PENN STATE AE SENIOR THESIS 2011 - 2012

TECHNICAL ASSIGNMENT 3

Alternative Methods Analysis

BRIANNE KYLE
Construction Management
Thesis Advisor: Dr. Chimay J. Anumba

December 2, 2011

RIVER VUE APARTMENTS | NEW LUXURY APARTMENTS RENOVATION| PITTSBURGH, PA

Executive Summary

Technical Assignment 3 is intended to identify areas of the River Vue Apartments project that are good candidates for research, alternative methods, value engineering, and schedule compression. These areas will form the basis for the final thesis proposal. River Vue Apartments is the innovative reuse of the former Commonwealth of Pennsylvania State Office Building located in Pittsburgh, PA. Across from Point State Park in the Golden Triangle, these new luxury apartments will offer some of the best views of the city to its residents. The existing building was constructed in the 1950s, and the new construction project is a 295,000 SF renovation of the 16 story building. New additions, to transition from an office building to a residential building, include 218 apartment units, a two-story interior valet-parking garage on the basement and first floors, a small retail space of approximately 1,900 SF, a building party / media room, and a small fitness center.

For River Vue Apartment, the three unique and challenging constructability issues include renovation as-built drawing inconsistencies, two exterior wall systems, and elevator control wiring. Also, other important challenges are site congestion, existing site utilities, and MEP systems coordination. After extensive time, research and collaboration, the project team must be able to handle each constructability challenge throughout the project. The project critical path is the key to the project's success. It is split into and modeled as two critical paths; one for the fit-out construction and the other for the core and shell construction. The fit-out construction critical path includes demolition, MEP rough-in, interiors, and MEP finishes. The core and shell critical path includes demolition, elevators, fire protection, and the main HVAC systems. Any delays of the activities on the critical path can impact the proposed project completion date. Maintaining the elevators and stairs for vertical transportation through the sixteen-story building is the biggest risk to the project completion date. Since a temporary hoist is not used on this renovation project, the existing elevators and stair towers transport the construction workers and materials to all the floors. Therefore, two work shifts are utilized to minimize downtime for the renovation of the elevators. Value engineering topics that were implemented on the River Vue Apartments project include removing one of the two parallel water feeders for the sprinkler system, which changes the loop system to a single-feed system, and changing the types of lighting fixtures, tubing for domestic water lines, wire for main electrical feeds, and cable for fire alarm devices. The project team pursued these value engineering ideas because the overall project costs were reduced.

After completing Technical Assignments 1 and 2 and the in-depth analysis of the constructability challenges, schedule acceleration scenarios, value engineering topics, and critical industry issues, there are several problematic features of the River Vue Apartments project. These problematic features include as-built drawing inconsistencies, elevator renovations, site congestion, MEP coordination, overlapping scheduled activities, and LEED certification. Also, they could be pursued through a detailed analysis of technical building systems and construction methods. The technical analysis methods include building information modeling, the elimination of the inefficiency by prefabricating MEP system components, sustainable techniques, energy management services, and industry and the economy.

Table of Contents

Constructability Challenges

In general, renovation projects add numerous constructability issues that can affect the total cost of the building and the construction schedule. After discussing the River Vue Apartments project with Turner Construction Company's project engineer Mr. Kevin Ludwick, there are a few unique and challenging constructability issues on the project.

Renovation As- Built Drawing Inconsistencies

The River Vue Apartments renovation project is the reuse of the former Commonwealth of Pennsylvania State Office Building. The state office building was constructed in the 1950s and renovated in the 1980s. After the 1980s renovation, the as-built drawings were not updated to show the new elements in the renovated building. If the as-built drawings are not consistent with the final building result, some building elements can be found in the construction field that were not expected to be found. For instance, while demolishing the existing building elements on the sixteenth floor near Elevator #7, a structural column was located in the middle of a proposed apartment unit's bedroom (Apartment #1510). Since the column was located in the middle of the apartment unit's bedroom, the column either had to be relocated somewhere else in the bed room or the apartment layout would have to be redesigned. Figure 1 shows the column location (marked with a circle) in the middle of the Apartment #1510's bedroom.

