November 10th, 2012

TECHNICAL ASSIGNMENT THREE

PENN STATE SENIOR THESIS

REPLACEMENT HIGH SCHOOL

MARYLAND

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EXECUTIVE SUMMARY

This technical report serves to identify areas within the Replacement High School Project that would be good candidates for research. Within this report there is a LEED evaluation, schedule acceleration scenarios, value engineering topics pertaining to the building, an overview of critical industry issues and four proposed technical analysis options. The culmination of this report along with the previous two will serve as the basis for the final thesis proposal.

The LEED evaluation performed for this building describes the areas in which points are being pursued and how they are being achieved. Each category is summarized and analyzed based on the appropriateness for this job. It was found that the project was pursing an appropriate level of certification, but had a few opportunities to make additional strides that could have been seen as beneficial to the owner.

An interview took place with the project engineer in order to discuss possible schedule acceleration scenarios for this school. To give the reader a sense of the schedule a short narrative is provided describing the critical path. It is in this section that the two biggest risks to the project completion date being met are discussed. In addition to this possible acceleration scenarios are investigated and analyzed based off of associated costs and techniques.

Value engineering topics were also discussed with the project engineer. The larger value engineering implementations, and the owner's reaction to them, are described in detail within this section. The majority of the value engineering decisions were dictated by the school district's budget, and therefore whenever there was a chance to lower costs within the building they were approved.

Within this report there is a brief summary of the results of the PACE Roundtable meeting that occurred on November 6th 2012. It was during this time that ideas were further investigated to investigate the appropriateness of technical analysis options for the final thesis proposal.

The final portion of this report sets forth four proposals for further investigation. Problematic features within the project were identified and possible solutions to these problems are proposed. A description of the analyses that need to be performed as well as needed research is outlined here. These analyses will serve as possible research topics for the spring semester.

Contents

LEED EVALUATION

***Reference Appendix A for the detailed LEED Scorecard**

The Replacement High School project is designed to achieve at least a LEED Gold-level rating. Using Version 2.2 of the USGBC's LEED® Green Building Rating System™ for New Construction a LEED Scorecard was developed. Of the possible 69 points, 45 are being pursued in sustainable sites, water efficiency, energy & atmosphere, materials & resources, Indoor environmental quality, and innovation & design process. Table 1 shows a general breakdown of points pursued across the 6 possible categories.

LEED FOR NEW CONSTRUCTION			
LEED Category	Points Possible	Points Pursued	Possible Points
Sustainable Sites	14	11	0
Water Efficiency	5	4	0
Energy & Atmosphere	17	8	1
Materials & Resources	13	6	1
Indoor Environmental Qualit	15	11	0
Innovation & Design Process	5	5	0
Total	69	45	2

Table 1: LEED Scorecard Summary

Sustainable Sites

The replacement high school is striving to obtain 11 out of the possible 14 points in sustainable sites. Several of these points are readily available and don't require active pursuit in order to qualify for them. For instance Site Selection and Development Density & Community Connectivity were two items that, because of the nature of the site, did not require any work in order to be eligible for the points. Additionally the four possible transportation credits were easily acquired because of the nature of the building. Because the building is a school, it is naturally designed to lend itself to have public transportation access, bicycle storage space, a smaller

Figure 1: Stormwater Management System

parking capacity vs. building occupancy, changing rooms, and fuel efficient vehicles. However, the project does incorporate an extensive storm-water management system in order to achieve two points under Stormwater Design. This system will capture and treat 90% of stormwater runoff which will limit pollution of natural water flows. The roof of the school has also been designed with materials that will reflect solar radiation in order to reduce the heat island effect and therefore minimize the impacts on microclimates. The school is also achieving one point under Brownfield Redevelopment.

The points in this category that are being pursued are logical. They can all be achieved with little to no additional cost to the owner. There are three credits that are not being chased, which are: Light Pollution Reduction, Heat Island Effect (Non-Roof), and Site Development (Protect or Restore Habitat). In order to achieve the light pollution credit, there would have to be a significant change in the envelope and exterior lighting system. This would inevitably require a good deal of work to achieve, but only offer one additional point. It would not be practical to try and attain a point by reducing the non-roof heat island effect either. This would require at least 50% shading of parking spaces or the use of something other than asphalt with an SRI index of at least 29. Finally because of the size, complexity, and time frame in which the building is to be built, it is advantageous to forgo the Site Development Protect or Restore Habitat credit. This allows the entire project site to be utilized and susceptible to disturbances.

