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University of Pittsburgh CHEVRON ANNEX

PITTSBURGH, PENNSYLVANIA

Technical Report 3

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EXECUTIVE SUMMARY

The purpose of Technical Report 3 is to become acquainted with the University of Pittsburgh's Chevron Annex project. The project is located in Pittsburgh, Pennsylvania and is a two phase project consisting of a renovation and an addition to the University's Chevron Tower and Ashe Auditorium. The addition is a three story addition, consisting of two floors of laboratory space and one story for a mechanical penthouse. The addition will tie into the existing Chevron Tower, east of the addition, on each of the new floors.

Technical Report 3 will analyze what challenges and difficulties were encountered by the project team during the Chevron Annex. This report investigates the project's challenges through multiple interviews with the project manager and superintendent. Areas of the project are identified that are good candidates for research, alternative methods, value engineering and schedule compression.

Constructability challenges encountered throughout the project are also examined in this report. Site constraints, micropile installation, steel erection, and working within an occupied space were identified as the most challenging constraints during the project. These challenges were overcome by careful coordination and phasing by the project team.

Also included in this report is a description of the critical path of the project schedule. The University of Pittsburgh's class schedule dictated the critical path, dividing the project into three phases. The biggest risks to the project and key areas of acceleration are also examined. These risks and areas for acceleration will be examined in the spring through technical analyses. Although not implemented on this project, different value engineering techniques were also examined. It was found that although value engineering may not be used on every project, there are still areas that can be analyzed to decrease the overall cost of a building.

A critical industry issue summary of the 2011 PACE Roundtable Meeting is also included in this report. Several topics were addressed during the conference, with the input of industry professionals and students. This open discussion gave students a better understanding of sustainability and green building, process innovation and technology applications.

To conclude this report, several problematic features are identified for the Chevron Annex. These features are the start of a detailed analysis of technical building systems and construction methods. A description of how these analyses will be performed is also included in this report. Eventually, these topics will be used as a basis for developing a proposal for this thesis project.

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CONSTRUCTABILITY CHALLENGES

SITE CONSTRAINTS

The construction of a building within any major city can be challenging because of the limited space that is available during construction. A tight site leaves limited space for storage, field offices, deliveries and heavy equipment. Similarly, the Chevron Annex is located in Oakland, Pennsylvania; which is a large neighborhood in Pittsburgh where the University of Pittsburgh's main campus is located. The building is located at the intersection of Parkman Avenue and University Drive on a gently sloping site. The site and surrounding buildings are shown in the aerial photograph below with the Chevron Annex outlined in **RED**.

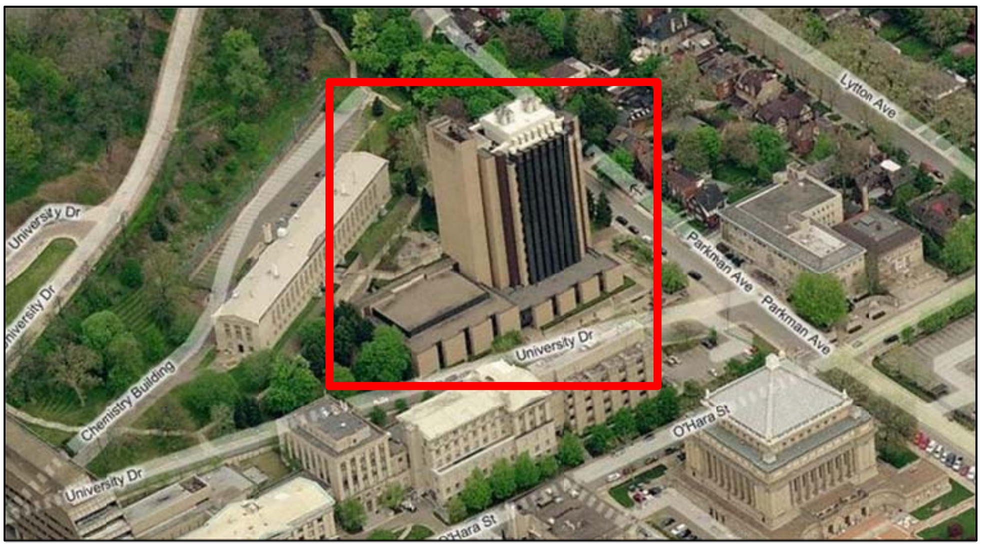

Figure 1 Bird's Eye View of the Chevron Annex and adjacent structures prior to construction