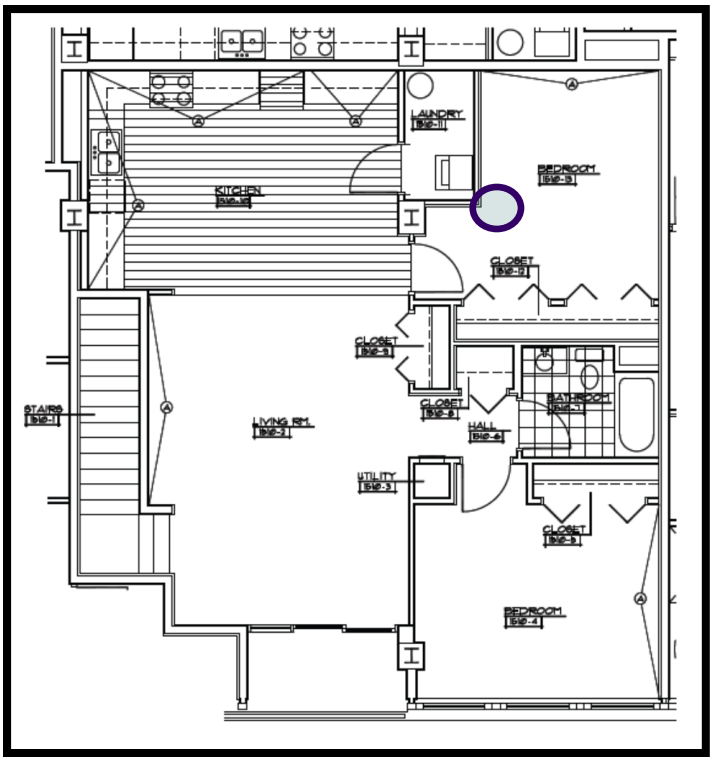

Figure 1: Original Column Location in Apartment #1510's Bedroom

To resolve this issue, Turner Construction Company contacted the structural engineers working on the project (Whitney Bailey Cox and Magnani, LLC) and the necessary subcontractors. After extensive time, research, and collaboration, the project team made a decision on how to solve the problem with the column. Redesigning the apartment layout could not be pursued because it would affect other trade operations such as MEP system components routing to the kitchen and bathroom locations and lighting spaces. If redesigning the apartment layout was pursued, it would cost more to redesign the MEP systems to accommodate for the column. Therefore, relocating the column was the approach pursued. The column was a structural and load-bearing column. Therefore, it could not be moved without the structural engineers determining how to transfer the load the column was carrying from the roof in its original location to its new location. After performing the necessary calculations, the structural engineers determine that the column could be relocated between the existing W10 and W16, shown in Figure 2.

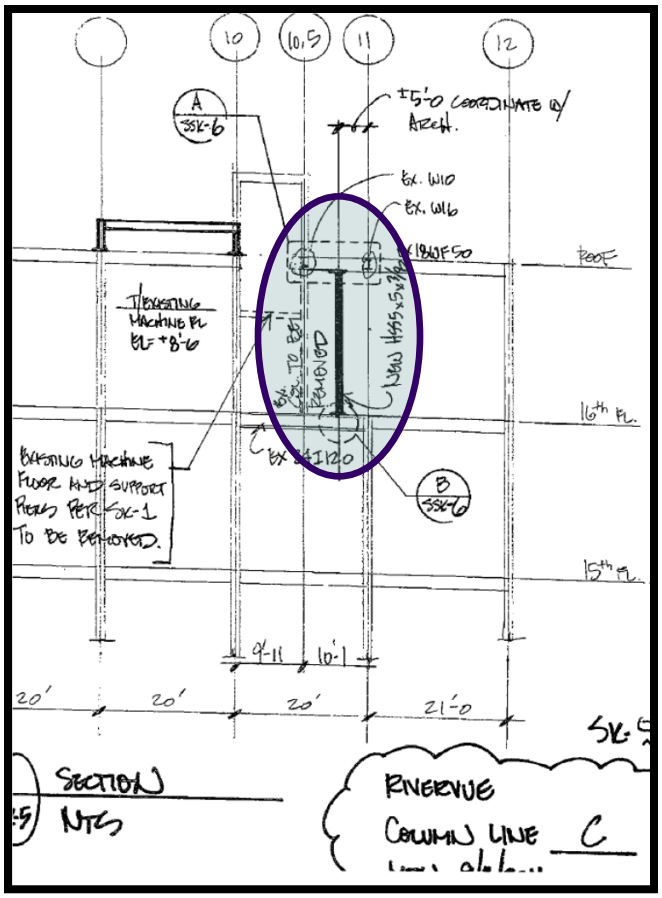

Figure 2: New Column Location

These design changes added time and material costs to the project. Also, since the design process took extensive time and research, the schedule was impacted as well because installation of other required building elements could not continue on that portion of the sixteenth floor until the column was moved.

Two Exterior Wall Systems

The River Vue Apartments building contains two exterior wall systems. These two systems include the original curtain wall system from the 1950s and the newer metal panel system mounted to the original curtain wall system during the 1980s renovation. The metal panel system is causing constructability issues. For instance, on the fifteenth and sixteenth floors, exterior inboard balconies are being installed for the private use of the apartment units' residents only. There are 18 balconies on each floor, and the total number of balconies is 36. For these two floors, the existing concrete slab system is 5-5/8" thick. To accommodate the new balcony slabs, the existing slabs on deck will be removed and replaced with new 5-5/8" normal weight concrete slabs with 1-1/2" x 20 GA composite deck. Also, after cutting the required existing steel, fill "T" double shear connections will be applied to the new steel components. Figure 3 and Figure 4 show sectional views of the new inboard balconies.

