ARCHITECTURAL ENGINEERING SENIOR THESIS

George Mason University
Student Union Building I

Fairfax, VA

Final Report

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Construction Management
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Student Union Building I

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General Building Data

Location:	Fairfax, Virginia
Occupancy Type:	Group B (Offices, Classrooms), A-3 (Meeting Rooms larger than 750ft2), A-2 (Restaurant, Dining)
Construction Type:	IIA
Size:	65,382 GSF
Number of Stories:	Four Stories
Dates of Construction:	Start: June 2009 Finish: July 2010 (Estimated)
Cost Information:	$17.5 million

Project Delivery Method: Design Build

Project Team

Architect:	Grimm + Parker Architects WTW Architects
Design Builder:	Hess Construction + Engineering Services
Civil Engineer:	ADTEK
Structural Engineer:	ReStl Designers
Electrical Engineer:	Hurd and Obenchain
Mechanical Engineer:	Shapiro and Duncan
Fire Protection and Security Consultant:	Protection Engineering

Architecture

- Brick veneer – field color to complement the brick of the existing building and accent color to complement the exposed horizontal concrete bands of the existing building
- Storefront window system with aluminum cladding at column
- Aluminum coping and extended soffit
- Stair tower next to Main Entry
- Aluminum coping and canopy over new Main Entry at George Mason Blvd, formally Aquia Creek Lane.
- Low walls and landscaping at entry steps and ramp

Structural System

Foundation:	-Geopier Piles System w/ 3,500 psi Concrete Footings at Steel Columns -3,500 psi Concrete Spread Footing at Exterior Wall
Framing:	-Structural Steel Building -Masonry Shear Walls - reinforced w/ #5@ 8" O.C. and 8 GA horizontal Bed Joint at every course
Facade:	-1/2" gypsum wall board w/ 7/8" resilient hat channel, followed by 6" CMU and 2" R18 Spray applied insulation. Hot dipped galvanized steel masonry ties secure brick veneer to CMU
Roof:	-1.5" 20 gauge Type B steel deck w/ fully adhered fiberglass-reinforced PVC Energy Star sheet roofing, 3" insulation supported on K-Series steel joists

MEP Systems

- Two AHU (1st Floor & 4th Floor) - 30,000 CFM, 460 Volts, 3 Phase
- Six Types of VAV Boxes (Max CFM ranging from 400 to 1200 CFM)
- Two 700 Nominal CFM Fan Coil Units - 120 Volt, Single Phase
- Two Base Mouinted 300 GPM Hot Water Pumps - 480 Volts, 3 Phase
- Total Load for Existing and New Student Union Buildings - 1,384.5 KVA, includes:
  - Existing Building Highest Demad Load - 528 KVA
  - New Motor Load - 421.8 KVA
  - New Receptacle Load - 235.5 KVA
  - New Lighting Load - 89.8 KVA

Table of Contents

Acknowledgements

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  - Greg Ramirez
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- IPD
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Executive Summary

The following is a comprehensive analysis for the George Mason University Student Union Building I, located on the Fairfax, VA campus. There are four main Technical Analysis Issues with a construction management emphasis in each topic. Also included in this analysis are Project Background Information, Client Information, Architecture, Site Information, and Structural Information. This analysis will consist of a general theme focusing on the students/general public.

Critical Industry Issue – BIM in Design-Build/IPD

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. 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 through recommendations specifically for BIM Execution Plan.

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. This section will include a Site Specific Safety Plan Rubric section (includes Reasons for Further Development) and a Site Specific Safety Plan proposed additions section.

Electrical Breadth – 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, a load design analysis of the current emergency power generator will be conducted. This section will also include a Contingency Plan Rubric section (includes Reasons for Further Development) and a Contingency Plan proposed additions section.

Structural Breadth –Building Envelope Analysis

During the project management interview conducted with Greg Ramirez of Hess Construction + Engineering Services, value engineering (VE) had been considered on the GMU SUB I project. One of the first VE items considered was the addition of metal panels. Through value engineering, the amount of brick was reduced to make way for more metal panels. This analysis will consider three options for the SUB I project, Metal-Faced Composite Panels, Pre-Cast Architectural Panels, Aluminum Storefront System. The results show an additional cost of $15,579.94 with a schedule reduction of one day. The reason for the addition is because of a survey given to students comparing the aforementioned building envelopes.

Introduction

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.

Figure 1 - Interior Rendering

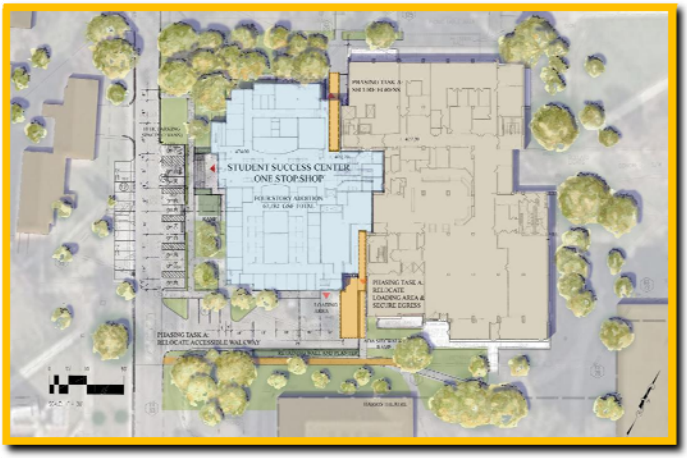

Figure 2 - GMU SUB I Site

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.

Project Overview

Client Information

At the current time, George Mason University is very familiar with the construction process and design-build contracts. Currently, George Mason University has eight construction projects being performed on the Fairfax, Virginia campus. The Design Build process will be discussed further in the next section, Project Delivery Systems.

Safety is very important for the university. The existing student union building, which is directly next to and will eventually connect to the new SUB I project, will remain open for student and faculty. With construction being performed directly next to this building, as well as all over campus the safety of the students and faculty poses a major issue. Safety will be discussed throughout the final report. Quality is another vital part of this project for GMU. As stated in the RFP, "The University intends to realize a project that meets its requirement for efficient and durable facilities as well as meeting contemporary standards for the student centers for intuitions for higher learning. It is its intension to encourage innovative planning resulting in the enhancement of campus life of students through the design of its facilities and its surroundings." With respect to quality, GMU had a $20,627,000 budget slated for the SUB I project.

To meet the owner's satisfaction, the master plan delineates a new campus framework to create an academic setting that is compact, rational and readable. Pedestrian "streets", semi-enclosed quadrangles, quality open spaces and vistas combine in a coherent whole. The campus framework provides a flexible structure for future campus program elements while creating a unique sense of place. The framework is comprised of six fundamental elements:

- Arrival
- Main streets and quadrangles
- Connections
- View and Landmarks
- Natural systems
- Compact Core

Project Delivery System

Design Build Participants

There are essentially three key players in the project delivery of the George Mason University Student Union Building I project. As stated in the client information section, George Mason University is the owner of this project. All third party inspections are subcontracted out to EMSI Engineering, Inc. The delivery method chosen by GMU itself is Design-Build. Essentially, all construction that is being performed on the Fairfax Campus is Design-Build. Hess Construction + Engineering Services is the design builder and Grimm + Parker is the Architect. Hess Construction + Engineering Services was chosen for their competitive low bid and expert knowledge in construction in the education field. Grimm + Parker is a key designer in educational facilities in the DC, Maryland, Virginia area.

Grimm + Parker have several consultants for each major design portions of the project. This includes mechanical, electrical, life safety, structural, civil, etc. These groups each perform designs of their respected division, code analysis, and preliminary Building Information Modeling. The trade contractors to Hess Construction + Engineering Services, on the other hand, are contracted under lump sum and were selected through the lowest competitive bid.

Please See Figure 3 below for further graphical detail.

Bonds and Insurance

Under the Commonwealth of Virginia, a Standard Performance Bond (CO-10) and a Standard Labor and Material Payment Bond (CO-10.1) were used between the contractor, surety, and owner. In effort to insure this risk management, Insurance Associates were brought in for this specific task.

Project Team Overview

Owner – George Mason University
Design Builder – Hess Construction + Engineering Services
Architects – Grimm + Parker Architects, WTW Architects
Civil Engineer – Adtek
Structural Engineer – ReStl
Mechanical Engineer – Shapiro & Duncan
Electrical Engineer – Hurd & Obenchain, Inc.
Fire Protection and Security Consultant – The Protection Engineering Group
Concrete Subcontractor – F&B Concrete
Electrical Subcontractor – Ennis Electric

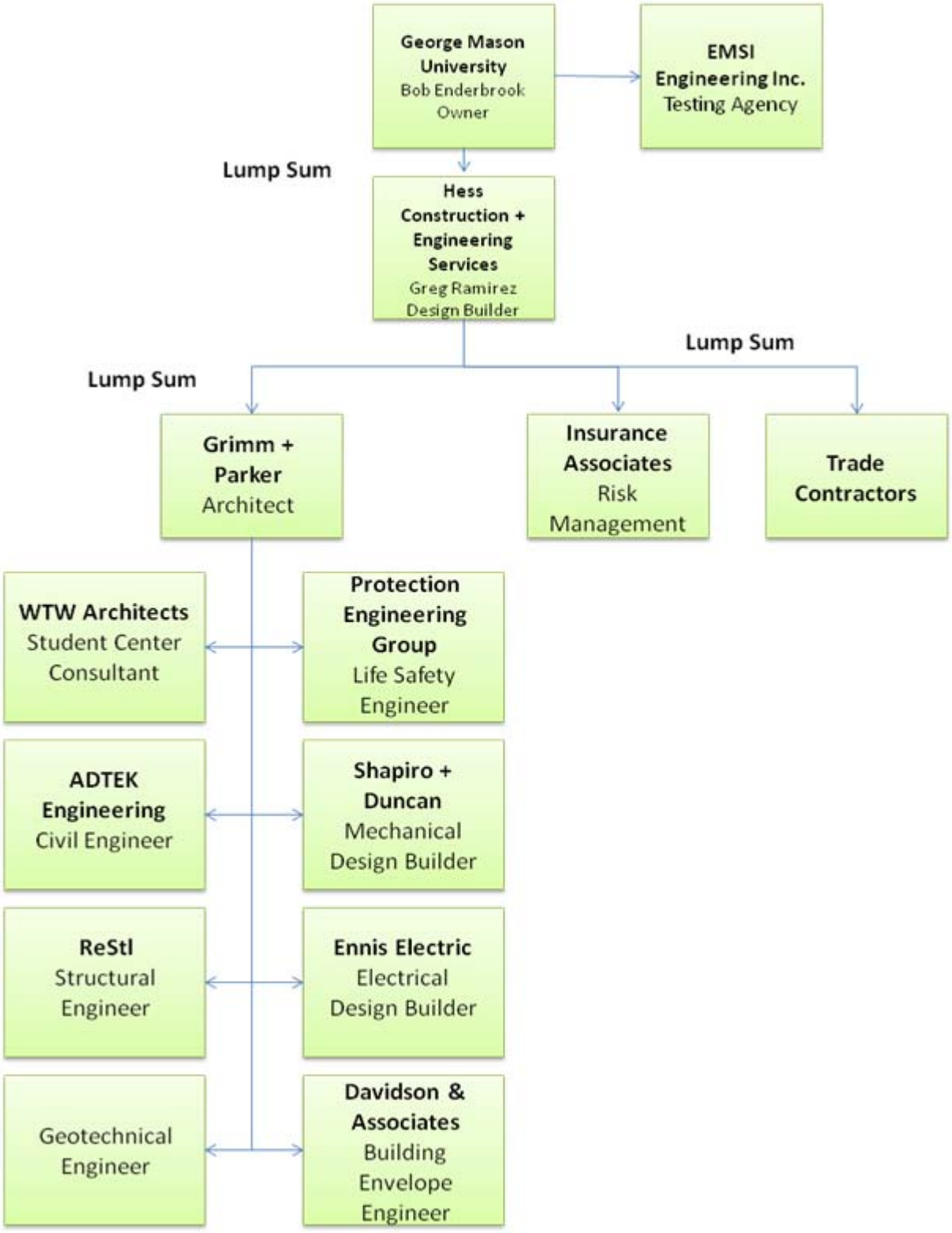

Figure 3 – Project Delivery System

Project Management Staffing Plan

This is the typical staffing plan for Hess Construction + Engineering Services. Hess's main focus is on educational construction in the DC, Maryland, and Virginia areas. This staffing plan shows both the on-site and in-home office personnel. The main focus will be on the on-site staff. This particular staffing plan also is for later in the project. At this current time, the GMU project is still in the early phases of construction. The following Figure 4 expresses the staffing plan.

Project Executive

The project executive is responsible for the entire staff for this specific project. Michael is a key contact person between the owner, architect, and the trade contractors' project managers. Michael attends the weekly owner's meeting at GMU. With an architecture background, Michael has played a vital role in the design process of the Student Union Building.

Project Manager

The project manager is responsible for the successful completion of the SUB I project. Greg's main responsibilities consist of writing and reviewing contracts, payment requisitions, and overall preparation of project schedule. Greg also works on preparing subcontractors' project procedure, processing change orders, and establishing a schedule of values.

BIM Manager

The BIM manager is responsible for the overall BIM process. Saurabh acts as a liaison between the subcontractor's BIM/IT personnel. He gathers all the BIM models, compiles the models together, and performs clash detection tests in Navisworks.

Field Engineer

The field engineer is responsible for tracking and distributing RFI's, reviewing submittal, and photographing the progression of the project.

Superintendent

The superintendent is responsible for the coordination between subcontractors on-site, maintaining the schedule, and creating a look-a-head schedule for future construction activities. Merrill in charge of quality control observations and maintains quality control through detailed daily reports.

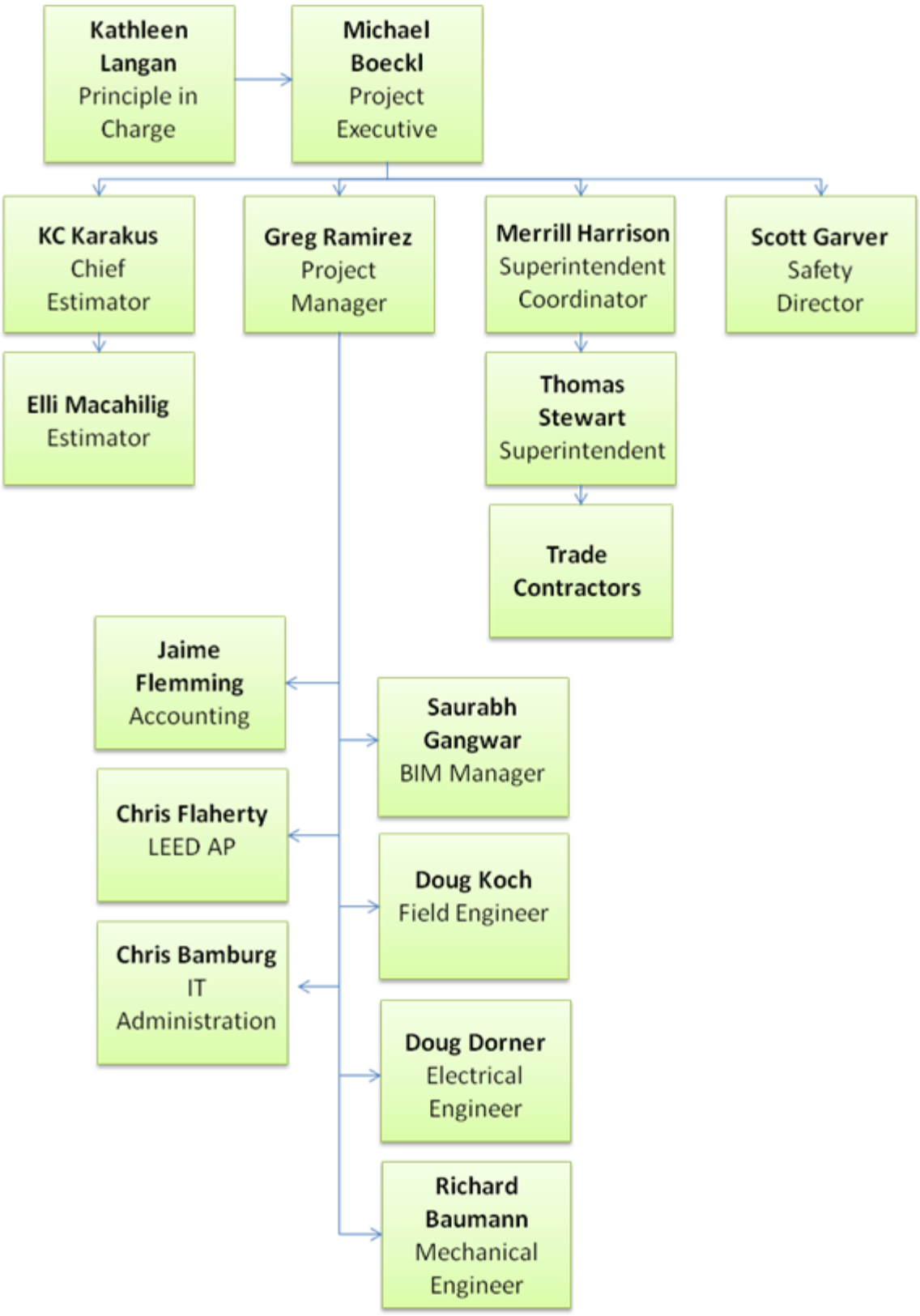

Figure 4 - Project Management Staffing

Architecture

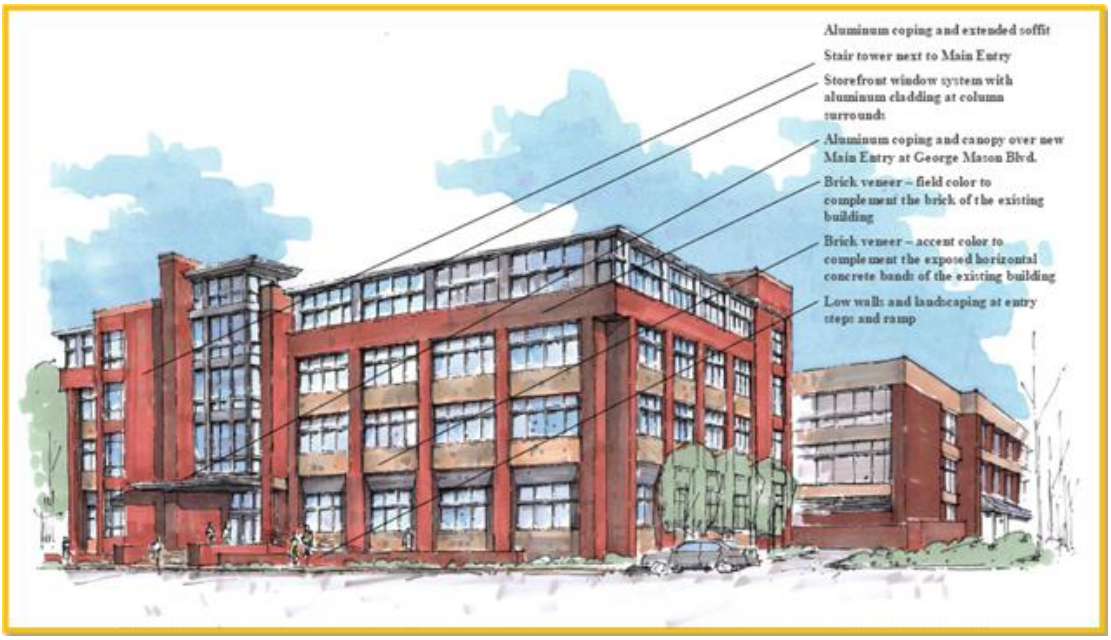

Figure 5 – SUB I Architectural Features

As shown in Figure 5, the exterior features will consist of Aluminum coping and extended soffit crowning the top of the building. The brick veneer will consist of a color to balance the brick of the existing Student Union Building and will also have an accent color to complement the exposed horizontal concrete bands of the existing building. Floors one through three will have a storefront window system with brick veneer where the columns are located, while the fourth floor will have a storefront window system with aluminum cladding where columns will be located. A stair tower will be located next to the Main Entry which will be protected by aluminum coping and canopy at George Mason Blvd.

Building Façade

Floors one through four have similar wall enclosures. The wall system consists of 1/2" gypsum wall board with a 7/8" resilient hat channel. This is followed by 6" CMU and 2" R18 Spray applied insulation. Hot dipped galvanized steel masonry ties secure the brick veneer to the CMU. Continuous membrane base flashing and weep holes will allow for proper drainage. All four floors will have aluminum storefront adding ample daylighting to the building.

Roofing

The Student Union Building I has a flat roofing system. The system is comprised of a fully adhered fiberglass-reinforced PVC Energy Star sheet roofing system with a minimum of 3" insulation on metal decking. This roofing makeup is then supported on top of K-Series steel joists. SUB I also has a parapet wall that runs along the outer edge of the roof. The parapet wall has a pre-formed aluminum roof edge with aluminum fascia and trim.

Site Information

The George Mason University Student Union Building I is located on the Fairfax, Virginia Campus (As Shown in Figure 6). The project is off of Aquia Creek Lane. The project is surrounded by a newly constructed 3 story Data Center (North), an existing 3 story Student Union Building (West), a 2 story Student Housing complex (East), and the 1 story Harris Theatre.

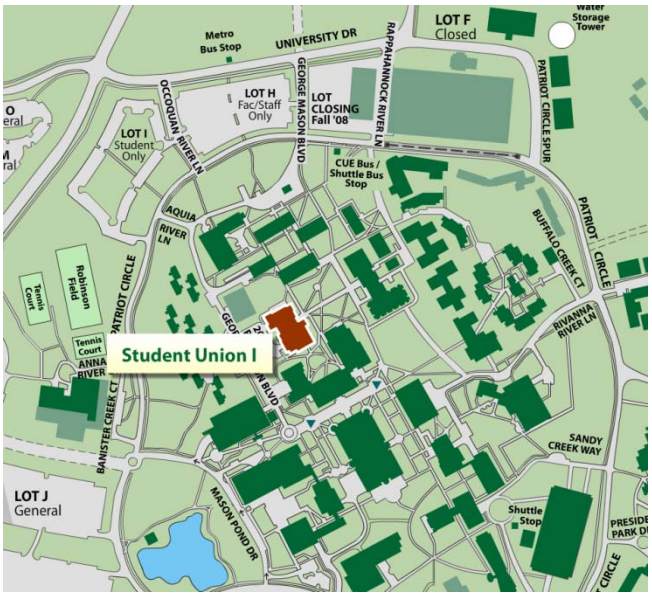

Figure 6 - SUB I Location on Campus

The item that makes this construction project so unique is that the site is very compact. The site is so tight, there will be no construction parking allowed on-site. Workers have the option to pay for a semester log parking spot. George Mason will also allow for on-campus construction material deliveries for the project at an alternate location if needed.

Geotechnical Consulting & Testing Inc. performed a subsurface evaluation by drilling (9) test boring. The borings were at refusal depths from 10 to 40 feet below the ground surface. Soils classified are in accordance with ASTM D2488 "Description and Identification of Soils" and the Unified Soil Classification System.GMU SUB I is located in a Piedmont Physiographic Province. The ground has a rolling upland surface underlying by complexly folded and faulted crystalline rocks. The rocks are generally fine to coarse grained, lustrous, greenish-gray, reddish weathering, quartz-rich schist, and lesser mica schist, phyllite, and gneiss.

The existing Student Union Building I is supported on a deep foundation system consisting of drilled piers. The maximum column loads for the building addition are anticipated at 480 kips and maximum wall loads of approximately 1 kip per linear foot. Due to the presence of deep undocumented existing fill, a deep foundation system is recommended for support of the proposed building addition. Based on the subsurface information and anticipated loads of the building, the estimated settlement of the 30" geopiers will not exceed 1/2". Subsequently, lifts of 12" aggregate will be placed into the hole and compacted to form a bell shape (As shown in Figure 7). Once this process is completed this will furnish a net allowable bearing capacity of 6,000 psi at the bottom surface of the footing element.

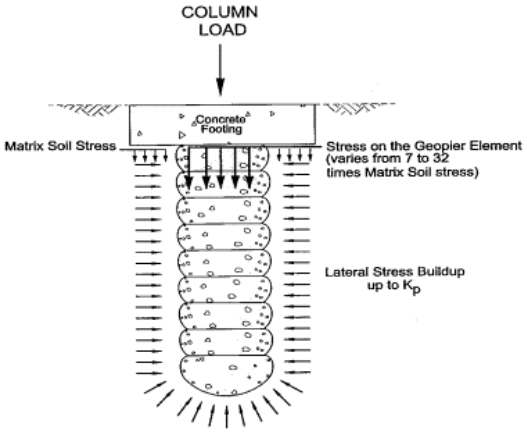

Figure 7 - Geopier Cutaway

Structural

The structural system used in the George Mason University Student Union Building I is structural steel.

The design loads for the Student Union Building I are as followed:

- Live Loads
  - Assembly Areas – 100 psf
  - Administrative Offices – 80 psf + 20 psf (Partitions)
  - Stairs and Corridors – 100 psf
  - Storage (Light) – 125 psf
  - Mechanical Rooms – 150 psf (or Heavier per Equipment Weight)
  - Roof – 30 psf
- Snow Loads
  - Ground Snow Load (Pg) – 25 psf
  - Snow Exposure Factor (Ce) – 1.0
  - Snow Importance Factor (I) - 1.2
  - Flat Roof Snow Load (Pf) – 26 psf + Snow Drift

(All Roof Areas are designed for Minimum 30 psf Live/Snow Load)

The Student Union Building will use wide flange beams and columns that conform to ASTM A992/A992M–06a. The typical beam is a W21x44 into a W21x44 girder. The wide flange beams range from W12x14 to W21x68. The wide flange columns range from W10x33 to W12x87. The Headed Stud–Type Shear Connectors conform to ASTM A108–07. These are Cold-Finished, Grade 1015 or 1020 shear connectors. Anchor Bolts conform to ASTM A307–07a, the anchor bolts are rated at 60,000 PSI Tensile Strength and are of the non-headed type. High–Strength Threaded Fasteners are specified to conform to either ASTM A325–07, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength, or ASTM A490–06, Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength.

The total floor thickness is 5.5”. The structural slab is comprised of 3.5” 4,000 psi lightweight concrete over a 2” 18 gauge composite steel deck supported on steel beams. The slab is reinforced with 6” x 6” – W4.0 x W4.0 W.W.F.

Critical Industry Issue – BIM in Design Build/IPD

Building Information Modeling (BIM)

Introduction to BIM

Building Information Modeling (BIM) can provide the architectural, engineering, and construction industries with almost unbounded opportunities with respect to design, coordination, and information sharing. BIM can also provide a greater understanding of building tectonics and systems integration. Building Information Modeling is a fairly new concept that is developing a trend in the construction industry. BIM is often perceived as a tool used in the preconstruction and design phases of the project. In this manner, BIM would be used specifically for visualization and the identification of errors and omissions. Initially, BIM was thought of as a tool to streamline the construction process. However, Building Information Modeling can be used in more than just the preconstruction and design phases. It is important in the development of virtual intelligence models, typically three dimensional, linked to other construction management tools (i.e. scheduling, estimating) that encourages collaboration, visualization and constructability reviews beneficial to all stakeholders throughout the lifecycle of the facility. If used effectively, Building Information Modeling will develop into a common industry trend through the benefits of project documentation, Mechanical, Electrical, and Plumbing (MEP) coordination, and as an integrated optimization tool for LEED.

BIM Integration in the Construction Industry

Project managers, architects and engineers may wonder how long it will take until the construction industry is fully integrated with BIM as a primary tool of analysis and distribution of all construction information. It is very hard to decipher this particular question. Members of the National Institute of Building Science (NIBS) have made this more realistic. In recent efforts, members of NIBS have moved the goal of interoperable, life cycle exchange of BIM closer in the United States. In 2006, NIBS initiated the development of the National Building Information Model Standard (NBIMS). In March of 2007, the first version was released for industry review. Through this the Industry Foundation Class (IFC) model was established. This model is contingent on the representation of specific information exchange. This is also a fairly new concept in the United States. The National Institute of Building Science's key goal is to support this technology transfer in the architectural, engineering and construction industry.

Benefits of BIM

In the architectural, engineering and construction industries, success is often measured to evaluate the effectiveness of new tools, methods, and ideas. Success can be sought as essentially building "better, faster, cheaper". Building information Modeling was found to have the strongest perceived impact on the quality, cost, and schedule of construction projects.

- Improved Construction Efficiency
- Reduced Risk
- Improved Communication through Visualization

- Increased Collaboration Among All Project Teams
- Clash Detection
- Reduced Time to Produce Material Takeoffs
- Maintainability
- Productivity Increases
- Spatial Coordination
- Fewer change orders
- Better understanding of each subs scope

It appears that BIM can bring this ideal closer to "better, faster, cheaper" reality for the construction industry. BIM as an information management system combined with virtual modeling has created opportunities for the "front-loading" of the design process, providing better decision making earlier in the process, allowing for increased clarity of information as well as increased collaboration within the design process to include all members of the project team. This front loading process allows the construction industry to analyze a building at the beginning stages through quantity takeoffs, cost estimating, construction planning and scheduling, tracking and managing changes of work and shop drawings, and managing site logistics with particular attention to safety. When discussing the modeling of specific entities such as building systems, structural, mechanical ductwork and piping; the interior and exterior spatial configurations can be assessed for further benefits of the construction process. Energy use simulations for LEED can also profit in the BIM construction process through daylight studies, energy calculations, and fluid dynamic qualities of Heating, Ventilation, and Air Conditioning (HVAC).

Challenges to BIM

There are many benefits to BIM; however the challenges must be assessed for a resolution in the future. These challenges include:

- Traditional Mentality
- Intellectual property licensing and security used within the model
- Untested liability issues
- Design and construction fees do not support the BIM process
- Contractual Concerns
- Specific standards for collaborative file sharing and exchange
- Ownership of the model at various stages of the project
- Elimination of shop drawings and submittals for only participating parties in the development of the model
- Level of Doubt from Clients

BIM Decision Making Process

To ensure proper utilization of BIM meets the expectations of all project team members, the BIM process should be phased throughout the project, as shown in Figure 8.

