
# THESIS PROPOSAL

**January 16th, 2014**

## SOUTH HALLS RENOVATION: EWING-CROSS

**UNIVERSITY PARK, PA**


**Quaid Spearing**

**Construction Option**

**Advisor: Dr. Anumba**

# SOUTH HALLS RENOVATION: EWING-CROSS

## EXECUTIVE SUMMARY

Ewing – Cross is part of the South Halls Renovation and New Construction project, which is located in University Park of the Pennsylvania State University. There are four identical dormitory buildings that are currently being consecutively renovated. This creates an opportunity to explore alternative solutions for Ewing – Cross that could be implemented on the remaining phases. With Ewing – Cross's construction schedule at only seven months, there are critical areas on the schedule that could hinder timely completion. As such, the focus of this thesis will be to explore alternative methods of construction that can accelerate the schedule while maintaining quality.

The first analysis will look at implementing modularization. Due to the fact that the bathroom slabs and portions of the façade are removed, there is a unique opportunity to modularize the bathroom units. The analysis would focus on investigating the different levels of modularization and how it could be implemented in a renovation project. Building the bathrooms offsite will reduce the concern of the finish schedule for the bathrooms being accelerated at the cost of quality.

The structural system for the bathrooms needed to be replaced due to delamination. The cast-in-place slabs were time consuming and greatly hindered the follow-on work that could occur in these areas. Analysis 2 will focus on implementing a precast concrete system, in an attempt to accelerate the schedule for the bathrooms. Utilizing precast concrete would create greater production rates while maintaining lower labor costs, because prevailing wages are not required off of the University Park campus. Analysis 2 will provide an opportunity for a structural breadth with respect to the design of the precast system and how it will tie into the existing structure.

The third analysis will focus on value engineering the limestone façade by implementing full thickness limestone panels. The costly limestone veneer panels can be eliminated and prefabricating the limestone walls offsite will be analyzed in an attempt to further save time on the schedule. Changing the façade material will create an architectural breadth in looking at the different patterns of limestone available. The prefabricated design will then be evaluated for cost reduction and schedule savings.

The final analysis will focus on resequencing the renovation phases in an attempt to turn the buildings over to Penn State more quickly. Penn State Housing almost entirely relies on the revenue generated from student housing; getting the project completed one semester sooner could produce a lot of revenue for the owner. The analysis will focus on investigating how the project team would renovate two buildings at once, and the logistical challenges that accompany this. The other three analyses that focus on offsite construction will lend themselves to this analysis by helping to alleviate jobsite congestion as well as reducing the construction schedule.

Through these four analyses, the expected outcomes are to provide potential cost and schedule saving solutions to the current issues faced on the project. The overall goal is to accelerate the project schedule while maintaining or improving the quality of the final delivered product.

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## PROJECT INTRODUCTION

Ewing – Cross is part of the South Halls Renovation and New Construction project, which is located in University Park of the Pennsylvania State University. Ewing – Cross is a 71,000 gross square foot four-story plus basement dormitory building that will house approximately 250 students. Also included in the South Halls Renovation is the addition of a new dormitory building, Chace Hall, as well as the renovation of three other dormitory buildings and the renovation and addition to Redifer Commons. Figure 1 below depicts the current sequencing of the renovation phases at South Halls.


**Figure 1: South Halls Phasing Schedule |** Image courtesty of Bing Maps

The project is delivered using a Design – Build delivery method. Barton Malow Company is serving as the construction manager for the project, along with Clark Nexsen fulfilling the role of the architect and MEP engineer. Barton Malow is contracted with Penn State on a $94.1M Guaranteed Maximum Price (GMP) contract, and Clark Nexsen is contracted with Barton Malow on a Lump Sum basis. The total cost for the Ewing – Cross renovation is approximately $15.2M; this equates to $214.15/SF.

The total project duration for the South Halls renovation is approximately 33 months, with the design phase beginning at the end of May in 2011. The notice to proceed was given on May 1st, 2012, with construction beginning on Chace and Haller-Lyons. Construction on Ewing-Cross began with the demolition and abatement of the interiors in May of 2013, and is expected to reach substantial completion in at the end of December 2013 in anticipation of student move-in for the 2014 spring semester. In total, the construction of Ewing-Cross is an aggressive seven month duration, with a unique phasing of the interior work.