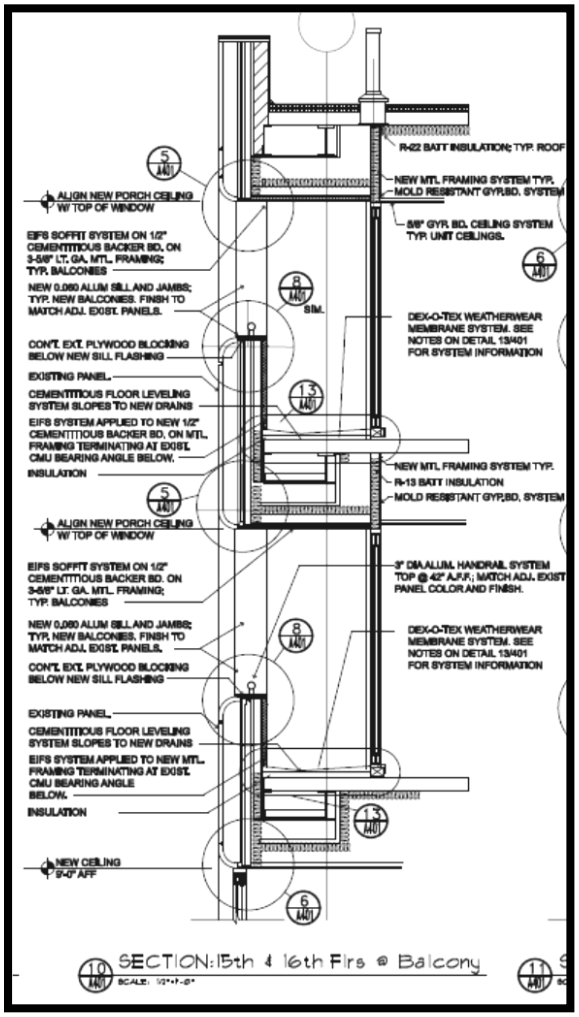

Figure 3: Section View of Inboard Balconies on the 15th and 16th Floors

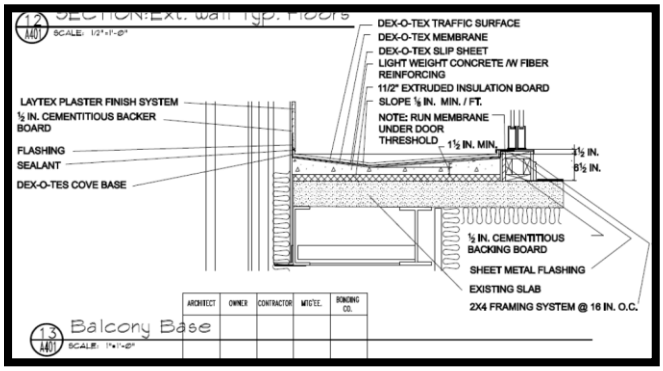

Figure 4: Section View of Inboard Balconies Slabs

During the construction of the new balconies, Turner Construction Company determined that the support and waterproofing details of the metal panel system added constructability challenges. The challenges occurred at the location of where the new inboard balconies and windows are to be installed. Specifically, during the bid period, the waterproofing details of the metal panel system were unknown. Since the details were unknown, numerous meetings with the designers and subcontractors were held to determine and finalize the waterproofing that would be necessary. In addition, the 1980s curtain wall system was a utilized metal panel system that the balconies penetrated in between multiple panel units. The integrity of the remaining panel units needed to be confirmed.

Elevator Control Wiring

With the existing transportation system, seven elevators originally occupied this building. These elevators include five main elevators, one freight elevator, and one small elevator on the south end of the building. Even though the freight elevator will remain for its existing function, the small elevator will be demolished. Also, only two of the main elevators will remain for building transportation purposes. These elevators will serve from the basement to the fifteenth floors, and they will be powered by the original elevator motors shown in Figure 5 and Figure 6. Two of the remaining elevators will accommodate the mechanical, electrical, and plumbing chases, and the last elevator will be in-filled with concrete.

Figure 5: Original Elevator Motors

Figure 6: Original Elevator Motors

The renovation process for the existing elevators has caused extensive investigation time to understand the control wiring involved. While attempting to remove three of the five main existing elevators, the control wiring malfunctioned. The malfunction occurred because the five existing main elevators are wired together to work and operate as one system. Therefore, removing three of the elevators from that "one system" has caused control issues. Also, to satisfy code requirements, the two remaining elevators used for building transportation purposes need to be modified, and this process is a challenge as well. After extensive time, research, and collaboration between the designers, general contractor, and the necessary subcontractors, the project team found that it is important to understand how the controls could work independently because it will help them better understand how they work together.

Other Constructability Issues

Site Congestion: Across from Point State Park and in the Golden Triangle, River Vue Apartments is located in the heart of Pittsburgh, PA. Since it is located on an urban site, site congestion is a challenge. It is a challenge because there is not enough room for staging materials and small equipment. Therefore, the first floor, which will be used as a parking garage when the building is completed, is used for staging throughout the project. Staging on the first floor can be utilized because the proposed parking garage work is not a significant amount at this time in the construction process.

Existing Site Utilities: The main issue with the existing site utilities was tying in the new systems to the existing systems. For instance, a new sanitary line needed to tie into the city sanitary line. Since this line is in use, the tying-in process needs to be coordinated.

MEP Systems Coordination: MEP systems coordination was extensive because of the existing steel and the tight constraints between the structure and future ceilings heights. The MEP designers coordinated their systems without using coordination software.

Schedule Acceleration Scenarios

Project Critical Path

A project's critical path is the sequence of project activities that contribute to the longest overall duration. It determines the shortest time possible to complete the project. Delay of the activities on the critical path impact the proposed project completion date. The project critical path is the key to the project's success.

For River Vue Apartments, the project critical path is split into and modeled as two critical paths; one for the fit-out construction and the other for the core and shell construction.

Fit-Out Construction Critical Path: Specifically, the fit-out construction critical path begins with the demolition phase of construction. When official work began on Monday, June 13, 2011, the beginning stages of the construction phase included the demolition of all the existing systems and asbestos abatement. After demolition, the project becomes a typical fit-out. The fit-out phase of construction starts with MEP rough-in, interiors, and finishes. This process is shown in Figure 7.