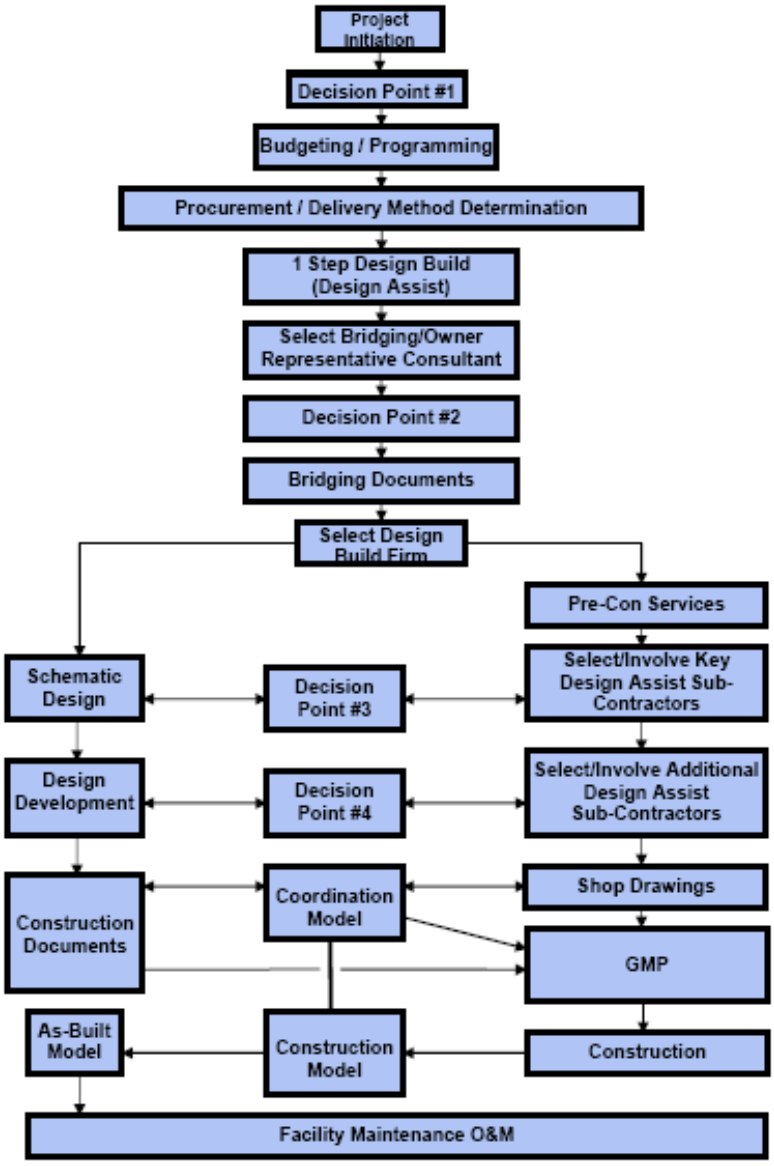

Figure 8 - BIM Process Design Build Flowchart

Four distinct decision points must be identified throughout the project. This will further establish the work scope of modeling on a project.

- Decision Point #1 – Project Initiation (0% Design)
- Decision Point #2 – Conceptual Design (10% Design)
- Decision Point #3 – Schematic Design (25% Design)
- Decision Point #4 – Design Development (50% Design)

Project Documentation through Building Information Modeling

Building Information Modeling can be used in the construction process as a single repository of data for the owner. As a project manager in the construction industry or a building owner, it is imperative to understand that construction document management is a vital element for the successful administration of a facility during the post-construction

phase. Typical construction documentation involves the contractor transferring the owner's set of files at the completion of the project in a number of boxes or file drawers. This information contains warrantees, operation and maintenance (O&M) manuals, and As-Built drawings. This information is organized in a specific manner according to the contractor. The use of Building Information Modeling can organize, maintain, and retrieve the data in a format both beneficial for the owner and contractor. In addition to these documents, BIM can also store schedules, cost estimates, shop drawings, fire ratings, and submittals. Since BIM represents real world elements, such as doors, windows, and walls, these documents can subsequently be linked to each item. This information can then be easily extracted in the post-construction for repairs or remodeling to the building or equipment. Unfortunately, little has been done to implement BIM in this stage of the construction process. Consequently, the greatest limitation for BIM in this stage is the inability to measure results in this manner. With continued research and development, the costs associated with BIM in this particular field can be greatly reduced. Building Information Modeling could essentially become the sole source of information in the construction process.

BIM/MEP Coordination

Building Information Model continues to change the process of collaboration and coordination in the construction industry. Individual attitudes, skills, and education are often seen as the keys to successful collaboration in order to manage processes and improve performance. The traditional way of coordination in the construction process was subsequently comparing and overlaying two dimensional drawings from multiple trades. Mechanical, electrical and plumbing systems are the active systems of the building that temper the building environment, distribute electrical energy, allow communication, enable critical manufacturing process, provide water and dispose of waste. Typically, different specialty contractors install these systems. The purpose of collaboration is to eliminate spatial and functional interference, especially in MEP systems. This process is time-consuming and expensive. The building design and construction industry are pushing for new technology advancements alongside collaboration delivery methods. Building Information Modeling has the opportunity to improve this inter-organizational collaboration. By using BIM, one can envision how designers and builders can plan out, in precise detail, the location and clearances needed for a complete and successful project.

Integrated Optimization Tool for LEED through Building Information Modeling

Sustainability is one of the leading changes in the construction industry today. Leadership in Energy and Environmental Design or LEED is the nations' accepted third party rating system in green building. LEED delineates five key areas that make a building environmentally and health conscious: sustainable sites, water efficiency, energy and atmosphere, material selection, and indoor environmental quality. Building Information Modeling allows designers the opportunity for creating and designing efficient, practical building. The ability to model different building systems in the design phase allows engineers to identify energy saving alternatives. By using BIM, the designers and engineers can automatically see if the current design meets a certain credit requirement. The specific BIM software can contain formulas, so calculations can easily be documented on the model. This can in turn provide a cost analysis of the project. This then allows the owner the

option to decide if the energy savings is worth the additional cost. The integration of Building Information Modeling and sustainability will allow better efficiency and fewer errors in the construction.

The Future of BIM

BIM will not be considered just as a tool to increase efficiency in various individual construction processes but rather would be adopted as a completely new methodology to do construction business. In the future, BIM's interoperability will improve through the following areas of focus.

- Acoustics
- Building control automation
- Building elements
- Cost estimating
- Facility operations and management
- Ingress, egress and traffic control
- Lighting and lighting effect
- Owner asset tracking and control
- Quantity take-offs
- Security
- Space Management
- Structure
- Visualization

Integrated Project Delivery (IPD)

Introduction to IPD

According to the American Institute of Architects, Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction. IPD leverages early contributions of knowledge and expertise through utilization of new technologies, allowing all team members to better realize their highest potentials while expanding the value they provide throughout the project lifecycle. IPD teams are guided by principles of trust, transparent processes, effective collaboration, open information sharing, team success tied to project success, shared risk and reward, value-based decision making, and utilization of full technological capabilities and support.

Fundamental Principles of IPD

- Mutual Respect & Trust
- Mutual Benefit & Reward
- Collaborative Innovation & Decision Making
- Early Involvement of Key Participants

- Early Goal Definition
- Intensified Planning
- Open Communication
- Appropriate Technology
- Organization & Leadership

IPD Roles and Responsibilities

Owner

The Owner is required to participate in establishing project metrics at an earlier stage than is typical in a traditional project, producing a substantially greater and more active role in evaluating and influencing design options. In resolving issues that arise on the project, the Owner will be called on more often to assist.

Contractors

Early involvement affects the contractors' scope of work on a project by their participation within the integrated team. The contractors' role increases significantly, in which contractors provide strategic services such as schedule production, cost estimating, phasing, systems evaluation, constructability reviews, and early purchasing programs during the early stages of design.

Architects

An extensive and thorough design process that incorporates input and involvement of other team members, during the design phase, is required by IPD. In these projects, extensive efforts to identify and resolve potential design conflicts that traditionally may not be discovered until construction are taken.

Benefits of IPD

Since 1964, the US Bureau of Labor Statistics shows construction alone, continues to decrease in productivity. This being said, IPD results in greater efficiencies. The United Kingdom's Office of Government Commerce (UKOGC) estimates that savings of up to 30% in the cost of construction can be achieved where integrated teams promote continuous improvement over a series of construction projects.

IPD provides positive values for the following three groups:

Owners

Early and open project communications and sharing of project knowledge allows owners to effectively balance project options to meet their goals. This in turn improves the team's ability to control costs and manage the budget, all of which increases the likelihood that project goals will be achieved, such as schedule, life cycle costs, and quality.

Contractors

IPD allows contractors to contribute their expertise in construction techniques early in the design process, while improving project quality and financial performance during the construction phase. This participation provides the opportunity for strong pre-construction planning, more timely and informed understanding of the design, anticipating

and resolving design-related issues, and visualizing construction sequencing prior to construction start, and improving cost control and budget management.

Architects
IPD allows the architect to contribution, while benefiting from the constructors' expertise during the design phase. For example, this becomes apparent with accurate budget estimates. The increased the level of effort during early design phases, results in reduced documentation time, and improved cost control and budget management.

Project Costs
A prime metric that is established at the project inception and tracked throughout the life of the project is the overall project cost. The cost of the actual work, non-incentive based compensation (fees for services) and appropriate contingencies are included in this overall cost. One item that affects cost is the direct connection between the design and quantity during all phases. This creates a powerful tool to determine and manage the project cost.

The opportunity to replace value engineering with target pricing benefits all the project participants. It promotes designing to a detailed estimate, rather than estimating a detailed design. As stated, information needs to be communicated effectively to all interested parties, for this to be accomplished.

Owners often favor lower price, whereas the designers or contractors may have a financial incentive to seek a higher target price. This conflict is managed through the IPD process with careful participant selection, open book estimating, and proper use of independent consultants.

Project Schedule
The reduction of construction time, due to the extensive planning and changes to project processes, is one of the main potential benefits of IPD. This benefit is a common factor for selecting IPD by the owner. Similar to BIM, the ability to link schedule, phasing and detailed construction sequencing early in the project will provide efficiencies, especially in the procurement of materials. This reduces the time from the completion of design to the beginning of active work on the site of a project.

Project Quality
In terms of the measurement of quality, IPD provides the opportunity to reduce errors within design documents as well as conflicts between trades. This often occurs well before purchasing systems and products for each individual project. IPD create an atmosphere where quality of service, design and execution are directly linked to the collaboration among the participants.

IPD with BIM Incorporated
Many individuals that were interviewed for this project agreed, BIM is one of the most powerful tools supporting IPD. As shown above, BIM can combine the design, fabrication information, erection instructions, and project management logistics in one database. It provides a platform for design, coordination, and information sharing throughout the

project. BIM and IPD work hand in hand to leverage the projects capabilities, such as site, time, or financial constraints.

Keys to Building an Integrated Team

The key to successful IPD project is to assemble a team that is committed to an effective, collaborative process in the following manner:

1. Identify the participant roles for the project, at the earliest possible time.
2. Pre-qualify members of the team.
3. Seek involvement from building officials, local utility companies, insurers, sureties, and other stakeholders.
4. Define the values, goals, interests and objectives.
5. Identify the organizational structure consistent with the participants' needs and constraints.
6. Develop project agreements that define the roles and accountability of the participants.

IPD vs. Design Build

Design Build

As shown in Figure 9, Design Build is characterized by a single point of responsibility for both design and construction activities. Design Build requires heavy involvement early by the owner to defining the project criteria, followed by decreased involvement later as the project progresses. Many IPD participants stated that owners typically choose Design Build in order to reduce project-based risk and transfer coordination effort to one contractual entity.

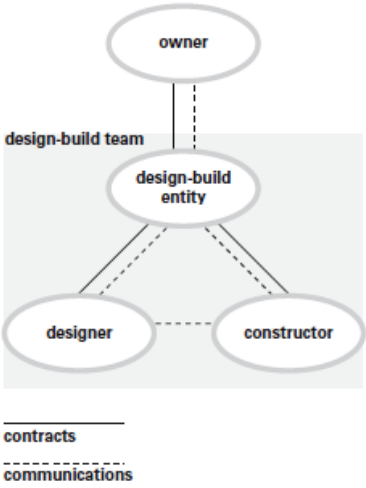

Figure 9 - Design Build

The design builder consequently accepts the owner's design criteria and exerts greater control over the project. Project success is often measured by delivery time or cost savings as compared to the agreed-upon Guaranteed Maximum Price.

Opportunities for IPD

Design Build is well-suited for increasing collaboration among the design and construction team members. Both the designer and constructor are retained at the same time so can implement IPD principles from the start. Members of these teams often have worked together and have established a rapport.

Challenges to IPD

The owner usually participates, in the traditional Design Build, through completion of the design and then seeks to minimize input and involvement. This results in minimized opportunities for project improvement and innovation. In order to achieve integration, the owner must adjust its traditional involvement in Design Build. The increased owner involvement necessary for IPD is a significant shift from traditional Design Build delivery and should be reflected in the owner/design builder agreement.

To create incentives for the Design Build team to seek project improvements rather than reduced first cost, the owner may want to alter the compensation model. Linking compensation to project goals such as building performance, sustainability, and accelerated delivery can be used to promote greater collaboration and better outcomes.

Several persons interviewed have expressed the modification of existing standard form contracts for Design Build to reflect an IPD approach. Single point responsibility of the Design Builder allows collaboration among parties under the design builder's control with little modification. The Design Build has been established long enough to be a well-understood baseline. But rather than altering the fundamental structure of the Design Build agreement, achieving an IPD delivery method can be accomplished by adding clarity of roles/responsibilities and scope of service.

BIM Execution Rubric

The purpose of the BIM Execution Plan is to provide the framework in which HESS will deploy building information modeling (BIM) for the construction, as-built documentation and facilities management of the GMU SUB I project. This plan will delineate the roles and responsibilities of the Owner, Construction Manager, Architect and Engineers, and Trade Subcontractors. A detailed scope of information about relevant business processes and supporting software will be provided by each party and shared among the parties.

Summary of BIM Process

HESS will manage the use of the design, coordination models throughout the construction process, and the transition of the design model to a completed as-built. Utilizing design models provided by the design team and fabrication/coordination models prepared and submitted by the listed trade contractors, HESS will maintain an up-to-date model throughout the construction phase. This model will be shared with the team through a BIM FTP site established and maintained by HESS. The model will be used to fully and properly coordinate and sequence the work of the trades, to maximize efficiencies during construction. Conflicts in the layout and sequencing/scheduling of the work will be discussed and resolved in a series of BIM coordination meetings. Temporary facilities layout and the use of site space are dynamically planned according to construction schedules or real construction progress. At any construction period, the building construction at the activity level and site space utilization can be displayed forward or backward in time. Through a visual simulation, even non-professionals may have a clear understand for site management process.

BIM processes such as clash detection, submittals, trade sequencing, etc. will be done using the Construction Logistics model. The Construction Logistics model will be updated and maintained throughout construction to create an accurate as-built digital record of the construction of the project.

The as-built BIM will be conveyed to the Owner on completion of construction, as a tool to assist in facility operation and maintenance.

Site Logistics/Coordination

Construction site management involves rational layout of site facilities with an optimum usage of space. This directly influences security, machine running, material supply, and power distribution. It also affects the construction progress and cost.

Construction site can only be arranged with project manager's own experience. Therefore, the use of experience inappropriately or are lack of experience can cause incorrect decision or operation to be made by the project managers.

To overcome the shortcoming of traditional site layout method and achieve visualization of site management and intelligent aided decisions the use of a 4D intelligence model is critical. The 4D site management model links a 3D model of construction project with a project activity schedule. The intelligence for the model involves 3D site model, time schedule, knowledge rules and the logical relationships between them, as shown in Figure 10.

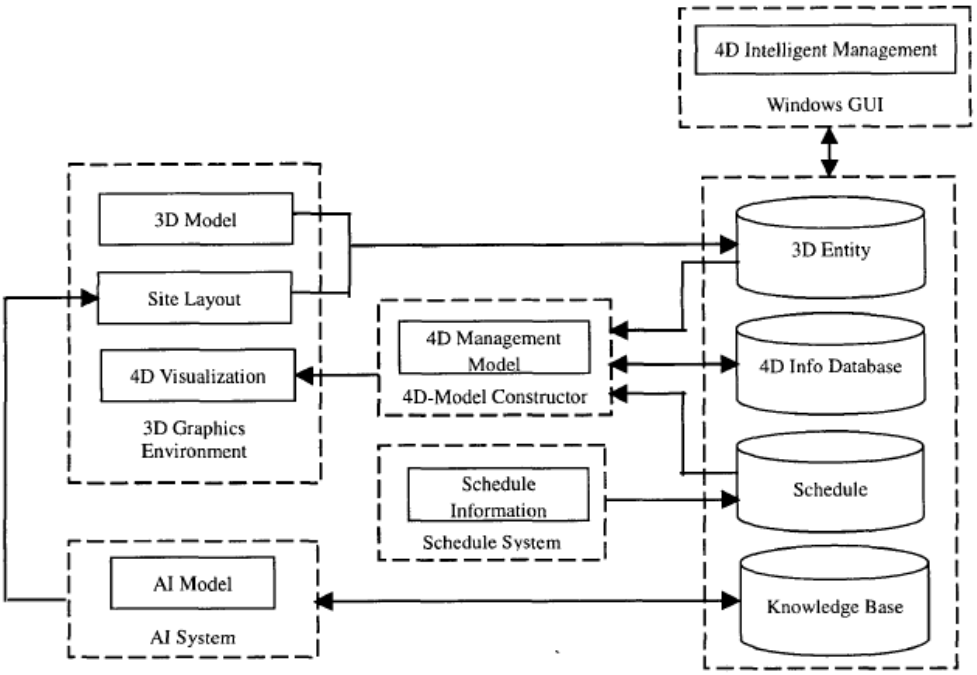

Figure 10 - Organization of 4D Intelligent Site Management Model

Hess BIM Execution Plan

The Hess BIM Execution Plan has recently been developed. So the execution plan was not used on this project.

As it pertains to site related activities, the following is the only sections in the Hess BIM Execution plan:

Civil Model: Model the following civil elements:

- Topography – 3D terrain of all site work as designed, including retaining walls.
- Landscaping elements: planting areas, such as raised planting beds and berms, parking islands, pools/ponds/other water features, terraces and other items not included elsewhere in the model.

The following elements will be modeled

- Topography
- Site Utilities to within 5 feet of perimeter
- Hard and Soft surfaces
- Other Site Objects

For the BIM Site Related Execution Plan, it would be beneficial to:

- Description of the Process
- Benefits
- Deliverables

By setting these items up in the BIM Execution Plan, the site utilization will greatly improve quality of site space, in an already confined area.

BIM Execution Plan Additions

Description

A 4D intelligence model is used to graphically represent both permanent and temporary facilities on site, with the construction activity schedule. The intelligence for the model involves 3D site model, time schedule, knowledge rules and the logical relationships. Additional information incorporated into the model can include labor resources, materials and associated deliveries, and equipment location. Because the 3D model components are directly linked to the schedule, site management functions such as visualized planning, short-term re-planning, and resource analysis can be analyzed over different spatial data.

Benefits

There are a couple of benefits for the utilization of a 4D site model. This would include:

- Generate site usage layout for temporary facilities, assembly areas, and material deliveries for all phases of construction
- Identify potential and critical space and time conflicts
- Select a feasible construction scheme
- Update site organization and space usage as construction progresses
- Provides Site Safety to the Contractors and the General Public
- Provides a detailed description of existing conditions (Underground Utilities)

Deliverables

The below deliverables indicate the proposed type of modeling that will be used at each phase of the project:

- Conceptual Stage

  - 3D Site Logistics Model

- Schematics:
  - 3D Site Logistics Model

- Design Development
  - 3D Site Logistics Model
  - 4D Site Logistics Model

- Construction Document
  - 3D Site Logistics Model
  - 4D Site Logistics Model

- Construction Phase:
  - 3D Site Logistics Model
  - 4D Site Logistics Model

Conclusion

Since BIM is already being used on the project it is advised to add and further develop a site logistics section in the BIM Execution Plan. Site utilization will greatly improve quality of site space, in an already confined area through this development.

Based on the IPD interviews and analysis the GMU SUB I project has similar characteristics of IPD. One reason lies with the owner progress meeting being held on a weekly basis. With an increase in owner involvement in these meeting and throughout the design and construction process, this project could be considered an IPD.

Site Specific Safety Analysis

Introduction
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. 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. In this section, the current site specific safety plan will be analyzed. After spending time one site, some specific additions will be proposed to the plan.

Negligence
When discussing, safety in the work place we must first look at negligence. Negligence is defined as "the failure to exercise the care that a reasonable person would exercise under the circumstances." There are four elements of negligence.

Four Elements of negligence:
1. Duty of reasonable care
2. Breach of duty of care
3. Injury caused by the breach of duty of care
4. Damages sustained by the plaintiff

The duty of care is an obligation imposed by the law on the basis of what is necessary to protect others from harm. Developing a site specific safety plan provides a mechanism by which the hazard exposures and the duties of all those involved can be specifically delineated.

Occupational Safety and Health Programs
The multitude of safety policies and programs required by various government regulations, such as OSHA, and current construction industry standards must be included in site specific safety plan.

These policies and programs are necessary:
- To verify the hazards associated with the construction task have been mitigated by the company safety policies and procedures
- To maintain compliance with OSHA requirements

An effective occupational safety and health program will include the following four elements:

- Management commitment and employee involvement
- Worksite analysis
- Hazard prevention and control
- Safety and health training

Advantages for a Site Specific Safety Plans

A significant number of construction safety case studies have shown noteworthy advantages of a well written site specific safety plan. Some of these advantages include:

- Administrative organization in complying with project requirements
- Adequate administrative preparation for the project.
- Reduction in the extent and severity of work related injuries and illnesses
- Improvement in employee morale and productivity
- Reduction in workers' compensation costs

When all of the specific safety policies and procedures are contained in a single document, an inspector can conveniently reference the Site Safety Plan to verify the presence and implementation of OSHA requirements — an immensely helpful measure in preventing citations.

Industry Problems

After considering the advantages, there are a few safety problems that not only the construction industry, but all industries as a whole, need to overcome to benefit the employee. These would include:

- Lack of clear cut contractual responsibility for safety
- Lack of an industry wide agreement on shop drawing responsibility
- The need for general and site specific safety training
- The need for workers to accept responsibility for their own actions

Responsibility

According to the American Society of Civil Engineers the following responsibilities will improve construction site safety, but will require full commitment from all parties.

Owners take an active role in project safety by:

- Assigning overall project safety responsibility and authority to a specific organization or individual (specifically retaining that responsibility)
- Designating an individual or organization to both monitor safety performance during construction and have responsibility for developing a coordinated project safety plan
- Designating responsibility for the final approval of shop drawings and details through contract documents
- Including prior safety performance as a criterion for contractor selection.

Engineers have responsibility for:

- Recognizing that safety and constructability are important considerations when preparing construction plans and specifications
- Assuring through the specifications that the design or details of the critical elements of temporary construction, erection and lifting schemes, complicated form work and scaffolding be prepared by a professional engineer.

Contractors have responsibility for:

- Maintaining the safety of their employees, their subcontractors' employees, and for others in their work area, based on the contractors' control of workers, equipment**,** methods, techniques, sequence of work, and schedule**;**
- Developing and implementing a coordinated safety program for each project with project specific safety guidelines including substance abuse programs. The safety program does not replace the contractor's responsibility for means and methods of construction.

Large Construction Project Site Safety Plan Outline

Tab Title	*Section Contents*
	Title Page
Plan Administration	Objective and Project Description Definitions
	Organization
	Orientation
	Training requirements and documentation
	Safety Meeting Schedule
	Competent Persons Identified
	Audits/Inspection schedules
	Accident Management
	Available Safety Assistance
	Interpretative Resolution Contact
	Dispute Resolution
	Contacts
	Forms (safety meeting, inspections, emergency contact poster, OSHA poster)
Project Safety Guidelines	Medical/First Aid Availability
	Fire Protection
	Housekeeping
	Hot Work and Flame Permit
	Confined Space Entry
	Personal Protective Equipment
	Appropriate Attire
	Signs, Signals and Barricades
	Elevated Work Areas
	Scaffolding
	Lockout/Tagout (Lo/To)
	Crane and Motorized Equipment Operation
	Crane and Motorized Equipment Inspections

	Crane Suspended Personnel Baskets Drug and alcohol testing requirements, if any Tool and Equipment Inspection Ground Fault Protection Physical Health Hazards Hazardous Materials Management Spill Prevention Demolition Excavations Special Project Precautions Site Restrictions
Responsibility	Project Manager Supervisors Safety Coordinator Workers
Emergency	Phone Numbers Emergency Procedures
JHA	Job Hazard Analysis

Site Layout Safety

Construction safety is one of the most important but least considered objectives in site layout planning and design. Considering the tight site considerations, it is vital to consider site layout with safety. A well documented construction site layout plan can improve the construction safety needs that will be identified and qualified in the site specific safety plan.

A proper site layout can lead to:

- Reducing the cost of materials handling
- Minimizing travel times of labor, material, and equipment on site.
- Improving construction productivity
- Promoting construction safety and quality

There are three major issues to consider when constructing a site layout plan. These include:

1. Proper positioning of temporary facilities
    a. To improve the safety of crane operations
    b. To minimize accidents caused by falling objects
2. Control of hazardous material and equipment on site
3. Reducing intersections between heavily traveled routes of construction resources

These three developed performance criteria can be used to measure and qualify the impact of the site layout planning.

Site Specific Safety Plan Rubric

Introduction

As stated in the Hess Construction + Engineering Services Project Safety Program, Hess is committed to establishing and maintaining a safe and healthy environment for all project personnel, its customers, members of the general public , students and staff affected by construction or occupying adjacent spaces or buildings. This is apparent in the quality site specific safety plan that has been assembled for the George Mason University Student Union Building I project. A continuous opportunity for improvement is one of the initial benefits of researching safety on any construction project. There are a couple items that I feel should have been either included or further developed in the GMU SUB I safety plan. This is based on the time spent both on the site in the summer and through discussions with the project design and management teams.

Some initial key items that will be looked at are as followed:

- Section 8 - Visitors
- Section 24 - General and Hess Specific Safety Requirements
    - General Work Rules
    - Electrical
- Section 25 – Job Hazard Analysis
- Section 29 - General Public Protection and Environment Health
- Section 32 – Site Specific Safety Considerations
    - Work Control Measures
    - Site Configuration
    - Occupied Renovations
    - Pedestrian Safety

Reasons for Further Development

*NOTE – Text in *Italics* are taken from the Hess Construction + Engineering Services Project Safety Plan.

Section 8 – Visitors

All visitors to the site must first obtain permission from an authorized HESS Representative and obtain and wear a hard hat and safety glasses. It is recommended that each visitor leave a driver's license or other appropriate ID card to ensure that the visitor is accounted for and returns any borrowed personal protective equipment.

Section 8 of the Hess Construction + Engineering Services GMU SUB I is a solid start for discussions of visitors. There are a couple of items that make this section intriguing for safety. Similar to projects on the Penn State University campus, George Mason University may use the construction site for educational purposes. George Mason University has a Civil, Environmental, and Infrastructure Engineering program. The George Mason University website describes this program as at the crossroads of civil engineering, information technology, and urban planning and engineering. As opposed to other construction projects, the project management team may find an increase in requests for tours. To provide the utmost safety for students, these tours should be regulated.

Section 24 - General and Hess Specific Safety Requirements

The bulk of the GMU SUB I safety plan is within this section. The General and Hess Specific Safety Requirements are broken down into twelve separate sections. These sections are especially detailed in rules and procedures. Based on the shear content and impact that this section will have on the project is a great place to advance the safety of the plan for the workers involved, students, faculty, and general public.

General Work Rules

In order to help assure the safety of all workers and the orderly progression of work, the following are to be considered basic safety requirements for all personnel on this project. These requirements are not intended to be all inclusive and may need to be amended, supplemented, or changed to meet specific project conditions such as the nature of the work and such other rules as required. The Contractor agrees in the performance of its work to observe and comply with the following requirements (in addition to other contractual and jurisdictional safety requirements):

- *All applicable federal, state, local, or other regulatory agency's safety rules and regulations including, but not limited to, the Occupational Safety & Health Act of 1970, as amended.*
- *The Contractor agrees to observe and comply with the Design-Builder's Project Safety Plan and Trade Contractor's Procedure Manual in effect. Contractors are required to develop their own project safety plan that promotes safety awareness among its associates.*
- *Promote and maintain a safe and healthy work environment.*
- *Prior to the start of work on the project, a site representative from each contract partner will attend a project safety orientation to review those practices that will be required for the project. Upon completion the site representative will review these practices with their personnel and provide documentation noting their attendance.*
- *SMOKING WILL NOT BE PERMITTED ON HESS PROJECT SITES*
- *The contract partner shall ensure their project supervision is knowledgeable and competent in all safety aspects of their work. This competent person is to be on site at all times while their work is in progress.*
- *Violation of any safety or site rule/regulation will be cause for disciplinary action up to and including termination. Contract partners, vendors and visitors will be subject to removal from the project.*
- *The use, possession, or sale of drugs, alcohol, weapons, and contraband are prohibited on the project. This includes all project parking areas. Those who are believed to have used or are under the influence of drugs or alcohol will be removed from the project. For more information reference HESS "Drug free Workplace Policy".*
- *A site-specific HAZCOM manual will be maintained in the HESS field office. Each contract partner is to provide copies of their Material Safety Data Sheet (MSDS) documentation for each material on site. This HAZCOM manual will be available to all site associates for review.*

- *A current copy of the contract partner's site specific/corporate safety policy will be maintained on site. This document shall be submitted to the contractor's project superintendent prior to the start of work and maintained on site.*
- *All chemical containers shall be labeled in accordance with all OSHA requirements.*
- *Each contract partner will conduct weekly toolbox safety meetings. Copies of these meetings and attendance sheets will be forwarded to HESS Construction Company, Inc. field office within two days of the meeting date. Periodically general site safety meetings will be conducted to inform site personnel of upcoming work and the potential hazards associated with this work.*
- *Daily housekeeping is the responsibility of each associate on site. Work areas are to be kept clean and uncluttered. Debris disposal is to occur at the end of each day. Protruding nails are to be pulled immediately.*
- *Horseplay, fighting, or running is prohibited while on the project site. All parties involved in such activities will be subject to disciplinary action up to and including removal from site.*
- *If you have any questions as to the safety aspects of your job or your responsibilities, contact your supervisor. Remember, only perform tasks in which you have been trained and authorized.*
- *Report all unsafe acts or conditions to your supervisor immediately.*
- *Observe a 50-lb. weight limit. If the object to be lifted weights more than 50 lbs. or you do not feel that you are physically capable, get help or a piece of lifting equipment to move it.*

This section is a good place to start when considering overall safety for a project. This section sets the groundwork for not only a safe site, but also the surrounding areas. Many of the aforementioned policies are strictly for on-site work. Inversely, the goal of the project here is to create a safe work environment. This applies to both the on-site workers and the faculty, students and visitors of the GMU Fairfax campus.