# ANALYSIS 1 – MODULARIZATION OF BATHROOM UNITS

## PROBLEM IDENTIFICATION

There have been numerous quality concerns with the bathrooms, especially with the finishes, such as the tile work. While the rest of Ewing – Cross follows a top-down construction method, all four floors of restrooms are working simultaneously. This makes it more difficult to track quality and ensure that all finish work, such as waterproofing the showers, is done properly and according to specification. Without proper coordination of all finish crews, it can become difficult to deliver a finished product that meets Penn State's standards, without the need for rework. In addition, Cooper – Hoyt and Hibbs – Stephens are essentially identical to Ewing – Cross, so any solutions identified could be implemented in those buildings as well.

## BACKGROUND RESEARCH

The removal of the bathroom slabs in Ewing – Cross in turn required that the brick façade be removed in front of the bathrooms. While the rest of the brick façade on the building will remain, opening the façade at the bathrooms creates a unique opportunity to use modularization in the bathrooms. The bathroom units could be built offsite, in a factory, and then shipped to the jobsite. By removing the construction of the bathrooms from the jobsite and placing them in a factory setting, there is potential improve the quality of the finishes. The units could be built at a reasonable pace, and the construction manager can then better track quality of the finish work. Modularization of the bathrooms would allow for a finalized unit to be installed, which would help to alleviate some of the rush to finish the bathrooms. Removing portions of the construction off of the jobsite would reduce congestion on the jobsite, which would be beneficial for Analysis 4.

Modularization of the bathrooms would also alleviate some of the burden of field installing the intricate MEP systems in the bathrooms. Modularization allows for the construction of the bathrooms to occur at essentially any point in the project, even during non-normal construction hours. The units could be built ahead of time and waiting to be installed as soon as the new bathroom slabs are in place. The modular design of the units would need to take into account how they will be connected to the structural system; further research would need to be performed to determine if modular units would have an integral structural system or be slid into place and rest on a traditional concrete slab system. Another concern would be the productivity rates and schedule savings achievable; this will be supported by research performed using knowledge gained from AE 570: Production Management in Construction. Modularization was a key focus of the course, and information obtained from this course will help garner a strategy for modular implementation at South Halls.

## POTENTIAL SOLUTIONS

With respect to the implementation of modularization of the bathrooms at Ewing – Cross, the results of the analysis will produce the following potential solutions:

- Recommend implementing modularization in an effort to reduce the bathroom schedule duration, improve the quality of the finish work, and decrease site congestion.
- Consider modularization as an alternative to traditional stick-built construction, but the calculated schedule/cost savings do not differ from the original method.
- Do not recommend implementing modularization because it does not produce schedule savings or the cost increases are too great to do so.

## ANALYSIS STEPS

- Research different levels of modularization.
- Investigate if any of the project team members have experience with modularization.
- Determine transportation and module size limitations.
- Develop preliminary bathroom modular design.
- Analyze modular units for production efficiency and potential cost/labor savings.
- Evaluate possible schedule savings.
- Determine installation process and site logistics for modular units
- Implement modularization to decrease site congestion and accelerate schedule
- Compare modularization duration results to the original bathroom schedule.

### RESOURCES

- AE 570 (Production Management in Construction)
  - Modularization Technical Report
- Barton Malow Project Team
- Industry Professionals familiar with modularization
- AE Faculty Members
- Project Documents and Specifications

## EXPECTED OUTCOMES

It is believed that the implementation of modularization will accelerate the schedule for the bathroom, while producing higher quality work. While quality and cost are very important to Penn State, the schedule is crucial because most of Housing's revenue comes from on-campus student housing. Modularization of the bathrooms has the potential to help in reducing the overall project schedule for quicker turnover to the owner.

## CRITICAL INDUSTRY RESEARCH

Modularization has been a key topic of discussion throughout various AE courses at Penn State. A lot of projects incorporate prefabrication, but very few fully utilize modular units, whether it is the entire building, or even just the bathrooms. The goal of my research will be to explore the effectiveness of modularization as well as the limitations. It is easier to implement modularization in new construction because there are few preexisting limitations placed on the project team. However, as Ewing – Cross is a renovation, it will be important to fully research and understand how the existing structure could impact the use of modularization. I will conduct interviews with project team members as well as industry professionals who have been on a project where modularization was used. I will also research past case studies of projects involving modularization. The results of the research will benefit the project team as well as provide an understanding of how modularization can be implemented in renovation projects in the future.

*Please refer to Appendix B for sample interview questions.

# ANALYSIS 2 – BATHROOM SLAB STRUCTURAL SYSTEM

## PROBLEM IDENTIFICATION

The majority of the existing structure at Ewing – Cross is to remain, with the exception of the bathroom slabs. These sections of the floor slabs were replaced due to delamination of concrete from the reinforcing bars (see Figure 3). The current design is a cast in place concrete floor slab on composite metal decking. The current construction schedule for bathroom slabs is 48 days for the Ewing stack and 38 days for the Cross stack. Figure 2 shows the typical sequencing for slab replacement at Ewing – Cross. This portion of the project is time consuming and limits the work that can occur in the bathrooms, while the slabs are shored and curing. This is also part of the reason that the bathrooms have all four floor finishes working simultaneously, placing the bathrooms on their own critical path.

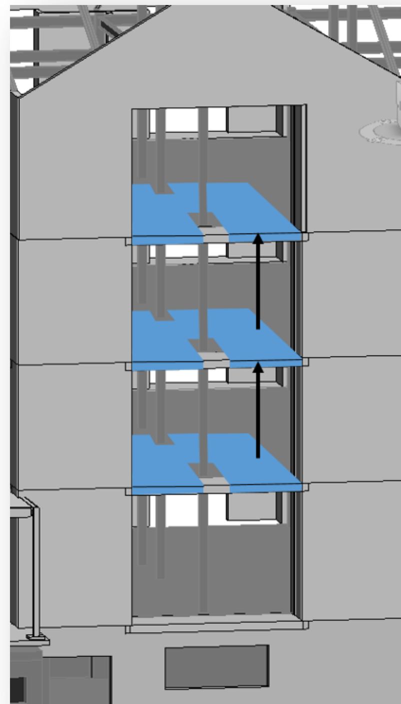

**Figure 2: Floor Slab Sequence** | Quaid Spearing

## BACKGROUND RESEARCH

In an attempt to accelerate the schedule for the bathrooms, the use of a precast concrete floor system for the bathrooms will be explored. Research would be conducted to determine if the tie-in to the existing structure could be simplified through the use of precast concrete. Utilizing precast concrete would also help in creating tighter tolerances and decreased variability in the floor, when compared to cast in place concrete. This would also tie into Analysis 1 – Modularization, because they would both work towards reducing the construction schedule and onsite congestion. The precast pieces could be poured offsite and arrive just in time for installation. Ultimately, if the slabs can be put into place quicker than the traditional cast in place method, this would allow the follow on trades to begin work in these areas much sooner. Once the precast concrete system is designed, the cost for labor, equipment, and material can be calculated and compared to the original cast in place system.

