THE PENNSYLVANIA STATE UNIVERSITY
5TH YEAR THESIS

Technical Assignment Three

Alternative Methods Analysis

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2175 K STREET NW
WASHINGTON DC
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2175 K Street NW, Washington DC

FOX ARCHITECTS

Project Team

Owner	Minshall Stewart Properties
Construction Manager	Appian Realty Advisors
Architect	FOX Architects
Civil Engineer	Vika
Structural Engineer	Rathgeber/Goss Associates
MEP Engineer	META Engineers
General Contractor	James G. Davis Construction

Project Specifications

Building Function	Class A Office Building
Construction Type	Occupied Renovation
Building Size	173,551 sqft (33,691 sqft new)
Number of Stories Above	11 stories (8 existing, 3 new)
Number of Stories Below	3 stories below grade parking
Construction Dates	February '07 to March '11
Project Delivery Method	CM Agent with GC
Building Cost	$15,500,000

Architecture

2175 K Street NW is located on the North Side of K Street at 22nd Street and Washington Circle. The eight-story structure was built in 1981. Currently, it is 108,000 gross square feet. Through the use of Transfer Development Rights, the building will be increased in height by three floors. This vertical addition will increase the existing gross square footage by 37,500 square feet.

The new 22nd and K Street façades will be a unitized glass and metal curtain wall system. A state-of-the-art solar louver system will screen the existing façade and provides passive solar shading to the new façade; while simultaneously knitting the entire building together. A new glass corner overlooking Washington Circle spans floors 2 through 11, blending the new and the old systems together.

Structure

The foundation consists of existing 48"x48"x24" footers, several of which underwent minor expansions to support the new loads imposed by the additional structure above. The existing building consists of cast in place concrete. Whereas the new structure is structural steel with lightweight slab on deck. Several columns within the existing building were reinforced with steel jackets or carbon fiber to support the additional loads imposed by the new steel structure.

Mechanical

The mechanical system for this project consists of a main cooling tower that services a self contained unit on each floor used for the conditioning of the tenant spaces. To condition the core of the building, a closed loop with VAV's was utilized. The new floors, 9 through 11, and existing Level 8 will be controlled by a new BAS system. The existing floors, B1 through 7, will be controlled by the existing pneumatic system. As tenant floors turnover, the owner will upgrade the entire building to run off of the new BAS system.

Electrical

The electrical service for the new construction enters at 2,000A and is distributed on a 208Y/120V system. The existing building has two 6,000A feeds. The existing switchgear was replaced with new switchgear that has the capacity to feed panels on Levels B3 through 11. A new backup generator was installed to service the whole building.

Lighting

The lighting is operated on a 120V system and uses energy efficient fluorescent lamps with electronic ballasts. The base building did not include common areas on the new floors. Lighting design and installation will be part of the tenant fit out.

Sustainability

This building is trying to obtain LEED EB. To help in this matter, a passive solar shading system was implemented. Another sustainable feature to this project is the use of a green roof. Such a roof is being installed on a portion of the ninth floor.

Timothy Conroy

Construction Management

http://www.engr.psu.edu/ae/thesis/portfolios/2010/tmc5014

Executive Summary

Technical assignment three focuses on problematic features of the project 2175 K Street NW Washington DC. Additional areas of focus are constructability challenges, schedule acceleration scenarios, and value engineering topics. After addressing the previous topics, several problematic features were identified and various technical analysis methods were discuss to address the features at hand.

The first area of emphasis is the constructability challenges. This section can be found beginning on page six. The features discussed within this section are as follows: existing penthouse and elevator machine room, building dried-in, elevator modernization, building occupancy, and restricted site.

Concerning the topic of existing penthouse and elevator machine room discusses the challenges of maintaining a dry and dust free space. Additionally, maintaining operational equipment throughout construction proved to be a challenge within itself. The next topic, building dried-in, involves the challenge of preventing water from penetrating the building envelope after the roof is removed. Following this, the challenges associated with the elevator modernization are discussed. Subsequently, the challenges associate with the building occupancy and the restricted site conditions are discussed.

The next area of focus is schedule acceleration scenarios that could possibly be implemented on the project. Within this section, the following areas are discussed: the critical path for the project, the biggest risks to completing the project on time, the key areas of potential acceleration, and the costs associated with each acceleration scenario.