There are two specific aspects that will be considered in this sections analysis. The first being, "Daily housekeeping is the responsibility of each associate on site. Work areas are to be kept clean and uncluttered. Debris disposal is to occur at the end of each day. Protruding nails are to be pulled immediately." Meticulous housekeeping of a site will not only keep the work site respectable amongst GMU staff, but will also keep the site and surrounding areas safe for all participants. The second aspect that will be analyzed is, "Report all unsafe acts or conditions to your supervisor immediately." These are very important concepts. Establishing specific procedures to go with both of these policies will be beneficial for the Site Specific Safety Plan.

Electrical

All electric wiring and powered equipment shall be installed in a workmanlike manner and maintained in good condition.

- *Ground Fault Circuit Interrupter (GFCI) protection is required for all electrical cords and tools including those plugged into permanent and portable generator power*

sources. Only three wire cords rated for hard or extra hard usage are permitted for use, and they must be rated for the required amperage.

- *Work on or near energized parts is prohibited unless authorized by HESS.*
- *Lockout/Tag out (Lo/To) Programs are required when applicable.*
- *Temporary power will be provided from services equipped with GFCI protection. All 120v receptacles will be protected by GFCI circuit breaker or GFCI receptacle.*
- *All portable welding machines and generator receptacles must also have GFCI protection.*
- *Test and reset GFCI's before each use.*
- *Temporary power stations will be inspected weekly for defects and/or damage. Each breaker will be labeled and open spaces covered with manufacturer's blank plate.*
- *Utilize Lock-out/Tag-out procedures to render inoperable equipment or circuits de-energized during the construction process. Provide tags indicating ownership of the lockout device and the equipment/circuit de-energized.*
- *All energized electrical rooms will have required signage i.e. "Danger Authorized Personnel Only," and all energized electrical panels will be maintained with dead front covers in place for the protection of personnel.*
- *Only qualified/authorized electricians will be permitted to work on energized electrical panels, rooms, and devices.*
- *Adequate lighting will be maintained at all times including bulb guards, lamps, wiring, suspension means, and grounding.*
- *Flexible cords are to be inspected daily prior to use and protected from damage. Flexible cords permitted for use must be No. 12 gauge or larger. Ensure all cords traversing areas subject to vehicular traffic and routed across aisles are protected from damage. Cords and leads run through doors and holes must be protected.* ***Cords exhibiting damage, missing ground pins, broken strain relief, or exposed wires are to be taken out of service.***

The electrical portion of the safety plan is an excellent place to further develop the General and Hess Specific Safety Requirements. The first reason for looking at this section is the risks involved with electrical. Considering electrical is one of the top four hazards on a construction site, there are many dangers involved with electricity. The other reason I will be researching this section is based on my emergency generation analysis. The risks involved with electrical outages in the SUB I project is critical. This is apparent based on the Student Health and Wellness center and the food court refrigeration units both located in the existing Student Union Building.

The item that I will be looking at more closely is the Lockout/Tagout portion of the safety plan. Establishing detailed procedures for this section will bring together the safety portion of the electrical analysis and the site specific safety plan.

Section 25 – Job Hazard Analysis

Supervisors will complete a Job Hazard Analysis (JHA) for activities with input from the associate(s) that will be assigned to perform the activities. The JHAs must be reviewed with

the associate(s) as appropriate to assist with safety training and planning of the activities to include proper selection and use of personal protective equipment (PPE).

When looking at a site specific safety plan, you must take into consideration the Job Hazard Analysis (JHA) of any project. On a project like GMU, where there students constantly around occupied facilities and the site itself is very tight, Job Hazard Analysis is vital to maintaining a safe work environment. The hazardous activities must be coordinated with all personnel incorporated with that specific task. One important aspect to realize when researching a JHA is the individual hazardous tasks will be further developed through that specific subcontractor. Setting up specific guidelines for the Job Hazard Analysis is important in maintaining a safe work site. Further development of this section will include these various guidelines. The aforementioned guidelines will be required for either specific conditions or a specific construction activity.

Section 29 - General Public Protection and Environment Health
HESS will provide perimeter fencing and/or other appropriate measures as necessary for separating and protecting the general public from construction activities. The perimeter sidewalks, entrances and roadways will be included in the Project Safety Surveys to address activities and/or conditions that could be harmful to the general public or the environment.

An adequate number of properly trained and equipped flaggers must be provided to ensure public safety where construction activities may endanger pedestrian or vehicle traffic.

For any construction activities which could potentially impact the health or comfort of building occupants or neighbors, such as noise, dusts, or odors, a risk assessment will be conducted to assess the impact and to prescribe administrative and engineering controls to minimize their impact.

Although the safety of the contractors on site is a vital aspect to a site specific safety plan, the overall safety of the general public will be a crucial aspect of this analysis. After reviewing this section it is vital to look at the environment health safety in regards to this project. There are two critical aspects that will be further researched in this section. These will include procedures for handling, removal, and reporting asbestos and procedures and regulations for storm water management.

When considering the environment health safety of this project, one item that had an impact on the project in July 2009 was the demolition and removal of the existing High Temperature Water Tunnel and pipes. This activity was initially delayed because of the potential risk of asbestos in the insulation. In the end, GMU concluded that the insulation did not contain asbestos. With this delay and the potential risk of further delays, adding procedures for asbestos handling, removal, and reporting would benefit the site specific safety plan. This will include a chart of suspected materials containing asbestos.

Another critical task on this project, specifically to the environmental health safety, was storm water management. Bi-weekly inspections were performed by George Mason

University Inspectors. A specific set of regulation set prior to the start of the project would further inform all participants on the SUB I project.

Section 32 – Site Specific Safety Considerations
Work Control Measures
Trade Contractor project management/supervision must submit a site specific Safety program and JHA for each phase of their work to HESS and attend a Pre-Construction Meeting that includes Project Safety requirements and hazard prevention planning. Trade Contractor associates must attend a New Associate Project Orientation that includes Basic Safety & Health Training and thereafter a Weekly "Tool Box Talk" Safety Meeting. On-site Safety inspections will be performed by each Trade Contractor Safety coordinator and HESS Management. Safety violations will be addressed immediately and if warranted follow the disciplinary procedures.

Contractor agrees to have a representative present at all scheduled job and safety meetings held while Contractor is performing work. Unless otherwise excused from attendance at such meetings by Contractor, Contractor hereby consents to a reduction in payment of $100.00 for each and every failure to attend job meetings; provided that such reduction will only be applied subsequent to Contractor receiving one written warning regarding its failure to attend such meetings.

To provide a safe site, the collaboration with Hess, GMU, and the site subcontractors is vital. To further this collaboration an Injury and Illness Prevention Program (IIPP) will be proposed. IIPP is a sub contractor site specific safety plan that will provided to Hess by the subcontractors. The IIPP will call out specific information that will be required by site subcontractors, such as the name and contact information for the on-site health and safety representative and competent person. The IIPP will then be used as a reference for all parties affected by that specific subcontractor. A list of items that shall be included in the IIPP will be provided in this section.

Site Configuration
Due to the tight configuration of the site, space will be at premium. Coordination (and cooperation) between trades and their operations will be vital to the success of the project. The "tightness" of the site shall be discussed as a component of all pre-construction meetings with trade contractors so that this element is a planned component of their operations. HESS will conduct weekly foreman's meetings which shall address upcoming operations and the coordination of trades and their operations.

The tight site configurations have been a topic of concern since the beginning of the project. Overall coordination is the ultimate solution for safety. One item that may be used is Building Information Modeling. BIM is already being used on the project, the use of the four dimensional model to visually coordinate specific tasks for the project can be beneficial. Considering BIM as a fairly new technology, a set of regulations must be established for the use of BIM in accordance with a safety plan. Another item to consider is the additional costs

for the use of BIM with safety. With this proposal, the cost facet for this section should have an effect on the overall project cost.

Occupied Renovations

Due to the close proximity of the existing Student Union Building, the potential exists that construction operations could impact occupants of the existing building. These disruptions could include dust, noise, odors, etc. Every effort shall be made through thorough planning and implementation to minimize these potential impacts to building occupants. The following are guidelines to be considered during planning of, and throughout construction operations:

- *Critical barriers are intact and effective, and are inspected regularly.*
- *Construction area ventilation system isolated from occupied areas, when necessary coordinate with building engineer to shutdown fresh air intakes.*
- *Minimize idling equipment, refueling of equipment, welding and cutting operations, use of dust generating equipment (such as concrete saws), and the use of chemicals near fresh air intakes.*
- *Inspect for visible dust or construction related odors in occupied areas.*
- *"Smoke eaters" being used for hot work.*
- *Housekeeping adequate to prevent dust accumulation at the project Construction activities, materials and equipment are isolated from building occupants.*
- *Construction noise is maintained at less than 60 dBA during occupied hours.*
- *Occupant complaints are investigated and addressed immediately.*
- *Precautions are taken to eliminate mold growth.*
- *Fire/Life/Safety Maintained.*
- *Doors/Fence marked "Construction Area-Do Not Enter".*
- *MSDS on site for all hazardous chemicals to be used, and are reviewed if they will be used in a location which could impact building occupants.*
- *Welding shields are used.*

Since the existing Student Union Building houses the Student Health and Wellness Center, access must be provided for Emergency Medical Staff to easily access that building. The emergency exits will be altered to all emergency exits to remain open. As mentioned, two emergency exits will have overhead protection to provide safety for students. Alternate emergency route diagrams will be provided in the site specific safety plan for GMU representatives and site contractors. This will allow for further GMU faculty and student safety in the existing student union building. Please refer to Figure 17 in Contingency Plan Section for effected Emergency Exits.

Pedestrian Safety

All street and sidewalk closures shall be coordinated in advance with the GMU Parking and Transportation Department.

This is a fairly brief section. Although, many of the items covered in the occupied renovations can be applied to this section. Advanced coordination with the GMU Parking and Transportation Department is a great start for pedestrian safety. Not only is the site

tight, but generally the entire area is very tight. Aquia Creek Lane runs parallel to the western face of the Student Union Building. This is a very tight two lane road. This is the only road that can access the SUB I project. Consequently, all deliveries will take place from the road. This makes coordination a very crucial aspect. The use of flagmen will also be considered.

As previously mentioned, the existing Student Union Building houses the Student Health and Wellness Center, access must be provided for Emergency Medical Staff to easily access that building.

Safety Additions
In addition to the Hess Construction + Engineering Services Site Specific Safety Plan, the following additions will be proposed.

Site Specific Safety Plan
All trade contractors are required to submit a written Site Specific Safety Plan and Job Hazard Analysis to Hess Construction + Engineering Services prior to the start of the project. Specific plans and programs must address safety issues within the construction site, such as construction materials and procedures, chemical handling, and fire hazards.

The Site Specific Safety Plan shall include:

- Contact information for the trade contractor's safety representative and on-site supervisor.
- Provisions for conducting and documenting job site safety inspections by supervision.
- How and when each contactor will conduct their toolbox safety talks.
- Specifications on all types of heavy equipment on-site and the necessary precautions for each piece of equipment.
- Hazard Communication Program (HAZCOM), as specified in the existing safety plan.
- Injury and Illness Prevention Program.
- Hot Work Permit Program (cutting, welding, and other open flame work requiring a permit), must include the location of any possible fire hazards and the fire-fighting equipment available to contain a fire on site.
- Detailed description of hazardous or unusual procedures, specified in Job Hazard Analysis Section.
- Assessment of the immediate impact of construction on the surrounding areas, including but not limited to vehicular and pedestrian traffic control, street closures, utility turn-offs, safety signs, safety warning lights (placement, quantity, and types), signs, or barricades, etc.
- Storm Water Pollution Prevention Plan.
- Excavation and Dust Control Plan.
- Emergency procedures addressing injuries, fire, or other emergency on-site.

Section 8 – Visitors

Upon entering the project site, all visitors are required to report to the project field office. Access to the site shall be denied to any individual who does not have justifiable business on the job site. All project site visitors shall sign a release before being authorized to proceed beyond the project office. All visitors must wear long pants, shirts with sleeves over the shoulder, hard hats, safety glasses, and hard-soled work shoes or boots when on site. It is recommended that each visitor leave a driver's license or other appropriate ID card to ensure that the visitor is accounted for and returns any borrowed personal protective equipment.

Requests for tours of the project site shall be carefully screened and limited in frequency and numbers of people. Tours of the site shall be approved by a Hess Construction + Engineering Service Project Manager and Superintendent.

Hess Construction + Engineering Service shall establish the time and travel route for any tour. Areas which may present hazards to the tour groups shall be prohibited. A designated member of the Hess Construction + Engineering Service management team shall guide the approved tours.

Section 24 - General and Hess Specific Safety Requirements

General Work Rules
Jobsite Requirement Checklist

___ 1. OSHA/VOSH POSTER
OSHA/VOSH poster
Virginia Workers' Compensation Poster
Emergency Phone Numbers
Hazard Warning signs

___ 2. OSHA/VOSH Permits
Trenching - Annual permit
Trench - Notification form
Cranes over 3 ton capacity
High Work (over 36 feet in height)
Hot Works
NPDES Sediment & Erosion Control or Notice of Intent (NOI)

___ 3. Written Safety Programs
IIPP (Injury and Illness Prevention Program)
Fall protection plan
Tool Box Talks Documentation
HAZCOM
Material Safety Data Sheets (MSDS)

___ 4. First Aid Kit and Personnel Trained in CPR/First Aid

___ 5. Personal Protective Equipment
Hard hats
Safety glasses
Ear plugs
Fall protection

___ 6. Fire Extinguishers
Office trailer
Storage trailer
Work area
Cab of crane
Flammables and Combustibles

___ 7. Operator's Manuals for Equipment

___ 8. Toilet Facilities
Quantity specified in OSHA Standards

___ 9. Stairways
For buildings of 3 stories or less, at least one stairway
For buildings of more than 3 stories, 2 or more stairways.

Electrical

General Electrical Safety

All work shall be conducted in accordance with the NFPA 70E Standard for Electrical Safety in the Workplace, by qualified electricians, on electrical systems and equipment that uses or controls electrical power.

Unless specifically approved for the location, electrical tools or equipment are not to be operated in wet areas or where potentially flammable dusts, vapors, or liquids are present.

Barriers and warning signs are to be installed to ensure all non-authorized personnel stay clear of the work area.

Lockout /Tagout

In accordance with OSHA regulation 29 CFR 1910.147, the Contractor is responsible for developing, implementing and maintaining a Lockout/Tagout Program (Lo/To). If applicable, the trade contractor shall submit a copy of its Lockout/Tagout Program to Hess Construction + Engineering Services before the start of any work. The purpose of this submission is to ensure the safety of the general public, students, and staff.

A log will be maintained by the trade contractor of all machines and equipment that are locked out and/or tagged out during the performance of the work of this contract. This log will include:

- Equipment that was worked on

- Date work was performed
- Name of the individual performing the work.

The trade contractor will submit this log to Hess Construction + Engineering Services on a monthly basis when Lo/To work is being performed.

Section 25 – Job Hazard Analysis (JHA)
A JHA shall be written based on the following conditions:

- Jobs with the highest injury/illness rates or highest potential to cause severe or disabling injuries/illness, even if no history of previous accidents exists.
- New tasks to the trade contractors operation.
- Tasks that have undergone changes in processes and procedures.
- Complex tasks that require written instructions.

The Job Hazard Analysis shall be performed in accordance with the OSHA 3071 JHA processes. The JHA will include:

- Description of work phase or activity
- Identification of all potential hazards associated with the activity, including supplemental site information (i.e. site characterization data, as-built drawings).
- A list of the trade contractor's planned procedures to mitigate the identified hazards.
- Identification of specialized training required.
- Identification of special permits required.
- Name and contact information of the trade contractor's competent persons responsible for inspecting the activity and ensuring that all proposed safety procedures are abided by.

The following construction activities are required, but are not limited to, in the Job Hazards Analysis:

- Concrete placement and false work
- Confined spaces
- Demolition
- Electrical work
- Excavations
- Handling of flammable materials
- Handling of hazardous materials
- Hot Works
- Roofing
- Steel erection
- Trenching and drilling
- Work performed four foot or higher above ground

Section 29 - General Public Protection and Environment Health
Asbestos Containing Materials

An assessment of work areas will be conducted to determine, before work has begun, the presence, location, and quantity of potential asbestos-containing materials that would be specifically impacted by construction. Unless specifically trained, trade contractor shall not disturb asbestos-containing materials. Asbestos abatement should be coordinated with Hess Construction + Engineering Services and George Mason University.

Any suspected asbestos containing materials should not be disturbed, damaged, or handled. The following materials may contain asbestos:

- Acoustical Plaster
- Adhesives
- Asphalt Floor Tile
- Base Flashing
- Blown-in Insulation
- Boiler Insulation
- Breeching Insulation
- Caulking/Putties
- Ceiling Tiles and Lay-in Panels
- Cement Pipes
- Cement Wallboard
- Cement Wallboard
- Chalkboards
- Construction Mastics
- Cooling Towers
- Decorative Plaster
- Ductwork Flexible Fabric Connectors
- Electrical Cloth
- Electrical Panel Partitions
- Electrical Wiring Insulation
- Elevator Brake Shoes
- Elevator Equipment Panels
- Fire Blankets/Curtains/Doors
- Fireproofing Materials
- Flooring Backing
- Heating and Electrical Ducts
- High Temperature Gaskets
- HVAC Duct Insulation
- Joint Compound
- Lab Hoods/Benches/Gloves

- Packing Materials (wall/floor penetrations)
- Pipe Insulation
- Roofing Shingles and Felt
- Spackling Compounds
- Spray-applied Insulation
- Taping Compounds
- Textured Paints/Coatings
- Thermal Paper Products
- Vinyl Floor Tile
- Vinyl Sheet Flooring
- Vinyl Wall Coverings
- Wallboard

If a material that is suspected to be asbestos-containing is disturbed and becomes airborne, the trade contractor shall immediately notify the Hess Construction + Engineering Services Director of Safety.

Storm Water Pollution Prevention

Projects that disrupt over one acre of land must adhere to the EPA's Phase I or II storm water requirements. Prior to project start, the Contractor is responsible for obtaining a NPDES Construction General Permit, developing a site-specific Storm Water Pollution Prevention Program (SWPPP) and implementing appropriate Best Management Practices (BMP).

The main objectives Storm Water Pollution Prevention Program are:

- Stabilize the site ASAP
- Protect slopes and channels
- Reduce impervious surfaces and promote infiltration
- Control perimeter of you site
- Protect receiving waters adjacent to your site
- Follow pollution prevention measures
- Minimize the area and duration of exposed soils

Hess Construction + Engineering Services will post the EPA Permit No. or the Notice of Intent (NOI) form and the name of site contact person at the entrance to the construction site. An updated version of the SWPPP will also be available on-site. The SWPPP will consist of the following items:

- Cover/title page
- Project and SWPPP contact information
- Site and activity description, including a site map
- Identification of all potential pollutant sources
- Description of controls to reduce pollutants

- Maintenance/inspection procedures
- Records of inspections and follow-up maintenance of BMPs
- SWPPP amendments
- SWPPP certification

The aforementioned best management practices would include the following:

- Structural
  - Silt Fences
  - Sedimentation Ponds
  - Erosion control blankets
  - Temporary or permanent seeding
- Non-Structural
  - Picking up trash and debris
  - Sweeping up sidewalks and streets
  - Maintaining equipment

Maintenance for the BMP will be conducted in the following manner:

- Conduct maintenance of BMPs regularly
- Whenever an inspection (formal or informal) identifies a problem or potential issue
- Keep record of all maintenance activities, including the date, BMP, location, and maintenance performed

Inspections will be conducted either after each rainfall event exceeding one half inch, or at minimum frequency, typically weekly or bi-weekly. Hess Construction + Engineering Services will maintain a signed inspection reports with the SWPPP that identify the dates of inspection, weather conditions, findings, and corrective actions.

When implementing an SWPPP, it is important to:

a. Train your staff and subcontractors
b. Ensure responsibility- Subcontractor agreements
   i. Roles and responsibilities should be documented clearly in the SWPPP
c. Implement your SWPPP before construction starts
d. Conduct inspections and maintain BMPs
e. Update and evaluate your SWPPP
   i. Are your BMPs working
   ii. Evaluate the effectiveness of your BMPs

Upon completion of the project, Hess Construction + Engineering Services will file for a Notice of Termination (NOT).

Section 32 – Site Specific Safety Considerations
Work Control Measures
Subcontractor Injury and Illness Prevention Program (IIPP)

Each subcontractor shall provide Hess Construction + Engineering Services with a written Subcontractor Injury and Illness Prevention Program. The IIPP in coordination with a Site Specific Safety Plan shall contain the following:

- The name, contact information, qualifications, and roles of the on-site Health and Safety Representative who is responsible for the implementation of the IIPP during the project.
- The trade contractor's policy and senior company officer statement on health, safety, and environment.
- The trade contractor's safety management and safety oversight plan in correlation with Hess Construction + Engineering Services Project Safety Program.
- The trade contractor's policy on substance abuse and testing policies.
- Code of Safe Practices.
- Training methods used to meet OSHA training requirements to ensure that Hess Construction + Engineering Services Project Safety Program requirements are communicated all subcontractor personnel.
- Incident reporting, first aid, and emergency procedures. Details for the management of work related injuries.
- The company safety recognition/incentive policy that will be in effect for this project.
- List of all competent persons with contact information overseeing those tasks in which OSHA requires such person(s), such as excavation, confined space, fall protection, etc.

Site Configuration

"*Safety zones*" around construction areas will protect workers and the general public from falling objects. A 10 ft clearance from buildings or structures shall be kept clear from accumulation of rubbish, and material. The interaction between dangerous/harmful facilities and sensitive facilities will be considered. These dangerous/harmful facilities can be noisy or even emit harmful substances. If possible, these types of facilities should be kept a far distance away from sensitive facilities, such as offices or student housing.

Occupied Renovations

Unless specifically approved by the Hess Construction + Engineering Services and George Mason University, no paints, solvents, or flammable, toxic, or irritating materials may be used in occupied areas of the George Mason University Campus.

Powder-actuated tools not permitted in occupied buildings without the approval of Hess Construction + Engineering Services and George Mason University. Such tools can pose hazards to students, faculty, employees, neighbors and property.

Pedestrian Safety

Pedestrians are subject to the Code of Virginia 46.2. The driver of any vehicle shall yield the right-of-way to any pedestrian.

- At any clearly marked crosswalk, whether at mid-block or at the end of any block

- At any regular pedestrian crossing included in the prolongation of the lateral boundary lines of the adjacent sidewalk at the end of a block
- At any intersection when the driver is approaching on a highway or street where the legal maximum speed does not exceed 35 miles per hour

Although pedestrians have the right-of-way at marked crosswalks and unmarked intersections, pedestrians must not move into the paths of moving vehicles suddenly to constitute a hazard. At all other points on roadways, pedestrians must give way to vehicles. It is the responsibility of supervisors to explain traffic rules to new members of their staff.

When necessary, work area will be equipped with safety signs, barricade tape, etc. and use of flagmen when pedestrian and/or vehicular traffic is impeded.

Electrical Breadth – Emergency Power Analysis

Introduction

Controlled power outages were addressed as a critical item of discussion in the project management interview in the Technical Assignment III. All utilities had to be coordinated with George Mason University in the event of any shutdowns. As it pertains to the constructability of the SUB I project, the occupied facilities of the existing Student Union Building directly to the east (See Figure 11) was expressed as a pertinent issue. In the event of any shutdowns, as to the owner's policy, George Mason University has to be notified two weeks prior to any controlled shutdown. After reviewing this information, it was taken into consideration that a Health and Wellness Center was located on the second floor of the Existing Student Union Building. The Health and Wellness Center consisting of:

Figure 11 – Building Locations

- Sixteen Exam Room
- Nurse's Station
- Immunization Room
- Short Term Stay Room
- Pharmacy
- 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.

Along with the Health and Wellness Center, but with less of an impact to life safety, several restaurants are located on the first floor of the existing Student Union Building. These restaurants include Damon's Restaurant, Chick Fil-A, and a coffee shop. These restaurants have access to walk-in refrigeration and freezer units for food. Refrigeration and freezing are the two most common forms of food preservation used today.

The major focus for this analysis will be on the Health and Wellness Center. Health care facilities are highly dependent on reliable sources of electrical power. This essentially makes electrical power a mission critical resource. Emergency power reliability means having emergency power available in sufficient quantity where, when, and for whatever

duration it is needed. Emergency generators are only operated during normal testing and maintenance or during emergencies.

The diesel generator is the technology of choice for the vast majority of alternate power. Approximately 80,000 mega-Watts of backup diesel generating capacity exists in the United States alone. This is a mature technology that has been developed and improved over the last 100 years. Their performance and environmental emissions continue to improve. Diesel generators have a low capital cost and, until recently, low fuel costs. Although, fuel costs are usually not an issue due to the fact standby generators rarely run.

Emergency Power Standards and Codes Review

Overall, emergency power generation codes and standards present two important questions. These include:

1. What types of emergency power regulations are necessary?
2. If regulations are necessary, what types are appropriate?

The first question can easily be answered. This can be researched on a social and economic standpoint. As a whole, society relies upon extensive public health and safety regulation of drugs, food, buildings, consumer products, as well as many other subject matters. As it pertains to economic policies, building owners do not bear all the costs of the consequences when a building loses power. Consequently, without government regulations, owners would under invest in backup power supplies.

From this we turn to the second question to see what types of regulations are necessary. When dealing from an economic standpoint, using a similar strategy as question one, there are two major categories of regulation.

- Command-and-control regulation
  - Technology-based regulations
  - Performance-based regulations
- Market-based regulation

The first regulation is command-and-control regulation, which has two subcategories: technology-based and performance-based regulations. The second regulation is market-based. A technology-based regulation specifies the equipment or method to be used. This will then be used to achieve such items as the desired emission reduction. In this contrast, a performance-based standard stipulates the performance needs to be satisfied. In the context of regulation, current standby generation regulations are a performance standard. It is specified that the standby source of power must be able to come online within 10 seconds for critical applications or 30 seconds for non-critical ones, which will be discussed later in detail. These requirements are not based on the electrical loads of the building but on the time it takes to start a diesel generator. In a social position, performance regulations yield greater social value than technical regulations because of the increased flexibility of performance standards. Performance regulations in turn allow for the same level of public benefits (i.e. improved power reliability, lower costs, and emissions reductions). Performance standards also encourage more innovation than technology standards.

The current standby generation codes and standards reflect the technical capabilities of diesel generators. Table 1 categorizes a range of critical facilities with alternate power needs. As shown below, college and universities appear on the list of critical facilities, along with medical centers.

Table 1 - Critical Facilities

Critical Facilities	
Type	**Examples**
Emergency Services	Police stations, fire stations, paramedic stations, emergency communication transmitters
Water Systems	Water supply pumping stations, wastewater pumping stations and treatment plants
Transportation Systems	Traffic intersections, aviation terminals and air traffic control, railroad crossings, electric rail systems
Medical Centers	Hospitals, nursing homes, mental health treatment facilities, specialized treatment center (e.g., out-patient surgery, dialysis, cancer therapy), rehabilitation centers, blood donation centers, medical clinics
Schools	Nursery schools, kindergartens, elementary schools, high schools, colleges and universities, business and trade schools
Day Care Operations	Registered facilities, sitter services, after-school centers
Senior Centers	Senior citizens centers, retirement communities
Social Service Centers	Homeless/transient shelters, missions and soup kitchens, shelters (for youths, families, and battered persons), heating/cooling shelters
Detention Centers	Jails, youth detention centers
Community Centers	Libraries, civic centers, recreational facilities
Public Assembly Structures	Stadiums, auditoriums, theaters, cinemas, religious facilities, malls, conference centers, museums
Hotels	Hotels, motels, boarding houses
High-rise Buildings	Apartments, condos, commercial
Food Services	Restaurants, supermarkets, food processing facilities
Industries	Hazardous material handling, computer centers, computer chip manufacturing facilities, banks

NFPA-110 Review
Section 4.4.3 of NFPA-110 - states that all emergency power supply systems should be permanently installed.

Section 5.2.1 of NFPA-110 - states that energy converters should consist only of the following rotating equipment:

1. Otto cycle (spark ignited)
2. Diesel cycle
3. Gas turbine cycle

Section 5.1.1 of NFPA-110 - states that liquid petroleum products at atmospheric pressure, liquefied petroleum gas, and natural or synthetic gas can be used for emergency power supply.

Section 7.2.5 of NFPA-110 - states that the emergency power supply should be installed in a location that permits ready accessibility. This will be further developed in a later section.

Section 7.3.1 of NFPA-110 - states that emergency power supply locations should be provided with battery-powered emergency lighting except if the unit is located outdoors in an enclosure that does not include walk-in access.

