Enabling Synergy Among Renovation Teams

Final Thesis Report

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Michael Webb
Construction Management

Dr. David Riley
Faculty Consultant

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Square 320

Project Overview

- Renovation of 4 historic buildings
- Construction of 12-story High End office
- Rejuvenating the District's East End
- Notice to Proceed: June 2006
- Substantial Completion: May 2007
- Total Duration: 23 months
- Currently at 85% Leased Tenants

Project Team

Owner –	Douglas Development Corp.
Architect –	Pei Cobb Freed & Partners
Engineer –	Tadjer Cohen Edelson, Inc.
CM –	James G. Davis Construction Corp.

Vital Building Statistics

Size –	302,000 SF	Class A Office
	74,300 SF	Parking
Height –	12-Stories Above Grade	
	5-Stories Below Grade	
Structure –	Renovation:	Steel Frame w/ Deck
	Tower:	Concrete
Delivery –	Design-Bid-Build	

Architecture

Tower - Heavily appointed granite and marble lobby with high-end bathrooms make a strong statement that luxury is what this building can provide any business. Custom curtain-wall is Pei Cobb Freed's signature of design of this Tower.

Renovation - Cleaned and re-appointed brick façade is complemented by new ornamental metal décor that's kept true to its original look.

Structure Systems

Tower

- 11, 50ksf caissons supporting 4" slab on grade base
- 8" slabs, 5 below grade & 12 above grade
- post-tensioned beams for full span & open floor plan

Renovation

- steel frame supporting historic load bearing terracotta floor
- steel beams connecting both bldgs creating atrium

Electrical Systems

Switchboards

–A: 3000A 480/277V, 3ø, 100,000 A.I.C.

–B: 4000A 480/277V, 3ø, 100,000 A.I.C.

Emergency Generators

- 600 kW, 480/277V, 3ø
- 4 W Diesel GENSET w/ 50 Gal. Day Tank

Mechanical Systems

Cooling Tower

- 2x 1800 GPM, 149,090 CFM, 2x 10 kW heaters

Water Cooled AC Units

- 13 VAV units: 11x Trane SCWFP, 2x Mammoth VVW
  - 766-GXC & 644-GXM

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“Enabling Synergy Among Renovation Teams”

Executive Summary

In light of the recent changes in the national economy, now more than ever companies are searching out new markets and lucrative job opportunities. The construction industry, while very different than most occupations in both project lengths and un-changing methods, is experiencing the same trends as other industries. New strategies are being implemented to ensure business can continue as usual. In the age of steadily rising energy prices there has been a dramatic shift from new construction to historical renovation work where buildings can be reengineered to be efficient, finding long term energy cost savings.

For James C. Davis Construction Company and all construction firms alike, historical renovation work is a promising rising market and significant effort should be made to alter their long-term strategies accordingly. The initial challenge with this comes from the considerable differences that exist between historical and new construction but those differences are believed to be small in comparison to the potential gains that can come from growing into that market.

This report will offer effective methods that if used correctly, have the potential to unlock the synergism that can only come when different parties are united in the hopes of achieving greater success as a whole rather than individual success along the way. Using the Square 320 project as the backdrop, this report evaluates three distinct areas that should be intentionally addressed on every renovation project in hopes of discovering significant cost savings, schedule acceleration, and more effective collaboration.

Encouraging joint meetings and early communication on the project site, when coupled with the utilization of cutting edge technologies, has the potential to expedite a project as the group forms and focuses forward on the overwhelming benefits of mutual success. By being innovative and forward-thinking, renovation projects can avoid design decisions that would result in severe financial penalty. Similarly, the desire to explore alternative technologies and pursue re-designed systems can unlock considerable savings for each party. Finally, by monitoring the growth and development of a group's working relationships, a broadened perspective can be reached in an effort to strengthen the interpersonal skills of the whole. Not only does it promote the benefits of the individual, but when all parts are working their highest efficiency, then the whole benefits as much. The Square 320 project provides many examples of how renovation work, when approached correctly, can be the source of great financial gain and team achievement.

