50 Connell Drive
Berkeley Heights, NJ

About the Building:

Owner: The Connell Company
CM: Turner Construction
Architect: HLW International

General Data:
- 4 Story High End Office Building with Cafeteria
- 185,000 Total Square Feet
- Pursuing LEED Gold Certification

Mechanical Systems:
- Concealed Mechanical Penthouse
- 2 pipe direct return air/water system
- (4) McQuay Destiny Air Handling Units
- Floor by Floor VAV Heating and Cooling Units
- (2) Closed Circuit Induced Draft 432 Ton Cooling Towers

Architectural:
- Granite Panel Facade with Curtain Wall Sections
- Reflective Roof with Fully Adhered Membrane

Construction:
- Schedule July 2007 – Jan. 2009
- Clearing of a Wooded 16 Acre Site
- Erected in Bays with 150 Ton Crawler Crane

Electrical/Lighting:
- 13.2 KV Main Power Feed
- (2) 15 KV Switchgears
- TP-1 Transformers Step Power from 480V to 277V
- Natural Gas Powered Emergency Generator
- Fluorescent lighting with multiple fixture types

Structural:
- Concrete Footings and Grade Beams
- Structural Steel Frame
- Composite Metal Deck Floor Slabs
- Vertical Steel Cross Bracing

Jason Salyer, LEED AP
Construction Management
http://www.engr.psu.edu/ae/thesis/portfolios/2009/jcs5018/

Technical Report #3
Alternate Methods Analysis

50 Connell Drive Office Building
Berkeley Heights, NJ

Submitted 11/21/08
Submitted by: Jason Salyer
Option: Construction Management
Thesis Advisor: Dr. Messner

Table of Contents

Executive Summary

This technical report describes constructability challenges, schedule acceleration scenarios, value engineering topics, problematic features and methods of analyzing the problematic features of 50 Connell Drive.

Constructability Challenges

- Imperfections with the exterior glass
- Time delays involved with the lobby finishes
- The prefabricated stone panels on the exterior wall were a challenge to align correctly

Schedule Acceleration Scenarios

- Work 10 hour days
- Perform shift work at night to avoid trade stacking in congested areas
- Separate the lobby into quadrants and use four separate finishing crews

Value Engineering Topics

- A re-design of the parapet eliminated aluminum panels and replaced them with a rubber membrane to save the owner $30,000
- The lobby stairs were changed from stainless steel to a stainless steel cladding
- The exterior canopies were changed from stainless steel to painted steel
- Value engineering of stainless steel items saved $550,000

Problematic Features

- Elimination of perimeter baseboard heaters
- Complications installing pre-fabricated exterior stone panels
- Time delays related to long lead granite finishes
- Project labor agreement mandates that only union workers are permitted on the site

Technical Analysis Methods

- Research by means of interviews, surveys and feedback from industry members
- Emphasis on value engineering, schedule reduction and constructability

A. Constructability Challenges

The top three constructability challenges on the project were:

- Imperfections with the exterior glass
- Time delays involved with the lobby finishes
- The prefabricated panelized stone panels on the exterior wall were a challenge to align correctly

Exterior Glass

The exterior glass proved to be a unique challenge for the project. The owner discovered a flaw in each of the 5’ wide by 7’ tall pieces of glass. All of the glass arrived on site with an imperfection running the length of the glass. This imperfection was in the form of a vertical line that ran down the center of the glass. This did not meet the strict quality requirements that the team had established. The owner expected a pure reflection. Turner had to reject 460 pieces of glass after they had already been installed.

This resulted in schedule delays. Each of the 460 pieces had to be uninstalled. It took three months to remove the glass and replace it.

A third party consultant was hired to investigate the cause of the flaw and who was responsible. It was determined that this imperfection was caused by a piece of debris that was on one of the rollers during the tempering process. Turner demanded that the vendor who supplied the material was held responsible for the cost of replacing the glass. The vendor initially disputed the claim and argued that Turner should accept the pieces in the condition that they arrived in. Turner was able to use their heavy national presence in the industry as leverage to convince the vendor that it was in their best interest to rectify the problem. As a result litigated was avoided and the vendor hired a subcontractor to remove the defective pieces and install 460 new pieces of glass. This delayed site work around the perimeter of the building.

