Fort Pickett Regional Training Institute Phase II
Blackstone, VA

Senior Thesis Proposal

Figure 1: Site Aerial - Courtesy of Barton Malow

Submitted 12/9/11
Kendall Mahan
Construction Management
Advisor: Craig Dubler
Senior Thesis: AE 481W

Executive Summary

As construction on the Fort Pickett Regional Training Institute project remains underway, a number of problematic and critical areas along the schedule have surfaced. The design and construction of the billeting buildings have exposed areas of opportunity for further investigation and potential alterations. The intent of this Senior Thesis Proposal will be to address problematic schedule concerns through further coordination, alternative construction methods, and the introduction of new technologies. The Senior Thesis Proposal outlines four construction management related analyses for investigation, as well as two breadths within the structural and mechanical options, with the intention of addressing these potential setbacks and accelerating the schedule.

Analysis 1 looks into the feasibility of utilizing modularized bathroom units in opposition to constructing the bathrooms in the field. The bathrooms are the most work intensive areas within the buildings, which make the schedule incredibly dependent on their completion. In addition, the buildings feature identical floor layouts, which create repetitious units for construction, an ideal characteristic for modularization. Since the idea of modularization is relatively new within the construction industry, this will also be a focus for the critical industry issue. Analysis 2 investigates the effects of implementing short interval production schedules (SIPS) on the project, in order to deal with crew balancing, sequencing, and work flow concerns. By incorporating SIPS into the erection of the precast hollow-core planks, the problems associated with scheduling should be mitigated. Analysis 3 involves the substitution of traditional work in place construction of the CMU veneer for the use of precast exterior façade panels. In addition to examining the potential schedule benefits associated with the panel alternative, breadth research will be conducted to analyze the structural and mechanical implications tied to the change. Finally, Analysis 4 will look into the feasibility of employing material tracking technologies on the project. The technology has the potential to enhance coordination and lessen risk associated with the precast hollow-core planks, but it will have to be determined if these benefits outweigh the financial costs of the system.

By conducting thorough investigations of the previously stated analysis areas, the results can be determined to be practical or unpractical for employment on the project. Additionally, the topics serve as a benchmark for the construction industry and similar projects encompassing similar situations. The outcomes of the four analyses are expected to serve as solutions to lessen potentially problematic areas along the project schedule at the Fort Pickett Regional Training Institute and accelerate the overall project schedule.

Table of Contents

Project Background

On February 27, 2010, the Virginia Army National Guard contracted Barton Malow to construct and design three barracks totaling 116,400 SF at the Fort Pickett Regional Training Institute in Blackstone, VA. The $28M contract was awarded as an option upon successful completion of Phase I of the Regional Training Institute. The three billeting buildings are being constructed in order to replace the potentially dangerous housing constructed during the World War II era. In order to facilitate operations, the Army Corps of Engineers served as the owner's representative, a role that is responsible for overseeing day to day operations of the project. The project was bid as a Design-Build delivery system, making integration between Barton Malow's design and construction teams critical for success.

Upon near completion of Phase I of the project, which included an auditorium, administration building, and offices, Barton Malow was provided notice to proceed with Phase II of the project. The phasing of the two phases created a complex construction approach, but also contributed to the current success of the project by allowing the team to accelerate the schedule. The three billeting buildings, as seen in Fig. 2 below, are composed of two floors that feature identical floor layouts. This situation created a unique opportunity to phase the three buildings in order to weaken the potential learning curve on the project, which also aided towards reaching the desired turnover date. The barracks feature a simple floor plan, where a central corridor stretches the length of the buildings with rooms located along the two sides of the corridor. The project also features the incorporation of a few new, innovative construction techniques, such as a precast hollow-core plank floor system and a structurally insulated panel roofing system.

The project's repetitive construction nature, as well as its incorporation of prefabricated materials, created an innovative implementation strategy on the Regional Training Institute. Although most of the project team had little exposure to the practices attempted to be employed, the team excelled and is currently on pace to reach their January 13, 2012 turnover date.