Water Efficiency

Four out of the five points are being pursued in water efficiency by the use of efficient landscaping and water use reduction. The site will have 11 bio-retention planting areas which aid in acquiring the points for efficient landscaping. The restrooms in the school will also utilize low flush fixtures to reduce the water demand for the building. The implementation of these two things will significantly reduce the water demand the school would have otherwise required.

Innovative wastewater technologies were not pursued for this project because they would have considerably increased costs to the plumbing system. However, the owner's goal for this project was to create a "modern, state-of-the-art educational facility for high school students" particularly in the field of science and technology. With that in mind, if innovative wastewater technologies were incorporated into the building they could serve an educational function while still saving in efficiency.

Energy & Atmosphere

The Energy and Atmosphere category will earn 8 out of the possible 17 available points. The school has optimized its energy performance by 28% and incorporated enhanced commissioning. Additionally measurements of the buildings energy usage will be taken to verify that the systems are performing as intended. This is important because it will show whether or not the building is more efficient due to the systems incorporated.

The equipment chosen to be used in this building uses less energy to operate than their counterparts. For instance the building will use energy efficient lights, computers, air handling units, dishwashers, refrigerators, etc. These steps will help decrease the impact that the building will have on the environment.

Figure 2: Horizontal Runs for Geothermal Wells

Points that should have been pursued related to On-Site Renewable Energy because the mechanical system utilizes geothermal wells. Because this system is being used it does not make sense to not acquire LEED points for it.

Materials & Resources

Of the possible 13 points in this category 6 are being actively pursued and one is possible. No points are being gained from Building or Material Reuse. This is logical for several reasons. The first of which being that this is an entirely new school that is being built. It would not make sense to reuse materials from the existing building into the design of the new school because everything is so out dated. On top of that, the existing school will be occupied until the new school is turned over. Therefore, it would not be practical to take down materials in the existing school to be used in the new one.

The points that are being pursed come from Construction Waste Management, Recycled Content, and Regional Materials. Although it is more expensive to divert construction and demolition debris as well as recyclable materials from landfills it is an important goal for the owner. It does serve to make the building more efficient in that it is promoting less pollution by creating a job where materials are salvaged. One way this is being accomplished on site is by the use of different designated dumpsters. For instance the mason has his own dumpster that is used only for concrete block scraps. Instead of these scraps being taken to the dump they are instead taken to a plant and

recycled. Regional materials within a 500 mile radius are also heavily used on this job to reduce the negative environmental impact associated with shipping materials from all over the world.

The points that the project is pursing in this category are logical. They could have possibly gained another point by introducing Rapidly Renewable Materials into the design, but the incentive to do so is not that great.

Indoor Environmental Quality

All points in this section are being pursued with the exception of Increased Ventilation, Indoor Chemical & Pollutant Source Control, and Daylight & Views. All mechanical equipment and ductwork will be cleaned at the completion of the project and the mechanical contractor is to replace all filters prior to balancing. This will ensure the owner is receiving a building with a mechanical system that is free of contaminates. The building also offers great control over thermal and lighting systems. Nearly every room has its own thermostat and variable lighting controls. Although this is more expensive than heating different zones of the school to a specific set point, it does allow individual control which has been known to improve efficiency among users in a building.

The two credits that aren't pursued that should be involve day-lighting and views. There have been many studies performed that directly link day-lighting in spaces to better test scores. Because the main purpose of every school is to educate the youth, it would seem that this would be one of the most important criteria when designing a school. This should be especially important to the owner with this school because, last year they had over 500 kids attending summer classes, which relates to over a third of the school's students.

Innovation & Design Process

All points under Innovation and Design Process were pursued. This is logical because it directly correlates to the owner's goal of building a state-of-the-art school. By implementing innovation into the design the owner is guaranteed to achieve this goal.

Conclusion

In conclusion the project has set forth a comprehensive and appropriate LEED level of certification. The building will be both efficient and innovative without incurring exorbitant costs. There are only a few items that should have been given a little more attention that are outlined above, such as the day-lighting category, but in all the strategies set forth are appropriate and meet the owner's goals.

PROJECT ENGINEER INTERVIEW

The purpose of this section of the report was to interview the Project Manager on the job and discuss schedule acceleration scenarios as well as value engineering topics. Unfortunately the Project Manager was not interested in participating so I spoke with the project engineer instead.