Lobby Finishes

There were significant time delays involved with the lobby finishes. These delays stem from two issues:

- A re-design of the stairs
- Lengthy approval process for the granite floor and walls

The granite for the walls was imported from Italy and the granite for the floors was imported from Canada. These materials are both long lead items. The project team underestimated the amount of time that would be required to approve the samples. The entire process of receiving the samples, approving and shipping them took two months longer than was expected. Since this process was longer than anticipated the schedule for the granite was delayed. By the time the stone was delivered to the site there were other trades working in the lobby.

Another constructability challenge was a re-design of the lobby stairs. The original designed specified a stainless steel staircase. The owner sought to reduce the cost of the stairs. This was accomplished by using regular steel with a stainless cladding. This change order resulted in four months to redesign and release the stairs. This was a major setback as it was expected to take just three weeks to approve the stairs. This additional time was due to owner and subcontractor delays related to the approval process. This issue was further complicated by the delays involving the lobby granite. The two work crews ended up interfering with each other and productivity within the lobby decreased.

To meet the project schedule the team decided had to plan the remaining lobby work very carefully. The lobby was divided into quadrants as seen on **Figure 1** on the following page. Four separate crews were used to install the granite in an effort to increase production. The amount of space in the lobby simply did not allow the stone crews and the stair crew to work together efficiently. To solve this problem the crew who was responsible for installing the stairs would perform their work during a night shift while the granite crews worked the day shift. The standard labor premium for the night shift is 10% but the subcontractor offered to absorb that cost due to the increased production.

