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Technical Assignment Three

University of Maryland Physical Sciences Complex

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EXECUTIVE SUMMARY

The content contained within this document will detail the industry issues surrounding the Physical Sciences Complex at the University of Maryland. The PSC is a 160,000 square foot new structure with a project cost of $98,000,000. The building is destined to be the most advanced science laboratory in the United States and has much to live up to. The project is the second phase of a three phase plan by the University of Maryland to revitalize the sciences program over the next decade with the services of Gilbane Corp. Included in this document is a constructability analysis, a schedule acceleration scenario analysis, a value engineering analysis, a PACE round table summary, and an industry research ideas analysis.

This document was created using the information provided in two key interviews with project personnel. These personnel include Rose Abousaid, the project structural engineer, and Dan Kodan, the project MEP engineer. In these interviews I asked each of them of the issues regarding constructability, schedule acceleration, and value engineering with respect to their fields of expertise. During these interviews I discovered several areas of focus. Constructability of the façade seemed to be a major issue, as well as the raised access flooring. Schedule acceleration scenarios were also discussed. It was discovered that the PSC sub-basement was able to begin construction months ahead of time due to an analysis of the structural members in the plaza. Furthermore, weather was a primary concern during the winter months with excavation and caused some delay in the schedule. Lastly, lead times on custom MEP equipment was a major risk to the project schedule. In all, a significant delay in the completion date of the PSC would result in a huge revenue loss for the University which ultimately would be transferred to Gilbane.

This document also describes the findings of the 21st annual Pace Roundtable meeting. In this meeting, various sessions were held in which 5th year AE student discussed industry issues with other professionals.

Following this event, research ideas were developed that could correspond to the PSC and how it could help in the long run. A focus on the life cycle cost of the building is the primary topic.

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Constructability Challenges

There is a significant list of constructability challenges surrounding the University of Maryland Physical Sciences Complex. Some of the challenges include the construction of the curtain wall, tying into the existing facilities, access to chilled water lines, raised access flooring issues, and coordination for LEED.

Curtain Wall

The first challenge, and by far the most critical, is the unique metal and glass curtain wall façade that encloses the exterior of the building and the elliptical center of the building. The façade poses several challenges for various reasons. The first challenge was erecting the façade. The curtain wall is modularized, as noted in the previous tech report, and was spec'd to be erected with a roof hoist in 5'x6' sections for the exterior. The interior however, was more difficult. The interior module pieces, when installed, are angled to accommodate the slight taper in the ellipse.

