Science and Technology Center

Coppin State University
Baltimore, MD

Technical Report III

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EXECUTIVE SUMMARY

This report provides a thorough analysis of a LEED strategy as well as project management topics for the Science and Technology Center at Coppin State University. The $76.2M GMP contract for Barton Malow includes two bid packages and is projected to be delivered over a two year period, with a substantial completion date in November 2014.

The LEED strategy involves an evaluation of the project scored against the most current point system, the LEED 2009 Scorecard. In making this a truly green building on campus, Coppin State University plans to use the Science and Technology Center as an interactive educational tool for sustainability. The project is currently tracking for LEED Gold certification with 68 points out of the possible 110 on the most updated point system. Some sustainable features of the new building include low-E glass within the curtain wall, a rainwater collection system and recycling 75% of waste during construction.

The following sections then touch on project management issues including schedule acceleration scenarios, cost reduction topics, and critical industry issues. The project has recently started construction after a delay from property acquisition issues so schedule acceleration is crucial to deliver the project by its original finish date. Some methods include adding double crews to the scopes of work and modularizing the curtain wall system to allow for faster installation. This report then goes into cost reduction items on the project and how the original design could be altered to find savings in the strict budget. This includes unitizing the curtain wall system into panels, using pro-press copper fittings for plumbing work, and combining hydronic piping for the heating and re-heating loops of the mechanical system. The last of this section includes critical industry issues that are referenced to Penn State University's PACE Roundtable event. This includes the discussion and summary of two breakout sessions about (1) Building Information Modeling (BIM) and Energy and (2) Modularization within the current industry. These topics were analyzed for research areas feasible to the Science and Technology Center, as well as this technical report.

Lastly, Technical Report III focuses on problem identification and technical analysis options required for depth and breadth areas of Senior Thesis. This touches on topics including details of the curtain wall system, combining of the hydronic piping of the mechanical system, structural concrete options, shallow foundation alternatives, and exterior façade changes. These areas will be the basis of research for the proposal of Senior Thesis.

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LEED EVALUATION

| INTRODUCTION |

Coppin State University Science and Technology Center (STC) is looking for a minimum LEED Silver certification and is tracking currently at a LEED Gold certification, according to their capital planning. [1] Preliminary expectation for the green building principles includes making the city greener with a new quad on campus, lowering the carbon footprint and the building operating cost. Additionally, the STC will serve as a showcase of sustainability and place an emphasis on energy efficiency. Some project team goals include incorporating daylighting to reduce electricity usage and high recycled content in all materials with an emphasis on local materials. Moreover, this building will serve as an interactive sustainable education tool for the campus and community. It is also noted that measurement and verification is critical to the facility maintenance team so future upkeep is manageable.

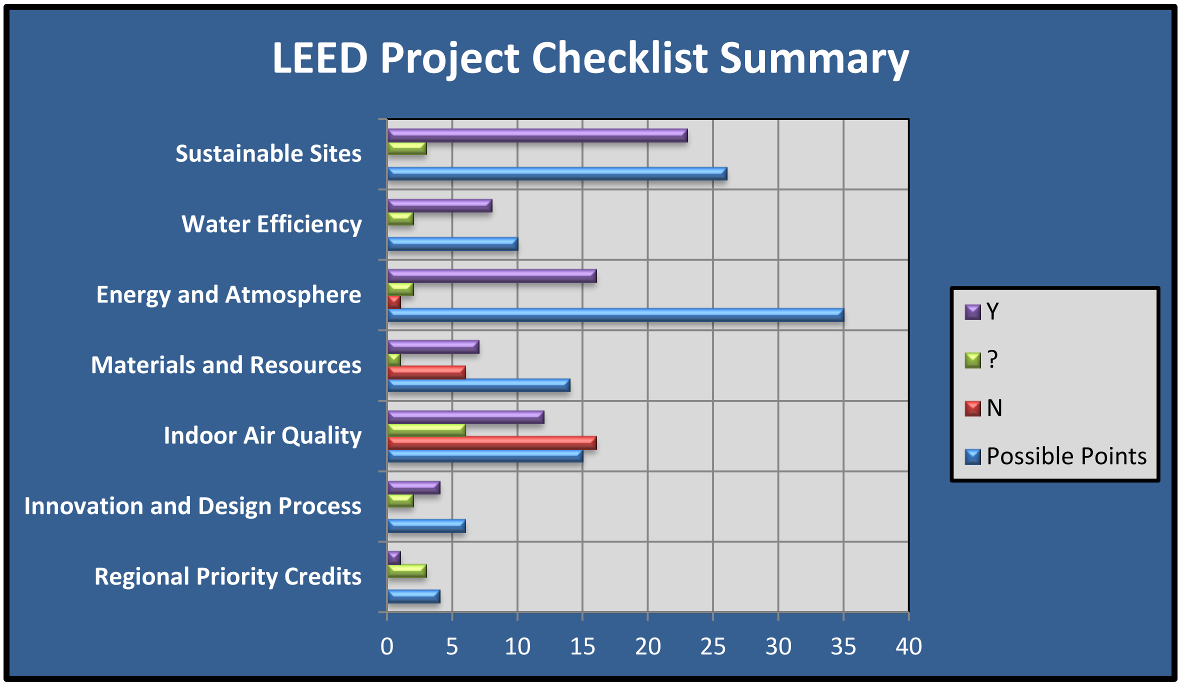
As shown in Table 1 below, the project team collaborated to achieve a project summary LEED scorecard total of 68 points with an additional 19 potential points. These 68 points track into the LEED Gold certification and include many of the goals discussed above. The potential points are represented in the second column (labeled "?") and defines additional points that could be achieved throughout the duration of the project with further evaluation. Figure 1, on the following page, is a visual representation of the points sought out versus the possible points.

