TECHNICAL ASSIGNMENT III

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Executive Summary

The Susquehanna Center Project consists of a renovation of 49,159 square foot and an addition of 58,640 square foot and costs $26.7M. Technical Assignments I & II gave an overview of the project from a construction management perspective and prepped for the alternative methods analysis that is done in this assignment.

Technical Assignment III is a smooth transition between the project key features analysis and the core thesis investigation. It forms a basis for the final thesis proposal by relating it to sustainability and investigating savings in the project's cost and schedule. It also addresses the critical industry issues mentioned in the PACE roundtable, followed by potential areas of research on the project.

First, it begins with an evaluation for LEED and where the project stands in sustainability. It walks through all the seven sections of LEED checklist version 3, which is the last update of the LEED rating system. This identifies all the sustainable features of the project which can be related to some of the thesis proposals. Second, it analyzes the project's schedule acceleration scenarios and the biggest risks on schedule. That analyses the need for schedule accelerations and what are the costs and techniques.

After it views a schedule study, it describes the key areas of value engineering that implemented on the project, and how savings were made in each respective area. The value engineering team proposed $2.21M worth of value engineering savings to the owner, about $1.65M out of which was accepted. The major value engineering areas include and not limited to: excess soil transportation, alternative materials, electrical and lighting systems, temporary utilities.

Next, it summarizes the key takeaways from the 21st annual PACE roundtable event that was held on November 5-6th at the Penn Stater Conference Center, The Pennsylvania State University. All this helps identifying all the information needed to produce a great technical analysis and thesis investigation for the project. Many of the takeaways have a good relationship with the Susquehanna Center project and that is further explained in the next section, which is the Problem Identification and Technical Analysis option section.

The Problem Identification and Technical Analysis option section helps sorting out the best potential areas of research for this project relating to the previous sections. It is the end of the smooth transition to the core thesis investigation which what the rest of the AE thesis capstone project is all about.

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LEED Evaluation*

LEED, Leadership in Energy and Environmental Design, is a program that promotes sustainable and green building through a verification point system run by U. S. Green Building Council (USGBC). The most up to date LEED point system is LEED version 3 which has total points of 110 points distributed between its different topics. Its topics are Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation in Design, and Regional Priority.

The Susquehanna Center initial design was targeting a LEED Silver Certification. The owner, Harford Community College, decided not to chase it in order to cut down short term costs. In this section, it is assumed that the project went according to the initial plans and it strived for LEED Silver Certification. Each one of the topics will be evaluated accordingly using LEED rating system version 3.

Sustainable Sites

In order to gain points in each of the 7 topics introduced by the LEED rating system, the building has to meet the prerequisites each one requires. For the Sustainable Sites topic, the building has to have a Construction Activity Pollution Prevention Plan. The Susquehanna Center does meet this prerequisite by creating and implementing an erosion and sedimentation control plan for all of the project's construction activities. That was done by stockpiling topsoil for reuse which also prevents its loss by rain or wind. In addition, sediment traps have been made to prevent sedimentation of storm sewers or receiving streams.

Points can be gained in the LEED system after the building meets the prerequisite for a particular topic, if there are any, and meets credits prescribed by the topic. The more credits it meets, the more points it gains. The Susquehanna Center is in an area that meets all the requirements to gain a point for the Site Selection credit, which is a not a farmland, previously undeveloped land, land within 100 feet of any wetlands…etc. It also has bicycle racks, changing rooms close to entrance, 5% parking for low-emitting and fuel efficient vehicles, and another 5% for vanpools and carpools.

Water Efficiency

Water Efficiency topic requires Water Use Reduction plan as a prerequisite before it can receive any points for the topic. It requires employing strategies that decrease the water use baseline calculated for the building by 20%.

Please refer to **Appendix A for the LEED Checklist*

LEED Evaluation: cont'd

The building is actually designed for 30% water use reduction by providing more efficient toilets, urinals, faucets and showerheads. That qualifies it for 2 points in addition to meeting the prerequisite. This percentage may increase to 40% which could add 2 more points.

The landscape irrigation in the project uses 100% treated water rather than potable water which qualifies it for full 4 points for the Water Efficient Landscaping section. Moreover, the project introduces an innovative wastewater technology that captures rainwater and uses it in the building as seen in **Figure 1**. This has been actually implemented in the project at the south side of the Arena Addition right below the roof cantilever despite the fact the project is not chasing LEED.

Figure 1: Drainage pipes along the south side of the basketball arena. The pipes create an architectural feature and functions as a roof rainwater collector.