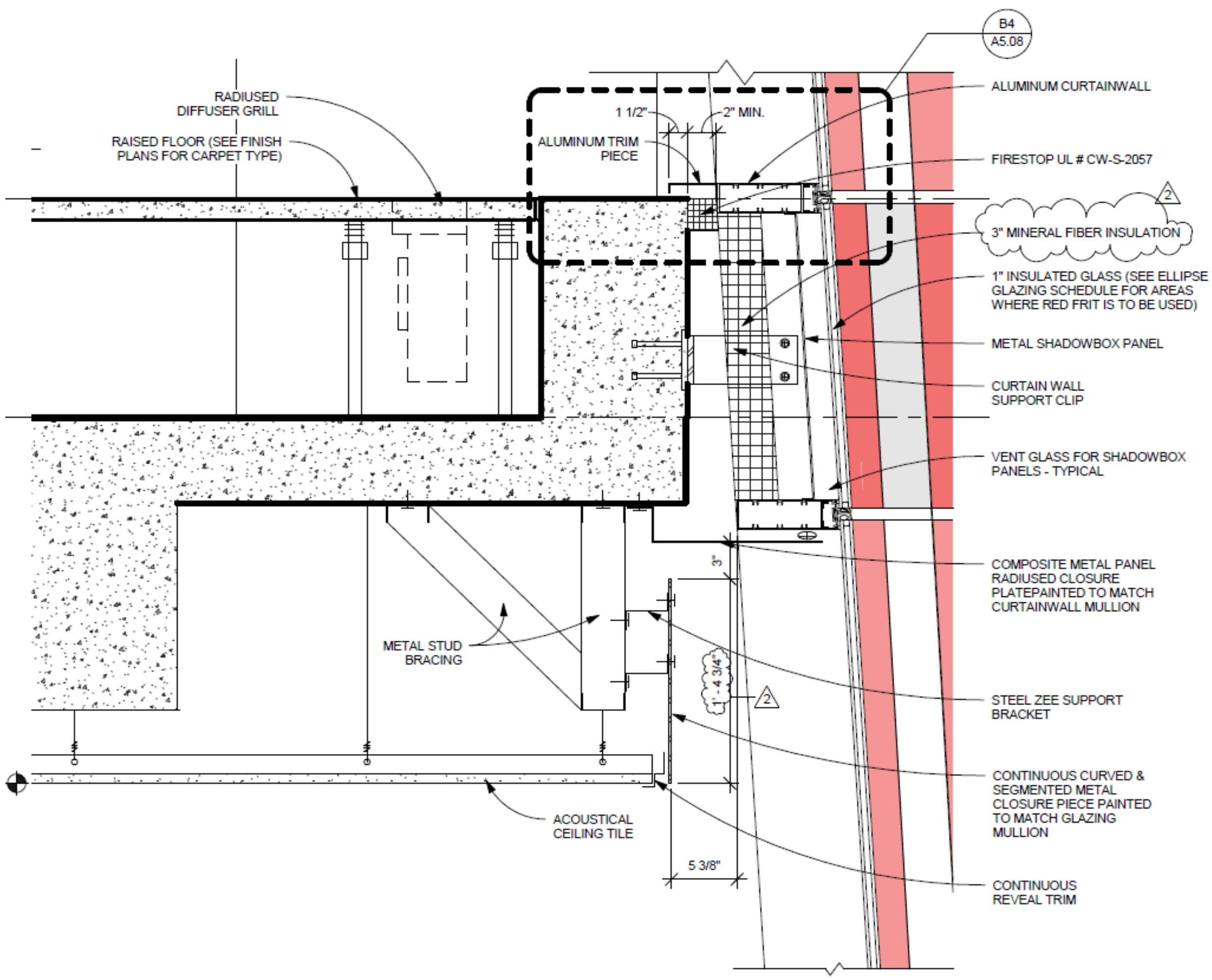

Figure.1

Figure.1, above, shows that slant in a detailed section of the interior façade. There are several things to be pointed out in this particular drawing. First, the "Curtain wall support clip" is a rigid member that is embedded into the slab. This poses a significant problem with coordination. Typically, a curtain wall of this complexity will not use a rigid member support clip to support it. The rigid member must be embedded with the concrete during curing, and therefor if there is any error in placement, must be removed and re-drilled to align correctly with the curtain wall. Typically, in this case a horizontal rail would be inserted into the slab, and a clip would then rest in that rail, which is capable of horizontal and vertical calibration. The second thing to point out on this detail is the placement of the shadow box. The purpose of this metal panel is to simulate the appearance of a translucent piece of glazing without allowing the viewer to see the structure of the building and slab. In this particular case, because the glazing is already a tinted red, the shadow box could be deemed as unnecessary. The 3" mineral fiber insulation could act as a shadow box its self while supplying the same amount of thermal protection. The aforementioned issues went unresolved during the fabrication of the curtain wall, and caused slight delays in the project schedule.

Existing Facilities

Another significant hurdle for the team at Gilbane was finding an efficient method of tying into the existing Computer Science and Space (CSS) building. The new PSC and the existing CSS are to be connected from basement level to the 3rd floor. Early in design, Gilbane worked closely with HDR, the architectural firm behind the PSC, to coordinate how the CSS will tie into the PSC. The existing documents for this 40-year-old building were not the most accurate, and as such, complication arose regarding placement of critical connections. It was decided that the CSS will undergo a renovation its self as an additional project in order to make it suitable for tie-in. During this renovation, accurate 3D models were made and used in conjunction with BIM to coordinate the connections between the PSC and the CSS, alleviating any major issues that would arise.