***See Appendix A for LEED Project Scorecard**

Table 1 – LEED 2009 Project Checklist

LEED 2009 for New Construction and Major Renovations - Checklist				
Y	**?**	**N**	**Category**	**Possible Points**
23	3	0	Sustainable Sites	26
8	2	0	Water Efficiency	10
16	6	16	Energy and Atmosphere	35
7	1	6	Materials and Resources	14
12	2	1	Indoor Air Quality	15
4	2	0	Innovation and Design Process	6
1	3	0	Regional Priority Credits	4
68	**19**	**23**	**TOTAL CREDITS**	**110**
Project Summary – LEED Gold: 60 to 79 pts. - LEED Platinum: 80-100 pts.				

LEED Credit Category Totals taken from LEED 2009 Checklist, See Appendix A.



LEED Credit Category Totals taken from LEED 2009 Checklist, See Appendix A

Figure 1 – LEED Project Checklist Summary

| SUSTAINABLE SITES |

In looking into each of the categories on the LEED 2009 scorecard, a further analysis of the credits can be shown. The current site for the STC was previously developed as a row home community. This correlates to the soil erosion and sedimentation control plan (SESC) as precautions are taken to control storm water runoff and dust generation. Other credits including alternate transportation are achieved through 2 public bus stations near the site location. Coppin State has also made strong efforts to purchase low-emitting and fuel efficient vehicles, as 5% is reserved for hybrids/low-emitting vehicles. The parking capacity will add minimal spaces and have vanpool requirements. In terms of site development, it is a project goal to add green roofs and restore/protect 50% of the site with native or adapted species. The quad green space achieves the maximizing spaces credit and contributes green space equal to that taken by the building area. Lastly, the heat island effect will be addressed with the color of the hardscape and tree coverage.

The sustainable site category is projected to complete almost 80% of the possible credits, with the remaining three credits classified as potential.

|WATER EFFICIENCY|

Water efficiency is another major category for the Science and Technology Center. The three credits under this category include water efficient landscaping, innovative wastewater technologies, and water use reduction. With water efficient landscaping, the irrigation of the site will utilize storm water and the landscape will incorporate drought resistant plant species. Wastewater technologies include waterless urinals and dual flush toilets (50% reduction in wastewater conveyance) and a greywater system through rainwater collection. The final credit includes reduction of water use by 40% and is planned to be achieved by the building through point-of-use water purification in the labs. [1] Overall, this category earns 8 of 10 possible points.

|ENERGY AND ATMOSPHERE|

This category includes a possible 35 points and the STC will aim to gain 13 of those points. A large part of the reason for the deficit here is the discussion to not incorporate solar photovoltaic (PV) panels. The payback period for the PV panels was estimated to be 10-12 years and was not included in the original budget from the owner. With the addition of PV panels, the building could inch closer to the LEED Platinum certification as 7 points would provide a substantial boost. Also, a 22% improvement is estimated for the energy performance within the new building. Much like the renewable energy credit, this could be upgraded to achieve a higher LEED certification. However, these two items result in a major addition to the budget and funding alternatives would be necessary.

On the contrary, the building envelope is designed to reduce energy with low-E glass, and a complex insulation backing system that prevents thermal bridging and wasted energy. The lighting system is designed to incorporate daylighting features, occupancy sensors, and utilizes less than 0.8 watts per square foot of the building.[1] A green roof and sun shades are also part of the design to further save energy and have a smaller carbon footprint.

|MATERIALS AND RESOURCES|

Due to a large part of the material involving asbestos from the existing demolished row homes, this material could not be reused and cannot be included in the calculation of the first two credits. The construction waste management includes a goal of 75% recycled or salvaged non-hazardous construction materials. Again, material reuse was not sought after due to the hazardous nature of many materials in the existing row homes. However, Coppin State plans to recycle 20% of materials based upon current best practices. Local materials, found within 500 miles of the job site, are strived to be utilized for up to 10% of materials on site.[2] The next credit includes renewable materials and CSU plans to use bamboo casework and rubber flooring to achieve this. Overall, 7 points of the 14 possible are projected to be gained though materials and resources.

| INDOOR ENVIRONMENTAL QUALITY |

This category includes 15 possible points ranging from minimum air quality and increased ventilation to low-emitting materials and thermal comfort. A large majority of these points will be gained through the design achieved. Due to the labs in this science building, increased ventilation rates will benefit the overall indoor air quality of the building. Also, low-voc materials will be used throughout the building to increase the low-emitting materials in all assemblies. The lighting control system touched on earlier will provide adequate daylighting and thermal comfort for inhabitants of the building, while still maintaining efficiency. In total, the building is projected to gain 12 of the points in this category.

| INNOVATION AND DESIGN PROCESS |

This category touches heavily on innovation in design and the benefits of the building. As for green education, the STC plans to utilize a web page, lobby kiosk, curriculum development, environmental signage and graphics to be proactive with sustainable education on campus. This building will largely serve as an educational tool for both the campus and surrounding community. Also, the building will be connected to the campus wide transportation and shuttle system thus promoting green methods of transportation. It will also be a part of the campus wide recycling program currently initiated. With these requirements completed, the STC hopes to achieve 4 of the 6 possible points here.