Section 7.4.1 of NFPA-110 - states that rotating energy converters should be installed on solid foundations to prohibit sagging of fuel, exhaust, or lubrication oil piping and damage to parts resulting in leakage at joints.

Section 7.4.1.1 of NFPA-110 - states that such foundations or structural bases should raise the engine at least 150 mm above the floor or grade level and be of sufficient elevation to facilitate lubricating-oil drainage and ease of maintenance.

NEC 517

This section of the National Electric Code covers health care facilities and includes the following:

- Hospitals
- Clinics
- Nursing Homes
- Diagnostic Imaging Facilities
- Doctor's Offices
- Dentist's Offices

Essential electrical systems are needed for life safety and must ensure continuity of service. Two separate systems are required:

1. Equipment System – Normal Power Source
2. Emergency System – On-Site Generator
    a. Life Safety Branch
        i. Illumination for Means of Egress
        ii. Exit Signs
        iii. Alarm Systems
        iv. Communication Systems

v. Generator Location
vi. Elevators
vii. Automatic Doors

b. Critical Branch
i. Task Lighting
ii. Fixed Equipment
iii. Receptacles
iv. Patient Care
v. Critical Care
vi. Maternity Wards
vii. Pharmacy/Medication
viii. Nurse' Stations

By code, all public buildings must provide emergency power for lights and alarms, as well as for elevators for handicapped egress. The aforementioned loads will be applied to the new 250KW Kohler emergency generator. These loads will be specified in a later section.

Emergency generators are required to start and take critical loads within 10 seconds. This is accomplished through an automatic transfer switch (ATS). This is also called out in the GMU project specifications. An automatic transfer switch is a self acting piece of equipment for transferring one or more load connections from one power source to another. Each transfer switch shall have a continuous current rating and interrupting rating for all classes of loads to be served. Switches must also be capable of withstanding the available fault current at the point of installation. The intent here is to determine the actual available fault current at the switch, as shown in Fig. 12, rather than specifying an arbitrary published rating.

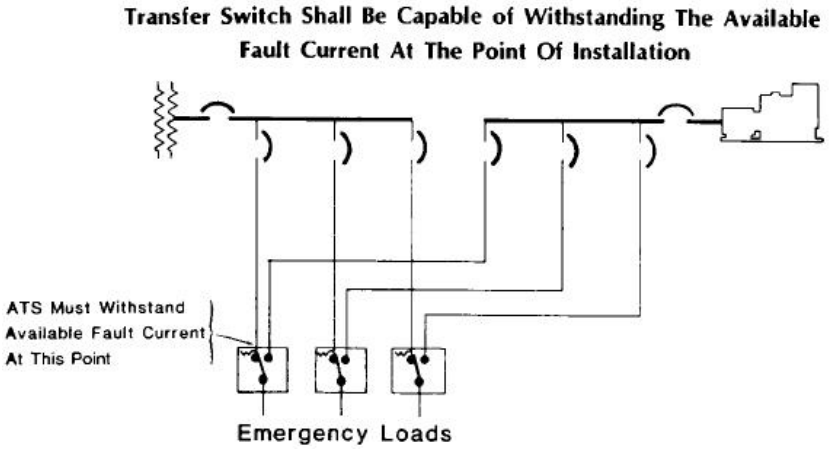

Figure 12 - Withstanding Current Rating

Inspection and Testing of Emergency Generators

According to NFPA 110, routine maintenance and operational testing, applies to the complete emergency and standby power system. This includes monthly testing of the transfer switch which entails electrically operating the transfer from a normal position to alternate position and return. To help assure such routine testing occurs, the standard stipulates:

- A program timing device shall be provided to exercise the EPS as well as a separate test switch on each transfer switch

- A written schedule for operational testing and a written record of such tests, including
    - the date of the maintenance report
    - identification of servicing personnel
    - notation of any unsatisfactory condition and the corrective action taken

Load Bank Test
Load bank testing is an important element of a comprehensive predictive maintenance program, as per code NFPA 110 Emergency and Standby Power Systems, which requires load bank testing for mandated emergency units serving critical areas in hospitals. A load bank is a stationary or mobile piece of equipment that provides operator-adjustable electrical resistance and reactance to simulate the actual electrical load the generator is intended to power. Load bank testing simulates the full electrical demands for one hour. The test monitors the engine and generator to ensure that each is doing its job.

Paragraph 6-3.5 of NFPA-110 states - Transfer switches shall be subject to a maintenance program including connections, inspection or testing for evidence of overheating and excessive contact erosion, removal of dust and dirt, and replacement of contacts when required.

Evaluation of Risks
When evaluating the risks involved with the emergency generator that will be installed on the GMU SUB I site, there are a few question that must be answered:

- 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 be powered by the emergency power?
- What are the risks involved with the emergency generator?*
- How can these risks be reduced?*

All questions will be answered individually, except the starred (*) items which will be answered together.

How crucial is it to maintain operation during power outages?
For the majority of the SUB I project maintaining power is a non-critical element, considering most areas are offices and conference rooms. In these areas, losses are going to be kept at a minimum. The Student Health and Wellness Center is the most critical aspect of the building, which is located in the existing portion. It is a critical; although this area is not life threatening as hospitals would be considered.

How quickly must the emergency power come on?
The generator starts instantly, but as specified the transfer of power must be able to come online within 10 seconds for critical applications through the alternators Fast-Response II excitation system (specified below). As stated, this is accomplished through and automatic transfer switch.

How long should the emergency power be available for?
The emergency generator will stay online until it senses that the power is back on through the or until the Kohler Diesel 250kW 250REOZJD Generator 966 gallon sub-base fuel tank (specified below) runs out (58 hours).

What locations within the facility will be powered by the emergency power?
The following locations will be powered by the Kohler Diesel 250kW 250REOZJD Generator (see Connected Electrical Loads to 250kW Generator Section for more information):

- Health and Wellness Center (Receptacles and Emergency Lights)
- Food Court (Refrigerator/Freezing Units)
- Corridors/Atrium (Emergency Lights)
- Elevator

What are the risks involved with the emergency generator? How can these risks be reduced?
One of the risks involved with the emergency generator for the GMU SUB I project involves pharmaceuticals. This would specifically include pharmaceuticals that need to be refrigerated. In 1999, a study was performed by Mater Misericordiae Hospital in Dublin. Researchers looked into the pharmaceutical risks involved with multiple concurrent computer failures. Their goal was to compile stability information for refrigerated drugs outside of normal storage conditions. Out of the 119 products tested, 85 needed refrigerated. The 11th Edition of the Data Sheet and Summary of Product Characteristics, as well as the relative pharmaceutical companies were consulted for all products. As shown below, six out of that 85, expired within 48 hours at temperatures above 8° Celsius (46.4° Fahrenheit). Product information for all 119 pharmaceuticals can be found in the Appendix.

Table 2 - Pharmaceutical Expiration within 48 Hours

Pharmaceuticals Expiration within 48 Hours					
Drug	**Manufacturer**	**Normal Stage**	**Max time at >8 C**	**Comments**	**Reference**
BCG-S medac inj	TechnoPharm	2-8 °C	24 hours	Valid for temperatures between 15-19.9 °C. Return to fridge. Effect on shelf life unknown.	Company
Eprex (with polysorbate)	Janssen-Cilag	2-8 °C	48 hours	Vials/syringes containing polysorbate 80. Valid for temperatures up to 25 °C. Return to fridge.	Company

Esmeron inj	Organon Teknika	2-8 °C	see comment	If left out of the fridge for more than 24 hours, store between 8-30 °C (do not return to fridge) and mark with 3 month expiry date.	SPC & Company
Oxbipp paste	Oxford	2-8 °C	24 hours	Return to fridge. Original expiry valid	Company
Oxbipp-g gauze	Oxford	2-8 °C	48 hours	Return to fridge. Original expiry valid	Company
Pancrex products	Yamanouchi	2-8 °C	see comment	Previously storage conditions were <15 °C. Company recommend discarding if out of fridge more than 2-3 hours	Company

Another critical item, deals with food refrigeration. The basic idea of the refrigerator is it uses the evaporation of liquid to absorb heat. The liquid refrigerant used in a refrigerator evaporates at an extremely low temperature. The cold temperatures inversely help food stay fresher by slowing down the activity of bacteria. For example, bacteria will spoil milk in two to three hours if left out at room temperature. On the other hand, by reducing the temperature of the milk, it will stay fresh for a week or two. These cold temperatures reduce the activity of the bacteria that much. If an extended power outage occurred, the bacteria will have an adverse effect on the food.

Another critical item that must be considered when installing a new emergency generator is location. This plays a major role for refueling the generator. The standard fueling truck has a 100 foot hose for refueling.

Risk Reduction Strategies

- Meet with local utility provider to assess the reliability of the existing power system.
- Respond to facility power outages as symptoms of marginal power supply, which may be related to the recent addition of new equipment.
- The entire emergency power supply system should be fully tested against the requirements of NFPA 110. This ensures minimum acceptable performance. Testing may run for periods of four hours or more, it is important that organization management, the medical staff, nursing, respiratory therapy, and other key staff participate in the test. As expressed in the GMU RFP, the test should be scheduled two weeks advance.

- Electricians, mechanics, and other maintenance technicians should be stationed in strategic locations throughout the facility during testing to monitor the functioning of critical equipment and to minimize response time for problems that may occur.
- Relevant infrastructure planning assessment as part of a master facility plan should be performed for any new construction. This will assure optimal location of the generator, fuel tank, support equipment, and proper redundancy. The addition of loads over time will also be identified through such planning.
- Maintain written procedures and record all test data. These help facility managers control the testing process and improve generator performance. Many facilities use standardized testing forms to collect test-related data (See Appendix).

Evaluation of Current Emergency Generator

The existing generator on-site was a Generac Diesel 80kW SD080 Series 2000 Generator. This is a 3 phase, 2 wire unit.

Figure 13 - Generac SD080

Figure 11 - Generac SD080

Table 3 - General Specifications for Generac SD080

SD080 General Specifications	
Prime Ratings kW	72
Prime Ratings kVA	90
Standby Ratings kW	80
Standby Ratings kVA	100
Hertz	60 Hz
EPA Tier Level	3
Dimensions (LxWxH)	111.8"x40"x92.3"
Dry Weight	3,832 lbs
Engine Manufacturer	Iveco/FPt
Cylinder Arrangement	4 Inline

Max Power at Rated RPM	1,800
Horsepower (Prime)	131
Fuel Tank	227 Gallon

The generator has a 390 mm Generac alternator is a 4-pole, Revolving Brushless, Direct Flexible Disc.

Evaluation of New Emergency Generator

The emergency generator that will be used on for the George Mason University Student Union Building I project is a Kohler Diesel 250kW 250REOZJD Generator. This is a 3 phase, 4 wire unit. This particular model will run at 100% for 58 hours. Approximately 75% of the capacity is taken for this model. This assumes everything is running.

Figure 15 - Kohler 250REOZJD

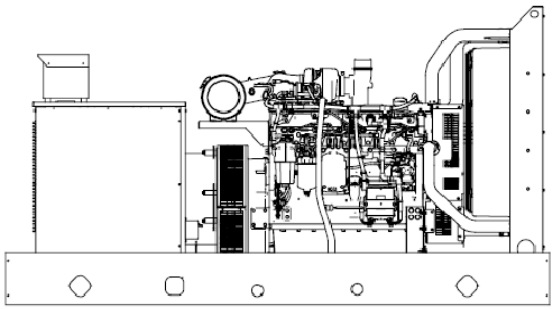

Figure 16 - Kohler 250REOZJD Schematic

Table 4 - General Specifications for Kohler 250REOZJD

250REOZJD General Specifications	
Prime Ratings Range kW	225-230
Prime Ratings Range kVA	281-288
Standby Ratings Range kW	250-255
Standby Ratings Range kVA	313-319
Hertz	60 Hz
EPA Tier Level	3
Dimensions (LxWxH)	193"x54"x132"
Dry Weight	10,000 lbs
Engine Manufacturer	John Deere
Engine Model	6090HF484

Cylinder Arrangement	6 Inline
Max Power at Rated RPM	287 kWm (385 BHP)
Horsepower	385
Fuel Tank	966 Gallon Sub-Base

The alternator is a 4-pole, Rotating-Field Brushless, Permanent-Magnet with 12 reconnectable leads. The below (Table 5) shows the generator set ratings for the 4UA10 alternator.

Table 5 - Alternator Generator Set Ratings

Alternator Generator Set Ratings							
				130°C Rise Standby Rating		105°C Rise Prime Rating	
Alternator	**Voltage**	**Ph**	**Hz**	**kW/kVA**	**Amps**	**kW/kVA**	**Amps**
4UA10	277/480	3	60	250/313	376	225/281	338

The following (Tables 6-7) show the fuel consumption of the 250KW Kohler emergency generator. Note - the recommended fuel for the model emergency generator is #2 Diesel.

Table 6 - Prime Fuel Consumption

Prime Fuel Consumption at	
100% load	59.1 Lph (15.6 gph)
75% load	45.3 Lph (12 gph)
50% load	31.6 Lph (8.3 gph)
25% load	18.4 Lph (4.9 gph)

Table 7 - Standby Fuel Consumption

Standby Fuel Consumption at	
100% load	66.5 Lph (17.6 gph)
75% load	50.4 Lph (13.3 gph)
50% load	35 Lph (9.2 gph)
25% load	20.5 Lph (5.4 gph)

Features:

- The generator set and its components are prototype-tested, factory-built, and production-tested.
- The 60 Hz generator set offers a UL 2200 listing.

- The generator set accepts rated load in one step.
- The 60 Hz generator set meets NFPA 110, Level 1, when equipped with the necessary accessories and installed per NFPA standards.
- The generator set complies with ISO 8528-5, Class G2, requirements for transient performance in all generator set configurations. Select the Decision-Maker® 550 controller for improved voltage regulation and ISO 8528-5, Class G3, compliance.
- The 60 Hz generator set engine is certified by the Environmental Protection Agency (EPA) to conform to Tier 3 nonroad emissions regulations.
- The low coolant level shutdown prevents overheating (standard on radiator models only).
- Integral vibration isolation eliminates the need for under-unit vibration spring isolators.
- A one-year limited warranty covers all systems and components. Two-, five-, and ten-year extended warranties are also available.

Alternator features:

- The brushless, rotating-field alternator has broad range reconnectability.
- NEMA MG1 , IEEE, and ANSI standards compliance for temperature rise and motor starting.
- Sustained short-circuit current of up to 300% of the rated current for up to 10 seconds.
- Sustained short-circuit current enabling downstream circuit breakers to trip without collapsing the alternator field.
- Self-ventilated and dripproof construction.
- Vacuum-impregnated windings with fungus-resistant epoxy varnish for dependability and long life.
- Superior voltage waveform from a two-thirds pitch stator and skewed rotor.
- Fast-Response(TM) II brushless alternator with brushless exciter for excellent load response.

Connected Electrical Loads to 250kW Generator

The following loads are connected to the Kohler Diesel 250kW 250REOZJD Generator:

- Fire Pump – 58.2 kVA
- Elevator – 10 kVA
- Receptacle – 87.07 kVA
- Emergency Lighting (New) – 20.63 kVA
- Emergency Lighting (Existing) – 6.91 kVA
- Refrigerator/Freezing Units – 23.95 kVA
- Misc. Security/Fire Alarm – 12.7 kVA

The total calculated kVA for the 250kW Kohler 50REOZJD generator is 219.47 kVA or 175.57 kW. Ennis electric stated that approximately 75% of the generators load was used. As a calculation check, (see full calculations in appendix) approximately 70% of the load is used with these calculations.

Alternatives to the Diesel Emergency Generator

Diesel generators do fail regularly. For instance, nuclear power plants are home to the most carefully maintained and pampered backup diesel generators. Thus far, approximately one percent of all nuclear power plant diesel generators fail to start when required. Fifteen percent of the diesel generators will fail if ran for 24 hours.

Alternatives to diesel generators do exist, as shown in Table 8. Also provided in Table 8 are kilo-Watt ranges, cost comparisons, and efficiency percentages. As it compares to the diesel generators, the alternatives' immaturity are expected to improve substantially in cost and performance as technology advances.

Table 8 - Distributed Generation Cost Comparison

Distributed Generation Cost Comparison					
Technology	**Size Range (kW)**	**Installed Costs (kW)**	**Heat Rate (Btu/kWH)**	**Approximate Efficiency (%)**	**Variable O&M ($/kWh)**
Diesel Engine	1-10,000	350-800	7,800	45	0.025
Natural Gas Engine	1-5,000	450-1,100	9,700	35	0.025
Natural Gas Engine w/CHP	1-5,000	575-1,225	9,700	35	0.027
Dual Fuel Engine	1-10,000	625-1,000	9,200	37	0.023
Microturbine*	15-60	950-1,700	12,200	28	0.014
Microturbine w/CHP*	15-60	550-1,700	11,000	28	0.014
Combustion Turbine	300-10,000	700-2,100	11,000	31	0.024
CombustionTurbine w/CHP	300-10,000	700-2,100	11,000	31	0.024
Fuel Cell	100-250	5,500+	6,850	50	0.01-0.05
Photovoltaics*	0.01-8	8,000-13,000	--	n/a	0.002
Wind Turbine	0.2-5,000	1,000-3,000	--	n/a	0.01
* Note - Under the 250 kW Generator Size					

Fuel cells are becoming increasingly popular. Fuel cells are very clean and quiet. Negatively, they depend on either large onsite fuel storage tanks or reliable supplies and

transportation of offsite fuel, although they can be powered by natural gas or hydrogen. When powered by hydrogen that is produced in a carbon-neutral manner, fuel cells emit only nitrogen oxide (NOx) at levels that are barely detectable. Natural gas and hydrogen fuel cells do not emit sulfur dioxide (SO_2).

Microturbines are lighter and quieter than diesel generators, almost as clean as fuel cells when fueled by natural gas, but are slightly less cost competitive than diesel generators. Like diesel generators, but not like fuel cells, microturbines use combustion to produce electricity.

For very short-term power needs, at the demand of minutes to hours or most critical conditions, uninterruptible power supplies (UPS) and/or batteries are installed. Since these systems only store power and do not produce it, they are not comparable to the technologies listed in Table 8.

Since LEED has become a primary issue in today's construction industry, the emissions for these alternatives will be considered as well. Table 9 below shows the range of emissions from diesel generators, while Table 10 shows nitrogen oxide (NOx) and particulate matter of 10 microns (PM10) for some alternatives to diesel generators.

Table 9 - Ranges of Pollutant Emissions from Diesel Generators

Pollutant Emissions - Diesel Generators		
Pollutant	**Low Range (lb/MWh)**	**High Range (lb/MWh)**
NOx	5.9	17.1
PM	0.74	3
CO_2	1482	1700
CO	7.6	30
VOC	0.73	2
SO_2	0.3	0.5

Table 10 - Emissions of NOx and PM10 for Some Alternatives to Standby Diesel Generators

Emissions of NOx and PM10 for Alternatives		
Alternative	**NOx (lb/MWh)**	**PM10 (lb/MWh)**
Lean Burn IC Engine	3	0.4
Small Gas Turbine	1.1	0.2
Microturbine	1	0.09
Rich Burn IC Engine w/catalyst	0.6	0.4

Combined Cycle Gas Generator	0.06	0.04
Phosphoric Acid Fuel Cell	0.03	0
Solid Oxide Fuel Cell	0.01	0

Although the previous emissions data shows diesel generator emissions are typically much higher than the alternatives, an extensive study by the University of California found that the use of diesel generators at the present rate and extent of electricity should not pose a threat to public health, except in rare cases where a generator is located in an enclosed area near sensitive populations.

Emergency Power Contingency Plan Rubric

Introduction

The Power Outage and Utility Failure Response Guide for George Mason University was created by the GMU Environmental Health and Safety Office. After researching the Site Specific Safety Plan for the project, with a specific focus on the general public, the aforementioned Power Outage and Utility Failure Response Guide will also be reviewed. Although, the planning and implementation of risk reduction approaches to address electrical power failure are the responsibility of the facility engineer, organization management, risk management, incident command leaders, and medical staff, allowing for improvements to the plan will increase safety for the general public, students, and staff at GMU.

As stated, the Site Specific Safety Plan will be utilized during construction and the Power Outage Response Guide will mostly be used after the construction of the SUB I project. Although, this would typically be the case for majority of projects, there is one other aspect that must be taken into consideration. The new emergency generator will contain loads from both the existing and new Student Union Buildings. During the construction of the SUB I project, the Power Outage Response Guide will be a critical document for this reason. The Power Outage Response Guide will also prove to be a very decisive plan because of the Student Health and Wellness Center, which is located on the third floor of the existing Student Union Building.

The entire Power Outage and Utility Failure Response Guide will be reviewed. As previously mentioned the GMU Response Guide contains five sections. These sections include:

- Introduction
- Scope
- Preparation
    - Emergency Lighting and Egress
    - Equipment and Data Protection
    - Sanitation
- Response Procedures

- Suspension of Work

The overall Response Guide, which was found on the GMU Environmental Health and Safety Office website, is a general guide for all buildings on the Fairfax Campus. To specifically tailor this guide to the needs of the SUB I building, many of the similar concepts that were used in the Site Specific Safety Plan will be used in this document. One key section of the Site Specific Safety Plan that will benefit the GMU Power Outage and Utility Failure Response Guide will be the General and Hess Specific Safety Requirements – Electrical section. To perform this task, the two sections that will be researched in detail are the Preparation and Response Procedures sections.

Contingency Plan Management Topics

The Joint Commission on Accreditation of Healthcare Organizations requires all hospitals to have plans for all internal and external disasters. Defining what would constitute an internal disaster is essential. Typically, this is any event that threatens the smooth functioning facility that presents a potential danger to patients or hospital personnel. This is not a requirement for a Health and Wellness, like the one located in the existing Student Union Building. Although the Joint Commission does recommend health care facilities perform a holistic management system that involves the following:

- Master planning for future flexibility and load growth.
- Utility management program that includes maximum demand loading, load profile analysis, fuel management, accurate and useful documentation and emergency power system maintenance.
- Complete an inventory of emergency power systems.
- Comprehensive initial assessment testing.
- Test generator fuel oil for usability on a regular basis.
- Conduct a commissioning assessment of the adequacy of emergency power systems for critical equipment over an extended period of time with review and rend analysis.
- Facilitate shutdowns, maintenance, reliability, and testing.
- Ensure that those individuals responsible for operating power systems have demonstrated competency in this role with continuous education.
- Investigate and resolve training and systemic issues.
- Communicate the capabilities and limitations of the emergency power system to the organization's leadership team.
- Establish contingency plans for members of the health care team to follow during any power loss, whether brief or sustained.
- Emergency management plan that stresses patient safety, risk assessments, and preparedness.
- Conduct regular vulnerability assessments.

Typically, contingency plans should address the following issues when providing power to a health care facility.

- Alarm Systems

- Emergency Communication Systems
- Exit Signs and Exit Route Lighting
- Storage for Biological Specimens and Pharmaceuticals

Reasons for Further Development

Preparation

To obtain information regarding scheduled power or utility outages please visit the Facilities Management Outages and Alerts *webpage (provided below). In the event of a utility failure there are actions that should be taken to protect equipment and assist in the safe evacuation of affected area.*
http://facilities.gmu.edu/alerts/index.htm

Although power outages are outside of the clinician's control, how health care clinicians respond to such an outage can be controlled. Every facility should have documented procedures for protection of building occupants – proactive actions for life safety – as well as procedures for response to credible threat scenarios. Preparation for a power outage is a crucial stage when dealing with health care facilities. Proactively assessing the Student Union Building's vulnerabilities will greatly reduce the risks for clinicians in the event of short term or sustained power loss. There are a few items that will be addressed in this section. These include:

- Joint Commission Recommendations
  - Test emergency generator at least once every 36 months
  - Test must be conducted for a minimum of four continuous hours
- Initial Testing of Emergency Generators
  - Load Bank Test
- Inspections of Emergency Generators
  - GMU Inspections
  - Weekly Inspections
  - Monthly Inspections
  - Inspection Documentation
- Training and Testing of All Operators Responsible for System Maintenance
- Communication Procedures
  - Can be divided into different phases
    - Phase 1 – Alert Phase
    - Phase 2 – Response Phase
    - Phase 3 – Expanded Response Phase
  - Effects that Occur from the Lack of Communication
- Emergency Management Education and Training
- Nursing Preparation
  - There are steps that can be performed by nurses in the event of power outage to minimize the effects and to keep patients safe.
- Performance Standards for Emergency Management
- Mitigation Activities
- Preparedness Activities

Emergency Lighting and Egress
Not all university facilities areas are equipped with emergency lighting or illuminated emergency exit signs. If you work in an area that is not equipped with emergency lighting consider purchasing a battery or wind-up powered flashlights.

In terms of egress, the proposed contingency plan will include critical evacuation routes for both the existing and new Student Union Buildings. This graphic representation will provide user groups with detailed exiting procedures in the case of an emergency or power outage. The only effected area during construction is the first floor of the existing SUB I building.

Equipment and Data Protection
All sensitive equipment should be connected to a fusible power-strip or surge protector. Some equipment may require an uninterruptible power supply (UPS) system to ensure that it does not sustain damage during a power outage, loose valuable data, or maintain power long enough to power down through a routine or emergency shutdown sequence. Setup computers to frequently auto-save data and utilize shared drives such as MESA, which are backed up daily by the Information Technology Unit.

This section is essentially a cautionary section for the students and the general user group to connect sensitive equipment to surge protectors. The emergency generator will be connected to some sensitive equipment loads. These would include:

- Lighting
- Health and Wellness Center
- Fire Pump
- Some Receptacles
- Elevator
- Fire Alarm
- Refrigerators/Freezers

It is important that the previously mentioned items are discussed in the contingency plan. This provides all user groups with detailed information about the loads involved. The contingency plan will directly indicate where all the emergency receptacles are located and how the receptacles will differ from not emergency receptacles.

Sanitation
To maintain sanitary conditions, restrooms must not be used whenever a disruption in water service occurs. Consider using antiseptic wipes or waterless hand sanitizer to disinfect your hands which can be kept in the office in case of an emergency.

This section should not be affected in the specific event of a power outage. One item that should be noted that pertains to this section involves the fire pump. Unlike the existing 100kVA generator, which contains the loads for only the emergency lighting, fire alarm system, security system and health care facility; the new 312kVA generator will also

contain the loads of the fire pump, as well as other previously mentioned loads. This will allow the fire pump to continue extinguishing water to specific fire protection devices.

Response Procedures

The following procedures for power outages for all GMU buildings were proposed in the Power Outage and Utility Failure Response Guide. These include:

- *Report the utility failure to Facilities Management*
- *Discontinue all non-essential work until utilities are restored.*
- *Exit the building and assist faculty, staff, and students who may not be familiar with evacuation procedures or the building floor plan.*
- *If it is unsafe to exit the building relocate to an area that has sufficient ambient light to avoid injury such as a lobby or conference room with windows.*
- *If emergency lighting is unavailable, remain calm, contact University Police, provide your location, and request assistance.*
- *If you are unable to use a cellular phone or desk phone to call for assistance or report a utility failure, locate a fax machine with phone handset. Fax machine phone lines should remain operational during a power outage.*
- *If a building is evacuated due to a utility failure, the building may not be reoccupied until University Police determine that the building is safe for re-occupancy.*
- *If you are required to evacuate a building it is suggested that you take all personal belonging with you and secure the area before leaving.*
- *In the event of a power failure, electronic access systems should remain operational using battery backup for a limited period of time following the power outage.*

This section is trying to focus on all user groups, which may include:

- General User Group
    - Registrar's Office
    - Office of Student Financial Aid
    - Health and Wellness (Non-Critical)
        - Alcohol, Drug, and Health Education
        - Sexual Assault Services
        - Wellness Education Resources
    - Student Success
        - Career Services
        - Academic Advising Center
    - Counseling and Psychological Services
    - Office of Disability Services
    - International and Multicultural
    - Diversity Programs and Services
    - Early Identification Program
    - Office of International Programs and Services
    - Multicultural Research and Resource Center
    - Honor Committee and Judicial Affairs

  - Auxiliary Services
  - Students
- Health and Wellness User Group

For the Response Procedures, this above mentioned section is focused toward the General User Group. This section is very well written for that particular user group. The Health and Wellness User Group, specifically nurses, will have their own procedures for a contingency plan. Breaking these procedures into the different user groups will allow for more detailed procedures given in the case of a power outage. This will also increase the safety for the all user groups by directing all persons after an emergency and will also mitigate other risk that may be caused by confusion or disorientation.

It is imperative that all procedures are reviewed on a regular basis so all health care workers will be prepared to effectively respond when the worst case scenario of a prolonged power outage occurs.

Emergency Power Contingency Plan Additions

In addition to the George Mason University Power Outage and Utility Failure Response Guide, the following additions will be proposed.

The Joint Commission Recommendations

- Complete an inventory of emergency power systems
- Conduct an assessment of the adequacy of emergency power systems for critical equipment over an extended period of time
- Ensure that those individuals responsible for operating power systems have demonstrated competency in this role
- Communicate the capabilities and limitations of the emergency power system to the organization's leadership team
- Establish contingency plans for members of the health care team to follow during any power loss

Initial Testing of Emergency Generators

- Load Bank Test
  - Required by NFPA 110
  - Simulates the full electrical demands
  - One hour
  - Monitors the engine and generator to ensure proper

Inspections of Emergency Generators

GMU Inspections

For continued reliability of the emergency generator it is critical for maintenance and testing to be performed in accordance with manufacturer's recommendations, instruction manuals, and the minimum requirements of NFPA 110.