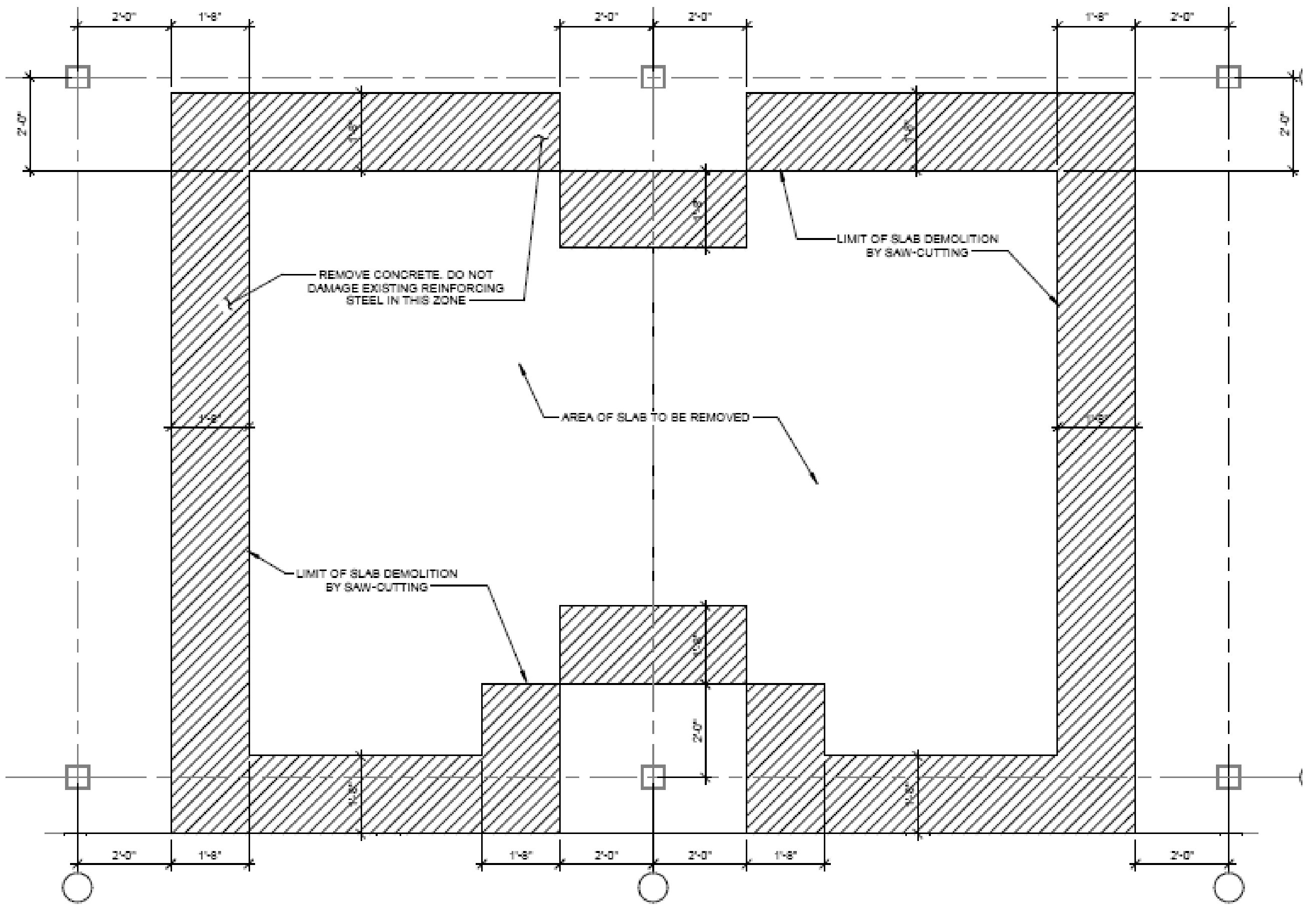


**Figure 3: Enlarged Bathroom Slab Repair Plan for Cast-in-Place Concrete |** SF503

## POTENTIAL SOLUTIONS

The results of the analysis will produce the following potential solutions with respect to the implementation of a precast concrete structural system:

- Recommend implementing a precast concrete system to reduce the bathroom structural schedule duration, decrease site congestion, and allow follow on trades to begin earlier.
- Consider a precast concrete system as an alternative to the cast in place system; however, there are no schedule/cost savings over the original system.
- Do not recommend implementing a precast system because it does not produce schedule savings or the constructability becomes increasingly difficult, i.e., not feasible to effectively separate bathroom structure from the rest of the building.

## ANALYSIS STEPS

- Evaluate the benefits of utilizing a precast system.
- Develop precast concrete system design to meet load requirements.
    - Analyze how the precast system will tie into the existing structure; determine size of steel angles and expansion bolts for tie-in to surrounding concrete slab.
    - Determine maximum allowable thickness of topping slab, and required strength of precast planks.
- Determine installation process and site logistics for a precast concrete system; additional crane requirements for lifting precast planks.
- Determine the costs and schedule duration of the precast system.
- Compare the cost and schedule of the precast system to the cast in place system.

### RESOURCES

- AE 404 & AE 308 (Structural courses)
- AE 473 (Prefab installation coordination)
- AE 570 (Production Management)
- Barton Malow Project Team
- Industry Professionals familiar with precast structural systems
- AE Faculty Members
- AE Classmates (Structural)
- Project Documents and Specifications

## EXPECTED OUTCOMES

The expected result is that a precast concrete system will allow for schedule acceleration of the construction in the bathrooms, while reducing onsite congestion. This system should also simplify the tie-in to the existing structure, while lowering the cost by moving portions of the construction offsite.

*See Appendix A for Structural Breadth requirements.

# ANALYSIS 3 – PREFABRICATION OF LIMESTONE FACADE

## PROBLEM IDENTIFICATION

As previously mentioned, maintaining the project schedule is of particular concern. In addition, the site at Ewing – Cross is very tight, by State College standards. Often construction activities overlap and any minor delay can offset several different activities from being completed on time. During the enclosure of Ewing – Cross, there was a delay in material acquisition; the limestone panels were delayed by two weeks, and the façade completion was delayed because of this. The delays caused by the limestone panels required Barton Malow to shift several other exterior activities around to maintain the schedule. Because eight of the twelve limestone bumpouts are attached to the existing brick veneer, there is an opportunity to utilize prefabrication.

## BACKGROUND RESEARCH

The use of a prefabricated limestone façade would be analyzed for several reasons; (1) removing construction from the jobsite would reduce jobsite congestion, (2) there is a potential to accelerate the enclosure schedule. Similar to Analysis 1, construction would be moved offsite, meaning that the limestone walls could be built ahead of time and waiting to be installed. Moving construction offsite would also have the potential to reduce the cost of construction because prevailing wage rates may not be required if the construction is not performed on the Penn State campus.