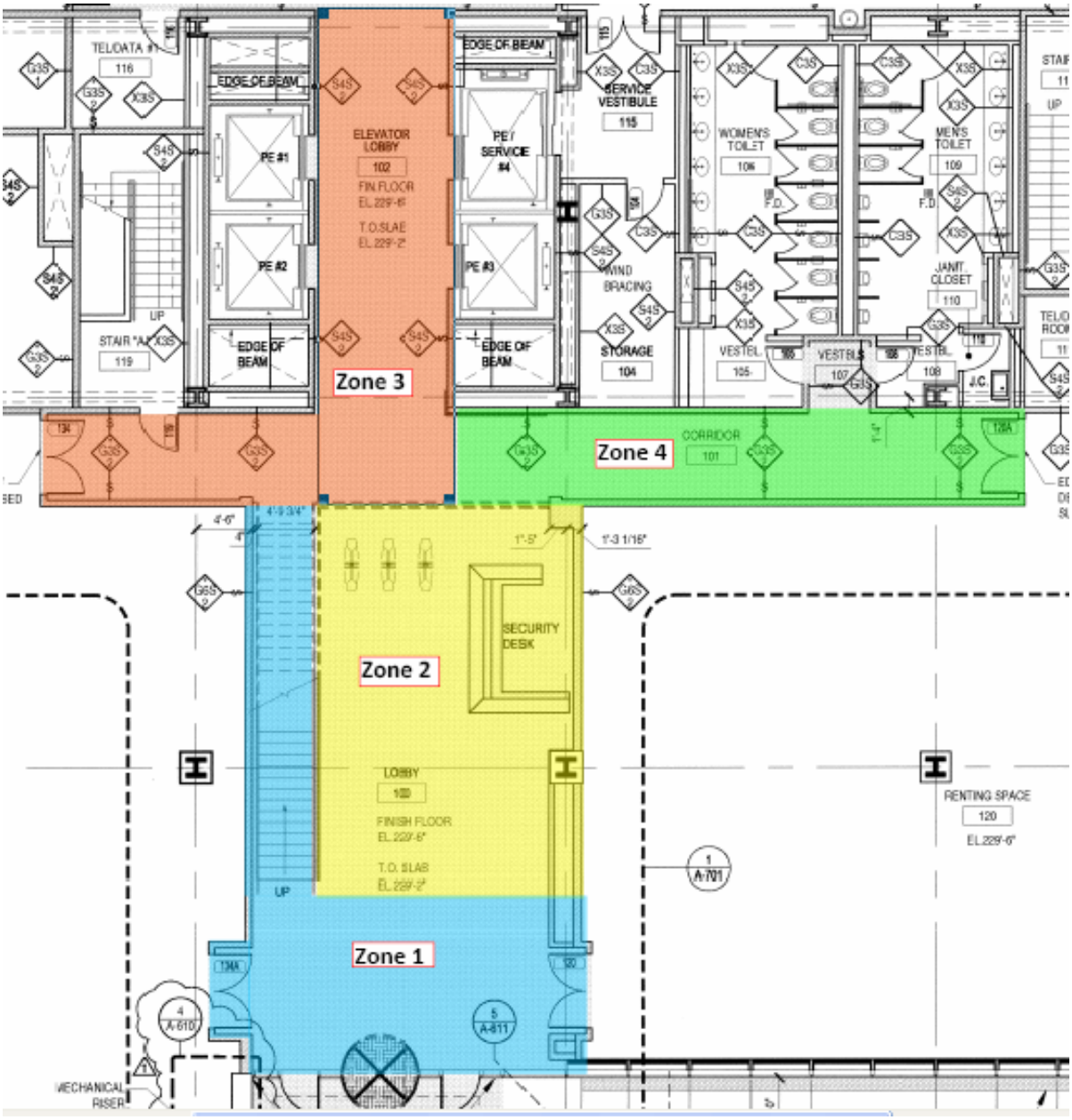

Figure 1 – Quadrants for Lobby Finishing Crews

Alignment Issues with Pre-Engineered Stone Panels

The exterior stone panels that the façade is built from were pre-engineered and delivered to the site on pre-cast trusses. This system was pre-fabricated in an effort to reduce construction time. The Project Superintendent described this system as a genius idea. However this system did not work as well as expected. Aside from inconsistencies in the stone and poor drawings that lacked dimensions the panels also proved to be very difficult to align.

The exterior wall is composed of three main elements: granite, limestone and glass. First the glass was installed and then the stone crews followed. The stone panels were fabricated as five foot wide sections. There is a joint between each of these sections that should measure ¼" wide. In some areas it was difficult to fit the sections precisely and impossible to get ¼" joints. Some of the pieces were installed with ½" joints. This difference may sound insignificant but two of the exterior walls are 300 feet long. This distance requires 60 separate panels to span that horizontal distance. If only a handful of those panels have the incorrect joint thickness it throws the alignment off. The tolerances are so small that there is no room for error. Turner noticed that as work proceeded on the panels both the vertical joints and horizontal joints appeared skewed as one looks down the length of the building.

It was determined that the reason the stone contractor had difficulty aligning the panels was because the window contractor did not align all of the glass correctly. To solve the problem 20% of the windows had to be removed and re-aligned.

B. Schedule Acceleration Scenarios

The project is a relatively standard core and shell office building. Aside from some high end finishes in the lobby and a kitchen/cafeteria area the critical path of this project is very similar to any other core and shell office building. Major items on the project's critical path include foundations, steel erection, MEP equipment installation in the penthouse, kitchen equipment installation, exterior enclosure and granite finishes to the main lobby and elevator lobbies.

The biggest risks to the project completion date are work delays related to the lobby finishes and site work. As mentioned earlier in this report the installation of the lobby's granite floor and walls was delayed by two months due to a longer than anticipated approval process. Work on the lobby stairs was delayed by four months due to cost overruns and a subsequent re-design.

There was also an excess 20,000 CY of soil on the site that had to be hauled away. This became a critical issue because all of the documents stated that the site was balanced and there was no need haul away any soil. To complicate issues even further the

subcontractor who was awarded the site work was not experienced with projects of this magnitude and the work became too much for them to handle. As a result there was a 20,000 CY pile of soil that sat on the west side of the site that delayed site work on that side of the building by approximately four months.

As a result of these delays that the CM encountered throughout the course of the project there is a need to modify the schedule to complete the project on time without incurring any liquidated damages. These liquidated damages total $15,000 per day for every day the project is delayed. To avoid a delay in the final completion date it is necessary to focus on the work items that were delayed. To accelerate the schedule to complete the work on time the construction crews can start working 10 hour days and perform work on Saturdays. If this is still insufficient the CM can make arrangements to have a night shift. It makes sense to use a night shift for the lobby work since there are serious delays in the lobby that threaten the schedule and multiple trades trying to perform work in the same space. If one trade works the night shift and the other works the day shift that would result in better efficiency since the two crews are not interfering with one another. A night shift costs 10% more than the standard day shift. Another cost of working more hours is a strain on the management staff.

