

ARCHITECTURAL ENGINEERING SENIOR THESIS

George Mason University Student Union Building I

Fairfax, VA

Technical Assignment III

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Construction Management

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Executive Summary

This Technical Assignment will identify several areas of the George Mason University Student Union Building I for further research. Over the course of this semester I have kept in contact with the design and project management team at Hess Construction + Engineering Services. The following Technical Assignment will continue investigating key issues concerned with the GMU SUB I project. These key issues are broken down into Constructability, Schedule Acceleration Scenarios, and Value Engineering Topics.

A formal interview was held on November 23, 2009 with Hess Construction + Engineering Services Project Manager, Greg Ramirez. The interview was conducted on-site at the GMU Campus. The interview also consisted of a site walkthrough to gain a further understanding of tasks completed since my internship on the GMU project this summer. The top three constructability issues that were discussed were Occupied Facilities, Tight Project Site, and Design-Build Challenges. This was the main topic of conversation throughout the interview. The next topic that was discussed consisted of Schedule Acceleration Scenarios. At the current time this is a key topic on the GMU SUB I site. A key feature in this portion was the conversation of the critical path. The interview concluded with numerous value engineering topics that were proposed for the project.

The next section includes some of my own observations. This section looks at some key problem issues that I have concluded from my work on-site and throughout this thesis project. Some of these topics have appeared in previous Technical Assignments.

Finally, I have developed four construction management analysis activities to address the problems and challenges that have appeared in the aforementioned sections. Each topic will give a synopsis of the problem, key research ideas, and a process for the final analysis of the problem and solution. These topics consist of Building Information Modeling, Delivery Method, Mechanical Systems Design, and Metal Panels. Through these topics there will be a discussion of constructability, schedule acceleration, and value engineering. I will also discuss possible breadth studies for the final proposal.

Project Manager Interview

On November 23, 2009, I conducted an interview with Hess Construction + Engineering Services Project Manager, Greg Ramirez concerning the George Mason University Student Union Building I Project. Greg is the Project Manager for the SUB I project. The interview was done on-site. The following topics were discussed in the interview constructability challenges, schedule acceleration scenarios, and value engineering topics. To gain further insight into these topics this Technical Assignment will identify areas of the project for further research.

Constructability Challenges

Occupied Facilities

The major issue expressed in the interview with Greg Ramirez was the issues involved with the occupied use 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. A secured construction site is vital to ensure safety among the students and faculty. George Mason University has been 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. On the lines of safety, Hess Construction + Engineering Services also have to maintain the Emergency Exits in the Existing Student Union Building. Overhead protected walkways are installed to allow the construction to continue where the new SUB I connects to the existing Student Union Building. Hess Construction + Engineering Services also has 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.

As it pertains to constructability and the adjoining occupied facilities on the project, all utilities had to be coordinated with the university in the event of any shutdowns. Specifically on this project both the relocation of the main electrical transformer and the water lines both located on the north side of the building (See Figure 1 for further details of Building Locations). 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. The main electrical transformer was located in the footprint of



Figure 1 – Building Locations

the SUB I project. 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. A similar shutdown event occurred with the installation of the new water lines. The existing water lines ran parallel building just under the footprint of the new SUB I project. Originally for the ease of a shutdown event, the new installed water lines were going to be connected to the existing lines inside the mechanical room of the Existing Student Union Building. Due to space limitations the new water lines had to be connected to the existing lines outside the existing building. A shutdown event still occurred during the off hours of the Existing Student Union Building.

Coordination plays a fundamental role in the constructability of this project. As mentioned previously, according to the George Mason University policy, the university has to be notified two weeks prior to any shutdown. Every week an owner's progress meeting is held. These meetings allow the design team the opportunity to notify the owner of any concerns with safety or any potential shutdown events.

Tight Project Site

One of the major issues that been brought up in both the First and Second Technical Assignments is the concern that the SUB I site is extremely tight. To reiterate, there is no construction parking allowed on-site. Workers have the option to pay for a semester long parking spot. George Mason University allows for on-campus construction material deliveries for the project at an alternate location if needed. This option has not utilized to this point in the construction of the SUB I project.