| REGIONAL PRIORITY CREDITS |

This category emphasizes geographically specific environmental priorities and incentivizes certain credits. These include credits that are specifically important to a certain area and enable bonus points to be earned on the LEED scorecard, with a maximum of 4 pts. This is an exclusive feature to the LEED 2009 checklist and is not pursuable under LEED v2.2, which is an earlier version than LEED 2009.[2] It was determined that the STC project will gain an additional bonus point for its site development of protecting/restoring the habitat with 50% native species. A potential second bonus point can be earned with the wastewater technologies of waterless urinals and dual flush toilets. These points are not necessarily new points added as a new section on the checklist, rather an expansion of current credits that give bonus points for credits that are important to that area. With that stated, the STC project hopes to gain 1 bonus point and a potential for 3 more depending on the outcome of the design.

| RECOMMENDATION |

In analyzing the LEED 2009 Scorecard from a category perspective, there are two categories that stand out with substantial credits not pursued. These include credits in energy and atmosphere and materials and resources. These points are the barriers that keep the project from a LEED Platinum certification. The largest majority of points not pursued on the checklist include energy performance and renewable energy under the third category. Credits like this include a study of how the building performs with the designed systems and additional strategies for renewable energy like solar PV panels. When looking at credits like these, it involves much coordination and consultation to decide if they are worth pursuing. In the case here, the STC design does not include solar PV panels due to budget constraints and owner design choices. Even more, the solar PVs have a payback period worth considering and weighing the benefits of installation or not. The actual energy performance of the building was determined to be around 22% improvement with the current systems. Due to the increased ventilation requirements and loads from the labs and computer spaces, this energy requirement is difficult to optimize.

With the above statements, the recommendation would be to continue with the points outlined to achieve a LEED Gold certification. In order to reach the next level, Platinum certification, the project would need to consider the options discussed above with renewable energy. This serves as the large deficit of points and could potentially push closer to the Platinum certification if utilized on the project. However, the cost of the adding these systems could push the project over budget and additional funding would be necessary. Moreover, the project is tracking at 68 points which corresponds to the middle of the range in LEED Gold certification. This gives the team a buffer for potential points that may not be able to be achieved further into the project. Overall, the University of Maryland, Baltimore is requiring at least a LEED Silver certification and the STC project is tracking to achieve even above that. This will truly be an educational learning tool for the Coppin State University campus and this LEED certification should provide great benefits to the community.

*Note: Reference 2, Appendix C was referred to for the category definitions of each section above.

SCHEDULE ACCELERATION SCENARIOS

| SUMMARY |

The project site is located in the southeast corner of the Coppin State campus where an existing neighborhood of 210 row homes stood. For construction to begin, these properties must be acquired by the university and demolished. The STC project was delayed at the initial phases for roughly 3 months due in part to the property acquisition issues. This unfavorable situation led to concerns of managing the schedule properly to deliver the final product within the original timeframe. By managing the critical path and keeping the project on track, this setback could be resolved as to not affect the final completion. Barton Malow is looking into methods of accelerating the schedule so further delays will not inhibit the final completion date.

| RISKS TO COMPLETION |

The major items of concern in terms of the critical path include property acquisition, site utilities, the curtain wall system, and, in general, the weather conditions during the project. These items can have the biggest impact on schedule durations and have the potential to set back the schedule with large delays. With being an academic university building, the final completion date is crucial to maintain as early occupancy will be most beneficial to the owner.

Property acquisition was one of the first issues come across by the STC project team. Initially, the project was to start in August 2012 with demolition of the existing row homes; however it was pushed back 2 months due to not having access to the properties. With this setback early on, the activities of the schedule afterwards were also pushed back. The difficult issue was that these items could not be started until the demolition and abatement was complete.

Site utilities were one of these items that could not initiate until the demolition phase was finished. An existing utility line ran directly through the new STC building footprint; the design called for new utilities to be redirected around this area so excavation could begin. This bottleneck was of great concern to Barton Malow because any time made up in the schedule during this phase could greatly affect the final completion date.

The curtain wall system design initially called for a stick built system that could take a greater amount of time to install on site. One option (discussed in next section) was to unitize the curtain wall into prefabricated modules that could be picked and set in place by a crane thus reducing installation time significantly. Due to the amount of curtain wall on the north face of the building, this design option has a major effect on the critical path and schedule.

Weather conditions are a risk assumed on every construction site, and it will be no different on the STC project. Due to the schedule delays, the excavation process is tracking to begin in November 2012 with foundations starting in January 2013. This is not the ideal situation as the winter conditions can have a major impact on the progress of work. Depending upon the severity of the winter this year in Maryland, the project could hit unforeseen weather delays. This will bring extra precautions for the concrete contractor as foundations will start in the middle of winter and maintaining the schedule it of utmost importance.

|AREAS OF SCHEDULE ACCELERATION|

Schedule items like those discussed above provide for major areas of schedule acceleration and have the potential to deliver the project by its original date. To save the lost time from the property acquisitions, the site utility contractor will double staff all crews and work weekends to accelerate the scope of work. In terms of schedule, this was the best method to choose as site utilities have to occur in a certain order. There are traffic lane closures that need to occur to work on the utility lines and the old lines cannot be disconnected until the new replacement pathways are in place. If this were to be accelerated, it could disrupt the workings of the city's utility system and cause more unnecessary issues.

