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INTRAMURAL BUILDING ADDITION AND RENOVATION – PHASE I

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Department of Architectural Engineering
Construction Option

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Revised PROPOSAL

EXECUTIVE SUMMARY

The purpose of the Proposal is to identify key research areas which correspond to the construction and design of the Intramural Building Addition and Renovation Project at University Park, PA. The themes of the proposal emphasize on the reduction of construction costs, acceleration of the schedule during the construction phase, and the opportunity of lessening design and construction discrepancies by the use of a more integrated and collaborative delivery method.

Analysis 1 | Prefabricating Building Enclosure

The Intramural Building new addition's enclosure consists primarily of brick veneer façade and curtain wall glazing. Covering large percentages of the building enclosure, the opportunity of utilizing prefabricated panels or modular façade systems would potentially accelerate the schedule and reduce labor costs. By eliminating the use of traditional methods to enclose the building the construction site would be less congested, offer higher quality and performance products and help move quickly on the critical path. Structural and architectural breadths will be performed to evaluate the feasibility, aesthetics and performance of implementing these systems.

Analysis 2 | Alternate Delivery Method

Discrepancies between the design team and subcontractors led to schedule delays in the project's building structural system and enclosure. The problem to identify is why this particular delivery method was utilized and if there are other, more integrated and collaborative methods to design and construct a building. An investigation into the delivery method used on the project will be conducted in order to determine the benefits of having a more collaborative and integrated project team.

Analysis 3 | Prefabrication Structural Effects

Linked to analysis one by the prefabrication of panels, this analysis will focus on a feasibility study of the impacts of the new structural loading. Because prefabricated brick panels usually weigh less than traditional brick systems, the loading on the exterior beams and columns would change, potentially reducing the sizing of these members. This would lead to lower material costs and provide savings. Additionally, how the panels will be connected to the structural system would be analyzed.

Analysis 4 | Phased vs. Empty Construction

The project is scheduled to be fully operational during the construction of the new addition and renovation. During the project, unexpected events can lead to delays which could potentially disrupt

the comfort of the occupants. Therefore, there are certain commitments which must be accepted by the occupants before the construction starts. This analysis focuses on how to make those decisions.

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Analysis 1: Prefabrication of Building Enclosure

Problem Identification

The building enveloped is comprised of three main components, insulated metal panels, brick on metal studs and curtain wall. Playing an important role in the critical path of the schedule, it is vital that these systems are installed properly and on time to prevent delays and weather issues. The project was planned to be enclosed fully before the harsh winter days arrived to the University, but detailing and material issues caused delays in the installation of the building's brick façade. This not only caused conflict for the subsequent activities, but also disrupted occupant's productivity by not allowing the heating system work in the existing portion of the building. The Intramural Building project presents the opportunity to accelerate the schedule and reduce costs through changes from the regular stick built curtain wall and traditional face brick construction to prefabricated/modular design.

Background

Three areas of concern come to mind when looking into the alternative design of the building enclosure; the building aesthetics should remain as desired by the owner, structural connections needed to join these panels to the structure and the schedule and cost benefits of the installation process. The face brick and glazing systems should match the existing building, and also meet the performance requirements. The façade of the building must be eye pleasant to bystanders in order to attract them into the building, and distribute the occupant load of gyms on campus. Maintaining the aesthetics planned by the design team and the owner is crucial as a value engineering decision; maintaining product quality, while decreasing costs and accelerating schedule. A standard of aesthetics needs to be established in order to evaluate the effectiveness of this analysis.

The implementation of these prefabricated modular systems must be researched in detail to evaluate how they potentially tie into the exterior frame. This is vital due to the watertight conditions required to have continuous work on site, and decrease the impact on the schedule. Existing connections of the curtain wall will be analyzed to identify problems, and operational glazing systems will be researched to comply with the building's design. Prefabricated brick veneer panels will be researched in order to find the right system that will properly connect to the exterior frame, meet the thermal performance, and customizable to meet aesthetics qualities.

Lastly, the effectiveness of installation and productivity of these prefabricated panels will be analyzed. The implications of manufacturing these panels will be investigated, in terms of cost per square foot of panel, costs and time of transportation, logistics during installation, and costs and duration of erection of these new systems. This will look into the constructability challenges of applying pre-fabricated systems.

Potential Solutions

This project is on special grounds because it is not directly funded by DGS as the other typical University buildings, making cost a priority. Ensuring that no costs are added to the project, suggests that installing these systems will be driven by how they impact the schedule. By looking into the different types of connections of these two systems to the building structure, they can be analyzed in terms of cost and feasibility of installation. If it is evident that costs can be reduced and the schedule accelerated, then the suggestion of this method may be viable.