Raised Access Flooring

The implementation of raised access flooring is a new idea to many construction projects. It serves as a means to create a more open space and allows for more control over the climate of the interior space. Figure.1 also shows the raised access flooring and its relative size in comparison to the slab and façade. Floors 1 through 3 will all have raised access flooring. Currently, the raised access flooring is undergoing balances and tweaks in the PSC in order to have it run in the most efficient manner possible. This is especially important because after the walls are framed, the raised access flooring can no longer be balanced without removing walls and equipment. If a major change were to take place as well, the raised flooring would have to be removed entirely to make that change for a particular zone. Also, if not installed to exact specification, it is possible that the supply air can leak through the individual tiles that make up the floor, creating a huge drop in performance. In order to ensure that the flooring is installed correctly, the site teams have been performing pressure tests for the past month, and tweaking the floor where necessary. This is one area where BIM coordination was hugely beneficial as it allowed for detailed placement of each individual tile piece and its components.

Central Plant Integration

The last major constructability issue would be the integration of central utility plant for the PSC. The PSC is set upon a college campus, and much like how Penn State handles its utilities, there is a central plant for chilled water, steam, etc. Because the PSC is such a large addition and will require a lot more resources, the central utility plant had to renovated to accommodate the additional space imposed by the PSC. This involved replacing the existing chilled water equipment with larger, custom manufactured equipment off site. The plant is about 300 yards away and requires new utility lines to meet the PSC's demand. This site team chose to place the new lines under the existing road, while at the same time repaving those roads. Existing two way roads during construction were split into a construction lane and a one way lane with a flagger.

Schedule Acceleration Scenarios

The critical path for the Physical Sciences Complex is extremely detailed. The entirety of the schedule for the PSC is around 3700 activities long. The critical path includes items such as excavation, framing, casework, slabs, waterproofing, and rough-in. Two of the main issues associated with schedule acceleration are weather and prefabrication.

Weather

One of the biggest risks to the critical path of the schedule for the PSC is the weather. Being in Maryland, the site is not immune to severe weather, in particular, snow. Luckily, during excavation there was only a minimal amount of snow fall. The real risk for delay comes with drilling 55' deep caissons in the dead of winter. The PSC cannot afford to delay excavation until the spring or summer when the ground is softer or when the weather is more forgiving because there is a strict timeline that must be met. In order to counteract the delay imposed by longer drill times, two caisson drill machines were used instead of one. The additional cost of renting the machine is dwarfed by the cost in a delayed launch for fall the academic semester in 2013.

Prefabrication

Prefabrication of critical members and equipment was very important in the construction of the PSC. Mentioned previously, some of the MEP equipment was custom manufactured. Unlike picking and choosing equipment from a suppliers catalog, this custom equipment has lead times that are months greater. The 800 ton chiller that is part of the central plant had a lead time of 6 months. Ensuring that this equipment is spec'd and ready for integration with the surrounding building was a crucial factor in determining when fabrication could begin. Many of the AHU's were also custom fabricated and were handled in the same manner. While Gilbane has no direct control over when the prefabrication begins, they can incentivize how the contractor handles the prefabrication. Early on, Gilbane made it clear that the MEP contractor can use the site tower crane to hoist and move the equipment if it arrived on time. Unfortunately, the equipment did not arrive on time, and the contractor had to acquire mobile crane to lift the equipment. This caused a delay in installation.

Acceleration Methods

There are methods available for acceleration on the project, both active acceleration and passive. Actively, acceleration can be achieved by working longer hours, hiring more crews, and renting more equipment. As mentioned with the caisson work, an additional auger and crew were implemented to maintain the schedule for the critical path with regards to foundations. Beyond this, there are passive means of schedule acceleration. Passive schedule acceleration includes things like BIM implementation, regular staff meetings, and open communications between trades. By far, the biggest method of ensuring an on time schedule is having regular meetings with the contractor from Gilbane's perspective. In an interview with Dan Kodan, the MEP engineer with Gilbane, he stated that the biggest method of expediting the process of construction was making sure that all parties know what the current schedule is and what the current issues are. Bi-weekly meetings were held to discuss sequencing so that there was never a dull moment in construction.

Another major source of passive acceleration comes in the form of BIM. In the same interview the Dan, he made it very clear that BIM has had a huge influence of the success of critical construction details such as the raised access flooring and tie-ins to existing utilities. The costs incurred by having additional staff and time dedicated to BIM analysis and implementation is once again dwarfed by the delay in project completion date. A late opening for the PSC means that the earliest academic semester in the building is pushed back an entire semester, resulting in huge losses for the University. The University realized early on that BIM is a key factor in the success of the PSC.

