2013

INTRAMURAL BUILDING ADDITION AND RENOVATION – PHASE I

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Department of Architectural Engineering
Construction Option

AE 481 W – FALL 2013
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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 | Structural Steel Connections

The structural design, being intricate and complex, has a combination of welded, bolted and bolted/welded connections. If the structural design could be altered, to minimize the number welds and maintain the structural sturdiness required, the schedule accelerated and the labor costs reduced. This analysis focuses on altering the design of structural connections in hopes of reducing the schedule, complexity, and costs.

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 Architectural Breadth details**

Analysis 2: Alternate Delivery Method

Problem Identification

Through analysis of the technical assignments, it has been learnt that 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?

Background

Technical report 1 contains information on how the Intramural Building is currently being delivered. Public school projects in Pennsylvania are required by current legislation to be delivered as a multiple prime with at least four separate contracts. This method has been thought to deliver projects in an effective manner, considering both costs and time. It will be interesting to see if an IPD approach could be taken into consideration while also considering the multiple prime method if required by legislature. 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?

Analysis Components

- Collect and attain information on current contractual agreements
- Interview owner (OPP) to determine the feasibility of using Integrated Project Delivery 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 Multiple Prime project.
- Identify aspects of IPD that could improve the coordination, communication and effectiveness for this project (design and construction focus)

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: Structural Steel Connections

Problem Identification

The project was experiencing delays on the critical path while the steel erection was scheduled to start, and it was very important for the schedule to have the building's structure up and steady to progress. Design information was improperly distributed between design team and steel fabricators, and steel was brought to site with unpredicted changes. The structural design, being intricate and complex, had a combination of welded, bolted and bolted/welded connections. While welded connections are more rigid than bolted connections, the time and labor spent while performing is substantially greater. The large moment plate connections on the project required a couple of skilled workers and a full day of hard work to finish one. If the structural design could be altered, to minimize the number welds and maintain the structural sturdiness required, the schedule accelerated and the labor costs reduced.

Background

There are several complex moment connections throughout the structure of the building, and two main questions arise when thinking about them; will the connections be as strong and resistant to loads with bolted connections? What are the requirements and implementations necessary to have minimal structural welds on major connections? Research will be deep and through on the different types and materials of bolts to meet the structural requirements to prevent failure. Bolted connections can withstand high loads and can join structural components with easily and quickly, but they require pre-planning and coordination to take place. Case studies can be researched to identify constructability concerns and the feasibility of minimizing welding implications. Structural calculations will have to be performed to identify size and location of holes on members, material of bolt, and resistance to shear, tension, and compression loads. In addition, the costs of implementing such design will be analyzed in terms of productivity rates (connections), material fabrication and equipment costs, and impact on schedule.

Analysis Components

- Research different types of bolt connections
- Investigate connections which minimize number of welds
- Determine schedule and costs impacts of different connections
- Analyze long and short term pros and cons of different connections
- Discuss with structural professors the design and feasibility of installation
- Communicate with Gilbane, HUB project – engineered bolted connections – prefabricated structural members. Constructability issues, impacts, costs

Expected Outcome

Altering the design structural connections by minimizing the welds can generate issues to the design and construction team, but would be easily fixed by using a more integrated, collaborative team. Fabricating steel members for bolted connections can be costly and take longer to produce; therefore design discrepancies need to be addressed with time and properly to prevent additional costs. Once the design and fabrication of these structural members is completed, the benefits of installation will greatly impact the labor costs and schedule of the project. Depending on the location of these connections, additional structural components might need to be added; if feasible this analysis will be successful.

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

Analysis 4: Phased or Empty Renovation?

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.

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.

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. 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.

Analysis Components

- Conduct research interviews with 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
- Research ways of creating a noise mock-up to help occupants experience construction environment before making phased occupancy decision.
- Investigate productivity rates of phased occupancy vs empty building renovation
- Research effects and costs of transferring occupants to a temporary facility

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%	5%	30%
Alternative Delivery Method	10%	-	5%		15%
Alternative Structural Connections	-	15%	10%	5%	30%
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

