateral wind forces required by code. Additionally the expansion joints will be examined to ensure the brick veneer does not crack or fail post installation.

Mechanical Breadth

The benefits of a heat recovery system will be validated. An efficient enthalpy wheel will be designed for the retail level of this facility. The building's energy cost savings with the addition of an enthalpy wheel will be examined.


Senior Thesis Final
Dec-15-13
Feb-10-14
Milestone
1
Jan-29-14
Milestone
2
Mar-31-14
Milestone
3
Apr-14-14
Milestone
4
Josue Fernandez
Construction Option
Prof. Dubler
Proposed Thesis Semester Schedule
January 2014-May 2014
Jan-13-14
Jan-20-14
Jan-27-14
Feb-3-14
Feb-10-14
Feb-17-14
Feb-24-14
Mar-3-14
Mar-10-14
Mar-17-14
Mar-24-14
Mar-31-14
Apr-7-14
Apr-14-14
Apr-21-14
Apr-28-14
May-5-14
May-12-14
Research DB delivery method
Project delivery method selection
Schedule impact of design build
Divide brick façade into sections for prefabrication
Design brick veneer units
Transportation logistics plan
Installation process guide
Cost impact analysis
Schedule impact analysis
Brick veneer unit structural analysis
Anchors and installation bolts analysis
Expansion joint thermal crack analysis
Building automation system control layout
BA Energy saving analysis
BA Life-cycle cost analysis
BA Cost impact analysis
BA Schedule impact analysis
Spring Break- Mar 9th-15th
Design and size enthalpy wheel
Energy cost savings of enthalpy wheel
Interview industry contacts for HUB
Identify software and hardware
Develop process standard
Create menu interface
Create HUB execution plan
Cost and time of implementation and maintenance analysis
Organize final report
Organize final presentation
ABET Evaluation and CPEP Update
Final Report- April 9th
Facility Jury Presentations- April 14th
Senior Award Banquet
Analysis Topic 1
Analysis Topic 2
Analysis Topic 3
Research Topic
Milestones
1 Analysis Topic 1 complete, Develop process standard in progress
2 Process Standard created, BA cost and schedule impact in progress
3 Analysis Topic 2 complete, HUB execution plan complete
4 Finalize the final report