LEED Evaluation: cont'd

Energy and Atmosphere

Energy and Atmosphere requires 3 prerequisites which are: Fundamental Commissioning of Building Energy Systems, Minimum Energy Performance, and Fundamental Refrigerant Management. Fundamental Commissioning of Building Energy Systems is to make sure certain building energy systems are going to be commissioned. Minimum Energy Performance is to establish a minimum level of energy efficiency for the building. Fundamental Refrigerant Management is to reduce stratospheric ozone depletion by not using CFC based refrigerants in HVAC systems. All the prerequisites are met in this project.

The first points that could be gained in this topic are from optimizing energy performance. The design team has to demonstrate a percentage improvement in the proposed building performance rating compared with the baseline building performance rating. The new addition showed 14% and the existing showed 10% at least. That qualifies the building for 2 LEED points. That percentage could increase to 18%/14% after the building is constructed and the actual testing is done, which could add 2 more points.

Materials and Resources

The prerequisite for Materials and Resources topic is to provide an easily-accessible dedicated area for the collection of recycling materials for the entire building. Despite the fact that the project is not going for LEED anymore, the construction team still recycles materials as per the owner recycling requirements. Since this project is a renovation and an addition project, more than 55% of the projects structure was reused. This qualifies the project for one LEED point in this topic. Also, more than 75% of the waste is recycled or salvaged, more than 20% of project contents are recycled, and more than 20% of the materials are extracted or manufactured within the region. All that adds to 8 points in this topic.

Indoor Environmental Quality

LEED also promotes increasing indoor environmental quality and that has two prerequisites: Minimum Indoor Quality Performance and Environmental Tobacco Smoke (ETS) Control. The first prerequisite is to establish a minimum IAQ performance to contribute in the comfort and well-being of occupants. That is done by meeting the minimum requirements of ASHRAE Standard 62.1-2007. The second prerequisite is to prevent or minimize exposure of building occupants, indoor surfaces and ventilation air distribution systems to tobacco smoke.

LEED Evaluation: cont'd

That is done in this project by prohibiting smoking in the building. The first point that the project was trying to earn is from providing natural ventilated space. That is done by providing a really nice patio space in the arena addition which has a view over the tennis courts and the beautiful landscape around the building. There was a construction indoor air quality management plan during construction and before occupancy that enhanced the overall IAQ. In addition, it was planned to use low-emitting materials, and use adhesives, sealants, and paints, flooring systems that comply with the volatile organic compound (VOC) limits. For instance, the use of terrazzo that has low VOC number. Moreover, Controllability of systems in lighting and thermal comfort weighs more LEED points. For example, the project was designed to have light sensors, LEDs.

Innovation in Design

The Innovation in Design topic give the opportunity to achieve exceptional performance above the requirements set by the LEED rating system. The project team is targeting 45% water use reduction, 95% in building material re-use, and 95% recycled or salvaged waste during construction. At the time of design, the team was still not sure whether they would be able to get points out of this or not. It all depends on what will turn out after the building is actually constructed. Also, one point could be gained because one of participant in the architect team is a LEED accredited professional. This helps support and encourage the design integration required by LEED.

Regional Priority

The Regional Priority topic is to provide an incentive for the achievement of credits that address geographically specific environmental priorities. For the projects specific zip code, three more points could be earned because of site selection, controllability of lighting systems, and thermal comfort design.

Schedule Acceleration

Critical path

In order to deliver a project successfully on time, one has to pay careful attention to critical path because they hold up the project. Critical path activities in this project exist mainly in the addition part of the project, since the renovation part was estimated to finish earlier and has more float time. **Figure 2** shows the sequence of the major critical path activities. It starts with mobilization in the site followed by excavation and then underpinning to support the existing structure. Foundations come after that which is very critical. This project is one of the best examples of how critical foundations are as it was held back because of the weather impact on foundations, pretty much stopped the whole project, and caused a delay. Roofing and slab on grade are next. MEP rough in, ductwork, and lighting come after that. The basketball arena has a wood floor which is also in the critical path. Finally, the project does not get completed until it is tested and commissioned.

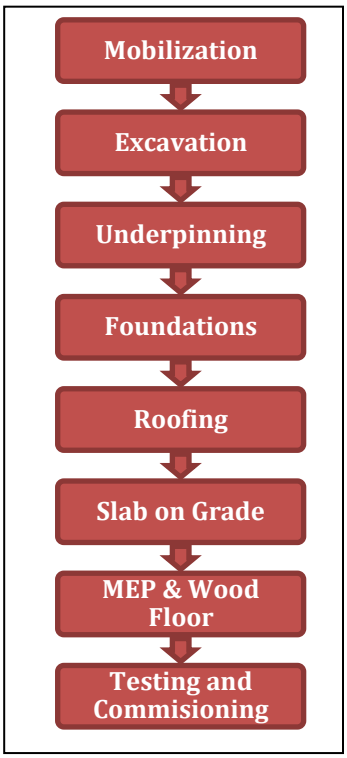

Figure 2:
Critical Path Sequence

Biggest risks to the project completion date

The project team has to deliver the Susquehanna Center project within the allocated time and budget, the schedule having more priority than the budget, as the owner is somehow strict to have the project delivered on the completion date. However, Turner had to request for a schedule extension as the weather impact on the foundations stage affected the project completion date. It was put till mid-November 2012, though it was originally scheduled to complete at September 17th, 2012. Once the campus re-feed of the domestic water was finished to remove the existing domestic line that ran along the south end of the building, there was an underpinning work scheduled to start at August 4th 2011. Footing excavation along the south face and extended up the west face of the arena addition was scheduled on August 16th. A 10" rainfall opposed to the anticipated 3" rain had fallen into site which caused a delay in placement of footings. Only the south spread footing had been placed by the end of August. Turner has submitted a change of order for an extension to the project schedule of 32 work days after they considered other critical path activities and usage of concrete accelerators to make up for the schedule delay. At the end, they have been granted a 38 working day extension after a series of discussions and meetings with the owner reps and different parties in the project.

Schedule Acceleration: cont'd

Schedule Acceleration costs and techniques

In this project, Turner picked trades that work long days and Saturdays just in case they fall behind on critical path activities. It is essential for them to finish their work early to open work for other trades. The concept is to get some preliminary work done that would allow Turner to increase manpower for regular hour trades by opening up additional areas of work. If multiple areas of work were available they would also push to get more manpower working in more locations at regular hours.

An example for a schedule acceleration scenario in this project was in the new concrete floor for the basketball arena. It was a critical path activity so it was really important to finish on time, but at the same time it has to be made sure that the slab is cured while keeping the moisture from getting to the underside of the wood floor. After all that is done, subcontractors will immediately start work on ductwork, lights, and theater equipment conduits. After that the seating assembly is installed.

Other specific schedule acceleration techniques utilized in this project are working overtime for critical path trades and activities and the usage of concrete accelerators. The cost for overtime is 1.5 of the labor rate. As for concrete accelerators, they cost an average of $1200/ ton. If all the concrete got accelerated on the slab on grade, it will cost around $39,000 for material, but they did not need to do it in this project, since they have been granted a schedule extension.

Value Engineering Topics

Value engineering has been a very important aspect in this project, as the owner wanted the best value possible. In order to do that, they stopped chasing LEED early in the project and asked Turner for a thorough value engineering report. Turner proposed $2.21M worth of value engineering savings to the owner, about $1.65M out of which was accepted. Some of them were minor changes, and other were major which decreased both schedule time and cost. In this value engineering summary, the major value engineering topics that were accepted by the owner are discussed. **Table 1** shows each one of the categories that the value engineering team looked at and the savings associated with it.

Category	VE Savings
Demolition	$6,500
Excavation	$730,781
Landscaping	$568
Concrete	$50,000
Masonry	$17,000
Miscellaneous Metals	$57,000
Roofing	$116,956
Drywall	$73,747
Ceramic Tile	$45,550
Terrazzo	$54,500
Wood Athletic Flooring	$91,158
Painting	$37,000
Signage	$49,000
Athletic Equipment	$12,200
Scoreboards	$6,900
Swimming Pool	$131,000
Plumbing and HVAC	$138,000
Electrical and Fire Alarm	$15,500
Underpinning	$27,888
Resilient Flooring and Carpet	$1,056
Athletic Equipment	$12,200
Telescoping Stands	$24,760
Furnish Lighting Fixtures	$190,000
Water Wells	$25,000
Final Cleaning	$45,000
General Requirements	$100,000
Audio-Visual Systems	$153,000
Total	**$2,212,264**

Table 1: Value Engineering Savings

Excess Soil

The original plan for the disposal of excess soils was to move it into another fairly far location. However, the value engineering team proposed to spread all the excess soils on site, specifically under the football fields nearby. This will eliminate the need of relocating the soil to another location, therefore savings on soil transportation. It was taken under account the layout, soil erosion control, strip and replacement of topsoil, placing, grading, compacting, and traffic control. All that resulted in $242,585 worth of savings in Excavation.

Alternative materials

One big aspect of value engineering is finding alternative materials with less value that would also work with the owner. For instance, the value engineering team suggested 80 mil TPO roofing instead of CSPE. 80 mil TPO roofing is cheaper and meets the owner requirements. This resulted in $116,956 in savings. In addition, it was also suggested to replace the terrazzo floor at the lobby and concourse. The alternative material would be stonehard 2 mil epoxy floor which was approved by the owner. This is the terrazzo at the new lobby in the addition.

Value Engineering Topics: cont'd

The terrazzo floor will remain as it is in the renovation since it was already installed. Terrazzo treads will also be replaced by painted concrete. All that resulted in savings of $54,500.

Electrical and lighting systems

The lighting system was redesigned and alternative lighting fixtures were suggested. For instance, T8 fixtures with prismatic lenses are suggested instead of LED's for signage lights. Total lighting savings were about $239,000. An alternative scoreboard (Daktronics) equal to the specified Nevco 2770 is suggested. Also, MC cable is suggested for branch circuits instead of conduits and tubing for everywhere where it is exposed except for branch circuits within the arena and multipurpose rooms.

Temporary Utilities

The scope initially included air conditioning of the renovated building to preserve the wood flooring. It turned out that it will not be needed as a new floor will be installed anyway. That means savings of about $100,000. That is included in the General Requirements category in **Table 1**.

Plumbing and HVAC

The mechanical design of the Susquehanna center indicates the usage of sensor lavatory faucets and flushometers. Instead, the value engineering team suggested standard low-flow fixtures in order to cut in some of the costs. They also recommended the use of grooved fittings instead of welded fittings for the hydronic systems greater than 2". Grooved fittings and couplings are allowed to be used in the project as it is indicated in the mechanical specifications.

Critical Industry Issues*

The 21st annual Partnership for Achieving Construction Excellence (PACE) Roundtable was held on November 5-6th at the Penn Stater Conference Center, The Pennsylvania State University. It was themed "Improving Efficiency through Innovation" with discussion topics about Supply Chain, Efficient Delivery of Services, and Operations and Management. The PACE Roundtable brings industry members, faculty, and students together to discuss the efficiency of all of the three mentioned main discussion topics and how it can be improved through innovation. **Appendix B** provides notes taken during the PACE roundtable. Each member can choose two topics, one in each session:

	Supply Chain	**Efficient Delivery of Services**	**Operations and Management**
Session 1	*Session 1A: Integrating strategies and* technologies	Session 1B: Measuring Effective Collaboration	Session 1C: Energy +BIM
Session 2	Session 2A: Modularization	Session 2B: Efficient use of Integrated Design	*Session 2C: Model Handover*

Table 2: PACE Roundtable discussion topics

Session 1A: Integrating strategies and technologies

The first session was about integrating strategies and technologies into the supply chain. First, challenges were discussed like quality of the supply, delivery delays, and international source communication. One of the students gave an example happening in his thesis project that they are bringing stone from India and took them forever to bring it from there. Communication was definitely a problem and apparently the project team did not plan properly for the lead time. It is much faster and easier to have a local supply, but if that was not possible, it is recommended to figure out the communication route and plan well beforehand. Also, communication has to be maintained throughout the project to keep all parties involved and updated. Storage is another challenge that could face the project team. It is almost always a good argument between having materials ordered early and storing them, and having materials ordered just in time for them to get installed. The risk here has to be managed very carefully. Finally, the level of design needed to procure is a supply chain challenge that many have a hard time going through.

Please refer to **Appendix B for the PACE Roundtable Student form*

Critical Industry Issues: cont'd

It is not recommended to procure using an incomplete design, and also the owner might not want to wait so long till the design finishes completely and procure late. Also, one thing that should also be kept in mind is the lead time required for materials in order to avoid any potential problems.

After some of the challenges were discussed, it was time to discuss the options of integrating strategies and technologies. Physical visits and mock ups are two obvious options. Another interesting option that was put in the table was supply barcodes. Tagging material makes it much easier for the quality control/quality assurance people to track all the material. It saves time in keeping the material logs and data. Commissioning, testing, and maintenance become more efficient when material barcodes are used. Another topic was raised here was vendor's involvement early in the game. The more the vendor is involved in the project, the easier it is to avoid any unforeseen challenges. Allocating resources and having an open access to information for all the parties involved eases the supply chain transactions.