SCHEDULE ACCERATION SCENARIOS

The critical path for this project is illustrated in Figure 3 below. It is important to note that at times the main categories listed below were often occurring simultaneously, but always subsequently in different sections of the building. Because items such as the athletic fields and the demolition of the existing building are not important to the completion of the high school they are not discussed in this section. HESS was given 18 months to complete the construction of a brand new replacement high school.

Following the notice-to-proceed the building pad preparations began. It is at this time that unsuitable soil was removed from the site and new soil was brought in and compacted. Afterwards foundations are started followed by underground utility rough-ins, and finally the substructure is considered complete once the SOG has been poured. After a section of the buildings substructure is complete the superstructure starts in that area followed by the enclosure/MEP rough-ins and finally the finishes.

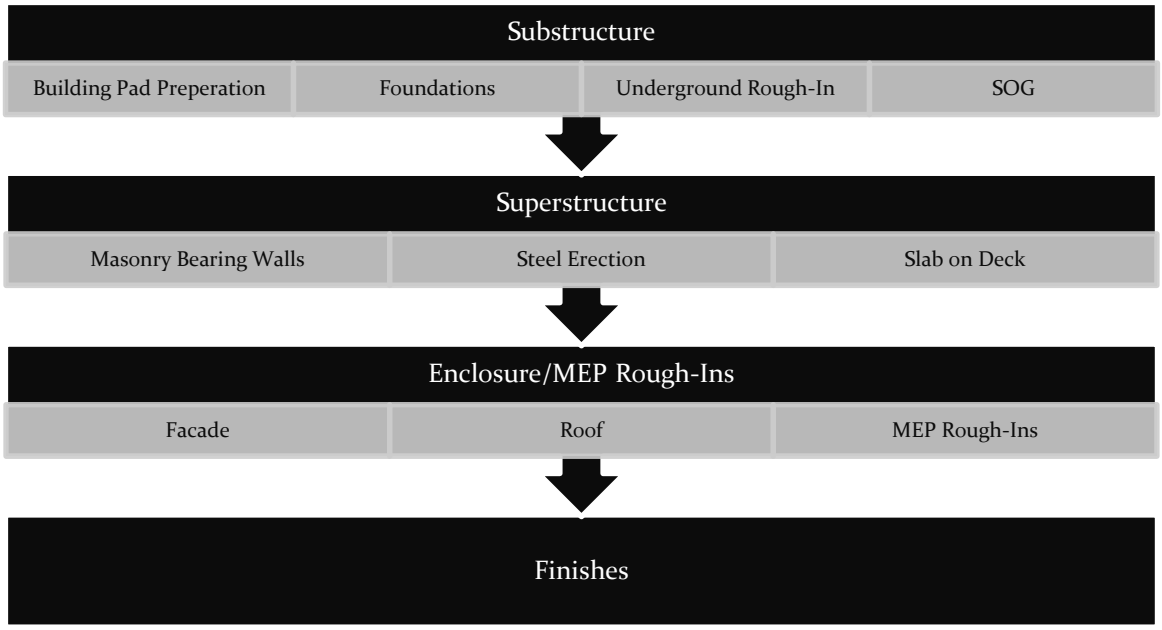

Figure 3: Critical Path of Schedule

The two biggest risks that the project team faced that could delay the completion of the school were delays caused by the owner and bad weather. Because the owner of this building is a school district, and the funding is provided by the state, there are a lot of behind the scenes decision making discussions that often take longer to approve than if you were working for a typical owner. In the case of this project the notice to proceed was given two months late, but the completion date could not change because students had to be able to occupy school for the start of the 2013 school year. This problem is amplified because the subcontractors are only held liable to complete their work in the time frames set forth in the bid documents schedule. This means that there is a loss of time of two months, giving the CM Agency 16 months to build a school, and you have to find ways to accelerate the work on an already aggressive schedule.

Bad weather was also a concern for HESS Construction. During construction Hurricane Sandy hit the east coast and caused the job to shut down for a day. Although this did not hinder the project to much there were concerns that the project team had prior to the storm making landfall. The team was concerned that the high winds could possibly blow over large unfinished masonry bearing walls. Had this happened weeks of work could have been lost and there would be a substantial amount of cleaning and repairs that would have had to be done. Aside from that a cold winter with heavy snows are also a risk to the completion date being met.

In order to speed up the schedule HESS had to find a subcontractor on the critical path that they could accelerate. Because they had a two month delay they had the opportunity to try and accelerate the mason or steel subcontractor. Because the structure of the building has more steel in it they chose to speed up the steel sub. They did this by having conversations with the steel sub and bringing on a second crane to work in two different areas of the building. This allowed the structure to be erected faster which led to the other subcontractors being able to start their work sooner.