The use of the limestone veneer panels was dictated solely by the schedule; the limestone panels have a higher cost when compared to a traditional full limestone façade. Since the façade would be constructed offsite, there is an opportunity to utilize full thickness limestone panels, in an effort to save costs on material.

Furthermore, much like Analysis 1, there are two main concerns with using a prefabricated wall system; the structural system necessary to connect the limestone façade to the brick veneer, and the productivity rates and schedule savings that are attainable. The modular design of the limestone façade would need to factor in the tie-in to the existing façade.

While the smaller projection stone panels are installed over top of existing brick veneer, the larger projection stone panels serve as the primary exterior wall. The large projections also house the mechanical chases (see Figure 4). For this reason, any changes in the wall composition of the large projection stone panels will need to be analyzed to ensure that condensation does accumulate within the mechanical chase. The mechanical breadth addressing these issues can be found in Appendix A.

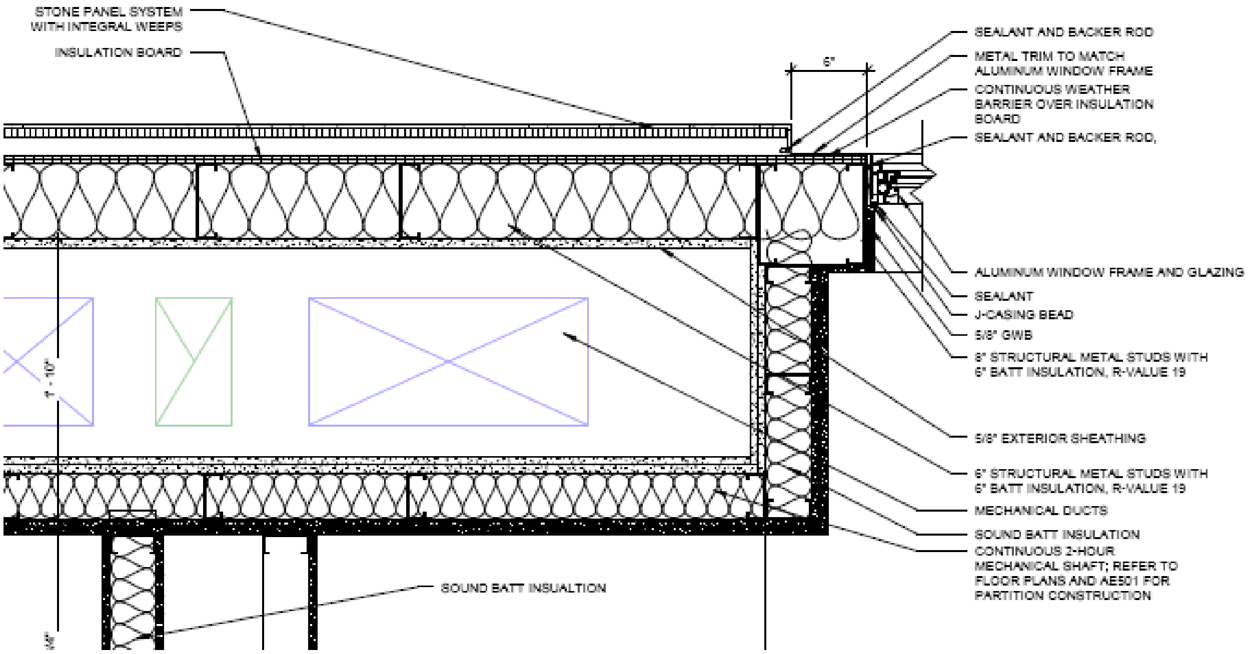


**Figure 4: Limestone Façade at Mechanical Shaft |** AE512

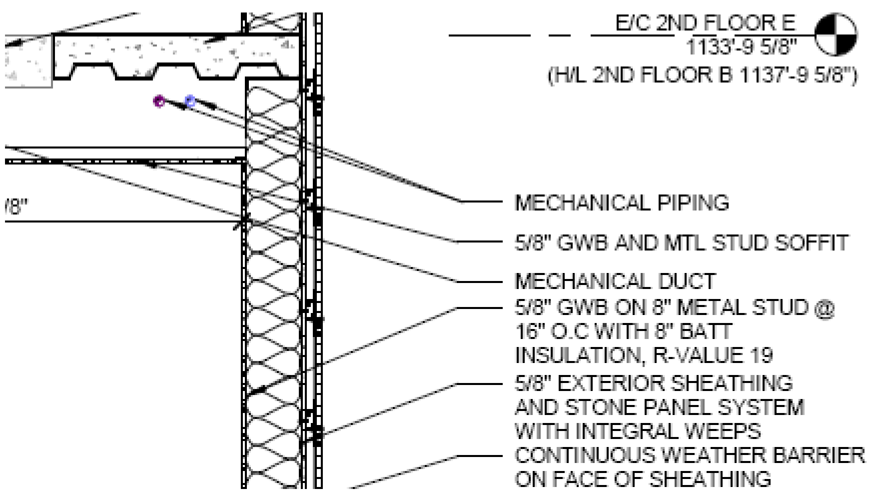


**Figure 5: Wall Section at Large Projection Stone Panels |** AE322

## POTENTIAL SOLUTIONS

The results of the analysis will produce the following potential solutions with respect to the implementation of a prefabricated limestone façade wall

- Recommend implementing a prefabricated limestone facade to reduce jobsite congestion, while reducing cost and accelerating the enclosure schedule.
- Consider a prefabricated limestone façade as an alternative to a built in place façade system, but no significant cost or schedule savings are achieved.
- Do not recommend using a prefabricated limestone façade because the cost to do so outweighs the benefit of accelerating the schedule.

## ANALYSIS STEPS

- Develop prefabricated limestone façade design and determine optimal limestone thickness for cost savings.
    - Research decorative limestone patterns that could be used; potential savings through offsite construction and full thickness limestone panels would offset costs of a more decorative panel.
- Gather information on possible connection types for tie-in to existing brick veneer.
- Evaluate connections and load requirements.
- Analyze the prefabricated system for cost savings.
- Determine transportation and size limitations.
- Determine installation process and site logistics for the prefabricated limestone façade.
- Compare the cost and schedule of the prefabricated system to the stick-built system.

### RESOURCES

- AE 404 & AE 308 (Structural courses)
- Barton Malow Project Team
- Industry Professionals familiar with prefabricated facades
- AE Faculty Members
- Project Documents and Specifications

## EXPECTED OUTCOMES

By removing the construction of the limestone façade offsite, the prefabricated walls can be installed on a just-in-time basis. This will reduce congestion on the jobsite and allow for a reduction in the schedule. Productivity should be improved, resulting in a lower cost for labor. It is believed that offsite prefabrication will reduce the schedule and help in making resequencing of the construction phasing (Analysis 4) possible.