Since the Student Union Building I site is so tight, coordination among trades is essential. To put this project as a whole in retrospect, the footprint of the building is 164'-8 1/2" by 116'2" and the site is approximately 260' by 150'. This allows for approximately 40 to 50 feet around three sides of the project. When considering the coordination especially during the early stages of the project, such as site utilities, foundations, concrete, and various site demolition. Greg Ramirez discussed during the interview that the northeast corner of the project posed a major concern after finding an abandoned fuel tank filled with slurry. The fuel tank was in the footprint of the building and in the area of the drilled Geopiers at the corner of the building (See Figures 2 and 3 for further details).

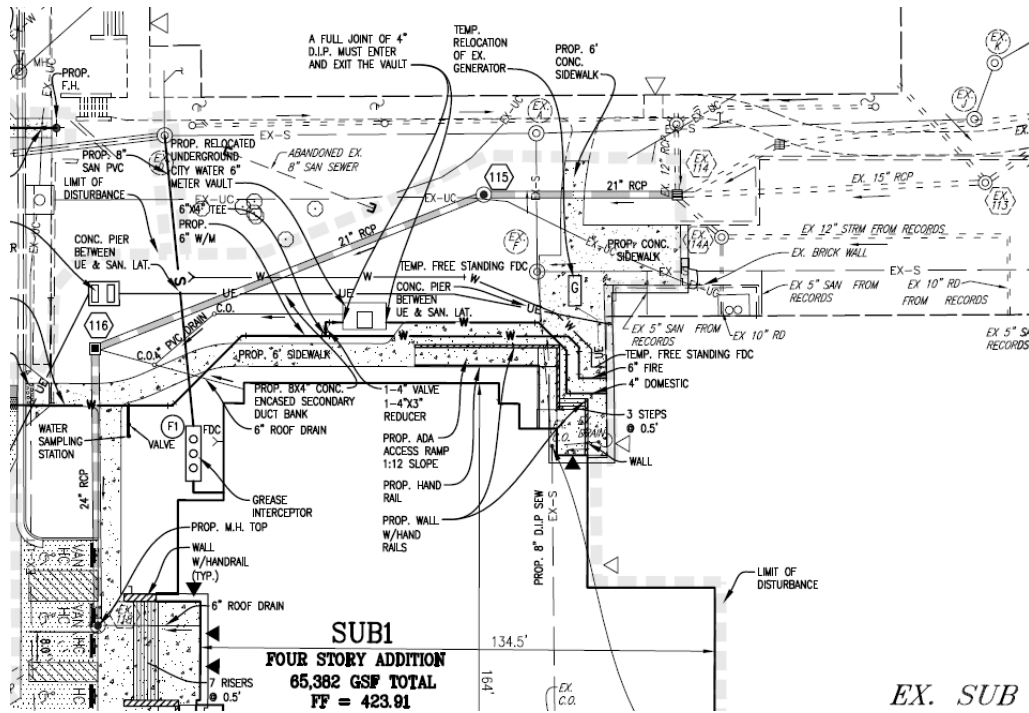


Figure 2 – Site Utilities (Northwest Corner SUB I)

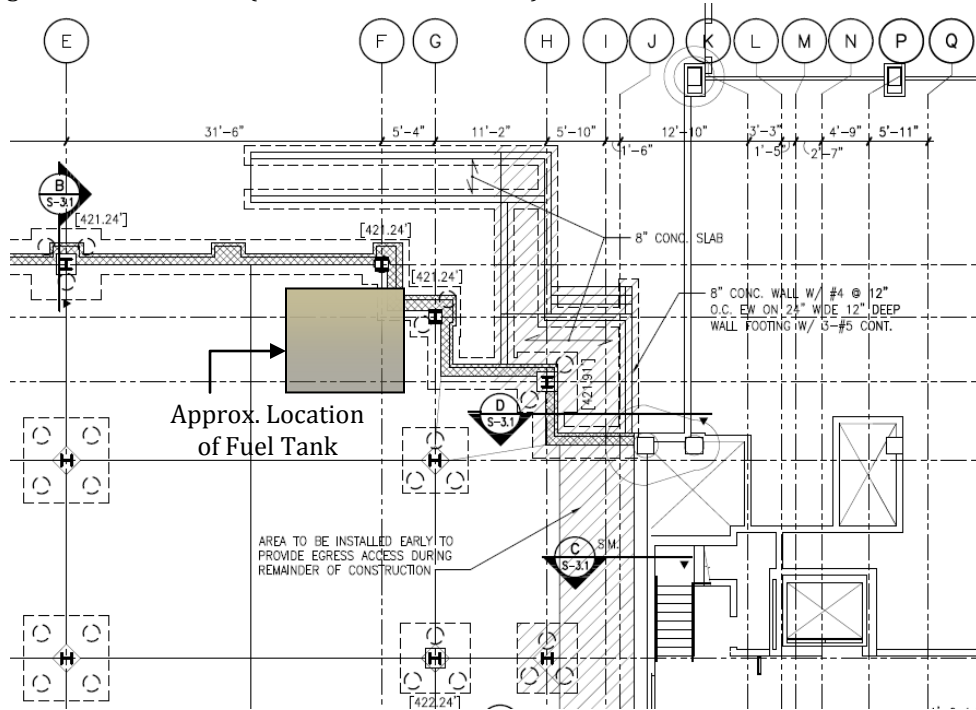


Figure 3 – Geopier and Foundation (Northwest Corner SUB I)

In this specific area, the fuel tank had to be removed; seven Geopiers had to be drilled, concrete work for the foundation had to be performed, and the installation of a new storm line needed to be connected to the existing storm line. These activities involve four different subcontracting companies. During this time on site, there were as many as

fourteen pieces of equipment including one excavator for demolition, one excavator with a drilling rig, two backhoes, and three skid steers.

To alleviate the potential problems that could have and could still possibly occur on the project site, the design team is responsible to hold coordination meetings with the subcontractors. In this case, the project team held weekly coordination meetings with the subcontractors. This allowed all the participants the ability to understand all the subcontractors' schedules and scopes of work. It also allowed the contractors the ability to ask questions and suggest other options to ease constructability.

Design-Build Challenges

The third and final constructability issue that was discussed by Greg Ramirez on the GMU SUB I project concerned with the delivery method type of design-build. On this particular project there were certain challenges that pertained to not having a full set of drawings and specifications. This was specifically a challenge with specialty items mainly with long lead times. It was expressed that these items were difficult to release. Another concern came with inspections of these long lead time specialty items. Two examples came within the installation of the new High Temperature Water (HTW) lines and the Fire Sprinkler system. The HTW lines needed a special inspection both to remove the existing High Temperature Water lines and to proceed with the turn-on of the new HTW lines to the Existing Student Union Building (See Image 1 for further details of HTW Removal). The lines had to be mitigated for these inspections. As it pertains to the Fire Sprinkler system, the Bureau of Capital Outlay Management or BCOM requires the Fire Sprinkler shop drawings to be approved before the wall close-in inspections occur. The BCOM process itself poses problems with the construction process. It is very difficult for the construction manager to foresee these specialty items if the specifications are not completed.

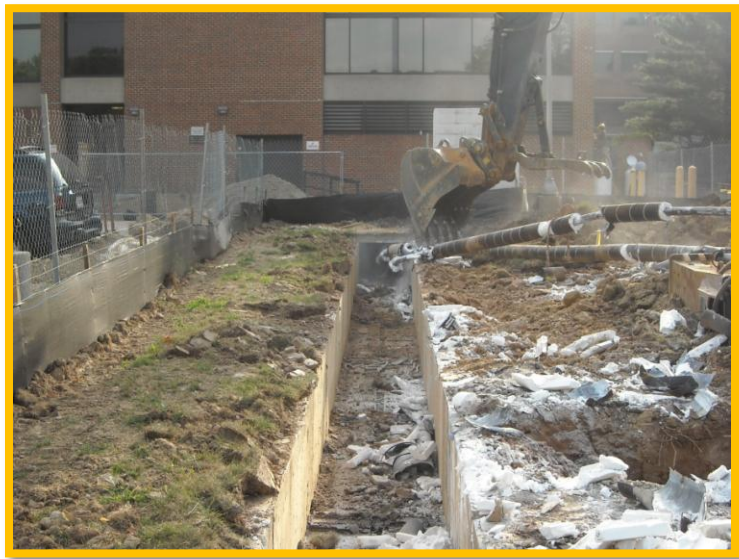


Image 1 – Demolition of HTW Lines

The design team felt the best way to mitigate any problems that may occur during this process was to utilize the owner progress meetings to stress the importance of some of these specialty items. By showing the importance of these items at the meeting allows the owner, design team, and the subcontractors involved to continue to work out issues and to close out any outstanding issues.

Project Manager Interview

Schedule Acceleration Scenarios

Critical paths are important to follow to maintain a steady flow for a project. They are also important for finishing any project on time or early (See Figure 4 for Critical Path Sequence for the GMU SUB I project). The first event in the critical path was the Site Work/Substructure/Geopier phase. This phase essentially entailed of getting the building out of the ground. This phase started in July of 2009. The next event in the critical path is the steel which started in November of 2009. Currently the steel in the project is 65 to 70 percent complete. Upon completion of the steel, work on the building envelope and spray insulation will start. This event is slated for the end of December 2009. The critical path will then move to the interior the MEP rough-ins and interior rough-in and finishes. Building closeout completes the critical path sequence in May 2010.

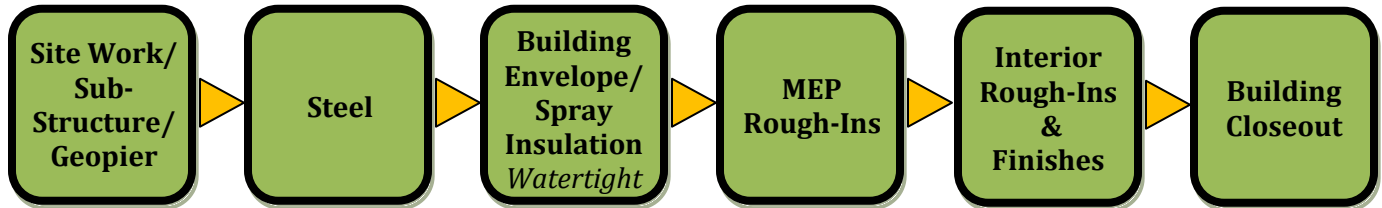


Figure 4 – Critical Path Sequence

One of the main things that Greg Ramirez discussed during the interview was the importance of the building to the occupants. This building provides occupancy for numerous user groups from all over the Fairfax Campus. All areas must be completed to accommodate these user groups. According to Greg Ramirez, the biggest risk to achieve this goal is a watertight status for the building. To this particular point of the project, weather has been an issue and has caused a slight delay in the project. Greg discussed many areas that have the potential to accelerate the project to achieve the substantial completion date. The first area for potential schedule acceleration is working overtime in the steel erection phase. This phase is dependent on the weather. Greg expressed that based on the weather to date; it may not be the best solution. The second area for potential schedule acceleration is in the building envelope. The building envelope consists of a 6" metal framing 16" on-center and spray foam insulation. These tasks are considered very quick processes. Some time could be made up to gain this watertight stage for the project. One benefit of the spray foam insulation is the foam is made of a watertight material and as soon as the insulation is installed the building is watertight. It was also stated that making all the exterior activities as productive as possible would benefit the schedule of the project. When asked about additional costs for schedule acceleration, it was acknowledged that there could be potential costs. One of the benefits of the Design-Build method is the items are not bought out until the later stages in the project, which allows the project to be proposed as a package with a time frame. This can alleviate costs induced with scheduling conflicts.