The following section discusses the value engineering strategies implemented by the project team and other potential areas of interest. Concerning 2175 K Street the space was leased prior to construction and the contract was signed with the tenant based upon the construction documents thereby eliminating the possibility for value engineering to be considered. Within this document, other possible areas where value engineering tactics could be implemented were listed.

Consequently, the following two sections first outline problematic features of the project that could be pursued though detailed analyses of technical building systems and construction methods; and second, outline the necessary technical analysis methods addressing the previously mentioned features. Additionally, each topic outlines how the conclusions will be quantified in an attempt to provide valuable feedback that might be able to be applied to other projects.

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A. Constructability Challenges

When the project team was interviewed, the following topics arose as the top constructability challenges. They are listed below in order of importance.

Existing Penthouse and Elevator Machine Room

Several challenges were encountered during the project with respect to the existing penthouse and elevator machine room. First, both areas housed equipment that needed to remain operational throughout the duration of the project to ensure the safety and wellness of the building tenants. Additionally, the need to keep the previously mentioned areas dry presented problems for the project team and field staff.

The existing penthouse needed to remain on-line to operate the existing building systems while the new structure was built up around it, and subsequently while the new penthouse was built and the new equipment installed. Additionally, DAVIS worded closely with the structural engineer to create connection details that allowed for minimal demolition of the existing penthouse columns and allowed said columns to be extended and used in transfer of the newly imposed loads from the new structure down to the existing building foundation. Only after the new penthouse was completed and the equipment installed and operational could the project team begin working on the decommissioning and removal of the old system.

Concerning the turnover from the old system to the new system, the old equipment remained in place while new system was commissioned and operated for a period of one week. This was done to prevent devastating consequences to the building tenants if the new system was to go off-line unexpectedly and the old system was already deconstructed. Thankfully, this backup plan was never put into action and the turnover went smoothly. To thank the subcontractors responsible for getting the project up to the turnover milestone, a pseudo topping out party was held.

Similarly, the existing elevator machine room (EMR) needed to remain operational while the new EMR was constructed. Consequently, the construction of the new EMR could not begin until the new steel structure and other supporting activities were also completed. The process of extending the existing elevator shaft from the old elevator machine room to the new one in itself presented a challenge. The major challenge associated with extending an existing elevator shaft up to a new elevator machine room is how to keep the existing shafts operational and more importantly keeping them dry. Because this project entails maintaining an operational building, special provisions needed to be put into place to ensure occupant safety and comfort.

In an effort to prevent the issues outlined regarding the existing penthouse, DAVIS constructed a temporary penthouse enclosure with a lower ceiling in order to accommodate the construction of

the level 10 slab to help ensure the room stayed dry. The three figures, Figure A.1 through Figure A.3, show the temporary enclosure that was previously mentioned.

Figure A.1

Figure A.2

Figure A.3

With regards to the elevator machine room, extra attention was given to ensure the new EMR would remain watertight. If water were to penetrate the room enclosure, measures were installed to prevent the movement of water further into the building. Other than the methods previously mentioned, a conventional approach was used concerning water proofing.

Building Dried-In

Another challenge that had to be dealt with in a manner as to prevent damage to the existing building was keeping the building dry. One of the first tasks DAVIS had to tackle was to remove the exiting roof and parapet wall on level nine to allow for the construction of the new structure to begin. The roof was constructed of a layer of ridged insulation, a substrate material, a vapor barrier, and hot applied asphalt. The challenge with removing this system from the building envelope was this roofing system was the sole means of preventing water from penetrating the building. Therefore the removal was a topic of much concern and had to be handled with due diligence. Once the roof system was removed, construction of the three new levels of structural steel could commence.

The reason why preventing water from penetrating the building envelope is so important is, as most people know, water causes mold. According to studies conducted by OSHA, the Occupational Safety and Health Administration, if a material is subjected to water exposure and is not dry within twenty-four hours, mold could potentially grow. On the other hand, if a material that is subjected to water exposure is dried within the twenty-four hour window, mold will not develop. To put things another way, water can cause a great deal of damage to a building if it is not intended to be there. With the risk of damage and health implications so vast, a great deal of effort was expended to prevent the migration of water into the building.

To ensure the building would remain dry, DAVIS installed a temporary roofing membrane on the existing roof level to help keep the building from leaking. Additionally, plastic flashing was used at the building perimeter to prevent water from entering the façade envelope through any roof penetrations or other such cavities. During construction, various other methods were utilized to

prevent water from penetrating the building envelope. If water were to migrate in, several systems were installed to limit the amount of damage the water could carry out. One example of such a system was dimensional lumber nailed to the concrete deck and sealant around the perimeter, creating a dam to prevent the migration of water further into the building and possibly down to the level below. This system was used around the entire building envelope and around all floor penetrations where sealant alone would not suffice.

