ARCHITECTURAL ENGINEERING SENIOR THESIS

George Mason University
Student Union Building I

Fairfax, VA

Thesis Proposal

Brett Robinson
Construction Management
AE Faculty Consultant: Chris Magent
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Executive Summary

The following proposal is intended to provide an overview of the four topics that will be researched in the spring semester for the final thesis report on the George Mason University Student Union Building I project. Based on the previous research of challenges faced for the SUB I project team, this proposal's main focus will be tailored to the surrounding occupied facilities and the small project site. The following four topics will each be dedicated to these challenges. A timetable and weight matrix will be included to further verify the procedures to accomplish the proposed solution.

Critical Industry Issue – BIM/IPD in Design-Build

For the first analysis, an investigation will be conducted on the impending impacts of building information modeling. Research will be done through various interviews and case studies. Through this research, an Execution Plan specifically tailored to Design-Build and the SUB I project will be developed. Another topic that will be assessed in this segment will be Integrated Project Delivery. This section will also address the topic of the tight site conditions that are experienced on the GMU SUB I project.

Analysis I – In-Depth Safety Plan

As a construction manager it is imperative to provide a safe, accident-free, and healthy work environment for everyone. Due to the difficult site condition and occupied facilities surrounding the SUB I project, developing in-depth site specific safety plan will be very beneficial to both the project team and the university. The safety plan will address risks and hazards associated with the project site.

Analysis II – Emergency Power Analysis

The Existing Student Union Building that will connect to the SUB I project has a Student Health and Wellness Center located on the third floor. Electrical shutdowns to this building were a critical issue expressed in the interview with the project management team. Health care facilities are highly dependent on reliable sources of electrical power. Based on the mechanical breadth topic criteria, design considerations of the emergency power generator will be conducted. A contingency plan will assist the facilities management in assessing the vulnerability of the medical facility during an outage.

Analysis III – Metal Panel Portion of the Building Envelope

As mentioned during the project management interview with Greg Ramirez of Hess Construction + Engineering Services, value engineering has already been considered on the GMU SUB I project. The addition of metal panels was one of the of the VE issues presented. It is believed that these metal panels will conflict with the architecture of the surrounding buildings. The building façade will be examined during this section. Pre-Cast Architectural Panels and a Prefabricated Building Envelope System will be considered as topics of interest. Two major items in this section will include the schedule reduction and tight site constructability or site logistics of the project.

Project Background

George Mason University has had rapid growth at all of the campuses over the last couple of decades. George Mason's student population has increased to over 18,000 undergraduates. This growth has led to an increased demand for on-campus Student Union support and office space as George Mason University develops its educational operation. To satisfy this order of expansion, GMU has facilitated a 65,382 Gross Square Foot, four story addition to the existing Student Union Building I, located off of Aquia Creek Lane, soon to be renamed George Mason Boulevard. The addition will house meeting spaces, offices, and student service and activity spaces. With this in mind, George Mason University has decided to implement a design-build process to construct the addition to the existing Student Union Building I. This process will be in accordance with the Commonwealth of Virginia design-build procedures. The building will cost approximately $17.5 million. The project started in June of 2009 and is slated to finish in July of 2010 (estimated). The architects on the project are Grimm + Parker Architects and WTW Architects. Hess Construction + Engineering Services will be the Design-Builder. As for the building itself, the structural system used is structural steel. The brick veneer will consist of a color to balance the brick of the existing Student Union Building. To meet the requirements of DEB Notice 120108- Virginia Energy Conservation & Environmental Standards, Section 709.1, SUB I project will follow the LEED Certification process. But due to the GMU central plant utilizing CFC-based refrigerants and no phase out plan, the project will not meet the prerequisite requirements (EApr3) of the LEED Rating System so the building is not eligible for certification through the USGBC. Hess Construction + Engineering Services will be providing the Bureau of Capital Outlay Management (BCOM) with the LEED documentation. This is a new process for BCOM with no established procedure, Hess Construction + Engineering Services will be providing a "self certification program" which will be a comprehensive, multi-layered review and approval process throughout design and construction that will demonstrate LEED compliance to BCOM.