C. Value Engineering

The Connell Company approached Turner and sought their advice on how to lower the cost of the project. The people at Turner examined the following value engineering ideas and presented them to the owner:

- Alter the parapet design
- Modify the lobby staircase from stainless steel to a stainless steel cladding
- Change the framing material of the exterior canopy

Parapet

Turner was able to save the Connell Company about $30,000 by altering the design of the roof parapet. The original design had aluminum panels on the inside of the parapet to provide a layer of weather protection. These panels extended along the entire 900 foot perimeter of the building. The construction team suggested that an alternate design be implemented. They determined that the aluminum panels were not necessary and eliminated them from the design. Instead of using the metal panels the new design simply extended the EPDM rubber roofing membrane up through the parapet and under the coping. Refer to **Figure 2** to see the re-designed parapet details. This resulted in a design that functioned just as well as the original design. The membrane has certain characteristics that make it desirable for this application. EPDM rubber has excellent

resistance to weathering, low temperature flexibility, low electrical conductivity and satisfactory resistance to polar chemicals.

There are several advantages to this system. The cost to extend the rubber membrane the extra distance was negligible compared to the cost of buying and installing the aluminum panels. Less labor was required since the same crew that installed the roof was now weather guarding the parapet. This reduced the schedule time to complete the parapet. The owner was very pleased with the re-design. Neither the quality nor the aesthetics were sacrificed to cut costs. This was an excellent implementation of value engineering.

