Tech. #3

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[FISK CORPORATE HEADQUARTERS]

Houston, Texas

Executive Summary

The purpose of this technical report is to isolate specific aspects of the Fisk Corporate Headquarters project that are key candidates for research and further evaluation. Once these aspects are realized, alternative methods to improve upon their efficiencies, costs, and quality will be studied and implemented. In order to isolate these project qualities, careful analysis of the project's LEED evaluation, potential schedule acceleration scenarios, value engineering, and applications of critical industry issues were completed.

The ownership team for the Fisk Corporate Headquarters project ultimately decided that the costs incurred by applying for LEED certification were not worth the benefits associated with gaining that certification. As such, this report focused on determining what kind of LEED rating the project could have achieved had the owner decided to accept these costs. After careful study, it was determined that the Fisk Corporate Headquarters project could have achieved 48 points and become LEED accredited. While the project did not score well in the sustainable sites or innovation categories, it was able to achieve over 60% of the available points in the materials and indoor environmental quality classifications.

Careful analysis indicated that the critical path activities on the Fisk project could be grouped into 5 main categories. Once these categories were isolated, they were further evaluated to determine if any schedule acceleration scenarios were possible. When a potential acceleration scenario was realized, that scenario was analyzed to define what new construction techniques and risks would have to be adopted by the project team for implementation. This report discerned that the cheapest, most effective way for the Fisk Corporate Headquarters project team to accelerate their schedule would have been through altering the sequencing of various critical path construction activities.

Some of the major value engineering items regarding the Fisk Corporate Headquarter include the removal of the second floor architectural canopy, changing the pre-fabrication shop façade, and switching to an asphalt parking lot. While Fisk Electric did use value engineering to lower their project costs in many areas, they also used value engineering to increase their perceived quality of the project's electrical system by upgrading some of their system components. Many of the value engineering items, like a reduction to the system's indoor air quality components, that were presented but not implemented are also discussed in this technical report.

Lastly, many of the critical industry issues discussed at the Penn State PACE Roundtable Discussion were studied. Some of the highlighted discussion topics, like the use of effective IPD and modularization, were researched in an effort to discern whether their implementation on the Fisk Corporate Headquarters project would have been beneficial to both the owner and the project team.

Technical Report 3 concludes with a look into potential opportunities for improvement regarding the Fisk Corporate Headquarters project. While the project was considered successful by both the project and ownership teams, some areas could still have benefited from either a change in construction practices or system design. Some aspects of the project that could be further analyzed, researched, and improved upon include the project's construction sequencing, LEED accreditation, electrical system, and the potential implementation of BIM to streamline specific construction activities.

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LEED Evaluation

As previously stated in Technical Reports 1 and 2, the Fisk Corporate Headquarters ownership team decided to place emphasis on lowering project costs. While many members of the team saw value in constructing a sustainable facility, the team ultimately decided that the added costs associated with applying for LEED certification were too substantial to undertake. This decision was realized during the early planning and design stages and eliminated the team's desire to try and acquire any specific LEED points over the project's duration.

Even though the project did not apply for official LEED certification, Fisk still made many sustainable design and construction decisions. They understood that a sustainable building was not only good for the environment, but also beneficial for the health and productivity of its inhabitants. As such, this report investigated what LEED rating the Fisk Corporate Headquarters project could have achieved using the new 2009 LEED version. While many of the points are already naturally attained by the facility, this report assumed that if an official LEED certification was desired by Fisk Electric, they would have agreed to incur some very minor costs in order to achieve a higher rating. The results of this analysis can be seen in Figure 1 below.

For the full potential LEED checklist, please reference Appendix A.

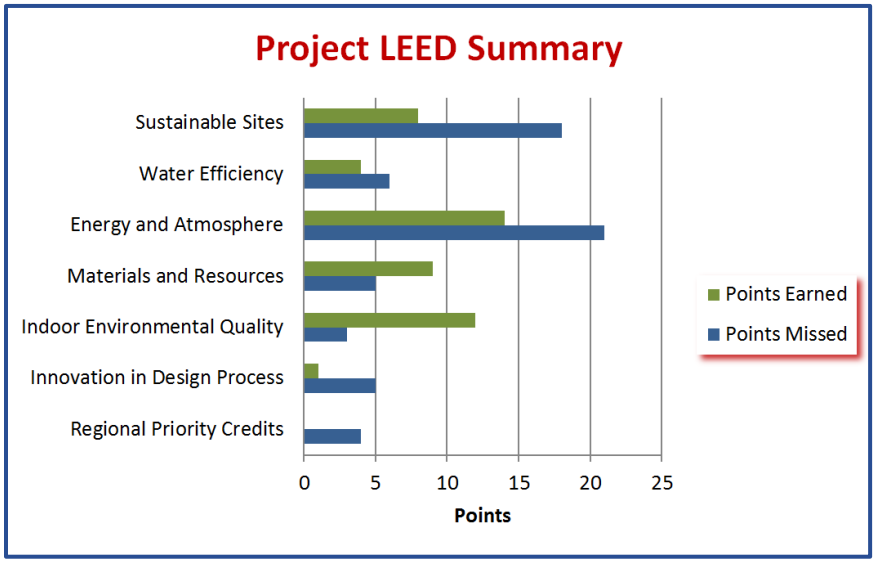

Figure 1: Fisk Corporate Headquarters - Potential LEED Summary

As evidenced above, the Fisk Corporate Headquarters would have been able to attain roughly 48 LEED points using the 2009 rating system had they decided to incur some small, upfront costs. This point total of 48 would have been enough to make the project LEED accredited. However, if the team had been able to identify an additional 2 points to increase the total to 50 points, the project would have been able to achieve a LEED silver rating. Members of the MEP design team believe that those two points could have been easily obtained by making some minor tweaks to the various MEP systems. The following sections detail how the Fisk Corporate Headquarters project would have been able to achieve points within each category described in Figure 2 had the owner desired to do so.

Sustainable Sites

Sustainable sites, the first LEED category, awards points based on not only the building's location, but also how the owner cultivates and maintains the site. Unfortunately, this category was one of the categories in which Fisk struggled to obtain points, scoring only 8 out of the potential 26 points.

Fisk Electric's new facility is located in an area filled with many smaller, spread out businesses. As such, Fisk was unable to gain any of the 5 possible points that come from developing a facility in an already developed community. Because this area is so spread out, multiple forms of alternative transportation cannot be found within close proximity to the Fisk Corporate Headquarters site, causing Fisk to lose another potential 6 points. Fisk compounded this loss of potential LEED points by choosing not to minimize their parking capacity or promote fuel efficient vehicles, which would have gained them 5 points. However, Fisk would have been able to gain a point in alternative transportation for having a bike rack since they did install a full shower in the pre-fabrication shop.

Even though choosing the site did not lead to many easy LEED points, the manner in which Fisk developed the site did. The site was previously used as the location for a concrete batch plant, causing the land to become contaminated and considered a brownfield. Fisk gained two points for not only choosing a previously developed site, but also redeveloping a brownfield. They also managed to gain 5 points for site development, a sophisticated storm water quantity control system, and minimizing the site's light pollution. However, Fisk's design team was not instructed to try and reduce the site's heat island effect, making the final two points within this category unattainable.

Water Efficiency

Water efficiency, the second LEED category, is one of the smaller categories in the new 2009 version of the LEED rating system and is worth 10 points. Fisk's new facility is projected to naturally obtain 4 points from this category. While this is an improvement on the previous section, a 40% success rate is not optimal. Fisk is projected to gain 2 points by planting some water efficient landscaping. Unfortunately, it is difficult to gain all four points in this category because of the extended periods of draught Houston, Texas sometimes experiences. The project team also decided to install many efficient plumbing fixtures, which are estimated to gain them another two out of a possible 4 points. Innovative wastewater technologies, the last two points, were not considered by the design team following the owner's instruction not to consider LEED points a design priority.

Figure 2: LEED Categories - Provided by LEED Online

Energy and Atmosphere

Even though the design team did not calculate the building's efficiency with regard to energy and atmosphere LEED points, communication with the design team did lead to an estimated number of potential points being developed for the purpose of this report. In regard to the building's energy performance, the team estimated the Fisk Corporate Headquarters project would be able to gain 7 out of the potential 19 points. However, members of the team believed this number could be easily increased by small tweaks to the various MEP system designs. No points could be awarded to the facility through the use of on-site renewable energy or green power because neither of these applications is being integrated into the building's design. However, the Fisk Corporate Headquarters project did specify an enhanced refrigerant management system. Coupled with Fisk's natural ability to employ enhanced commissioning and measure and verify their system, they could have gained another potential 7 LEED points. Based on this analysis, Fisk should be able to obtain 14 out of the possible 35 points which are attributed to energy and atmosphere by the 2009 version of LEED.

Materials and Resources

The most theoretical portion of the LEED evaluation with regard to the Fisk Corporate Headquarters building stems is the materials and resources category. Since Fisk chose not to try for any kind of LEED accreditation, the project team did not spend any of the extra money required to gain points in this category. For the purpose of this report, it was assumed that if Fisk was attempting to gain LEED accreditation, they would have approved required minor spending in this category that would have allowed them valuable points.

The first four credits in this category stem from building reuse, or maintaining an existing building during a renovation process. Because the Fisk Corporate Headquarters project was classified as new construction, all 4 building reuse points were unavailable. The remaining 10 credits which deal with construction waste management, material reuse, recycled contract, regional materials, and certified wood would have been easily obtainable had Fisk chosen to spend the required money. The only remaining point Fisk would not have been able to achieve comes through the use of rapidly renewable materials which were not specified in the original building's design.

Indoor Environmental Quality

Fisk's new corporate headquarters project's most successful LEED category is indoor environmental quality. Even though the owner did not prioritize the LEED points, they did emphasize the importance of maintaining a high level of indoor air quality for the health and productivity of the employees that would be working in the new building. As such, the building would have been able to achieve 12 of the possible 15 LEED points. The only points Fisk would not have been able to achieve are indoor chemical and pollutant source control, controllability of systems with regard to thermal comfort, and daylight views. Because the building is an office building and the inhabitants would be exposed to low levels of indoor pollutants, the design team did not develop an extensive enough pollutant source control system to warrant a LEED point. The last two points were not obtainable strictly as a result of how Fisk wanted their new facility to be laid out and controlled. Fisk Electric did not feel that their employees needed to be able to have individual control over the temperature of their workstations. Instead, Fisk wanted the system to be designed in a way that allowed the building to be thermally controlled in large zones,

eliminating the availability of the thermal control LEED point. Fisk also wanted to maximize their available space by placing workstations within the center of each floor's layout. These workstations are flanked on all sides by offices, eliminating their connection to the outside and making the daylight view potential point unavailable.

Innovation in Design, Regional Credits

Because Fisk chose to eliminate LEED from their project during the early stages of project planning and design, it was very difficult to project the project receiving any points with regard to innovation in design or regional priority credits. The only credit they would have been able to obtain would have stemmed from the project's architect being a LEED accredited professional. The remaining 9 credits would have been unobtainable unless Fisk chose to modify their approach to the project.

Critical Evaluation

Even though Fisk chose not to actively pursue LEED accreditation, the ease with which they could have achieved accreditation or even a silver rating showed that they did manage to install many sustainable features in their building. Fisk also displayed a high level of commitment to their employee's well-being through their emphasis on maintaining a high level of indoor air quality. However, not putting forth the small amounts of money and effort that are required to gain LEED accreditation might have been a poor decision. If for some reason Fisk desires to move facilities in the near future their headquarters building would have a higher resale value if it had been LEED accredited. Also, because of Fisk's involvement in the construction industry, building a new facility that placed an obvious emphasis on LEED and the environment could have gained Fisk Electric clients who are interested in constructing complex, sustainable facilities.

Schedule Acceleration Scenarios

As previously stated in Technical Reports 1 and 2, the ownership team did not emphasize the project schedule of the Fisk Corporate Headquarters as heavily as project cost, quality, and safety. The project schedule was created and maintained by Tutor Perini's on-site project manager and was approved biweekly by Tutor Perini's corporate office. Even though it was not the project's deciding factor, the schedule was created in a manner that would help ensure the success of the project's other major factors. The following sections detail key aspects, risks, and potential acceleration scenarios within the Fisk Corporate Headquarters project schedule.

Critical Path

The critical path for the Fisk Corporate Headquarters project spans approximately 11 months and encompasses a wide variety of construction activities. These activities can be grouped into 5 main activities or groups as depicted by Figure 3 below:

Figure 3: Critical Path Diagram

Because the building is only two stories tall and has a relatively small building footprint, it was scheduled by major construction activity and not by area. The first major critical path element is the foundations. The element begins with the drilling of the foundational caissons and finishes with the installation of the first floor slab on grade. Upon completion of the slab on grade, Tutor Perini began the building's steel erection sequencing. This critical path section includes not only the main building structure, but also the stairs, metal deck, second floor slabs, and all the building's fire proofing. Once the metal deck was installed, the contractors could begin running MEP overhead and installing the metal wall studs. After the structural sequence was complete, the next item on the critical path sequence was the completion of the building's enclosure. This group of scheduling activities was placed on the critical path because none of the building's final interior finishes could be installed until the building was completely sealed and enclosed. Once enclosed, the next major activity on the critical path was the final trim-out of the building's ceiling and wall MEP systems. After those activities were complete, Tutor Perini could begin the building's final testing phase which spanned approximately two weeks. At the end of that duration, Tutor Perini could turn the building over to Fisk Electric and owner move-in could begin.

Scheduling Risks

As previously stated, the Fisk Corporate Headquarters project schedule was not one of the project's main points of emphasis. Because of this, the schedule was created in a manner that would minimize owner risk and the chance of additional costs being added to the project. However, some minor scheduling risks were still inherited by the owner. The biggest scheduling risk on the project was that Tutor Perini decided not to start the utility tie-in process until the job was over. Even though these activities were not a part of the project's critical path, they posed a risk to the owner because they were begun so late in the process.

If something would have gone wrong with the tie-in, the job completion would have been substantially delayed while the project team would have been forced to coordinate with the city of Houston.

The other major scheduling risk to the project completion stems from a topic discussed in Technical Report 2 called the "two dimensions". Because of the unique order in which the team choose to sequence the fabrication and assembly of the exterior façade system, the team created a scheduling risk if the two involved parties were not properly coordinated. If either party did not construct their system according to the agreed upon "two dimensions", the systems would have to reconstructed, considerably slowing the overall duration of the building envelope construction duration. Due to its place along the critical path, the project team knew that if the building envelope duration increased for any reason, the overall project schedule would be compromised and costs would be incurred by the project team.

Acceleration Options, Costs, and Techniques

Even though there was not an emphasis placed on the project schedule by the owner, the project team had many ways in which they could accelerate the schedule if needed or per the owner's request. The cheapest, easiest way in which the project team could accelerate the schedule was through sequencing changes. As it currently stands, the schedule was constructed trade by trade, meaning that one trade's activity did not begin until the previous one was completely finished. This scheduling method was especially prevalent during the structural and enclosure phases of the project. It allowed the team to minimize risk while maximizing individual trade production by insuring that trades would never get in the way of one another. While this does work to minimize risk, it also provides an easy opportunity for the schedule to be cheaply accelerated if the need arose. For instance, the foundation to superstructure phase was set up beginning with drilling the caissons, then rebar and pour caissons and pile caps, place the slab on grade subgrade, install the slab on grade, and then begin steel erection with the columns. All these aforementioned activities were scheduled one after the other with no overlap of any kind. However, after careful examination of Figure 4, it becomes obvious that some of these activities could be happening simultaneously. There is no reason why the steel could not begin to be erected as soon as the caissons were poured before the slab on grade was completed. The installation techniques would be the same as before and the only potential minor cost difference would stem from the need for increased coordination between the different trades. Similar cheap schedule acceleration options like the steel columns can be found throughout the schedule and could have been simply implemented if the project team so desired.

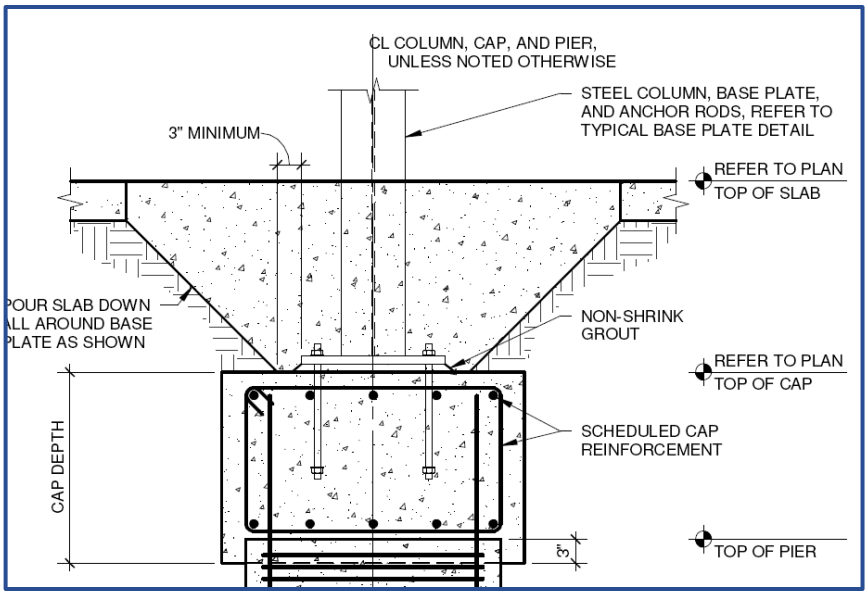

Figure 4: Steel Column Foundation - Courtesy of Fisk Electric

The other way the schedule could have been accelerated if the need arose would have been through utilizing different installation techniques. A vast majority of the building systems found on the Fisk Corporate Headquarters project were assembled in place using a technique called stick construction. While this technique is reliable, it is not the most efficient in terms of activity durations. Had the team desired, they could have used a relatively newer installation technique known as pre-fabrication or modular construction. In modular construction, large parts of the building, such as sections of the exterior façade, are assembled in a controlled environment in large sections. These sections are then transported to the construction site where they are hoisted into their final resting place and connected to the surrounding systems. Even though it takes a much shorter amount of time to install these modular pieces together compared to traditional construction means, pre-fabrication does have other negative effects on a project. Typically modular pieces cost more to install from a material standpoint because the systems need to be redesigned in order to fit together in a modular fashion. For instance, if the Fisk Corporate Headquarters project team decided to build the facades using modular construction practices, they would have had to redesign the façade backup to be able to support large panels being attached to them. Another drawback associated with modular construction is the need for a heightened level of coordination between team members. Because the ownership team decided not to implement BIM on their project, it would have been much more difficult for them to coordinate, design, and construct modular system pieces. Because of the lack of emphasis on overall project schedule compared to cost and quality, the project team ultimately decided that implementing costly modular construction practices would not be beneficial to the project.

Value Engineering Topics

As previously stated in Technical Reports 1 and 2, one of the most important aspects of the Fisk Corporate Headquarters project to the owner was overall costs. Fisk Electric took many steps to ensure that their new facility would be of the quality they desired, at a relatively low overall cost. One way they accomplished this task was through extensive project value engineering. Value engineering often carries a negative connotation as it can manifest in simple cost cutting on a project. However, it is important to remember that sometimes value engineering results in the owner adding value to the project by expanding a specific project system. In the case of the Fisk Electric project, the owner value engineered improvements to their electrical system which was credited with increasing the value of the system even though it increased the overall project costs. While not all value engineering ideas were implemented, the following sections detail ways in which value engineering was implemented on the Fisk Corporate Headquarters project.

Architectural Canopy

The first major value engineering installment on the Fisk Electric project occurred during the early stages of project design. Originally, the project was going to apply to be LEED certified. As such, architectural measures were taken to help aid in the building's overall energy efficiency. After completing careful solar studies using solar charts like the one found in Figure 5, the architectural firm designed a large, canopy structure located just above the second floor that stretched around the building in the areas exposed to direct sunlight. This overhead canopy would shade the glass from direct sunlight and make the glass function similarly to north facing glass. North facing glass behaves the best in terms of energy efficiency and would have significantly decreased the building's energy consumption. However, midway through the design process, the owner decided not to attempt to acquire a LEED certification for the building. Upon reaching that conclusion, Fisk Electric ultimately decided that the initial cost of this large canopy was no longer worth the efficiency benefits the building would receive. The architectural canopy was immediately value engineered out of the project and Fisk Electric's project budget was adjusted accordingly.

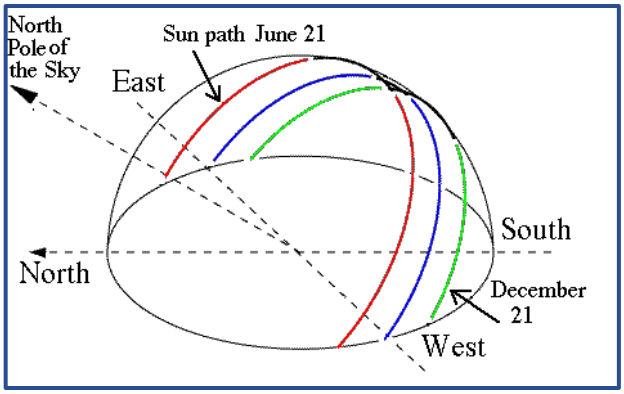

Figure 5: Solar Chart - Courtesy of Google Images

Prefabrication Shop

Another key area in which the ownership team looked to reduce project costs was the prefabrication shop. The prefabrication shop began as a 20,000 square foot building with a lathe and stucco exterior façade. However, after closer examination of the overall project program and a study of Fisk Electric's pre-fabrication space requirements, the ownership team decided they could afford to shrink the prefabrication shop by approximately 4,000 square feet. They then reduced the prefabrication shop's footprint to its current size of 16,380 square feet. This 20% reduction in building footprint served as one of the largest value engineering savings decisions implemented on the Fisk Corporate Headquarters project.

The second way value engineering was applied to the prefabrication shop was through the changes made to the building's exterior façade. As previously stated, the building façade was originally comprised of a lathe a stucco exterior building skin. However, when Fisk Electric decided to shrink the building's footprint, they took the time to investigate the rest of building's systems to see if they could find more ways to help reduce the cost of the pre-fabrication shop. After careful study, the ownership team determined that they could apply value engineering principles to the façade in order to maintain the building's appearance and quality while lowering the façade costs. They decided the best way to do this was to eliminate the lathe a stucco façade and supplement it with a layer of elastomeric paint applied directly to the CMU wall. As evidenced below in Figures 6 and 7, the two different wall façade types look very similar, but by switching to an elastomeric wall coating, Fisk Electric was able to experience significant façade savings.

Figure 7: Stucco Exterior - Courtesy of Google Images

Figure 6: Elastomeric Paint - Courtesy of Google Images

Parking Lot

The last area Fisk Electric targeted for cost-reduction value engineering was the facility's parking lot. At the beginning of the design phase, Fisk Electric wanted a large, concrete parking lot that could hold not only its office employees, but also have a large paved area for parking trucks and equipment. Once the project began approaching the construction phase, the ownership team ultimately decided that they could afford to reduce the size of the parking lot in an effort to lower the project's costs. They also decided to switch the parking lot to asphalt. Asphalt is a much cheaper material to procure and install; however, it is not widely implemented in Houston, Texas because of the city's weather patterns. Ironically, the switch to asphalt ended up costing the owner more money than concrete would have because of the weather the project experienced during construction. One value engineering item that was suggested but not adopted was a change in the quality of the parking lot lighting. The project management team suggested to ownership that they could increase the quality of the parking lot lighting while only incurring some minor additional costs. However, upon further review by the ownership team, it was decided that the value engineering proposal would not be implemented.

Electrical System

As previously mentioned, sometimes owners actually value engineer systems or components into their building that end up adding costs to the overall project. In the case of the Fisk Corporate Headquarters project, Fisk Electric targeted their electrical system as one worth upgrading throughout the course of the

Figure 8: Lutron Panel
Courtesy of Lutron

project even if it meant increasing the overall project cost. Originally, the electrical lighting plan called for fluorescent strip fixtures without any kind of centralized control system. However, over the course of the project, many advances were made in the industry LED fixtures and centralized lighting control panels. Fisk Electric's project management team discovered that they could add some LED lights in specific high-profile areas at a minimal cost. They also were able to work out a deal with Lutron in order to acquire two Lutron control panels. These panels gave the owner more control over their lighting system while also providing future flexibility. Fisk Electric reviewed these possible changes and ultimately decided to add these components to the electrical system. Figure 8 shows a Lutron control panel similar to the ones installed in the Fisk Corporate Headquarters facility.

Critical Evaluation and VE Items Not Implemented

While the above sections detailed some of the major value engineering ideas utilized on the Fisk Corporate Headquarters project, many other ideas were discussed but not executed. As previously stated, the rejection of attempting to make the building LEED certified brought about many value engineering opportunities for the project team. Some of these opportunities involved lowering the efficiency of the mechanical system and saving on some up-front installation costs. However, Fisk Electric ultimately decided that their system efficiency was more valuable to them over the long term and the changes were not implemented. Another group of value engineering items related to the building's mechanical system that were not realized stem from the facility's indoor air quality. Originally, the mechanical engineer designed the system to achieve a majority of the LEED points related to indoor air quality. Once LEED certification was abandoned, the question arose as to whether or not many of these system components were now required. In the end, Fisk Electric decided that for the health, safety, and productivity of their employees, they would be better served by keeping a high level of indoor air quality within their building so the original LEED system components were maintained.

While Fisk Electric did employ a fair number of cost-cutting techniques under the mantra of value engineering, they also did value engineer some increased quality components in their facility plan. Most of the value engineering ideas employed on the project achieved ownership goals; conversely, some ideas, like the switching from asphalt to concrete, actually ended up costing the owner more money while lowering the project quality. However, Fisk Electric and the ownership team did an excellent overall job of utilizing value engineering ideas that maintained or improved the quality of their building while still lowering the total project costs.

Critical Industry Issues

PACE Roundtable Introduction

The PACE Roundtable Discussion serves as an opportunity for the Penn State Architectural Engineering faculty and students to gather with industry professionals and discuss critical issues and topics related to the construction industry. This year, some of the topics discussed included modularization, BIM to owner turnover, and Integrated Project Design. In order to maximize the potential for student to industry professional interaction, the Roundtable Discussion started with a student panel discussion, followed with two breakout sessions, and finished with smaller feedback discussion groups. The two breakout sessions were created in order to give the students and industry professionals the chance to discuss various topics of their choosing in a group setting. The final small group sessions were an opportunity for the students to meet more personally with the industry professionals to discuss and gain feedback on the information they had learned throughout the course of the day. The following sections detail some of the lessons the students were able to learn through the breakout sessions and the feedback discussions.

Figure 9: PSU PACE Symbol
Courtesy of PSU PACE

Session #1: Delivery of Services – Efficient Use of Integrated Design

"Efficient Use of Integrated Design" was the name of the first breakout session attended at the PACE Roundtable Discussion. The goal of this breakout session was to discuss steps project teams could take to ensure success if they did choose to implement an integrated design process on their project. While many legal and trust barriers still make integrated project design difficult to implement, this session tried to focus solely on how teams could have a positive experience working together when placed in an IPD environment. At times, the session's moderator had to remind the industry members that the purpose of the session was to discuss how an effective team functions, not the hurdles IPD still needs to overcome. Even though the discussion sometimes strayed from its original intent, many valuable lessons and insights were still gained by listening to the various industry professionals' experiences and opinions regarding the efficient use of integrated design.

A common theme portrayed by all the industry professionals present at the session was the benefits a job experiences when all project team members believe they are working together toward common goal. They all stressed the importance of teams believing that they are working for the betterment of everyone, not just each individual entity. As such, the industry members unanimously believed that the most crucial element of successful integrated design is the establishment of a universal objective for the entire team to pursue. Once recognized, the next unanimous step in the process appeared to be finding ways to ensure proper communication between all pertinent team members. The industry professionals all agreed that without communication, there was no way for an integrated team to effectively work together. Terms like co-location, web conferencing, and frequent meetings were all discussed as ways to guarantee communication success. The industry members all agreed that once those two steps were established, the last step to guarantee success was for the integrated team to simply commit to the established steps for the entire project duration.

Throughout the course of the breakout session, many ideas surfaced that could lead to pertinent research topics related to the Fisk Corporate Headquarters project. As previously stated, the ownership team decided to utilize a traditional Design-Bid-Build delivery method on the project. This delivery method is considered by many industry professionals to be the exact opposite of an Integrated Project Design or Delivery method. However, the traditional Design-Bid-Build delivery method is also considered to be the most common and reliable. Given these differences, a unique opportunity is presented to research how the overall design process would have been affected had the owner chosen to implement a more integrated approach. Analysis could be completed regarding how efficient the design team was at making decisions and sharing information on the Fisk Corporate Headquarters project compared to projects of a similar size that utilized a more integrated design process. Upon completion of the comparison analysis, one could then predict how an integrated design approach would have either positively or negatively affected the building's design process.

Another extremely unique research opportunity presented by the Fisk Corporate Headquarters project that ties into effective team use is the relationship between the owner and contractor on the project. Since Fisk Electric is owned by the project's construction manager, an investigation could be undertaken in an effort to see if this unique relationship created a naturally integrated team. If it did, further analysis could be pursued to determine just how beneficial this relationship was and how it could have been improved and utilized further.

Figure 10: PACE Symbol
Courtesy of PACE

Session #2: Supply Chain - Modularization

The second attended session titled "Modularization" attempted to discuss innovative ways to apply effective modularization techniques to construction projects and the positives and negatives of implementing them. Many of the industry professionals in the session belonged to organizations of various skills and backgrounds, giving the modularization discussion perspective from not only large general contractors, but also various trade contractors. Since Fisk is an electrical contractor, many of the discussion topics can not only be applied to their building, but their potential everyday business practices.

Figure 11: Modular MEP Rack - Courtesy of Google Images

Throughout the course of the session, many different examples of modularization were discussed. Some of the examples of modularization described by the industry professionals, like modularized façade panels, are fairly common and are used often on construction sites. However, the most interesting modularization discussion in the session actually stemmed from a practice that is fairly uncommon. It centered around the use of modularized, multi-trade overhead racks that M.C. Dean and Southland Industries were working together to build and install on a large job in the D.C. area. Figure 11 depicts a large

overhead MEP module being hoisted into a new building, similar to the ones described to the students during the breakout session. A professional representative from Southland Industries gave insight to the students as to how the two large MEP contractors were able to come together to prefabricate and install these large overhead racks. The professional also gave insight as to how the contractors were able to handle the legal liability that came with both contractors working on the same overhead rack. This unique industry example gave the students valuable insight into how modularization can be innovatively used to efficiently complete various construction tasks.

Like the first session, some of the topics discussed throughout Session #2 provided the students with research ideas that they could then implement on their individual thesis projects. In the case of the Fisk Corporate Headquarters project, almost all the systems were installed via traditional stick construction methods. Using effective modularization could have possibly shortened activity durations and accelerated the overall construction schedule. An investigation could be undertaken in an effort to see what building systems could have been modularized, and how modularizing those systems would have benefited the construction team.

Industry Member Discussion

The last small group discussion was between two students and industry professional Raj Vora. Mr. Vora works for Southland Industries in the capacity of the Director of Business Development. He is a professional engineer and has worked for over ten years in the mechanical contracting industry. As such, much of the discussion between him and the students centered on how the day's discussions could be applied to the MEP contracting industry. Mr. Vora and the students spent a majority of their time discussing how modularization and pre-fabrication have affected the MEP contracting industry in the past 5 years. The students and Mr. Vora both believed that modularization is the future of the construction industry. They spent time discussing the potential benefits and drawbacks associated with modularization and some innovative ways modularization was beginning to be used within the industry. Mr. Vora even showed the students some modularization photographs and videos compiled by Southland Industries. However, he stressed to the students that while modularization can be very beneficial, it is very project and company specific.

After discussing modularization, Raj Vora worked with the students to help them identify ways they could apply the PACE Roundtable Discussion to their individual thesis projects. Both students walked away from the conversation with great ideas regarding how the day's discussions could be researched and implemented on their thesis projects. Mr. Vora gave both students a comprehensive list of industry professionals that they could contact for both thesis information and general industry questions. Overall, the 21st installment of the PACE Roundtable Discussion was a great success and not only gave the students ideas that they could use for the thesis project, but also gave the students the opportunity to build relationships with knowledgeable construction industry professionals.

For the notes taken during the PACE Roundtable, please reference Appendix B.

Problem Identification and Technical Analysis Options

Even though the Fisk Corporate Headquarters project was considered a successful project by both the ownership and construction teams, improvements to the project could have been made in certain areas that would have benefitted both teams. Because Fisk Electric placed emphasis on the project's overall cost and quality rather than schedule, the future technical research outlined in this report will focus on improving the building regarding those two aspects. The potential project improvements are detailed in the following sections.

Project Sequencing

The first potential improvement on the Fisk Corporate Headquarters projects stems from the sequencing between activities on the project schedule. As previously stated, many major construction activities were scheduled one following another without any overlap. Even though the owner did not prioritize the project schedule, they did place a heavy emphasis on the overall project's cost. As evidenced by the general conditions investigation detailed in Technical Report 3, Fisk Electric ended up carrying the cost of general conditions because of their unique relationship with the project's construction manager. Because of this, a correlation can be drawn between the overall project duration and direct costs incurred by the owner. The purpose of completing a technical analysis in an effort to improve the project's sequencing, and therefore shortening the overall schedule, is to minimize the cost of the time related general conditions items carried by Fisk Electric throughout the construction process.

In order to complete a detailed study of how the project sequencing can be improved, the first step will be to complete an analysis of the project schedule. After targeting potential areas for sequencing improvement, research regarding the systems involved will commence to guarantee an adjustment to the activity sequencing is possible. If any of the activities have other dependencies that cannot be altered, those activities will remain sequenced as originally proposed. Once the research is complete, the project will then be rescheduled according to the approved sequencing changes. Finally, the schedule will be reevaluated compared to the existing general conditions in order to determine the amount of savings that would have been available to the owner had different project sequencing been employed.

LEED Certification

Another potential improvement available to the Fisk Corporate Headquarters project would have been LEED certification had the ownership team made the decision to apply. Even though it would have potentially cost more money, achieving a LEED certification would have improved the overall quality of the building as evaluated by both the owner and the construction industry as a whole. The purpose of completing a LEED certification technical analysis is to suggest minor changes the owner could have implemented in an effort to improve the building's energy efficiency, gain tax returns, and maintain the appearance of an environmentally responsible owner in the eyes of the public.

As previously stated in this technical report, it is believed by many of the members of the project team that by instituting minor design and construction tweaks to the project plan, the Fisk Corporate Headquarters project could have achieved LEED certification with relative ease. In an effort to propose a plan to achieve this certification, the first step is to complete a thorough investigation of the various construction areas where LEED practices could have been executed in an effort to gain LEED points. Upon completion of that analysis, research would be undertaken to ensure that these construction area LEED points are achievable in Houston, Texas. Further research would then be conducted to see if any regional priority LEED points could be applied to the Fisk Corporate Headquarters project. Finally, a thorough detailing of the added costs associated with achieving LEED certification would be compiled in order to present the cost increases compared to increased level of facility quality.

This attempt at LEED certification also presents an opportunity to tweak the building's mechanical system in order to improve the building's energy efficiency rating. Independent research will be completed in conjunction with communication with the building's contracted mechanical engineer in order to find ways to improve the system. Minor design changes will then be completed and analyzed in an effort to see how these changes affect the building's LEED score.

Electrical System Redesign

One unique improvement opportunity regarding the Fisk Corporate Headquarters project is through the potential changes that can be made to the electrical system. While an electrical system redesign is not typical of a construction management thesis, the author of this report has an academic background in electrical systems. As such, it is worth investigating whether or not an electrical system redesign could be undertaken in an effort to not only increase the system's quality, but also minimize the system's cost. This system redesign will also target the systems efficiency by comparing the specified equipment with other available industry supplements. In order to complete this redesign, the system will be individually calculated to ensure it meets all code and power requirements.

Once the system is redesigned, it will be analyzed from constructability and cost standpoints so that it can be compared to the originally designed system. Any changes between the two systems will be documented and any significant new construction concerns with the new system will be addressed. The new system and equipment will then be completely evaluated to determine whether or not it is an improvement in terms of quality and costs to the original system.

Implementation of BIM for Façade "2 Dimensions" Construction

The last opportunity for improvement on the Fisk Corporate Headquarters project is through the implementation of BIM in order to better coordinate the construction of the façade wall. As reported in Technical Report 2, the "2 dimensions" process utilized on the project required close coordination between all involved trades. However, it is believed that the entire process could have benefitted from implementing BIM techniques. The purpose of this analysis is to determine whether or not virtually mapping out the "2 dimensions" would have improved the overall efficiency of the process. In order to complete this analysis, research would be conducted in an effort to determine exactly what steps would need to be taken in order to virtually construct the "2 dimensions" and then portray this information to individual trades. Research would then need to be conducted to determine the time saves by the involved trades. The only way to accomplish this would be to contact the involved trades in order to gather information regarding how long it took them to complete the entire process. The new BIM process durations would then be estimated and the results would be compared in an effort to see how beneficial virtually mapping the "2 dimensions" would have been.

Appendix A: LEED Checklist

LEED 2009 for New Construction and Major Renovations

Project Checklist

Fisk Corporate Headquarters Project - Potential LEED Points

Sustainable Sites — Possible Points: 26

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

Energy and Atmosphere — Possible Points: 35

Y	?	N			
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
7		12	Credit 1	Optimize Energy Performance	1 to 19
		7	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			
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			
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

		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

		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

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

Appendix B: PACE Roundtable Submission Form

Session #1

Topic: Delivery of Services – Efficient Use of Integrated Design

Research Ideas:

1. How efficient was the design team at making decisions and sharing information in a non-integrated design format?
    a. Could there have been significant room for improvement if the team had utilized an integrated design procedure?
2. Did having the owner and constructor being owned by the same entity create a natural integrated team? Why or Why Not?
    a. If so, did the entities find this relationship to be beneficial?
    b. How could it have been improved?
3. Did the project team feel like the manner in which they interacted contributed to a team effort or did they work in "silos"
    a. If so, what steps could have been taken to increase the level of teamwork between the different trades.

Session #2

Topic: Supply Chain - Modularization

Research Ideas:

1. Look into the possibility of redesigning the façade so that it can be installed in a modular fashion instead of traditional stick construction.
    a. Could potentially be only windows or brick individually that come in large modules
    b. Remember to weigh the cost of added crane time that would not have been on site if the project was stick built*
2. Would using multi-trade overhead modular racks be beneficial on the Fisk Corporate Headquarters project?
    a. Because BIM was not used for coordination, that added cost would have to be considered
3. Could some aspect of the offices, like the walls, have been somehow modularized due to their repetitive nature?

Industry Member Discussion

Key Feedback: Raj Vora – Southland Industries

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

1. Modularization – specifically finding ways to modularize MEP systems that coordinate with other typical building systems
    a. Multi-trade MEP racks
    b. Modularizing walls to include MEP trim-outs
    c. Coming up with new, innovative ways to prefabricate MEP systems individually
    d. Researching how much money is actually saved using pre-fabrication
    e. What is the break-even point in terms of the scale of MEP systems where using pre-fabrication no longer becomes beneficial
        i. How system specific is this break-even point?

Suggested Resources:

What industry contacts are needed? Is the information available?

1. Southland Industries – Yes, they have experience with the pre-fabrication of multi-trade overhead racks. They have also specifically coordinated the modularization of Mechanical and Plumbing systems with other trades such as drywall.
    a. Andy Paxton – Project Manager
    b. Andy Rhodes – Design Engineer
    c. Raj Vora – Director of Business Development
2. Truland Systems – Yes, Truland has extensive information regarding the pre-fabrication and modularization of electrical systems and how that prefabrication can interface with other systems.
    a. Chuck Tomasco – Project Executive
3. It would be beneficial to acquire an industry contact that designs and installs fire protection systems.