*See Appendix A for Structural and Architectural Breadth requirements.

# ANALYSIS 4 – RESEQUENCE RENOVATION PHASES

## PROBLEM IDENTIFICATION

The current phasing of the South Halls project sees the first renovation, Haller-Lyons, taking twelve months to complete, with the remaining three buildings taking seven months each to complete. This puts the total construction duration at approximately 33 months, from May 2012 to January 2015. Each of the renovated dormitories will house approximately 248 students. As such, the sooner that Penn State can have each dormitory back online, the more revenue they stand to generate. Having the project completed even one semester quicker would allow them to start their payback period that much sooner.

## BACKGROUND RESEARCH

This analysis will focus on the phasing of the South Halls renovation to determine how multiple buildings could be renovated at once to accelerate the schedule and turn the project over to Penn State quicker. The goal will be to renovate Cooper – Hoyt and Hibbs – Stephens at the same time, allowing the project to finish seven months ahead of schedule, or a semester earlier. Renovating the final two buildings simultaneously is initially thought to be ideal because there is an inherent learning curve from having already renovated Haller – Lyons and Ewing – Cross.

Attempting to deliver a project seven months sooner raises several concerns; it would create an aggressive schedule as well as increase the jobsite congestion. This ties into the other three analyses, which focus on prefabrication and moving construction offsite. If several areas of the project can be effectively constructed offsite and then quickly installed onsite, renovating multiple buildings at once becomes more feasible.

It would also need to be determined if Penn State has the capability to house twice as many students elsewhere on campus. After speaking with the project manager for the Office of Physical Plant, it was determined that taking multiple buildings offline is more feasible during the spring semester because student enrollment is typically lower during the spring, when compared to the fall semester. There are also renovations occurring in Redifer, as well as the east and west connectors from Redifer to Cooper – Hoyt and Hibbs – Stephens respectively. The Redifer work could pose a challenge to completing Cooper – Hoyt and Hibbs – Stephens together, so the entire sequencing of the South Halls project will be analyzed to determine the best sequence for the renovations.

## POTENTIAL SOLUTIONS

The results of the analysis will produce the following potential solutions with respect to resequencing the renovation phasing at South Halls:

- Recommend resequencing the renovation phasing to allow owner turnover to occur one (1) semester sooner.
- Consider resequencing the renovation phasing as an alternative, but the cost to do so exceeds the revenue the owner would stand to generate.
- Do not recommend resequencing the renovation phasing because the cost to do so far exceeds the budget or the owner does not have the capacity to have multiple dormitory buildings down at the same time.