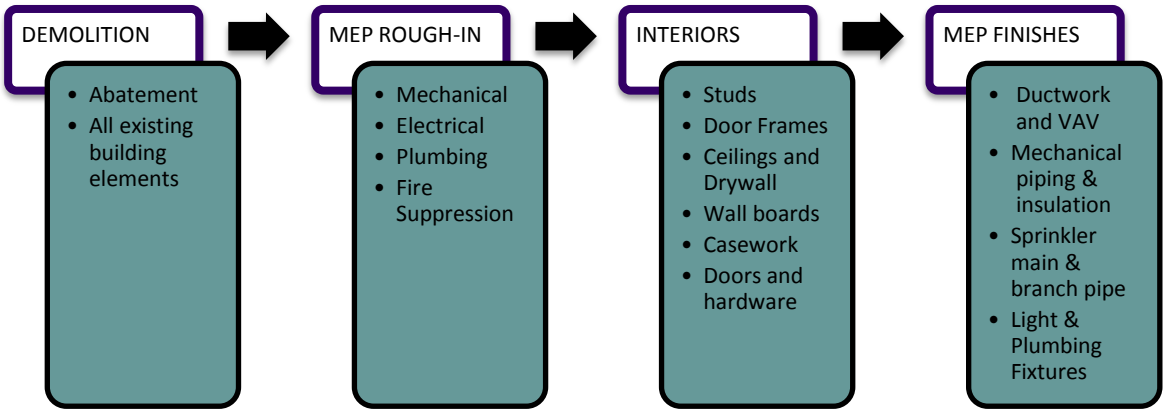

Figure 7: Project Critical Path for Fit-Out Construction

The following tasks and dates are included below to better understand how critical these construction schedule activities are to the overall project completion date.

- Abatement and Demolition: 6/13/2011 – 10/21/2011 (95 days)
- MEP/FP Rough-In: 7/25/2011 – 2/10/2012 (145 days)
- Interiors: 7/25/2011 – 6/15/2012 (235 days)
- MEP/FP Finishes: 11/21/2011 – 7/27/2012 (180 days)

Core and Shell Systems Critical Path: In addition, the main core and shell systems critical path begins with demolition as well and continues with the construction of the elevators, fire protection system, and main HVAC systems. The core is one of the major construction areas of the building because vertical transportation of workers and materials is accessible through this area. Therefore, if core construction is delayed in any way, the schedule will be greatly affected. The process is shown in Figure 8.

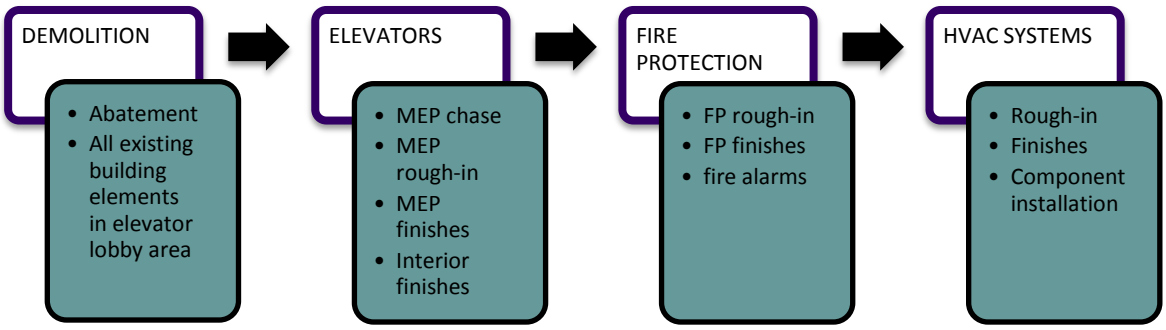

Figure 8: Project Critical Path for Core and Shell Construction

The following tasks and dates are included below to better understand how critical these construction schedule activities are to the overall project completion date.

- Abatement and Demolition: 6/13/2011 – 10/21/2011 (95 days)
- Elevator Lobbies and Stair Towers MEP/FP Rough: 7/25/2011 – 12/9/2011 (100 days)
- Elevator Lobbies and Star Towers Interiors: 7/25/2011 – 2/10/2012 (145 days)
- Elevator Lobbies and Stair Towers MEP/FP Finishes: 11/21/2011 – 2/10/2012 (60 days)

Risks to the Project Completion Date

The construction process is always unpredictable because major constructability issues can occur at any moment throughout the project. Therefore, big risks are associated with completing the project on schedule and within budget. For the River Vue Apartments project, maintaining elevators and stairs for vertical transportation through the sixteen-story building is the biggest risk to the project completion date. Since a temporary hoist is not used on this renovation project, the existing elevators and stair towers transport the construction workers and materials to all the floors. In addition, another risk to the project completion date is the winter weather conditions and heavy rainfall. These weather conditions make it difficult to complete the site work and to access the building for the April 2, 2012 ground floor through fifth floor turnover.

Acceleration Costs and Techniques

There is one key schedule acceleration technique that has been implemented on the River Vue Apartments project. Since the construction of the elevators is a key activity in the core and shell construction critical path, two work shifts are utilized to minimize downtime for the renovation of the elevators. For acceleration technique costs, the second work shift was determined early enough in the construction process to purchase it in the elevator constructor's contract. Therefore, no cost changes were necessary. If other acceleration is needed, contingency dollars will need to be approved for use by the owner (River Vue Associates, LP).

Another schedule acceleration technique that was implemented on the River Vue Apartments project is prefabrication of some MEP components. Ductwork and the electrical rough-in is prefabricated offsite for the project. The electrical rough-in is a pre-engineered system for the apartment units, and it includes a rough-in box. The rough-in box includes pre-cut wiring with snap-in connectors at each wire end operating as quick connection plugs. Even though prefabrication is already used on the project, more MEP/FP components on the fit-out construction critical path could have been prefabricated to accelerate the schedule.

Value Engineering Topics

Value engineering is the process of "reducing construction time and lifecycle cost of a project without sacrificing the design" (Clough, G. Sears, and S. Sears 160). "Many construction contracts now include value engineering incentive clauses, and value engineering applies after the contract has been rewarded" (Clough, G. Sears, and S. Sears 160). Also, it applies to the planning and designing of a construction project as well as to the construction of it (Clough, G. Sears, S. Sears 160-161). If changes are made to the drawings, specifications, or other contract provisions, it is important to understand that owner approval is required (Clough, G. Sears, and S. Sears 161).