Limited equipment storage and staging was another problem caused by the congested site. Limited lay-down space was available to place large pieces of equipment that were needed to work on the exterior of the building. To alleviate this problem, a small area west of the site was cleared, but the steep slope of the area caused contractors to work inefficiently and unsafely. With many workers and equipment moving around the small site, coordination and safety was a key issue involved with the constraints of the site.

Additionally, the tight site was analyzed and carefully planned to utilize the site and surrounding areas as efficiently as possible. Delivery schedules were carefully coordinated to minimize the congestion on the streets surrounding the site and were requested to be made on smaller trucks to help them maneuver through the city streets better. A storage area was located on a parking lot north of the project (Figure 2). Two conex storage trailers were placed in this parking lot, along with pallets and other miscellaneous items that needed to be stored for a short period of time. Field offices were forced a quarter mile west of the project site (Figure 3). Parking for upper management was also located next to the field offices. Figure 4 displays the locations of the site, office and lay-down areas.

Figure 2 Storage Area Located North of the Project Site

Figure 3 Field Offices Located West of the Project Site

RED: Project Site

BLUE: Field Offices & Limited Parking

GREEN: Lay-down/Storage Areas

Figure 4 Overhead View of Project Area

MICROPILE AND STEEL ERECTION

As discussed in Technical Report One, the Chevron Annex is a vertical addition to the Ashe Auditorium. The Annex will be accessible from both the Chevron Tower and the Ashe Auditorium. The addition requires a new steel frame and foundation system that consists of structural steel beams and columns that rest on pile caps supported by micropiles.

The installation of the micropiles and steel for the Chevron Annex was a main constructability issue during this project. The reason these two items caused problems during installation was because they needed to be installed and erected inside an existing auditorium.

The maneuvering and installation of the micropiles were challenging, especially on the upper portions of the auditorium riser sections. To overcome this constraint, the micropile installation was carefully engineered up front to ensure all equipment and materials could be handled and maneuvered throughout the building. An 8' x 8' opening was created in the southeast corner of the existing Ashe Auditorium for access of the micropile drilling rig (Figure 5). All other support equipment was sized or broken down and reassembled to fit through this hole. All of these parameters were carefully explained prior to the subcontract award.

Figure 5 Opening Created for Micropile Drill Rig

Micropiles at the upper sections of the auditorium were installed with the same equipment; however, seats were removed and a shelf was created on which to position the drill rig. Heavy timber cribbing was used to level up the platform given the stair and seating risers. A special track/ramp was also designed with a pulling winch to allow the drill rig to climb into position (Figure 6).

Figure 6 Track/Ramp used for Micropile Drill Rig

During the steel erection, weekend and night shift crane picks had to be used. Staging for the crane and steel was located south of the building on University Drive (Figure 7). University Drive was initially to be closed six weeks for steel erection. However, the University decided to let the MEP trades perform their underground utility work after the crane was pulled. This closure lasted an additional three weeks, thus closing University Drive for a total of nine weeks.

Figure 7 Steel Staging Area on University Drive

In addition to the micropiles, the long columns with large gussets and long lateral bracing also presented challenges during construction. The 60 foot long tube sections had to be lifted down through the existing auditorium roof and presented challenges because they had large prefabricated gussets on them (Figure 8). Additionally, the large holes that were cut through the roof then had to be weather protected immediately after the members were put through.

Figure 8 Steel Column Being Lifted Through Existing Auditorium Roof

WORKING WITHIN AN OCCUPIED SPACE

The Chevron Annex is a vertical addition to the existing Ashe Auditorium and will also be connected to the Chevron Tower. Both, the Ashe Auditorium and Chevron Tower were to remain fully operational throughout the construction and renovation of the building. Working in and adjacent to a functional chemistry research and teaching facility has challenges similar to healthcare construction. Consequently, temporary enclosures and dust free conditions were required and had to be maintained to mitigate the transmission of dust, odors and other particulates that might contaminate ongoing experiments. Access to existing walkways, corridors and other adjacent areas also had to be maintained.