Unitizing the curtain wall system is also a method of acceleration in regards to labor time on site. In lieu of a stick built curtain wall system with the mullions and glazing, a unitized system would include the entire panel prefabricated and delivered to site. In making the building water tight, this schedule item is crucial to interior work. With the mass amount of curtain wall on the northwest corner of the building, this could delay the interior finishes if it remains as a stick built system. In turn, the unitized option was suggested as a value engineering option and is currently in the process of approval.

|COST AND ACCELERATION TECHNIQUES|

As mentioned with site utilities, the main method of schedule acceleration will be to double crew the workforce. This will be carried on through the entire job in an effort to make up the lost time from property acquisition issues. This additional labor cost was included in all scopes for the base bids of each subcontractor, therefore each subcontractor will be held to the outlined schedule. The cost of the double crew does not add any additional costs to the project for the reason of being included in the base bids. If the project is completed by the original finish date, this could amount to 3 months of general conditions costs saved. Based on the General Conditions estimate of Technical Report II, there will be a savings of approximately $40,000/month (not including Project

Management Team costs).[4] This could amount to a total savings of $120,000 (approximately $405,000 including the Project Management costs) for the project. With the budget of such high concern, this savings could have a huge impact on the STC project.

The other area of schedule acceleration included the design change of the curtain wall. By making it a unitized system, this would save an immense amount of labor costs and schedule time. A preliminary estimate by the project team suggests that $750,000 to $1,000,000 could be saved in reduced labor costs and cut schedule time.

By planning with these methods and forecasting the schedule, this project has the possibility of making up the lost time in the initial phase and has the potential to deliver by the original finish date. There are no negative cost impacts from the double crew method and there is only cost savings with changing the curtain wall design. These scheduling techniques should make this project flow easier and align with the original goals of the owner.

COST REDUCTION TOPICS

|SUMMARY|

Due to the bidding of subcontractors during the time of this posting, this section has been omitted. This information is held confidential until all scopes of work are bid out.

CRITICAL INDUSTRY ISSUES

|SUMMARY|

The 21st Annual PACE Roundtable was held on November 6th at the Penn Stater Conference Center in State College, PA. The organization, PACE (Partnership for Achieving Construction Excellence), is "a collaborative organization of industry innovators, engineering students, and faculty who work together to achieve excellence in the construction industry."[5] It was created in 1992 by Penn State faculty member, Dr. Sanvido, for Penn State Architectural Engineering students to learn about industry challenges and to interact with industry professionals.[5] Each year the PACE Roundtable event focuses in on an industry trend and this year the title was "Improving Efficiency through Innovation." The Roundtable included two breakout sessions to discuss critical industry issues like process innovation, sustainability and green building, and technology applications. The breakout sessions this year relevant to these topics included information about supply chain, efficient delivery of services, and operations and maintenance.

|BREAKOUT SESSION 1C: ENERGY & BIM|

This breakout session titled, "Operations and Maintenance: Energy & BIM," focused on the idea of incorporating a building information model (BIM) with a building automation system (BAS) and how this could incorporate energy savings.

The initial issue brought up was that designs are getting more complex, but the facility managers are not keeping up with the technology. New buildings are constantly updated with state of the art technology that must be maintained by the facility managers who do not operate with that same state of the art technology. Moreover, it is difficult to give training for the facility managers due to the learning curve of the technology. Nowadays, a BIM is being pushed to include all of the features possible, yet this may not even be useful for the owner of the building. The solution here is to have the project team collaborate with the end users of the software to know what is useful. A contractor may not have facility manager experience and vice versa. This gap of communication must be closed in order to have a successful and integrated building model.

Another issue discussed included integrating a BIM with a BAS – the main focus of this session. Currently, the facility managers operate with in-house, offline software for their purpose of a BAS. This consists of all controls and information necessary to manage prevention and maintenance in the building. In addition, the operators of this BAS are familiar with their own technology and do not need additional training. However, there is a question posed here, "Why not incorporate a BIM and a BAS in the same software for optimized performance?" This would reduce the waste of the system in general; the controls of the BAS are in the BIM and information relative to physical location is at the hands of the facility manager. A user could navigate the model to any location in the building and bring up the controls on any one piece of equipment. It can be pitched as the next best technology, just as BIM was a few years ago. However, to enable this technology, a link must be found between the two different software (BIM and BAS). A user would have to restructure their offline BAS software to incorporate it into a live BIM. This stands yet another question, "Is it good enough to have a model and a building automation system side by side, as it is currently?" In the end, it is up to the owners if the technology is upgraded and integrated. The obstacle here is making this idea beneficial to retrofit current systems.