Implemented Value Engineering Areas

On the River Vue Apartments project, the project team implemented several key areas of value engineering. Several changes to the MEP systems were implemented, and it did not affect the overall final product in its functionality for the owner (River Vue Associates, LP). One of the two parallel water feeders for the sprinkler system was removed on each floor of the building. The removal changed the sprinkler system from a loop system to a single-feed system. The new single-feed system meets the code requirements, and it reduces the amount of piping, valves, and fire alarm devices.

Other value engineering areas include the types of lighting fixtures, tubing for domestic water lines, wire for main electrical feeds, and cable for fire alarm devices. Specifically, the specifications for the lighting fixtures were opened up to multiple manufacturers. This aspect promoted competition throughout the manufacturers and reduced overall costs for the lighting fixtures. For domestic water lines, chlorinated polyvinyl chloride (CPVC) and cross-linked polyethylene (PEX) tubing were used instead of copper. Since cost, corrosion, and water-quality are concerns related to copper tubing, the project team decided to use CPVC tubing for the water lines. In addition, PEX piping was used on the project because it is an adaptable, flexible, and easy-to-use tubing system, and it has fewer fittings which makes it faster to install. For main electrical feeds, aluminum wire was utilized instead of copper. The main reason the project team chose to use aluminum wiring versus copper wiring was to save on costs. For fire alarm cable's, plenum-rated cable was utilized instead of the standard conduit and wire system. The project team determined that plenum-rated cable was better because of its fire-resistant properties.

Value of Engineering Areas Not Implemented

Even though the project team implemented key areas of value engineering, several areas were considered, but they were not implemented on the River Vue Apartments project. The following ideas are areas of value engineering that were considered for the project.

- Simplify the corridor ceilings to delete the intermediate gypsum wall board bulkheads and provide a continuous acoustical ceiling tile ceiling
- Replace the plastic laminated column covers with gypsum wall board and accent color paint
- Change exterior light fixtures from LED lamps to standard lamp types
- Delete the curved metal panel ceilings in the elevator lobbies and change the ceiling system to a standard acoustic grid and tile

Critical Industry Issues

See Appendix A for PACE Roundtable Student Form

On Wednesday, November 9, 2011, the PACE Roundtable was held at the Penn Stater Conference Center Hotel. The theme for this year's Roundtable consisted of examining the methods to keep moving forward while integrating new tools, processes, and industry drivers. The main discussion topics were Sustainability/Green Building, Process Innovation, and Technology. For the Sustainability/Green Building sessions, energy management services and learning systems for training a sustainable workforce were discussed. For the Process Innovation Session, assembling/procuring an integrated team and integrated decisions for high performance retrofit projects were discussed. For the Technology session, BIM services for the owner (the role of the design and construction professional) and strategies and opportunities for taking BIM into the field were discussed.

Energy Management Services

During the Energy Management Services session, many key topics were discussed. The first topic discussed was the meaning of energy management in the construction industry. Energy management is the control of energy throughout the lifecycle of a building. To better understand how to optimize the project, many of the industry professionals involved in the discussion said it is important to determine where the energy comes from and where it goes. They agreed that the major part of energy management is determining the efficient operation of the MEP systems in a building. Therefore, during the schematic phase, a highly-qualified design team should be involved early to develop the value-engineered systems needed to efficiently operate. After the preconstruction, procurement, and construction phases, energy management still needs to be enforced when the building is occupied. Occupant behavior has a huge impact on energy management. For instance, since the building occupants want to be comfortable, the MEP systems are automatically controlled by the individuals seeking their comfort level. Therefore, the controls and systems need to be simplified to the degree that the occupants will be able and willing to properly use them. Also, if the building occupants are aware and trained about their energy consumption and how it affects the environment, they would be willing to contribute more to the lifecycle of the building. In addition, even though energy management is mainly focused on the efficiency of the building's systems, it is not about making only the building efficient. The industry members stated that the fuel and power coming into the building to operate the systems need to be efficient as well. If the fuel, power, and systems are efficient, the building will definitely have a longer lifecycle and will consume less energy.

The next topic discussed was how energy management is delivered. Many of the industry professionals agreed that it is a performance-based energy contract, and it is based on the outcome. Measurement and verification is the key to the contract. It starts when the project is just a concept, and it consists of measuring certain energy aspects before the project and measuring the same aspects after the project is completed. These measurements verify the energy performance of the building. Also, the owner is

taught and trained in facility management. Therefore, once the project is completed, the owner operates the facility based on the baseline data provided by the contractor.

The final topic discussed was the skill sets architectural engineering students need to succeed in energy management services. Many industry members would like the students to have more training in programming. Also, they stated that understanding the details of the applied energy to the project was very important as well. If students understand the details of the applied energy, they can better understand energy auditing and how to identify problems for the yearly energy profiles.

Integrated Decisions for High Performance Retrofit Projects

During the Integrated Decisions for High Performance Retrofit Projects session, many key topics were discussed. The first topic discussed was how to successfully form and operate an integrated project team. The integrated project design team should ideally consist of everyone in the industry that is included on the project. Also, for the team to operate successfully, it is important to have a design manager that is respected. The design manager will need to be a figure head that the other team members will want to follow throughout the course of the project. In addition, it is important for the team to understand who needs to know what aspects of the project and when exactly they need to know it. If everyone communicated during the design process, fewer problems could possibly occur during the construction and occupancy phases of the project. Also, the attitudes and skill sets of the team members are very important to determine the right process for the design and construction of the project.

The next topic discussed was how the integrated project design team determines their design decisions. Many of the industry professionals stated that early team involvement was very important for renovation projects because the team has to make important design decisions regarding the existing building. These decisions mainly rely on the as-built drawings for the project. Therefore, it is important to have an integrated project design team that can look at the drawings and base their decisions on what it is best for the lifecycle of the building. For instance, some decisions discussed included gutting the shell of the building versus adaptive reuse of the building and replacing the entire MEP system versus replacing components of the current MEP system. In addition, many of the industry professional described what processes are best for most renovation projects. They stated that it is beneficial to salvage as much of the existing building and systems that is allowed because older equipment is sometimes more reliable with newer controls.

The final topic discussed was how to incorporate these topics of the session into the architectural engineering senior thesis project. Many of the industry professionals agreed that it is important to first talk with the owner and determine what the major goals they have for the project. After discussing the owner's goals, the next step would be to identify the key systems that could utilize an integrated project design team. The industry professionals recommended that most MEP systems could be more efficient if the systems were designed using the team. Then, it is beneficial to talk to the MEP system designers about how they developed their systems used in the project. Also, it is important to discuss what

systems would they have wanted to use for the project instead and what were the restrictions that kept them from using those systems. In addition, if they designed the systems individually, an integrated project design team approach could be proposed. Therefore, the true design goals for the project could be accomplished.

Industry Panel: Differentiation in a Down Economy

During the Industry Panel discussion, the key topic discussed was differentiation in a down economy. Since the economic downturn, several industry professionals stated that the economy is not going to change dramatically in the near future. One industry professional said that the economy cannot improve and grow as a whole until it can create jobs for the unemployed. Therefore, the industry professionals found that they had to change the way they operate their companies and projects. To be able to operate and differentiate themselves from the completion during the tough economy, the industry members are looking for young talent that digs into the specialties. The specialties are important to master in a very competitive market. Even though the economy is down, opportunities are still available in certain areas of the United States and in certain divisions. Many of the industry professionals said that there are a lot of opportunities in the Washington, DC market, education, and healthcare right now. Also, they described that they foresee this year to be an important step in the right direction for the economy.

Critical Industry Issues That Apply to the River Vue Apartments Project

After attending the breakout sessions and the industry panel at the PACE Roundtable, students broke out into one-on-one focus groups with industry professionals. The topic of the small group discussion was research topics for the fifth-year students' research topics. After discussing the River Vue Apartments project with Mr. Chris Lasky and Mr. Tim Jones from Massaro Construction Management Service, LLC, it was determined that some of the critical industry issues apply to the project.

Since River Vue Apartments is a residential building, occupant comfort is very important. However, it is a challenge to keep all the residents comfortable because comfort is an individual feeling. Also, it is a challenge to have an energy efficient MEP system that is beneficially used. Most building occupants do not understand how much their behavior in a building can harm the environment. To solve this issue, the residents could be trained about energy usage, but there are other ways to increase residential building efficiency. Therefore, one topic to research would be new ideas for MEP systems that are energy efficient but simple enough for the occupants of the building to use the system correctly without jeopardizing their comfort. In addition, another topic to research would be how the current economy is affecting the River Vue Apartments project.

Problem Identification

After completing Technical Assignments 1 and 2 and the in-depth analysis of the constructability challenges, schedule acceleration scenarios, value engineering topics, and critical industry issues, there are several problematic features of the River Vue Apartments project. These problematic features could be pursued through a detailed analysis of technical building systems and construction methods.

As-Built Drawing Inconsistencies

Since the existing building was constructed in the 1950s and renovated in the 1980s, the as-built drawings are very inconsistent. Renovation drawing inconsistencies caused two constructability challenges on the River Vue Apartments project. These challenges included a column located on the sixteenth floor in the middle of Apartment #1510's bedroom and unknown waterproofing details. The column had to be relocated, which took extensive amounts of time, research, and collaboration between the project team members. In addition, the waterproofing details for the metal panel existing curtain wall system were unknown during the bid period. Since the inboard balconies penetrate the metal panel system in between multiple panel units, the support and waterproofing details added challenges. If the as-built drawings are inconsistent, more building elements could be found during the demolition phase of construction, and it could cause more constructability issues.

Elevator Renovations

With the existing transportation system, seven elevators originally occupied this building. However, only two of the main elevators will remain for building transportation purposes. These elevators will serve from the basement to the fifteenth floors, and they will be powered by the original elevator motors. The elevator renovations are one of the major activities on the critical path. The renovation process for the existing elevators has caused extensive investigation time to understand the control wiring involved. While attempting to remove three of the five main existing elevators, the control wiring malfunctioned. The malfunction occurred because the five existing main elevators are wired together to work and operate as one system. Therefore, removing three of the elevators from that "one system" has caused control issues. Also, to satisfy code requirements, the two remaining elevators used for building transportation purposes need to be modified, and this process is a challenge as well.

It is important for the elevators to operate efficiently because maintaining the elevators and stairs for vertical transportation through the sixteen-story building is the biggest risk to the project completion date. A temporary hoist is not used on this renovation project because the existing elevators and stair towers transport the construction workers and materials to all the floors. Therefore, two work shifts are utilized to minimize downtime for the renovation of the elevators. Since the elevators are critical to the building's completion, research into new motors and a better elevator system might be beneficial to the project.

Site Congestion

River Vue Apartments is located in the heart of Pittsburgh, PA. Since it is an urban site, site congestion is a problematic construction feature. There are some areas outside for staging, but the first floor is temporarily used for material and small equipment staging. Also, the schedule consists of a lot of overlapped activities. Having multiple trades working to complete the activities on the site causes problems with production efficiency. Coordination of the multiple trades is very important for the successful completion of the project.