Even though this method proved successful, it did have some negative aspects associated with it. Due to the fact that HESS was accelerating the schedule that the steel sub was contractually obligated to, HESS had to cover the cost of bringing on the additional crane. This cost therefore came out HESS's profit.

Other methods that were discussed for accelerating the schedule involved working overtime. That could mean switching to 10 hour days or working a sixth day. HESS would be liable for any costs associated with doing this.

VALUE ENGINEERING TOPICS

There were three notable instances of value engineering that were implemented on this job. They were a reduction in school size, a change in finishes, and a change to the telecom package.

The biggest and most significant VE change was the reduction in the size of the school. The school was initially designed to have three educational wings as can be seen in Figure 4, but one of the wings was omitted (reference Figure 5) so that the project could stay on budget. This seriously detracted from the goals of the owner. The building was initially designed with population growth in mind. As the building stands right now, it will not be large enough to accommodate all of the students enrolled there. This means that the school will have to set up trailers to house the surplus of students. This was a large sacrifice that the owner had to make that they didn't have control over.

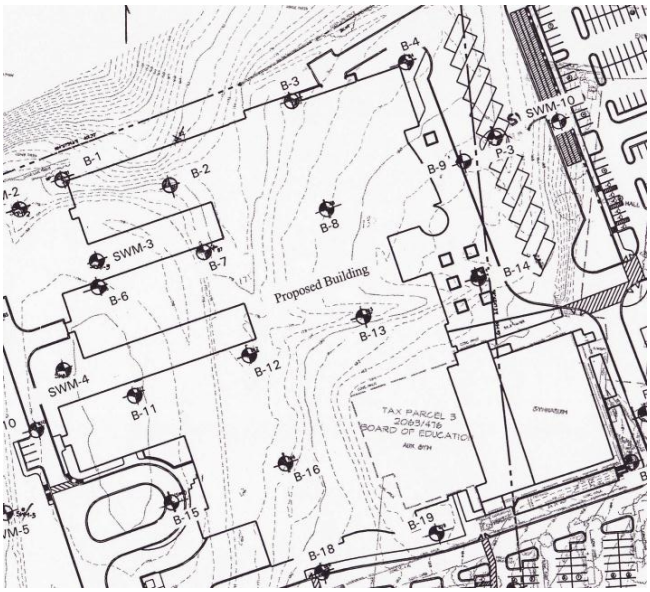

Figure 4: Original Building Footprint

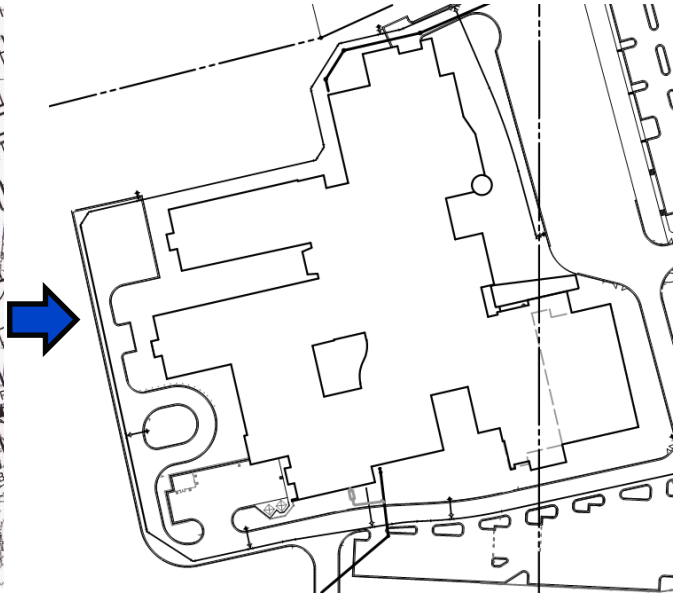

Figure 5: Revised Building Footprint

In another attempt to save money, some of the finishes were changed as well. For instance, instead of using custom casework throughout the school, the owner was forced to select casework with a more standard finish to stay on budget. This was also the case when selecting floor finishes. The owner was not very satisfied with having to make these decisions because they wanted the biggest, best, and nicest things for their school, but instead had to select a lesser product that achieved the same result.

One more way the owner tried to reduce costs was by changing the scope of the telecom package for the building. Instead of having the contractor purchase and install all of the equipment, the school decided that they would buy their own equipment. The contractor is still responsible for roughing in all of the data wire, but not for supply the equipment.