Figure 2 - Interior Rendering

Figure 1 - GMU SUB I Site

Technical Analysis Issues

Critical Industry Issue – BIM/IPD in Design-Build

Problem Background

One of the critical topics at this year's PACE Roundtable Meeting was Building Information Modeling. The GMU SUB I project is strictly utilizing 3D modeling for the coordination of the major trades on-site. These trades would include the architecture, steel, MEP, and fire protection systems. There are a few problems with the use of this tool on the GMU SUB I project. As expressed in the PACE Roundtable Meeting, BIM is not being used to its fullest potential. The subcontractors are not contractually obligated to the use of the tool. This can create many constructability and scheduling conflicts further into the project. Another problem that was discussed during the interview, the design team felt the construction was much further along than the design. This was expressed as a problematic feature of BIM in the design-build delivery method.

Potential Solutions

The use of BIM could have been used throughout the project to assist in the design and site coordination. Since a 3D Model was used for coordination of major trades, this is a great opportunity to further investigate the full implementation of BIM on this project. Another item that will be considered when doing the research will be Integrated Project Delivery (IPD). The use of IPD throughout the project could also benefit the project with early contributions of knowledge and experience. IPD can also bring a proactive approach throughout the project duration. The utilization of these tools could save time and solve constructability problems earlier in the project. I propose to develop a Building Information Modeling Execution Plan according to the Design-Build delivery method and the GMU SUB I project.

Solution Methodology

1. Research
    a. Case Study Research
        i. BIM in the Design Build Delivery Method
        ii. Integrated Project Delivery with Design Build
    b. Industry Interviews
        i. BIM
            1. Software Programs Used
            2. What BIM Goals should be set for the project
            3. How does BIM improve integration of the Design of the project
            4. How does BIM improve integration of the Construction Team
            5. What are the BIM Deliverables especially in information exchanges
            6. Important Processes/Procedures when using BIM
            7. Cost of Implementation
        ii. IPD
            1. Role in Design-Build
                a. Benefits of IPD

   b. Detriments of IPD
   c. Cost of Implementation
2. IPD with BIM
   a. Benefits of this process
   b. Detriments of this process
   c. Cost of Implementation
3. IPD without BIM
   a. Benefits of this process
   b. Detriments of this process
   c. Cost of Implementation

2. Compile and Analyze Research
   a. Is it beneficial to use IPD with BIM on this Project
   b. Is it beneficial to use IPD without BIM on this Project
3. Develop Outline for Crucial Elements in Execution Plan
4. Develop an Execution Plan specifically tailored to Design-Build and the SUB I project according to the research
5. Evaluate Execution Plan

Preliminary Resources and Tools

- Hess Construction + Engineering Services SUB I Project Management Team
- Industry Professionals
- Professional Journals
- buildingSMART alliance
- The National Institute of Building Sciences
- The American Institute of Architects
- Autodesk Revit
- Autodesk Navisworks
- Microsoft Project

Expected Outcome

I expect that the research involved with Building Information Modeling, Integrated Project Delivery and Design-Build will allow for a greater understanding in the challenges faced in the industry. An execution plan that is tailored specifically to the design-build delivery method would be developed according to the information gathered from the case studies and professional industry interviews. This execution plan could greatly benefit this project as well as projects in the future.

Technical Analysis Issues

Analysis I – In-Depth Safety Plan

Problem Background

One of the first constructability challenges expressed by Greg Ramirez on the George Mason University Student Union Building I project was the occupied facility of the Existing Student Union Building. The Existing Student Union Building will remain open to students and faculty throughout the duration of the SUB I project. This poses a constant safety concern for the project team. Also, George Mason University has been ever more concerned with the safety of its students since the injury of a student tripping over a silt fence on another construction site. The contractor, responsible for the incident, compensated for the student's medical bills. In respect to this particular project, Hess Construction + Engineering Services will have to maintain the Emergency Exits in the Existing Student Union Building. Overhead protected walkways were installed to allow the construction to continue where the new SUB I connects to the existing Student Union Building. Hess Construction + Engineering Services will also have to maintain a safe environment to allow access for any vendors providing services for the existing building. This would include kitchen and food vendors, office vendors, and/or trash and recycling collection.

Potential Solution

As a construction manager it is imperative to provide a safe, accident-free, and healthy work environment for everyone. Due to the close proximity of the jobsite to occupied areas and planned changes in the means of egress of occupants, special precautions must be taken to ensure the safety of everyone in the area. The development of an in-depth site specific safety plan will further assist in the accomplishment of this goal.