Communication and networking is very critical in construction. Supply chain is no exception. Sometimes you have to dig in to get the information you need and not rely on the first thing you hear. For example, a project manager asked the subcontractor whether they have the supply ready for installation or not. The subcontractor the material has been ordered and everything will be ready by the time it is scheduled, which is three weeks. After a week, the project manager was in contact directly with the supplier and asked them if they have the order for the project or not. They did not. It turned out that the subcontractor missed some of the paperwork for the order. The breakout session concluded by discussing coordination and how important it is with vendors. Sequencing the tasks is critical in getting the most efficient product and the best performance.

Session 2C: Model Handover

The second session attended was titled Model Handover. It kicked off by three questions: why, how, and what. Why would an owner be interested in more advanced model handover strategies? Easier, More manageable data, potential energy savings, continual relationship, and easier information sharing. Having all the construction documents presented in one model makes it handy to pull any information needed right from the model. Andrew Rhodes from Southland Industries emphasized that every item in the model should have a unique ID and connects to documents for that item outside of the model. This helps tracking them very easily. For example, if we click the lighting fixtures in the model, it should take you to a spreadsheet of all the lighting fixtures. Any changes that need to be made can be done right from there.

Critical Industry Issues: cont'd

As for the "how" question, we first need to analyze the client. Does the owner really need this, or does he have the sufficient experience to deal with it? The model handover service makes more sense for experienced owners rather than inexperienced ones.

However, contractors can sell their products and try to convince the owner of its importance, added value, and tangible benefits. An industry member comments on that by saying we need to educate ourselves about the owner before we educate the owner. It might be a better idea though to understand what the client really needs and base the contractor's service off of that. One of the industry members comments that if you do not mention the words "BIM" or "Model" it will attract much more attention to you, because people sometimes get distracted with those words. Make it simple and straight to what the client really needs.

Now comes the last question which is "what". Different industry members in the room conceive it differently due to their different experiences and roles in each company. It could be an extra service added to the list of CM services. Its cost is relatively cheap compared to what you actually get in the long run. Many companies just do it all the time for certain clients and not for others. It depends on the client and whether it is private, public, repeated…etc.

There were many side topics that were discussed in the breakout session that could have some relation to the big topic. One of them is nature of each construction activity and how can some of them be compressed, therefore reduce the schedule time efficiently. For instance, It is sometimes perceived for the total time to install a mechanical filter is about 3 hours, when the actual task takes about an 30 minutes, but finding the right brand filter to put it in takes 2 hours and a half. This task could see some potential reduction if it is planned well. It also seems to be a potential depth topic in the Susquehanna Center project. The pool restoration in the project took longer than anticipated because testing it failed, so the project team had to drain the water off the pool, find the cracks, fix them, and do the test all over again. All that is a minimum of 2 weeks delay.

The session concluded by wrapping up the main topics discussed. The model handover could mean potential savings for the contractor and the owner. It really makes more sense if the lifecycle costs of the project are analyzed. One example of how it might help reduce the lifecycle costs is minimizing callbacks. If it is possible to cut the trips back to get something missing from three to two, the results would be significant. Projects have to be planned early and there should be staff on board from day one.

Critical Industry Issues: cont'd

Industry Member Discussion

Mr. John Bechtel from the Office of Physical Plant was the industry member in our discussion group. The discussion resulted in different ideas for the Susquehanna Center. Since it is a renovation and addition project, surveying study could be initiated about it, specifically laser scanning. Also this could be tied with the pool restoration testing problem that we talked about earlier. One potential solution that could have solved the problem is the usage of advanced laser scanning tools. Also tied to the schedule problems are the weather impacts the project had. It rained during the foundations stage, which caused a delay in the project.

Problem Identification and Technical Analysis Options

After interviewing the project manager and knowing better about schedule acceleration scenarios, value engineering topics, and critical industry issues related to the project, it helped identify any problems and technical analysis options. Those several problematic features of the project would open the door for potential areas of research in the project.

Façade renovation of the existing Susquehanna Center

The façade of the existing Susquehanna Center has been completely redesigned and renovated which greatly impacted the structural system. The façade was a regular concrete wall enclosing the fitness center. By renovating it, it made the fitness center bigger by replacing the concrete load bearing wall with a curtain wall of a curved shape. The façade also created a canopy right outside of the fitness center which makes it more aesthetically pleasing. In addition to the structural system, the mechanical and lighting systems are also affected

Alternate façade systems could be analyzed and compared to the previous system and to the new one. In each of the options the structural and mechanical systems would be different and all that has to be under budget and not over time. Also taking into account that the owner wanted to replace the old brick wall into a glass and steel façade, because they wanted more light into the building. . All this makes it a good area to do a construction management study on with architectural, structural, mechanical, and lighting breadths.