To overcome this challenge of working in an occupied space, the project team had to install multiple layers of temporary protection. Additionally, anterooms were installed near the stairwells for the transitions between the construction and clean areas. Temporary partitions, sticky mats and negative air machines were also utilized to decrease the transmission of dust and odors. The project team also used recirculating air machines with increased filtration, as well as day to day training with the work force to reinforce the requirements of working next to functional laboratories.

The highest risk areas where dust and dirt may compromise and infiltrate into the existing tower were assessed and protected. Additionally, the existing Chevron Tower was in an extreme negative air condition in order to evacuate any chemical gases and odors. This negative air condition tended to suck the dirt from the jobsite into the existing tower, making the job more difficult with cleanliness. The temporary partitions and sticky mats were constructed between the buildings and were later added by the University as a requirement.

SCHEDULE ACCELERATION SCENARIOS

PROJECT CRITICAL PATH

In Technical Report Two, the Chevron Annex was broken up into two phases consisting of a renovation and an addition to the University's Chevron Tower and Ashe Auditorium. However, the project had three phases relating to the critical path of the project. These phases are listed below and were set in stone by the University of Pittsburgh to prevent any delays concerning the students' return to classes.

- Phase 1 – Complete renovations to the existing Lobby and Ground Floor areas prior to the start of school in August 2010
- Phase 2 – Complete all work in and around the auditoriums to allow them to be placed back into service by January 3, 2011
- Phase 3 – Complete the superstructure, including working labs by the start of school in September 2011

Demolition and excavation necessary for the micropile installation were the first critical path activities for the project. Next, the micropiles and pile caps were reinforced and installed. After the installation of the micropiles and pile caps, the structural steel for the addition was erected. Slab on decks were then placed, allowing the overhead MEP rough-ins to follow on the lab floors. Enclosure of the building started once the structural steel had been erected. After the building was enclosed, the finishes and laboratory casework were delivered and installed. Once the lab casework was in place, final MEP connections were made. Lastly, all of the final MEP connections were made to allow for LEED provisions of fume hood testing, commissioning, building flush out and final cleaning prior to occupancy.

BIGGEST RISKS FOR COMPLETION

Throughout the duration of the project, there were a few risks that were encountered that interfered with the final completion date of the project. Ongoing active interference from the Construction Manager and other prime contractors was the first risk encountered. Constant checks and balances by the CM were done throughout the entire project that made the completion date seem almost impossible to reach. Tension rose over construction quality, the completeness of design, and impacts involved with the schedule and budget. Disputes also occurred over assumptions of what remaining design features could have been anticipated at the time of the negotiated bid, as well as who owned what work. This made the change order process extensive and difficult.

Additionally, the ongoing changes that were requested by the University threatened the original duration of the project. Constant change orders were developed; however, there was no additional time added to the schedule. This made it difficult for all the trades to coordinate and complete the work in time, while minimizing clashes in the field. Another risk encountered during the project was the timely laboratory casework delivery. Many of the laboratory casework components had a 12-16 week lead time for delivery. This was a problem because the laboratory casework was a huge component of the building. Final mechanical connections could not be made until the casework was delivered, which constantly pushed back the start date for the testing and balancing of the systems. This would also push back any other inspections that needed to be done once the systems were tested and balanced. This becomes an increasing problem because inspections are usually scheduled months in advance, making it difficult to estimate the time of certain inspections.

AREAS FOR ACCELERATION

The Chevron Annex project had a tight schedule with minimal float. The project team looked closely at how the schedule could be accelerated to give them the best chance to complete the project on time. After much consideration, a few areas were able to be accelerated. One area that had room to be accelerated was the installation of the micropiles. Installing the micropiles was a critical path item that had a prespecified schedule developed and built into the subcontracts. Since this item was so complex and labor intensive, it needed to be accelerated and was done by working overtime in order to meet the prespecified schedule.

Another area that needed acceleration was the laboratory casework fabrication. However, this item could not be accelerated because the fabrication schedule was inflexible and rigid. This became a problem because a majority of the MEP work depended on the locations and sizes of the laboratory casework. Inspections also depended on the final connections to the casework, making it difficult to schedule the inspections in advance.