Figure 2: RTI Campus Courtesy of Barton Malow

Analysis 1: Modularization of Bathroom Units

Problem Identification

Although the Fort Pickett Regional Training Institute features a simplistic design layout, the project was hindered by its ability to accelerate the construction of the bathroom units. The RTI's floor layouts feature a repetition of two bedrooms with a common bathroom, a design approach that minimizes the costly bathroom fixtures, as well as constrains the MEP work and tile finishes to a concentrated area. Although the design is favorable from a cost standpoint, the bathrooms remain a problematic area, due to their level of detail and work within such a limited area. The bathrooms consist of a built-in shower, toilet, tile finishes, and MEP conduit for the mentioned fixtures, as well as the sinks located on the common wall between the bedrooms and bathrooms.

Background Research Performed

The idea of modularization for construction purposes continues to gain momentum in the construction industry, although the practices remain relatively new. The billeting buildings feature bathrooms that utilize an identical design, making the situation ideal for modularization approaches. The ability to work on the project this summer has provided me with the opportunity to see the challenges encountered with the current design first hand. A constant problem faced by the project team was the amount of work involved with the construction of the bathrooms in comparison to the bedrooms. The rooms were able to be constructed with ease, leaving the completion of the bathrooms as the main schedule driver. Another great opportunity to further my background on the concept of modularization was the 2011 PACE Roundtable. Many of the industry professionals explained that it has the potential to greatly accelerate the schedule and boasted tremendous support for the idea. In addition, I had the opportunity to speak with Ted Border of Whiting-Turner Construction, a member of a team that had the opportunity to implement this technique on a project at Muhlenberg College in Allentown, PA. Whiting-Turner was given the task of erecting 5 buildings composed of 90 modules in 150 days. With such a significant schedule challenge, the only feasible alternative was prefabricated modules.

Due to the potential that modularized units possess for accelerating project schedules, modularized units will serve as the critical industry issue to be researched. Research will attempt to address how to deal with projects that possess unrealistic project schedules and activity durations. The goal of the research will be to weigh the impacts placed on a project when implementing the modularization of building units within tight windows. The study will serve as a benchmark for the construction industry and a tool for future considerations of using modularization on future projects.

Potential Solutions

With so much work encompassed in the bathrooms and so little space to perform the work, modularization appears to be an ideal solution, but there are a number of things to consider outside of the schedule. Modularization provides an opportunity to significantly cut into the project schedule, but it also typically comes with elevated construction costs. Modularization would result in improved quality, safety, labor costs, and construction times in a controlled environment, but there are also a number of introduced variables. It will be critical to investigate transportation strategies and restrictions, erection techniques, equipment costs, increased structural design, bracing, and sequencing. Additionally, further design considerations and coordination will need to be directed towards earlier stages of the project timeline, since the units will be attached to long lead-times. Upon completion of this analysis, there are a number of potential solutions that can be reached:

- It will be deemed feasible to utilize a modularization approach, including MEP work, fixtures, and finishes.
- It will be deemed feasible to prefabricate walls within the bathrooms and forgo the construction of the fixtures and finishes off-site.
- It will not be feasible to incorporate modularization and prefabrication techniques for the project.

Methodology

In order to properly investigate this technical analysis, the following steps must be performed:

- Perform research on the application of modularization within the construction industry.
- Adequately research the advantages and disadvantages of using modularized units.
- Conduct further conversations with Ted Border of Whiting-Turner to develop a better understanding of the strategies implemented and challenges faced in the field.
- Contact and possibly visit Ray Sowers of Oncore to investigate the manufacturing process associated with modular units in the shop.
- Derive an implementation strategy, including manufacturing, transportation, and erection, of the units.
- Determine the feasibility of utilizing modularized units on the Regional Training Institute.

Expected Outcome

Modularization has the ability to drastically cut into any project's schedule, so it is expected that the schedule will be greatly accelerated. Unfortunately, modularization comes with a number of introduced costs and challenges, so it will critical to deem if modularization is in the best interest of the project team. In addition, a 3D model was used for clash detection and prefabricating MEP racks in the corridor, so the manipulation of this model for modularization

should be come with limited cost elevations regarding modeling. It is expected that the project's schedule will be greatly accelerated and the cost savings associated with the project team's overhead will offset the introduced costs.