Two sets of instruction manuals should be kept by GMU for all major generator components. One set should be kept in a secure, convenient location near the equipment. The other set should be kept in a different secure location. These manuals should contain the following:

- Detailed explanation of the operation of the emergency power supply system
- Instructions for routine maintenance
- Detailed repair instructions
- Illustrated parts list and part numbers
- Illustrated and schematic drawings of electrical wiring systems, including operating and safety devices, control panels, instrumentation and annunciators

Weekly Inspections
Properly trained personnel should oversee routine maintenance, inspection and operational testing of the emergency generator and associated components. According to NFPA 110, healthcare facilities must inspect their emergency generators weekly. At a minimum, weekly inspection should include a check of the following:

- Fuel Check
  - Main and day tank fuel supply levels
  - Day tank float switch
  - Piping
  - Hoses
  - Connectors
  - Operating fuel pressure
  - Obstructions to tank vents and overflow piping
- Oil Check
  - Proper oil level
  - Oil operating pressure
  - Lube oil heater
- Cooling System Check
  - Coolant level
  - Water pump(s)
  - Jacket water heater
  - Belts
  - Hoses
  - Fan
- Exhaust System Check
  - Drain condensate trap
  - Possible leakage
- Battery System Check
  - Possible corrosion
  - Specific gravity
  - Electrolyte level (a level between 1250 and 1275 is acceptable)

    - Battery charger
- Electrical Check
    - General inspection of wiring and connections
    - Circuit breakers/fuses
- Prime Generator Check
    - Debris/Foreign objects
    - Loose or broken fittings
    - Guards and components
    - Unusual condition of vibration, leakage, noise, temperature or deterioration

Monthly Testing
Healthcare facilities must exercise their emergency generators under full load at least monthly. The unit should run for 30 to 40 minutes under actual load. All aforementioned weekly-check items must be observed. Battery specific gravity hydrometer readings should be taken.

Testing Documentation
A written record of generator inspections, exercising, operation and repairs must be maintained for at least three years on the GMU premises and be available for review by the fire inspector on request. This record must include:

- Date of the report
- Name(s) of the person(s) providing the service
- Identification of unsatisfactory conditions
- Corrective action taken (including parts replaced)
- Testing of repairs recommended by the manufacturer

Training and Testing of All Operators Responsible for System Maintenance

- Cross-training testing
- Competency training
    - Responses to various internal failures
    - Responses to simultaneous multiple utility failures
    - Operation of different equipment during tests versus the same equipment every month
    - Understanding EP test-related interactions with other systems and equipment

Communication Procedures

- Can be divided into different phases
    - Phase 1 – Alert Phase
        - Staff remain at their regular duties and wait for further instructions from their supervisors.
    - Phase 2 – Response Phase

        - Designated staff report to supervisors or the command post for instructions.
    - Phase 3 – Expanded Response Phase
        - Expanded response phase during which additional personnel are required.
- Effects that Occur from the Lack of Communication
    - Major Contributor to
        - Anxiety
        - Panic
    - Major Effects Persons Trapped in
        - Elevators
        - Dark Stairwells
        - Isolated Rooms

Emergency Management Education and Training

- As a part of new employee orientation, all GMU employees will receive general information about the Contingency Plan. Student Health and Wellness employees are introduced to their roles in emergency response as a part of the department orientation program.
- All employees are required to participate in emergency management and response training as a part of their department continuing education. All employees are required to complete computer-based learning modules on emergency management annually.
- All on-duty employees are required to participate fully in emergency response drills in a variety of emergency situations.
- Department orientation and continuing education will include:
    - Overview of Emergency Management Plan
    - Specific roles and responsibilities
    - Notification systems
    - Communication systems
    - Logistics

Nursing Preparation

- There are steps that can be performed by nurses in the event of power outage to minimize the effects and to keep patients safe
- Nurses should know and understand what actions they must take to ensure that even a temporary electrical outage does not result in patient harm
- Nurses should learn more about departmental and facility plans for a power outage.
- Nurses should participate in the development of contingency plans

Performance Standards for Emergency Management

- Employees must be able to demonstrate basic knowledge of emergency management by participating in emergency response exercises and safety surveillance activities.

- Designated Medical areas will meet objectives identified for specific response exercises.
- Performance standards must be established prior to the contingency plan to be used as an evaluation tool during emergency response drills.

Mitigation Activities

- Hazard vulnerability analysis
- Building Maintenance Program, designed to maintain the building in compliance with life safety code
- Continuing reassessment of condition of facility and generator testing
- Establishment of a decontamination unit
- Staff education and training
- Purchase of response equipment and train staff to use
- Safety and Security risk assessments
- Planned reduction of hazardous materials
- Installation and monitoring of security

Preparedness Activities

- Contingency planning based on Hazard Vulnerability Analysis
- State-wide and local mutual aid and alternative site agreements
- Agreements with vendors to provide critical supplies and pharmaceuticals
- Staff education and training
- Staff call-in rosters
- Emergency response drills including: fire, tornado, evacuation and other drills

Evacuation Routes

The only effected area during construction is the first floor of the existing SUB I building.

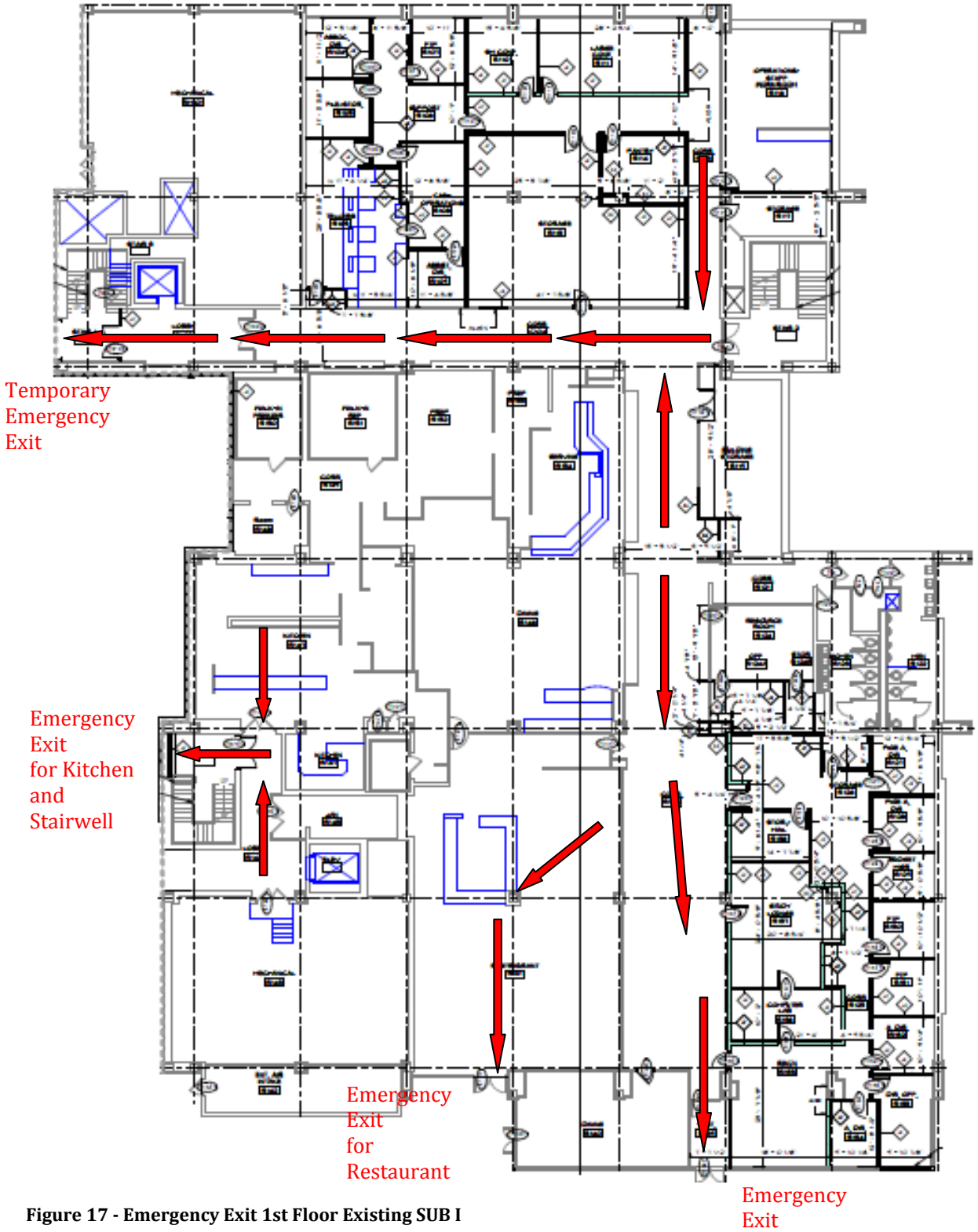

Figure 17 - Emergency Exit 1st Floor Existing SUB I

Emergency Generator Loads

The following loads are connected to the Kohler Diesel 250kW Emergency Generator:

- Fire Pump
- Elevator
- Receptacle
- Emergency Lighting (New)
- Emergency Lighting (Existing)
- Refrigerator/Freezing Units
- Misc. Security/Fire Alarm

Structural Breadth – Building Enclosure Analysis

Introduction

During the project management interview conducted on November 23, 2009 with Greg Ramirez of Hess Construction + Engineering Services, value engineering (VE) had been considered on the GMU SUB I project. One of the first VE items considered was the addition of metal panels. Through value engineering, the amount of brick was reduced to make way for more metal panels. This analysis will consider three options for the SUB I project:

- Metal-Faced Composite Panels
- Pre-Cast Architectural Panels
- Aluminum Storefront System

Each analysis will look at different components of the materials proposed. These will include:

- Standard Sizes and Dimensions
- Moisture Performance Properties
- Thermal Performance Properties
- Structural Performance Properties
- Connection Types
- Potential Problems

There will also be an evaluation of the load distribution on beam C4-C5. Most importantly a cost analysis, schedule analysis, and the site logistics for each product will also be considered.

Metal-Faced Composite Panels

George Mason University Student Union Building I will be using metal-faced composite panels on the project. These panels will be supplied by Laminators Incorporated and are called the Omega-Lite Panels, see Figure 18. The Omega-Lite Panels are composed of a polyallomer, corrugated core between two finished aluminum sheets. Aluminum is commonly used because of cost, corrosion resistance, and durability.

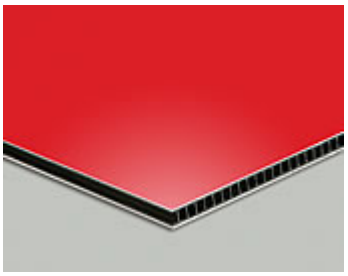

Figure 18 – Omega-Lite Panels

Typically, metal panels are generally proprietary designs in which a manufacturer adapts their system to the architect's design. As part of the design, the architect will select a type of metal panel system and provide architectural details that depict the relationship of the metal panel system to the adjacent building systems. Generally, architects do not provide comprehensive detailing for the metal panel system as part of the construction documents. The project specifications and shop drawings, as well as shop drawing and submittal review, are critical to the success of the project.

In the specification, the designer must select a metal panel system that will meet requirements of two items. These are design criteria and performance criteria. Performance criteria need to include:

- Wind loading
- Seismic design criteria
- Deflection criteria
- Air infiltration criteria
- Water test performance criteria
- Panel flatness criteria
- Panel tolerance criteria
- Thermal movement criteria
- Performance testing criteria
- Fire resistance ratings, if required
- Sound transmission criteria
- Insulation criteria
- Performance criteria for air and moisture barrier

Standard Sizes and Dimensions

The standard size of metal-faced composite panels is generally less than 10 feet by 10 feet.

The thickness of the metal sheets is typically less than 0.05 inches (1.10 mm.) and the overall panel typically is up to 1/4 inches thick (6 mm). In the Omega-Lite case, the panel thickness is 6 mm (1/4 inch) and the smooth face aluminum is 0.021 inch (0.53 mm) thick. As for the total thickness of the system, it depends on the structural support system for the panels. Generally, the greater the size and span of the panel, the deeper the thickness of the system. Thickness can typically range from 2 inches deep for small panels to over 6 inches deep if the panels are large and need to span end to end between supports. The panels at GMU will utilize hat tracks, so the thickness will be on the smaller size.

Moisture Performance Properties

Metal panel systems will use a face sealed barrier system to prevent water leakage for metal panel systems. Panel joints are vital to the water tightness of the system, since metal is impervious to water. How the joints perform is a factor of the panel design and construction. The Omega-Lite panels are designed based on a barrier system design, the joints between will be face sealed.

Metal panels have higher coefficients of expansion for thermal movement compared to other exterior cladding, such as concrete or masonry. The expected movement of metal panels, due to changes of temperature, need to calculated by designers. Generally, the thermal expansion for aluminum is 12.3 $x10^{-6}$ inch/inch °F. Therefore, joints must be wide enough to accommodate thermal expansion and differential movements between panels. Joint sizes can vary from 1/4 inch wide for small panels to 1 inch wide for larger panels.

There are a couple of factors that influence joint size. This would include panel size, panel location on the building, and tolerance issues. As a rule, larger panels require larger joints.

Panel edges must be configured with a return so that a properly designed sealant joint with backing materials can be installed. When adhered to metal panels less than 1/4 inch thick, sealants do not provide durable performance. Two sided adhesion for joint expansion and contraction must also be taken into consideration.

Thermal Performance Properties

The amount of insulation placed in the cavity or within the backup wall creates the thermal performance characteristics for non-insulated metal panel systems.

Structural Performance Properties

Metal panel systems are typically considered nonstructural elements that are used to form a curtain wall; however, these nonstructural elements typically must be structurally designed. The panels must be designed to resist out-of-plane loads (such as wind or seismic loads), and must be also designed to resist in-plane loads (seismic loads and vertical/dead loads). Loads from the panels must be transmitted to the building's structural frame. In addition, the panels must allow thermal movements and must be designed so that they do not act to restrain the building's structural system as it deforms under lateral and gravity loads.

Composite metal panels are not as impact resistant as flat plate metal panels. Stiffeners can be welded or adhered to the rear surface depending on the size of the panels. This will not be a problem on this project.

Aluminum panels are proprietary designed according to the Aluminum Association's *Specifications for Aluminum Structures* and is based on in-house research by the metal panel manufacturer.

Connection Types

These panels are generally fastened by proprietary installation systems. The panels can be either directly fastened to the structural system or be fastened to a secondary structural system of metal studs, hat tracks and supporting channels (See Figure 19). The hat channel and support system can also be part of the water resistive design for the panels, especially for more complex systems which include flat plate

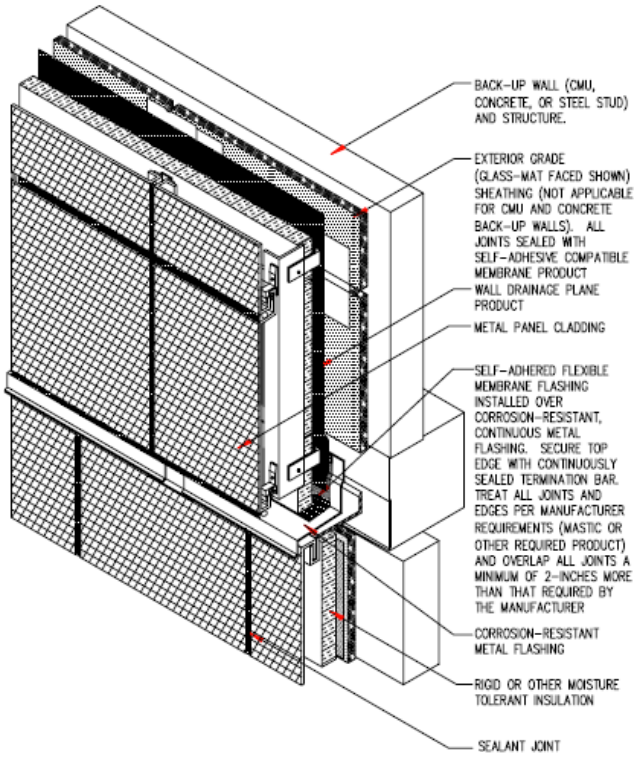

Figure 19 - Metal Panel Connection

and metal-faced composite panels.

Potential Problems
There are some potential problems that are associated with metal panels. These include:

Pitting
When exposed to weather and pollution over time, the protective coating for metal panels can result in a pitted appearance. Pitting detracts from the appearance of the panel and the building, but has no structural bearing.

Oil Canning
Oil canning is defined as a waviness of the metal in the panel. Oil canning is usually caused by problems in fabrication, design, or installation. Oil canning detracts from the appearance of the panel, and normally structural integrity is not affected. Flatness criteria should be discussed when selecting metal panels, to the set design criteria. Support for the design, shipping, and erection process must be considered to limit oil canning for all panels.

Shadowing
Shadowing can occur from Installation welds or stiffeners on the backsides of metal panels.

Dissimilar Metals
Two types of problems can occur when dissimilar metals are used on a building. These are water runoff staining and/or galvanic corrosion.

Water running off one type of metal onto another can stain and corrode the other metal. Runoff from metal surfaces can also stain some types of stones and other materials.

Galvanic corrosion occurs when one type of metal is in physical contact with another type of metal. The less noble metal will corrode, and this corrosion can affect the panel structurally. When dissimilar metals are in close proximity, they should either be physically separated or reviewed for galvanic action potential.

Dissimilar metals will not be used on the GMU SUB I project; therefore water runoff staining or galvanic corrosion will not be a concern.

Evaluate Load Distribution on Frame
A typical exterior beam was analyzed for this portion of the research. The beam was C4-C5 on the Structural plan S-1.4 (See Figure 20)

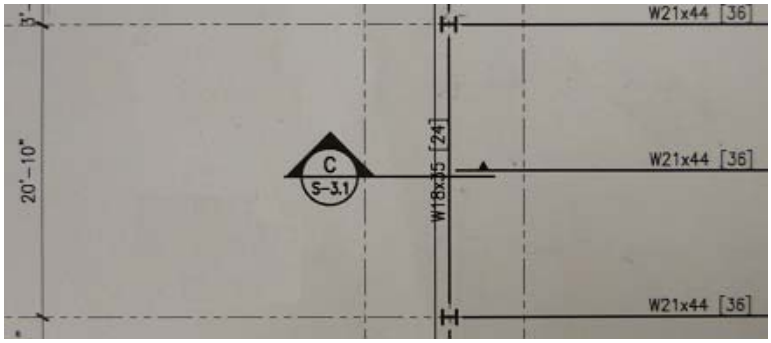

Figure 20 - Beam C4-C5

The loads on the wall are as followed:

Point Load from Beam C-E between Column Lines 4-5

- Lightweight Concrete – 44 psf
- Deck – 3 psf
- Live Load - 80psf +20psf (partitions)
- Superimposed Dead Load - 15 psf
- Beam Weight - 810.33 lbs

Distributed Load from Exterior (See Figure 21)

- Curtain Wall – 12 psf
- Medium Weight 8" CMU – 55 psf
- 4" Brick – 42 psf
- Metal Panel – 1.1 psf

See Full Calculations in Appendix

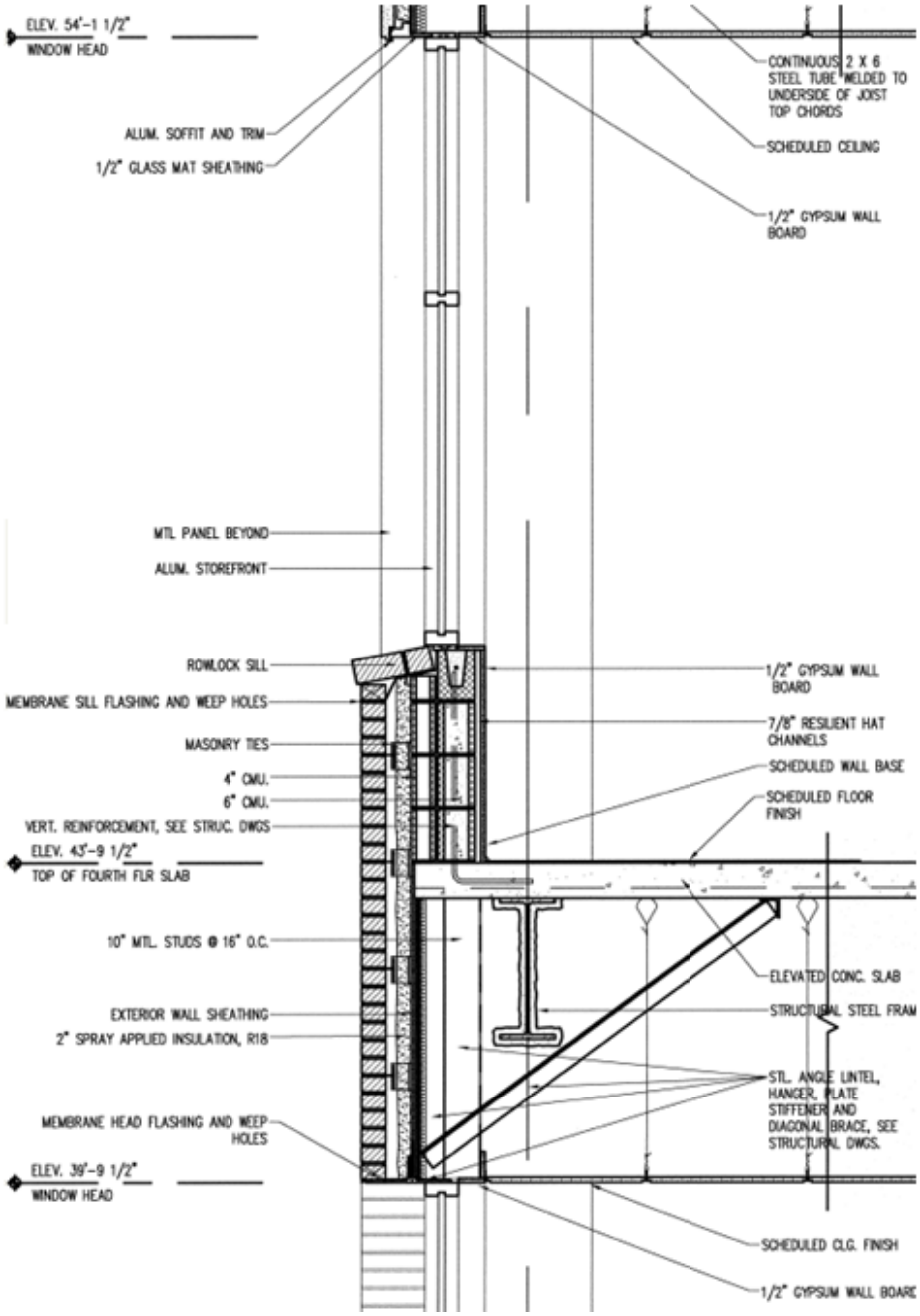

Figure 21 - Section through Beam C4-C5

Check Moment
ΦM_n =515 kft
M_{max} = 513.23 kft
513.23 kft < 515 kft therefore OK

Check Deflection
Δ_{max} = 0.694"
Δ = 0.426" < 0.694" therefore OK

Cost Analysis
Aluminum composite panel systems average $30.00psf installed. The GMU Omega-Lite Panels will cost closer to $24.00.

Company	Cost per Sq. Ft.	Description
CVT Construction	$24.00*	Laminators Incorporated Omega-Lite Panel

The total cost for of Metal Panels is $41,546.49. Please see Cost Analysis in Appendix.

Schedule Analysis
After discussing the scheduling with a CVT Construction Incorporated project manager, it was stated that a jobsite with fantastic production will achieve 2,500 sq. ft. of metal panel per week; because of GMU's complexity the production numbers should be closer to 1,500 sq. ft. per week (300 sq. ft. per day). There is a total of 1732 sq. ft. of metal panel used on the project. This would equate to a total of 5.77 days, which is essentially 6 days.

Please see Schedule Analysis in Appendix.

Site Logistics
Site Equipment
The installation of the metal panels will utilize scaffolding around the North, South, and East sides of the building (See Figure 22). The Standard Masonry Scaffold (Fully Planked per OSHA and Hess Safety regulations) is 5 ft wide. This can easily be accommodated around the building. Material storage will be on the Southern (See Figure 22) side of the construction site.

Figure 22 – Building Location

Building Information Modeling

The use of 4Dimensional modeling will be utilized on the project (Refer to the BIM Execution Rubric).

Pre-Cast Architectural Panels

This analysis will look at the installation of pre-cast architectural panels in place of the metal panels. There are four types of pre-cast panels used for building envelopes:

1. Cladding or curtain walls
2. Load-bearing wall units
3. Shear walls
4. Formwork for cast-in-place concrete

For this project, pre-cast cladding or curtain walls will be researched. These panels are the most common used pre-cast concrete panel for building envelopes.

Pre-cast concrete panel are designed to provide the appropriate level of durability for the planned exposure. These are often specified (i.e air entrainment, maximum absorption, minimum compressive strength, etc.) to enhance the durability of the concrete. There are a number of ways to improve durability. These would include:

- Specifying minimum compressive strengths
- Maximum water to cement ratios
- Appropriate range of entrained air

The product that will specifically be looked at in this analysis is the Metal Stud Crete Pre-cast Panel. The Metal Stud Crete composite panels consist of light-gauge steel studs and a reinforced concrete facing or topping on one side of the studs, with the Metal Stud Crete metal connector pro-viding a shear-flow connection between the steel studs and the concrete.

Standard Sizes and Dimensions

All sizes are available due to the fabrication styles of the pre-cast architectural panels. Measurements must be approved through the submittal process. There are manufacturing tolerances that must be considered. These include:

Manufacturing Tolerances

1. Overall height width of panels measured at the face exposed to view:
    a. 10’ or less: ±1/8”
    b. 10’ to 20’: +1/8”,-3/16”
    c. 20’ to 40’: ±1/4”
    d. Each additional 10’: ±1/16”
2. Overall height and width of panels measured at the face not exposed to view:
    a. 10’ or less: ±1/4”
    b. 10’ to 20’: =1/4”,-3/8”
    c. 20’ to 40’: ±3/8”

d. Each additional 10': ±1/8"

Moisture Performance Properties

Barrier system is the most common moisture protection system used with pre-cast concrete wall systems. The application of a sealer or a concrete coating can also be used when additional moisture protection is needed.

Joints in a pre-cast concrete envelope are an important aspect of the facade design. To prevent leakage, an adequate joint seal between pre-cast units or between pre-cast and other building components must be maintained. It should also be designed to withstand the movement of the joint and should consider structural, thermal, and all other factors that affect the performance. The thermal expansion for concrete is 8.0 $x10^{-6}$ inch/inch °F. As stated in the metal panel section, joints between panels must be wide enough to accommodate this thermal expansion and differential movements between panels then sealed with sealant to prevent water penetration through the wall cavity.

Thermal Performance Properties

Like metal-faced composite panels, the amount of insulation placed in the cavity or within the backup wall creates the thermal performance characteristics for pre-cast system.

Structural Performance Properties

When constructed as a curtain wall or veneer, no building loads are transferred to the pre-cast concrete wall systems. Lateral loads (i.e. wind and earthquake) and vertical loads (i.e self weight) must be resisted directly by the pre-cast concrete wall system. These loads must be transferred through the wall system and to the building's structure. Other loads must also be taken into consideration, such as erection, impact, construction, and transportation. It is important to avoid imposing unwanted loads onto the panels and use them to simply enclose the space.

The concrete facing is 2" normal-weight concrete having a minimum compressive strength of 2,500 psi (17.2 Mpa) at 28 days with Galvanized Welded Wire Fabric. The concrete panels are designed in accordance with PCI Design Handbook Pre-cast and Prestressed Concrete (MNL 120), Design Responsibility for Architectural Pre-cast Concrete Projects (ACI 533.1R-02), and ACI 318 Structural Concrete Building Code.

Connection Type

An important concept when considering pre-cast concrete panels is what connection type will be utilized. Numerous types of anchors are used by the manufacturers, but they are typically characterized as gravity or lateral connections. The ability to transfer loads to the supporting structure and provide stability are the primary purposes for the connections. The criteria used to design the connections including:

- Strength
- Ductility

- Volume Change Accommodations
- Durability
- Fire Resistance
- Constructability

In the case of the Metal Stud Crete product, the connector transfers shear stresses between the concrete facing and the light-gauge steel stud. As shown in Figure 23, the strip is fastened to the web of the stud and the flange of the track. The strip connector with stud frame attached is then embedded into the concrete facing. The strip is fabricated from No. 18 gauge thick (0.047 inch [1.19 mm]) steel.

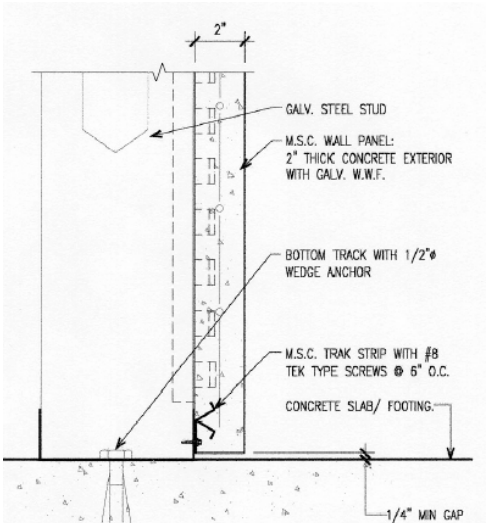

Figure 23 - Metal Stud Crete Strip

Potential Problems

The only potential problems that may occur are from distress and deterioration. This can be caused many ways, poor quality control during erection, out of tolerance fabrication, or improper handling. Anchors that are improperly connected can cause panel cracking, displacements, or other distress conditions. Improper fabrication or handling of the pre-cast panels may cause distress and deterioration that may not become evident for several years.

Evaluate Load Distribution on Frame

A typical exterior beam was analyzed for this portion of the research. The beam was C4-C5 on the Structural plan S-1.4 (See Figure 20)

The loads on the wall are as followed:

Point Load from Beam C-E between Column Lines 4-5

- Lightweight Concrete – 44 psf
- Deck – 3 psf
- Live Load - 80psf +20psf (partitions)
- Superimposed Dead Load - 15 psf
- Beam Weight - 810.33 lbs

Distributed Load from Exterior (See Figure 21)

- Curtain Wall – 12 psf
- Medium Weight 8” CMU – 55 psf
- 4” Brick – 42 psf
- Architectural Pre-cast – 35 psf

See Full Calculations in Appendix

Check Moment
ΦM_n =515 kft
M_{max} = 517.62 kft
517.62 kft > 515 kft therefore will have to increase the size of the beam.

