Bradley Williams
Construction Option
1/30/2014
Advisor: Ed Gannon

Thesis Project Proposal for Spring 2014

Taylor Hall – George Mason University

Photo Courtesy of Gensler

Table of Contents

Executive Summary

This document serves as a proposal of the research work that is to be completed during the Spring 2014 semester and serves as a contract with the Architectural Engineering faculty of Pennsylvania State University. Four construction related analyses will be conducted on Taylor Hall, a 70,000 SF dormitory housing 295 freshmen students at George Mason University in Fairfax, VA. In addition to the depth analyses, two non-construction related breadth analyses will investigate further issues with a related depth.

The first analysis pertains to the addition of a green roof above a multi-purpose room on the first floor of the dorm. Since GMU is making a large stride towards sustainability and educating its students in such practices, the green roof was an important feature of the building to the owner. Because of budget restraints, the green roof was the first item to be removed from the building. Research will be done to see how expensive a green roof addition would be and how the installation of the system would affect the critical path of construction. A structural breadth would be done to investigate if the current structural system would allow such an installation and what would be needed for added reinforcement if it doesn't.

The current structural system in place uses prefabricated load bearing cold-formed stud walls and is said to be a quicker alternative compared to a concrete structural system. Since this system is typically intended for larger buildings and has been causing issues with permit approval, the novel idea of stick-built framing will be analyzed for application as Taylor Hall's structural system. This will involve schedule and cost analysis in a comparison of the systems.

Since the building's façade lays on the critical path and Taylor Hall is a schedule driven project, the installation sequence of the façade system will be analyzed for constructability. By taking into account resource allocation, vertical installation in a section as opposed to horizontal, and site constraints, a more efficient sequence of installation can be determined. This will help protect the critical path of the project and insure that it is completed in a timely manner.

Lastly, the critical industry issue of “Prevention through Design” will be researched and applied to Taylor Hall. This is especially important due to its practicality it this particular application and the fact that students are accessing the job site weekly for tours. The idea of raising sill heights to reduce the risk of fall hazards will be put into place and the itinerary of student tours will be analyzed and re-designed accordingly. In addition to the research done on fall prevention through design, an architectural breadth will be completed to determine the feasibility of the new design with GMU and BCOM standards and its constructability.

To finalize the report is a short conclusion outlining the work that will be completed in the next semester. Attached is a schedule of when each analysis will be completed along with an assigned grading weight based on the complexity of each topic.

Ultimately, each topic works towards achieving the goals of the owner and will create ideas that may be used on future campus projects and dormitories. Those goals being:

- Increase the awareness for sustainable design and ideas
- Reduce the cost of construction while maintain quality
- Reduce the risk of schedule delay during construction
- Reduce the risk of injury for construction workers, future students, and maintenance personnel

Technical Analyses

Green Roof Addition

Taylor Hall, being a green building and an educational opportunity to teach freshman about sustainability, was originally intended to include a green roof above a first floor multi-purpose room. It is important to the owner that George Mason University strives towards a green future with its buildings, but after the building was set to be over budget, it was the first item to be eliminated.

Green roofs provide several benefits to the building, including water run-off elimination, reduction of glare into the above rooms, and insulation properties for the space below it. For this building in particular, the green roof provides a learning opportunity for the students who reside inside it. After learning from the design-builder that it was removed from the original design, it provided an opportunity to investigate how adding the green roof would affect the bottom line of the project.

The addition of the green roof over the multi-purpose room would be analyzed for cost and schedule implications by completing a detailed estimate and schedule of installation. Information would be pulled from literature sources as well as interviews with Balfour Beatty Construction team members who have experience with green roof installation.

In addition to the aforementioned analyses, a breadth topic analysis will investigate the current structural components supporting the roof to see if it can adequately support a green roof system without further reinforcement. This will be discussed further in the Appendix.

Expected outcomes from this analysis are that the green roof can be completed without affecting the critical path of Taylor Hall and will create the educational and sustainable environment desired by the owner. This will, however, come with a price which may or may not be offset pending the results of the technical analysis topic.