BIM and 3D Laser scanning for renovation projects

One of the most efficient ways to create a BIM model for the Susquehanna Center is to use 3D laser scanning tools. A BIM model does not only help with clash detection, but it also could be a center of all the construction documents needed from architectural drawings to change of orders, and from specifications to lighting fixtures spreadsheets. 3D laser scanning could also be used during construction. It can update the parties involved in construction by scanning the building periodically and sending the information to a database accessible by the respective parties. The Susquehanna Center makes it a perfect project to do this research on as it consists of a renovation and an addition.

BIM in helping schedule tasks compaction

Another area in this project that could be researched on is the use of BIM to compact some of the schedule tasks. This research will be conducted on construction schedule activities and study whether they could be reduced or overlapped with other activities. This requires knowledge of the quantity of crews, their availability, and types. Additionally, in order to conduct this research there should be knowledge of the building systems analyzed.

For instance, if the mechanical system can see potential reduction, the mechanical system design itself should be analyzed in order to avoid any defects that could happen because of this.

Weather impact on different building systems

Weather has a big impact on construction projects and it has the power to stop any project, therefore bad consequences on schedule and cost. Schedulers add a float to the most weather sensitive activities to be on the safe side when a weather impact happens. It also depends on the techniques and strategies that the construction team follows to prevent weather from affecting construction.

LEED effect on Lifecycle costs

An interesting thing to know about this project is whether the owner made the right decision really when they decided not to chase LEED. When is it going to pay back if they followed the LEED plan they had in mind when designing the building? Even if the owner did not afford it at the beginning, could they have brought a third party to invest on the building? Was the LEED plan they had earlier sufficient to do it or they needed to upgrade it? A thorough lifecycle investigation on current buildings systems with a sustainability study should help solve the above questions.

Quality checks prior to construction on renovation projects

The main reason why the pool restoration took longer than anticipated in the Susquehanna Center project is the failure of the first test they had on the pool. The test was done while the pool tiles were not installed yet, so they will not have to take off the tiles in case it fails after the tiles are installed. It turned out that the concrete and mortar on the pool had cracks and needs to be fixed before installing the tiles. This raises the question of the quality of the checks done prior to construction to help schedulers know the status of the pool. The better the quality of the pre-checks, the better the estimate of how long the construction team needs to finish the job.

Appendix A
LEED Checklist

Appendix A
LEED Checklist

LEED for New Construction and Major Renovations

v3 / 2009 **Registered Project Scorecard**

Susquehanna Center renovation + Expansion

401 Thomas Run Road, Bel Air, Maryland 21015

hord | coplan | macht

Harford Community College

Yes	No	?		
39	45	25	**PROJECT TOTALS (Pre-Certification Estimates)**	110
			Certified: 40-49 **Silver: 50-59** Gold 60-79 Platinum: 80+	**45**
				6

Yes	No	?			D/C	Design or Construction Submittal			Responsibility
8	14	**4**	**SS: SUSTAINABLE SITES**					**26**	
Y			Prereq 1		C	**Construction Activity Pollution Prevention**		**Req'd**	TC
1			Credit 1		D	**Site Selection**		**1**	HCM + SR
	5		Credit 2		D	**Development Density and Community Connectivity**		**5**	
	1		Credit 3		D	**Brownfield Redevelopment**		**1**	
	6		Credit 4.1		D	**Alternative Transportation -** Public Transportation Access		**6**	
1			Credit 4.2		D	**Alternative Transportation -** Bicycle Storage and Changing Rooms		**1**	HCM + SR
3			Credit 4.3		D	**Alternative Transportation -** Low-Emitting and Fuel-Efficient Vehicles		**3**	HCM + SR
2			Credit 4.4		D	**Alternative Transportation -** Parking Capacity		**2**	HCM + SR
		1	* RP Cr 5.1		C	**Site Development -** Protect or Restore Habitat		**1**	HCM + SR
		1	Credit 5.2		D	**Site Development -** Maximize Open Space		**1**	HCM + SR
	1		* RP Cr 6.1		D	**Stormwater Design -** Quantity Control		**1**	SR
	1		Credit 6.2		D	**Stormwater Design -** Quality Control		**1**	SR
		1	Credit 7.1		C	**Heat Island Effect -** Nonroof		**1**	HCM + SR
		1	Credit 7.2		D	**Heat Island Effect -** Roof		**1**	HCM
1			Credit 8		D	**Light Pollution Reduction**		**1**	BKM
6	0	**4**	**WE: WATER EFFICIENCY**					**10**	
Y			Prereq 1		D	**Water Use Reduction:** Reduce by 20%		**Req'd**	BKM
			Credit 1		D	**Water Efficient Landscaping**		**2 to 4**	SR
2							Reduce by 50%	2	SR
2							No Potable Water Use or Irrigation	4	SR
		2	* RP Cr 2		D	**Innovative Wastewater Technologies**		2	BKM
			Credit 3		D	**Water Use Reduction**		**2 to 4**	BKM
2							Reduce by 30%	2	
		1					Reduce by 35%	3	
		1					Reduce by 40%	4	

Appendix A
LEED Checklist

2	23	9	EA: ENERGY & ATMOSPHERE					35		
Y			Prereq 1		C	**Fundamental Commissioning of Building Energy Systems**		**Req'd**		HCC
Y			Prereq 2		D	**Minimum Energy Performance**		**Req'd**		BKM
Y			Prereq 3		D	**Fundamental Refrigerant Management**		**Req'd**		BKM
2	15	2	* RP Credit 1		D	**Optimize Energy Performance**		**1 to 19**		BKM
1							12% for New or 8% for Existing Building Renovations	1		
1							14% for New or 10% for Existing Building Renovations	2		
		1					16% for New or 12% for Existing Building Renovations	3		
		1					18% for New or 14% for Existing Building Renovations	4		
	1						20% for New or 16% for Existing Building Renovations	5		
	1						22% for New or 18% for Existing Building Renovations	6		
	1						24% for New or 20% for Existing Building Renovations	7		
	1						26% for New or 22% for Existing Building Renovations	8		
	1						28% for New or 24% for Existing Building Renovations	9		
	1						30% for New or 26% for Existing Building Renovations	10		
	1						32% for New or 28% for Existing Building Renovations	11		
	1						34% for New or 30% for Existing Building Renovations	12		
	1						36% for New or 32% for Existing Building Renovations	13		
	1						38% for New or 34% for Existing Building Renovations	14		
	1						40% for New or 36% for Existing Building Renovations	15		
	1						42% for New or 38% for Existing Building Renovations	16		
	1						44% for New or 40% for Existing Building Renovations	17		
	1						46% for New or 42% for Existing Building Renovations	18		
	1						48%+ for New or 44%+ for Existing Building Renovations	19		
0	6	0	* RP Credit 2		D	**On-Site Renewable Energy**		**1 to 7**		
	1						1% Renewable Energy	1		
	1						3% Renewable Energy	2		
	1						5% Renewable Energy	3		
	1						7% Renewable Energy	4		
	1						9% Renewable Energy	5		
	1						11% Renewable Energy	6		
	1						13% Renewable Energy	7		
	2		Credit 3		C	**Enhanced Commissioning**		**2**		
		2	Credit 4		D	**Enhanced Refrigerant Management**		**2**		BKM
		3	Credit 5		C	**Measurement and Verification**		**3**		BKM + HCC
		2	Credit 6		C	**Green Power**		**2**		HCC + BKM