Analysis 2: Implementation of SIPS

Problem Identification

The Fort Pickett Regional Training Institute is composed of three billeting buildings, which creates an ideal opportunity for phasing, but a heightened concern for scheduling and crew balancing. With so many precast and prefabricated elements being utilized throughout the construction process, there must be greater coordination and planning to ensure that the schedule remains on pace. Although there are a number of critical activities, none play as an important of a factor as the precast-hollow core planks. Following the erection of the first floor's load bearing walls, the precast hollow-core planks are to be set, which makes the entire schedule dependent on a timely activity duration. Without the planks in place, the topping slab cannot be poured, the second floor's load bearing walls cannot be erected, and the building enclosure cannot start.

Background Research Performed

In order mitigate the scheduling and crew balancing problems with the precast hollow-core planks, I plan to implement short interval production scheduling (SIPS). SIPS take a project schedule and break the task into smaller and more detailed items, which can include crews, crew sizes, and durations. The SIPS are manufactured using input from the construction management team and responsible subcontractor's foremen, which creates a more accurate depiction of the time to be allotted for tasks. Utilizing SIPS has the potential to greatly increase coordination on the project by designating work areas and providing a better detailed schedule of work. This gives the workers a clear depiction of exactly where they are to be at any given part of the day, eliminating inefficiencies and stoppages in work. Because of the value added to project using SIPS, Hensel Phelps has taken advantage of every opportunity available to implement this scheduling technique, particularly building designs that feature repetitive sequences; these include prisons, dormitories, and hotels. They have successfully incorporated SIPS into a number of projects, specifically the Pentagon renovation project by shaving four years off of the total project schedule. Using my background with the use of SIPS within my coursework, as well as lectures from Hensel Phelps personnel, I believe that SIPS have the capability to greatly benefit the Fort Pickett project.

Potential Solutions

A Upon completion of this analysis, there are a number of potential solutions that can be reached:

- It will be deemed value adding and should be implemented in order to address concerns with crew balancing and scheduling, while accelerating the project schedule.
- It will be deemed value adding and should be implemented in order to address concerns with crew balancing and scheduling, but doesn't accelerate the project schedule.

- It will be deemed non-value adding and should not be implemented.

Methodology

In order to properly investigate this technical analysis, the following steps must be performed:

- Perform research on the implementation of SIPS, specifically case studies.
- Conduct interviews with employees within Hensel Phelps that have experience with the use of SIPS on past or current projects.
- Develop an implementation strategy for precast hollow-core planks on the Fort Pickett project with consideration to the current project schedule and manpower.
- Conduct a feasibility study and analyze the potential use of SIPS on the Fort Pickett Regional Training Institute project.

Expected Outcome

It is believed that the use of SIPS will accelerate the overall project schedule by creating greater coordination during the erection of the precast hollow-core planks. The incorporation of SIPS will generate greater coordination and a better sequencing strategy, while providing every project participant a greater understanding of what they are responsible for at any given time. Deviating from the SIPS can be troublesome, but using the input of all of the involved parties, accurate and feasible SIPS should be able to be manufactured to successfully expedite the project schedule and improve flow. As a result, the project will incur no additional costs, greater coordination, lessened risk, and greater flow.

Analysis 3: Precast Exterior Façade Panels

Problem Identification

The billeting buildings feature a simplistic building construction means with a limited amount of complex building systems. Although the building designs are not overly complicated, there are a number of items that strongly pertain to the success of the project along the critical path of the schedule, particularly the building enclosure. The veneer is made-up of precast concrete lintels, smooth-face CMU block, and split-face CMU block, which varies in size, color, texture, pattern, and mortar. Due to the magnitude of the work involved, constructing the curtain wall on-site presented a lengthy duration. The curtain wall was incredibly complex and was responsible for the start of construction of the interior trades, which made it a key concern for the project team.