Check Deflection
Δ_{max} = 0.694”
Δ = 0.434” < 0.694” therefore OK

Cost Analysis

Company	Cost per Sq. Ft.	Description
RS Means	$30.85	Uninsulated 4" Thick, Smooth Gray, 4'x8'
RS Means	$23.73	Uninsulated 4" Thick, Smooth Gray, 8'x8'
RS Means	$19.73	Uninsulated 4" Thick, Smooth Gray, 8'x16'
RS Means	$29.10	Uninsulated 6" Thick, Smooth Gray, 20'x10'
Nitterhouse	$30.00 to $35.00	7" Architectural Wall Panel

The total cost for Architectural Pre-cast Panels instead of Metal Panels is $60,588.64, an addition of $19,042.14. Please see Cost Analysis in Appendix.

Schedule Analysis
Phoenix Steel Erectors stated that approximately 30 per day can be done. There are a total of 78 panels used on the project. This would equate to a total of 2.2 days, which is essentially 3 days, a schedule reduction of 3 days.

Please see Schedule Analysis in Appendix.

Site Logistics
Site Equipment
Due to the significant weight of the pre-cast architectural panels, a crane will be utilized for the installation. The crane that was used for the structural steel installation was a 40 ton P&H truck crane with approximately 160' of lattice boom. This will not be a viable resource due to the confined site area.

Aluminum Storefront System
This analysis will look at the continuation of the storefront in place of the metal panels. As defined, a storefront is a thin aluminum-framed wall, typically one story in height, containing in-fills of glass or metal panels (See Figure 24). The product that will be considered for this analysis is United States Aluminum Series 451 Center Glazed Storefront.

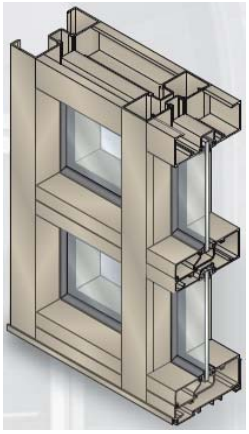
Figure 24 - Aluminum Storefront

An interior glazed stick-built system will be considered for this analysis, due to tight site configurations. In the stick-built system, the storefront mullions and glass are installed and connected together piece by piece, from the interior of the building.

Standard Sizes and Dimensions
All sizes are available from the manufacturer. Measurements must be approved through the submittal process. Some important aspects of the storefront are as followed.

- 2" x 4-1/2" frame
- 1" Glazing infill
- Screw spline assembly
- Shear block assembly

Moisture Performance Properties
When discussing moisture performance, water penetration resistance is a function of many components. These include:

- Glazing Details
- Frame Construction and Drainage Details
- Weather Stripping and Frame Gaskets
- Perimeter Flashings and Seals

There are five means of force that can allow water to penetrate the exterior wall system. These forces comprise of:

- Gravity
- Kinetic Energy
- Air Pressure Difference
- Surface Tension
- Capillary Action

Water penetration for aluminum storefronts are likely to occur at the interior and/or onto insulating glass below. To mitigate water infiltration, all of these forces must be accounted for in the system design, watertight frame corner construction and good glazing pocket drainage are critical.

Thermal Performance Properties
Similar to moisture performance, thermal performance is a function of the following:

- Glazing Infill Panels
- Frame Construction behind Opaque (spandrel and column cover) Areas
- Perimeter Details

As stated earlier, aluminum has a very high thermal conductivity. Therefore, it is common practice to incorporate thermal breaks of low conductivity materials, (i.e. PVC, Neoprene rubber, polyurethane, and polyester-reinforced nylon), for improved thermal performance.

A thermal break is typically ¼" thick minimum. These thermal breaks can be up to 1" or more with a polyester reinforced nylon. These deeper thermal breaks can improve thermal performance and condensation resistance of the system.

The main purpose of the gaskets is to cushion the glass on the interior and exterior faces of the glass (See Figure 25). Gaskets tend to be stretched during installation and will shrink back to their original length in a short time; they will also shrink with age and exposure to ultraviolet radiation, creating problems with moisture protection. A gap usually occurs in the gasket at the corners after shrinkage. Properly designed systems allow water that enters at the gasket corners to weep out through the snap cover weep holes. The use of vulcanized corners and diagonally cut splices will mitigate shrinkage of gaskets.

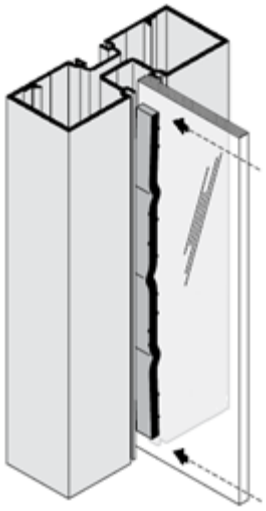

Figure 25 - Storefront Gasket

The function of insulation and air/vapor barriers make up the thermal performance of opaque areas. Wide swings in temperature and humidity are caused by the lack of interior air adjacent to opaque areas; to minimize condensation these areas are subject to careful detailing of insulation and air/vapor barriers.

Structural Performance Properties

Aluminum storefront systems must transfer back to floor structure. Thermal changes and wind, which is significantly different than movement of the building structure, will cause the storefront to demonstrate movement. Therefore the connections to anchor the storefront must be designed to allow differential movement while resisting the loads applied.

Connection Types

Since the project is already utilizing an aluminum storefront system connection details will be given in the submittal process from the manufacturer. Figure 26 is a cross section of the storefront glass and mullions.

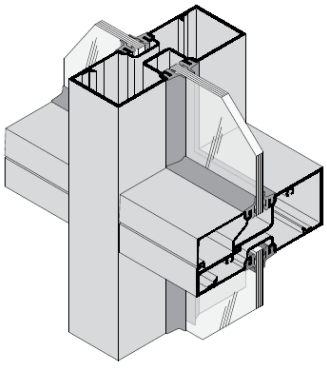

Figure 26 - Cross Section Storefront Glass and Mullions

The following Figure 27 is a cross section of the storefront contact to the wall. It is important to silicone all contact areas to ensure proper moisture and thermal control. It is also imperative to shim at anchor points and under verticals and

setting blocks to achieve a proper plumb setting.

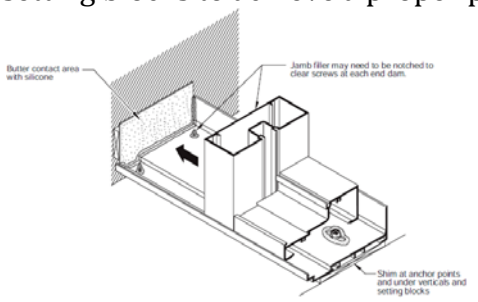

Figure 27 - Cross Section of Storefront Contact to Wall

Potential Problems

Glazing failures

As it applies to storefront systems, glazing problems which include:

- Visual obstruction from condensation or dirt
- Damage to opacifier films from material degradation
- Condensation and/or heat build-up

Failure of gaskets and sealants

As stated, failures can occur from storefront wall movements, prolonged exposure to water, heat/sun/UV degradation. Significant disassembly would repair the gaskets. The installation of exterior surface wet sealing at all glazing and frame joints is often performed, when restoration of internal seals is not physically or economically feasible.

Evaluate Load Distribution on Frame

A typical exterior beam was analyzed for this portion of the research. The beam was C4-C5 on the Structural plan S-1.4 (See Figure 20)

The loads on the wall are as followed:

Point Load from Beam C-E between Column Lines 4-5

- Lightweight Concrete – 44 psf
- Deck – 3 psf
- Live Load - 80psf +20psf (partitions)
- Superimposed Dead Load - 15 psf
- Beam Weight - 810.33 lbs

Distributed Load from Exterior (See Figure 21)

- Curtain Wall – 12 psf
- Medium Weight 8” CMU – 55 psf
- 4” Brick – 42 psf

See Full Calculations in Appendix

Check Moment
ΦM_n =515 kft
M_{max} = 514.64 kft
514.64 kft < 515 kft therefore OK

Check Deflection
Δ_{max} = 0.694"
Δ = 0.428" < 0.694" therefore OK

If a storefront system is chosen the use of permanent exterior sun shades cannot be utilized due to the momentum already exerted on the beam.

Cost Analysis

Company	Cost per Sq. Ft.	Description
RS Means	$27.75	Storefront system, Aluminum Frame, Clear 3/8" Plate Glass, To 12' High, Institutional Grade
CVT Construction	$33.00	Storefront system, Aluminum Frame, Clear 3/8" Plate Glass, To 12' High, Institutional Grade

The total cost for an Aluminum Storefront System instead of Metal Panels is $57,126.43, an addition of $15,579.94. Please see Cost Analysis in Appendix.

Schedule Analysis
Storefront productions vary by installation and fabrication method, but typically 350 Sq. Ft. per day is a good consideration. This would equate to a total of 4.95 days, which is essentially 5 days, a schedule reduction of 1 day.

Please see Schedule Analysis in Appendix.

Site Logistics
Site Equipment
As stated previously, an interior glazed stick-built system was for this analysis, due to tight site configurations. In this stick-built system, the storefront mullions and glass are installed and connected together piece by piece, from the interior of the building. Material storage will be on interior of the SUB I building.

Building Information Modeling
The use of 4Dimensional modeling will be utilized on the project (Refer to the BIM Execution Rubric).

Penn State HUB Survey

Fifty Penn State students were surveyed about the architecture and natural day lighting at the HUB-Robeson Center. The following information will be taken into consideration when considering a change in building envelope system.

The results are as followed:

Q1. How important is architectural design for you?

Very Important	10	20%
Important	19	38%
Average	16	32%
Slightly Important	4	8%
Not Important	1	2%

Q2. Which Building front is more visibly pleasing to you?

Aluminum Storefront (Existing)	39	78%
Architectural Pre-cast Concrete Panels	7	14%
Metal Panels	4	8%

Q3. How important is the natural day lighting for you?

Very Important	20	40%
Important	24	48%
Average	5	10%
Slightly Important	0	0%
Not Important	1	2%

Q4. Are you satisfied with the natural day lighting inside the HUB?

Yes	45	90%
No	3	6%
Undecided	2	4%

Conclusion and Recommendation for Building Enclosure

After performing the analysis for the building enclosure section, it is proposed that the continuation of storefront is used on the SUB I project. There is an additional cost of $15,579.94. There is a schedule reduction of one day. One major factor in the decision making was the student survey. A resounding 78% of students preferred the storefront to the metal panels 8%. This is a significant difference in opinion. Structurally, as stated, if a storefront system is chosen the use of permanent exterior sun shades cannot be used due to the momentum already exerted on the beam. In this instance, the use of a light weight interior shading system will be used to block out any glare or unwanted daylight. Overall, the continuation of the storefront will have a positive impact on the students on the George Mason University Fairfax campus.

Summary and Conclusions

After a thorough investigation of the previous four technical analysis:

Critical Industry Issue – BIM in Design-Build/IPD

Since BIM is already being used on the project it is advised to add and further develop a site logistics section in the BIM Execution Plan. Site utilization will greatly improve quality of site space, in an already confined area through this development.

In-Depth Safety Plan

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. It is recommended that the Job Hazard Analysis section and the Site Specific Safety Conditions include further safety deliverables that are to be provided to the design builder, to maintain as safe project site for the general public.

Electrical Breadth – Emergency Power Analysis

Although, it is typical for the building owner to perform an emergency power contingency plan, it is important to include items such as the standards for inspection, maintenance, and documentation of emergency generator testing. Also, if changes are made to exits during construction, it is important to include and maintain these emergency exit paths.

Structural Breadth –Building Envelope Analysis

After investigating the properties, potential problems, cost, and scheduling, it is recommended the continuation of storefront on the SUB I project is used. The results show an additional cost of $15,579.94 with a schedule reduction of one day. One major reason for the addition is because of a survey given to students comparing the aforementioned building envelopes. The storefront was preferred by 78% of students as compared to the 8% for metal panels.

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Appendix Table of Contents

BIM Interview Questions
Background Information

- What is your title and what are your responsibilities in this company?
- How many years of experience do you have personally with BIM?
- How many years of experience does your company have with BIM?
- What BIM software do you use? Why did you choose this software?
- How many projects have you executed with BIM so far?
- What benefits are coming out of using BIM on these projects?
- What is the impact of BIM (cost, time, overall project delivery time, quality) on design/engineering for the project?
- What are the factors involved for successful implementation of BIM?
- What issues and concerns are you encountering on projects that incorporate BIM?

BIM Execution Planning

- Have you or your company ever been involved in the development of a BIM Execution Plan on a project?
- Yes:
  - Who was involved?
  - What decisions were made?
  - What process did you use to develop the plan? Can I get a copy?
- No:
  - Are you planning to?
  - Who should be involved; make decisions?

Concluding Questions

- What are the future trends for BIM?
- Do you have any additional comments or items that you feel are important to consider?
- Can you refer us to other BIM experts or firms/companies we can interview?

Saurabh Gangwar – Hess Construction + Engineering Services
Background Information

- What is your title and what are your responsibilities in this company?
  - My job title is BIM Manager. I am responsible to strategize the BIM Implementation throughout the company in various phases, Preconstruction, Construction, Facilities Management, Estimation, Marketing etc. I am also responsible for quality control on BIM Execution on all BIM projects.

- How many years of experience do you have personally with BIM?
  - 18 months in college and 18 months in industry

- How many years of experience does your company have with BIM?
  - 18 months

- What BIM software do you use? Why did you choose this software?
  - We use Autodesk Revit MEP and Revit Architecture as Parametric model authoring tools. We also use AutoCAD MEP and AutoCAD Architecture on projects where a few team members are modeling in these softwares. We use Autodesk Navisworks for clash detection, visualization, construction sequencing and facilities management. We use chose these softwares since they are the most widely used parametric softwares in the industry.

- How many projects have you executed with BIM so far?
  - We are currently using BIM on six projects.

- What benefits are coming out of using BIM on these projects?
  - The biggest benefits that we have reaped so far are clash detection and visualization. However we are currently experimenting with 4D simulation for construction sequencing, construction logistics and embedding O&M information in models to create Facilities Management models. The next big benefit we plan to use BIM is for Estimation.

- What is the impact of BIM (cost, time, overall project delivery time, quality) on design/engineering for the project?
  - We have revamped our submittal process using BIM. We use BIM as a tool for all Trade Coordination purposes. This is helping immensely in reducing review time for submittals, thus fast tracking the schedule. Also all submittals are pre coordinated for all clashes thus we have reduced field clashes to a minimum, thus improving our project quality. The reduced time and fewer clashes in field results in a direct cost saving.

- What are the factors involved for successful implementation of BIM?
  - Support from higher senior management
  - Proper planning
  - Mandating right softwares to overcome interoperability issues
  - An emphasis on team work
  - Considering BIM as a new methodology to do business rather than just a technology

- What issues and concerns are you encountering on projects that incorporate BIM?
  - The biggest hurdle to overcome is people's traditional mentality. It really hard to convince people to change their methodology which they have successfully used for decades
  - Interoperability
  - Contractual concerns regarding safeguards of intellectual property

- Convincing team members to risk investment in new technology in a downturn economy

BIM Execution Planning

- Who was involved in the development of the BIM Execution Plan on a project?
  - BIM Manager, Director of Pre Construction, Chief Operating Officer

- What decisions were made?
  - Define the Submittal Process
  - Define the FTP protocols, file nomenclature etc
  - Roles and responsibilities of Information Managers
  - Define the Level of Details
  - Define the Clash Detection Process
  - Define the use of BIM for As Built Facilities Management Model

- What process did you use to develop the plan?
  - We studied a few BIM Execution Templates prevalent in the industry
  - Customized them with our experience on our first BIM project
  - Incorporated the contract requirements from the prevalent contract documents in the industry e.g. AIA, Consensus Docs, AGC etc
  - Brain Storming with other team members

Concluding Questions

- What are the future trends for BIM?
  - BIM very soon will not be considered just as a tool to increase efficiency in various individual construction processes but rather would be adopted as a completely new methodology to do construction business. It will inflow seamlessly in all the processes from design, estimation, preconstruction, construction, facilities management- the whole lifecycle of a project.

- Do you have any additional comments or items that you feel are important to consider?
  - No

- Can you refer us to other BIM experts or firms/companies we can interview?
  - Grimm + Parker, Shapiro & Duncan, Truland, Crystal Steel, Ennis Electric, SHW

Ben May – May Construction
Background Information

- What is your title and what are your responsibilities in this company?
  - Owner

- How many years of experience do you have personally with BIM?
  - 14-15 years

- How many years of experience does your company have with BIM?
  - 5 employees
    - 8 years
    - 6 years
    - 3 years
    - 2 years

- What BIM software do you use? Why did you choose this software?
  - Autocad – Majority of the time because it is what clients request
  - Bentley
  - Deso
  - Archicad

- How many projects have you executed with BIM so far?
  - 60 projects

- What benefits are coming out of using BIM on these projects?
  - Better way to build
  - Better coordination
  - Better understanding of project
  - Better understanding of each subs scope
  - Fewer change orders

- What is the impact of BIM (cost, time, overall project delivery time, quality) on design/engineering for the project?
  - With solid measurements and a solid matrix you should 2 to 3 times the return on investment and as high as 10 to 20 times on BIM.
  - Scheduling – Sometimes depends on the initial schedule and who builds the schedule (is it realistic) If it is put together properly 5 to 8 percent reduction in schedule with delivery time

- What are the factors involved for successful implementation of BIM?
  - Don't Force BIM
  - Experienced 3D Modeling group
  - Experienced Subcontractor with 3D Modeling group
  -

- What issues and concerns are you encountering on projects that incorporate BIM?
  - Always concern with new technology
  - Some clients high level of doubt – Is it worth it

BIM Execution Planning

- Have you or your company ever been involved in the development of a BIM Execution Plan on a project?

- Yes:
  - Who was involved?
    - Owner
    - GC
    - Sub
    - Engineers

  - What decisions were made?
    - Budget for BIM
    - Who is responsible for BIM Delivery Method
    - How often to meet
    - Owner deliverables
    - Goals, problems, and issues to be solved

  - What process did you use to develop the plan?
    - Meeting of the Minds
    - What was the best approach - Old Fashion way with White Board

Concluding Questions

- What are the future trends for BIM?
  - BIM can go in every direction
  - Quality Takeoffs
  - Involvement of total robotic stations
  - Faster and Cheaper
  - More design build projects will be built entirely in 3D
  - Real time use on-site with Superintendent in-field
  - Whole host of new software
  - Facility Management

- Do you have any additional comments or items that you feel are important to consider?
  - No

Jim Salvino – Clark Construction

Background Information

- What is your title and what are your responsibilities in this company?
  - Senior MEP Manager
  - Responsibilities – Mechanical, Electrical, Communications, Elevators, Commissioning
  - Johns Hopkins – Electrical, Communications

- How many years of experience do you have personally with BIM?
  - 3 years

- How many years of experience does your company have with BIM?
  - 5 years
  - Johns Hopkins – 1st and Biggest BIM project for Clark

- What BIM software do you use? Why did you choose this software?
  - Autodesk
  - Navisworks – Does exactly what it advertised to do – Clash Detection, Modeling with a schedule (These items are very important on a hospital project)

- How many projects have you executed with BIM so far?
  - Unknown

- What benefits are coming out of using BIM on these projects?
  - Spatial Coordination especially with MEP
  - Pertaining to MEP - Haven't seen too many benefits using in 4D
  - Good to see other trades scope of work

- What is the impact of BIM (cost, time, overall project delivery time, quality) on design/engineering for the project?
  - Given the right people with the right knowledge that work with to maintain a clash free model, huge advantages in schedule and quality of work
  - Trades understand other trades scope of work (Plumber putting pipes in with respect to others work)
  - There is a huge impact if mechanical pieces don't fit on site

- What are the factors involved for successful implementation of BIM?
  - Experience of people
  - Establishing rules early
    - File management
    - Set up of the system
    - Color Standards
    - Layer Standards
  - Johns Hopkins – 1,000,006 sq ft
    - 4 segments
    - 16 drawings
    - 12 floors
    - 3 plumbing
    - 2 electrical
    - 1 sheet mental
    - 1 pneumatic tube
    - Dealing with a lot of drawings

- What issues and concerns are you encountering on projects that incorporate BIM?

- People need to learn to get use to it especially navisworks
- People being over their head – not coordinating a certain way (always have to deal with this)

BIM Execution Planning

- Have you or your company ever been involved in the development of a BIM Execution Plan on a project?

- Yes:
  - Who was involved?
    - Jim Salvino, Modeling team, Trade contractors, Intern
  - What decisions were made?
    - Execution plan was not published until after coordination was done
    - Establishing policies and procedures (Provides tools into forcing you to do something a certain way)
  - What process did you use to develop the plan?
    - Meeting of the minds
    - Talked through issues discussed

Concluding Questions

- What are the future trends for BIM?
  - Coordination is the biggest thing
  - Some developments in low level scheduling will be helpful
  - Good thing is everyone is excited about it
  - Continue to pursue links for building maintenance

- Do you have any additional comments or items that you feel are important to consider?
  - People should not get too focused on BIM
  - Only a small part of what we do
  - BIM is not fully the answer
  - Still out there to build a building on time and on budget

IPD Interview Questions
Background Information

- What is your title and what are your responsibilities in this company?
- How many years of experience do you have personally with IPD?
- How many years of experience does your company have with IPD?
- How many projects have you worked on that has used IPD?
- What was your role/responsibility on the IPD team?

IPD Research

- What is your definition of IPD?
- What are some of the benefits you have experienced with IPD?
- What is the impact of IPD (cost, time, overall project delivery time, quality) on design/engineering for the project?
- What are the factors involved for successful implementation of IPD?
- What issues and concerns are you encountering on projects that incorporate IPD?
- How often were meetings held with IPD process?

IPD vs. Design-Build

- What are the major differences between IPD and Design-Build?
- What are some of the benefits with the Design-Build process?
- What are some of the drawbacks with the Design-Build process?

The Use of IPD and Building Information Modeling (BIM)

- How many projects have incorporated BIM with IPD?
- What are some of the benefits you have experienced with BIM with IPD?
- What are some of the drawbacks you have experienced with BIM with IPD?
- Was a BIM Execution Plan used with the IPD process?
- Yes:
  - Who was involved?
  - What decisions were made?
  - What process did you use to develop the plan?
- No:
  - Who should be involved; make decisions?

Concluding Questions

- What are the future trends for IPD?
- Do you have any additional comments or items that you feel are important to consider?
- Can you refer us to other IPD experts or firms/companies we can interview?

Chris Leary - KlingStubbins
Background Information

- What is your title and what are your responsibilities in this company?

  - Design Principle
    - Delivery of projects
    - Financial aspects
    - Keeping Clients happy

- How many years of experience do you have personally with IPD?
  - One true IPD project - Autodesk

- How many years of experience does your company have with IPD?
  - See above

- How many projects have you worked on that has used IPD?
  - See above

- What was your role/responsibility on the IPD team?
  - Delivery of projects
  - Financial aspects
  - Keeping Clients happy

IPD Research

- What is your definition of IPD?
  - Very specific noun – Contractual Relationship
  - Crystallized over the last couple of years
  - IPD came out of the Lean Management exercise
  - A lot of IPD type behavior in Design Bid Build and CM at Risk
  - IPD behaviors especially in Design Build are a good things to get ready for an actual IPD project
  - AIA California IPD: A Guide

- What are some of the benefits you have experienced with IPD?
  - As an architect, you get more project out of it
  - IPD cuts out the waste
  - IPD embraces new technologies like BIM

- What is the impact of IPD (cost, time, overall project delivery time, quality) on design/engineering for the project?
  - IPD really cuts the waste out, which can be very beneficial in cast ans schedule reductions
  - If things go wrong, IPD agreement keeps the team together so the problem can be resolved

- What are the factors involved for successful implementation of IPD?
  - Experience helps but ability to coordination is the most important
  - If willing to sign a contract, need trusting relationship
  - It comes down to trust, but trust comes down to experience
  - Very good RFP

- What issues and concerns are you encountering on projects that incorporate IPD?
  - Initial Costs, but this method is a way to make things affordable
  - Fear

- How often were meetings held with IPD process?
  - Scripted for project itself
  - Project implementation weekly meetings
  - Formal weekly (higher level) meetings
  - Dispute meeting (highest level) – as needed

IPD vs. Design-Build

- What are the major differences between IPD and Design-Build?
  - Owner involvement
    - Design Build
      - Very specific project the owner agrees on economical plan and then leaves
      - Motivating the team to build it fast and cheaper
    - IPD
      - Owner keeps a seat at the table at all times and has control over other mitigating factors like quality
      - Team finds economy in giving back to the project like quality

- What are some of the benefits with the Design-Build process?
  - Good delivery method if you have an owner that doesn't want to make a lot of decisions
  - Very predictable

- What are some of the drawbacks with the Design-Build process?
  - Not a lot of owner involvement

The Use of IPD and Building Information Modeling (BIM)

- How many projects have incorporated BIM with IPD?
  - One true IPD project - Autodesk

- What are some of the benefits you have experienced with BIM with IPD?
  - Right Now the construction industry is paper oriented and very inefficient
  - You will get the most use out of BIM with an IPD project

- What are some of the drawbacks you have experienced with BIM with IPD?
  - It's a newer technology (greater risk)
  - Track record – the industry isn't using it to the best of its ability

- Was a BIM Execution Plan used with the IPD process?
  - Used on the Autodesk AEC Solutions

- Yes:
  - Who was involved?
    - The BIM Execution Plan was written as a presentation to the owner to win the project
    - Ideally in an IPD project everyone would have input
  - What decisions were made?
    - Get everyone's needs out on the table
    - What do people need to get out of the model
  - What process did you use to develop the plan?
    - Some parts of the project are high tech and the others are very low tech
    - This meeting was one of the lower technical portions of a project, use of a white board and people giving input and ideas

Concluding Questions

- What are the future trends for IPD?
  - Challenge to make IPD more mainstream
  - Very hard to prove value, because it's such a sophisticated tool
  - Need a team that is up for the challenge
  - IPD will allow for furthering the ability for offsite fabrications, things built on site right now are inefficient
  - Building technologies will evolve from IPD and some others will fade away

- Do you have any additional comments or items that you feel are important to consider?
  - When there is a bad day on an IPD project the team is forced to stay together, focus, and perform

- Can you refer us to other IPD experts or firms/companies we can interview?
  - Autodesk
  - Lean Construction Institute
  - AGC BIM Form
  - HGA Architect

John Moebes – Crate&Barrel

Background Information

- What is your title and what are your responsibilities in this company?
  - Director of Construction for Crate&Barrel
  - Responsibilities:
    - Management of the Lease Hold Improvements Capital Expenses
    - Management of the four person Construction Department that functions as construction management at agency for Crate&Barrel.

- How many years of experience do you have personally with IPD?
  - I am not sure that we have done a formal (AIA-sanctioned) version of IPD, but we have done our Hybrid version since 2007.

- How many years of experience does your company have with IPD?
  - Three

- How many projects have you worked on that has used IPD?
  - Seven

- What was your role/responsibility on the IPD team?
  - Member selection
  - Determination of goals and objectives
  - Progress evaluation
  - Forensic analysis

IPD Research

- What is your definition of IPD?
  - Abolition of the paradigm of sequential content creation in a project.
    - All content creators should be involved at the beginning of the process: architects, engineers, suppliers, fabricators, installers, inspectors.
    - All needs must be vetted, understood, "married" at the beginning of the process.

- What are some of the benefits you have experienced with IPD?
  - Dramatic reduction in schedule and cost.
  - More efficient buildings.
  - More productive teams.

- What is the impact of IPD (cost, time, overall project delivery time, quality) on design/engineering for the project?
  - Greater understanding of fabrication and installation requirements
  - More effective value management

- What are the factors involved for successful implementation of IPD?
  - Finding team members that don't have cultural blocks to working differently
  - Good leadership from the owner.
  - Willingness on all sides to re-write standard contracts.

- What issues and concerns are you encountering on projects that incorporate IPD?
  - The need to have more meetings due to the increased collaboration.
  - The need to create new types of contract documents that explain the IPD process.

- How often were meetings held with IPD process with Owner?
  - Weekly

- How often were meetings held with IPD process with Architect/Design Team?
  - Weekly

- How often were meetings held with IPD process with Subcontractors?
  - Weekly

IPD vs. Design-Build

- What are the major differences between IPD and Design-Build?
  - I am not really sure!
  - I think that IPD allows more design than design/build does.

- What are some of the benefits with the Design-Build process?
  - Well defined contracts
  - Proven results within certain disciplines.

- What are some of the drawbacks with the Design-Build process?
  - Design can suffer, too much emphasis on build.
  - Can happen too late in the process when used at a subtrade level.

The Use of IPD and Building Information Modeling (BIM)

- How many projects have incorporated BIM with IPD?
  - All

- What are some of the benefits you have experienced with BIM with IPD?
  - Greater understanding of the proposed building
  - Coordinated designs

- What are some of the drawbacks you have experienced with BIM with IPD?
  - Learning curves
  - Hardware
  - "Shifting Sands"

- Overall, what are your thoughts about these two processes together?
  - You can't do one without the other

- Was a BIM Execution Plan used with the IPD process?
- No:
  - Who should be involved; make decisions?
    - There was no formal BEP, but we are on track to produce one.

Concluding Questions

- What are the future trends for IPD?
  - Very bright for certain trades, dim for others
  - I think that certain owners will continue to exploit it, others will use traditional methods for the time being.

- Do you have any additional comments or items that you feel are important to consider?
  - Not really, but we can discuss further over the phone.

- Can you refer me to other IPD experts or firms/companies we can interview?
  - Matt Lindner
  - Rob Rutherford.

Rob Rutherford – Steel Fab Inc.