It can be seen that adhering to the budget provided by the state caused a lot of VE implementation, all of which the owner was not very happy to have to do. The only VE change that was not accepted was the use of PVC sewer above grade in the building. The reason this was declined was because it was not code compliant because the building has plenum ceiling spaces.

CRITICAL INDUSTRY ISSUES

Several Industry issues were discussed during the 21st Annual PACE Roundtable meeting on November 6th 2012 at the Penn Stater Conference Center. The PACE Roundtable meeting was an open forum, in which students and members of the construction industry discussed key topics. The day consisted of a student panel discussion, two breakout sessions, and a small focus group with several students and an industry member. Reference Appendix B for notes taken during the meeting.

Student Panel Discussion

The student panel discussion was designed to give the industry members an understanding of what AE students are working on at Penn State. It focused on the AEI BIM thesis competition and BIM studio. Students who either participated or were currently participating in these activities shared their experience with the audience.

The students talked about the difficulty of working in groups and how the project format mirrors that of actual industry practices. They discussed how they felt it was a more conducive environment to learning, and taught them a lot about the importance of presentation skills. They clearly laid out the advantages and disadvantages of taking part in these courses.

Breakout Session #1 – Delivery of Services: Efficient use of Integrated Design

The first breakout session I attended discussed topics related to integrated project delivery (IPD). IPD can be defined in many different ways because it can carry several different functions. For the purpose of our discussion we defined it as an integrated project team with a core set of goals that focus on delivering a better more efficient product. The discussion during this session focused on why it is advantageous to use this delivery method, the barriers to using IPD, and what is required to make it successful.

We started the discussion off by talking about why the industry is seeing a switch to IPD. One reason we came up with was that it has been heavily influenced by advanced technologies. The nature of building is becoming more complex and the use of new technologies, such as BIM, provide opportunities for improvement. An integrated project team can also lead to a project that produces less waste, saves money, is more environmentally friendly, and decrease the overall project schedule. By getting individuals from all phases of construction involved early, many issues can be circumvented before they arise. By utilizing the expertise of the team members earlier on in the project more efficient plans can be created.

What I found must interesting about this discussion were the barriers that prevent IPD from being feasible or successful in some instances. As it stands right now the way contracts are written is not conducive to the IPD style. There is some resistance to IPD because it requires all members of the team to take on more risk and trust one another. The roles and responsibilities of the team members change and become more blurred. It is more difficult to assign blame when a problem arises and any costs associated with mistakes are shared amongst the team.

However, if a team sets up the goals that they have at the very beginning of the process, IPD is much more likely to be successful. It is very important to do this on a project by project basis because each project is specific to itself in terms of roles and processes. If a team is successful at doing this they will likely see a drop in design issues, learn from the expertise of other members, and develop clear interdependencies/links between works.

The reason that I attended this breakout meeting was because there was a lot of issues that arouse on my project that I believe could have been avoided had an IPD system been implemented. For instance, there were many issues that arouse from the design documents. Six months into the project there were already over 300 RFI's associated with the drawings. There was also a lot of miscommunication between HESS, the construction manager, and the subcontractors about delivery dates and when things had to be onsite and complete. Had IPD been implemented successfully there would have been a better understanding between all parties about what needed to be done and when. Additionally the schedule would have been more accurate for the completion of some work activities. The other reason I think it would have been beneficial is because of the issues associated with the BIM models the project team ran into. This project is using BIM for clash detection and fabrication models. However, because of the lack of integration, the BIM modeling fell far behind and was less able to benefit the project as was initially intended.

Breakout Session #2 – Supply Chain: Modularization

The second breakout session I attended discussed modularization. We discussed the industry trends, examples of modularization, and challenges.

The industry professionals discussed how they were seeing more multi-trade modularization with every passing year. They touched on how it helps increase quality, speed, and safety. Because the modules are constructed in a controlled environment i.e. a warehouse, it is easier to construct than if it were put together out in the field. When

working in a warehouse there are no concerns about weather because all the work is taking place inside. This also makes the process much safer because laborers aren't working in inclement weather. To add to that they are also able to work from ground level as opposed to being on ladders in the field for some operations. Because modules are often very similar and repeated units they can be produced very fast. All of these factors make it advantageous to incorporate modules in a construction process. Even when there is a break even in the cost's associated with modularization it still reduces your risks.