Background Research Performed

To minimize the risk associated with completing the building enclosure in a timely manner, the use of precast panels will be investigated. Precast panels have the potential to significantly cut into the project schedule, but with this reduction also comes the introduction of a number of other variables. Manufacturing the panels off site will result in cheaper labor costs, a safer work environment, better working conditions, and higher productivity. The use of precast panels will also shift the mentality of the design team by forcing them to consider the building enclosure earlier in the design phases. The work will be shifted to a controlled environment and will be performed in an earlier phase of the project, so that the panels can be erected as soon as the billeting buildings' structures are completed. By simultaneously manufacturing the panels off site, it will significantly shorten the project's schedule. There are a number of potential drawbacks that must be considered as well. Typically, precast panels are more expensive than constructing a CMU wall veneer in the field, due to shipping costs, erection equipment, and other hidden costs. Outside of changing the variables associated with the enclosure, the panels will also affect the buildings' structures and mechanical properties. Using precast panels will alter the structural design of the billeting buildings by shifting load points and changing the dead load placed upon the load bearing walls. The operating costs and mechanical properties of the building will be altered by negatively or positively impact the buildings' operating performances. Combining experience obtained through my course loads, as well as speaking to a number of experts in the topic, such as Dr. Richard Behr, the use of precast panels should provide a more favorable alternative. Overall, there are a number of items that will need to be thoroughly investigated to conclude if the use of precast panels is more beneficial to the project in comparison to the traditional field constructed CMU enclosure.

Potential Solutions

A Upon completion of this analysis, there are a number of potential solutions that can be reached:

- It will deemed as a viable and advantageous alternative to the field constructed CMU veneers, in regards to the costs, schedule, quality, structural alterations, and mechanical changes associated with the use of precast panels.
- It will be deemed a lesser alternative to the field constructed CMU veneers, in regards to the costs, schedule, quality, structural alterations, and mechanical changes associated with the use of precast panels.

Methodology

In order to properly investigate this technical analysis, the following steps must be performed:

- Perform research and investigate the available precast panel alternatives.
- Conduct an interview with Dominic Argentieri of Davis Construction to further my understanding of available panels.
- Conduct an interview with Dr. Richard Behr in order to gain a better understanding of the impact various panels have on the building enclosure.
- Design the desired panel system for the buildings' enclosure.
- Conduct mechanical and structural analysis of the impacts the precast panels make on the buildings.
- Develop an implementation strategy, including manufacturing, transporting, and erection of the panels.
- Investigate the feasibility and effects generated from using the alternative precast panels on the Fort Pickett Regional Training Institute project.

Expected Outcome

By implementing precast exterior façade panels, it is believed that the Fort Pickett Regional Training Institute will be provided with a more beneficial building enclosure method. The panels will shorten the erection process, as well as the overall project schedule, but will result in higher costs. It is expected that the precast panels will cause the project to alter the structural system by increasing the metal stud sizes to incorporate a greater bearing load and ultimately increase the cost of the structural system. The buildings should benefit from the use of precast panels from an operating cost and energy standpoint, since most panels utilize greater insulation values.

Analysis 4: Integration of Material Tracking Technologies

Problem Identification

Although the use of precast hollow-core planks and structurally insulated roof panels have given the project team a great opportunity to accelerate the project schedule, they also carry a significant amount of risk. With the possible introduction of modularized rooms and precast façade panels, there is a significant amount of coordination and planning that needs to be allocated to the materials. Many of the material have long lead times, are manufactured off-site, and require careful planning for deliveries. With the use of such specialized building materials, it is absolutely critical that extreme planning and consideration goes into tracking materials. A missed delivery or misplacement of materials could result in a major project delay and potentially bring work to a standstill. Although the management of materials is critical for a number of items, the precast hollow-core planks hold the greatest potential to derail the project and bring construction to a hold. With so many activities dependent on the placement of the planks, it is dire that the materials arrive on-site as needed and in the correct specifications of the design.

Background Research Performed

In order to combat the chaos introduced with so many prefabricated and shop manufactured items, a material tracking system could be utilized. There are currently a number of software programs that are on the market, including LocateWare and Vela. Both programs involve a complex tracking system that range from the actual manufacturing of the product to the installation of the product on-site. Within the proposed material tracking technology is the use of radio frequency identification (RFID) tags on materials, so that the materials can be tracked easily. In order to utilize material tracking, it will require the manufacturers, subcontractors, and construction management team to buy-in to the system. The technology consists of material tracking software, scanners, and RFID tags, which range from high-end active tags to cheaper passive tags. The tags have the capability of storing information in regards to installation, delivery, storage, and warranties within the tags. In addition, the active tags have the ability to contain GPS and proximity tracking. Giant's Stadium was constructed using the aid of material tracking technologies for the precast concrete elements, which made the coordination and erection sequence remarkably efficient. The costs of the software, tags, scanners, and overhead required to implement the system must be investigated further, but the technology has the ability to enhance coordination and minimize the risk of not having the proper materials available on site.