## ANALYSIS STEPS

- Gather information concerning the total project schedule and sequencing of construction.
- Interview OPP project manager and owner's rep to determine feasibility of simultaneous renovations.
- Develop sequencing plan and analyze site logistics for simultaneous renovations.
    - Factor in any of the first 3 analyses that will successfully improve site logistics.
- Determine construction manager capabilities to implement plan.
- Perform cost analysis of GC and CM fees and determine feasibility of costs
- Compare the cost and schedule of the resequenced phasing to the original phasing

### RESOURCES

- Penn State Housing
- OPP Project Management team
- Barton Malow Project Team
- AE Faculty Members
- AE 572 (Project Development and Delivery Planning)
- AE 570 (Production Management
- Previous South Halls feasibility studies

## EXPECTED OUTCOMES

Through proper planning and the addition of offsite construction from the first three analyses, it is believed that it will be feasible to implement renovating multiple buildings at once in order to shorten the total project schedule. Doing so will require increasing the project management staff and their fees, but should be offset by the owner being able to generate revenue one semester sooner, ultimately saving Penn State money.

## THESIS INVESTIGATION OBJECTIVES

Table 1 below shows a weight matrix that shows the breakdown of time allocated to each analysis. Also included is the distribution of the four core thesis investigations areas of: Critical Issue Research, Value Engineering Analysis, Constructability Review, and Schedule Reduction/Acceleration. The majority of time will be spent on schedule reduction and the constructability review of several systems within Ewing – Cross. This correlates with the theme of my thesis proposal in focusing on offsite construction to reduce the construction schedule.

**Table 1: Weight Matrix**

| Critical Issue / Analysis | Critical Issue Research | Value Engineering Analysis | Constructability Review | Schedule Reduction/ Acceleration | Total |
|---|---|---|---|---|---|
| Bathroom Modularization | 10% | | 10% | 10% | 30% |
| Precast Structural System | | 10% | 10% | 5% | 25% |
| Prefabricated Limestone Façade | 5% | 10% | 5% | 5% | 25% |
| Resequence Renovation Phases | 5% | | 5% | 10% | 20% |
| **Total** | 20% | 20% | 30% | 30% | **100%** |

## CONCLUSIONS

Maintaining the high level of quality that Penn State expects while still meeting the project schedule has been the most critical aspect of the South Halls Renovation. Penn State Housing's budget almost entirely relies upon the revenue generated from on-campus student housing. As such, delivering South Halls even one semester sooner would allow Penn State to start generating a great amount of revenue. My four analyses focus around the theme of reducing the schedule through offsite fabrication, while also maintaining or exceeding the current level of quality.

# APPENDIX A: BREADTH TOPICS AND MAE REQUIREMENTS

## STRUCTURAL BREADTH: ANALYSIS 2 AND 3

The precast structural system, described in Analysis 2, provides an opportunity for a structural breadth that will focus on ensuring that all load requirements are still met after redesigning the slabs as precast, rather than cast-in-place. The current cast-in-place floor slab system for the bathrooms takes 48 days for Ewing and 38 days for Cross. Switching to a precast plank system would allow critical follow on trades, such as the finish work, to occur sooner in the project. Switching to a precast floor system would involve analyzing the load requirements; in addition, the bathroom column layout may need to be reconfigured to allow for precast planks, and to also ensure that loads are still properly transferred from both the precast slabs and the existing surrounding slabs. Further investigation will be required to understand how the precast system will tie into the existing structural system, such as through the use of steel angles secured to the existing concrete slab with expansion bolts. The ultimate goal of implementing a precast system would be to reduce the construction schedule by removing the time consuming portion of cast-in-place concrete. Different types of concrete would also be analyzed to determine if a higher strength concrete could be used to allow for reducing the overall floor thickness to allow for a topping slab, and because the floor to floor heights at Ewing – Cross are limited as is.. Utilizing precast planks would also require additional welding and additional crane usage. These additional factors will be taken into consideration when comparing the cost and schedule of a cast-in-place floor slab and a precast floor system.

A structural breadth is also incorporated into the prefabricated limestone façade in Analysis 3. If the limestone façade is fabricated offsite, research will need to be performed to determine how the wall system will attach to the existing brick veneer. The current stick-built system sees 8” metal studs directly attached to the brick veneer; sheathing and Tyvek are then installed, with the limestone panels secured to the sheathing. With this entire assembly built offsite, the connections that secure the metal studs to the brick veneer will then need to be analyzed to ensure that they will hold the thicker limestone panels with a greater load, when compared to the limestone veneer panels.

## ARCHITECTURAL BREADTH: ANALYSIS 3

With respect to Analysis 3, the implementation of a prefabricated façade system with full thickness limestone panels, there is a potential to utilize a more decorative limestone pattern. The current limestone veneer is 1/4” thick limestone, with backing. Increasing the thickness of the limestone would allow decorative designs to be carved into the limestone without cracking, as the thinner 1/4” veneer would. The limestone pattern could play off of other themes across the Penn State campus, or create another avenue for the architect to distinguish the South Halls dormitories. The cost to use a more decorative limestone panel would be offset through moving the construction offsite, as well as utilizing traditional limestone panels, which have a lower cost when compared to the currently used veneer limestone.

## MAE REQUIREMENTS

A majority of my analyses try to take advantage of knowledge gained from graduate level courses from the MAE curriculum. Information from AE 570 – Production Management in Construction will be used for Analyses 1 and 2. AE 570 dealt with increasing productivity and efficiency on jobsites. Both Analyses 1 and 2 deal with moving construction offsite; this will involve tracking how the production rates may increase or even decrease, when compared to onsite construction.

AE 572 – Project Development and Delivery Planning will also be used in Analysis 4 in looking at resequencing the renovation phases. AE 572 focused on improving the delivery method process to increase design and construction efficiency. Construction efficiency will be crucial for Analysis 4 because renovating multiple buildings at once will increase the site logistical challenges. The Design-Build GMP delivery method will not be altered; knowledge from AE 572 will be primarily used to better understand how jobsite efficiency can be improved for a Design-Build project.

# APPENDIX B: SAMPLE INTERVIEW QUESTIONS

1. *Have you had experience on a project where modularization was implemented? If so, what was the project, and the reasoning for doing so?*

2. *What were the benefits of implementing modular system/units? Were there significant schedule savings compared to traditional construction?*

3. *What coordination or logistical challenges did you face because of implementing modularization?*

4. *Were there additional costs incurred through the use of modularization?*

5. *How would you implement modular bathroom units in a renovation project? What limitations would the existing structure place on implementing modularization?*

6. *Would you recommend implementing modular bathroom units?*

7. *Would you recommend integrating the structural system into the modules, or utilizing a separate precast concrete system?*

# APPENDIX C: SPRING SEMESTER SCHEDULE

**Quaid Spearing**
**Spring Schedule**
**Facultry Advisor: Dr. Anumba**

Proposed Thesis Semester Schedule

January 2014 - May 2014

| 1/13/2013 | 1/20/2013 | 1/27/2013 | 2/3/2013 | 2/10/2013 | 2/17/2013 | 2/24/2013 | 3/3/2013 | 3/10/2013 | 3/17/2013 | 3/24/2013 | 3/31/2013 | 4/7/2013 | 4/14/2013 | 4/21/2013 | 4/28/2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Milestone 1 2/3/13** | | **Milestone 2 2/17/13** | | **Milestone 3 3/7/13** | | | | **Milestone 4 3/31/13** | | | | |
| Research Modular Design | | | | | | | | Spring Break | | | | Final Report - April 9 | Faculty Jury Presentation - 14-18 | | Senior Banquet - May 2 |
| Revise Proposal or Update | Create Module Design & Results | | | | | | | | | | | | | | |
| | | Precast System Design & Research | | | | | | | | | | | | | |
| | | | Develop Install Plan & Cost/Schedule | | | | | | | | | | | | |
| | | | | | Prefab System & U-Value (Mech. Breadth) | | | | | | | | | | |
| | | | | | | Develop Install Plan & Quantify Results | | | | | | | | | |
| | | | | | | | | Research & Analyze Feasbility of New Sequence | | | | | | | |
| | | | | | | | | | | Determine Cost and Schedule | | | | | |
| | | | | | | | | | | | | Finalize Report | | | |
| | | | | | | | | | | | | | Jury Present | ABET Assessment | |
| | | | | | | | | | | | | | | Update CPEP & Report | |

| | Milestone | Analyses & Breadths |
|---|---|---|
| 1 | Modular Analysis & Design Complete | Modularization of Bathroom Units |
| 2 | Bath Slab Anaylsis and Precast Design Complete | Bathroom Slab Structural System |
| 3 | Limestone Façade Prefab Design Complete | Prefabrication of Limestone Façade |
| 4 | All Analyses Complete | Resequence Renovation Phases |