In regards to the aesthetics, the prefabrication could potentially increase the performance, views, and quality of the building enclosure. Virtually same hand-laying techniques can be implemented in prefabricated brick veneers, while constructing them in controlled environments and enforcing more vigilant quality control. Obtaining similar products with a faster installation will potentially accelerate the schedule and also meet the expectations of the owner.

Lastly, on the productivity of implementing these two enclosure systems could possibly reduce site congestion and onsite labor. Using traditional methods, skilled labor is necessary to both stick build a curtain wall and lay individual bricks. The costs to having workers onsite for long periods of time add up substantially compared to utilizing prefabricated installation methods. Laborers perform their work in controlled environments, without the weather factor impeding their flow of work, while at the same time reducing the production costs. In addition, when using traditional methods, materials would be stored onsite during the installation of the system, which take up space and create site congestion. Analyzing these cost and time implications will be beneficial information to prove the feasibility of implementing these methods.

Analysis Components

- Research different types of prefabricated curtain wall and brick veneer systems and their connections to structures. Look for the possibility of having glazing installed/opening in brick veneer.
- Determine costs and implications of connections / evaluate implementation to prefabricated panels. Bracing needed?
- Define the specific areas of where these prefabricated systems should be implemented, and if some redesign is needed. Define sizes of panels.
- Investigate process of prefabrication, cost savings, efficiency, transportation, and installation. How to coordinate with other trades?
- Evaluate schedule and cost reduction scenarios
- How will it be installed? Develop site logistics and procedure plan. Equipment and crews
- Develop plan to procure subcontractor
- Compare analysis results with the original. Costs and schedule implications.

Expected Outcome

The implementation of prefabricated systems to this project will provide the project team and owner with both cost and time savings. By fabricating the majority of the building enclosure offsite and installing panels as they arrive on site, the project's schedule can be reduced substantially while also reducing the amount of labor on site, which will result in cost savings. In addition, the acceleration of this schedule will allow the project to remain on track without the need of doubling man power and increasing work hours.

***See Appendix A for Structural and Mechanical Breadth details**

Analysis 2: Alternate Delivery Method

1.1. Problem Identification

Through analysis of the technical assignments, several issues occurred with coordination of the design and construction of project elements. Discrepancies between the design team and subcontractors led to schedule delays in the project's building structural system and enclosure. The problem to identify is why this particular delivery method was utilized and if there are other, more integrated and collaborative methods to design and construct a building. The University has construction projects, renovation and new construction, all year long and experiences different project teams every time. Some of these projects undergo many change orders, design issues, safety conflicts, while other are very successful in meeting time frames and budgets. If the Intramural Building project was to be delivered with a more collaborative and integrated way, what kind of issues would have they faced and avoided?

1.2. Background

Technical report 1 contains information on how the Intramural Building is currently being delivered. Utilizing a CM at Risk lessens the responsibility of the University on holding contracts and managing work, therefore stress free. The IPD method has been thought to deliver projects in an effective manner, considering both costs and time, while heavily involving the owner. It will be interesting to see if an IPD approach could be taken into consideration while also considering the CM at Risk method. Therefore, several concerns come to mind; does the entire delivery method need to be changed in order to introduce a more collaborative and integrated project team? If so then which delivery method should go along with IPD? How would this affect the current construction of the project?

1.3. Analysis Components

- Collect and attain information on current contractual agreements
- Interview owner (OPP) to determine the feasibility of using IPD method
- Analyze Penn State projects that currently attempt collaborative efforts, what working well and not? South Halls – Barton Malow / HHD - Massaro
- Research case studies on implementation of IPD and their success rate (construction journals, ENR, etc.)
- Analyze schedule and constructability impacts through the documentation of similarities and differences between IPD project and CM @ Risk project.
- Identify aspects of IPD that could improve the coordination, communication and effectiveness for this project (design and construction focus)

1.4. Expected Outcome

The results of this investigation will demonstrate how vital working together is when constructing a building. It will identify the potential benefits of decreased design and construction errors by integrating work process and the possible contractual and work pitfalls. Differences between the current and more integrated project delivery method will be analyzed while understanding the different constructability issues and overall costs and schedule reductions.