Potential Solutions

A Upon completion of this analysis, there are a number of potential solutions that can be reached:

- It will be deemed beneficial to the project with the reduction of risk and potential schedule acceleration outweighing the costs associated with the material tracking technology.
- It will be deemed not beneficial to the project with the costs of the technology outweighing the potential risks of not having the proper materials on-site for construction.

Methodology

In order to properly investigate this technical analysis, the following steps must be performed:

- Perform research on the use of material tracking technologies, specifically case studies of projects that have incorporated the technology into the construction process.
- Conduct interviews with Skanska and other construction companies that have experience using RFID tracking systems.
- Develop an implementation strategy for the use of RFID tagging on the Fort Pickett project.
- Investigate the feasibility, as well as advantages and disadvantages, associated with utilizing material tracking technologies on the Fort Picket project, specifically impacts to the project's schedule, costs, and coordination.

Expected Outcome

The use of material tracking technology has the capability of significantly improving coordination on the project, but it also carries a somewhat expensive first-time cost. Although the technology is expensive, it is believed that the pros will outweigh the cons associated with the system. With a majority of the planks identical in design, the buildings will most likely only require the use of the cheaper passive tags, an alternative that will lessen some of the financial burden of incorporating the technology. A problem that's expected to be a concern is the problems tied into having all of the project participants' buy-in to the use of the system. Without full participation by all of the project players, the technology can be deemed as useless, so it will be an item that will need to be analyzed thoroughly.

Analysis Weight Matrix

The table, shown below in Fig. 3, illustrates the emphasis and amount of time that will be allocated towards each of the four proposed analyses during the course of the Spring 2011 semester. In addition, the table displays the amount of relevance each analysis exemplifies within the core areas of investigation required for this course, including critical issue research, value engineering, constructability review, and schedule acceleration.

Analysis Description	Critical Issue Research	Value Engineering	Constructability Review	Schedule Acceleration	Total
Modular Bathroom Units	5%	5%	10%	15%	**35%**
SIPS	10%			10%	**20%**
Precast Façade Panels	5%	5%	10%	10%	**30%**
Material Tracking Technology	10%			5%	**15%**
Total	**30%**	**10%**	**20%**	**40%**	**100%**

Fig. 3: Analysis Weight Matrix

The table demonstrates that the greatest focus will be placed on the modularized bathroom units and precast façade panels. Although the other two analysis topics will be thoroughly investigated, the greatest research will be dedicated to the modular and precast analysis areas, since they play the greatest role towards accelerating the project schedule, the main focus of my senior thesis. In accordance with the purpose of my analysis areas, the schedule acceleration category will be responsible for 40% of the research efforts.

Conclusions

The intent of the proposed senior thesis, as well as each of the four previously described analyses, are to focus on problematic scheduling concerns and address them with alternative construction methods, coordination tactics, and innovative technologies. Modularization continues to gain momentum and is viewed as a viable approach towards accelerating projects within tight time windows, but a number of new variables must be investigated to fully evaluate their worth within the construction industry. The implementation of short interval production schedules remains new to the industry, but their results appear to be incredibly advantageous from a coordination and scheduling standpoint. The turn towards precast and prefabricated products continues to display their worth from a scheduling perspective, but it remains to be known if these schedule savings outweigh the cost elevations. Material tracking, although previously associated with industrial manufacturing purposes, are making noise within the construction industry, but it must be investigated if it's worth carries over from the other fields. The results are expected to serve as a benchmark for the Fort Pickett Regional Training Institute, as well as similar projects encompassing similar situations. By examining the outlined analysis areas, the end results are hoped to better the construction industry by providing thorough investigations of the advantages and disadvantages associated with enacting the alternative strategies.