Appendix A
LEED Checklist

8	4	**2**	**MR: MATERIALS & RESOURCES**					**14**	
Y			Prereq 1		D	**Storage and Collection of Recyclables**		**Req'd**	HCM + HCC
			*[RP] Cr1.1		C	**Building Reuse** - Maintain Existing Walls, Floors and Roof		**1 to 3**	HCM
1							Reuse 55%	1	
		1					Reuse 75%	2	
		1					Reuse 95%	3	
	1		Credit 1.2		C	**Building Reuse -** Maintain Interior Nonstructural Elements		**1**	
			Credit 2		C	**Construction Waste Management**		**1 to 2**	TC
1							50% Recycled or Salvaged	1	
1							75% Recycled or Salvaged	2	
			Credit 3		C	**Materials Reuse**		**1 to 2**	
	1						Reuse 5%	1	
	1						Reuse 10%	2	
			Credit 4		C	**Recycled Content**		**1 to 2**	HCM + TC
1							10% of Content	1	
1							20% of Content	2	
			Credit 5		C	**Regional Materials**		**1 to 2**	HCM + TC
1							10% of Materials	1	
1							20% of Materials	2	
	1		Credit 6		C	**Rapidly Renewable Materials**		**1**	
1			Credit 7		C	**Certified Wood**		**1**	HCM+TC
11	2	**2**	**EQ: INDOOR ENVIRONMENTAL QUALITY**					**15**	
Y			Prereq 1		D	**Minimum Indoor Air Quality Performance**		**Req'd**	BKM
Y			Prereq 2		D	**Environmental Tobacco Smoke (ETS) Control**		**Req'd**	HCC
1			Credit 1		D	**Outdoor Air Delivery Monitoring**		**1**	BKM
	1		Credit 2		D	**Increased Ventilation**		**1**	
1			Credit 3.1		C	**Construction Indoor Air Quality Management Plan -** During Construction		**1**	TC
1			Credit 3.2		C	**Construction Indoor Air Quality Management Plan -** Before Occupancy		**1**	TC
1			Credit 4.1		C	**Low-Emitting Materials -** Adhesives and Sealants		**1**	HCM + TC
1			Credit 4.2		C	**Low-Emitting Materials -** Paints and Coatings		**1**	HCM + TC
1			Credit 4.3		C	**Low-Emitting Materials -** Flooring Systems		**1**	HCM + TC
1			Credit 4.4		C	**Low-Emitting Materials -** Composite Wood and Agrifiber Products		**1**	HCM + TC
1			Credit 5		D	**Indoor Chemical and Pollutant Source Control**		**1**	HCM + BKM
1			Credit 6.1		D	**Controllability of Systems -** Lighting		**1**	BKM
1			Credit 6.2		D	**Controllability of Systems -** Thermal Comfort		**1**	BKM
1			Credit 7.1		D	**Thermal Comfort -** Design		**1**	BKM
		1	Credit 7.2		D	**Thermal Comfort -** Verification		**1**	BKM+HCC
		1	Credit 8.1		D	**Daylight and Views -** Daylight 75% of Regularly Occupied Spaces		**1**	HCM
	1		Credit 8.2		D	**Daylight and Views -** Views for 90% of all Regularly Occupied Areas		**1**	
1	2	**3**	**ID: INNOVATION IN DESIGN**					**6**	
					C/D	**Innovation in Design**		**1 to 5**	
		1	Credit 1.1			Innovation or Exemplary Performance		1	BKM
		1	Credit 1.2			Innovation or Exemplary Performance		1	HCM
		1	Credit 1.3			Innovation or Exemplary Performance		1	TC
	1		Credit 1.4			Innovation or Exemplary Performance		1	All
	1		Credit 1.5			Innovation or Exemplary Performance		1	All
1			Credit 2		D	**LEED® Accredited Professional**		**1**	HCM
3	0	**1**	**RP: REGIONAL PRIORITY**					**4**	
					C/D	**Regional Priority** *www.usgbc.org/DisplayPage.aspx?CMSPageID=1984*		**1 to 4**	
1			Credit 1.1			Regional Priority		1	HCM + SR
1			Credit 1.2			Regional Priority		1	BKM
1			Credit 1.3			Regional Priority		1	BKM
		1	Credit 1.4			Regional Priority		1	BKM

Appendix B

PACE Roundtable
Student form

Appendix B: PACE Roundtable Student form

Student Name Haitham Alrasbi

Session #1

Topic: Supply Chain: Integrating Strategies and technologies

Research Ideas:

(1) Barcodes and tagging materials, and how it helps reduce schedule time for activities.

(2) Communication in Construction.
- Effective supply chain communication strategies

Session #2

Topic: Operations and Management: Model Handover

Research Ideas:

(1) - Put all documents and drawings in one model.
- Assign everything with a unique ID to help tracking materials and documents.

(2) Schedule tasks compaction.
- Use BIM
- filter change: 30 min to install / 3 hours to find brand.

Industry Panel: Differentiation in a Down Economy

Research Ideas:

(1) The process of BIM, not actual tasks.

(2) Time management and learning from BIM studio and BIM thesis.

Appendix B: PACE Roundtable Student form

Industry Member Discussion

Key Feedback:

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

* 3D Laser Scanning and BIM
  - Existing Building vs New Construction
* Facade renovation
  - Architectural, structural, mech, ltg. - etc
* LEED and lifecycle costs
  - how would BIM help?

Suggested Resources:

What industry contacts are needed? Is the information available?

- Mr. John Bechtel (OPP)
- Mr. Andrew Rhodes (Southland Industries)