Background Information

- What is your title and what are your responsibilities in this company?
  - Project Manager

- How many years of experience do you have personally with IPD?
  - 5 years – strictly with Create&Barrel

- How many years of experience does your company have with IPD?
  - Same

- How many projects have you worked on that has used IPD?
  - Unknown

- What was your role/responsibility on the IPD team?
  - Project Manager

IPD Research

- What is your definition of IPD?
  - Like a tool box – pick and choose what you want to do
  - At Steel Fab Inc. – Use a Hyper IPD (Everything except contracts)
  - Use a 2 party contract with Crate&Barrel

- What are some of the benefits you have experienced with IPD?
  - Being at the table early to contribute
  - Can answer basic RFI's in meetings rather than in the field
  - VE very beneficial early
  - Better understanding of everyone's scope of work

- What is the impact of IPD (cost, time, overall project delivery time, quality) on design/engineering for the project?
  - On a hospital project – ¼ million dollar savings on brace connections, this was caught early in a 30 minute conference call

- What are the factors involved for successful implementation of IPD?
  - Contractors have to drive IPD

- What issues and concerns are you encountering on projects that incorporate IPD?
  - A lot of bad press
  - Industry is a contract, everyone is scared
  - Lawyers are against IPD, Fight tooth and nail for a contract
  - IPD is more of a mindset than a contract

- How often were meetings held with IPD process?
  - Nice way to get everyone together is web conference that is recorded
  - 2 – 3 times a week
  - Whole team very active (owner with 10 other parties online)

IPD vs. Design-Build

- What are the major differences between IPD and Design-Build?
  - Accountability
  - Design Build – Everyone helps everyone
  - IPD – You start to become accountable, Ability to integrate

- What are some of the benefits with the Design-Build process?
  - Having more control over the design, Easy to make decisions immediately
  - IPD – Doing for the good of it all (over analyze)

- What are some of the drawbacks with the Design-Build process?
  - No accountability outside of the design build process
  - A lot of suggesting and convincing

The Use of IPD and Building Information Modeling (BIM)

- How many projects have incorporated BIM with IPD?
  - Steel is fully BIM (½ Manufacturing, ½ Construction)

- What are some of the benefits you have experienced with BIM with IPD?
  - Huge advantages
    - Distribution of drawings
    - Revisions of drawings
    - Tracking of drawings
    - Drawing management
    - Exact quantities takeoffs
  - Average steel for a project 220 tons before BIM Reduced to 120 tons
  - 3D coordination is helpful
  - Crate&Barrel
    - Overall cost down $150,000

- 9 weeks ahead of schedule
- 90% of this was caused by IPD

- What are some of the drawbacks you have experienced with BIM with IPD?
  - Without vigorous owner support this will fail
  - A lot of Architects don't want to do it
  - Coordination is sometimes like a hot potato, people just keep passing it on

- Was a BIM Execution Plan used with the IPD process?
  - Varying levels
    - Some rigid
    - Some loosey goosey
  - The more formal the Execution Plan is the better the results

- Yes:
  - Who was involved?
    - Owner
    - Contractors
  - What decisions were made?
    - Constructability Documents
    - Logistics of machinery
    - Common modeling practices
    - Overall standardizations

Concluding Questions

- What are the future trends for IPD?
  - Hope it's a bright future
  - Nervous about the legal aspects
  - Contractors really have to drive this
  - Have to look at it as a toolbox

- Do you have any additional comments or items that you feel are important to consider?
  - None

- Can you refer me to other IPD experts or firms/companies we can interview?
  - Tocci – Q5 – John Tocci and Laura Handler

Michael Tardif – Grunley Construction

Background Information

- What is your title and what are your responsibilities in this company?
  - Director Integrated Project Delivery Systems

- How many years of experience do you have personally with IPD?

- 5 years

- How many years of experience does your company have with IPD?
  - 1st Project with Grunley just signed

- How many projects have you worked on that has used IPD?
  - See above

IPD Research

- What is your definition of IPD?
  - Project Delivery System (Entered into IPD agreement)
  - Principle Designer and Contractor brought on up front (same time) - Check Contract Dates (Gap is the opportunity to possibly have a IPD system)
  - Shared Risk, Shared Reward
  - Some government may not be allowed to enter in an IPD agreement (this applies to schools)
  - Two types of contracts for IPD
    - AIA – 2 set IPD (Forming of a LLC)
      - Formal Multi Party
      - Transitional Doc
    - Concensus Doc 300
      - All consistent of AIA
      - Big difference you don't create a corporation

- What are some of the benefits you have experienced with IPD?
  - Less risk for everyone and contract

- What is the impact of IPD (cost, time, overall project delivery time, quality) on design/engineering for the project?
  - Have to look at the statistical data relative for substantial gains in cost and scheduling
  - Typically you have a 20% gain in cost effectiveness (Construction process not very efficient – 20% not that hard to accomplish)

- What are the factors involved for successful implementation of IPD?
  - 1st item – Needs to be owner driven
  - 2nd item – Contractors and Design Team have to be committed

- What issues and concerns are you encountering on projects that incorporate IPD?
  - Biggest risk is there are so little experience
  - People often commit then go back to their old habits
  - Fairly limited scope
  - Working out the kinks
  - Team development

- How often were meetings held with IPD process?
  - Weekly meetings
  - Meetings tend to be more efficient and production
  - Meetings with model data capabilities
  - Important - people attending meetings must have the authority to act for their organization (Can't say have to go back and ask the boss)

IPD vs. Design-Build

- What are the major differences between IPD and Design-Build?
  - Design Build - Scope is rarely detailed in the beginning of the project
  - Design Build – Owner has a great deal of cont4rol over cost but to a lesser degree over schedule
  - Design Build - Owner has little to no control over scope and quality
  - IPD – Scope defined as part of the IPD process

- What are some of the benefits with the Design-Build process?

- What are some of the drawbacks with the Design-Build process?
  - Design Build Scope is rarely detailed in the beginning of the project
  - More risks for everyone, mainly contractor with price and schedule

The Use of IPD and Building Information Modeling (BIM)

- How many projects have incorporated BIM with IPD?
  - Will be using BIM on the 1st project with IPD

- What are some of the benefits you have experienced with BIM with IPD?
  - Used most effectively in IPD
  - BIM Supports IPD
  - IPD adds experience to the collaborative process
  - BIM supports collaborative effort of expression to 3D reality and adds value to the process
  - BIM allows for different methods to build a building
  - IPD is visual
  - If modeling is done correctly with far richer detail, 4D modeling , cost analysis, scheduling control emerges
  - Look at a complex detail or coordination meeting – You spend 90% of the time convincing and understanding what they are looking at and the other 10% of the time thinking that others in the meeting understand it the same exact way

- What are some of the drawbacks you have experienced with BIM with IPD?
  - New process, it's tough getting people on board
  - Varying levels of expertise
  - Chicken and the egg dilemma

- Was a BIM Execution Plan used with the IPD process?

- Yes: (In the developing stages)
  - Who was involved?
    - Everyone involved in the IPD process
    - Need everyone's buy-in
  - What decisions were made?
    - N/A
  - What process did you use to develop the plan?
    - N/A

Concluding Questions

- What are the future trends for IPD?
  - Leary to make trend analysis on something with so little experience but trends seem to be consistently positive
- Do you have any additional comments or items that you feel are important to consider?
  - None
- Can you refer us to other IPD experts or firms/companies we can interview?
  - DPR Construction – Tom Krajewski - tomkr@dprinc.com – Experienced in IPD mostly in the West Coast
  - Mortenson Construction – Derek Cunz – Denver - Derek.Cunz@mortenson.com

Pharmaceuticals Expiration					
Drug	**Manufacturer**	**Normal Stage**	**Max time at >8 C**	**Comments**	**Reference**
Acthar gel	Aventis	2-8 C	7 days	Cumulative within the shelf-life for temperatures up to 25 C. Return to fridge. Original expiry valid	Company
Actrapid inj	Novo Nordisk	2-8 C	4 days	Valid for temperatures 15 - 25 C. Return to fridge. Original expiry valid. In-use at room temperature: 6 weeks for vials; 4 weeks for Penfill and NovoLet	SPC & company
Adrenaline topical soln	TechnoPharm	<25 C	N/A		Company
Anectine inj	Glaxo Wellcome	2-8 C	14 days	Valid for room temperature. Return to fridge. Effect on shelf life unknown.	Company
Apomorphin inj	Teclapharm	2-8 C	2-3 days	Return to fridge. Effect on shelf life unknown	Company
Ativan inj	Wyeth	2-8 C	1week	Valid for room temperature. Return to fridge. Original expiry valid. Stability not guaranteed if exposed to higher temperatures or second exposure.	Company
Audicort ear drops	Wyeth	2-8 C	see comment	If left out of fridge for any length of time, return to fridge and reduce shelf life by 6 months	Company

B.I.P. Paste	Ovelle	2-8 C	see comment	No stability data available. Kept in fridge because paste splits less. Reconstitute by stirring	Company
BCG-S medac inj	TechnoPharm	2-8 C	24 hours	Valid for temperatures between 15-19.9 C. Return to fridge. Effect on shelf life unknown	Company
BiCNU inj	Bristol-Myers Squibb	2-8 C		No stability data available.	Company
Calcium Leucovorin inj	Faulding (DBL)	2-8 C	1month	Valid for temperatures up to 22 C. Return to fridge. Effect on shelf life unknown.	Company
Calogen liquid	SHS	<5 C	see comment	Can be stored <15 C . Stability studies to determine reduction in expiry date have not been completed.	Company
Calsynar vial/amp	Aventis	2-8 C	28 days	Cumulative within the shelf-life for temperatures up to 25 C. Return to fridge. Original expiry valid	Company
Cerezyme inj	Genzyme	2-8 C	2-3 days	Valid for temperatures up to 25 C. Return to fridge. Effect on shelf life unknown. Inspect visually before use	Company
Chloramphenicol minims	Chauvin	2-8 C	5 days	Valid for temperatures up to 25 C. Return to fridge. Effect on shelf life unknown.	Company
Chloromycetin drops	Goldshield	2-8 C		No stability data available	Company

Chymodiactin inj	Knoll	2-8 C	18 months	Valid for room temperature. Return to fridge. Change expiry from 36months to 18months	Company
Daktacort cream	Janssen-Cilag	2-8 C	6 weeks	Valid for temperatures up to 25 C. Return to fridge. Effect on shelf life unknown.	Company
DDAVP inj	Ferring	2-8 C	4 weeks	Cumulative. Valid for temperatures up to 25 C. Return to fridge. Decrease shelf life pro rata eg. halve if left out for 2 weeks and discard if left out for 4 weeks. Current shelf life is 2 years	Company
DDAVP intranasal soln	Ferring	2-8 C	4 weeks	Cumulative. Valid for temperatures up to 25 C. Return to fridge. Decrease shelf life pro rata eg. halve if left out for 2 weeks and discard if left out for 4 weeks. Current shelf life is 3 years	Company
Desferal inj	Novartis	<25 C	N/A		SPC
Desmospray	Ferring	<25 C	N/A		SPC
Diftavax inj	Pasteur Merieux	2-8 C		Potency can not be guarnanteed if exposed to temperatures >8 C	Company
Digibind inj	Glaxo Wellcome	2-8 C	14 days	Return to fridge. Effect on shelf life unknown.	Company
Dimercaprol inj	Knoll	2-25 C	N/A		Company

Dysport inj	Ipsen	2-8 C	2 days	Valid for temperatures up to 25 C. Return to fridge. Original expiry valid.	Company
Engerix B inj	SmithKline Beecham	2-8 C	2 weeks	Valid for temperatures up to 21 C. Return to fridge. Original expiry vaild.	Company
Epiglu	Synapse Medical	<8 C	see comment	Return to fridge/freezer. Effect on shelf life unknown. May be expected to last at least 2 months out of the fridge. Do not use "if the solution does not drip from the vial in a clear consistency"	Company
Eprex (with polysorbate)	Janssen-Cilag	2-8 C	48 hours	Vials/syringes containing polysorbate 80. Valid for temperatures up to 25 C. Return to fridge.	Company
				Effect on shelf life unknown.	
Eprex (with HSA)	Janssen-Cilag	2-8 C	15 days	Vials/syringes containing HSA. Not manufactured since 1998. Valid for temperatures up to 25 C.Return to fridge. Effect on shelf life unknown.	Company
Ergometrine inj	Antigen	2-8 C	1 month	Valid for temperatures up to 25 C. Mark with one month expiry date.	Company

Ervevax inj	SmithKline Beecham	2-8 C	1 week	Valid for temperatures up to 21 C. Return to fridge. Original expiry valid.	Company
Erwinase inj	Ipsen	2-8 C	1 month	Valid for temperatures up to 25 C. Return to fridge. Original expiry valid.	Company
Esmeron inj	Organon Teknika	2-8 C	see comment	If left out of the fridge for more than 24 hours, store between 8-30 C (do not return to fridge) and mark with 3 month expiry date	SPC & Company
Flolan inj	Glaxo Wellcome	<25 C	N/A		SPC
Fungizone inj	Bristol-Myers Squibb	2-8 C	4 days	Valid for temperatures up to 25 C. Return to fridge. Effect on shelf life unknown.	Company
Gammabulin inj	Baxter	2-8 C	1 week	Valid for temperatures up to 25 C. Return to fridge. Effect on shelf life unknown.	Company
Geref 50 inj	Serono	2-8 C		No further information available from the company	Company
GlucaGen Hypokit	Novo Nordisk	2-8 C	126 hours	Valid for temperatures 15-25 C. Return to fridge. Original expiry valid. Can be stored up to 25 C for 18 months	SPC & Company
Havrix Monodose inj	SmithKline Beecham	2-8 C	2 weeks	Valid for temperatures up to 21 C. Return to fridge. Original expiry valid.	Company

HB-Vax II inj	Pasteur Merieux	2-8 C		Potency can not be guarnanteed if exposed to temperatures >8 C	Company
Heminevrin infusion	AstraZeneca	2-8 C	1 month	Valid for room temperature. Return to fridge. Effect on shelf life unknown.	Company
Heminevrin syrup	AstraZeneca	2-8 C	1 month	Valid for room temperature. Return to fridge. Effect on shelf life unknown.	Company
Hepatect inj	Intra Pharma	2-8 C	72 hours	Valid for temperatures up to 30 C. Take transport into account. Return to fridge. Original expiry valid.	Company
HibTITER inj	Wyeth	2-8 C	3 days	Valid for temperatures up to 25 C. Return to fridge. Original expiry valid.	Company
Histoacryl	B/Braun	<5 C		Exposure to heat or light may lead to early polymerization	Company
Humalog vials & cartridges	Eli Lilly	2-8 C	28 days	Valid for temperatures up to 30 C. Can return to fridge (except cartridges in pens). Mark with 28 day expiry	SPC & Company
Humulin Isophane & Mixture 30/70 1.5mlcartridges	Eli Lilly	2-8 C	21 days	Valid for temperatures 15-25 C. Can return to fridge. Mark with 21 day expiry	SPC & Company
Humulin vials and 3.0ml cartridges	Eli Lilly	2-8 C	28 days	Valid for temperatures 15-25 C. Can return to fridge. Mark with 28 day expiry	SPC & Company

Insulatard inj	Novo Nordisk	2-8 C	4 days	Valid for temperatures 15-25 C. Return to fridge. Original expiry date valid. In-use at room temperature: 6 weeks for vials; 4weeks for Penfill and NovoLet	SPC & Company
Intraglobin F inj	Intra Pharma	2-8 C	72 hours	Valid for temperatures up to 30 C. Take transport into account. Return to fridge. Original expiry valid.	Company
Leukeran tabs	Glaxo Wellcome	2-8 C	1 week	Valid for room temperature. Return to fridge. Effect on shelf life unknown.	Company
Liquigen liquid	SHS	<5 C	see comment	Can be stored <15 C. Stability studies to determine reduction in expiry date in progress.	Company
Megalotect inj	Intra Pharma	2-8 C	72 hours	Valid for temperatures up to 30 C. Take transport into account. Return to fridge. Original expiry valid.	Company
Mengivac A&C inj	Pasteur Merieux	2-8 C		Potency cannot be guaranteed if exposed to temperatures >8 C	Company
Mixtard inj	Novo Nordisk	2-8 C	4 days	Valid for temperatures 15-25 C. Return to fridge. Original expiry valid. In-use at room temperature: 6 weeks for vials; 4weeks for Penfill and NovoLet	SPC & Company

Monotard inj	Novo Nordisk	2-8 C	4 days	Valid for temperatures 15-25 C. Return to fridge. Original expiry valid. In-use at room temperature: 6 weeks	SPC & Company
MUSE pellets	AstraZeneca	2-8 C	see comment	SPC allows for unopened pouches to be kept by patient for up to 14 days before use. Valid for temperatures <30 C (melting point of wax pellet)	SPC & Company
Mydrilate eye drops	Boehringer-Ingelheim	2-8 C	1 week	Valid for room temperature. Return to fridge. Original expiry valid.	Company
				However, if left at room temperature close to expiry date, discard.	
Nardil tabs	Hansam	2-8 C	1 week	Valid for 25 C. Return to fridge. Original expiry valid. Additional information available from company	Company
Neosporin eye drops	Glaxo Wellcome	<25 C	N/A		SPC
Nimbex inj	Glaxo Wellcome	2-8 C	1month	Valid for room temperature. Return to fridge. Effect on shelf life unknown.	Company
One-Alpha solution	Leo Laboratories	2-8 C	Few days	Return to fridge. Effect on shelf life unknown. License recently changed from store below 15 C	Company

Orthoclone OKT3 inj	Janssen-Cilag	2-8 C	see comment	Consider consequences of graft failure. Room temperature stability is currently being evaluated.	Compnay
Otosportin eye drops	Glaxo Wellcome	<25 C	N/A		SPC
Oxbipp paste	Oxford	2-8 C	24 hours	Return to fridge. Original expiry valid	Company
Oxbipp-g gauze	Oxford	2-8 C	48 hours	Return to fridge. Original expiry valid	Company
Pancrex products	Yamanouchi	2-8 C	see comment	Previously storage conditions were <15 C. Company recommend discarding if out of fridge more than 2-3 hours	Company
Pavulon inj	Organon Teknika	2-8 C	6 weeks	Store between 8-25 C (Do not return to the fridge) and mark with a six week expiry date	SPC & Company
Perfan inj	Aventis	<20 C	N/A		SPC
Pneumovax II inj	Pasteur Merieux	2-8 C		Potency can not be guarnanteed if exposed to temperatures >8 C	Company
Polio, oral vaccine	SmithKline Beecham	2-8 C	4 days	Valid for temperatures up to 21 C. Take transport into account. Return to fridge. Original expiry valid.	Company
Profasi inj	Serono	<25 C	N/A		SPC
Proxymetacaine minims	Chauvin	2-8 C	1 month	Store at temperatures not exceeding 25 C for up to 1 month only	SPC

ReoPro inj	Eli Lilly	2-8 C	60 hours	Cumulative. Valid for temperatures up to 30 C. Take transport into account. Original expiry valid.	Company
Roferon A soln for inj	Roche	2-8 C	28 days	Valid for temperatures up to 25 C. Return to fridge and mark with a 28 day expiry date.	Company
Saizen inj	Serono	2-8 C	see comment	No further information available from the company	Company
Sandostatin LAR inj	Novartis	2-8 C	see comment	Information only available on request for a specific query	Company
Sandostatin sc inj	Novartis	2-8 C	see comment	Information only available on request for a specific query	Company
Solvito N inj	Fresenius Kabi	2-8 C	see comment	There are no stability problems if stored at room temperature. Return to fridge	Company
Somatuline LA inj	Ipsen	2-8 C	72 hours	Valid for temperatures up to 25 C. Return to fridge. Original expiry valid.	Company
Suprefact inj	Aventis	2-25 C	N/A		SPC
Synacthen inj	Novartis	2-8 C	see comment	No further information available from the company	Company
Syntocinon inj	Novartis	4-22 C	N/A		SPC
Tetabulin inj	Baxter	2-8 C	1 week	Valid for temperatures up to 25 C. Return to fridge. Effect on shelf life unknown	Company

Tetanus vaccine	Medeva Pharma	2-8 C	Months	Valid for room temperature. Return to fridge. Effect on shelf life unknown. Avoid repeated exposures to room temp.	Company
Thiotepa inj	Wyeth	2-8 C	see comment	Must be stored in a fridge	Company
Tracrium inj	Glaxo Wellcome	2-8 C	14 days	Valid for room temperature. Return to fridge, effect on shelf life unknown. SPC states that short periods at up to 30 C are permissible but only to allow transportation or temporary storage outside of a cold store	SPC & Company
TuberculinPPD RT 23	Statens Serums Inst.	2-8 C	see comment	Studies show stability at 25 C for several months. Original expiry valid if left out of the fridge for a short period.	Company
Twinrix inj	SmithKline Beecham	2-8 C	2 weeks	Valid for temperatures up to 21 C. Take transport into account. Return to fridge. Original expiry valid.	Company
Ultratard inj	Novo Nordisk	2-8 C	4 days	Valid for temperatures 15 - 25 C. Return to fridge. Original expiry valid. In-use at room temperature: 6 weeks	SPC & Company
Varidase topical	Wyeth	2-8 C	1 week	Return to fridge. Effect on shelf life	Company

				unknown	
Varitect inj	Intra Pharma	2-8 C	72 hours	Valid for temperatures up to 30 C. Take transport into account. Return to fridge. Original expiry valid.	Company
Vivotif capsules	Medeva Pharma	2-8 C	7 days	Studies show acceptable declines in vaible count. Valid for temperatures 20-25 C. Effect on shelf life unknown.	Company
Xylocaine (0.5%, 1%, 2%) + adrenaline 1:200,000	AstraZeneca	2-8 C	1 week	Valid for room temperature. Return to the fridge. Effect on shelf life unknown	Company
Xylocaine 2% + adrenaline 1:80,000	AstraZeneca	<25 C	N/A		SPC
Xyloproct ointment	AstraZeneca	<5 C	1-3 days	Valid for room temperature. Return to fridge. Original expiry valid.	SPC & Company
&yloproct suppository	AstraZeneca		see comment	Patient may store at room temperature for 2 months during use.	SPC & Company

GMU SUB I

Emergency Generator – Monthly Test Log

Generator Model: _____ Engine Model: _____ Date installed: _____

Standby kW nameplate rating: _____ 30% of standby rating = _____ Fuel type: _____ Normal operating temp: _____

Month	Test Date	Time Meter Reading		Transfer Switch		Battery Specific Gravity	Oil Pressure	Operating Temp.	Load kW	Tested By	Comments
		Start	End	Inspection	Test						
January											
February											
March											
April											
May											
June											
July											
August											
September											
October											
November											
December											

Electrical - Energency Generator Analysis (250 kW)

Connected Electrical Loads

Fire Pump = 58.2 KVA (E-0.1)

Elevator = 10 kVA (E-0.1)

Receptacle Load

Existing - 257
New - 130
> 387 receptacles

180VA x 387 = (69660 VA)(1.25) = 87075 VA = 87.07kVA
↳ Expansion

Lighting New

63 fixtures

2 lamps @ 28W = 56W

$\left(\frac{56W}{0.9}\right)(63)(1.25) = 4900$ VA

⊗ 62 Fixtures (Exit Signs)

2 lamps @ 3.7W = 7.4W

$\left(\frac{7.4}{0.9}\right)(62)(1.25) = 637.22$ VA

⊗ 10 Fixtures (Exit Signs)

2 lamps @ 3.7W = 7.4W

$\left(\frac{7.4}{0.9}\right)(10)(1.25) = 102.78$ VA

31 fixtures

2 lamps @ 32W = 64W

$\left(\frac{64}{0.9}\right)(31)(1.25) = 2755.56$ VA

Electrical - Emergency Generator Analysis (Cont.)

Lighting New (Cont.)

54 fixtures
2 lamps @ 42W = 84W
$\left(\frac{84}{0.9}\right)(54)(1.25) = 6300\,VA$

13 fixtures
2 lamps @ 50W = 100W
$\left(\frac{100}{0.9}\right)(13)(1.25) = 1805.6\,VA$

$4900\,VA + 637.22\,VA + 102.78\,VA + 2755.56\,VA + 6300\,VA + 1805.56\,VA$
$= 16500.56\,VA\ (1.25) = 20625.7\,VA$ ← Expansion
$= 20.63\,KVA$

Lighting Existing

71 Fixtures
2 lamps @ 28W = 56W
$\left(\frac{56}{0.9}\right)(71)(1.25) = 5522.22\,VA$

46 fixtures
2 lamps @ 3.7W = 7.4W
$\left(\frac{7.4}{0.9}\right)(46)(1.25) = 472.78\,VA$

1 fixture
2 lamps @ 3.7W = 7.4W
$\left(\frac{7.4}{0.9}\right)(1)(1.25) = 10.28\,VA$

Electrical - Emergency Generator Analysis (Cont.)

Lighting Existing (Cont.)

9 Fixtures

2 lamps @ 36W = 72W

$\left(\frac{72}{0.9}\right)(9)(1.25) = 900\,VA$

5522.22VA + 472.78VA + 10.28VA + 900VA

= 6905.28 VA = 6.91 KVA

Refrigerator/Freezing Units

208V 30.7A (RLA) = (19.156.8 VA)(1.25) = 23946 VA

L Expansion

= 23.95kVA

Misc Security / Fire Alarm 12.7kVA

Total KVA

58.2 + 10 + 87.07 + 20.63 + 6.91 + 23.95 + 12.7

= 219.47 kVA

≈ 175.57 kW

Check - Ennis Electric Stated Approx. 75% of Generator's load was used

250kW × 0.75 = 187.5kW

$\frac{175.57}{250}$ = 70% OK

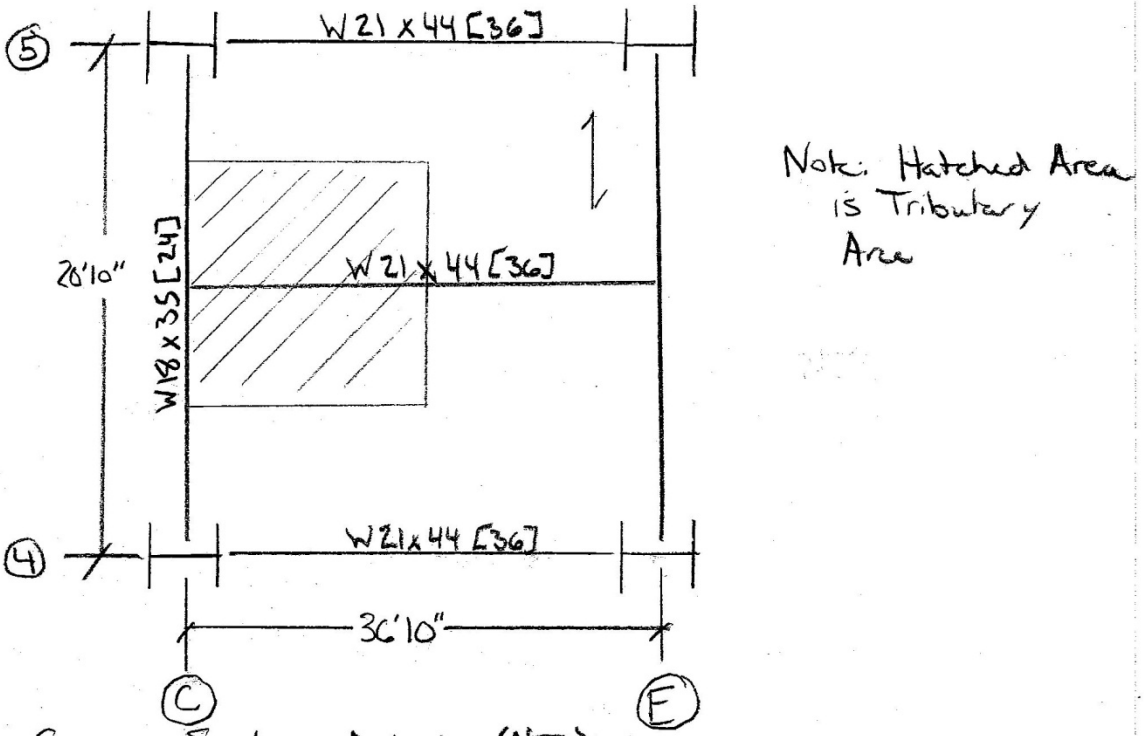
Structural Analysis - Beam C4-C5 Floor 4

Assumption - All Steel is in Tension
- Full Composite Action because:
  - Number of Shear Studs
  - Distance between Shear Studs

W18 x 35 [24] over 20'10" Span

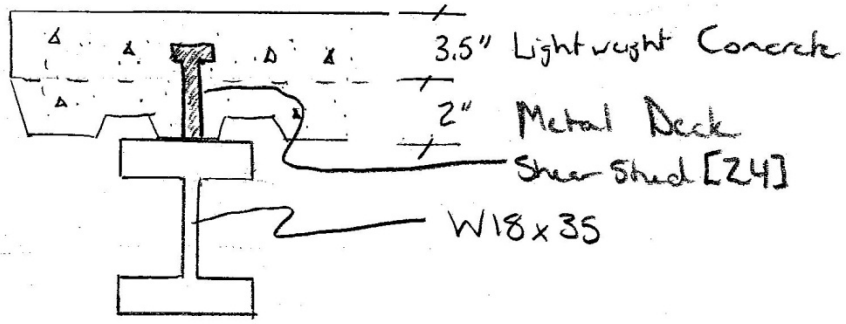
Note: Shear Connections at C4 & C5

Plan View (NTS)



Note: Hatched Area is Tributary Area

Cross Section Detail (NTS)



Structural Analysis - Beam C4-C5 Floor 4 (Cont.)