A last issue under discussion was energy and how we, as an industry, measure it. The main focus here was how an energy model is most valuable and under what circumstances does it work best. To begin, an energy model is most valuable in the design phase, more specifically during conceptual design in regards to the mechanical system. The purpose here is to accurately model the energy usage to predict retrofits and better energy use. This can be done by measuring the systems before and after; the main concern is that the end user utilizes the systems as they were designed. Without discipline the energy model and the design goes to waste because it is not reaching full optimal performance. This yields a whole other topic of how to manage the building and its occupants to use the building as it was designed. It is a fight of energy efficiency versus comfort. A middle ground must exist where the building systems can operate as designed with minimal impact from occupant changes. This could include leaving the lights on all night or bringing in additional space heaters that affect energy use, but may be more suitable to the occupant. A possible solution is to make an incentive type program where the energy use of the building is made public to occupant view. This way it is an active means of prevention and could positively impact the energy usage.

| BREAKOUT SESSION 2A: MODULARIZATION |

The second breakout session titled, "Supply Chain: Modularization," focused on the idea of prefabrication and modularization to improve production on site. It incorporated current trends, recommendations, challenges, and possible research topics for Senior Thesis.

Currently, in the industry, modularization can be seen in many facets of design. From the MEP system design perspective, rack piping working with multiple trades is trending. This could include the fire protection piping, the plumbing piping, and the coordination with the drywall contractor. The advantages of modules like this are that of quality control and labor costs. For one, the modules being fabricated in a shop environment (opposed to the job site) can be put together much safer, faster, and of higher quality due to the controlled environment. Also, less skilled labor is necessary in the field thus cutting down on field installation costs.

Some recommendations for success include early involvement from subcontractors, planning with modularization as a design idea, and correct delivery methods. Subcontractors must be involved early in the design phase for proper planning of the modular units. Modularization heavily circulates around correct planning and having the design in place. This way collaborative efforts can be made early in the process and can eliminate future problems. Also, the design must start with modularization in mind. It cannot be an afterthought that is incorporated to say that modular design was considered. A successful design is planned and designed around the modular features of the building – this could mean modular-friendly corridors or repetitious design. Lastly, correct delivery methods must be used in this process. The project delivery must enable early involvement and planning with the subcontractors, which may otherwise not be involved.

With this new trend come its many challenges of creating a successful design. Preplanning was discussed above and is a crucial factor with any modular design. Site logistics must also be planned for when considering modularization. A site must have enough space to incorporate these modular building sections in terms of a laydown area. Also, transportation to these laydown areas has to be considered. The size of the modules may be determined by local road restrictions or weight limits. Once on site and ready for installation, the tolerances of the connections are another area of concern. Each module must meet the tolerances for installation so other systems are not affected by the module. The site equipment used to actually install the units is also a limitation. Depending on the size and weight of the modules, special equipment may be necessary. Once installed, the aesthetic appeal of the module should look as if it was not built in a modular unit. With all of these challenges it can be seen that modularization takes an immense amount of planning in design.

The last part of the breakout session detailed issues pertaining to research topics within the Senior Thesis. One area of concern was discussed within the challenges section – equipment size. An analysis could be done to see the limitations of the modular units against the specifications of the lifting/placing equipment. This would inevitably be the sole factor that controls the final installation, even if all other obstacles are overcome. Another area of research entails the analysis of a typical preconstruction process of traditional design versus modular design. The major differences would show how to plan for a better outcome and what challenges could occur. Yet another topic could be actually tracking the savings of a modular design against a typical design. This could include any actual savings and what methods would be used to track the process through every step. All of these areas of research could lead to a better understanding of the modularization process and what improvements are necessary.

| ANALYSIS OF BREAKOUT SESSIONS |

These breakout sessions were very informative from a student's perspective and provided a great connection between the academic areas and the industry issues. What was unique about the first session was that the industry members were suggesting ideas that changing current technology may not be beneficial. An owners representative stated that a BIM and a BAS side by side works efficiently now and the benefits of the new integrated technology doesn't outweigh the new training and software necessary. Also, there were some unique ideas with regard to the second session and modularization. The challenges involved with preplanning and having the right delivery method is one major issue in making modularization successful.

With relating these topics to the Science and Technology Center, there are some links that specifically apply to the breakout sessions. First, BIM and energy can always be applied to a new building, especially one with complex features such as the STC. The benefits to incorporating BIM with the BAS include improved maintenance procedures and prevention of equipment repair. With this technology not available yet, the focus turns towards the energy model and how it can be utilized to improve building efficiency. By designing the systems per the energy model, a building can be turned over with the right tools to be maintained in the proper fashion. However, the building occupants and managers are the ones who have to abide by the energy model and the purpose of the spaces. In regards to the STC, the lab and computer spaces will make up a majority of the energy use and if these spaces are not maintained as specified by the energy model, then the building itself will not be as energy efficient. Therefore, the occupant behavior and maintenance is crucial to a potential LEED Gold building. The modularization topic in the second session also relates to the STC because there is a potential to unitize the curtain wall system to make installation fluid and to cut down on schedule time. More research can be performed to realize the specific benefits and savings of a modular curtain wall. This stands to be a great method of improving schedule duration on the STC project.

Industry contacts that would be able to advise on these areas of interest include Nick Umosella who was able to give great insight on the modularization methods and his experience with constructing modular designs. Also, many AE faculty members were able to give great insights on the possible direction of the industry and how these two areas covered in the breakout sessions could affect our future as upcoming professionals. Additionally, the entire Barton Malow team on the STC project lent some great advice on abilities of modularization and possible BIM usage.