Solution Methodology

1. Research
    a. OSHA requirements for safety plans
    b. Specific Party Responsibilities
        i. Contractor
        ii. Owner
        iii. Design Engineers
    c. Existing Site Specific Safety Plans on the SUB I Project
        i. Implemented Site Specific on SUB I Project
        ii. Safety Requirements by George Mason University
    d. Safety Plans in accordance to other construction projects on the GMU Campus
        i. Data Center – Whiting Turner Construction
        ii. The Mason Inn Conference Center and Hotel - Balfour Beatty
        iii. Performing Arts Center
2. Develop a basic rubric for crucial safety specific items
    a. Means of Egress to Existing Student Union Building
    b. Job Site Security
    c. Pedestrian Traffic

    d. Existing Building Traffic
3. Develop an in-depth SUB I specific safety plan
4. Implementation Strategies
5. Evaluate the safety plan in regards to:
    a. OSHA requirements
    b. Owner requirements
    c. Contractor requirements

Preliminary Resources and Tools

- OSHA 1926 – Safety and Health Regulations for Construction
- ASCE – Policy Statement 350
- George Mason University SUB I Request for Proposal (RFP)
- George Mason University Representatives
- Hess Construction + Engineering Services SUB I Project Management Team
- Industry Professionals

Expected Outcome

Through extensive research, I expect to develop an in-depth, easy to use site specific safety plan. This safety plan will provide the construction management team with a clear representation of the hazards and risks anticipated on the project. The safety plan will incorporate not only all trades and subcontractors but the student, faculty and vendors of George Mason University.

Technical Analysis Issues

Analysis II – Emergency Power Analysis

Problem Background

To continuing with the challenges faced with the occupied facilities, particularly as it pertains to constructability and the adjoining Existing Student Union Building on the project, all utilities had to be coordinated with the university in the event of any shutdowns. In the event of any shutdowns, as to the owner's policy, George Mason University has to be notified two weeks prior to any shutdown. Specifically on this project the relocation of the main electrical transformer. The electrical transformer was located in the footprint of the SUB I project on the north side. The transformer had to be relocated to the northwest corner of the site. Underground electrical conduit was installed before the relocation to further the process. Shutdown had to occur during the off hours of the Existing Student Union Building. As I looked further into this situation, I found there is a Health and Wellness Center located on the third floor of the Existing Student Union Building. The Health and Wellness Center consists of sixteen exam rooms, nurse's station, immunization room, pharmacy, and lab. Any power outages that could occur due to construction on the SUB I project could be deemed as a harmful situation to many individuals. This could also cost the university thousands of dollars in medicine that are to be refrigerated.

Potential Solutions

Health care facilities are highly dependent on reliable sources of electrical power. Each health care facility must assess the risks of an electrical power failure. Each risk carries a variable degree of magnitude and impact to the medical facility. Planning and facilitating the development of contingency plans while assessing the vulnerability of the medical facility during an outage. I propose to establish a contingency plan to reduce the risk of adverse events.

Solution Methodology

1. Research
    a. How crucial is it to maintain operation during power outages
    b. How quickly must the emergency power come on
    c. How long should the emergency power be available for
    d. What locations within the facility will and will not be powered by the emergency power
    e. Contingency Plan for the Health and Wellness Center
    f. GMU Testing of Emergency Generators
        i. Procedures
        ii. Testing
2. Standards and Codes for minimum design, installation, and testing of these systems
    a. National Electric Code (NFPA 70)
    b. Standard on Health Care Facilities (NFPA 99)
    c. Standard for Emergency and Standby Power Systems (NFPA 110)
3. Evaluate Risks

   a. Assess risks of the current system
   b. How can these risks be reduced
4. Evaluate the current Emergency Generator
   a. Specifications
   b. Scheduled Shutoff
5. Evaluate the new Emergency Generator
   a. Specifications
      i. Fuel Tank
      ii. Support Equipment
      iii. Proper Redundancy
   b. Scheduled Shutoff
   c. Optimal Location of the Generator
6. Develop a basic rubric for a power outage contingency plan
7. Develop an in-depth SUB I power outage contingency plan
8. Implementation Strategies
9. Evaluate the contingency plan in regards to:
   a. Code requirements
   b. Owner requirements

Preliminary Resources and Tools

- Hess Construction + Engineering Services SUB I Project Management Team
- Industry Professionals
- National Fire Protection Association
- Emergency Power Supply System
- The Joint Commission
- Other Hospitals/Student Wellness Centers

Expected Outcome

Through extensive research, I expect to develop an in-depth, easy to use contingency plan for the George Mason University Student Health and Wellness Center. This contingency plan will provide the university with a clear representation of the hazards and risks anticipated with an outage event. This contingency plan will include procedures for facility managers to control the testing process and performance improvement purposes. I will also look into the designing and requirements for a new emergency generator.