Appendix A

Breadth Topics and MAE Requirements

Breadth Topics

Structural Breadth (Contributes to Analysis #3)

The Fort Pickett Regional Training Institute project is comprised of three billeting buildings that utilize cold formed metal stud framed walls as the sole structure of the buildings. Currently, the enclosure consists of a CMU veneer that is supported by the load bearing walls. As mentioned in Analysis 3, in order to expedite the project schedule, the field constructed CMU veneer will be substituted for precast façade panels, which will ultimately result in a structural redesign. The precast panels will more than likely be heavier and place a greater load on the walls, which will result in redesign of the metal studs. It is expected that the studs will simply need to be increased in size, which would eliminate costly structural alternatives, such as a steel member structural system. In addition, since the buildings are for the Virginia Army National Guard, a blast analysis will be conducted. Using the aid of a structural option student within the Architectural Engineering department, a blast analysis will be performed on software that tests the durability of the proposed precast panels in comparison to the traditionally built veneer.

Mechanical Breadth (Contributes to Analysis #3)

In addition to analyzing the impacts the precast panels will make on the buildings' structures, the mechanical properties of the panels will be studied. The panels will be investigated to compare the effects that both systems make on the operating cost and lifecycle of the buildings. Precast panels have a number of different variations that incorporate differing resistance and protection values. Some panels even feature insulation built into the panels, which is expected to heighten the mechanical properties of the buildings. Veneers constructed in place typically demonstrate fairly high water penetration protection, so it will be a key concern to find a panel system that completely resists moisture and air penetration.