Similar to the first breakout session, I found the challenges associated with modularization to be the most interesting aspect of the conversation. I was not aware of the amount of preconstruction planning that was involved in modularization. I did not know the importance of getting the trades involved early so that they could plan the construction process for modules. It also did not occur to me that prefab coordination would have to be written into the scopes of work for it to work well. Although I found it intuitive that the size of the modules would be limited, it did not occur to me that it is necessary to have a sufficient lay down area on the site, or that transportation was such a huge concern.

The reason I attended this session was to get ideas about possible aspects of my building that could be prefabricated to accelerate the critical path, make the job safer, and potentially save money. I was looking less at modularization of parts of the building and more into prefabrication possibilities. It would be very difficult to efficiently make modules for my building because the spaces are not repeated. In all I think I took away some important concepts.

Industry Member Discussion

During the industry member discussion section of the day the students split off into groups of three and talked to an industry professional about their respective thesis and ideas. I spoke with Christi Saunders and Steve Ayer and found the discussion to be relatively helpful. Steve and Christi suggested that I look into doing an architectural breadth to address the possibility of increasing day-lighting within the school. They informed me that there have been many studies performed that directly links day-lighting with increased test scores in schools. They also suggested looking into increasing the efficiency of the BIM applications on my project by looking into different contract wording and scheduling. Both Christi and Steve are viable industry contacts that I gained that I could bounce ideas and questions off of, but unfortunately are not experts in the aforementioned areas.

For this assignment I am also interested in looking into changing the geothermal system into a hybrid system. This would greatly decrease the upfront cost of the system, allow for the football field and track that the field sits over to be completed sooner and lead into a structural breadth as well. If the geothermal field was decreased in size than the AHU's would have to be larger, which would increase loads on the structure. I brought this idea up during our meeting, but it was not Christi or Steve's area of expertise so they could not provide much insight.

I found the meeting to be very helpful and it gave me some different research ideas for my building that I would not have considered otherwise. It is always helpful when you can get insight from experienced individuals who have worked in the industry.

PROBLEM IDENTIFICATION AND TENCHICAL ANALYSIS OPTIONS

Analysis 1: Mechanical System

Through my discussions with the project engineer it became apparent that the owner had to VE a lot of items in order to meet the provided budget. In order to address the high costs of the building I would suggest changing the mechanical system so that the owner doesn't have to compromise on so many aspects of the building. If I am able to lower the cost by a sufficient amount it would mean that the owner would have sufficient funds to purchase the high end equipment and finishes they desire.

The current mechanical system is a geothermal system with 437 wells at a depth of 400 feet. Although the life cycle costs of a geothermal system are beneficial, the upfront costs of installing one are exorbitant. I would propose implementing a hybrid geothermal system so that the owner still gets the benefits associated with using a geothermal system, but the installation costs would be diminished. By changing the mechanical system to a hybrid one the size of the air handling units would increase. This would lead to a structural analysis to determine whether or not the building could handle the extra loads.

In order to complete this analysis I would need to gather research on geothermal systems and hybrid geothermal systems. I would need to determine the cost benefits of sizing down the geothermal fields and the implications this would have on the size of the AHU's. I will need to talk with the project team to find out how much the current geothermal system costs and the price associated with drilling wells. Once I can determine the size of my revised AHU's I would then perform load calculations in the areas where these units exist on my building. I could then analyze the cost benefits and perform a life cycle analysis to determine whether or not this would be a viable option for the owner to pursue.

Analysis 2: Building Envelope

During my discussion with the industry members the topic of an architectural breadth came up. The envelope of my building does not currently allow for credits to be achieved in daylighting. It was discussed that there have been studies done that directly relate natural daylighting in schools to higher performing students. I think this would be a great topic to research more because the school does not have a high academic standing. Last summer they had over a third of their school enrolled in summer courses.

For this analysis I would research the benefits of daylighting in schools. I would look into how much better schools with natural daylighting perform compared to their

counterparts. I would then look into ways of altering the envelope of the building so that these credits could be achieved. I would analyze the costs associated with changing the façade system vs. the expected improvement of the students.

In order to perform this analysis I would have to get a better understanding of how funds are distributed to public schools. I would also have to create several models to ensure that my design would allow adequate lighting to the rooms within the building. I would also have to look into good lighting design practices so that the design is practical and doesn't create problems for the students.

Analysis 3: Integrated Project Delivery

As discussed earlier in this report this replacement high school project incurred a lot of problems that I believe could have been avoided had and IPD system been the delivery method. I believe there would have been many benefits had this been the delivery method chosen, not only for the owner but the project team as well.