The installation and phasing of the exterior skin is another area that had the potential to be accelerated. The exterior skin and finishes of the building caused a number of problems during construction. Additionally, the long lead time of the Terra Cotta panels led to problems in the schedule. Coordination between trades and the phasing of the different systems created difficulties during installation. Although this did not impact any of the critical path activities, it is suggested that the manpower of these tasks could be used elsewhere once finished. These resources could be re-assigned to other tasks, possibly decreasing the duration of the project.

Other areas of acceleration are expected to be analyzed in detail in the spring. Integration of technology in the field, as well as other schedule acceleration tools will be researched and discussed through a variation of methods. The acceleration of the schedule will also alleviate stress from the owner and project team during the project and turnover of the building.

VALUE ENGINEERING TOPICS

Upon conversations with the project manager, there were no items that were seriously considered for value engineering. The project bids were well within the budget, so no significant value engineering was required. However, there was a $50,000 credit that was provided by the University for the absence of grooves in the terra cotta tiles; but this was due to a fabrication error and was not a true value engineering item.

Although there was no value engineering used on the project, there are some changes that are recommended if a reduction in price was ever wanted. A major area of price reduction for the project is the amount of high class and customized finishes used throughout the project. Complicated and detailed architectural millwork significantly increased the project's value. Additionally, the exterior façade finishes were manufactured and shipped across seas, also increasing the cost of the project dramatically. Using more modular and standard finishes would help reduce the cost of the project. Another area that would decrease the overall cost of the project would have been to create a horizontal addition, rather than a vertical one. A vertical addition adds complications to the structure, as well as coordination and safety issues that result in an increase in cost. However, it was determined that the reason that a vertical addition was chosen was because of the limited space available throughout the campus.

Although value engineering may not be used on every project, there are still areas that can be analyzed to decrease the overall cost of a building. Detailed and high class finishes, as well as complex MEP systems can usually be eliminated and replaced by simpler and cheaper versions. However, these solutions may be impractical and can decrease the efficiency and value of a building. It is up to the project team and the owner to analyze and decide whether or not value engineering is worth the time and money on certain projects. In the Chevron Annex's case, it was decided that since the building was within the University's budget that value engineering was not needed on this project.

CRITICAL INDUSTRY ISSUES

The 2011 PACE Roundtable Meeting was held on November 8-9, at The Penn Stater Conference Center. This meeting is an open forum discussion of key topics between students and industry professionals. The event began with a kick-off lecture from each of the key Construction professors. A brief presentation was given by Dr. Leicht, Dr. Riley, and Dr. Messner on their respective research topics. Once this was completed, the conference was divided into two break-out sessions; each with three subtopics. After the break-out sessions were finished, two panel discussions were held. The first panel discussion consisted of four industry members discussing the topic of "Differentiation in a Down Economy." The second discussion was a combination of industry and student panel members talking about "Hands-On Learning in Design and Construction." The final part of the meeting was a focus group that involved students meeting with an industry member to discuss their potential research topics.

The first break-out session included the following topics:

1. Energy Management Services
2. Assembling/Procuring an Integrated Team
3. BIM Services for the Owner – The Role of the Design and Construction Professional

For this session, the Energy Management Services discussion was attended. The definition and key factors involved with energy management was discussed. Energy management is defined as the efficient operation of a building, as well as the analysis of how to optimize this process. It was also suggested that the biggest factor concerning energy management is the occupants' behaviors. This topic was discussed in further detail by analyzing how and why the occupant behavior is such an important factor in the energy management services.

Additionally, the industry members were asked to develop key areas of research that they would like the students to look into for their Thesis. A number of ideas and topics were suggested; however, there were a few key areas that were of particular interest. Suggested topics include the analysis of building systems and controls, as well as the opportunities for performance contracts. Another suggested area of research is a study of how operational costs compare to the costs of construction using actual data.