Technical Analysis Issues

Analysis III – Metal Panel Portion of the Building Envelope

Problem Background

The original design called for a brick veneer with metal panels. Through value engineering, the amount of brick was reduced to make way for more metal panels. Currently, the Existing Student Union Building has a brick veneer with precast architectural panels. It is believed that the use of metal panels will not only conflict with the design of the connecting Student Union Buildings, but also conflict with neighboring buildings.

Potential Solutions

A potential solution to this design conflict to the neighboring building is to use Pre-Cast Architectural Panels where Metal Panels are utilized. By reevaluating this exterior design of the SUB I project, the aforementioned façade types could potentially create a schedule acceleration on the project with a cost savings benefit. One major factor to consider the use of Pre-Cast Architectural Panels is site logistics. Another potential solution is the use of a prefabricated building envelope system. This system will essentially cost more in the beginning but will cause labor savings and schedule reductions. Both of these panel systems will be placed with the use of a crane. Like the precast panels, a site logistics consideration must be taken into account when evaluating this product. Another key aspect of research is the structural component of this evaluation. An in-depth look at the structural load path and detailed connections will be taken into consideration.

Solution Methodology

1. Research
    a. Metal Panels - Contact Subcontractors
        i. Costs
            1. Panel Costs
            2. Delivery Costs
        ii. Schedule
            1. Lead Times
            2. Construction Scheduling
        iii. Specifications
            1. Standard Sizes and Dimensions
            2. Architectural Properties
            3. Moisture Performance Properties
            4. Thermal Performance Properties
            5. Structural Performance Properties
                a. Durability
                b. Quality
                c. Evaluate Load Distribution on Frames
        iv. Connection Types
            1. Metal Panel to Steel
            2. Metal Panel to Masonry
        v. Planning

1. Using BIM
    a. Showing Installation of Panels
    b. Site Logistics of Panel Work
2. Site Layout
3. Site Equipment

b. Pre-Cast Architectural Panels - Contact Subcontractors
    i. Costs
        1. Panel Costs
        2. Delivery Costs
    ii. Schedule
        1. Lead Times
        2. Construction Scheduling
    iii. Specifications
        1. Standard Sizes and Dimensions
        2. Architectural Properties
        3. Moisture Performance Properties
        4. Thermal Performance Properties
        5. Structural Performance Properties
            a. Durability
            b. Quality
            c. Evaluate Load Distribution on Frames
    iv. Connection Types
        1. Pre-Cast Architectural Panel to Steel
        2. Pre-Cast Architectural Panel to Masonry
    v. Planning
        1. BIM
        2. Site Layout
        3. Site Equipment

c. Prefabricated Building Envelope System - Contact Subcontractors
    i. Costs
        1. Panel Costs
        2. Delivery Costs
    ii. Schedule
        1. Lead Times
        2. Construction Scheduling
    iii. Specifications
        1. Standard Sizes and Dimensions
        2. Architectural Properties
        3. Moisture Performance Properties
        4. Thermal Performance Properties
        5. Structural Performance Properties
            a. Durability
            b. Quality
            c. Evaluate Load Distribution on Frames
    iv. Connection Types
        1. Prefabricated Building Envelope System to Steel

2. Prefabricated Building Envelope System to Masonry

v. Planning
1. Using BIM
a. Showing Installation of Panels
b. Site Logistics of Panel Work
2. Site Layout
3. Site Equipment

2. Evaluation of both system
a. Cost Impacts
b. Schedule Impacts
c. 3D Modeling
i. Site Logistics
ii. Installation of Systems
3. Summarization and Recommendation of Façade Element

Preliminary Resources and Tools

- George Mason University Master Plan
- Metal Panel Subcontractors
- Pre-Cast Architectural Panel Subcontractors
- Prefabricated Building Envelope System Subcontractors
- GMU SUB I - Specifications
- Microsoft Project
- Autodesk Revit
- Autodesk Navisworks

Expected Outcome

By analyzing the building façade in this manner, I believe that the GMU SUB I building will have a better connection architecturally to the George Mason University Master Plan. The use of Pre-Cast Architectural Panels will reduce the systems cost of the façade, while the use of a Prefabricated Building Envelope System will reduce the schedule duration. This schedule duration reduction is very crucial. At this particular point of the project, weather has been an issue and has caused a slight delay in the project. Consequently, any schedule reduction would be beneficial to the project.