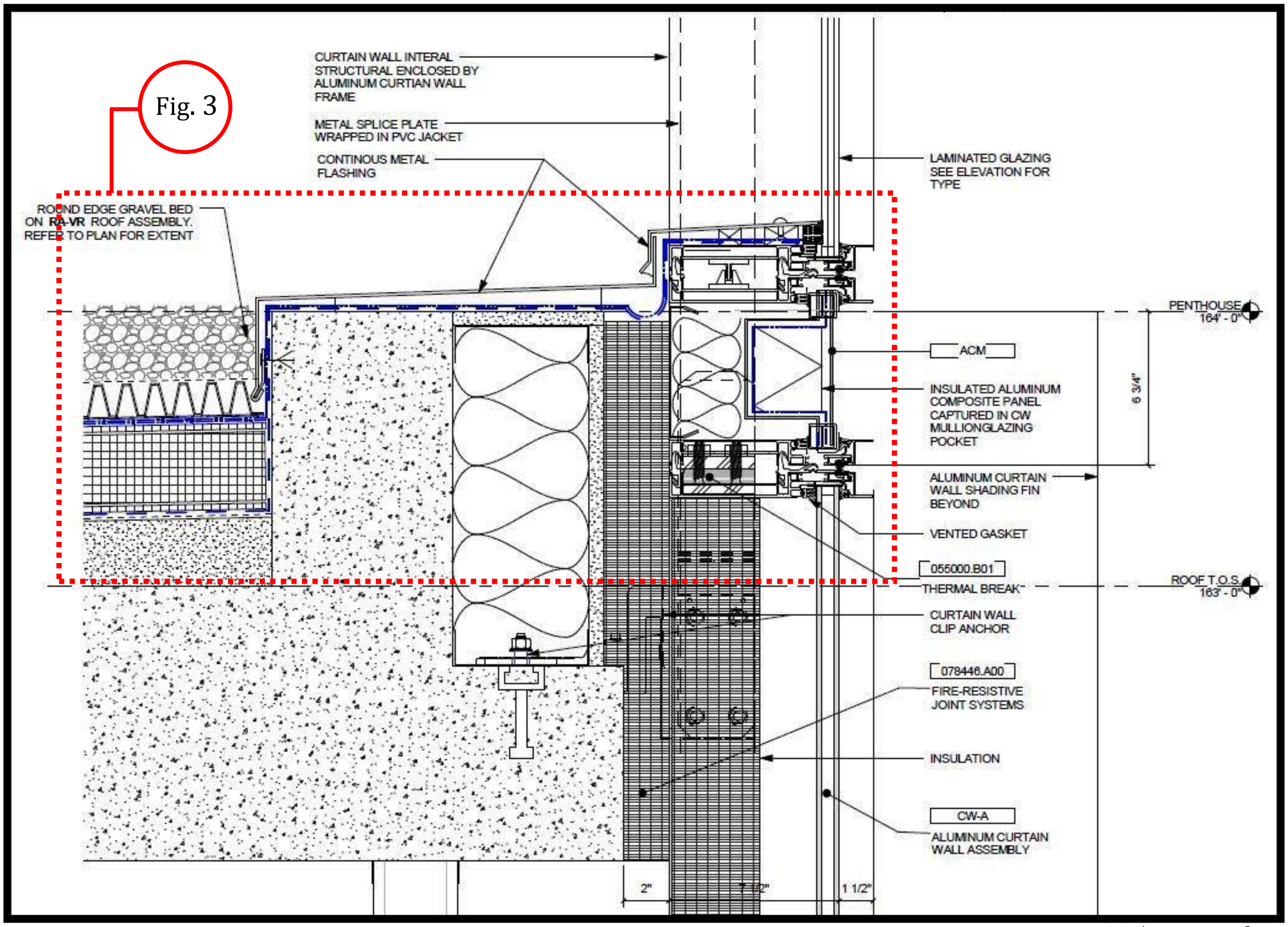
PROBLEM IDENTIFICATION AND TECHNICAL ANALYSIS OPTIONS

| UNITIZED CURTAIN WALL SYSTEM |

One of the major issues early on with this project is the schedule and the initial project delay. This 3 month delay initiated the project team to find methods of acceleration and areas of improvement in the schedule. One major idea was to reduce the duration of the curtain wall construction, especially with the large portion on the northwest corner of the building. Even with a double crew, this curtain wall was originally designed to be stick built with mullions, framing, and the glazing panels. This takes a great deal of time compared to the counterpart method of a unitized curtain wall system. Not only would this modular design decrease the installation time, but it would also cut down on the amount of field labor and costs. As touched upon in the cost reduction section, this method is being considered as a replacement option to the original design. If this were not instituted permanently, there are many areas of research that would achieve a thorough analysis of this building option.