Architectural Breadth | Technical Analysis 1

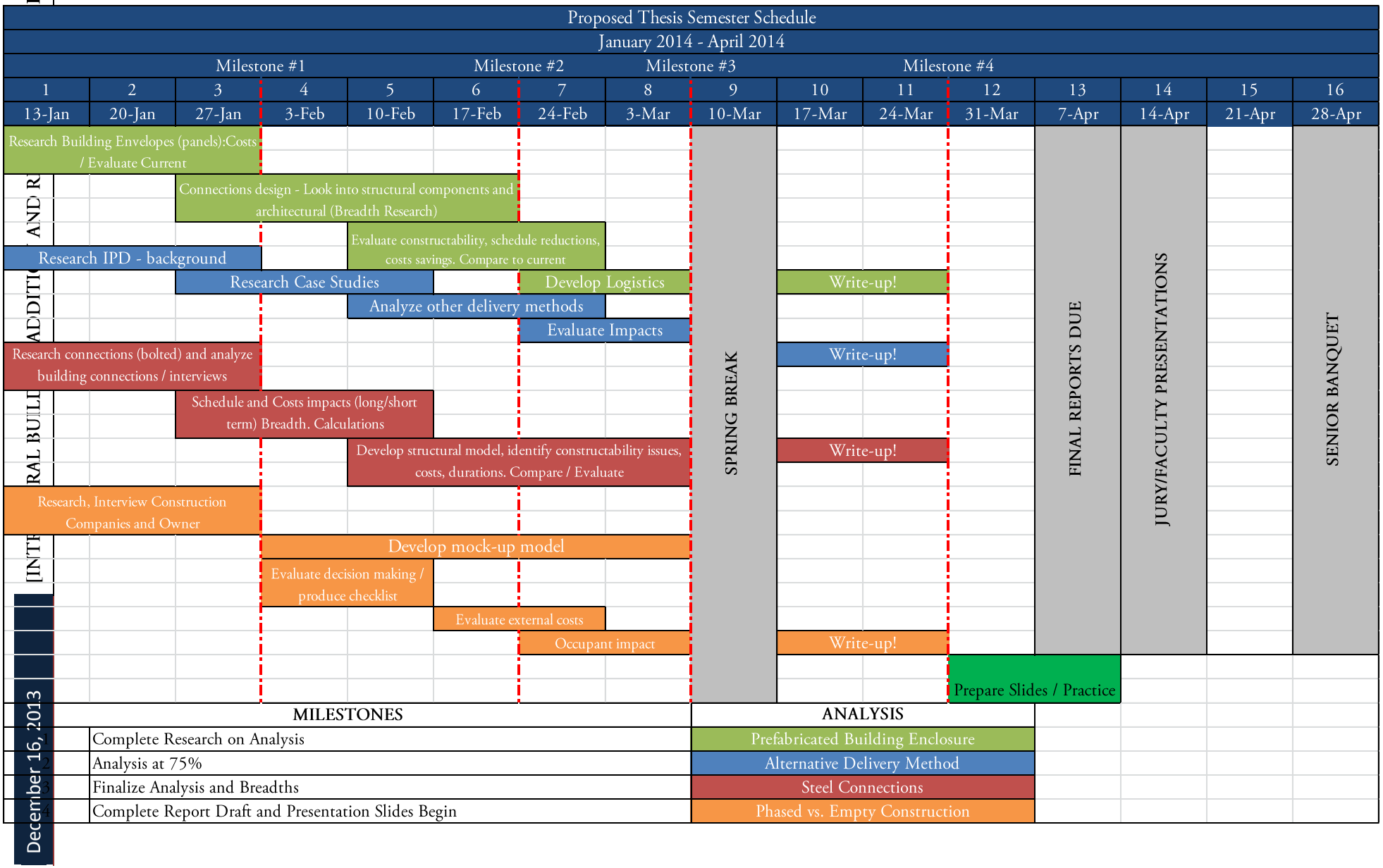
The architectural breadth will be directly associated with the building enclosure. The areas of benefit for the prefabricated brick panels is along the West and South-West portions of the building which contains 20 feet high wall sections divided by windows which are not evenly spaced. Proposed change for the brick portion is to evenly space the windows to allow for prefabrication of same size panels to be shipped and erected on site. In addition, the incorporation of a modular curtain wall system will provide the opportunity to research modular systems which are operational and easier to install than stick built systems. Both structural and thermal concepts will be considered to evaluate the possibility of incorporating these two systems. It is also very crucial to prevent major changes to the façade, while keeping the owner pleased with not only the performance, but also the aesthetic view of the building. Architectural sections, views and details will be included to illustrate the proposed system.

Structural Breadth | Technical Analysis 1 and 3

The structural system of the intramural is oddly shaped and contains complex connections. Since connections were designed to be welded, bolted and both; an evaluation and alteration of design will be performed to minimize the amount of welds on site in hopes of reducing the costs of the labor and durations associated with the inspections and placement of welds. The redesign of these structural connections might need additional members to have the same structural performance, and also need to be specially fabricated. Even though these might raise the costs of steel fabrication, the on-site labor costs have the potential to be reduced, as well as the installation times. A thorough investigation on the several connections of the building can be performed to identify where it would be beneficial to minimize welded connections or implement more bolted connections in regards to provide structural support. In addition, prefabricating brick panels and curtain wall systems presents the need of developing a tie in system to hang, erect and connect these two systems to the structural steel and floors. Different connections and tie-ins will be researched in hopes to attach these systems to the building's structure while still keeping the building water-tight.

APPENDIX B

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