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Senior Thesis Final Proposal

Penn State AE Senior Thesis

UMBC
Performing Arts &
Humanities Facility
Baltimore, MD

Courtney L Glaub
Construction Management
Dr. Chimay Anumba

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Executive Summary

The Senior Thesis Final Proposal is intended to discuss the three analyses that will be performed for the final thesis report on the UMBC Performing Arts & Humanities Facility. Each topic is centered on the theme of improving the efficiency in the construction industry. The topics include the use of precast brick through prefabrication, the comparison between a mobile crane and a tower crane, and the use of PV panels on the roof.

Analysis #1

Since the university has certain goals for this project to be completed on time and efficiently for the students, the use of prefabrication may be very useful. Also, being that the building is made up of three different structural elements, this poses a challenge of erecting the building because adjacent work has to stop in order for a certain area to be completed. The confusion of the sequence of elements will also lead into the masonry having difficulties erecting the brick veneer façade in the same manner. The goal of this analysis is to replace the brick veneer with precast brick panels. A preliminary design of a precast masonry wall system will be performed to see how the use of prefabrication will impact the schedule, cost and trade coordination on site.

Analysis #2

Being that the site utilizes a tower crane positioned on the southwest corner of the building that has a very large swing radius for a smaller building footprint, it is not necessary to have such a large crane. There is enough space on site that the possibility of using a few mobile cranes instead may help save time and cost. The goal of this analysis will be to investigate the production, cost, schedule and site logistic impacts associated with utilizing mobile cranes instead of a tower crane that would allow the project to stay below the budget and on time.

Analysis #3

The UMBC Performing Arts & Humanities Facility is projected to achieve LEED Silver Certification upon completion. However, the project has utilized very few sustainable techniques that could provide a financial benefit to the university. The goal of this analysis is to perform a preliminary design of a building integrated PV energy system and determine the financial achievability to incorporate the system into the power plan to reduce energy costs for the owner. This analysis will include the second part of the structural breadth by analyzing load requirements and additional structural support for the PV panels. Also, an electrical breadth study will be performed to determine how much power will be produced from the PV panels and to see how much energy is saved over the years.

Project Background

The UMBC Performing Arts & Humanities Facility project includes a new state-of-the-art facility for the University of Maryland Baltimore County's Arts and Humanities departments that will enhance its teaching, research and public outreach programs while simultaneously improving the visibility of the arts and humanities as a major component of campus and community life.

The Performing Arts and Humanities Facility (PAHF) will be situated on 4.8 acres on the west side of Hilltop Road, adjacent to the existing Fine Arts, Engineering and ITE Buildings. The construction for this new $67 million building consists of a four story, 90,000sf facility providing a variety of performing arts amenities. The building includes a 275 Seat Proscenium Theater, a 100 Seat Black Box Theater, Scene Shop, Theater Rehearsal Studio, Acting/Directing Studio, Dressing Rooms, Support Spaces, Seminar Rooms, Classrooms, Conference Rooms and Administrative Offices. Another part of the project includes upgrades to the existing Central Utility Plant and a concrete structure/tunnel connecting the existing Plant Tunnel to the new Performing Arts Facility.

An interesting aspect of the PAHF is that it's comprised of multiple structural features. The exterior façade of the building consists of an assortment of materials creating a strong relationship with the current campus buildings. The North elevation, shown in Figure 1, is primarily comprised of brick veneer with certain areas being backed up by CMU. Also shown is a curtain wall system made up of aluminum framing with insulating glass. The Northeast elevation showing the Proscenium Theater on the left, in Figure 2, is made up of stainless steel wall panels, backed up with concrete and steel studs. The remaining building elevations are made of aluminum composite metal wall panels and different types of corrugated metals.

Figure 1: North Elevation

Figure 2: Northeast Elevation

The largest challenge associated with this project is the complicated relationship between the site excavations, structural excavation, foundations and structural elements. Certain areas are isolated structurally causing a delay in the progress of adjacent work. Although there are struggles throughout the construction of this building, the UMBC PAHF project is participating in the United States Green Building Council's Leadership in Energy and Environmental Design (LEED®) program and is striving for a LEED® Silver Certified rating. This project is expected to be the first building on campus to earn LEED® Certification.