Building Elevator Modernization

As previously mentioned, the task of keeping the existing elevator machine room operational until the new EMR was completed and able to operate the building elevators introduced a number of challenges. Addressed in the above section, "Existing Penthouse and Elevator Machine Room," keeping the exiting shafts and subsequently the new shaft extensions dry was a daunting but manageable task.

Another challenge, not addressed above, was how to go about making the shafts safe to allow work to be performed within them. Additionally, because the building was to remain occupied and operational throughout construction, the bank of three elevators needed to remain operational as well. To address this challenge, DAVIS, as required by contract, only closed one elevator at a time as to always have two elevators operating to transport tenants vertically through the building.

This challenge created both scheduling and operational difficulties. The impact this had on the schedule involved the implications of only being able to work on one elevator at a time. Each modernization was determined to take eighteen weeks to complete and was scheduled accordingly. The operational challenges included isolating the shaft and maintaining the existing elevator machine room so the existing elevators were able to be operated during construction of the new elevators. This can be seen in Figure A.4 Temporary Elevator Shaft Separation. Such maintenance had to remain in place until the new EMR was able to come on-line.

Figure A.4 Temporary Elevator Shaft Separation

This presented a number of issues. The equipment in the existing EMR was dated back to the 1960's when the building was originally constructed and the task of maintaining two operational

elevators proved to be quite difficult. Workers were required to work relentlessly on the switchboards that controlled the elevators movement because one elevator would consistently get stuck on the B3 level in the garage. Any time when only one elevator was operating, the tenants would grow tired of the construction and complain to the building manager whom would in turn get the word to the owner and eventually to DAVIS. For this reason, this issue was always held at a heighted level of importance.

Furthermore, a temporary enclosure was constructed around the existing elevator machine room to keep dust and other foreign particulates out to accommodate maintenance and create a code compliant space. Davis bought a sixteen week per elevator schedule from ThyssenKrupp Elevator, TKE, to eliminate six weeks in comparison to the initial eighteen-week duration. This was done to incorporate two weeks, per elevator, of contingency to be used if needed. Additionally, TKE performed some work in the existing elevator shaft prior to completion of the new structure to get a start on the renovation of the first elevator.

As previously mentioned, ensuring the safety of the tenants and the workers within the elevator shaft, was of utmost importance. To do this, a temporary floor was constructed beneath the elevator car being worked on located at the eighth-floor level. This provided not only a safe working platform from which to perform work but it also served to prevent debris from falling down the shaft and potentially having an adverse affect on the other shafts. Additionally, a temporary wall was constructed to separate the shaft under construction from the other two shafts. This barrier ran the entire building height from B3, parking garage level three, up to existing elevator machine room located on the existing roof.

This challenge needed to be effectively managed as to not impact the critical path of the project schedule, which will be discussed in section "B. Schedule Acceleration Scenarios." If the schedule required, a shorter schedule could have been bought from the elevator subcontractors. This would have elevated some of the pressure on other activities allowing for a faster turnover of the building. DAVIS included the previously discussed sixteen week duration in their contract schedule with the owner thereby reducing the risk associated with the schedule.

Building Occupancy

Concerning occupancy, as stated in the contract, the building was required to remain operational throughout construction. This presented the project team with additional challenges to manage. In comparison, many challenges could have been avoided if the project would have entailed a vacant office building undergoing renovations. The added difficulty stems from ensuring the safety and wellbeing of the building tenants.

Along similar lines, the site has a high-rise residential building neighboring to the north. This residential complex shares a common wall between it and the office building in question. This adds yet more challenges with respect to noise and noise producing activities. The limit on when

certain activities could be performed had an adverse affect on the schedule. In other words, this added to the degree of difficulty concerning scheduling which the project team had to overcome. It was stipulated by local codes that noise producing activities, above a predetermined limit, could not be performed during normal business hours in an attempt to not affect the nearby office spaces. Additionally, these same activities could not be performed at night due to the proximity of the high-rise residential complex. This was done in an effort to not disturb the residents and their sleep routines. These two constraints drastically limited the window during which a number of activities could take place.

To accommodate the previously mentioned noise constraints, DAVIS decided to perform these activities from 7:00 to 9:00 AM and from 4:00 to 6:30 PM daily. A few examples of such work were the demolition of select building elements, the installation of anchor bolts, etcetera. Additionally, work was performed on Saturdays from 8:00 AM to 5:00 PM. It was decided very early on during the preconstruction phase that working on most if not all Saturdays was necessary to ensure the project would stay on schedule. The time slots during the weekdays were determined to cause the least amount of disturbance to the building tenants. This is not to say all disturbances were alleviated but a vast majority was averted.

These noise constraints also introduced a more dynamic challenge. The previously mentioned time slots that were determined to be acceptable by DC regulations were a more static approach. The fact of the matter was DAVIS had to continually address complaints generated by the building tenants and the tenants of the neighboring residential building. These complaints caused a number of phone calls to be made from the building owner, the construction manager, and the owner of the nearby residential buildings to the project executive overseeing the job for DAVIS. On a few occurrences, there would be a phone call made from the construction manager on the job to the vice president at DAVIS who was responsible for overseeing the project and the project team. This simple fact caused this challenge to be of great concern to the project team at DAVIS. To limit the number of phone calls and complaints, DAVIS was very strict with the predetermined time constraints and handled the occasional phone call with great care and diligence in an attempt to prevent a minor disturbance from attracting undue attention.

Restricted Site

Finally, the amount of space available on the site for activities such as mobilization, cranes, deliveries, staging, etcetera created another layer of challenges for which the team had to adapt to and manage. As shown by the image to the right, labeled Figure A.5 Site Layout Plan, the space was quite limited. The site was boarded on two sides by neighboring buildings, a high-rise residential to the north and a commercial building to the east. Additionally, to the south, the project was constrained by K Street and to the west, 22nd Street.

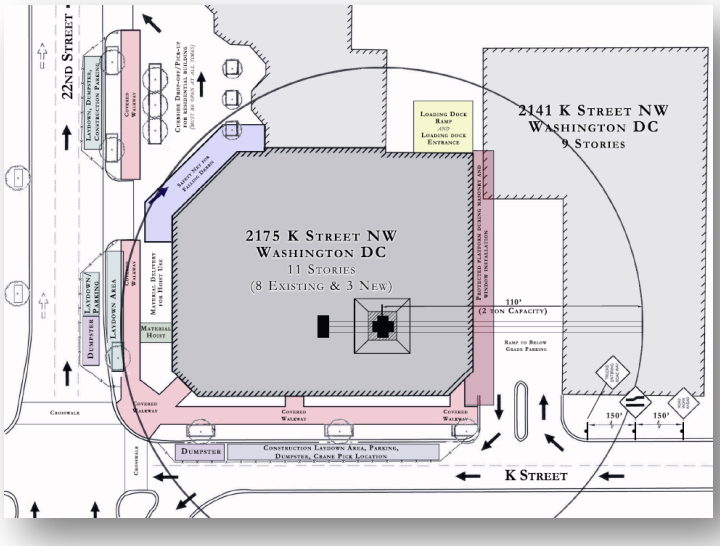

Figure A.5 Site Layout Plan

To allow for the previously mentioned activities, DAVIS obtained a public space permit to allow them to block off a lane of traffic along both K Street and 22nd Street as shown in Figure A.5 Site Layout Plan. These lanes were utilized for deliveries and the necessary pedestrian overhead protection. To solve the crane placement challenge, DAVIS hired a structural engineer to design shoring that would allow the tower crane to be installed on cribbage in the existing roof as shown in Figure A.6 to the right. The location shown above was chosen because of a tenant elevator shaft that was to be installed to service the newly added floors. This decision limited the amount of make-up work that would be need after the crane was removed.

Figure A.6 Tower Crane Base and Cribbage

B. Schedule Acceleration Scenarios

Critical Path

The critical path for this project consisted primary of tasks associated with the structural improvements to the existing building, the new structural steel making up the additional three levels, and the elevator modernization.

First on the critical path were the structural improvements to the exiting foundation, shown in the figure to the right, and the exiting structural concrete columns that were needed to allow the load imposed by the new structural steel to be safely transferred into the bedrock beneath the building. To do this, the project team had to enlarge a number of the buildings spread footings in both the x-direction and the y-direction, the depth could remain the same.

Figure B.1 Foundation Spread Footing Expansion

Figure B.2 Column Reinforcing

Subsequently, the team had to install additional reinforcement to key columns within the building to allow them to carry the new load. This was done by installing a system of either steel jackets and/or carbon fiber. Figure B.2 Column Reinforcing, located to the left shows a column that was reinforced with a steel jacket. These systems were designed by a licensed professional engineer and installed accordingly.

Consequently, the installation of new structural steel also ended up on the critical path. Once the existing building could carry the load imposed by the new structure, the team began installing the steel columns on concrete piers, steel girders and beams, and the steel composite metal decking. This aspect of the project presents an opportunity for possible schedule acceleration which will be discussed in the "Schedule Acceleration" section of this document.

Finally, the critical path was capped off with the modernization of the building's three elevators. As discussed in a previous section, the task of modernizing and extending the three building's elevator and shafts proved to be the key contributing factor to the project schedule after the structural steel was completed. This was because only one elevator could be removed from service at a time, leaving the remaining two operational for the building tenants. Each elevator was scheduled to take sixteen weeks to complete and they were scheduled in series, the second elevator could not be completed until the first was turned over and operational. These activities also provide an area of possible schedule acceleration to be discussed in the following sections.

The critical path for this project presents a few areas that could be researched further for use in schedule acceleration.

Project Risks

The most prevalent risk that needed to be properly managed was the installation and modernization of the building's elevators. To help mitigate some of the risk associated with this activity, DAVIS decided to meet weekly with the elevator contractor TKE to make certain that there were no issues with other trades or the elevator installation. Additionally, during these meetings, DAVIS could address any issues that arose as quickly as possible to limit the potential schedule impact. If any issues were to impact the schedule, this would have a direct impact on

the project completion date which has significant cost impact with respect to the general conditions costs and liquidated damages. The cost of general conditions per week was estimated at $16,500, which computes to approximately $2,400 per day. Additionally, the liquidated damages amount to $70,000 per week, which equals $10,000 per day.

Schedule Acceleration

As previously discussed in the "Critical Path" section of this document, steel installation and elevator modernizations are pivotal areas for possible schedule acceleration. These two scenarios have one key aspect in common, both would have additional cost associated with them. The cost benefit associated with potentially shorting the project duration could be realized in terms of the cost of general conditions. As previously mentioned, general conditions cost approximately $16,000 per week, therefore if additional manpower would reduce the project duration by a week without costing more than $16,000 per week, this would be a feasible scenario.

Concerning the structural steel installation, one technique could be to simply "purchase" overtime for the trades involved. The resulting cost would depend on how aggressively DAVIS needed to accelerate the schedule. For example, the steel installation would have likely taken approximately $3,000 per day. This amount was calculated based upon the overtime differential for an ironworker being $45 per hour. A crew of eight men working eight hours per day was assumed.

With regards to decreasing the elevator modernization schedule, the associated cost per day was calculated to be approximately $2,000. To reach this number, a crew of two men working eight hours per day at a rate of $115 per hour. This rate was attributed to the strong elevator unions in the DC area.

C. Value Engineering Topics

Prior to the start of construction, the owner fully leased the space based upon the construction documents; therefore, no value engineering was done. The proposed tenants already accepted the construction documents (CD) thereby negating the need to reduce the cost of construction. This is a result of the owner "selling" the construction documents to their tenants. DAVIS, as a result, could not deviate from the CD's in any way due to the terms of the owner's lease with the tenants.

If needed the following items could be considered to reduce the cost of the building without reducing the quality:

- Install more efficient light fixtures
- Utilize a hard ceiling, i.e. drywall, instead of metal grid ceiling in the restrooms
- Allowing alternate SCU's other than the specified McQuay units
- Use stone tile in lieu of dimensional stone for the lobby walls (the floors were already to be stone tile)
- Limit the building to one operational elevator to allow for two elevators to be worked on simultaneously
- Replace the curtain wall subcontractor with a different one based upon poor reviews

Alternate Self Contained Units

A typical result of specifying a specific manufacture is paying a higher price for the given equipment. To prevent this, an owner could use a performance specification and give the general contractor the ability to competitively bid the equipment to have the best chance of ensuring the lowest price or best value whichever is preferred.

Elevator Modernization

The option to limit the building to one operational elevator would allow DAVIS to work on the remaining two simultaneously. This could effectively remove the amount of time associated with one of the elevators seeing as how there would be one less item in the elevator schedule. This could potentially reduce the overall project schedule by sixteen weeks. This could save approximately $264,000 some of which would need to be used to pay for an additional elevator crew. This extra crew was not needed in the original schedule due to the linear nature of the activities.

Curtainwall Subcontractor

The project was a hard bid with a majority of emphasis on the lowest possible cost. For this reason, DAVIS selected a subcontractor whose reputation was less than desirable. This decision ended up causing adversarial relationships between DAVIS and the subcontractor. Part of the reason for the subcontractor being the lowest bid was because of the limited effort expended on

designing and detailing the various connections involved with the curtain wall and louver systems. For this reason, progress was limited which had a dramatic affect on the overall project schedule, which in turn caused other trades to be delayed from starting or finishing their respective tasks.

D. Problem Identification

In this section of the document, the following areas or topics were identified as potentially benefiting from a detailed analysis of building technical systems and/or construction methods. Included with each topic is a description of the problematic feature that could be addressed through research and analysis.

Site Layout

As discussed in the above section, the site is quite congested and space is very limited. This had a negative effect on the ability to store and sort material when delivered to site. Additionally, there was very limited space available to use as laydown or shakeout areas. Therefore, the site quickly became unorganized and cluttered. One area of focus could be how to better manage the space available to make for a more productive site.

Pedestrian Safety

Research could be done on this topic to determine what measures DAVIS put into place in comparison to what is required by OSHA. Additionally, after compiling a list of the accidents or injuries that occurred on the project research ways of improving the safety plan as to prevent the same incidents or similar ones from happening again. The safety plan on a project is critical to measuring the success of the project but is too often neglected or poorly maintained. It seems as though much effort is placed on keeping the workers safe but much less is effort is placed on the pedestrian's safety. This research could potentially create tools to help reinforce safe operating procedures that could be applied to all future projects.

Curtainwall

As mentioned in the section, "Value Engineering Topics," there were a few issues with the curtainwall and the subcontractor tasked with the installation of said system. During the bid phase of the project, DAVIS asked all subcontractors who were interested in bidding the project for references who could attest to their past performance. The subcontractor, which ended up being awarded the job, was lacking in this area. Most of their past jobs proved to be successful but their reputation was tainted by some negatively. The project manager (PM) who was assigned the job assured DAVIS that the negativity was caused by a past project manager to was later let go. Near to the beginning of the construction phase, the PM was focused solely on this job and was proving the negative reputation as incorrect. Later, when the PM was placed on more jobs, the progress began to diminish. One area of focus would be how to better address and manage this issue, or consider the affect of awarding the contract based primarily on the lowest number.

Elevator Modernization (Schedule Impact)

The modernization of the existing building's elevators controlled a large portion of the project schedule. This was primarily due to the requirement of maintaining two operational elevators throughout construction. This presents a prime topic for further research. What effect would allowing the modernization of two elevators being done simultaneously have on the schedule and thereby affect other trades. Additionally, if by doing this, the schedule could be shortened, money could be saved through shortening the amount of time DAVIS would have to provide the general conditions.

Elevator Modernization (Operational EMR)

Along the same lines as the previous topic, by allowing two elevators to be modernized at the same time and thereby shortening the duration from when the first two elevators were taken out of service to when the third elevator became operational; the length of time that DAVIS would have to ensure the exiting EMR remained operational would also be shortened. The challenge of maintain the existing EMR proved to be a daunting task. The switchboards used to control the movement of the elevators were very out dated and would malfunction on a regular basis. Therefore, to keep the owner and tenants happy, elevator technicians were continually brought in to fix the equipment, which was quite costly.

Structural Steel Installation

The installation of the structural steel, as discussed in the schedule acceleration section, was determined to be a potential area of improvement. Because this task takes place on the critical path, shortening the duration of this activity would have the greatest amount of effect on the overall project schedule. It might be beneficial to investigate the benefit of reducing the duration of this activity and determine the effect on subsequent tasks. Additionally, as mentioned a number of times, shortening the project schedule would reduce the cost of the general conditions and ensure the project is completed on or before the required date. This would also eliminate the possibility of having to pay for liquidated damages, which can amount to a substantial amount of money. This becomes crucial in light of the current economic situation because many contractors have reduced their fee in order to win the bid. With a smaller fee comes a smaller profit margin, which could be completely zeroed out by liquidated damages or even cause the contractor to owe additional money.

Existing Penthouse

The task of maintaining an operational penthouse while the new one was constructed presented a number of challenges. One alternate method of completing such a task could be to set up temporary equipment to handle the building loads to allow for the removal of the existing equipment. One suggestion would be to set up the temporary equipment on the existing roof where it would pose less of a challenge to work around. This would be beneficial because work

in the existing penthouse could not begin until the new penthouse was completed. Another suggestion could be to allot space on the existing roof, new ninth floor, to house the new equipment and utilize the existing cooling tower until the new cooling tower could be installed. This would allow the work on the mechanical system to begin much earlier and reduce the amount of work that needed to be done on the new roof.

Building Dried-In

Research could be done to find alternate means of maintaining a dry building. As mentioned previously, this was a big challenge for the project team to manage. On several occasions, water penetrated the building envelope, bypassed the protective measure and caused damage to the existing building that DAVIS had to then remedy.

Alternate SCU's

Another area of potential cost savings would be if the owner would have utilize a performance specification instead of specifying a particular manufacture for the self contained units. Research could be done as to determine the amount of money that could have been potentially saved by allowing DAVIS to competitively bid out the mechanical equipment. Additionally, to determine the rational used by the owner in deciding to specify a certain manufacturer.

Building Occupancy

It would be interesting to determine how the building occupants affected the project schedule. Time could be spent to figure out how many days, if any, were added to the schedule due to tenant complaints or other such hindrances caused by renovating an occupied building. Additionally, after quantifying these occurrences, determine ways of preventing them from happening on future projects.

LEED and the Potential Approaches Late in Construction

The owner of this project wasn't overly familiar with LEED and what earning a certification entailed. Because of this lack of knowledge, the discussion was delayed. The first time LEED was mentioned in a project meeting was after the structural steel and a fair percentage of the MEP was installed. The owner then decided LEED was a very important or desirable goal they would like to achieve. The next step was the owner decided to hire a consulting firm to determine if a LEED certification could be achieved and what route they should take to lessen the amount of effort needed to achieve said certification. This tends to occur on projects more often than it should, which presents an interesting topic of possible research. It would be interesting to investigate the various methods an owner could take to achieve LEED certification at a less than desirable point in the project schedule. With respect to the project at hand, the main area of focus would be on energy efficient strategies that could positively affect the long-term cost of operating the building. The owner's final decision was to pursue a LEED for Existing Buildings (LEED EB) rating and the primary tool for measuring the buildings

performance is to create a baseline of energy usage then either maintain or reduce that baseline over a period of time. More research would need to be done to determine the specifics of the rating system.

Peak Energy Shaving

Along the same lines as the previous topic, research into strategies for reducing the peak demand of the building to lessen energy consumption could prove to be an extremely valuable technique. This topic could go hand-in-hand with the previous topic making for a more thorough investigation. One example of such a strategy would be to utilize the variable rate at which the electric utility charges based upon the time of day and incorporate an ice storage system. This system uses cheaper energy rate to produce ice at night and use the thermal properties to offset the thermal load on the mechanical system during the day. Another possible alternative would be to run the buildings backup generator during peak times to lessen the demand for electricity off the city grid.

Starbucks

Another aspect of the project that directly affected the schedule was the Starbucks coffee shop located on the ground floor of the building. DAVIS had to pay Starbucks $1,500 per day because of reduced revenue generated due to the covered walkway hiding the Starbucks sign. Another option would have been to close Starbucks at a rate of $3,000 per day. The second option was not chosen but could have proven favorable because work needed to be done within the store, which was delayed or slowed due to keeping the store operational. This topic presents the opportunity to investigate which option would result in a more favorable outcome.

E. Technical Analysis Methods

Based upon the list of problematic features discussed in the previous section, the following four were determined to be the most worthy of further research. The following paragraphs will include a description of what analyses will need to be completed, including any additional research needed to supplement the topics.

Elevator Modernization (Schedule Acceleration)

To summarize, this section would include both the schedule impact of working on two elevators at the same time and the cost associated with maintaining the existing elevator machine room. Not previously mentioned, investigating the impacts the proposed changes would have on the tenants could be another topic of research. Because the elevator modernization was determined to be on the critical path, it was determined to be an important topic of focus. Considering the liquidated damages amount to $70,000 per week and general conditions cost $16,000 per week, accelerating the schedule is a very desirable goal.

To properly investigate this topic, research would have to be done on how much effort in terms of manpower and money was spent in maintaining the existing EMR and how much time could have been saved if the owner would have allows DAVIS to take two elevators out of service. Based on the project schedule, the sixteen weeks that would be saved might not come off the schedule in its entirety. There is a possibility that less time would come off the schedule based on the sequencing of trades.

To aid in this research, DAVIS construction has volunteered to assist in the collection of information regarding durations and schedule impacts. Additionally, they have agreed to answer questions, should they arise.

The end goal of this research would be to quantify the value of accelerating the schedule and to determine what drawbacks, if any, exist.

Energy Saving Strategies and LEED Approaches

To conduct the research necessary to investigate the above topic, a baseline would need to be established from which to measure possible solutions against. To do this, the owner would need to be contacted to determine what systems are currently in place and what the total building usage currently is. After which, a breakdown would need to be created based upon the building systems as a percent of the total load. This would allow for the comparison between the current systems and any proposed new retrofits.

To properly investigate this topic, research into the following areas would be needed. Building illumination, water consumption, waste management, etcetera. Additionally, research into the requirements of LEED for Existing Buildings would be needed.

DAVIS construction has volunteered to assist in the research needed to fully investigate this topic. Additionally, several contacts were made at the PACE Roundtable who could be contacted if questions should arise.

In an effort to quantify the results of the research, a comparison between the baseline systems and new systems could be used. In addition, a LEED EB scorecard could show what points if any could be achieved and if a LEED certification is possible. Lastly, a cost savings analysis could be conducted to determine how much money the owner could save over a period of time if the proposed changes were incorporated.

Value Engineering Strategies

Within this topic, research into possible value engineering (VE) strategies, such as the ones mentioned above with respect to cost savings and schedule impacts, could be beneficial seeing as how no VE was done on the project. To accomplish this, research into the various building systems would be needed. After all VE is complete, the goal would be to take the newly

proposed ideas to the tenants who will be moving into the spaces and determine if they would have been willing to accept the ideas. Additionally, the owner would have to be contacted to determine, based upon the amount of money that could have been removed from the budget, the cost savings in terms of rent that they would be willing to pass onto the tenants. This might prove challenging to accomplish.

Although not done by the owner, value engineering is still a viable topic of research because at the very least, the findings could be shared with the owner for use on future renovations. If they see the type of ideas that a tenant is willing to accept they might be more inclined to consider VE strategies in the future.

Similar to the last couple of sections, DAVIS has graciously offered to assist in any way possible throughout the research process to ensure the best possible outcome is achieved. Additionally, other classmates can be used to gather and review ideas or concepts regarding this matter.

To quantify the results of this research, a comparison would need to be made between the original cost of construction and the new cost of construction. Other than focusing solely on first time cost, lifecycle cost could be analyzed to determine the effect the value engineering would have on the long-term financial impact on the owner.

Public Relations (Tenant and Subcontractor)

As outlined previously in this document, the tenants played a major role on the speed at which work was put into place. If they had any complaints, the progress would diminish. Along the same lines, the relationship between the curtainwall subcontractor and the general contractor had a profound effect on the project schedule. Based upon the current status of the project, research into the amount of time lost due to tenants complaints and mismanaging the curtainwall subcontractor could be beneficial.

Concerning the tenants, it would be interesting to determine what sparked the complaints and what, if any, were the effects on the schedule or budget. Consequently, what could be done to prevent future complaints. In other words, create a document that could be used to outline what activities resulted in the most complaints and how to avoid them. With the current state of the economy, renovation work is on the rise. Owners cannot afford to build new therefore, they are renovating their existing properties.

With reference to the curtainwall subcontractor, investigating what caused the issues regarding their reduced quality of work and what, if any, impact their poor performance had on the schedule. Base upon the results of the analysis with respect to the schedule; determine a monetary value associated with delays.

The main contact, with respect to the tenants, would be the building operations manager. He was the portal from which the complaints made it from the tenants to the construction manager and the general contractor. On the other hand, in relation to the curtainwall, the main point of contact would be the project manager of the company responsible for the design and installation and the project team at DAVIS.

To quantify the results of the aforementioned research, a comparison between the original budget and the final budget of the project would be needed. Additionally, any schedule impacts would need to be noted to determine if money savings based on general conditions was potentially lost due to delays. Another important factor to address would be the amount of overtime at the subcontractor's expense was needed to maintain schedule as much as possible.

F. Works Cited

Cotter, Patrick. James G. Davis Construction Corporation Assistant Project Manager. Timothy Conroy. November 2009.

All photos were provided by DAVIS construction.