Analysis 3: Prefabrication Structural Effects

Problem

The use of prefabricated panels to substitute the current exterior façade requires an evaluation of the structural loading. The current designed system, metal stud back-up brick façade weighs 55 pounds per square foot. When evaluating the use of the SlenderWall panel, which weighs 30 pounds per square foot, it very obvious that the current structural design will be able to sustain the loading of the panels. Regardless of the weight of each panel being almost half the weight of the current system, a structural analysis can be performed to see the beam deflection and the possibility of using different size wide flange beams. Using the knowledge learned in AE 308 and AE 404, these structural evaluations can be pursued. If the new structural beams can not only hold the weight of the fabricated panels, but also the weight of the slab for the building, then substantial cost savings could be seen with the fabrication of steel.

Method

- Research and understand the different types of connections within a panel (Bearing and Tieback), their purposes and locations.
- Understand and explain the structural details of the selected panel. How will it be connected to the building frame – drawings and details
- Feasibility of switching beam and column sizes due to different loading
    - Structural calculations – column redesign & composite beam calculations
- Cost analysis of proposed and current system

Expected Outcome

The use of prefabrication was analyzed previously in section 2, but structurally would potentially provide cost savings in the fabrication of structural members. If the loading of the building exterior façade changes, the structural members could be reduced in size, making the building structurally sound and cheaper.

***See Appendix A for Structural Breadth details**

Analysis 4: Phased or Empty Renovation?

1.5. Problem Identification

The project is scheduled to be fully operational during the construction of the new addition and renovation. During the project, unexpected events can lead to delays which could potentially disrupt the comfort of the occupants. Therefore, there are certain commitments which must be accepted by the occupants before the construction starts. Building occupants would have to deal with utility shutdowns, continuous construction noises and vibrations during work hours, dirt and residue, and area relocation. All these disruptions are presented to the occupants before the project begins, to analyze how comfortable and efficient their work can be done and decide on the phased occupancy or a shutdown of the building to retrofit and finish construction.

1.6. Background

Through conversations with building occupants, many complaints and possible scenarios were discussed into how disturbances can be reduced when phasing construction. Currently undergoing renovations on the mechanical, electrical, and fire suppression systems in the existing building, the occupants found themselves overwhelmed with the amount of activities that were taking place, interrupted by machinery and equipment sounds, unable to use particular bathrooms, and dealing with delay related conditions. Obtaining information of the owner and occupant's needs and discussing other alternatives considered for renovating the project will help understand the reason behind why phased construction was used.

1.7. Potential Solutions

The opportunity to research and identify ways of reducing disturbances on building occupants could potentially help the owner and project team to plan sequencing of work to obtain ideal quality, increase work productivity and safety awareness of occupants. Construction standards usually present minimum criteria that must be met by the design team, construction team, and contractors. Penn State follows the OSHA guidelines, which mostly are concerned with the safety of workers and the process of construction. Several Universities have their own guidelines of construction and renovation that not only ensure projects to be successful, but keeping adjacent building occupants content and healthy. In addition, external costs will be evaluated when considering phased construction over renovating the building without occupants; pros and cons of moving occupants to a temporary facility, utilities, and effects on productivity.

1.8. Analysis Components

- Conduct research from different university (owners) to understand order of preference when the project is a renovation/retrofit
- Identify main problems of building occupants when dealing with phased construction

- Identify phases of construction which create the most disturbances to building occupants, both adjacent and existing buildings.
- Identify building occupants' risks during renovations and construction, effects on productivity. Look into noise and vibration disturbances to occupants.
- Investigate productivity rates of phased occupancy vs empty building renovation
- Develop construction standards for renovation projects, in terms of indoor air quality, traffic of work, communication, etc.
- Research effects and costs of transferring occupants to a temporary facility

1.9. Expected Outcome

When deciding how to implement a renovation project, several decisions have to be disputed and understood by all parties for a better construction experience. Occupant experience and the delivery of the desired product is a top goal by the project team. Proposing an alternative to the current way of construction can potentially improve the work quality of occupants by minimizing disturbances and allow construction activities to flow steadily. In addition, understanding how to improve the decision-making will help to shape future projects.

Spring Thesis Objectives

Analysis Matrix

In order to organize and allocate time for the Spring Semester, a weighted matrix was developed and it can be seen in Table 1. The table represents the time distribution between the four major areas of research. The percentage values embody the estimated and projected time to be spent in each individual analysis and breadth.