Analysis #1: The Use of Precast Brick through Prefabrication

Problem Identification

Since the university has certain goals for this project to be completed on time and efficiently for the students, the use of prefabrication may be very useful. Also, being that the building is made up of three different structural elements, this poses a challenge of erecting the building because adjacent work has to stop in order for a certain area to be completed. The confusion of the sequence of elements will also lead into the masonry having difficulties erecting the brick veneer façade in the same manner. Their work will have to stop if other work adjacent to it is not complete, causing major delays.

Research Goal

The goal of this analysis is to perform a preliminary design of a precast masonry wall system and see how the use of prefabrication will impact the schedule, cost and trade coordination on site.

Methodology

- Research precast masonry wall panel systems
- Contact a manufacturer for design consultation
- Design a preliminary precast system for the exterior façade
- Analyze the impact to the structure from the precast system loads
- Determine transportation requirements to ship the precast
- Analyze the impact to the cost, schedule and constructability

Resources and Tools to be Used

- Precast Manufacturer
- Industry Professionals
- AE Faculty
- Relevant literature
- Whiting Turner and Architect/Engineer

Expected Outcome

After completing extensive research and an in-depth design, it is believed that a precast masonry panel system will effectively reduce the masonry schedule and eliminate any delays that the trade coordination may have. While the precast system may prove to be more expensive than the hand-laid masonry, the savings to the schedule time would greatly help getting the project done even faster.

Analysis #2: Mobile Crane vs. Tower Crane Comparison

Problem Identification

As mentioned above, it is critical for the project to stay on schedule and get completed by a certain date for the students to start using the new facility. Being that the site utilizes a tower crane positioned on the southwest corner of the building that has a very large swing radius for a smaller building footprint, it is not necessary to have such a large crane. This type of crane takes numerous trucks to transport it to the site and then have to erect the crane when it arrives. There is enough space on site that the possibility of using a few mobile cranes instead may help save time and cost. This would allow the project to stay below the budget and on time for school to start.

Research Goal

The goal of this analysis will be to investigate the production, cost, schedule and site logistic impacts associated with utilizing mobile cranes instead of a tower crane.

Methodology

- Determine what size mobile cranes must be used to make all the picks
- Determine a new site logistics plan
- Contact Whiting Turner & suppliers to determine the overall costs of the tower crane and mobile crane
- Analyze the productivity of the mobile cranes compared to the tower cranes
- Determine the schedule impacts of a mobile crane instead of a tower crane
- Perform cost comparison

Resources and Tools to be Used

- Whiting Turner Project Team
- Crane Suppliers
- AE Faculty
- Relevant literature

Expected Outcome

After extensive research, it is believed that utilizing a few mobile cranes instead of a tower crane will accelerate the schedule and also have some cost impacts. This acceleration will lead to the construction team completing the project on time and effectively per the owners requests.

Analysis #3: Feasibility Study on PV Roof Panels

Problem Identification

The UMBC Performing Arts & Humanities Facility is projected to achieve LEED Silver Certification upon completion. However, the project has utilized very few sustainable techniques that could provide a financial benefit to the university. Features such as photovoltaic (PV) roof panels can be identified as a possibility, not only to provide more LEED points but also the energy produced will be sold back to the grid and eventually save the university money in the long run.

Research Goal

The goal of this analysis is to perform a preliminary design of a building integrated PV energy system and calculate how much energy is produced to determine the financial achievability to incorporate the system into the power plan and reduce energy costs for the owner.

Methodology

- Research PV panel technologies and sustainable design techniques
- Determine the quantity of panels to be placed on the roof
- Contact PV panel manufacturers for design consultation
- Analyze how the structure will be affected with added PV panel loads
- Feasibility analysis on life cycle cost and payback period

Resources and Tools to be used

- Industry Professionals
- AE Faculty
- Project Engineers/Designers
- AE 498D (Photovoltaic Systems Design and Construction)
- Relevant literature

Expected Outcome

Through extensive research and design, it is expected that a building integrated photovoltaic energy system will provide the university with an impressive financial benefit through reduction in power grid dependency. It is not practical to produce all of the building energy loads with the PV system; however a significant portion will be accounted for with the renewable energy source. It is believed that the financial model will prove that the PV system is affordable and financially beneficial due to the life cycle cost considerations.