The second break-out session included the following topics:

1. Learning Systems for Training a Sustainable Workforce
2. Integrated Decisions for High Performance Retrofit Projects
3. Strategies and Opportunities for taking BIM into the Field

For the afternoon session, the Integrated Decisions for High Performance Retrofit Projects discussion was attended. This session consisted of a discussion on the importance of front end planning and integration needed during retrofit projects. It was suggested that one of the most critical steps during a retrofit project is the testing and balancing of major systems prior to their removal. This is critical because not all systems in retrofit projects need to be completely replaced, reducing the overall cost of the project. Additionally, the early involvement of the Integrated Project Team is important in planning out who needs to know what and when they need to know it. This involvement can be organized and coordinated through a method called Pull Planning. This method has been used on large scale projects and is proven to be an effective coordination tool.

Similar to the first break-out session, the industry members were asked to develop key areas of research that they would like the students to look into for their Thesis. The main area of interest was a study of companies having success in Integrated Project Delivery (IPD). Additionally, the industry members would like the students to examine the critical process steps involved and how each team approached this idea.

After the break-out sessions and panel discussions, a focus group was formed to discuss potential research topics that were inspired by the break-out session topics. One of the groups consisted of Andy Paxton from Southland Industries and two Penn State students; Justin Woishnis and Robert Mroskey. The students both discussed what they learned during the break-out sessions, as well as what they intended on researching for their Thesis projects. While conversing, both students found it beneficial to hear Andy's perspective on the industry and what he thought about their research topics. Consequently, the focus group proved to be beneficial to the students by helping them develop their research ideas.

TECHNICAL ANALYSIS METHODS

After detailed technical reports on the Chevron Annex, a few features of this project were looked at as problematic features. The problematic features viewed throughout this project are seen as areas that could improve the overall quality of the building. Additionally, areas were identified that could have been made more efficient; resulting in potential time and money savings. It is understood that not all of these areas of analysis can be studied; however, many of them can be combined into a single area of interest.

INTEGRATION OF TECHNOLOGY IN THE FIELD

There is an increasing interest and use of technology throughout the construction industry. Companies are spending a critical amount of time and money trying to utilize different types of technology to help them gain an edge on other companies. However, the Chevron Annex did not utilize any new or unique methods or technology during construction. It is suggested that effective uses of technology will prove to save time and money throughout the project. The main form of technology that will be analyzed will be the use of personalized Tablet PC.

Tablets are offering construction users new ways to speed up communication, obtain client approvals, complete inspections, arrange logistics and manage other complications in an industry that is highly mobile. Utilizing the use of tablets in the field is one of the different types of technology that will be researched. It will be recommended that tablets be issued to each member of upper management, and will be used to record work hours, quantity reports, quality control and other forms of documentation used throughout the project. The amount of information a superintendent needs to efficiently increase the productivity of the company will also be looked into.

Information on the use of technology in the field will be obtained from sources such as Engineering News Record (ENR) and other construction publications. Additionally, a case study will be used to compare the average cost savings on a project when using certain forms of technology in the field. The initial cost of investment will be researched, as well as payback period on the investment. This analysis method can also be combined with the pull planning and other schedule acceleration tools. Additionally, other forms of technology may be analyzed to develop a full understanding of the different types of technology that are being used throughout the construction industry.

TESTING AND BALANCING OF LABORATORY SPACES

Laboratory spaces have extreme cautions relating to the cleanliness and precision of the areas. The Chevron Annex developed some complications when it came time to turn on the mechanical equipment for the testing and balancing of the systems. The owner insisted on the laboratory spaces being completely dust free before any of the systems could be turned on; however, there were still long lead items that needed to be installed that produced dust and debris. This interrupted the owner's occupancy date, resulting in schedule complications.

It is thought that through detailed coordination and scheduling meetings that this problem could have been avoided. In order to fully analyze this problem, the schedule will be reviewed and adjusted accordingly. Multiple laboratory spaces will be also be analyzed from a number of areas of interest. The type of systems used, timing of commissioning and parties involved will be evaluated to determine the best possible solution for the phasing of the systems. This area of analysis can also be combined with the pull planning and other schedule acceleration tools.

PULL PLANNING & OTHER SCHEDULE ACCELERATION TOOLS

The schedule is always a driving factor on a project for the owner and project team. Similarly, the Chevron Annex's schedule was also an important part of the project. Some of the key activities and milestones were in question throughout the project due to the lack of coordination and involvement of all parties involved. Early involvement and coordination from all parties involved can help reduce the complications and schedule problems involved with many projects.