For this analysis I would research the steps that need to be taken to implement an effective IPD approach. I would compare process maps of the current CM Agency at Risk delivery method vs. an integrated project design approach. In my comparison I would show the differences between coordination and communication through the different phases of the project.

Analysis 4: Façade Prefabrication

The fourth analysis I want to perform is to investigate prefabricated panels for the exterior of the building. The reason I want to look into this is because I believe it could save time on the schedule.

The exterior of the building is comprised of ground face CMU, metal panels, and glazing. I will be investigating a precast system for the CMU only. I will have to look into two separate ways of connecting these panels to the structure because there are areas where the exterior wall is bearing CMU and structural steel. A problem associated with exterior panels is the architectural finish, more specifically the joints, so I will investigate ways to diminish this unwanted appearance.

I will have to look into construction methods on how to build and transport the panels as well as determine a good size. I will need to perform case studios on buildings that have used this technique before and talk with industry professionals about the best ways to implement this idea.

APPENDIX A: LEED SCORECARD

LEED for New Construction v2.2
Registered Project Checklist

Yes	?	No				
11		3	**Sustainable Sites**		14 Points	
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required	Required
1			Credit 1	**Site Selection**	1	1
1			Credit 2	**Development Density & Community Connectivity**	1	5
1			Credit 3	**Brownfield Redevelopment**	1	1
1			Credit 4.1	**Alternative Transportation**, Public Transportation Access	1	6
1			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1	1
1			Credit 4.3	**Alternative Transportation**, Low-Emitting & Fuel-Efficient Vehicles	1	3
1			Credit 4.4	**Alternative Transportation**, Parking Capacity	1	2
		1	Credit 5.1	**Site Development,** Protect or Restore Habitat	1	1
1			Credit 5.2	**Site Development,** Maximize Open Space	1	1
1			Credit 6.1	**Stormwater Design,** Quantity Control	1	1
1			Credit 6.2	**Stormwater Design,** Quality Control	1	1
		1	Credit 7.1	**Heat Island Effect,** Non-Roof	1	1
1			Credit 7.2	**Heat Island Effect,** Roof	1	1
		1	Credit 8	**Light Pollution Reduction**	1	1

Yes	?	No				
4		1	**Water Efficiency**		5 Points	
						Required
1			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1	2
1			Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1	2
		1	Credit 2	**Innovative Wastewater Technologies**	1	2
1			Credit 3.1	**Water Use Reduction**, 20% Reduction	1	2
1			Credit 3.2	**Water Use Reduction**, 30% Reduction	1	2

8	1	8	**Energy & Atmosphere**		17 Points	
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required	
Y			Prereq 2	**Minimum Energy Performance**	Required	
Y			Prereq 3	**Fundamental Refrigerant Management**	Required	
			***Note for EAc1**: All LEED for New Construction projects registered after June 26th, 2007 are required to achieve at least two (2) points under EAc1			
6		4	Credit 1	**Optimize Energy Performance**	1 to 10	
				10.5% New Buildings or 3.5% Existing Building Renovations	1	
				14% New Buildings or 7% Existing Building Renovations	2	
				17.5% New Buildings or 10.5% Existing Building Renovations	3	
				21% New Buildings or 14% Existing Building Renovations	4	
				24.5% New Buildings or 17.5% Existing Building Renovations	5	
				6 28% New Buildings or 21% Existing Building Renovations	6	
				31.5% New Buildings or 24.5% Existing Building Renovations	7	
				35% New Buildings or 28% Existing Building Renovations	8	
				38.5% New Buildings or 31.5% Existing Building Renovations	9	
				42% New Buildings or 35% Existing Building Renovations	10	
		3	Credit 2	**On-Site Renewable Energy**	1 to 3	
				2.5% Renewable Energy	1	
				7.5% Renewable Energy	2	
				12.5% Renewable Energy	3	
1			Credit 3	**Enhanced Commissioning**	1	
	1		Credit 4	**Enhanced Refrigerant Management**	1	
1			Credit 5	**Measurement & Verification**	1	
		1	Credit 6	**Green Power**	1	

continued…

Yes	?	No			
6	1	6	**Materials & Resources**		13 Points
Y			Prereq 1	**Storage & Collection of Recyclables**	Required
		1	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1
		1	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Walls, Floors & Roof	1
		1	Credit 1.3	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
1			Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
1			Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
		1	Credit 3.1	**Materials Reuse**, 5%	1
		1	Credit 3.2	**Materials Reuse**,10%	1
1			Credit 4.1	**Recycled Content**, 10% (post-consumer + ½ pre-consumer)	1
1			Credit 4.2	**Recycled Content**, 20% (post-consumer + ½ pre-consumer)	1
1			Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured Regi	1
1			Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured Regi	1
		1	Credit 6	**Rapidly Renewable Materials**	1
	1		Credit 7	**Certified Wood**	1