Analysis Weight Matrix

The weight matrix, shown below in Table 1, depicts how each analysis accounts for the three main core areas of investigation. The percentages represent expected time and effort that will be allocated for the core areas in each respective analysis.

Analysis Description	Research	Value Engineering	Constructability Review	Schedule Reduction	Total
Prefabrication of Precast System		20%	5%	15%	40%
Crane Comparison			15%	15%	30%
Feasibility Study on PV Panels	30%				30%
Total	30%	20%	20%	30%	100%

Table 1: Weight Matrix for Distribution of Core Areas of Investigation

Timetable

In order to stay on task and meet project goals, a preliminary semester timetable has been developed to schedule work progression for each technical analysis. See APPENDIX B for the spring semester preliminary timetable.

Conclusions

Through in depth research and thorough investigations, the proposed technical analyses will provide a comprehensive review of improving efficiency in the construction industry. It is expected that by prefabricating a precast system of brick veneer, it will reduce the schedule and help save on the cost of the project. Comparing the mobile crane with the existing tower crane will help eliminate the costs of the tower crane and potentially reduce the schedule by having a more accessible piece of equipment that can be broken down and removed easily from site. Finally, incorporating a photovoltaic energy system on the roof of the building will reduce energy costs for the owner and add to the sustainable features of the project.

This proposal is intended to be a working submission with revisions expected based on feedback from the thesis consultants.

APPENDIX A – Breadth Topics

Breadth Topics

The following topics involve a more detailed analysis in distinct technical disciplines with the major. Each topic contributes to one of the previously mentioned analyses, which are identified accordingly.

Structural Breadth: Contributes to Technical Analysis # 1 and Technical Analysis # 3

The current façade on the humanities portion of the building consists of built up brick veneer. The substitution of the brick veneer walls with a precast panel system will be analyzed to determine the effects on the existing structure. Placing the precast panel system on the structure may impact the loads on connections which would then need to be reconfigured.

The addition of photovoltaic panels on the roof will also require a structural analysis to determine the loading and support requirements.

Any additional support and connections that are determined to be required for the precast panels and the photovoltaic system will be designed and evaluated for cost and schedule impacts.

Electrical Breadth: Contributes to Technical Analysis # 3

The electrical system has 15kv medium voltage feeders that come off of the substations. A unit substation consists of two 15kv, 600 amp switches (incoming); one 15kv, 600 amp switch (outgoing); 2500 KVA transformer; and 3200 Amp, 480Y/277 volt, 3 phase, 4 wire, 60 hertz switchgear. Power will be distributed at 480Y/277 volts and dry type transformers will be provided to supply 208Y/120 volt loads.