Analysis Description	Industry Research	Value Engineering	Constructability Review	Schedule Reduction	Total
Prefabricate Building Enclosure	-	15%	10%	10%	35%
Alternative Delivery Method	10%	-	5%		15%
Prefabrication Structural Effects	-	15%	10%	10%	35%
Phased or Empty Renovation	5%	-	10%	-	15%

Table 1: Analysis Weight Distribution

Conclusion

This report is intended to propose topics for analysis for the Architectural Engineering Senior Thesis. Of the four, three focus on current industry issue that are prevalent in the industry today as seen in the PACE roundtable. The importance in the financing and delivering of the project explains why the focuses of the technical analysis are on ways of reducing costs and improving the schedule.

The idea of prefabricated components is a process used to accelerate the schedule of a project. This would be beneficial to building enclosure of the Intramural Building Addition since the project has faced set-backs in their schedule. The use prefabricated panels for the curtain wall and brick veneer would allow the project to get ahead of the schedule. The idea of integrating projects in a collaborative manner has been growing in the construction industry. Investigating how this would benefit the way the IM Building will help future projects to adapt this method of building and planning. Examining all topics thoroughly will provide the necessary information to conduct analyses for a research thesis. The outcome of these analyses potentially could improve the construction and design process of the project.

APPENDIX A

Breadth Topic Analysis

Structural Breadth | Technical Analysis 1 and 2

In analysis 1, it was proposed to prefabricate brick veneer system which could potentially accelerate the schedule and reduce construction labor costs. An investigation of prefabricated brick panels comprised of different components to the existing system will be conducted to meet or exceed performance required by the building (energy loads and R-values). A study of energy use will be done with existing and proposed design to demonstrate the change on the mechanical system.

Mechanical Breadth | Technical Analysis 1

In analysis 1, it was proposed to prefabricate brick veneer system which could potentially accelerate the schedule and reduce construction labor costs. An investigation of prefabricated brick panels comprised of different components to the existing system will be conducted to meet or exceed performance required by the building (energy loads and R-values). A study of energy use will be done with existing and proposed design to demonstrate the change on the mechanical system.

APPENDIX B

Interview Questions

Interview Questions - IPD

(1) *Have you had experience with implementing an integrated and collaborative project?*

(2) *What measurable benefits have you experienced with such? Pitfalls?*

(3) *What drove you into selecting an integrated delivery method? Owner? Project? Contractors?*

(4) *What could you tell me to be aware of, if I wanted to implement this in a project? In terms of contract administration, daily workloads, interaction with project teams?*

Interview Questions – Prefabricated Building Enclosures

(1) *Have you had previous experience on a project implementing modularization? What was this project, size, type, and why and how was it implemented? Results?*

(2) *What are some of the potential benefits and downsides of these systems?*

(3) *What kind of connectors or tie in have they been using in these projects to merge into the building structure? Labor intensive? Costly? Installation procedures?*

(4) *Would you recommend such system? Unitized curtain wall? Prefabricated brick veneer?*

(5) *In terms of quality, any differences between traditional and modularized? Durability? Performance? Possible issues?*

APPENDIX C

Spring Semester Schedule

Proposed Thesis Semester Schedule

January 2014 - April 2014

	Milestone #1				Milestone #2			Milestone #3		Milestone #4					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
13-Jan	20-Jan	27-Jan	3-Feb	10-Feb	17-Feb	24-Feb	3-Mar	10-Mar	17-Mar	24-Mar	31-Mar	7-Apr	14-Apr	21-Apr	28-Apr

- Research Building Envelopes (panels):Costs / Evaluate Current
- Connections design - Look into structural components and architectural (Breadth Research)
- Evaluate constructability, schedule reductions, costs savings. Compare to current
- Research IPD - background
- Research Case Studies
- Develop Logistics
- Write-up!
- Analyze other delivery methods
- Evaluate Impacts
- Research connections (bolted) and analyze building connections / interviews
- Write-up!
- Schedule and Costs impacts (long/short term) Breadth. Calculations
- Develop structural model, identify constructability issues, costs, durations. Compare / Evaluate
- Write-up!
- Research, Interview Construction Companies and Owner
- Develop mock-up model
- Evaluate decision making / produce checklist
- Evaluate external costs
- Occupant impact
- Write-up!
- Prepare Slides / Practice

SPRING BREAK

FINAL REPORTS DUE

JURY/FACULTY PRESENTATIONS

SENIOR BANQUET

MILESTONES	ANALYSIS
Complete Research on Analysis	Prefabricated Building Enclosure
Analysis at 75%	Alternative Delivery Method
Finalize Analysis and Breadths	Steel Connections
Complete Report Draft and Presentation Slides Begin	Phased vs. Empty Construction