Tentative Timetable

Week	Date Starting	Date Ending	BIM	In-Depth Safety Plan	Emergency Power Analysis	Metal Panel Building Envelope
0		1/10		OSHA & Specific Party Research	Research Standards and Codes	
1	1/11	1/17	Industry Interviews	Existing Site Specific Safety Plans Research	Research Standards and Codes	Research Metal Panels
2	1/18	1/24	Industry Interviews	Other GMU Construction Projects Safety Plans Research	Evaluate Risks	Research Pre-Cast Architectural Panels
3	1/25	1/31	Case Study Research	Compile and Analyze Research	Evaluate the current & New Emergency Generators	Research Prefabricated Building Envelope System
4	2/1	2/7	Compile and Analyze Research	Develop a basic rubric for crucial safety specific items	Minimum Design Calculations, Installation, and Testing for New Generator	Cost Impacts
5	2/8	2/14	Compile and Analyze Research	Develop in-depth SUB I specific safety plan	Develop basic rubric for a power outage contingency plan	Schedule Impacts
6	2/15	2/21	Develop Outline for Crucial Elements	Develop in-depth SUB I specific safety plan	Develop in-depth SUB I power outage contingency plan	Site Logistics
7	2/22	2/28	Develop Execution Plan	Implementation Strategies	Implementation Strategies	Summarization and Recommendation of Façade Element
8	3/1	3/7	Evaluate Execution Plan		Evaluate the contingency plan	
9	3/8	3/14	Spring Break - Write Final Report			
10	3/15	3/21	Write Final Report			
11	3/22	3/28	Proof Read Final Report			
12	3/29	4/4	Create Presentration			
13	4/5	4/11	Practice Presenation			
14	412	4/18	Present			

Weight Matrix

The weight matrix below represents how time will be allocated among research and analysis previously mentioned within the proposal.

Description	Research	Value Engineering	Constructability Review	Schedule Reduction	Total
Critical Industry Issue – BIM	10	0	10	5	25
In-Depth Safety Plan	10	0	10	0	20
Emergency Power Analysis	10	0	10	0	20
Metal Panel Building Envelope	5	15	5	10	35
Total	35	15	35	15	**100**

Table 1 – Weight Matrix Illustrating Time Distribution

Conclusion

The George Mason University Student Union Building I is a vital building in the expansion of the Fairfax campus. Like any project, there are challenges faced throughout the duration on site. It was expressed in the project management interview with Greg Ramirez of Hess Construction + Engineering Services that a tight project site with the occupied facilities of a college campus were the top constructability issues.

Although there are other issues involved on the project, the four analyses that were chosen best fit my interests in the project and will not only benefit the project but also my continuing education in the Architectural Engineering – Construction Management field. The research that will be conducted will further my understanding of the topics selected. The topics selected involve not only the critical issues expressed by the project management team but also key industry topics. In this case, the topic is Building Information Modeling. Along with key industry topics, research in breadth topics such as structural and mechanical will further my career in the industry. I feel that becoming aware of critical issues early will benefit the project, the owner, and the surrounding management team. The abovementioned areas of research will also allow me to further educate other individual related to that particular project or issue.

Appendix
Breadth Topics

Mechanical Breadth

Based on the Mechanical Breadth Analysis rubric, I will research the effects of Emergency Power to the occupied GMU Student Health and Wellness Center. Through this research I will answer the following questions:

- How crucial is it to maintain operation during power outages?
- How quickly must the emergency power come on?
- How long should the emergency power be available for?
- What locations within the facility will and will not be powered by the emergency power?
- What Contingency Plan is already in place for the Health and Wellness Center?
- What are the GMU Testing procedures for Emergency Generators?

This research will also look at the minimum design, installation, and testing for the new emergency generator that will be installed on site.

Structural Breadth

The breadth areas that will be considered in the metal panel building envelope analysis will be structural. The structural system will be impacted due to the change from metal panels to either precast architectural panels or a prefabricated building envelope system. The new imposed loads will need to be considered when installing the new façade to the building. To accomplish this, an analysis of the load paths will be performed for the new systems. If the existing structural system is not capable of supporting the proposed new loads, one option is to resize the structural members to allow for the imposed loads. Both value engineering and schedule reduction are crucial when considering these façade and structural changes.