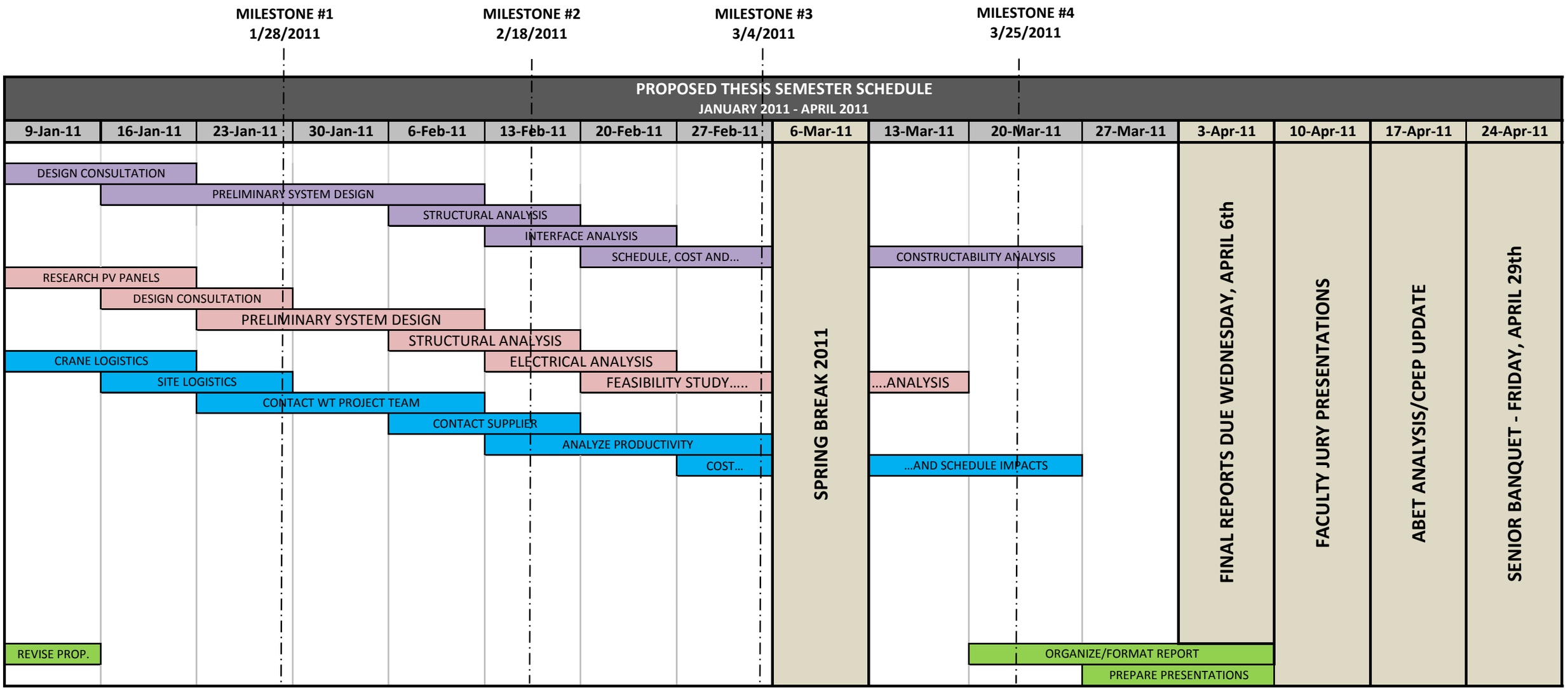
Integrating renewable energy from a photovoltaic system into the energy system will be analyzed to determine the electrical equipment and connection requirements and also to calculate how much power will be produced to save energy in the future. The electrical system shown above will be altered to make tie-ins for the renewable energy source. Additionally, a constructability review will be performed to ensure the electrical system is suitable for the requirements of the PV panel system.

APPENDIX B – Spring Semester Preliminary Timetable

SENIOR THESIS FINAL PROPOSAL
1/13/2011 (REVISED)

UMBC PERFORMING ARTS AND HUMANITIES FACILITY

COURTNEY GLAUB
CONSTRUCTION MANAGEMENT
DR. CHIMAY ANUMBA



MILESTONE ACTIVITY LIST:

1. COMPLETE ALL DESIGN CONSULTATIONS FOR ANALYSES #1 AND #2
2. COMPLETE PRELIMINARY DESIGNS FOR PRECAST FAÇADE AND PV SYSTEM
3. COMPLETE ALL SPECIFIC ANALYSES FOR EACH ANALYSIS
4. COMPLETE ANALYSIS #2

ANALYSIS DESCRIPTION:

- ANALYSIS #1: PRECAST BRICK THROUGH PREFABRICATION (STRUCTURAL BREADTH)
- ANALYSIS #2: COMPARISON OF MOBILE AND TOWER CRANE
- ANALYSIS #3: STUDY OF PHOTOVOLTAIC ENERGY SYSTEM (ELECTRICAL & STRUCTURAL BREADTH)

ONE OF THE ANALYSES WERE DROPPED PER DISCUSSION WITH ADVISOR