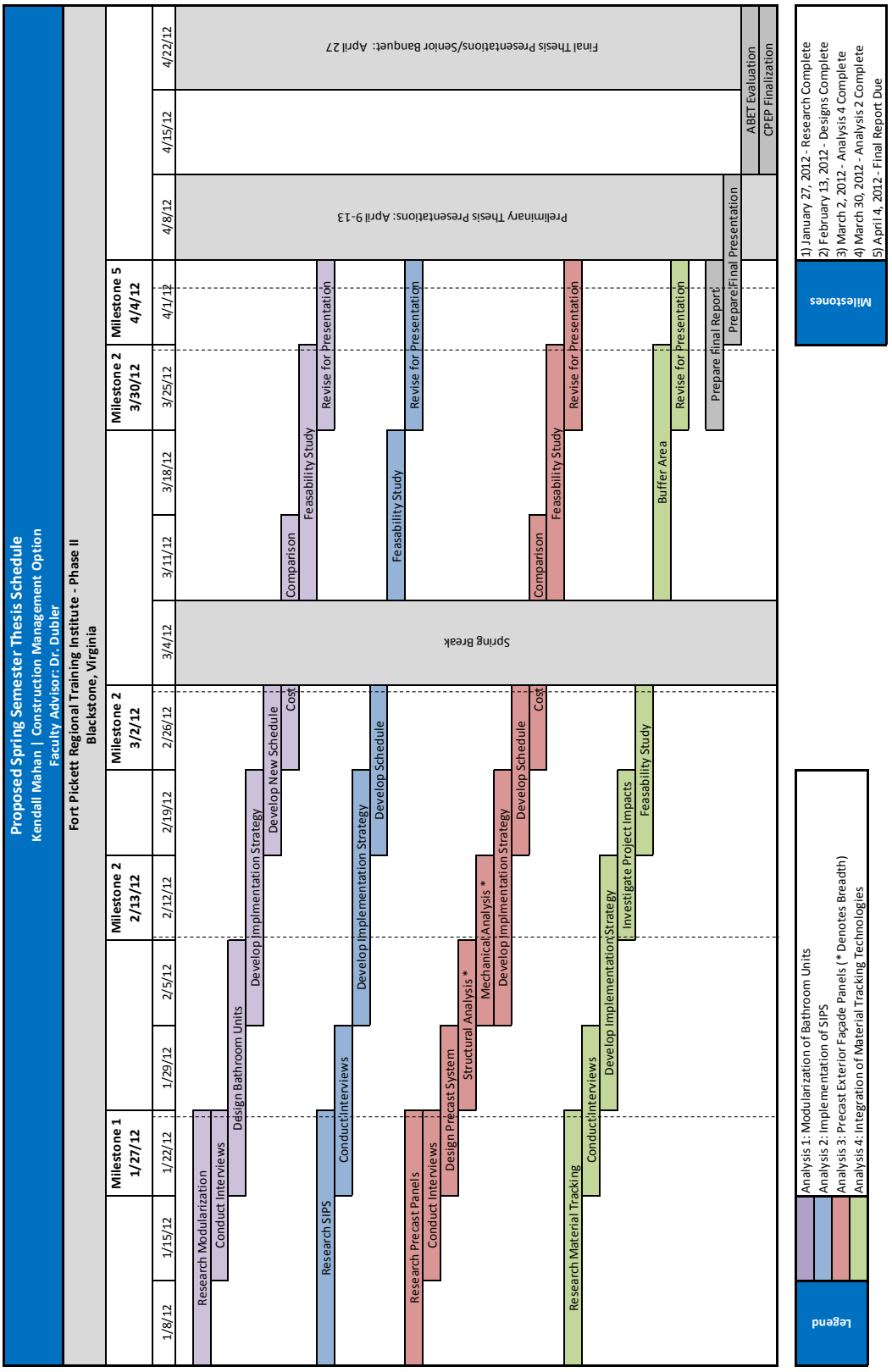
MAE Requirements

The information and knowledge acquired from a number of MAE 500 level courses will be applied throughout my senior thesis, particularly AE570 and AE572. The most relative and prominent course for my senior thesis intentions is AE570: Production Management. Within the structure of the class, SIPS were heavily investigated, which will be incredibly beneficial in the development of Analysis 2, the implementation of SIPS on the precast hollow-core planks. In addition, the class outlined a number of production techniques and sequencing strategies that have been proven to better the flow of construction on the job site. With a number of precast and prefabricated elements, it will be critical to manage the flow of work.

The second class that is intended to be incorporated into my senior thesis work is AE572: Project Delivery Methods. Although there is no intent to investigate delivery methods as an analysis study, the introduction of modularized rooms, precast panels, and material tracking software will force a shift in the mentality of the project participants in order to achieve proper coordination. The design of these long lead-time items will need to be addressed much earlier in the project's life, causing greater coordination within the current Design-Build delivery system. These impacts will not be key focal points within the areas of research, but the effects placed upon these changes will need to be considered and addressed.

Appendix B

Senior Thesis Timetable


Proposed Spring Semester Thesis Schedule
Kendall Mahan | Construction Management Option
Faculty Advisor: Dr. Dubler
Fort Pickett Regional Training Institute - Phase II
Blackstone, Virginia
Milestone 1 1/27/12
Milestone 2 2/13/12
Milestone 2 3/2/12
Milestone 2 3/30/12
Milestone 5 4/4/12
1/8/12
1/15/12
1/22/12
1/29/12
2/5/12
2/12/12
2/19/12
2/26/12
3/4/12
3/11/12
3/18/12
3/25/12
4/1/12
4/8/12
4/15/12
4/22/12
Spring Break
Research Modularization
Conduct Interviews
Design Bathroom Units
Develop Implementation Strategy
Develop New Schedule
Cost
Research SIPS
Conduct Interviews
Develop Implementation Strategy
Develop Schedule
Research Precast Panels
Conduct Interviews
Design Precast System
Structural Analysis *
Mechanical Analysis *
Develop Implementation Strategy
Develop Schedule
Cost
Research Material Tracking
Conduct Interviews
Develop Implementation Strategy
Investigate Project Impacts
Feasability Study
Comparison
Feasability Study
Revise for Presentation
Feasability Study
Revise for Presentation
Comparison
Feasability Study
Revise for Presentation
Buffer Area
Revise for Presentation
Prepare final Report
Prepare Final Presentation
Preliminary Thesis Presentations: April 9-13
ABET Evaluation
CPEP Finalization
Final Thesis Presentations/Senior Banquet: April 27
Legend
Analysis 1: Modularization of Bathroom Units
Analysis 2: Implementation of SIPS
Analysis 3: Precast Exterior Façade Panels (* Denotes Breadth)
Analysis 4: Integration of Material Tracking Technologies
Milestones
1) January 27, 2012 - Research Complete
2) February 13, 2012 - Designs Complete
3) March 2, 2012 - Analysis 4 Complete
4) March 30, 2012 - Analysis 2 Complete
5) April 4, 2012 - Final Report Due