A great example of schedule acceleration that actually occurred on site was when the sub-basement began construction. Initially, the sub-basement had to wait on the formwork to be removed from the plaza area, which required that the roof be poured and cured. However, with additional rebar, the structural integrity of the plaza could be maintained even without the formwork in place. This allowed the sub-basement to begin work almost two and a half months ahead of schedule. Although extra costs were incurred by the additional shop drawings and rebar, the costs were counteracted fully by the reduction in schedule.

Value Engineering Topics

Value engineering was used on the PSC but was not a huge focus. There are several areas in which a first time analyses proved that an alternative means or method would save money. In this section some of those methods are discusses as well as areas for potential improvement.

The first topic for value engineering that was implemented on the PSC, and the biggest topic, was the choice to renovate the existing utility plant instead of having equipment localized for the PSC. It was discussed between Gilbane and HDR that renovating the central plant would, in the long term, save money for both Gilbane and the University. As mentioned in the summary, the PSC is the second phase of a three phase plan by the University to update and reinvigorate the sciences department on campus. Knowing that there will be further additions to the campus made it easier to understand that having a powerful and up-to-date central plant would save money instead of having multiple localized chillers. The true value of this choice isn't exactly known considering it can only be known when phase three begins, but it's estimated to be within 2-3 million dollars.

The second topic is the metal duct work for the return air systems. The initial design for the return air ductwork was shown as rectangular. The sheet metal contractor contacted Gilbane and raised the concern about how circular duct work is easier to manufacture, requires less time to manufacture, and can be assembled in the field faster than rectangular ductwork. Overall this saved approximately 200k dollars from the total cost of the MEP installations.

The third topic is the backfill used for the site. Initially it was planned that the backfill material was to be recycled tires with other composite parts. This would have achieved an additional LEED point for the project, but it would also create additional costs in the ways of materials and labor. It was decided that sacrificing a LEED point by replacing the recycled backfill with stone would save approximately 50k dollars in material and labor.

Overall, the value engineering done by Gilbane and HDR ensures a higher profit for these companies. Considering the contract type is GMP, anything that Gilbane can do in the ways of saving money means they can focus on other critical branches of construction with the PSC. Also, other topics for value engineering were discussed but not implemented. It was widely discussed that the implementation of the green roof was unnecessary, that the costs do not reflect a substantial gain in the LEED scoreboard. Although the idea is still floating around that the green roof be removed, it so far has not been decided upon. The green roof has yet to be installed and can still be redacted.

Critical Industry Issues

This section of the tech report discusses the findings during the PACE Roundtable meeting from November 6th, 2012. During this event, I was able to split off into groups to discuss industry issues in a group of both 5th year students and industry professionals. There were two group discussions, followed by a smaller discussion with a single industry profession and two other students.

In the first session of group discussion, I attended the meeting dedicated to Operations and Maintenance: BIM and Energy, moderated by John Messner. In this session I learned a lot about what are the most important issues related to BIM implementation in the modern era. It is getting to the point that buildings are so complex and complicated that it would be almost impossible to construct one with 2D drawings alone. The level of coordination required to properly construct a building today vastly outpaces what may have been required 20 years ago. Furthermore, while many owners are on board with the idea of BIM, many still do not know what it is, or do not understand what the benefits of it are. It is up to the construction professionals and companies, like Gilbane, to educate owners to the benefits of BIM and why additional costs upfront will make a huge difference in savings down the road for both the owner and the CM firm.

The current issue with energy and its relation to BIM is that there is no real standard that would allow a BIM design to fully make use of the energy analysis. At the moment, BIM makes use of static information for equipment such as running temperature, filter life-times, and power usage. The actual influence that this equipment has on its surroundings and how it affects occupants is still done by hand.

Two of the most interesting things I took away from this session was the fact that vibration sensors are being used along with BIM to indicate if equipment is malfunctioning, and that occupant behavior is extremely hard to control. I think it is very innovative that vibration sensors can be calibrated to detect malfunctioning objects. This allows staff to act early on system failures, and saves money up front if something were to go wrong. With regards to occupants, several of the industry professionals at the meeting said they have first-hand experience with people misusing the space. This means they use extra space heaters, or leave windows open, or don't cover fume-hoods (which leads to massive energy losses). So the question arose of how can we, as the professionals behind the building, coerce the occupants to think of their energy footprint as much as we do. BIM monitoring of spaces and energy usage was a proposed idea, in which individuals in the building are capable of reading what the efficiency of the building is. Similar to how a house-owner would monitor their kilowatt-hours, would the building occupants monitor their energy footprint.