$f'_c = 4$ ksi

$f_y = 50$ ksi

$f_u = 65$ ksi

Lightweight Concrete

Concrete Depth 5.5"

2" Metal Deck

2" Ribs 6" O.C. // to Girder

3/4" Shear Studs

$b_{eff} = 5' - 2.5"$

$= 62.5"$

* Assume Full Composite Action

Q_N for 1 Stud = 21.2

$C_c = 0.85 f'_c A_c$

$= 0.85(4\text{ksi})(3\tfrac{1}{2}")(62.5) = 743.75k$

$T_S = A_s f_y = (10.3)(5\text{ksi}) = 515$ k

∴ PNA is in Concrete

$a = \frac{T_S}{0.85 f'_c b_{eff}} = \frac{515\text{ k}}{0.85(4\text{ksi})(62.5")} = 2.42"$

$\Sigma Q_N = 21.2(24\text{ studs}) = 508.8k$

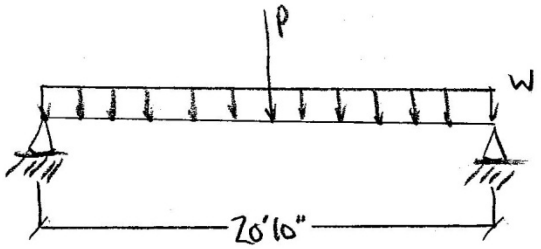
Y_1 = TFL

$a = \frac{\Sigma Q_N}{0.85 f'_c b_{eff}} = \frac{508.8\text{ k}}{0.85(4\text{ksi})(62.5")} = 2.39"$

$Y_2 \quad \frac{5.5"}{\frac{a}{2}} = \frac{5.5"}{\frac{2.39"}{2}} = 4.59"$ ∴ $Y_2 = 4.5"$

∴ $\phi M_n = 515$ kFt.

Structural Analysis - Beam CH - C5 Floor 4 (cont.)



Point P

Lightweight Concrete - 44psf (Vulcraft pg 47)

Deck - 3psf (2.61 PSF Vulcraft 2VLI pg 46)

LL - 80psf + 20 psf (Partitions) (S-0.1)

S.DL - 15psf

Beam - $\frac{36'10"}{2} \times 44 = 810.3316$

Tributary Area = $\frac{36'10"}{2} \times \frac{20'10"}{2} = 191.84$ sq ft

P = (44psf + 3psf + 15psf)(191.84 sq ft)(1.2) + (100 psf)(191.84 sq ft)(1.6)
+ (810.3316)(1.2)

P = 45,939.69 lb = 45.94k

Distributed Load - W

Curtain Wall - 8.25psf Glass + 3.5 psf = 11.75 ≈ 12psf
(usalum, com)

Medium Weight 8" CMU - 55psf
(Penn State - Dept of ABE)

4" Brick - 42 psf
(Penn State - Dept of ABE)

Metal Panel - 1.1psf
(CVT Construction - Aaron Winters)

Structural Analysis - Beam C4-C5 Floor 4 (Cont.)

Sq Ft of Glass - 13'x8' = 104 ft²

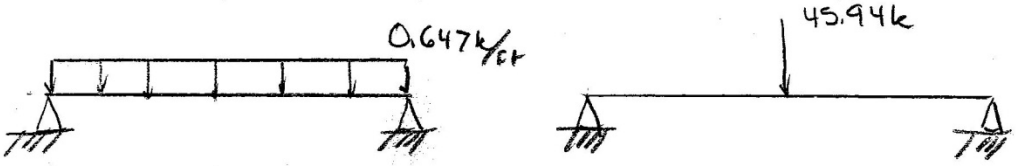
Sq Ft of CMU = 20'10" x 2'8" = 55.56 ft²

Sq Ft of Brick = 20'10" x 7' = 145.83 ft²

Sq Ft of Metal Panel = 13'x2' = 26ft²

W = (12psf x 8') + (55psf x 2'8") + (42psf x 7') + (1.1psf x 2')

$W = 538.87 \frac{lb}{ft}(1.2) = 646.64 \frac{lb}{ft} = 0.647 \frac{k}{ft}$



$M_{max\ Center} = \frac{wl^2}{8}$

$= \frac{(0.647k)(20'10")^2}{8}$

$= 35.102\ k\text{-}ft$

$M_{max\ Center} = \frac{Px}{2}$

$= (45.9k)\left(\frac{20'10"}{2}\right)$

$= 478.125\ k\text{-}ft$

$M_{max} = 478.125 + 35.102 = 513.227\ k\text{-}ft < 515\ k\text{-}ft$

Ok

Check Deflection

$I_{LB} \Rightarrow$ $Y_1 = TFL$ $Y_2 = 4.5$

$= 1430\ in^4$

$\Delta_{Max} \Rightarrow \frac{L}{360} = \frac{20'10"(12)}{360} = 0.694"$

$\Delta = \frac{5wl^4(1728)}{384EI_{LB}} + \frac{Pl^3(1728)}{48EI_{LB}}$

$= \frac{5(0.647)(20'10")^4(1728)}{384(29000)(1430)} + \frac{45.9(20'10")^3(1728)}{48(29000)(1430)}$

4

Structural Analysis - Beam C4-C5 Floor 4 (Cont.)

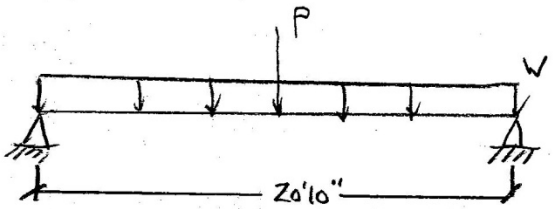
$\Delta = 0.066 + 0.36 = 0.426'' < 0.694''$

Ok

Structural Analysis - Beam C4 - C5 Floor 4 (cont.)

Note: This Analysis will consist of Architectural Precast Panels in Place of Metal Panels

$\phi M_n = 515$ kFt see pg 2. for Details



Point - P

Lightweight Concrete - 44psf (Vulcraft Pg 47)

Deck - 3 PSF (2.61 PSF Vulcraft 2VLI pg 46)

LL = 80psf + 20psf (Partitions) (S - 0.1)

SDL - 15psf

Beam = $\frac{36'10"}{2}$ x 44 = 810.331b

Tributary Area = $\frac{36'10"}{2} \times \frac{20'10"}{2}$ = 191.84 sq ft

P= (44psf + 3psf + 15psf)(191.84 sq Ft)(1.2) +
(100psf)(191.84 sq ft)(1.6) + (810.331b)(1.2)

P= 45,939.69 lb = 45.94 k

Distributed Load - W

Curtain Wall - 8.25psf Glass + 3.5psf = 11.75 ≅ 12psf
(usalum.com)

Medium Weight 8" CMU = 55psf
(Penn State Dept of ABE)

4" Brick - 42psf
(Penn State Dept of ABE

Arch Precast - 35psf
(Metal Stud Girts)

Structural Analysis - Beam C4-C5 Floor 4 (cont.)

Sq Ft of Glass - $13' \times 8' = 104\ ft^2$

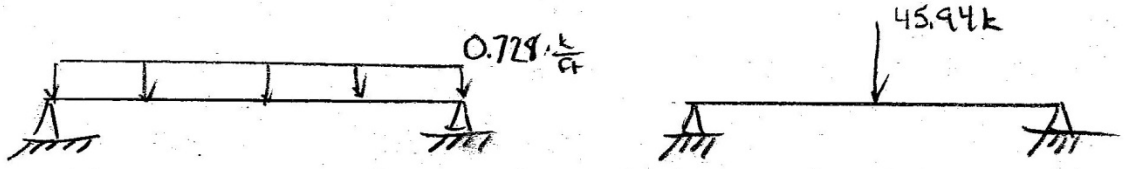
Sq Ft of CMU - $20'10'' \times 2'8'' = 55.56\ ft^2$

Sq Ft of Brick - $20'10'' \times 7' = 145.83\ ft^2$

Sq Ft of Precast - $13' \times 2' = 26\ ft^2$

$W = (12\ psf \times 8') + (55\ psf \times 2'8'') + (42\ psf \times 7') + (35\ psf \times 2')$

$W = 606.67\ \frac{lb}{ft}\ (1.2) = 768\ \frac{lb}{ft} = 0.728\ \frac{k}{ft}$



$M_{max\ Center} = \frac{wl^2}{8}$

$= \frac{(0.728\ k)(20'10'')^2}{8}$

$= 39.49\ kft$

$M_{max\ Center} = \frac{P_x}{2}$

$= (45.9k)\left(\frac{20'10''}{2}\right)$

$= 478.125\ kft$

$M_{max} = 478.125\ kft + 39.49\ kft = 517.62\ kft$

$517.62\ kft > 515\ kft$ No

Check Deflection

$I_{LB} \Rightarrow Y_1 = TFL \quad Y_2 = 4.5$

$= 1430\ in^4$

$\Delta\ Max \Rightarrow \frac{L}{360} = \frac{20'10''(12)}{360} = 0.694''$

$\Delta = \frac{5wl^4(1728)}{348EI_{LB}} + \frac{Pl^3(1728)}{48EI_{LB}}$

Structural Analysis - Beam C4-C5 Floor 4 (cont

$$\Delta = \frac{5[0.728)(20'10")^4(1728)}{(384)(29000)(1430)} + \frac{(45.9)(20'10")^3(1728)}{(48)(29000)(1430)}$$

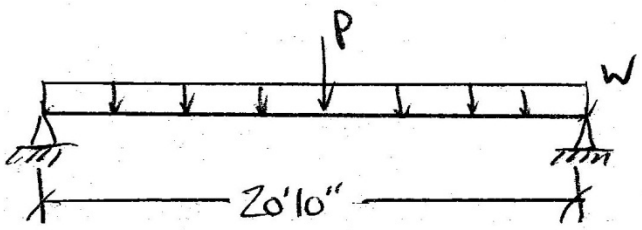
$$\Delta = 0.074 + 0.36 = 0.434 < 0.694"$$

Ok

Structural Analysis - Beam C4-C5 Floor 4 (cont.)

Note: This Analysis will consist of Storefront Glass in Place of Metal Panels

ϕM_n = 515 kFt See pg 2 for Details



Point - P

Lightweight Concrete - 44psf (Vulcraft Ps47)

Deck - 3psf (2.61psf Vulcraft pg 46)

LL = 80psf + 20 psf (Partitions) (5.0.1)

SDL = 15psf

Beam = $\frac{36'10"}{2}$ x 44 = 810.33lb

Tributary Area = $\frac{36'10"}{2} \times \frac{20'10"}{2}$ = 191.84 sq ft

P = (44psf + 3psf + 15psf)(191.84 ft²)(1.2) + (100psf)(191.84 ft²)(1.6) + (810.33lb)(1.2)

P = 45,939.69 lb = 45.94 k

Distributed Load - W

Curtain Wall = 8.25psf Glass + 3.5psf = 11.75 ≈ 12psf (usglum.com)

Medium Weight 8" CMU = 55 psf (Penn State Dept of ABE)

4" Brick = 42psf (Penn State Dept of ABE)

Structural Analysis - Beam C4-C5 Floor 4 (cont.)

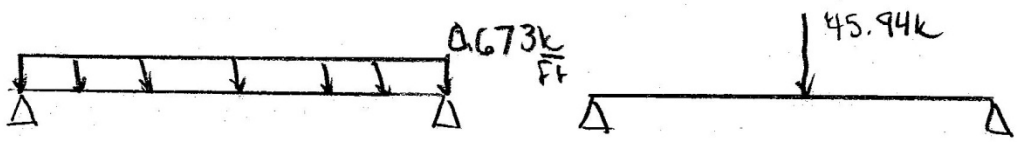
Sq Ft of Glass: $13' \times 8' + 13' \times 2' = 130 ft^2$

Sq Ft of CMU - $20'10'' \times 2'8'' = 55.56 ft^2$

Sq Ft of Brick = $20'10'' \times 7' = 145.83 ft^2$

$W = (12psf \times 8') + (12psf \times 2') + (55psf \times 2'8'') + (42psf \times 7')$

$W = 560.67 \frac{lb}{ft} (1.2) = 672.8 \frac{lb}{ft} = 0.673 \frac{k}{ft}$



$M_{max\ Center} = \frac{wl^2}{8}$

$= \frac{(0.673)(20'10'')^2}{8}$

$= 36.513\ k\text{-}ft$

$M_{max\ Center} = \frac{P_x}{2}$

$= \frac{(45.9k)(20'10'')}{2}$

$= 478.125\ k\text{-}ft$

$M_{max} = 478.125 + 36.513 = 514.64\ k\text{-}ft$

$514.64 < 515$ ok

Check Deflection

$I_{LB} \Rightarrow Y_1 = TFL \quad Y_2 = 4.5$

$= 1430 in^4$

$\Delta_{Max} \Rightarrow \frac{L}{360} = \frac{20'10''(12)}{360} = 0.694''$

$\Delta = 5\frac{wl^4(1728)}{384 E I_{LB}} + \frac{Pl^3(1728)}{48 E I_{LB}}$

$= \frac{5(0.673)(20'10'')^4(1728)}{(384)(29000)(1430)} + \frac{(45.9)(20'10'')^3(1728)}{(48)(29000)(1430)}$

$\Delta = 0.069 + 0.36 = 0.428'' < 0.694''$ Ok

Building Enclosure Cost Analysis

George Mason University Student Union Building I					
Metal Panel Schedule Summary					
West Elevation					
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft²)**	**Cost / Sq. Ft.**	**Total Cost**
Metal Panel	2	10	20	$24.00	480.00
Metal Panel	14	10	140	$24.00	3,360.00
Metal Panel	3	10	30	$24.00	720.00
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	13	2	26	$24.00	624.00
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	13	2	26	$24.00	624.00
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	13	2	26	$24.00	624.00
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	13	2	26	$24.00	624.00
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	1	4.5	4.5	$24.00	108.00
Metal Panel	13	2	26	$24.00	624.00
Metal Panel	13	2	26	$24.00	624.00
Metal Panel	13	2	26	$24.00	624.00
Metal Panel	13	2	26	$24.00	624.00

South Elevation					
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft²)**	**Cost / Sq. Ft.**	**Total Cost**
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	12	2	24	$24.00	576.00
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	7	2	14	$24.00	336.00
Metal Panel	4	1.5	6	$24.00	144.00
Metal Panel	4	1.5	6	$24.00	144.00
Metal Panel	5	1.67	8.35	$24.00	200.40
Metal Panel	26	1.5	39	$24.00	936.00
Metal Panel	15.33	1.5	22.995	$24.00	551.88
Metal Panel	15.33	1.5	22.995	$24.00	551.88

Metal Panel	4.33	1.5	6.495	$24.00	155.88
Metal Panel	4.33	1.5	6.495	$24.00	155.88
Metal Panel	3	10	30	$24.00	720.00
Metal Panel	15	2	30	$24.00	720.00
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	15	2	30	$24.00	720.00
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	15	2	30	$24.00	720.00
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	15	2	30	$24.00	720.00
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	14.67	2	29.34	$24.00	704.16
Metal Panel	14.67	2	29.34	$24.00	704.16
Metal Panel	14.67	2	29.34	$24.00	704.16
Metal Panel	14.67	2	29.34	$24.00	704.16
Metal Panel	40.67	1.67	67.9189	$24.00	1,630.05
Metal Panel	11.67	2	23.34	$24.00	560.16
Metal Panel	7.67	2	15.34	$24.00	368.16

East Elevation					
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**	**Cost / Sq. Ft.**	**Total Cost**
Metal Panel	4	8.67	34.68	$24.00	832.32
Metal Panel	4	7	28	$24.00	672.00
Metal Panel	4	7	28	$24.00	672.00
Metal Panel	5.33	2	10.66	$24.00	255.84
Metal Panel	1.5	4.5	6.75	$24.00	162.00
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	1.33	4.5	5.985	$24.00	143.64
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	2.67	10	26.7	$24.00	640.80
Metal Panel	3	10	30	$24.00	720.00
Metal Panel	13	2	26	$24.00	624.00
Metal Panel	13	2	26	$24.00	624.00

Metal Panel	13	2	26	$24.00	624.00
Metal Panel	11.5	2	23	$24.00	552.00
Metal Panel	13	2	26	$24.00	624.00
Metal Panel	13	2	26	$24.00	624.00
Metal Panel	13	2	26	$24.00	624.00
Metal Panel	10.67	2	21.34	$24.00	512.16

Total Cost
$41,546.49

George Mason University Student Union Building I					
Pre-Cast Architectural Panel Schedule Summary					
West Elevation					
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**	**Cost / Sq. Ft.**	**Total Cost**
Pre-Cast	2	10	20	$35.00	700.00
Pre-Cast	14	10	140	$35.00	4,900.00
Pre-Cast	3	10	30	$35.00	1,050.00
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	1	4.5	4.5	$35.00	157.50
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	13	2	26	$35.00	910.00

South Elevation					
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**	**Cost / Sq. Ft.**	**Total Cost**
Pre-Cast	2.67	10	26.7	$35.00	934.50

Pre-Cast	12	2	24	$35.00	840.00
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	7	2	14	$35.00	490.00
Pre-Cast	4	1.5	6	$35.00	210.00
Pre-Cast	4	1.5	6	$35.00	210.00
Pre-Cast	5	1.67	8.35	$35.00	292.25
Pre-Cast	26	1.5	39	$35.00	1,365.00
Pre-Cast	15.33	1.5	22.995	$35.00	804.83
Pre-Cast	15.33	1.5	22.995	$35.00	804.83
Pre-Cast	4.33	1.5	6.495	$35.00	227.33
Pre-Cast	4.33	1.5	6.495	$35.00	227.33
Pre-Cast	3	10	30	$35.00	1,050.00
Pre-Cast	15	2	30	$35.00	1,050.00
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	15	2	30	$35.00	1,050.00
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	15	2	30	$35.00	1,050.00
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	15	2	30	$35.00	1,050.00
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	14.67	2	29.34	$35.00	1,026.90
Pre-Cast	14.67	2	29.34	$35.00	1,026.90
Pre-Cast	14.67	2	29.34	$35.00	1,026.90
Pre-Cast	14.67	2	29.34	$35.00	1,026.90
Pre-Cast	40.67	1.67	67.9189	$35.00	2,377.16
Pre-Cast	11.67	2	23.34	$35.00	816.90
Pre-Cast	7.67	2	15.34	$35.00	536.90

East Elevation					
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**	**Cost / Sq. Ft.**	**Total Cost**
Pre-Cast	4	8.67	34.68	$35.00	1,213.80
Pre-Cast	4	7	28	$35.00	980.00
Pre-Cast	4	7	28	$35.00	980.00
Pre-Cast	5.33	2	10.66	$35.00	373.10
Pre-Cast	1.5	4.5	6.75	$35.00	236.25
Pre-Cast	2.67	10	26.7	$35.00	934.50

Pre-Cast	1.33	4.5	5.985	$35.00	209.48
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	2.67	10	26.7	$35.00	934.50
Pre-Cast	3	10	30	$35.00	1,050.00
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	11.5	2	23	$35.00	805.00
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	13	2	26	$35.00	910.00
Pre-Cast	10.67	2	21.34	$35.00	746.90

Total Cost
$60,588.64

George Mason University Student Union Building I					
Aluminum Storefront Window Schedule Summary					
West Elevation					
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**	**Cost / Sq. Ft.**	**Total Cost**
Storefront	2	10	20	$33.00	660.00
Storefront	14	10	140	$33.00	4,620.00
Storefront	3	10	30	$33.00	990.00
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	13	2	26	$33.00	858.00
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	13	2	26	$33.00	858.00
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	13	2	26	$33.00	858.00
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	13	2	26	$33.00	858.00
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	1	4.5	4.5	$33.00	148.50

Storefront	13	2	26	$33.00	858.00
Storefront	13	2	26	$33.00	858.00
Storefront	13	2	26	$33.00	858.00
Storefront	13	2	26	$33.00	858.00

South Elevation					
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**	**Cost / Sq. Ft.**	**Total Cost**
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	12	2	24	$33.00	792.00
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	7	2	14	$33.00	462.00
Storefront	4	1.5	6	$33.00	198.00
Storefront	4	1.5	6	$33.00	198.00
Storefront	5	1.67	8.35	$33.00	275.55
Storefront	26	1.5	39	$33.00	1,287.00
Storefront	15.33	1.5	22.995	$33.00	758.84
Storefront	15.33	1.5	22.995	$33.00	758.84
Storefront	4.33	1.5	6.495	$33.00	214.34
Storefront	4.33	1.5	6.495	$33.00	214.34
Storefront	3	10	30	$33.00	990.00
Storefront	15	2	30	$33.00	990.00
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	15	2	30	$33.00	990.00
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	15	2	30	$33.00	990.00
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	15	2	30	$33.00	990.00
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	14.67	2	29.34	$33.00	968.22
Storefront	14.67	2	29.34	$33.00	968.22
Storefront	14.67	2	29.34	$33.00	968.22
Storefront	14.67	2	29.34	$33.00	968.22
Storefront	40.67	1.67	67.9189	$33.00	2,241.32
Storefront	11.67	2	23.34	$33.00	770.22
Storefront	7.67	2	15.34	$33.00	506.22

East Elevation					
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**	**Cost / Sq. Ft.**	**Total Cost**
Storefront	4	8.67	34.68	$33.00	1,144.44
Storefront	4	7	28	$33.00	924.00
Storefront	4	7	28	$33.00	924.00
Storefront	5.33	2	10.66	$33.00	351.78
Storefront	1.5	4.5	6.75	$33.00	222.75
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	1.33	4.5	5.985	$33.00	197.51
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	2.67	10	26.7	$33.00	881.10
Storefront	3	10	30	$33.00	990.00
Storefront	13	2	26	$33.00	858.00
Storefront	13	2	26	$33.00	858.00
Storefront	13	2	26	$33.00	858.00
Storefront	11.5	2	23	$33.00	759.00
Storefront	13	2	26	$33.00	858.00
Storefront	13	2	26	$33.00	858.00
Storefront	13	2	26	$33.00	858.00
Storefront	10.67	2	21.34	$33.00	704.22

Total Cost
$57,126.43

Building Enclosure Schedule Analysis

George Mason University Student Union Building I			
Metal Panel Schedule Summary			
West Elevation			
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**
Metal Panel	2	10	20.00
Metal Panel	14	10	140.00
Metal Panel	3	10	30.00
Metal Panel	2.67	10	26.70
Metal Panel	13	2	26.00
Metal Panel	2.67	10	26.70
Metal Panel	13	2	26.00
Metal Panel	2.67	10	26.70
Metal Panel	13	2	26.00
Metal Panel	2.67	10	26.70
Metal Panel	13	2	26.00
Metal Panel	2.67	10	26.70
Metal Panel	1	4.5	4.50
Metal Panel	13	2	26.00
Metal Panel	13	2	26.00
Metal Panel	13	2	26.00
Metal Panel	13	2	26.00
Total Area West Elevation			536.00

South Elevation			
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**
Metal Panel	2.67	10	26.70
Metal Panel	12	2	24.00
Metal Panel	2.67	10	26.70
Metal Panel	7	2	14.00
Metal Panel	4	1.5	6.00
Metal Panel	4	1.5	6.00
Metal Panel	5	1.67	8.35
Metal Panel	26	1.5	39.00

Metal Panel	15.33	1.5	23.00
Metal Panel	15.33	1.5	23.00
Metal Panel	4.33	1.5	6.50
Metal Panel	4.33	1.5	6.50
Metal Panel	3	10	30.00
Metal Panel	15	2	30.00
Metal Panel	2.67	10	26.70
Metal Panel	15	2	30.00
Metal Panel	2.67	10	26.70
Metal Panel	15	2	30.00
Metal Panel	2.67	10	26.70
Metal Panel	15	2	30.00
Metal Panel	2.67	10	26.70
Metal Panel	14.67	2	29.34
Metal Panel	14.67	2	29.34
Metal Panel	14.67	2	29.34
Metal Panel	14.67	2	29.34
Metal Panel	40.67	1.67	67.92
Metal Panel	11.67	2	23.34
Metal Panel	7.67	2	15.34
Total Area South Elevation			690.49

East Elevation			
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**
Metal Panel	4	8.67	34.68
Metal Panel	4	7	28.00
Metal Panel	4	7	28.00
Metal Panel	5.33	2	10.66
Metal Panel	1.5	4.5	6.75
Metal Panel	2.67	10	26.70
Metal Panel	1.33	4.5	5.99
Metal Panel	2.67	10	26.70
Metal Panel	2.67	10	26.70
Metal Panel	2.67	10	26.70
Metal Panel	2.67	10	26.70
Metal Panel	2.67	10	26.70

Metal Panel	3	10	30.00
Metal Panel	13	2	26.00
Metal Panel	13	2	26.00
Metal Panel	13	2	26.00
Metal Panel	11.5	2	23.00
Metal Panel	13	2	26.00
Metal Panel	13	2	26.00
Metal Panel	13	2	26.00
Metal Panel	10.67	2	21.34
Total Area East Elevation			504.62
Total Area			1731.10

Total Days
5.77

George Mason University Student Union Building I				
Pre-Cast Architectural Panel Schedule Summary				
West Elevation				
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**	**Quantity**
Pre-Cast	2	10	20	1
Pre-Cast	14	10	140	1
Pre-Cast	3	10	30	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	13	2	26	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	13	2	26	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	13	2	26	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	13	2	26	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	13	2	26	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	1	4.5	4.5	1
Pre-Cast	13	2	26	1
Pre-Cast	13	2	26	1

Pre-Cast	13	2	26	1
Pre-Cast	13	2	26	1
Total Panels West Elevation				17

South Elevation				
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**	**Quantity**
Pre-Cast	2.67	10	26.7	1
Pre-Cast	12	2	24	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	7	2	14	1
Pre-Cast	4	1.5	6	1
Pre-Cast	4	1.5	6	1
Pre-Cast	5	1.67	8.35	1
Pre-Cast	26	1.5	39	1
Pre-Cast	15.33	1.5	22.995	1
Pre-Cast	15.33	1.5	22.995	1
Pre-Cast	4.33	1.5	6.495	1
Pre-Cast	4.33	1.5	6.495	1
Pre-Cast	3	10	30	1
Pre-Cast	15	2	30	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	15	2	30	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	15	2	30	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	15	2	30	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	14.67	2	29.34	1
Pre-Cast	14.67	2	29.34	1
Pre-Cast	14.67	2	29.34	1
Pre-Cast	14.67	2	29.34	1
Pre-Cast	40.67	1.67	67.9189	1
Pre-Cast	11.67	2	23.34	1
Pre-Cast	7.67	2	15.34	1
Total Panels South Elevation				28

East Elevation				
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**	**Quantity**
Pre-Cast	4	8.67	34.68	1
Pre-Cast	4	7	28	1
Pre-Cast	4	7	28	1
Pre-Cast	5.33	2	10.66	1
Pre-Cast	1.5	4.5	6.75	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	1.33	4.5	5.985	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	2.67	10	26.7	1
Pre-Cast	3	10	30	1
Pre-Cast	13	2	26	1
Pre-Cast	13	2	26	1
Pre-Cast	13	2	26	1
Pre-Cast	11.5	2	23	1
Pre-Cast	13	2	26	1
Pre-Cast	13	2	26	1
Pre-Cast	13	2	26	1
Pre-Cast	10.67	2	21.34	1
Total Panels East Elevation				21
Total Panels				66

Total Days
2.2

George Mason University Student Union Building I
Aluminum Storefront Window Schedule Summary
West Elevation

Description	Length (Ft.)	Height (Ft.)	Area (Ft^2)
Storefront	2	10	20
Storefront	14	10	140
Storefront	3	10	30
Storefront	2.67	10	26.7
Storefront	13	2	26
Storefront	2.67	10	26.7
Storefront	13	2	26
Storefront	2.67	10	26.7
Storefront	13	2	26
Storefront	2.67	10	26.7
Storefront	13	2	26
Storefront	2.67	10	26.7
Storefront	1	4.5	4.5
Storefront	13	2	26
Storefront	13	2	26
Storefront	13	2	26
Storefront	13	2	26
Total Area West Elevation			536.00

South Elevation			
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**
Storefront	2.67	10	26.7
Storefront	12	2	24
Storefront	2.67	10	26.7
Storefront	7	2	14
Storefront	4	1.5	6
Storefront	4	1.5	6
Storefront	5	1.67	8.35
Storefront	26	1.5	39
Storefront	15.33	1.5	22.995
Storefront	15.33	1.5	22.995
Storefront	4.33	1.5	6.495
Storefront	4.33	1.5	6.495
Storefront	3	10	30

Storefront	15	2	30
Storefront	2.67	10	26.7
Storefront	15	2	30
Storefront	2.67	10	26.7
Storefront	15	2	30
Storefront	2.67	10	26.7
Storefront	15	2	30
Storefront	2.67	10	26.7
Storefront	14.67	2	29.34
Storefront	14.67	2	29.34
Storefront	14.67	2	29.34
Storefront	14.67	2	29.34
Storefront	40.67	1.67	67.9189
Storefront	11.67	2	23.34
Storefront	7.67	2	15.34
Total Area South Elevation			690.49

East Elevation			
Description	**Length (Ft.)**	**Height (Ft.)**	**Area (Ft^2)**
Storefront	4	8.67	34.68
Storefront	4	7	28
Storefront	4	7	28
Storefront	5.33	2	10.66
Storefront	1.5	4.5	6.75
Storefront	2.67	10	26.7
Storefront	1.33	4.5	5.985
Storefront	2.67	10	26.7
Storefront	2.67	10	26.7
Storefront	2.67	10	26.7
Storefront	2.67	10	26.7
Storefront	2.67	10	26.7
Storefront	3	10	30
Storefront	13	2	26
Storefront	13	2	26
Storefront	13	2	26
Storefront	11.5	2	23

Storefront	13	2	26
Storefront	13	2	26
Storefront	13	2	26
Storefront	10.67	2	21.34
Total Area East Elevation			504.62
Total Area			1731.10

Total Days
4.95

Penn State HUB Survey

Subject - Natural day lighting at the Penn State HUB-Robeson Center

Q1. How important is architectural design for you? (Please Check One)

_____ Very Important
_____ Important
_____ Average
_____ Slightly Important
_____ Not Important

Q2. Which Building front is more visibly pleasing to you? (Please Check One)

_____ Aluminum Storefront (Existing)

_____ Architectural Precast Concrete Panels

_____ Metal Panels

Q3. How important is the natural day lighting for you? (Please Check One)

_____ Very Important
_____ Important
_____ Average
_____ Slightly Important
_____ Not Important

Q4. Are you satisfied with the natural day lighting inside the HUB? (Please Check One)

_____ Yes
_____ No
_____ Undecided