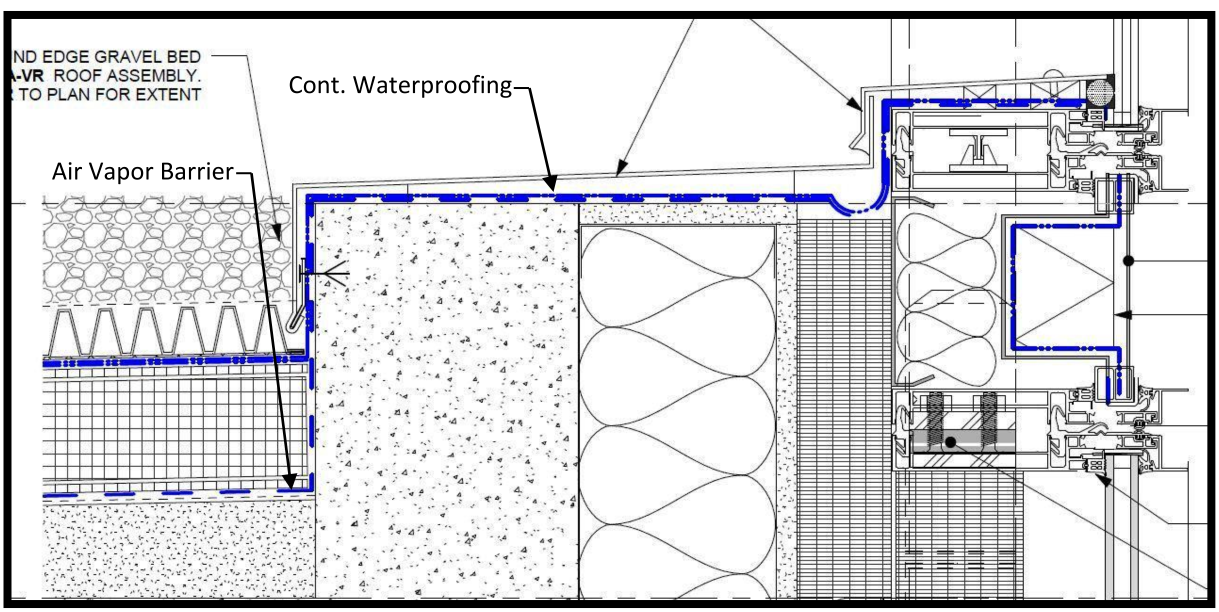
A cost analysis of the stick built system compared to the modularized system could be performed to realize any real cost savings and where they occur. This would include tracking the actual install of the stick built system with time and materials. This procedure would establish a benchmark for comparison to the alternative modular system. To find information on the modular system, cost for shop fabrication and labor would need to be acquired. A total estimate of fabricating the panels off site would then be calculated for comparison to the stick built costs. Moreover, the installation time of the modular panels would be tracked with the necessary equipment. This may include the use of different equipment, such as a crane for hoisting the panels into place. The field labor costs would be cut down due to the smaller amount of skilled labor on site. With this comparative analysis performed any real cost savings or losses are realized and could pose as a possible solution for this building design.

Another issue addressed with the curtain wall system includes the waterproofing detail on the north side near the roof line. The curtain wall itself proceeds past the top of the roofline, thus creating a very intense waterproofing detail. As seen in Figures 2 and 3 on the next page, the metal flashing, air barrier, and waterproofing are very detailed and complex. This connection could have quality control problems during the installation and could potentially lead to water issues at this connection. Possible solutions could involve additional research on a design change to incorporate a simplified connection in order to minimize error during installation. Water issues could be a major problem when turned over to the facility managers; making the corrective actions now could lead to a better design of the waterproofing. In addition, communication with the installer could result in a better method of waterproofing from the field experience.



Drawing A057 – Detail 3

Figure 2 – Waterproofing Detail at North Exterior Section



Call out of Figure 2

Figure 3 –Detailed Waterproofing Call Out

| HYDRONIC PIPING DESIGN |

Another problematic feature that can be looked at includes the combining of piping loops for the heating and reheating loops. This, as well, was looked at for a value engineering option, but is currently in the process for approval; the university would like to have both piping loops separated. If this system was changed from the original design, it could save an excess amount of pipe and 4 pumps (with additional electrical savings). The sets of lines service the AHU pre-heat coil loop and the VAV box re-heat coil loop. They each supply 150 degree water and could easily be combined with a small upgrade of pipe size, from 4" to 5".

A cost analysis could be performed to realize the exact savings of this system and if it's something worth installing. With the university wanting to keep the loops separate, a cost analysis could be used as a tool to persuade the university into changing the design. This would result in less field installation time and save on additional pumps necessary.

| STRUCTURAL CONCRETE |

The building footprint for the STC is skewed in relation to the north and south ends with it being narrower at the center. In terms of construction, this unique shape could result in material waste and additional time for field labor. The majority of the structure is made up of structural cast-in-place concrete that uses formwork to support it during the casting process. Due to the odd shape, this could result in more time spent on creating the formwork for each part of the building. This impacts productivity levels and could take additional time compared to a different design. An analysis could be performed to take into account this excess time and show the loss potential loss in productivity. The skewed shape could also contribute to wasted material, both formwork and concrete. Overall this could translate to both material and schedule savings.

| GEOPIER FOUNDATION SYSTEM |

The STC project site was determined to have unfavorable soils to the south end on the building footprint and needed additional support for the foundations. The building was designed to have rammed aggregate (Geopier) foundations put in place on the south end where the soil bearing pressure did not meet design loads. This system consists of drilling holes that will be filled with aggregate compacted in lifts. Each lift is typically 4 feet and compacts down to 3 feet causing a bulge in the layer of aggregate. When doing this in successive lifts it creates a ribbed aggregate pier structure that relies on friction and compression for bearing strength. An alternative for this could be achieved through a different shallow foundation support system. A combined footing or mat foundation could be analyzed for consideration. This would include cost efficiency, time, and labor concerns for the alternate systems.

| PUNCH WINDOWS ON EXTERIOR FAÇADE |

One of the major features on the exterior façade includes the large use of glazing. Between the curtain walls on the north end to the strip windows on the east and west facades, this amounts to a majority of the material as glazing. Although architecturally pleasing, this can be a very expensive method of construction. In this analysis, research can be done of how much savings would be realized by switching to punch windows instead of the large strips of glazing on the east and west exteriors. The aesthetic appearance would be considered on how it would change the overall design of the building and the vision of the architect. Cost would also be a main factor considered during this analysis. The owner and client have outlined a strict budget for this project and there have been many design changes to reduce the cost impacts on the budget. It was outlined as high importance to the owner to keep the interior finishes the same as the original design as much effort was put into the interior design. However, there were leniencies on the design of the exterior and changing to typical windows could be a valid option.