Stick-Built Framing vs. Infinity Structural System

One of the original value engineering ideas implemented on the project was the replacement of the concrete structural system with an Infinity Structural System. The Infinity Structural System is comprised of load bearing, cold formed metal stud walls that are prefabricated off site and installed at a relatively quick rate. These walls support a special metal deck that has more surface area for load bearing and a standard concrete slab to top off each elevation.

Through an interview with specialty sub-contractor, Miller & Long, the Infinity Structural System can be set in place at a rate nearly three times faster than a concrete structural system. A secondary interview with a Balfour Beatty Construction superintendant conversely stated that it actually causes more problems than it solves and that it takes roughly the same time as a concrete system.

The owner is partial to the Infinity Structural System due to its recent application and success on another campus project nearing completion, but given the scale of application, it may not have been the best choice for Taylor Hall. Furthermore, because of its complex design, the system is causing critical delays as permit approvals are log jamming further construction.

A popular topic in the DC metropolitan area, and another value engineering proposal for Taylor Hall, included the use of a prefabricated wood framing structural system, commonly referred to as "stick-built" construction. This system is primarily used for residential applications and buildings not exceeding 5 stories in height, nominating Taylor Hall as a perfect use of this system.

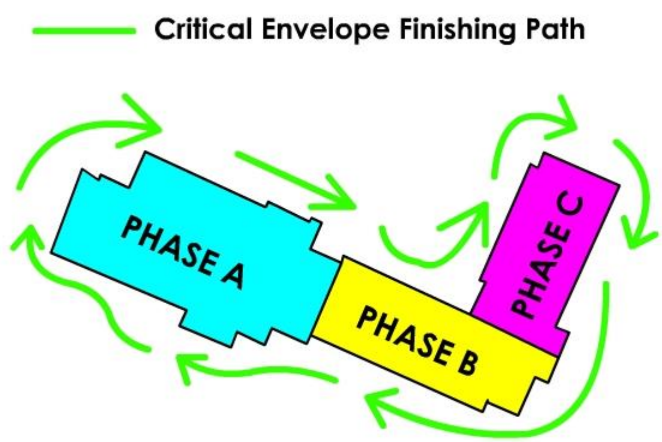
Since the system is prefabricated similarly to the Infinity Structural System, but does not included concrete pours on decks, the schedule reduction characteristics of stick-built construction will be analyzed. Secondly, the cost of the stick-built system will be compared to the current system. These will be done by completing a cost estimate of system replacement and gathering scheduling data via interviews from specialty sub-contractors currently using stick-built construction methods. For more information on the concerns of using stick-built construction, Benchmark Construction will be contacted as recommended by Professor Rob Leicht. A cost and schedule comparison will be presented to conclude the analysis.

Based on research already completed, the benefits of the stick-built structural system are predicted to outweigh the benefits of the Infinity Structural System, especially when considering its application. These benefits will be primarily in schedule reduction rather than cost since it is still prefabricated.

Façade Installation Sequencing and Constructability Analysis

Since Taylor Hall is a schedule driven project, and the building dry-in date lies on the critical path, the façade of the building must be installed as quickly as possible. Currently, the façade system is installed in a clockwise, rotation about the building beginning with the north-west corner of the building. Initial brick lying begins horizontally along a section of the building based on the below graphic and then further up the façade of that particular section. Starting with scaffolding erection and ending with brick installation, the façade system's schedule is critical to the completion of the building.

Figure 1. Phase and Flow Diagram



After analyzing the project schedule, it appears there may be an area for improvement when it comes to the sequence that the façade is installed. A potential solution to the schedule would be starting on a more critical corner of the building where site constraints may cause delays further in construction of the façade. Vertical installation, as opposed to horizontal installation within a building section, and resource allocation are also a concern when looking into the sequencing of the façade.

This analysis will look into how re-sequencing the façade's installation will ultimately reduce the constructability concerns of the project team. Concerns of weather implications, resource allocation, safety, and complexity of installation will be investigated. Data will be collected from various literary resources and interviews conducted with project team members. After re-sequencing, a new detailed schedule will be generated and compared to the current system in place.

Upon completion of the analysis, the new façade installation sequence is believed provide a safer and more constructible option compared to the current sequence being used. Furthermore, it will eliminate possibly unforeseen issues involving site constrains and resource allocation and delivery.

Prevention through Design (Critical Industry Research)

After the attendance of the PACE Roundtable break-out session in early November, titled Prevention through Design, it was decided that it was particularly necessary for Taylor Hall to incorporate this emerging industry topic. Prevention through design, or PTD, is safety conscience design incorporated into the project to protect workers during the construction phase, the inhabitants of the building, and the facility maintenance personnel who will need to access controls of the building.

From the roundtable discussion, the main problem preventing this topic from being included in every project's contract is as follows: Prevention through design is not commonly incorporated into many projects primarily due to the insufficiency in knowledge of safety related issues from a design professional's prospective and the lack of involvement of construction team and facility managers in the design phase of a project.

Taylor Hall is a perfect application of PTD for several reasons. Since Taylor Hall utilizes a Design-Build delivery system and GMU has a department of facility maintenance in place already, the design of the building can be altered to suit their needs for safety. Secondly, it is particularly of importance for George Mason University to have a safe job site due to weekly tours given to students and knowing that the dorm will house freshman students, who may not be in the most responsible age group when it comes to concern for safety.

The goal of incorporating PTD in Taylor Hall is to create a safer environment for construction workers, future students, and maintenance personnel. This will be done by researching the affects of raising sill heights to 48" wherever possible and analyzing the total amount of risk that is reduced by using this simple safety conscience solution.

To analyze this particular idea, fall statistics will be obtained from OSHA literature and site tour information will be gathered from Balfour Beatty Construction team member interviews. (A sample of interview questions is contained in the Appendix.) Based on how many students are entering the job site and the rate of falls, a percentage of falling risk can be calculated. Secondly, a new tour itinerary can be created to reduce students' exposure to ledges without permanent safety features installed during site visits. Together, these safety improvements will be summarized in a report that can potentially be used to in future GMU dorm construction projects.

With this research topic comes the addition of an architectural breadth to see how the new safety features will affect the appearance of the building. This is detailed further in the Appendix.

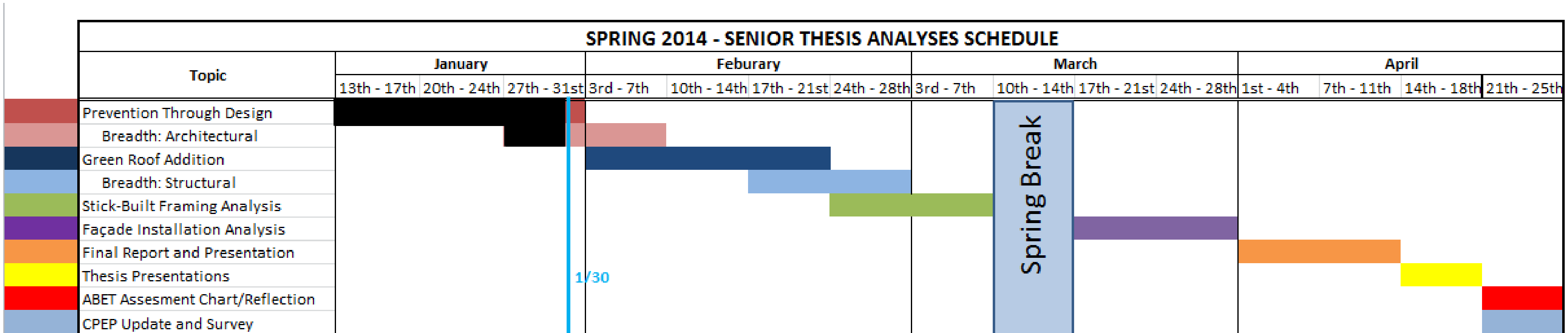
Conclusion

Through the four analyses mentioned in this paper, it is believed that George Mason University will have better building in place through value-added decisions, safer construction practices and design, and more constructible options for installation of critical path items. This will help ensure the owner's continued investment of interest in hiring Balfour Beatty Construction as a Design-Builder of construction manager for their projects on campus.