Yes	?	No			
11		4	**Indoor Environmental Quality**		15 Points
Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
1			Credit 1	**Outdoor Air Delivery Monitoring**	1
		1	Credit 2	**Increased Ventilation**	1
1			Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
1			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1			Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1			Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
1			Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
1			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
		1	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1			Credit 6.1	**Controllability of Systems**, Lighting	1
1			Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
1			Credit 7.1	**Thermal Comfort**, Design	1
1			Credit 7.2	**Thermal Comfort**, Verification	1
		1	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
		1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Yes	?	No			
5			**Innovation & Design Process**		5 Points
1			Credit 1.1	**Innovation in Design**: Provide Specific Title	1
1			Credit 1.2	**Innovation in Design**: Provide Specific Title	1
1			Credit 1.3	**Innovation in Design**: Provide Specific Title	1
1			Credit 1.4	**Innovation in Design**: Provide Specific Title	1
1			Credit 2	**LEED® Accredited Professional**	1

Yes	?	No		
45	2	22	**Project Totals** (pre-certification estimates)	69 Points

Certified: 26-32 points, **Silver:** 33-38 points, **Gold:** 39-51 points, **Platinum:** 52-69 points

APPENDIX B: INDUSTRY DISCUSSION

Student Name BRADY SHEERIN

Session #1

Topic: DELIVERY OF SERVICES: EFFICIENT USE OF INTEGRATED DESIGN

Research Ideas:

(1) WHAT ARE THE KEY/CORE COMPETENCIES NEEDED IN INTEGRATIVE PROJECTS/PROCESSES?

(2) HOW DO YOU FOSTER TRUST BETWEEN PROJECT PARTICIPANTS TO ENSURE IPD WILL BE SUCCESSFUL? WHAT NEEDS TO BE IN PLACE SO THAT ITS SUCCESSFUL?

Session #2

Topic: SUPPLY CHAIN: MODULARIZATION

Research Ideas:

(1) LOOK INTO DEVELOPING A UNIQUE PRECAST EXTERIOR PANEL FOR SCHOOL FACADE TO DECREASE CRITICAL PATH

(2) LOOK INTO THE AREAS WHERE IT IS MOST ADVANTAGEOUS TO USE PREFAB/MODULARIZATION

Industry Panel: Differentiation in a Down Economy

Research Ideas:

(1) NOT APPLICABLE TO THIS PACE ROUNDTABLE MEETING

(2)

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O&M TURNOVER
ENERGY MODELS

CHRISTI SAUNDERS
STEVE

Industry Member Discussion

Key Feedback:

Which research topic is most relevant to industry? What is the scope of the topic?

- PERFORM AN ARCHITECTURAL BREADTH TO INCREASE DAYLIGHTING R/L OF THE RELATIONSHIP BETWEEN IMPROVED TEST SCORES & DAYLIGHTING
- BIM O&M TURNOVER, MAKING SURE THE OWNER IS RECEIVING THE INFORMATION THAT THEY WANT AND IS USEFUL.
  - ALSO MAKE SURE THEY CAN READ/USE
- R/L OF THE PROBLEMS W/ MY BUILDINGS BIM PROCESS LOOK INTO & SIPS SCHEDULE / CONTRACT WORDING TO INCREASE EFFICIENCIES.
- IN THE FIELD BIM, VISUALIZATION IS VERY HELPFUL
- SWITCH GEOTHERMAL SYSTEM TO A HYBRID & ANALYSE ASSOCIATED COSTS.

Suggested Resources:

What industry contacts are needed? Is the information available?

CHRISTI SAUNDERS - BIM ORM
- HER BOSS HAS DETAILED SIPS OUTLINES FOR MANAGEMENT

STEVE AYER - ARCH BREADTH

I WOULD NEED CONTACTS THAT CAN HELP ME W/ DAYLIGHTING IDEAS TECHNIQUES & SOMEONE WHO COULD ASSIST W/ BIM ?'S

PENN STATE PROFESSORS ARE AVAILABLE & DISCUSSION BOARDS

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