Steidle Building Renewal Project


Rendering courtesy of Mascaro Construction Company

Thesis Proposal

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Construction Option

EYP/

mascaro construction . . . build with the best

PennState

Executive Summary

For this proposal, three areas were identified for critical analysis where alternative solutions could be implemented to add value to the project through cost savings, schedule reductions, increased project quality, and increased team communication. In addition to these three analyses, an industry research topic was also selected for evaluation of its implementation on this project.

Analysis 1: Resequencing the Stairwells

Prioritizing the stairwell erection would lessen the need for rented scaffold systems, as well as possibly reducing the critical path. Furthermore, erecting the stairwells before MEP work starts would allow for the adjacent mechanical shafts to be prefabricated as the stairwells could provide the necessary support for installation. Resequencing the stairwells can lead to schedule savings on the critical path time and cost savings from reducing the scaffold rental period and prefabricating the adjacent mechanical shafts.

Analysis 2: Prefabricating the South Façade

The South Façade of the Steidle Building contains repeated elements that make it very amenable to being prefabricated. Primarily, this entails designing and fabricating the columns as an assembly that would then be tied into the original structure. Prefabricating the columns can result in a higher quality product as well as cost savings through a reduction in on-site erection time.

Analysis 3: Evaluating the BIM Process Models

Part of the delivery of this project involved implementing the use of BIM in a variety of ways. This analysis seeks to evaluate the Level 1 process map and key Level 2 maps for improvements to the communication and collaboration of the project team members

Industry Research Topic: Best-Value Analysis for Subcontractor Selection

A trend in the construction industry has been shifting away from the lowest-bidding subcontractors to those that offer the best value overall. The process behind determining value for the owner and evaluating subcontractors based on those values over different project delivery methods will be researched.

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Project Background

The Steidle Building Renewal Project is a combined renovation and new construction building. It is a mixed-use facility that will house classrooms, offices and laboratories for the Department of Materials Science and Engineering at The Pennsylvania State University. The building itself is approximately 100,000 square feet over 5 stories (including the mechanical penthouse). Construction is expected to go from June 2014 to June 2016 and is budgeted for $52 million.

In addition to Penn State, there are two other key project stakeholders. The first is the architects for the project, EYP Architects and Engineers. The second is the construction managers, Mascaro Construction Company. All three parties were involved in the early stages of Pre-construction to design, budget, schedule and plan out the project. The project itself is being delivered using a Construction Manager at Risk approach while bidding out the subcontracts as lump sum contracts. However, the project team still maintains a high level of collaboration and coordination through the use of Building Information Modeling (BIM) technologies, Pre-Installation Conferences and bimonthly Owner-Architect-Contractor meetings.

This project was broken up into three phases. The first phase was Demolition. During this phase, the original central wing of the building was wholly removed while the interior systems, like the ductwork or wall partitions, were torn out to prepare for the renovation. The second phase was Structural Work. During this phase, the concrete structure of the central wing was installed, starting with the new micro-pile foundation. Also during this phase, work commences in the existing building on the interior systems. The third phase was Interior Installations. During this phase, interior work is conducted throughout the whole building. Also during this phase, the South Façade is constructed and the existing brick is refurbished.

Analysis 1: Vertical Transportation Systems

Problem Statement

One of the scheduling issues that arose on this project was the erection of the stairwells. The way that the schedule was originally sequenced meant that the stairs would not be fully built and open for use until about midway through the Interiors phase of the project. While this wasn't necessarily a problem for the overall construction process, it did result in additional costs from having to rent the scaffolding stairs for the extended period.

Proposed Solutions

The first alternative addressed in this analysis will be to reschedule the erection of the stairwells while offsetting the potential costs of doing so through other sources of reducing costs. Specifically, the schedule shall be resequenced so that the stairwells are erected during the Structural phase instead of during the Interiors phase. One of the sources of savings is from the reduced rental period of the scaffold stairs. By erecting the stairwells sooner, the scaffolds can then be removed from the site while people utilize the stairs that are a part of the building. Another potential source is from prefabricating the mechanical shafts next to each of the stairwells (shown at left). If the stairwells are built before work starts on the vertical MEP elements, then the added structural support from the stairwells allow for the shafts to be prefabricated and then lifted into place with a crane. This could not only reduce costs but also improve the quality of the installed MEP elements.

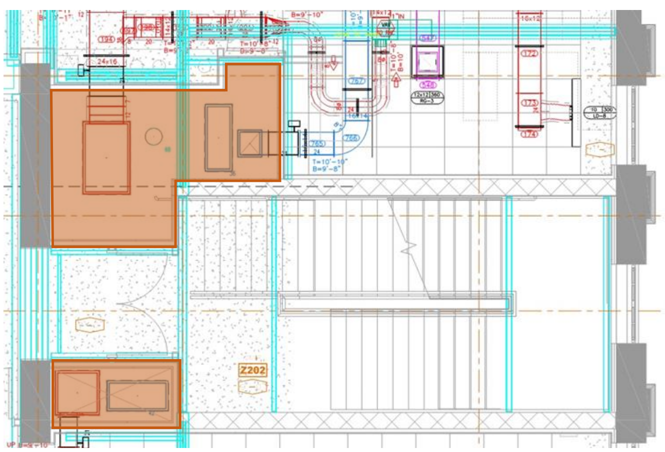


Figure 1: Locations of the MEP Shafts (highlighted in red) next to the East Stairwell

The second alternative addressed will be to reschedule the installation of the building's elevator and evaluating whether or not the acceleration costs are outweighed by the reduced costs stemming from having the elevator available at a sooner time. This includes not only eliminating one of the rented scaffold stairs but also eliminating the need for a boom lift to deliver materials to the different floors. The elevator prescribed for the building is able to handle loads up to 4000 pounds in order to allow the Department of Materials Science and Engineering to move equipment between floors. However, this also means that if the elevator were to be operational and certified earlier during construction, then it could be used to deliver materials and equipment to each of the floors. This would replace the need for lifts or a crane on site for the majority of the Interiors phase of the project, aside from larger building elements like the Air Handling Units. Additionally, as with the resequencing of the stairwells, if resequencing the elevator installation activities can shorten the time of the critical path, then the costs of renting items like the site trailers or fencing can be reduced.

Analysis Method

1. Review the original schedule, focusing on the relationships between activities that either precede or follow erecting the stairwell
2. Interview the project manager and superintendent to obtain relevant information on the stairwell erection process, including:
   a) Steel crew productivity rates and associated costs
   b) Elevator installation rates and
   c) Scaffold stair rental rates
   d) MEP prefabrication costs
   e) Lift and crane rental rates
3. Develop two initial resequenced schedules based on the two proposed solutions
4. Obtain feedback from the project team
5. Develop the final resequenced schedules and perform the cost analyses
6. Compile findings into final report

Expected Outcome

The resequenced stairwell schedule will be the most cost effective measure compared to the original schedule or resequencing the elevator activities. The same level of quality desired by the project team will be provided by both alternatives. There will be costs associated with accelerating the manufacturing of the stairwell steel or the elevator, but those costs will be more than accounted for by the savings from the reduced scaffold rental period, the use of the prefabricated MEP shafts, or the reduced crane rental periods.

Analysis 2: Prefabricating the South Façade

Problem Statement

Another issue that provides an opportunity for prefabrication is the installation of the limestone façade on the south side of the building (shown at right). Limestone is a heavy, expensive material that is typical installed by hand in relatively small pieces compared to the overall assembly. This results in a lengthy installation time which delays the point at which the building becomes dried-in. A system needs to be developed that can reduce the amount of time spent on site installing the façade.

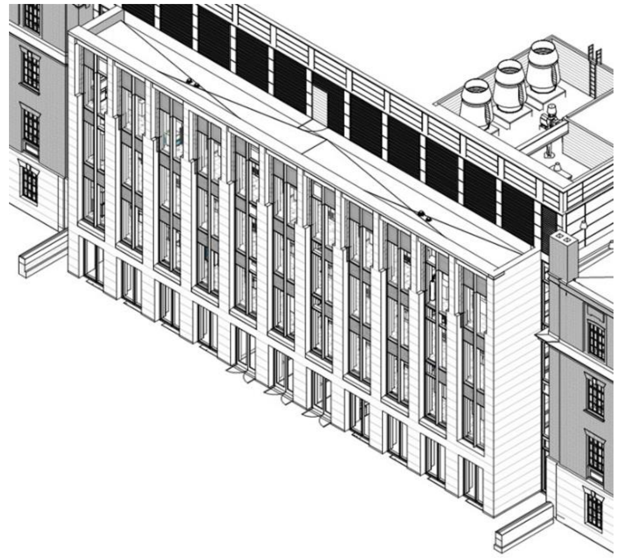


Figure 2 - The South Facade of the Steidle Building

Proposed Solution

The objective of this analysis will be to propose a prefabricated column design that maintains the architectural integrity of the original design while saving on-site time, reducing costs and increasing the quality of the assembly. There will be several potential designs that will be analyzed based on two different design aspects. The first aspect will be using either an entirely prefabricated column, while the second will use two columns split between the second and third floors. The second aspect will be utilizing different materials for the façade: not just using limestone as originally planned, but also replacing the limestone with materials like painted precast concrete or sandstone. All of the different column designs will be analyzed to see which is the most economical. Additionally, the different column designs will be evaluated based on structural connection, life-cycle durability, thermal conductivity and moisture penetration requirements (see Appendix A for details).

Analysis Method

1. Research industry capabilities for prefabricated stone façades or precast concrete façades
2. Analyze the original façade design to determine how the columns perform structurally and how the façade itself is supported
3. Develop the initial prefabricated designs, including the structural connections
4. Obtain feedback from the project team about the designs and their impact to the project

5. Develop the final prefabricated designs based off of the project team’s input
6. Perform a schedule, cost, thermal conductivity and moisture penetration analysis of all of the designs using the previously researched information
7. Propose one of the prefabricated column designs as an alternative to the current façade design in the final report.

Expected Outcome

Of the developed designs, the bisected columns using limestone will most likely be the selected choice. Penn State is usually very particular about using limestone for their buildings, so using precast concrete may be a very tough option to convince Penn State to accept. Given how heavy limestone is, the columns will need to be split in two in order to limit the impact of the increased weight on items like transportation or crane size. That said, using the prefabricated columns will still be cheaper than the traditionally-installed façade originally designed.

Analysis 3: Researching Alternative 3D Coordination Methods

Problem Statement

On this project, BIM has been a very integral part from the start. One of the biggest areas in which it is being utilized is for 3D Coordination purposes (e.g., Clash Detection). However, there were still problems on this project relating to it. Communication at the start of preconstruction was not very well established and as such the project went out to bid with about 40,000 clashes unresolved in the BIM model. The BIM Execution Plan needs to better define communication and collaboration practices within its process models, especially when addressing 3D coordination.

Proposed Solution

Research will be conducted into previously used 3D Coordination practices on building projects. An emphasis will be given to Penn State projects on which BIM was deemed to have been successfully used. Based on the researched information, the existing BIM Process Design will be analyzed and modified to promote interactions directly between EYP and Mascaro Construction without necessitating constant involvement from Penn State as an intermediary. Furthermore, the process for 3D Coordination will be better imbedded into the design process. These changes will reflect the highly collaborative environment that developed as the project progressed, but will attempt to promote that environment at the onset of the project.

Analysis Method

1. Research methods for implementing 3D Coordination activities on a BIM-integrated project, especially those used on Penn State
2. Evaluate the original process designs to determine where communications breakdowns could have potentially occurred
3. Interview various members of the project team, especially those that worked directly with BIM, to refine the areas where communication needed to have been better
4. Adjust the Level 1 process design and Level 2 process for 3D Coordination to incorporate improvements to project communications where deficiencies were identified
5. Propose final adjusted process design as part of the final report

Expected Outcome

Adjusting the BIM Execution Plan to incorporate more interactivity will help to improve the Design Review and 3D Coordination processes. This includes additional preconstruction meetings between EYP and Mascaro and a streamlined review process for resolving clashes. It will result in more direct communication between the architect and construction manager, easing the burden on Penn State. This will also help to reduce costs in the long run as project team members won't have to spend as much time with the BIM model trying to resolve clashes during construction.

Industry Research Topic: Best-Value Analysis for Subcontractor Selection

Background Information

When selecting a subcontractor based on who has the lowest bid, there are several issues that could crop up during construction. For starters, the cheapest contractor at bid isn't necessarily the cheapest contractor overall (i.e. claims contractors). Furthermore, a contractor bidding the project may not be able to perform the required work due to insufficient capital or experience, and even if the contractor is affordable and competent they might be nearly impossible to work with. Therefore, owners are shifting their focus from choosing the lowest bidder to determining which contractors offer the best value for their price. So if an owner wants to find the best-value contractor, what methods and processes exist or are being developed that can help determine the most "valuable" contractor?

Research Focus

There are many different aspects to evaluating contractors based on best-value, so this research will focus on the selection criteria specific to Penn State's Office of Physical Plant (OPP). Furthermore, the focus will be narrowed to looking only at MEP contractors. On the other hand, OPP is often involved in a variety of projects with differing project delivery methods. As such, the criteria for projects being delivered with the CM at Risk, Design Assist, and Integrated Project Delivery methods will be different for MEP contractors. These difference will be incorporated into the research.

Research Process

1. Perform initial research into Best-Value Analysis (NOTE: may not be specific to construction contracting)
2. Develop an initial questionnaire to determine what "value" OPP and their contracted construction managers look for in subcontractors
3. Conduct 3 to 4 interviews with OPP personnel to gain feedback on the questionnaire's content
4. Redevelop the questionnaire based on the obtained feedback
5. Distribute the questionnaire to approximately 30 members of OPP's staff involved with subcontractor selection
6. Collect and interpret the data.
7. Select and propose the Best-Value criteria that ought to

Conclusions

These three analyses and the industry research topic offer solutions that can add significant value to the Steidle Building Renewal Project. They potentially add value to the project through reducing costs, saving schedule time, increasing quality and improving team communication.

The first analysis evaluates the resequencing the stairwells. The second analysis involves different systems for a prefabricated façade. The third analysis evaluates the communication between project team members in relation to the 3D Coordination activity within the BIM Execution Plan. The industry research topic seeks to develop a set of best-value criteria for OPP to use when analyzing MEP subcontractors.

All of these sections deal with various elements of pre-planning. The first two focus on prefabrication opportunities and the necessary planning elements therein. The other two focus on pre-construction planning activities that can help save the project team time and money in the long term and on subsequent projects.

Appendix A: Breadth Analysis Topics

Along with the aforementioned depth analyses, there will be two additional breadth analyses. One is a structural breadth and the other is a mechanical breadth. Both will be done in conjunction with the analysis of the prefabricated façade.

Structural

The structural breadth for this proposal will be to analyze the structural connections of both the limestone and precast concrete prefabricated columns. This includes and anchors, relieving angles and/or lintels. As changes are made to the materials of the faces, their structural connection requirements will also change. The existing connections will be evaluated to see if they can handle the change in loading. If not, then a different connection system will need to be included with the proposed prefabricated wall design.

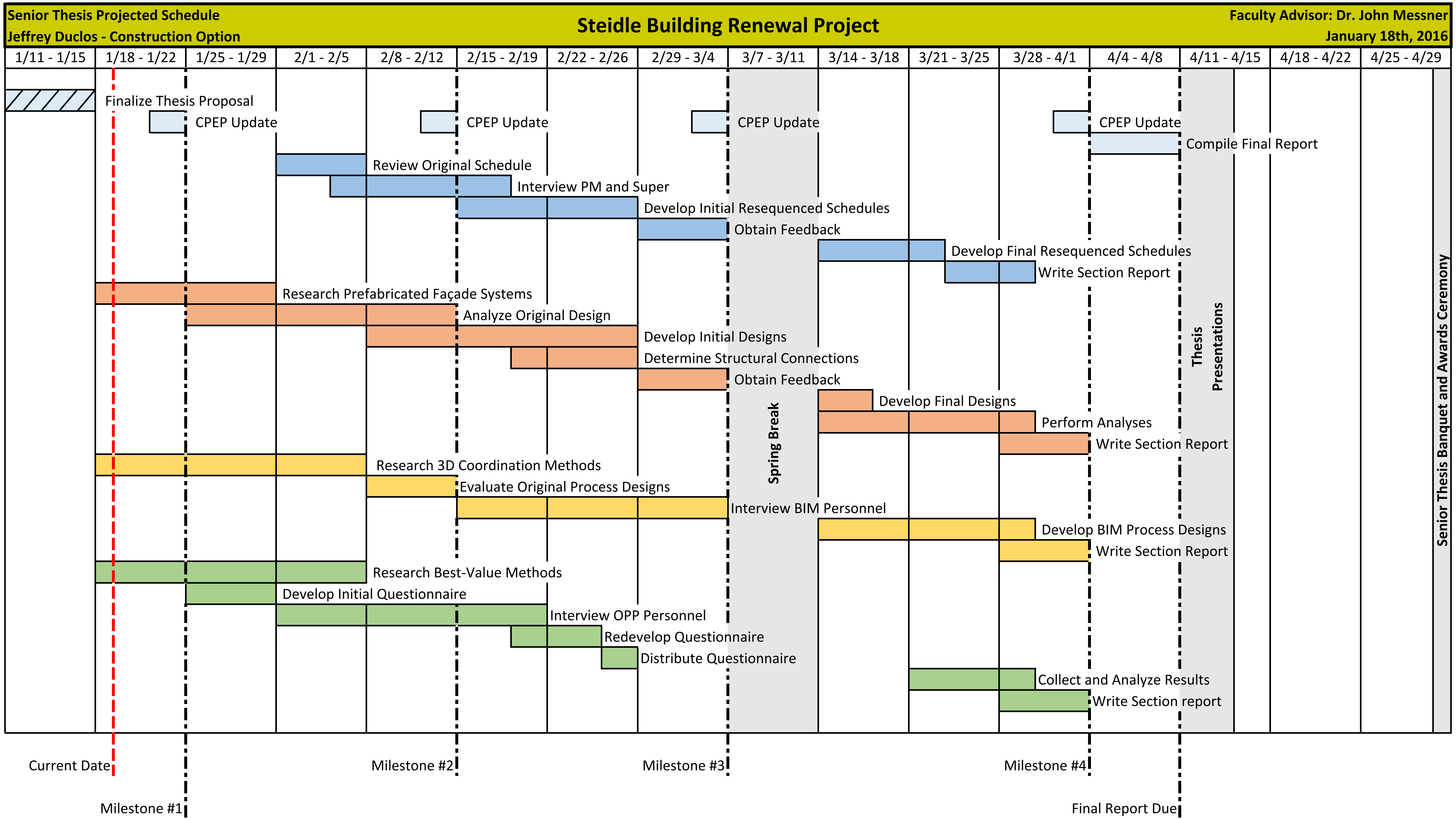
Mechanical

The mechanical breadth for this proposal will be to analyze the differences in thermal and moisture performance between the limestone and precast concrete system. Temperature differences and water penetration are of the biggest reasons for the failure of the building envelope. Therefore, when a change to the envelope is made, it is prudent to see of the original thermal and moisture requirements are met or exceeded. This analysis will be performed by researching the specs for each of the materials. Then, the two assemblies will be evaluated by determining how each assembly affects the building load as a relative change in percentage, with the end difference heavily factoring into which façade system is selected. They will also be evaluated on where the vapor barrier would need to be installed in the assembly and how that would be accomplished.

Appendix B: Masters Course Integration

The third depth analysis will be based off of the content taught by Dr. John Messner in AE 597G: Building Information Modeling Execution Planning. According to the Penn State College of Engineering's website, "The goal for this course is for students to learn the application of Building Information Modeling on Architecture/Engineering/Construction (AEC) projects and within AEC companies." This analysis aims to take the information from that course and apply it to a real-world project that incorporated BIM into its planning, design and construction phases. This is a natural extension of the course's goal by deepening the understanding of how BIM is executed and evaluated throughout a project, not just at the start of the project.

Appendix C: Thesis Progress Chart



Thesis Elements Key:	
(light blue)	General Work
(blue)	Analysis 1: Vertical Transportation Systems
(orange)	Analysis 2: Prefabricating the South Façade
(yellow)	Analysis 3: Researching Alternative 3D Coordination Methods
(green)	Industry Research: Best-Value Analysis for Subcontractor Selection