MEP Coordination

MEP systems coordination was extensive because of the existing steel and the tight constraints between the structure and future ceilings heights. The MEP designers coordinated their systems without using coordination software. It is important to research better ways of coordinating these systems in a more efficient process.

Overlapping Scheduled Activities

A detailed construction plan and sequence was utilized for the River Vue Apartments project to ensure timely project completion. For the construction phase, the project schedule's tasks are the main tasks that reflect the site work, structural system, roofing system, glazing, abatement and demolition, interiors, rough-in and finishes, occupancy, and completion. On June 13, 2011, official work on the construction phase began. The beginning stages of the construction phase include the demolition of all the existing walls and systems and asbestos abatement.

Once demolition and asbestos abatement is complete on the lower floors, the construction of the basement and first floors parking garages begins. Demolition and abatement continue up the building to the upper floors while the construction of the lower floors occurs. During this construction sequence overlap, the site work for the new parking garage ramps on the east side of the building is completed. Also, new utility lines are constructed as well as a new patio on the North side of the building.

In addition to the site work occurring during the construction of the parking garages, the 218 apartment units are constructed starting on the second floor and moving up to the sixteenth floor. The building is turned over to the owner in two phases. Ground-5 will be available in April 2012, and the entire building will be turned over by October 2012. Since the schedule has overlapping scheduled activities, any delays in certain activity areas can quickly cause the project's completion day to be pushed back.

LEED Certification

River Vue Associates and all the members of the project team determined the overall project goal is to achieve a LEED certified rating on the River Vue Apartments project. There are several main design aspects that contribute to the sustainable features of the building. Design features that contribute to the LEED Certification goal include the white-colored EPDM rubber membrane used for the roofing system that will minimize the amount of heat absorbed by the material. Also, the thermally insulated

glazing for the new window system will reduce the amount of heat gain within the building from natural daylighting. Even though River Vue Apartments is LEED Certified, there are many more sustainable features that can be analyzed and pursued to create an even more efficient building.

The level of certification for River Vue Apartments is appropriate because it reflects the owner's and project team's goals to achieve a LEED Certified rating. However, even though River Vue Apartments is LEED Certified, there are many more sustainable features that can be analyzed and pursued to create an even more efficient building. To obtain a possible higher rating, there are several additions that could be developed. These additions include using components that are locally manufactured and shipped to the construction site, installing photovoltaic glass in the curtain wall system, installing photovoltaic panels on the upper roof, installing a green roof garden area on the lower roof, and collecting rain water to reuse. These topics require further research for possible proposal ideas.

Technical Analysis Methods

The technical analysis methods focus on improving the efficiency of the technical building systems and construction methods of River Vue Apartments.

Technical Analysis Method #1: Building Information Modeling (BIM)

BIM was not utilized on the River Vue Apartments project. However, a BIM execution plan could have benefitted two major building aspects. As described in the Constructability Challenges section in the report, the MEP systems coordination was extensive because of the existing steel and the tight constraints between the structure and future ceilings heights. Since the MEP designers coordinated their systems without using coordination software, the coordination process took an extensive amount of time, research, and collaboration between the designers and the trade subcontractors. For instance, if 3D MEP coordination was utilized on the project, the time could have been cut in half. Another major building aspect that might have benefitted from using BIM is the apartment units. Since the layout of the apartment units display consistent uniformity, especially on the third through fourteenth floors, a virtual mockup might be beneficial as a visual aid during the construction phase of the project.

Even though BIM is useful and beneficial as a visual aid and coordination tool, it is expensive to implement on the project. The owner, River Vue Associates, needs to understand that the use of BIM will potentially increase the total cost of the project. Therefore, it is important to explain to the owner the reasoning and advantages of using BIM on the River Vue Apartments project.

The analysis will include understanding Penn State University's BIM Execution Guide and putting the necessary BIM uses into affect on the River Vue Apartments project. To perform the analysis, research will need to be conducted. The research could include speaking with industry professional contacts, Penn State AE professors, and conducting case studies to understand the BIM uses that pertain to the problematic features of the project. It is critical to talk to all the members of the project team involved with the area of construction that the BIM analysis is focusing on. Also, extensive research will need to be performed on how much the use of BIM affects the overall cost of the project and how much construction time does it actually save. The cost values and the schedule for the BIM execution plan used need to be compared to the actual building costs and schedule.

Technical Analysis Method #2: Elimination of Inefficiency by Prefabricating MEP System Components

Since the MEP system is uniform for the apartment units, the use of prefabricated systems could benefit the project in many ways. Prefabrication can reduce field installation time because the labor time is occurring in a prefab shop. Then, the end product is delivered to the site to be quickly installed. This shorter installation time can reduce the cost of the project as well because field labor involves more safety risks, and it is more expensive.

The analysis will include the critical design elements that need to be coordinated between the entire project team to have the prefabrication process efficiently work. With prefabrication, there will be less

waste on the site. Therefore, sustainability can be analyzed and incorporated as well. In addition, to perform the analysis, case studies could be utilized because projects that have consistent uniformity throughout the building would help better understand what systems can use prefabrication. Also, extensive research will need to be performed on how much the prefabricated system components affect the overall cost of the project and how much do they impact the schedule. The cost values and the schedule for prefabrication need to be compared to the actual building costs and schedule.

Technical Analysis Method #3: Sustainable Techniques

River Vue Associates and all the members of the project team determined the overall project goal is to achieve a LEED certified rating on the River Vue Apartments project. The level of certification for River Vue Apartments is appropriate because it reflects the owner's and project team's goals to achieve a LEED Certified rating. However, even though River Vue Apartments is LEED Certified, there are more sustainable features that can be analyzed and pursued to create an even more efficient building.