Project Manager Interview

Value Engineering Topics

As stated previously, the delivery method is Design-Build. This method does not specifically lock down products for the project. In this case, value engineering is being performed everyday on the project. There were many items of value engineering that were discussed in the interview with Greg Ramirez. One of the main points that was stated in the interview was that any value engineering done on the project will for all intents and purposes benefit the owner.

There were five major areas where value engineering was utilized.

- Metal Panels
- Steel
- Door Security
- HTW Tunnel Lines
- Curtain Wall

Metal Panels

On the east side of the building, the original design called for brick veneer and metal panels. A change in the design was proposed. The change consisted of the deletion of brick veneer and utilizing more metal panels. The change would save money and time on the schedule.

Steel

Changes in the aesthetics of the GMU project, led to additional steel being added to the building's superstructure. Sixteen tons of steel were added to the building. This change cost an additional \$50,000. This design change was proposed by the owner.

Door Security

At the time of the installation of the CMU masonry stairwells, the design of the security was not completed and the door frames were not released. The design team decided to prep the doorways to receive all security measures. This will allow the owner the ability to upgrade the security in the future if needed.

HTW Tunnel Lines

While removing the existing High Temperature Water lines, it was decided by the design team to remove all the lines as opposed to leaving ten feet that was originally proposed. This cost the design team approximately \$5,000. This change gives the owner all new lines to the Existing Student Union Building.

Curtain Wall

Originally, the design for the GMU SUB I called for a storefront system. It was decided by the design team to utilize a curtain wall system. This system will cost more money than the

storefront system but will provide a far superior product for the owner in terms of leak issues.

The only value engineering idea that was proposed but not used was a green roof. Based on the purpose of the project, the green roof was deemed not beneficial for the owner or the building occupants as opposed to the EPDM roofing system that will be used. Since the design is still in the early stages of construction, value engineering will continue to play a vital role in the George Mason University Student Union Building I project.

Observations

Problem Identification

Along with the constructability issues listed above, there are several complications on the George Mason University Student Union Building I project. These issues vary in complexity, but would require research to fully understand the problem and to develop a resolution to the problem. The issues are as followed:

- Design-Build Challenges
- On-Site Tree Preservation
- Building Information Modeling
 - Use in Site Coordination
 - Non-Contractual
- Design Discrepancies with Existing Student Union Building
- Numerous Unmarked Underground Utilities
- Addition of 75 feet of Underground Conduit Commissioned by Virginia Power
- Lack of a Sustainable Procedure through BCOM
- Lack of Sustainable usage in the Energy Performance Category
- User group/Occupancy Material List (Long Process)
- Site Lighting Discrepancies
- BCOM Approval Process (Long Process)
- Design Issues with Drawings

Due to the fact that the project and site is fairly small some of the major issues that have been brought up throughout the last three Technical Assignments will be considered first for further research.

Observations

Technical Analysis Method

Upon further review of the aforementioned conflicts and issues, four construction management activities have been chosen for further research and analysis. The contents of this Technical Analysis will include a brief synopsis of the problem, any research needed, how the analysis will be completed, and possible breadth studies.

Building Information Modeling

SCHEDULE ACCELERATION SCENERIOS/CONSTRUCTABILITY

Synopsis

Since Building Information Modeling was a critical topic at this year's PACE Roundtable Meeting, it would be a good fit for the GMU project. The GMU Project is utilizing 3D modeling for the coordination of the major trades on-site. This would include the architecture, steel, MEP, and Fire Protection systems. There are a few problems with the use of this tool on the project. The subcontractors are not contractually obligated to the use of the tool. This can create a lot of problems 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 poses to be problematic for the 3D model. The use of BIM could have been used throughout the project to assist in the design and site coordination. The full use of this tool could have saved time and solved constructability problems earlier in the project.

Research

To complete this analysis, further research through case studies must be utilized. Particularly, research must be done with the use of BIM in the Design-Build Method. Both the benefits and problems must be looked at to gain a further understanding of the tool. Additional research will be conducted in respects to scheduling and costs for the use of BIM throughout the design and site coordination of the project.