The above analyses and later mentioned breadth analyses will be accomplished over the course of the Spring 2014 semester and weighted based on the complexity of research and time involved in completion of each. Below is an outline and schedule of when the analyses will be completed and how they are to be weighted.

Overview of Grading Weights

Analysis (***Including Breadth***)	**Percentage of grade**	**Start Date**	**Completion Date**
Green Roof Addition *Structural Breadth*	25%	2-3-2014	2-19-2014
Stick-Built Framing Comparison	25%	2-24-2014	3-7-2014
Façade Installation Sequence and Constructability Analysis	15%	3-18-2014	3-29-2014
Prevention through Design *Architectural Breadth*	35%	1-13-2014	1-31-2014



Name: Brad Williams
Project: Taylor Hall - GMU
Advisor: Ed Gannon
Option: Construction
Date: 1/21

Submittal Schedule

Prevention Through Design	7-Feb
Breadth: Architectural	7-Feb
Green Roof Addition	21-Feb
Breadth: Structural	28-Feb
Stick-Built Framing Analysis	7-Mar
Façade Installation Analysis	28-Mar
Final Report and Presentation	11-Apr
Thesis Presentations	16-Apr
ABET Assesment Chart/Reflection	25-Apr
CPEP Update and Survey	25-Apr

Appendix

Breadth Topics

Structural: Multi-purpose Room Structural Analysis for Green Roof Application

Within the depth analysis looking into the addition of a green roof, a breadth topic will analyze the structural integrity of the roof below it. This will specifically show whether the current structural system in the roof of the first floor multi-purpose room (K-series joists) is capable of supporting the future addition of a green roof without further reinforcement. An investigation to metal decking, beam sizing and footing sizing will also be conducted as necessary. Existing structural members, including columns and footings, will be resized if they are deemed inadequate for the new load. If further structural reinforcement is required, the spacing of the joists, columns, and footings will be altered. If changes are to be made based on my investigation, a cost analysis of structural system upgrades will be calculated so that the desired green roof can be applied.

This analysis will be done by accessing notes from AE 404, CE397 and by performing a simple structural analysis of the system in place with the new dead loads of the vegetation. Using beam tables for K-series joists and RS Means, new reinforcement can be sized and priced to meet the necessary load requirements. Concluding the investigation, a report of any structural changes will be presented along with any associated cost changes.

Architectural: Altering Sill Heights for the incorporation of Prevention through Design

In order to decrease the risk of falls for workers and future maintenance staff, the mechanical equipment access points throughout the building and in the mechanical room will be analyzed. Considering factors such as access height, the use of a ladder in a high traffic area, and ease of access in general, high risk locations will be investigated and new solutions for relocation will be proposed. To be considered for relocation, access points must be greater than 8 feet above the finished floor level since anything greater will require a ladder. Access points in the entrance and common areas will also be considered due to their proximity to high volumes of moving students. Having easily accessible maintenance locations for mechanical equipment will greatly relieve pressure on George Mason University staff and further influence Prevention through Design. The findings of this investigation, along with any mechanical access modifications (marked on drawings), will be presented in a report.

Interview Questions Draft for Prevention through Design:

Balfour Beatty Construction – Assistant Project Manager

(1) Q: What current fall risks do you see with the design of Taylor Hall?

(2) Q: What fall protection methods are being applied to the façade of Taylor Hall during construction?

(3) Q: How many students are accessing the site during a given week?

(4) Q: How many construction workers access a standard dorm room during the course of a week?

(5) Q: What path do you typically take students into the building when giving tours?

(6) Q: How close do students typically get to a wall surface or ledge during the tours? OR Rate students fall exposure on a scale of 1 to 10 during a typical tour.