The analysis will include an investigation into the several additions that could be developed. These additions include using components that are locally manufactured and shipped to the construction site, installing photovoltaic glass in the curtain wall system, installing photovoltaic panels on the upper roof, installing a green roof garden area on the lower roof, and collecting rain water. With sustainability, mechanical and electrical systems can benefit as well. Therefore, breadth analyses will need to be performed in these areas. Also, for the green roof garden and photovoltaic panels on the roof, a structural analysis will need to be performed to see if the new loads on the two roofs affect the existing structural system. To perform the analysis, research will be conducted on the appropriate sustainability techniques for River Vue Apartments. A building life-cycle study will be performed and analyzed to better understand how the techniques can affect the efficiency of the mechanical and electrical systems throughout the building's life. Also, extensive research will need to be performed on how much the sustainability techniques affect the overall cost of the project and how much do they impact the schedule. The cost values including life-cycle costs and the schedule for the sustainability techniques need to be compared to the actual building costs and schedule.

Technical Analysis Method #4: Energy Management Services

As described in the Critical Industry Issues section of the report, many key topics were discussed about energy management services at the PACE Roundtable. Many industry professionals agreed that the major part of energy management is determining the efficient operation of the MEP systems in a building. Occupant behavior has a huge impact on energy management. For instance, since the building occupants want to be comfortable, the MEP systems are automatically controlled by the individuals seeking their comfort level. Therefore, the controls and systems need to be simplified to the degree that the occupants will be able and willing to properly use them. Also, if the building occupants are aware and trained about their energy consumption and how it affects the environment, they would be willing to contribute more to the lifecycle of the building.

The analysis will include an in-depth understanding of how to incorporate new ideas into making the MEP systems more energy efficient but simple enough for the occupants of the building to use the systems correctly without jeopardizing their comfort. In addition, even though energy management is mainly focused on the efficiency of the building's systems, it is not about making only the building efficient. The industry members stated that the fuel and power coming into the building to operate the systems need to be efficient as well. If the fuel, power, and systems are efficient, the building will definitely have a longer lifecycle and will consume less energy. To perform the analysis, research will need to be conducted. The research could include speaking with industry professional contacts, Penn State AE professors, and conducting case studies to understand what MEP systems can be utilized in a simple and functional form. Also, extensive research will need to be performed on how much the simplified, energy-efficient systems affect the overall cost of the project and how much do they impact the schedule. The cost values including life-cycle costs and the schedule for the new systems need to be compared to the actual building costs and schedule.

Technical Analysis Method #5: Industry and the Economy

As described in the Critical Industry Issues section of the report, many key topics were discussed about differentiation in a down economy at the PACE Roundtable. The construction industry has been affected by the economic downturn, and several industry professionals stated that the economy is not going to change dramatically in the near future. Therefore, the industry professionals found that they had to change the way they operate their companies and projects, and they have to differentiate themselves from the competition in the construction market. Even though the economy is down, opportunities are still available, and many of the industry professionals described that they foresee this year to be an important step in the right direction for the economy.

The analysis will include how the current economy is affecting the River Vue Apartments project. In the down economy, it would be beneficial to see how Turner Construction Company achieves their success. Also, it would be important to understand how they differentiate themselves from the competition in the Pittsburgh construction market. To perform the analysis, case studies will need to be conducted and industry professionals who have been affected by the economic downturn could be contacted to describe their experiences. Also, extensive research will need to be performed on cost values throughout the years of the economic downturn. The cost values need to be compared to the actual building costs of the River Vue Apartments project.

References

Clough, Richard H., Glenn A. Sears, and S. Keoki Sears. Construction Contracting: A Practical Guide to Company Management. Seventh Addition. Hoboken, New Jersey: John Wiley & Sons, Inc., 2005. Print.

Ludwick, Kevin. Personal Interview. 11 November 2011.

Appendix A: PACE Roundtable Student Form

Student Name Brianne Kuyk 11/9/2011

Session #1

Topic: Energy Management Services

Research Ideas:

(1) New MEP systems are being installed in the building during the renovation. How efficient are they and how can they be updated to increase the energy efficiency of those systems.

(2) Since it is a apartment residents building, how can you train the occupants to use a sufficient and efficient energy system correctly. What types of energy systems are most effective in a residential building.

Session #2

Topic: Integrated Decisions for High Performance Retrofit Projects

Research Ideas:

(1) understand how the MEP system was designed. If IPD was not used, what changes to the system could have been put into effect if it was used.

(2) Conduct a case study about the project delivery method. Compare the current project delivery method on the River Vele Apartment project to a IPD project delivery method.

Industry Panel: Differentiation in a Down Economy

Research Ideas:

(1) Analyze how the current economy is affect the River Vele Apartments project - cost-wise, material, etc.

(2) Perform case studies that

Industry Member Discussion

Key Feedback:

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

- Since apartment unit construction is repetitive, prefabricate elements that are able to be prefabricated.
- Look at energy usage in residential buildings
  - very high due to occupant behavior and comfort.
- Analyze site congestion since it is an urban site
  - prefabricate to take up less site space
- Prefab smaller components of different trades
- Analyze life cycle costs and the cost of what it takes to maintain and implement.
- How can you control the quality, but still get the end product?
- make the results reflect what is beneficial.
- Analyze visual or actual mock ups of apartments in a shop
  - improves installation time if trades know where the elements are suppose to go.

Suggested Resources:

What industry contacts are needed? Is the information available?

Mr. Chris Lasky - Massaro Construction Management Service, LLC

Mr. Tim Jones - Massaro Construction Management Service, LLC.

* received their business cards