Analysis

Based on the research, developing a project specific implementation plan for the use of BIM in the Design-Build delivery method would be beneficial to any project. The use of this implementation plan can evaluate how successful the execution of a BIM implementation plan would be on the GMU SUB I project. To quantitatively evaluate the success of BIM on the GMU SUB I project, a comparison of the case study data to the time and cost data collected from the project will be conducted.

Delivery Method

CONSTRUCTABILITY

Synopsis

One of the major problems that was expressed in the interview was the delivery method for the project. The challenges pertained to not having a full set of drawings and specifications. This was specifically a challenge with specialty items particularly with long

lead times. It was expressed that these items were difficult to release. Another concern came with inspections of these long lead time specialty items.

Research

To complete research for this topic analysis, several case studies will be performed for Design-Build and other delivery methods that may improve the constructability of the project. The pro and cons of each delivery method will be evaluated through these case studies. Additional research must be completed to evaluate the cost and scheduling effects these methods may have on the project.

Analysis

Based on the research, an analysis of each delivery method will be conducted. All aspects of the Design-Build method will be observed. The analysis will provide a conclusion to determine if the Design-Build method was the correct choice in delivery systems. An additional analysis will be conducted to evaluate any improvement that could be done by both the owner and design team to ease constructability.

Mechanical Systems Design

VALUE ENGINEERING

Synopsis

Since sustainability was a critical topic at this year's PACE Roundtable Meeting, it would be a good consideration for the GMU project. 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. This is a new process for BCOM with no established procedure. Hess Construction + Engineering Services will be conducting a "self certification process" that will demonstrate LEED compliance to BCOM. After looking over the LEED points checklist it seems that the project really lacks in the Optimized Energy Performance category. By reevaluating the Mechanical System on the project the GMU SUB I project will gain valuable energy efficiency for the owner.

Research

Further research must be done for various options pertaining to mechanical systems that are currently available on the market. These mechanical systems will be evaluated on efficiency and cost based on the GMU Design Manual and the GMU base specifications.

Breadth Study

In the consideration of AE 310 (Introduction to HVAC) an energy analysis will be performed to determine the percentage of energy saved based on the new mechanical system. Sizing of the current system will be considered throughout this process.

Analysis

A detailed takeoff must be performed for all the components of the existing mechanical system and new mechanical system. Various quotes from subcontractors in the DC/Virginia

area should be acquired to gain a true market rate estimate for the current and new systems. An investigation will also be done to see how this change in the system will impact the substantial completion of the GMU SUB I project.

Metal Panels

VALUE ENGINEERING

Synopsis

It was expressed in the interview that some value engineering was done on the exterior design. As mentioned, the original design called for a brick veneer with metal panels. The Existing Student Union Building has a brick veneer with precast architectural panels. The use of metal panels may conflict with the design of the neighboring buildings. By reevaluating the exterior design of the SUB I project, this could potentially be a schedule accelerator with a cost savings benefit.

Research

Further research must be done on various precast architectural panels. This research will include cost, lead time, and connection types. Another key research topic is a structural analysis of each product.

Breadth Study

The load paths for both of the metal panels and architectural precast panels must be completed to fully understand the potential of these products. The addition of load onto the building structure may cause an increase in the structural steel design of the SUB I project. This topic will utilize techniques provided in AE 308 (Introduction to Structural Analysis) and AE 404 (Steel and Concrete Structural Analysis).

Analysis

From the research, an analysis will be done on the precast architectural panels for constructability with the SUB I project. Various connection details will be necessary to support the system. Since the site is very tight, site logistics plays a vital role in this product. This may be a crucial factor whether this product is deemed viable for the SUB I project. A cost estimate must be completed to compare both the metal panel system and the precast architectural panels. Various quotes from subcontractors in the DC/Virginia area should be obtained to gain a true market rate. An analysis of the lead times for both products may also have a great impact on the schedule.