Pull planning and other schedule acceleration tools will be analyzed to determine which one proves to be more effective in different types of construction projects. Research on these tools will be performed to find out the initial cost of investment to implement them in a project, as well as train the project team on how to use the tools. Companies using these tools will also be examined to determine the effectiveness of the tools from a user's point of view.

FUTURE MODELS FOR FACILITY MANAGEMENT

Owners are increasingly requesting different as-built models to be turned over once projects are completed. Although not requested for the Chevron Annex, it is recommended that the University starts requesting models upon project completion for future use. As-built models can provide a number of services to the owner once a project is completed. Additionally, the facility management personnel will benefit from models upon project completion; especially in a high-tech laboratory space like the Chevron Annex. Operation and maintenance of MEP systems tend to become easier and better understood from the use of accurate as-built models. Operation and Maintenance data can also be combined into certain as-built models, making it easier to track the inspections and maintenance used throughout the building.

A number of as-built models will be reviewed and analyzed to determine which models prove to be more useful and successful. In addition, it is recommended that the facility management team be educated on whichever type of model is chosen by the University. The time and costs involved with training the facility management team, as well as the cost of updating the models will be examined.

INNOVATIVE ENERGY SOURCES

A main topic of interest in the construction industry is the different types of alternative energy sources and how to decrease the amount of energy used throughout a building. Multiple types of energy sources will be analyzed; including fuel cell generators, evacuated tube solar collectors and a closed loop water cooling system. Although not practical for the entire building's energy production, some of the alternative energy sources may be used for smaller areas of interest. Smart purchases of energy will also be analyzed, as well as some main organizations that mandate clean energy. Some of the organizations that will be studied include PACE (Property Assessed Clean Energy) and IFMA (International Facility Management Association).

In addition to the alternate energy sources and organizations, the pre and post occupancy efficiencies of LEED Certified building systems and controls will be analyzed. LEED Certified buildings will be analyzed with respect to their building systems' efficiencies before occupancy and during occupancy. How the systems actually perform during occupancy as compared to the expected performance will be compared. It will be suggested that the USGBC incorporate some sort of re-certification for LEED Certified buildings to confirm that the buildings are performing to the requirements after certification. Re-Certification of LEED Certified buildings will help ensure that occupants and owners are conforming to the requirements put in place in order to be LEED Certified.

EXTERIOR SKIN REDESIGN AND SCHEDULE ACCELERATION

The installation and phasing of the exterior skin caused a number of problems during the construction of the Chevron Annex. Additionally, the long lead time of the Terra Cotta panels led to problems in the schedule, as well as coordination issues between trades. Phasing of the different systems also created difficulties during installation.

A redesign and re-sequence of the façade will be performed. Redesigning and re-sequencing the façade will require the analysis of the building's structure, as well as a case study dealing with the efficiency of workers and exterior system sequencing. Different scaffolding and support systems will be researched to help reduce the number of movements by the exterior crews. The exterior eyebrow will also be analyzed to determine if a better method is available to construct the feature. Redesigning the exterior eyebrow will also develop different loads on the building's frame and will require a model of the building's structure.

This section can also be combined with the integration of technology in the field, as well as the pull planning and other schedule acceleration tools.

TRANSITION PLANNING AND MANAGEMENT FOR PHASED CONSTRUCTION

Working in and adjacent to a functional chemistry research and teaching facility is difficult for both the owner and project team. Mitigating the transmission of dust, odors and other particulates that might contaminate ongoing experiments is a main concern of the owner. This challenge became extremely difficult when it came time to start up the mechanical equipment for testing.

This research topic will be further investigated by creating 3D and 4D Models to help coordinate all of the parties involved with the project. Early involvement of these members will be stressed in order to reduce conflicts in the field, as well as complications with the schedule. Different laboratory spaces and health care facilities will be analyzed to determine efficient and cost effective ways to eliminate the challenges presented when working in and adjacent to an occupied space. Additionally, multiple Integrated Project Teams will be analyzed in order to determine all the necessary parties that need to be involved.