APPENDIX A – LEED EVALUATION – PROJECT CHECKLIST

LEED 2009 for New Construction and Major Renovations

Project Checklist

Project Name: Coppin State University - Science and Technology Center

Sustainable Sites — Possible Points: 26

Y	?	N			
23	3			**Sustainable Sites**	**26**
Y			Prereq 1	Construction Activity Pollution Prevention	
1			Credit 1	Site Selection	1
5			Credit 2	Development Density and Community Connectivity	5
	1		Credit 3	Brownfield Redevelopment	1
6			Credit 4.1	Alternative Transportation—Public Transportation Access	6
1			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
3			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3
2			Credit 4.4	Alternative Transportation—Parking Capacity	2
1			Credit 5.1	Site Development—Protect or Restore Habitat	1
1			Credit 5.2	Site Development—Maximize Open Space	1
	1		Credit 6.1	Stormwater Design—Quantity Control	1
1			Credit 6.2	Stormwater Design—Quality Control	1
1			Credit 7.1	Heat Island Effect—Non-roof	1
1			Credit 7.2	Heat Island Effect—Roof	1
	1		Credit 8	Light Pollution Reduction	1

Water Efficiency — Possible Points: 10

Y	?	N			
8	2			**Water Efficiency**	**10**
Y			Prereq 1	Water Use Reduction—20% Reduction	
4			Credit 1	Water Efficient Landscaping	2 to 4
	2		Credit 2	Innovative Wastewater Technologies	2
4			Credit 3	Water Use Reduction	2 to 4

Energy and Atmosphere — Possible Points: 35

Y	?	N			
13	6	16		**Energy and Atmosphere**	**35**
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
6	3	10	Credit 1	Optimize Energy Performance	1 to 19
	1	6	Credit 2	On-Site Renewable Energy	1 to 7
2			Credit 3	Enhanced Commissioning	2
2			Credit 4	Enhanced Refrigerant Management	2
3			Credit 5	Measurement and Verification	3
	2		Credit 6	Green Power	2

Materials and Resources — Possible Points: 14

Y	?	N			
7	1	6		**Materials and Resources**	**14**
Y			Prereq 1	Storage and Collection of Recyclables	
		3	Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
		1	Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
2			Credit 2	Construction Waste Management	1 to 2
		2	Credit 3	Materials Reuse	1 to 2

Materials and Resources, Continued

Y	?	N			
2			Credit 4	Recycled Content	1 to 2
2			Credit 5	Regional Materials	1 to 2
1			Credit 6	Rapidly Renewable Materials	1
	1		Credit 7	Certified Wood	1

Indoor Environmental Quality — Possible Points: 15

Y	?	N			
12	2	1		**Indoor Environmental Quality**	**15**
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
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 and Sealants	1
1			Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
1			Credit 4.3	Low-Emitting Materials—Flooring Systems	1
1			Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1
1			Credit 5	Indoor Chemical and 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 and Views—Daylight	1
		1	Credit 8.2	Daylight and Views—Views	1

Innovation and Design Process — Possible Points: 6

Y	?	N			
4	2			**Innovation and Design Process**	**6**
1			Credit 1.1	Innovation in Design: Specific Title	1
1			Credit 1.2	Innovation in Design: Specific Title	1
	1		Credit 1.3	Innovation in Design: Specific Title	1
1			Credit 1.4	Innovation in Design: Specific Title	1
	1		Credit 1.5	Innovation in Design: Specific Title	1
1			Credit 2	LEED Accredited Professional	1

Regional Priority Credits — Possible Points: 4

Y	?	N			
1	3			**Regional Priority Credits**	**4**
1			Credit 1.1	Regional Priority: Specific Credit	1
	1		Credit 1.2	Regional Priority: Specific Credit	1
	1		Credit 1.3	Regional Priority: Specific Credit	1
	1		Credit 1.4	Regional Priority: Specific Credit	1

Total — Possible Points: 110

Y	?	N		Possible Points
68	19	23	**Total**	**110**

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

APPENDIX B – CRITICAL INDUSTRY ISSUES

PACE Roundtable Information Sheet included in hard copy submission

APPENDIX C – REFERENCES

Rendering on Cover Page Courtesy of www.coppin.edu/CapitalPlanning/STC.aspx

1. "Science and Technology Center." *Coppin State University*. Web. 04 Nov. 2012. <http://www.coppin.edu/info/200871/science_and_technology_center>.

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3. "Questions about Windows and Condensation?" *National Fenestration Rating Council.* Web. 08 Nov. 2012. <http://www.nfrc.org/documents/condensation.pdf>.

4. "Technical Report II." *Nicholas* Zitterbart. Published 13 October 2012. http://www.engr.psu.edu/ae/thesis/portfolios/2013/naz5020

5. "PACE Home." *PACE Home*. Web. 10 Nov. 2012. <http://www.engr.psu.edu/pace/default.aspx>.