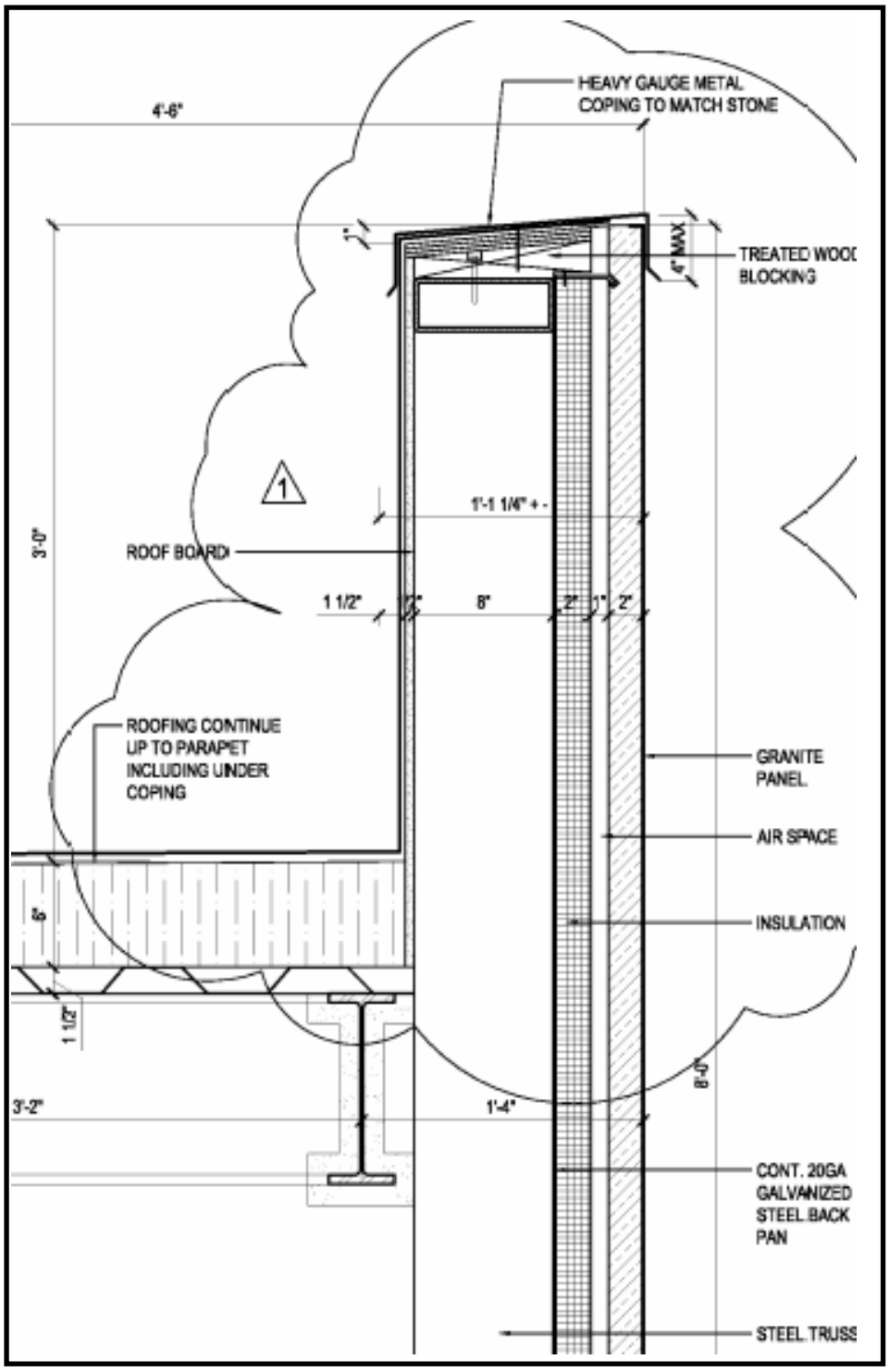

Figure 2 – Parapet Detail Showing Rubber Roofing Under Coping

Lobby Stairs

As mentioned in an earlier section the lobby staircase was an item that implemented value engineering. Refer to **Figure 3** for a rendering of the lobby. The original design called for stainless steel. Stainless steel is a very expensive product and as a result Turner began looking for ways to reduce the cost. This was a challenge because the owner did not want to compromise the aesthetics of the final product. Turner's solution was to use regular steel with a stainless steel cladding. Since the cladding is a very thin layer the material cost was lower than the original design. A cladding would have the same exact appearance as the original design.

This correlated very well with the goals of the owner. They were able to save money by changing the design of the stairs while retaining the desired final appearance. Nobody would ever be able to distinguish the cladding from solid stainless steel. The owner was able to reinvest this money into other areas of their business.

Figure 3 – Rendering of Lobby

Exterior Canopy

The outside of the building has a canopy covered walkway built from steel and glass. Refer to **Figure 4** below for a rendering of the canopy. Similar to the lobby stair design, the original design of the canopy specified stainless steel. The architect and the owner both desired the finish that a stainless steel would provide. However the owner was not happy with the cost that would be required to install stainless steel. Turner suggested changing the design to an aluminum frame. This would have reduced cost but the owner rejected the idea because it did not provide the desired finish. The solution that the team implemented was to use regular steel with a painted finish that closely matches that of a stainless steel. The owner was pleased with the affect that the paint provided. However there are concerns that a painted finish will require maintenance in the future. This is a reality that the Connell Company is willing to accept because of the immediate savings. Value engineering on the canopy along with value engineering on the lobby stairs saved the owner a total of $550,000.

Figure 4 – Rendering of Exterior Canopy

D. Problem Identification

Elimination of Perimeter Baseboard Heating

The building utilizes perimeter baseboard heating around the entire building. It may be possible to eliminate some or possibly all of these heaters by using a more energy efficient façade. This re-design could possibly reduce the size of the boilers and reduce the building's overall energy consumption. It would also reduce some of the MEP work that is required with the heaters. That could result schedule compression. There would most likely be a higher upfront cost associated with the use of a more energy efficient building envelope but the immediate savings of reducing the boiler size and eliminating the baseboard heaters combined with the reduced life cycle operating costs could make this system very attractive to the owner.

Complications Installing Pre-Fabricated Exterior Stone Panels

The pre-fabricated exterior stone panel wall system was intended to streamline the installation process however the system did not perform as well as expected. As mentioned earlier the tolerance for each panel is ¼" with no margin for error. To complicate issues even further the details on the construction documents were lacking information. The subcontractor responsible for installing the exterior stone panels had great difficulty aligning the panels correctly because the window contractor did not place the glass in the correct location.

Granite Finishes

The granite that was imported from Italy and Canada resulted in schedule delays related to the procurement process. It seems that this problem could have been avoided by ordering long lead items earlier in process. In order to do this the construction manager would need to put pressure on architects and engineers to have the design completed early in the process. All parties who are involved with this material need to understand that it is a long lead item and measures must be taken to ensure that there will be adequate time to approve, ship and install the materials. It is paramount that the owner and architect know what type of finish they desire so that submittals can be approved in a timely manner. It is also paramount that they understand the impact on the schedule if the approval of long lead items becomes delayed.