The idea of occupant awareness is incredibly crucial to the lifecycle of a building. I think that the PSC can benefit greatly from the ideas discussed in session one.

In the second session I attended the group meeting for Model Handover, also in the category of Operations and Maintenance. This session focused on the method of BIM handover to building owners and facility staff. The questions we set out to answer were "Why" "How" and What."

The benefits of full digital hand over are obvious to most people in the industry. A few electronic files with detailed specs on everything in the building is far easier to manage than 90 4" binders where there is no search function to locate specific equipment or lights. Again, the benefit of upfront costs and labor are sometimes difficult to see from an owner's perspective, especially one who has never been involved with BIM. From "day 1" the model for handover must begin assembly. Everything from cut-sheets, to submittals, to design docs must be associated with their respective part in the model.

Another topic that arose in this session was the idea of what needs to actually be transferred to the owner. Someone mentioned in the meeting that it was just as important to educate one's self on the owner as it is to educate the owner on BIM handover. This statement is very important, because BIM, while mostly helpful, may not always been the solution to a problem. Knowing what an owner needs, for how long they need it, and for what reasons he or she needs it can allow for a CM firm to dedicate resources to precisely those causes.

In the meeting, I touched on how the model handover will help with the lifecycle cost of the building. The lifecycle cost of a building is everything that is required to keep it running, including the maintenance staff. Having a model for reference reduced the amount of staff needed, and also reduces the amount of time that staff must focus on issues. Having a model which directs a facility manager to an equipment shed for a precise piece of equipment may save a few hours on locating the equipment necessary to work on a particular chiller or steam pump. Having a schedule for filter replacements, for valve maintenance and more is beneficial to the owner and will save on costs.

Overall, this session brought a lot of interesting ideas into light and showed me that the primary issue with advancing the rate at which buildings adopt this form of facility maintenance is education of its benefits to owners and staff.

During these sessions I met Tyler with Gilbane, and John Bechtel. These two industry members could serve as contacts for further discussion and information regarding the topics discussed during the Pace Roundtable event. John, being with the Office of the Physical plant at PSU, said it might be of interest to me to take a look at the Millennium Science drawings to have a more in depth understanding of the underground vibration isolation labs at the PSC.

PROBLEM IDENTIFICATION AND TECHNICAL ANALYSIS

There are several areas of interest I would like to pursue with the PSC. The first issue, which I find the most interesting, is the façade system and its apparent complications. I am very interested in façade systems in general and I am especially fortunate that the façade on the PSC is capable of a lot of improvement. To expand slightly on what was previously discussed regarding the façade, I would like to perform a detailed estimate to calculate the exact savings achieved through modifying the design of the façade. The design modification would include a removed shadow-box, a non-rigid support clamp, and a modified roof connection joint. It would be necessary for me to get in contact with the façade contractor and discuss methods of installation and choices for certain design aspects. I predict that this communication may be strained, since the result of several complications on the project are, in part, the responsibility of said contractor.

Another issue of focus is the raised access flooring and how it can be made easier to balance and if the perceived benefits of it actually outweigh the additional costs and maintenance. I order to perform this analysis I would need to research other buildings that have included raised access flooring and discover what the purpose was, if that purpose outweighed costs, and if any additional headaches came along with its installation. It would also be important for me to reach out to mechanical option students and professionals to further discuss the systems in the PSC.

I'd also like to perform a type of life-cycle cost analysis on the PSC. While the construction and schedule of the building are extremely important, I feel as though many people lose sight of the fact that these buildings are going to be around for almost 100 years. The costs of running the building and staffing it tower over the costs of constructing it. It may be beneficial to both parties, in this case Gilbane and the University of Maryland to have a mutual agreement regarding the maintenance of the building. With this, I find that having a facility maintenance service run by Gilbane would be a means of reducing the life-cycle cost of the building, thereby saving the owner money, and at the same time reducing the potential headache on Gilbane by having control over the building as well as making a profit off of the services.

Pace Roundtable Worksheet: