# Ian Bower

## Technical Report Three

## The Concordia Hotel

## 10/12/2012

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## Executive Summary

The following technical assignment is a comprehensive report analyzing key facets of the Concordia Hotel project that affect the project execution. The renovation project will take place from November 2011-January 2013. The project is located in the heart of D.C. restraints of a restrictive site and tight schedule combined with the many complications of renovating a nearly 50-year-old building have created a unique and extremely challenging project for The Turner Construction Company.

The main purpose of this technical assignment focuses on identifying potential research topics that can be analyzed and presented in the thesis proposal. This report consists of a LEED evaluation, schedule acceleration scenarios, an assessment of value engineering topics, critical industry issues and lastly problem identification and technical analysis options.

The LEED (Leader in Energy and Environmental Design) evaluation is a key aspect of this report. A LEED scorecard was developed below for this section of the report and the results of its analysis were then summarized. This analysis consisted of considering the appropriateness of each point in relation to the Concordia project. After conducting a preliminary evaluation of the LEED points met by the project it was discovered that this project is capable of attaining gold certification. This is an appropriate level of certification based on the client and project goals. After conducting an evaluation of the LEED certification potential a careful research was used when looking at schedule acceleration scenarios.

The thorough schedule acceleration scenarios make-up a substantial portion of this report. In order to better understand areas that had potential for schedule accelerations a thorough understanding of the critical path was required. The critical path and the schedule were very tight and the proposed project completion date had many risks of not being met. In order to help alleviate some of this risk schedule acceleration techniques and costs were evaluated. The schedule acceleration scenarios have great potential to save time similar to how value engineering has great potential to save cost.

Many of the project's systems were value engineered to find alternatives that met the project and the owner's goals. A description of the key areas of value engineering was composed to discuss the categories that were implemented on this project. Every item that was actually implemented was assessed for whether it correlated or detracted from the owner's goals. While many ideas were considered not all of them were actually implemented on this project. Part of this analysis was to discuss some of the ideas that were considered, however, not utilized on the project. Some of the topics considered in value engineering for my project directly aligned with discussions at the PACE Roundtable sessions.

After attending two sessions at the PACE Roundtable at The Penn Stater Conference Center it was realized that there are critical industry issues which relate to my project. Two sessions were attended; the first session was concerning Integrating Strategies and Technologies and the second session was a discussion of Modularization. After completing a brief summary, of the results of these sessions, many of the details that were surprising to me became apparent. A careful consideration of these issues was made in order to analyze their affect and possible application to my project. After these discussions were complete key contacts were made in order to facilitate research and application of these ideas. These critical industry issues have provided great potential for technical analysis options.

When identifying problems and options for technical analysis, some of the critical industry issues were problems faced on the Concordia renovation. The project as a whole was very successful considering the tight schedule and the extensive demolition and renovation of a near 50-year-old building. While the project was successful, for the most part, there were still some problems that the construction team has faced. Some of these problems include the MEP system's design, coordination and installation. Site logistics and demolition have also posed problems for the construction team. These two problems provide great potential for a detailed analysis of the technical building systems as well as the means and methods of construction. The other major problem areas are the consideration of alternatives to the applied structural rehabilitation methods, the façade, and lastly the MEP systems. Through the analysis of a BIM product the site logistics, demolition, and the MEP system's problems can all likely be solved. The structural rehabilitation methods, the façade and MEP building systems will be be researched and analyzed in order to present viable alternatives that meet the project team and the owner's goals.

## Leadership in Energy and Environmental Design (LEED) Evaluation

LEED-NC

**LEED 2009-New Construction, Major Renovations**

| | | | | | Pts. |
|---|---|---|---|---|---|
| 74 | 2 | 4 | 30 | **Total Proposed Project Score** | 110 Points |

The Concordia
Washington, D.C.

Certified 40-49 points Silver 50 to 59 points
Gold 60-79 points Platinum 80 points and above

| Yes | M+ | M- | No | | | |
|---|---|---|---|---|---|---|
| 22 | | 1 | 3 | **Sustainable Sites** | | 26 Points |
| Y | | | | SSPR 1 | **Construction Activity Pollution Prevention** | Required |
| 1 | | | | SS1 | **Site Selection** | 1 |
| 5 | | | | SS2 | **Development Density & Community Connectivity** | 5 |
| 1 | | | | SS3 | **Brownfield Redevelopment** | 1 |
| 6 | | | | SS4.1 | **Alternative Transportation**, Public Transportation Access | 6 |
| 1 | | | | SS4.2 | **Alternative Transportation**, Bicycle Storage & Changing Rooms | 1 |
| 3 | | | | SS4.3 | **Alternative Transportation**, Low-Emitting and Fuel-Efficient Vehicles | 3 |
| 2 | | | | SS4.4 | **Alternative Transportation**, Parking Capacity | 2 |
| | | 1 | | SS5.1 | **Site Development,** Protect of Restore Habitat | 1 |
| 1 | | | | SS5.2 | **Site Development,** Maximize Open Space | 1 |
| | | | 1 | SS6.1 | **Stormwater Design,** Quantity Control | 1 |
| | | | 1 | SS6.2 | **Stormwater Design,** Quality Control | 1 |
| 1 | | | | SS7.1 | **Heat Island Effect,** Non-Roof | 1 |
| 1 | | | | SS7.2 | **Heat Island Effect,** Roof | 1 |
| | | | 1 | SS8 | **Light Pollution Reduction** | 1 |
| 3 | | 1 | 6 | **Water Efficiency** | | 10 POINTS |
| Y | | | | WEPR1 | **Water Efficient Landscaping**, Reduce by 50% | Rquired |
| | | | 4 | WE1 | **Water Efficient Landscaping**, No Potable Use or No Irrigation | 4 |
| | | | 2 | WE2 | **Innovative Wastewater Technologies** | 2 |
| | | | | WE3 | **Water Use Reduction**, 30%, 35%, OR 40% Reduction | 4 |
| 20 | 2 | | 13 | **Energy & Atmosphere** | | 35 POINTS |
| Y | | | | EAPR1 | **Fundamental Commissioning of the Building Energy Systems** | Required |
| Y | | | | EAPR2 | **Minimum Energy Performance** | Required |
| Y | | | | EAPR3 | **Fundamental Refrigerant Management** | Required |
| 13 | | | 6 | EA1 | **Optimize Energy Performance** | 19 |
| | | | 7 | EA2 | **On-Site Renewable Energy** | 7 |
| 2 | | | | EA3 | **Enhanced Commissioning** | 2 |
| 2 | | | | EA4 | **Enhanced Refrigerant Management** | 2 |
| 3 | | | | EA5 | **Measurement & Verification** | 3 |
| | 2 | | | EA6 | **Green Power,** 35% for 2 years | 2 |

Figure 1 LEED scorecard

| | | | | | | |
|---|---|---|---|---|---|---|
| 74 | 2 | 4 | 30 | **Total Proposed Project Score** | | 110 Points |

The Concordia
Washington, D.C.

Certified 40-49 points Silver 50 to 59 points
Gold 60-79 points Platinum 80 points and above

| Yes | M+ | M- | No | | | |
|---|---|---|---|---|---|---|
| 8 | | 1 | 5 | **Materials & Resources** | | 14 Points |
| Y | | | | MRPR1 | **Storage & Collection of Recyclables** | Required |
| 2 | | | 1 | MR1.1 | **Building Reuse**, Maintain Existing Walls, Floors & Roof 55%, 75%, or 95% | 3 |
| | | | 1 | MR1.2 | **Building Reuse,** Maintain Interior Nonstructural elements | 1 |
| 2 | | | | MR2 | **Construction Waste Management**, Divert 50-75% from Disposal | 2 |
| | | | 2 | MR3 | **Materials Reuse**, 5-10% | 2 |
| 2 | | | | MR4 | **Recycled Content**, 10-20% (post-consumer + ½ pre-consumer) | 2 |
| 1 | | 1 | | MR5 | **Local/Regional Materials**, 10-20% manufacture, harvested regionally | 2 |
| | | | 1 | MR6 | **Rapidly Renewable Materials 2.5%** | 1 |
| 1 | | | | MR7 | **Certified Wood** | 1 |
| 14 | | | 1 | **Indoor Environmental Quality** | | 15 Points |
| Y | | | | EQPR1 | **Minimum IAQ Performance** | Required |
| Y | | | | EQPR2 | **Environmental Tobacco Smoke** (ETS) **Control** | Required |
| 1 | | | | EQ1 | **Outdoor Air Delivery Monitoring** | 1 |
| 1 | | | | EQ2 | **Increased Ventilation** | 1 |
| 1 | | | | EQ3.1 | **Construction IAQ Management Plan**, During Construction | 1 |
| 1 | | | | EQ3.2 | **Construction IAQ Management Plan**, Before Occupancy | 1 |
| 1 | | | | EQ4.1 | **Low-Emitting Materials**, Adhesives & Sealants | 1 |
| 1 | | | | EQ4.2 | **Low-Emitting Materials**, Paints & Coatings | 1 |
| 1 | | | | EQ4.3 | **Low-Emitting Materials**, Carpet Systems | 1 |
| 1 | | | | EQ4.4 | **Low-Emitting Materials**, Composite Wood & Agrifiber Products | 1 |
| | | | 1 | EQ5 | **Indoor Chemical & Pollutant Source Control** | 1 |
| 1 | | | | EQ6.1 | **Controllability of Systems**, Lighting | 1 |
| 1 | | | | EQ6.2 | **Controllability of Systems**, Thermal Comfort | 1 |
| 1 | | | | EQ7.1 | **Thermal Comfort**, Design | 1 |
| 1 | | | | EQ7.2 | **Thermal Comfort**, Verification | 1 |
| 1 | | | | EQ8.1 | **Daylight & Views**, Daylight 75% of Spaces | 1 |
| 1 | | | | EQ8.2 | **Daylight & Views**, Views for 90% of Spaces | 1 |
| 6 | | | | **Innovation & Design Process** | | 6 Points |
| 1 | | | | IDI1.1 | **Innovation in Design**: Green Cleaning Program | 1 |
| 1 | | | | IDI1.2 | **Innovation in Design**: Low Emitting Ceiling & Wall Systems | 1 |
| 1 | | | | IDI1.3 | **Innovation in Design**: Education and Outreach Program | 1 |
| 1 | | | | IDI1.4 | **Innovation in Design**: EP SSc2 | 1 |
| 1 | | | | IDI1.5 | **Innovation in Design**: EP SSc4.1 | 1 |
| Y | | | | BACKUP | **Innovation in Design**: Low Mercury Lighting | |
| | | | N | BACKUP | **Innovation in Design**: EP SSc4.2 | |
| | | M- | | BACKUP | **Innovation in Design**: Waste Managemnt | |
| | | M- | | BACKUP | **Innovation in Design**: EP MRc2 | 1 |
| 1 | | | | ID2 | **LEED® Accredited Professional** | 1 |
| 1 | | 1 | 2 | **Regional** | | 4 Points |
| | | 1 | | RP1.1 | **Innovation in Design**: Green Cleaning Program | 1 |
| | | | 1 | RP1.2 | **Innovation in Design**: Low Emitting Ceiling & Wall Systems | 1 |
| 1 | | | | RP1.3 | **Innovation in Design**: Education and Outreach Program | 1 |
| | | | 1 | RP1.4 | **Innovation in Design**: EP SSc2 | 1 |
| | | | N | BACKUP | | |
| | | | N | BACKUP | | |

Figure 2 LEED scorecard

*Summary of Results*

The United States Green Building Council (USGBC) developed the LEED rating system to certify buildings according to points earned for implementing sustainable practices and materials on a building project. The levels of certification vary according to the amount of points earned (USGBC).

*Points/Category Summary*

After thoroughly analyzing the LEED scorecard and assessing the points that the building can earn it was found that the building is capable of attaining 110 points. After further evaluation it was realized that 74 out of the 110 points were likely to be approved. 22 points were awarded in sustainable sites, 3 points were awarded in water efficiency, 20 points were awarded in energy & atmosphere, 8 points were awarded in materials & resources, 14 points were awarded in indoor environmental quality, 6 points were approved innovation & design process and lastly 1 point was awarded in regional priority credits. While the original estimate of 110 was very high, the 74 points were much more appropriate and more likely to be attained. The appropriateness of each point category is discussed below.

Sustainable Sites

The sustainable sites category was awarded twenty-two points. This category broke down into fifteen separate sections where points could be awarded. The main purpose of the sustainable sites section of the LEED scorecard is to promote an environmentally sensitive site. The category consists of required construction activity pollution prevention which Turner has met with its development of an erosion and sediment control plan. The Turner Construction Company has also met the requirements of site selection, development density & community connectivity and brownfield redevelopment with this renovation project. The project has also taken advantage of the points associated with alternative transportation. The points that were achieved in this category were from public transportation access, bicycle storage & changing rooms, low-emitting and fuel efficient vehicles and lastly parking capacity credits. A significant amount of points were earned, unfortunately many points were not able to be earned.

The project was not able to achieve the points associated with site development SS5.1 due to the inability to protect or restore the preexisting habitat. The project was also unable to earn the points in storm water design and light pollution reduction due to the changes in the green roof and the illumination levels not being met with site size constraints.

Water Efficiency

The water efficiency category focuses on the reduction of water consumption over a building's life cycle. It provides credits for reducing the loads on wastewater systems and municipal water supply systems through the reduction of individual building's water usage. This category broke down into four separate sections in which three points were gained. The project was required to meet a water use reduction of 20% and the only other section that this project achieved was an extra water use reduction of 35% when they increased water savings 15%. Unfortunately in this category two out of the four sections did not earn any points.

The sections that did not offer any points were the water efficient landscaping or the innovative wastewater technologies. The project was pursuing two points for water efficient landscaping, however,

the credit was denied. The space constraints of the building did not allow for an innovative wastewater technology to be installed.

Energy and Atmosphere

The energy and atmosphere category promotes the cutback in energy use over the lifecycle of a building. This requirement is used to make sure that all of the building's energy systems are meeting their design standards through the proper operation and commissioning procedures. Before any credits can be earned the systems must first be commissioned. This is another category where a large amount of points were earned; twenty points were given to this category. This category breaks down into nine possible sections where LEED points could be received. The project will meet the fundamental building systems commissioning, minimum energy performance, and fundamental refrigerant management once final documentation has been completed. The project will be awarded points in the optimize energy performance section, enhanced commissioning, enhanced refrigerant management and lastly measurement and verification. Thirteen points were awarded while six were denied to the project for the section, optimize energy performance. The project has been awarded two points for enhanced commissioning and enhanced refrigerant management and three points for the measurement and verification section of energy & atmosphere. These are appropriate areas that the project can achieve points with appropriate documentation of course.

The areas of energy & atmosphere that were not awarded points are the on-site renewable energy and green power. These two were expected and are appropriate because Turner and the owner have not considered installing renewable energy sources. In consideration of green power, the resolution of this section was appropriate because the energy will be purchased if needed with the feasible cost.

Materials and Resources

The materials and resources category creates an incentive for owners to utilize salvaged materials, highly renewable materials, materials that possess a high amount of recycled content, and locally extracted and processed materials. This category requires the owner to help reduce the amount of solid waste that is disposed of in landfills. The Concordia project got eight points for the materials and resources category which breaks down into nine sections where points could be earned. The points earned in this section were appropriate to the project and the owner's goals. The project plans to achieve the storage & collection of recyclables with accurate documentation and tracking. The building reuse category allotted two points to the project for its reuse of existing wall, floors and the roof. Two points were also earned in construction waste management with 50% diversion of waste. Recycled Content succeeded in applying 2 points to the project, this is a required initiative outlined by the specs which wil be thoroughly tracked in construction. The last points to be earned were one point in local/regional materials and lastly in certified wood. These points were all appropriate because they met the project and the owner's goals.

The areas that did not meet the requirements were building reuse, materials reuse and the last was rapidly renewable materials. The building reuse section was not pursued because the interior nonstructural elements were all gutted and removed to make way for fresh new interiors. The materials reuse and rapidly renewable materials credit was not pursued.

Indoor Environmental Quality

The indoor environmental quality promotes the quality design of an indoor environment which increases natural day lighting and improves indoor air quality. It is an important category which focuses on occupant health. In the indoor environmental quality category there were seventeen sections where fourteen points were achieved. The project will meet the required minimum Indoor Air Quality (IAQ) performance and the Environmental Tobacco Smoke (ETS) control. The project will essentially meet every section in this category appropriately. The project will meet all these credits with the proper documentation required in the specifications and through its development of an IAQ management and testing plan.

The project was denied one credit in indoor chemical & pollutant source control.

Innovation in Design

Innovation in design provides incentives to the design teams to be innovative in the development of alternative sustainable design solutions. This category was broken up into ten sections in which six points were accepted. The three sections that were denied are innovation in design waste management, EP SSc4.2 and EP MRc2. Waste management was not met due to having already committed to waste audits.

The second was not met due to only being able to achieve one SSc4 exemplary performance point. And the last section was not met simply because if the MRc1.1 credit achieves 55%, this credit will likely not reach 95% diversion.

Regional Priority Credits

The regional priority category focuses on credits for region based environmental factors. Only one point was achieved in region specific environment priority because of the ability to achieve this credit based on MRc1.1.

*Critical Evaluation*

These categories were all important when composing the overall LEED certification of the Concordia project. It was the goal of the owner to acquire LEED consideration and certification on this project in order to reduce lifecycle costs, to be considerate of the environment and improve occupant satisfaction. LEED certified structures have many benefits which include increased occupancy, higher real estate fees and increased employee productivity. These are just a few of the key benefits that LEED buildings offer. The owners had a strong desire to create a high efficiency building that properly balanced the environment and the customers it services. It was decided after careful consideration of the LEED points earned that a LEED Gold certification is appropriate and meets the owner and the project's goals.

## Schedule Acceleration Scenarios

*Critical Path*

The initial critical path ran through demolition, micro-piles, new structural core, elevator installation, and finally the MEP system installation and commissioning. It was critical to complete the demolition in a safe and timely manner paying close attention to shoring for each of the floors as demolition moved throughout the structure. Due to the structures close proximity to surrounding residential structures there were restrictive work hours. Turner construction workdays were restricted due to noise ordinances and work could not begin until after seven.

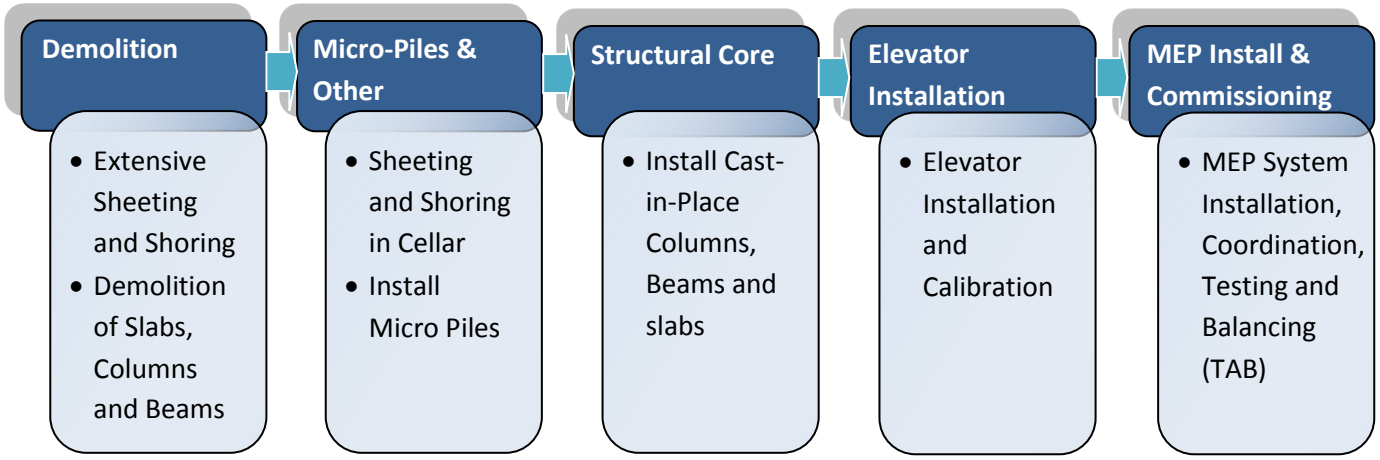


Figure 3 critical path

*Schedule Risks*

Some of the biggest risks to the project completion date included the resolution of existing building problems, existing conditions which varied from design, design changes made by the owner, difficulty completing work in some tight space conditions and lastly overall coordination of the MEP systems with its many complications.

Key existing building conditions required an extensive demolition initiative which posed a potential risk to the schedule. The demolition activities included removing the existing stairwell/elevator core, existing slabs and the entire façade. These demolition efforts were required to make the stairwell/elevator core larger, install new steel staircases and the new façade. These tasks, required precision and above all safety, which slowed progress. After demolition the rehabilitation actions began for the non-demolished, existing structural systems.

The resolution and rehabilitation of the existing structural system presented a risk to the schedule due to tight spaces and the extensive structural improvements. The main structural efforts were micro-pile drilling to strengthen the foundation and new structural beams, columns and Carbon Fiber Reinforcement Panels (CFRP) to strengthen the slabs. Installing 78 micro-piles and their pile caps, in the cellar level a very confined space, caused a strain on productivity. The structural advancements critically impacted the design and coordination of the placement of the MEP systems.

The MEP system installation posed a risk to the schedule, which was caused by potential clashes with the structural systems and the restrictive overhead space. In order to counteract that risk a large amount of BIM design was implemented to coordinate quality construction while preventing clashes. The BIM product was used to design the MEP system, determine the core drill locations and assure no clashes between MEP systems or core drills and CFRPs.

The precise locations for the core drills were required to meet the high quality and coordination of the MEP systems and the partitions that concealed them. Accuracy for these penetrations was required so as to not cut through CFRP's. Making just one cut into the CFRP would render it structurally inadequate.

*Acceleration Options*

The key areas that have the potential to accelerate the schedule include, the sequencing of the demolition, bringing in a second micro-pile drilling crew, expediting deliveries of materials with long lead times and accelerating several trades. While some of these opportunities have already passed it is crucial to understand what areas could have been accelerated. It is also crucial to understand the risks associated with each of these scenarios due to the fact that these risks can outweigh any advantages to implementing acceleration. A careful consideration must be made of the cost, which will result from such accelerations and whether or not they outweigh the benefits of the time gained.

*Acceleration Techniques & Costs*

Conducting demolition on multiple floors, either two to three is a great technique to help accelerate the schedule. The cost would be minimal and the technique would be simple to implement a new sequence of demolition. Conducting demolition efforts on two to three floors at a time will have increased crew size costs and shoring on the floors being demolished. There is also a great deal of risk associated with conducting demolition on multiple floors these risks can be assessed and minimized. While there are costs and risks involved with this scenario the capability of it to accelerate the schedule is a beneficial outcome.

Completing the micro-pile drilling required in the cellar level more efficiently is another great opportunity for schedule acceleration. This task creates risks for the project moving forward and a disruption to the sequence of the construction project. A technique that can decrease this tasks duration is bringing in a second crew and a second piece of equipment. This acceleration scenario would result in an increased cost due to crew size and the cost of the second piece of equipment. The cost of bringing in a second crew and piece of equipment is high; however, the potential for it to accelerate the schedule is a beneficial outcome. There is also a risk of deteriorating productivity due to cramped spaces, safety concerns and coordination issues. High costs are not only associated with this technique it is also seen when expediting equipment and materials with long lead times.

Expediting equipment with long lead times is a great way to accelerate the schedule and complete work concurrently. Equipment such as generators, switchgear, air handling units and any other major MEP systems can be rush designed, fabricated and delivered in order to maintain or accelerate the schedule. It can be very expensive to apply this technique to the project; fortunately, the owner is willing to consider the cost in order to prevent greater loss of revenues. Expediting equipment will only supplement the deliveries; the schedule will require overtime and an increase in laborers in order to be maintained

The main technique that will be used to accelerate the schedule is through the utilization of overtime. This project is on a very tight schedule and it has become apparent that meeting the project completion date of December 23rd 2012 is no longer possible. New plans have been made to attain the final punch list and turnover February 13th 2013 through the utilization of this schedule acceleration technique. This is a very viable technique, however there will be costs associated with its implementation.

Studies have found that loss of production can be very harmful and counterproductive to utilizing excessive overtime. The AACE International Recommended Practice No. 25R-03 Estimating Lost Labor Productivity In Construction Claims states that "Acceleration (directed or constructive)-The deliberate or unintentional speeding up of a project may result in lengthy periods of mandatory overtime, the addition of second shifts, or the addition of more labor beyond the saturation point of the site or that can be effectively managed or coordinated, all of which may have distinct impacts on productivity,"(AACE International Recommended Practices). Located within the same document is a description "Excessive overtime-Numerous studies over many years have consistently documented the fact that productivity typically declines as overtime work continues. The most commonly stated reasons for this result include fatigue, increased absenteeism, decreased morale, reduced supervision effectiveness, poor workmanship resulting in higher than normal rework, increased accidents etc." One author has gone so far as to suggest, "…on the average, no matter how many hours a week you work, you will only achieve fifty hours of results." The thought underlying this statement is that while overtime work will initially result in increased output, if it is continued for a prolonged period, the output may actually decline for the reasons stated earlier. Thus, long term overtime may lead to increased cost but decreased productivity. The effect of continued overtime work on labor productivity is, perhaps, one of the most studied productivity loss factors in the construction industry."(AACE International Recommended Practices). A reputable faculty member in the PSU AE program states that he has experienced this and believes that laborers working 6-8 hour days a week have a productivity loss of 20-30%. Often times these laborers are watching the clock on the sixth day and productivity suffers from it. With this said the other critical issue is safety risk involved with this schedule acceleration scenario. With overtime work accidents increase and these typically include minor accidents that can add up to be a serious harm to production on a project.

Some of the activities that have the opportunity to accelerate the schedule include the mechanical piping system, the elevator, window installation, framing/drywall; interior finishes and lastly plumbing trim out. These trades can be accelerated through overtime and bringing in extra laborers to help complete the outstanding work. This initiative has the likelihood to accelerate the schedule; however, it runs the risk of increased cost and reduced productivity. Overtime can be very expensive; in this case it outweighs the cost of not meeting the project completion date.

While overtime costs have been estimated based on labor rates and estimated time for completion, the penalties for not meeting the project completion date has to be considered. I have estimated that the Turner Construction Company is to be penalized $32,000 a day for the delayed occupancy. This is considering 80% occupancy of 100 rooms at $400/night. Some of the costs of this application of overtime have not been listed and they include things like productivity loss, safety and housekeeping issues. Considering that the Turner Construction Company could be more that 30 days over schedule this results in a penalty of almost a million dollars. The 30 days over schedule will also cause losses associated with general conditions costs that were not originally budgeted for. The overtime currently seems to be a

viable option for schedule acceleration; however, this will be more thoroughly addressed next semester in the spring.

| Mechanical Piping System | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|
| Workdays | # of Tradesmen | Hrs/Day | # of Days | Premium Rate | Total Cost | Start Date | Finish Date | Due to the nature of the VRV piping installation, there are a limited spaces for extra laborers |
| M-F | 10 | 3 | 35 | $22.00 | $23,100.00 | 2-Oct | 16-Nov | |
| Sat | 8 | 8 | 6 | $22.00 | $8,448.00 | 2-Oct | 16-Nov | |
| | | | | Total | $31,548.00 | | | |

Table 1 mechanical piping system

| Elevator | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|
| Workdays | # of Tradesmen | Hrs/Day | # of Days | Premium Rate | Total Cost | Start Date | Finish Date | This acceleration will achieve an early construction elevator by December 15th, Final elevator inspection and turnover is Jan 17, 2013 |
| M-F | 6 | 3 | 60 | $50.00 | $54,000.00 | 8-Oct | 4-Dec | |
| Sat | | | | | | | | |
| | | | | Total | $54,000.00 | | | |

Table 2 elevator

| Window Installation | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|
| Workdays | # of Tradesmen | Hrs/Day | # of Days | Premium Rate | Total Cost | Start Date | Finish Date | This will be monitored and could serve the intended purpose in less time. Once window installation is sufficiently ahead of interior wall rough-in and framing, this OT can be stopped. |
| M-F | 8 | 2 | 15 | $20.00 | $4,800.00 | 29-Sep | 13-Oct | |
| Sat | 8 | 8 | 4 | $20.00 | $5,120.00 | 29-Sep | 13-Oct | |
| | | | | Total | $9,920.00 | | | |

Table 3 window installation

| Framing/Drywall | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|
| Workdays | # of Tradesmen | Hrs/Day | # of Days | Premium Rate | Total Cost | Start Date | Finish Date | The current assessment of This acceleration is that it should be short term and monitored closely. We need to get internal framing out in front of the rough-in trades to allow multiple floors of in-wall rough-in to become available. |
| M-F | 21 | 2 | 10 | $20.00 | $8,400.00 | 8-Oct | 19-Oct | |
| Sat | | | | | | | | |
| | | | | Total | $8,400.00 | | | |

Table 4 framing/drywall

| Plumbing Trim-Out | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|
| Workdays | # of Tradesmen | Hrs/Day | # of Days | Premium Rate | Total Cost | Start Date | Finish Date | This is based on the possible need reduce negative float on the final fit-out. Use of this will be evaluated and re-considered prior to implementation. |
| M-F | 5 | 2 | 30 | $20.00 | $6,000.00 | 6-Nov | 18-Dec | |
| Sat | | | | | | | | |
| | | | | Total | $6,000.00 | | | |

Table 5 plumbing trim-out

| Interior Finishes | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|
| Workdays | # of Tradesmen | Hrs/Day | # of Days | Premium Rate | Total Cost | Start Date | Finish Date | This will be based on opportunities identified/forecasted on a weekly basis to insure maximum negative float values are reduced |
| M-F | 10 | 3 | 40 | $25.00 | $30,000.00 | 1-Nov | 1-Jan | |
| Sat | 10 | 8 | 8 | $25.00 | $16,000.00 | 1-Nov | 1-Jan | |
| | | | | Total | $46,000.00 | | | |

Table 6 interior finishes

## Value Engineering Topics

*Description of VE Use on Project*

In order to save costs to the owner, the Turner Construction Company proposed multiple alternatives to finishes for both the interior and exterior and many other areas of the construction project. These alternatives were proposed to the owner and investigations were made into the potential cost savings that could be achieved through the adoption of these alternatives. After weighing the saving potentials with the potential costs, decisions were made to accept certain alternatives if they in fact met the owner's goals. There were many key areas that were considered, however, only a select few were actually implemented. The key areas included exterior finishes, plumbing, HVAC/plumbing, roofing and interiors.

*Link of VE to Owner's Goals*

The Turner Construction Company wanted to meet the owner's goals which were low cost, low maintenance, high quality, high aesthetic appeal and employing products which environmentally friendly. Many of the alternatives did meet the goals of the owner; however, a select few alternatives did not possess a strong correlation to the owner's desires.

The Turner Construction Company considered replacing the exterior finish on the southern side of the structure. They considered a replacement of the Arriscraft veneer Panels with Stucco finish on the exterior sheathing and metal stud with insulation and air barrier on the southern façade. This exterior finish was considered and implemented on the southern facing side because it had the least amount of visual exposure. This change correlated to the owner's goals by providing a savings potential without the loss of aesthetic appeal.

The second value engineering proposal was to replace copper piping, for domestic water at the bathroom units, with CPVC pipe. This has been an option that the owner was willing to consider due to the savings potential and the advantages of its high construction quality, corrosion resistance and noise reduction. Since this product is not recyclable it detracted from the owner's goal of utilizing environmentally friendly materials.

The next few areas to be analyzed were the millwork and interiors specifically in the guestrooms of the Concordia. It was proposed that there could be a cost savings associated with cabinetry by purchasing manufactured products rather than custom-made cabinetry. While this has met the owner's desire of saving money it does not meet their goal of high design quality and aesthetic appeal. The other value engineering alternative associated with the guestrooms is an alternative countertop material. Turner Construction Company has proposed alternatives to this with Avonite tops with SSM Carocin. While this meets the owner's goals of saving money it does not meet the goals of high quality and the aesthetic appeal.

Access panels were the next portion of the project that was considered in value engineering. It has been proposed to provide "stealth" panels to replace the specified panels requested by the design team. While this resulted in an increased in cost it met the goals of the owner with aesthetic appeal and high quality finish.

Turner Construction Company considered scored stucco finish to replace metal composite panels in order to meet the owner's goals of cost savings while still maintaining high quality. The Construction Company considered a Sovent System to replace sanitary venting in order to meet the owner's goal of saving cost while still maintaining a high quality of construction.

Utilizing CPVC piping to replace steel sprinkler piping was considered in order to save cost while still maintaining quality construction. Value engineering was proposed in order to replace the ThermoPlastic Roofing (TPO) with a hot fluid applied membrane in order to once again meet the owner's goal of saving costs for the project while maintaining a high quality of construction.

*Ideas for VE Not Implemented*

Many ideas were considered for this project, unfortunately, only a select few were actually implemented on this project. Some of the specific items that were considered but not implemented were a change of interior paints, deleting a ground loop, alternate wall system, lighting fixture alternatives, eliminating IT capabilities, an alternate door control system and lastly eliminating Sustainable materials. The specific detail of each VE idea that was not implemented is presented below.

One idea that was not implemented was changing from a special interior paint to one of a lesser quality. "Scuffmaster" is an interior paint that is harder to scuff or mark, it was proposed that this be replaced a standard and cheaper paint. The owner decided that they wanted to stick with the "Scuffmaster" because it had the potential for lower maintenance which outweighed the possible cost savings. The next system that was assessed but not implemented was the camera systems. While an alternative was suggested it did not meet the owner's stringent standard of quality. Value Engineering suggested

Another suggestion was deleting the ground loop system for the lighting system based on the idea that the structure could be grounded without a tie-in to ground loop. This idea was not implemented because the engineer did not recommend acceptance because of the safety issues associated with it and the fact that the savings were minimal.

An alternative to the cast in place concrete at the stair and elevator shafts was to install reinforced masonry CMU walls fully grouted. This proposal was not accepted because the engineer stated, "Existing structure doesn't meet current structural codes requirements-if accepted this re-design would trigger bringing structure to current code."

The lighting fixtures were next to be reviewed which was to reduce quantities and changing the specifications in the back of house areas, which would result in a reduction of the branch wiring. While this met the owner's desire to reduce costs it did not correlate with their initiative to maintain a high quality of construction and aesthetic appeal.

The Turner Construction Company also considered deleting video teleconferencing in the boardroom/conference room. This idea was not accepted because even though it did have cost savings potential it did not maintain the owner's standard of high quality.

The entry door control system was value engineered in order to find a system of lesser cost with the same capabilities. This idea was not applied due to the fact that it did not maintain quality even though it had a great potential of savings costs.

The last value engineered system that was considered but not implemented was to eliminate FSC certified wood for the millwork in the guest rooms. This was not applied because of the desire of the owner to attain a LEED Gold rating.

## Critical Industry Issues

I attended two sessions, the first session was Integrating Strategies and Technologies and the second session was Modularization. Below is a summarization of the results of these sessions, the most surprising details of these discussions, some of the issues that might affect or be applied to my project and lastly a listing of the key contacts that will be capable of advising me in the area of interest.

Session 1: Supply Chain 1A-Integrating Strategies and Technologies

*Summary*

The first session I attended at the PACE Roundtable was 1A Supply Chain Integrating Strategies and Technologies. The result of this meeting was an in depth exposure to the ideas related to material deliveries and many of the logistical issues associated with their delivery. It exposed me to the possibility of improving a project's delivery with proper management of these critical issues. There were many examples to help understand the ideas associated with Integrating Strategies and Technologies. One of the most notable examples was a company delivering stone from India. The delivery of the materials was a logistical nightmare because of the long distance, time zone differences, language barrier and the logistics associated with having that material shipped overseas. The main theme of the discussion was to consider the many steps that must be taken to ensure that materials are delivered in a timely fashion.

These steps include an early procurement and risk planning for the many complications with delivery of materials. The steps for ensuring a timely delivery include early ordering to plan for long lead times and planning for the many logistical risks associated with the delivery and transport to the construction project. Taking a leadership role, having follow-through and assuming the risk associated with ordering the projects, whether by the owner or the contractor, can make a difference between whether the materials are delivered on time or behind schedule. Some of the facilitators that help relieve the logistical issues associated with delivery are the advances in technology that have been developed in the past few decades. These include the many advancements to help streamline and track the delivery of materials to the construction project and finally to the location of installation. This tracking employs the use of bar codes, which in turn can be used for operation and facility management to facilitate the owner's operation of a highly efficient building.

Another step that can be taken in order to assure the successful project delivery is storage options that can outweigh the costs associated with delays due to materials not being delivered on time. Companies have ordered and delivered materials to storage in order to take advantage of cost savings due to likely inflation and savings in preventing delay in the project completion date. With the storage of materials and products there are several restrictions on what materials and systems can be stored for an extended amount of time. For instance, products like medical equipment cannot be stored for a long time based on the fact that hospital owners and medical staff require the most up to date equipment. Medical equipment is usually ordered and installed right away in order to provide owners and staff with the most up to date systems.

Another system that cannot be stored for a lengthy period of time is major MEP systems which will result in fouled bearings and bad seals if they are stored for a long period of time.

This is a brief summary of the many discussion areas and the issues associated with each of these areas. Many of the ideas and issues presented were surprising to me and allowed a greater consideration for their effect in project delivery.

I have learned about the many issues with long lead times for generators and switchgear in my undergrad and graduate coursework; however some of the details present during this discussion were surprising to me. The idea of storing materials in order to take advantage of costs savings was very interesting to me. Bill Moyer of Davis Construction stated that his company was storing materials for a project for approximately two and a half years. They were storing a prefabricated façade system, in order to take advantage of cost savings associated with material inflation and the savings associated with no schedule delays. Having all the phases of the construction materials developed at one time was an initiative to take advantage of savings with a larger scale order rather than several smaller orders. I have heard of storing materials but never have I heard of storing such a large system for so long. I was also surprised to hear the many examples that were offered by industry members that showed the many logistical issues with getting materials and products delivered. Industry members like Bryan Franz and others brought up key examples that helped illustrate the complications with the delivery of materials and products. Another example was a delivery of stone from Italy that got stuck in customs for three months causing delays and headaches for the project team. Early procurement and risk planning might have helped alleviate the delays in the delivery of this system and result in a successful project completion which is an issue that can be analyzed with my project.

*Areas of Interest*

The issues of managing deliveries, materials and all the parties involved with the delivery is a likely area of analysis that can be applied to my project. Since the project site is located in the heart of D.C. the site is extremely restrictive preventing a large amount of material staging. Applying ideas of managing procurement and the risks associated with early procurement will be key to assuring that the materials, products and systems are delivered in a timely fashion. Storage of materials at an off-site location is an issue that should be considered in order to outweigh the costs of productivity loss and congestion on site. Employing just-in-time delivery of these systems from storage facilities will also be beneficial to reducing the congestion of the site and improving productivity. Understanding the parties involved with the production of materials and systems will facilitate this initiative to increase productivity and increase the chances of timely delivery. Having an awareness of the major players and digging into where a material comes from, where it is sourced and making sure materials are going to be coming when we need it will help increase the odds of a successful project completion. I hope to analyze the storage of materials at an off-site storage facility for many materials like Carbon Fiber Reinforcement Panels (CFRP) and major MEP systems. I would also like to analyze the key players in the production of the façade and assess the areas in which these deliveries could be optimized and if the materials could be stored at an off-site facility. Understanding these steps and the key players associated with them is a crucial factor in producing a successful project and this understanding will be facilitated by key contacts in industry.

Some of the key industry players that can help provide a greater understanding of these key issues include Bill Moyer of Davis Construction and Bryan Franz a PHD candidate in the Pennsylvania State University (PSU) Architectural Engineering (AE) program.

Session 2: Supply Chain 2A-Modularization

*Summary*

The second session I attended at the PACE Roundtable was 2A Supply Chain Modularization. The results of this session are extensive and I have composed a brief summarization of this session. We first spoke of the trends of modularization specifically discussing the areas that are typically modularized to help improve efficiency of a project. Areas that are typically modularized include MEP systems such as piping, ductwork, conduit and now even finishes. Modularization is moving into a direction of multi-trade application to improve quality and accelerate the schedule. Increasing attention is being paid to the prefabrication of drywall, interior finishes and even systems as extensive as concrete. This idea can also be applied to areas like formwork, curtain wall, bathroom systems, headwalls, casework, brick panels, central utility plants, pipe racks, and the stud back-up panels.

Next, we spoke about the extensive amount of planning and initiatives that must be taken in order to apply modularization to a project. It is critical to begin a design with the intent of employing modularization rather than taking a finished design and planning to modularize it. It is much more effective to meet modularization requirements when one designed accordingly. Early involvement is critical in the design phase when utilizing prefabrication and modularization. Bringing the end users together and in early in the design of the project is important, especially where areas are repetitious. The delivery method of the project can either hinder or facilitate the completion of the application of modularization.

The last thing that industry members discussed with students was some of the disadvantages associated with modularization. Some of the disadvantages included the extensive amount of planning, site logistics, tolerances, aesthetics, and modular size. In reference to planning, it is the planning associated with designing a project to be modularized rather than working backwards. When it comes to site logistics it is important to plan the fabrication space and the laydown area for deliveries. Extensive planning should be used when considering the sequence of work to be completed.

Tolerances are another important detail to consider when stacking modular units because any discrepancies on the lower units will be exaggerated in the modular units above. Aesthetics of the modular units is important to provide aesthetic appeal and to hide the fact that the units were prefabricated. The sizes of the modular units are restricted by the capabilities of the vehicles shipping them to the construction site. Summarizing the main points of the discussion really brought attention to some very surprising details.

Some of the most surprising details were the extent of planning in design involved. The second most surprising detail was the fact that delivery methods have an effect on the project's success, Lastly, is the large amount of disadvantages that will prevent this idea from being implemented on a project. I thought it was very interesting and surprising that it is crucial to design a project to be modularized rather than taking a finished design and making it capable of being modularized. I was surprised to find that

implementing modularization is greatly impacted by the delivery method. A design-build is more likely and more capable to produce a modularized product compared to a CM @ risk. This is because more of the subcontractors get together with the construction manager and the owner to coordinate and plan how to construct modularized units with multi-trades. As I stated previously, there are more than several disadvantages associated with the application of modular units, however, these are typically outweighed and planned for as a result reducing costs for equipment rentals and accelerating the schedule.

*Areas of Interest*

Since my project is a renovation that resulted in completely gutting the MEP systems, interior partitions and finishes and lastly a demolition and reinstallation of a new façade there is a great potential for modularization of these systems to improve the project and to successfully meet the project completion date. My hopes are to design modular systems for the MEP and interior partitions as well as the façade. The project had a very restrictive space overhead so designing a modularized MEP system and constructing a mock-up would help clarify any design oversights and highlight areas for improvements. These are critical issues and a better understanding of these issues and how to move forward with this application will be better understood through communication with industry contacts.

The key industry members that I met and that will advise me on this matter will be Mr. Raj Vora of Southland Industries rvora@southlandin.com and Mr. Charles Tomasco of Truland Systems Corporation ctomasco@truland.com.

*Student Panel-Integrated Educational Experiences*

Many discussions and industry trends are leaning more and more towards applying collaborative approaches to the construction industry. This application has found many advantages and benefits with reduced cost, change orders and design flaws. The industry is adopting this more and more as a standard and as a requirement. This push in industry has resulted in the exposure in of collaboration BIM/IPD in college settings.

The Pennsylvania State University offers student exposure to multiple disciplines to enable us to be capable of solving key construction issues. This multi discipline exposure has been exemplified in the universities' approach to providing opportunities for the different disciplines to collaborate. This extensive collaboration is employed to give students a greater experience of teamwork across the field that would typically be experienced in the work field. Four students presented, moderated by Professor Robert Holland, the many benefits of taking a BIM collaborative studio and a BIM collaborative thesis. They discussed their opinions of the program and their good and bad experiences associated with the program. Students discussed what each of their reasons was for enrolling in the program. Students also discussed what some issues were with deciding leadership, direction, design, and responsibilities of each team member based on their discipline and/or background. For the most part all the students had very positive and challenging experiences that will benefit them in their future career paths.

*Industry Member Discussion*

Prior to the conclusion of the 2012 PACE Roundtable industry members met with 3-4 students to discuss their project. Industry members began with questions about the size, location, cost, delivery method and type of project. Once they had these details they moved on to ask which sessions we attended and what

details stood out the most to us in reference to application to our project. I spoke with Michael BarnHart and Brooke Exley of Forrester Construction Company about my project and the research areas I am considering to explore.

In reference to the breakout session 1, Supply Chain 1A-Integrating Strategies & Technologies, I spoke to them about my interest in improving site logistics and deliveries of the materials to the site. The project is in the middle of DC and therefore the site is very cramped and does not allow for much material lay-down or shake out so many materials will be installed directly from the delivery truck. For the Concordia project my goal is to propose just-in-time delivery through the careful coordination between all the parties involved with the materials' ordering, fabrication and delivery. Researching each system and understanding the key players will be beneficial to planning these operations.

I discussed my experience in breakout session 2, Supply Chain 2A-Modularization, and the details that stood out to me. I was very interested in this session because of the ability to apply it to the Concordia project. The Concordia project is an extensive renovation of the structure, the façade, interior finishes and the MEP systems. This project is a great candidate for the application of modularization and prefabrication to the construction process. I plan to complete extensive research on planning and applying modular designs. After discussing with Michael and Brooke they agreed that I have a great opportunity to apply this research after an assessment of the costs they imagined that the delivery and cost of construction would be vastly improved.

*Suggested Resources*

- Integrating Strategies and Technologies
  - Bill Moyer of Davis Construction bmoyer@davisconstruction.com
  - Bryan Franz a PHD candidate in the Pennsylvania State University (PSU) Architectural Engineering (AE) program bwf114@psu.edu
- Modularization
  - Mr. Raj Vora of Southland Industries rvora@southlandin.com
  - Mr. Charles Tomasco of Truland Systems Corporation ctomasco@truland.com

## Problem Identification and Technical Analysis Options

*Problematic Features*

After completing three technical reports and analyzing the multiple facets of this project I have identified several problematic features of my thesis project that could be pursued through a detailed analysis of technical building systems and construction methods. The key problematic features of my thesis project have arisen with the site logistics, extensive demolition and rehabilitation of the existing structure, the roofing system, MEP systems and façade. I also plan to address the application of a green roof system or a cool roof system combined with on-site renewable energy sources. These features provided complications to the construction project and they could be solved through a detailed analysis of technical building systems and construction methods. The key to conducting this detailed analysis is through extensive research and understanding of the building systems alternatives that can be used.

*Consideration of Methods*

Analysis will be completed through the research of alternate building systems and application of modeling software. The research of alternate building systems and having a greater understanding of their advantages and disadvantages, one will be more capable to support proposed alternatives. I will complete my analysis of these problems by researching the applied systems and their potential alternatives. After conducting a thorough research of the alternative and applied systems I will do a detailed assessment of the advantages, disadvantages of cost, constructability and logistical issues associated with each system. I plan to specifically research ENR, construction journals, conduct interviews and meetings with faculty and staff to understand and consider alternate systems. Once I have gathered all these details I plan to discuss with more industry professionals to get their opinions on any other possible alternatives and their opinion on these alternate systems. Only once all this information has been gathered can I critically assess the alternatives for their applicability. I will utilize Excel to compare the results of my research of the different systems. Conducting an analysis of the design and construction will be completed via the application of BIM. The application of the BIM product will create many benefits associated with the design and construction of the many complicated portions of the project. BIM will help facilitate the analysis of alternate means and methods of construction. This is the method I will apply to research the specific building systems I will propose alternative systems for.

*Building Systems Research*

Having a greater understanding of the different types of structural reinforcement options can allow for critical assessments of alternate systems and the advantages associated with them. My goal is to analyze the CFRP's and consider other means for strengthening slabs and other members. I plan to analyze the many alternatives for strengthening a structure and making comparisons of each different system based on cost, constructability and logistical issues. Conducting a thorough search of new and advance façade and curtain wall systems will facilitate a proposal of an alternate system. My goal is to also consider the MEP systems to see if alternatives could be applied to improve the efficiency of the systems. Considerations will also be made of on-site renewable energy sources and the systems that they employ. Thorough analysis and research of these systems is critical to my proposal of viable alternate systems. Research will be conducted on the green roof and cool roof system to have a better understanding of the two different system types. This research will be critical in order to better understand the design and construction issues associated with each system.

*Design and Construction Analysis*

Using BIM for the design and construction analysis will help solve the problematic features of the Concordia project. BIM will be used in order to thoroughly plan out site logistics, sequencing of trades, design, coordination and lastly installation of MEP systems. The BIM design will help analyze the demolition sequence and help show a progression of the construction process through the utilization of 4D Modeling. My goal is to create a model that can be used by the superintendent to track progress and productivity. I hope that the model can be used to improve productivity and accelerate the demolition schedule safely and efficiently. I also plan to use the BIM model to coordinate the installation of the

CFRP's. I believe that the Benefits of improving productivity will be achieved once again through the application of the BIM product. The BIM product will also provide benefits associated with the MEP system design, coordination and installation. The Turner Construction Company constructed a BIM product to undertake this responsibility and they noted the many benefits associated with design, clash detection, and core drill locations for the MEP system. BIM will also facilitate the planning and design of modular units and it will improve site logistics with the sequencing of deliveries and installation. BIM will provide many benefits and will likely solve many of the problematic features of the Concordia Project. In order to propose alternative systems it is critical to understand the design and constructability issues associated with each alternative. Conducting analysis of schedules, scales of systems, and productivity of installation will allow for an accurate assessment of the schedule and construction impacts that the alternates will have. Understanding the impacts of the alternate systems will allow for justifications and rationalizations of new system types that will solve the problematic features of the building.

1. Application of BIM more extensively
    a. Demolition
    b. Site logistics
    c. MEP system design, modularization/prefabrication and installation
2. Alternative structural rehabilitation methods, facades, and MEP systems
3. Renewable energy sources
4. Green roof system

## Work Cited

1. http://www.sde-us.com/docs/emailblasts/JetBlue/LostLabor.pdf

Student Name Ian Bauer

**Session #1**

Topic: Supply chain - Integrating Strategies + technologies

*Research Ideas:*

(1) Managing deliveries, materials and all of the parties involved

(2) Technology opportunities for tracking material deliveries

**Session #2**

Topic: Supply chain - Modularization

*Research Ideas:*

(1) starting with a modular design setup rather than trying to take a finished design and trying to modularize it.

(2) delivery methods that facilitate modularization

**Industry Panel: Differentiation in a Down Economy**

*Research Ideas:* Student Panel, what are the advantages

(1) All students were typically satisfied with their experience with the BIM collaboration thesis and studio

(2) Difficult to decide on leadership, design direction and responsibilities of each member with all the multiple disciplines.

**Industry Member Discussion**

**Key Feedback:**

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

Modularization - understanding the planning and organization required to then deliver a modularized structure is extensive but necessary. Soon modularization could be the standard.
- Modular construction is being applied more + more and companies are interested in taking advantage in the savings potentials
- understanding the analysis of the cost - benefit is key to justifying the application of this construction method.

Integrating Strategies + Technologies - Understanding materials + systems and who the key players are in the ordering, fabrication + delivery is key to keeping a project on schedule and assuring a successful project completion. It
- This is a relevant topic to industry because some materials are delivered long

**Suggested Resources:**

*What industry contacts are needed? Is the information available?*

Bill Mayer of Davis Construction bmayer@davisconstruction.com
Bryan Franz baf114@psu.edu
Mr. Raj Vora rvora@southlandm.com
Mr. Charlie Tomasco ctomasco@trufand.com