Another problem with these finishes is their long transit to site resulted in higher shipping costs than materials that can be obtained locally. These items are far beyond the 500 mile radius that the U.S. Green Building Council has set as the threshold for achieving LEED

points. Not only does this make it more difficult to achieve the desired LEED Gold certification but it also contradicts the owner's desire to implement sustainable building practices. There would be benefits by replacing the material with one that is cheaper and more readily available.

Project Labor Agreement

The project labor agreement mandated that all work is performed by union workers. There is a belief among certain members of the Turner staff that a union workforce results in decreased productivity and a lower quality finished product than that of a non union workforce. This statement is an opinion and there are many people in the industry who disagree. If there was dissatisfaction regarding the performance of a particular trade on this project it seems that tactics could have been employed to rectify the problem. This could have been accomplished by removing poor workers and replacing them with quality workers, withholding payment for unacceptable performance or encouraging quality work by offering incentives for a job well done.

E. Technical Analysis Methods

The topics above will be closely examined by performing an in depth analysis. The analysis will investigate the critical research required, value engineering, schedule reduction and a constructability review.

Analysis I: *Elimination of Perimeter Baseboard Heating*

To investigate whether it would be feasible to eliminate the baseboard heaters and reduce the size of the boilers by improving the energy efficiency of the building envelope it would be necessary to determine the cost of the new system. In order to calculate this cost it will be necessary to analyze the envelope and determine what design changes must be made to improve its performance. These design changes may be in the form of using a triple pane glass or adding more insulation behind the walls. This would require research on the topic. Input from industry professionals who have expertise in this area would be essential. Contacting people who have experience with both the design and construction of high performance building envelopes would provide feedback on how such a system could be implemented on this project. This would make it possible to get a good idea of the upfront cost, life cycle costs, constructability challenges and schedule impacts associated with such a system.

Analysis II: *Complications Installing Pre-Fabricated Exterior Stone Panels*

The pre-fabricated stone panels were more complicated to install than expected. An analysis of these panels would aim to determine how those problems could be eliminated.

These problems could be solved by using a better design or perhaps by changing how the execution in the field was performed.

Research would be conducted on similar systems. General contractors, subcontractors, engineers and architects who have used pre-fabricated exterior wall sections would need to be contacted in order to learn what works well and what doesn't work well for these systems. Schedule, cost and constructability would be the main issues of concern.

It would be interesting to investigate whether problems could have been avoided simply by awarding the glass and the stone to the same contractor. This would reduce the amount of coordination that is required between parties and also shift the responsible of the exterior wall to a single contractor. Problems related to the quality of the detailing on construction documents could possibly be avoided if the exterior wall was awarded as a design-assist. This delivery method would make a single contractor responsible for the design and installation of the wall. This would provide a powerful incentive to ensure that the system is designed as well as possible. To determine whether these would be good solutions it would be necessary to contact people within the industry who have expertise in this area.

Analysis III: *Granite Finishes*

The construction manager needs to take responsibility for avoiding schedule delays. In the case of the granite finishes these delays were largely a result of the owner and architect delaying the approval process. Since the granite is a long lead item these delays can have a negative affect on the project schedule. An analysis of this item would focus on what techniques a construction manager can use to influence other peoples decisions. It would be useful to understand the techniques that can be applied to tactfully put pressure on other people. In this case it would include how to accelerate other people's decision making process or how to influence them to choose materials that are local and easier to obtain. Construction managers must be able to use their knowledge to leverage the thinking of less experienced people who have an affect on the success of the project. These people skills are something that is acquired over time. Interviews or surveys could be conducted on experienced construction managers to gain an understanding of how they deal with people.

Analysis IV: *Project Labor – Union vs. Non Union*

A study could be conducted to determine the effect of a union vs. non union workforce on the outcome of projects. Research would be conducted on labor rates, productivity and the overall performance quality of each workforce. If labor has a measurable effect on projects another study should be performed on the forces within the market that control the labor force and what, if anything, can be done to make it more favorable to the project team. This research would consist of interviews and surveys.