When construction companies look to the future with a strategy for investing their energy and attention in these financially difficult times, this report will shed some light on the increasing benefits and growing necessity to rebuild and recycle historical buildings as an alternative to tearing them down and starting from scratch.

Introduction

The Square 320 Project is favorably located at 1199 F Street NW, the corner of 11th and F, in the resurgent East End submarket of Washington DC. Square 320 incorporates the renovation of four historic buildings with the new construction of a 12-story Class A office building. This exciting renovation project sits on top of 5-stories of below-grade parking totaling 76,075SF and offering 167 parking spaces. Above grade, the new 12-story concrete tower and the renovated historic buildings will together create 360,600 SF of rentable office space.

The tower's skin, a custom curtain-wall designed by famed architectural firm Pei Cobb Freed, is just one of many attempts made in this project to appeal to a wealthier base. Additional dramatic features in this project including structural steel bridges that connect the bronze and aluminum curtain wall system to the restored historic masonry buildings, all under the cover of a 110-foot skylight and highly appointed stone-top restrooms, a green roof, and the copper panelized skin.

On the opposite side of the site, the renovation teams are working to bring back to life three buildings, each over 100 years old. Each building will sport all new interiors built upon a strengthened steel decking structure. Despite the element of unknown, work is progressing well in the historical buildings. The historic storefronts will be replicated with an aluminum system of decorative stone and cast iron ornaments at the street level.

Douglas Development, the project's developer, has played a significant role in the rejuvenation of the older run-down East End neighborhood in Washington DC. Douglas sees this part of the city as an exciting new place to gather and live in luxury – they, along with Davis, continue to spearhead the development of this area.

When completed in the spring of 2009, Square 320 will be an ideal place to work, shop, and play in Washington, DC with luxury office space offering a very close proximity to museums, sporting events, and the DC nightlife. When you combine that with a posh consumer shopping district, the East End is definitely the popular place to be.

Background

The duality of the Square 320 project is all the more clear in the dissection and analysis of its construction. The differences between the historical renovation and the Class A office tower are clearly seen in the types of challenges and issues both buildings have encountered during their construction. In a sense, there are almost two different projects competing for the attention of a single staff.

Douglas Development is a long standing client of DAVIS with many years of work in the District of Columbia. After coming off a successful, and yet similar new construction and renovation project on the Atlantic Building just down F Street, Douglas

Development was excited about the work they do together and quickly got connected to do it all over again.

Douglas Development selected the site of 1199 F Street NW as part of a much larger plan to expand the central business district of DC and rejuvenate the East End. Many years ago, the East End housed high-end businesses, cosmopolitan shopping, and comfortable living options but in recent years the area has weakened. Douglas saw this market opportunity and has been involved with multiple projects, residential and commercial, working to revitalize the area and return it to its earlier status.

Douglas Development has worked with DAVIS on a handful of projects, and as such, there is a strong working relationship and an unspoken understanding of exactly what one expects from the other. Douglas's primary concerns with the project rely in two areas, as designed quality and the on time delivery of the designed product. Douglas maintains a strong reputation as a real-estate broker in the Northern Virginia metropolitan area. Therefore, they have certain standards that must be upheld. In Square 320 those standards are focused on protecting the luxury of the building and ensuring that the tenants can move in on time as planned. In fact, currently there are many law firms that have not only committed to moving in but have also begun working to fit-out their space and finish their floors in the office tower. Furthermore, Douglas has made a commitment to design and pay for highly luxurious office space that would attract the wealthiest of tenants. This is most evident in the level of attention that was paid to both the design, construction, and finishing of the tower's lobby, bathrooms, and fitness center. Douglas' priority is to create an environment where upper class professionals come to work, this is the product that they have sold the tenants and it is DAVIS' responsibility to ensure that product is delivered.

Douglas has been most concerned with the timely move-in of the tenants into the office space. Their desire has always been to offer very high-end and luxurious office space for Washington's growing companies and to have them settle in as soon as possible. In order to attract the upper echelon of companies, Douglas' main focus of the project was the proper execution of finishing the luxurious spaces. These finishes included granite stone top bathrooms with highly machined stainless steel partitions and front louvered wooden doors. And by far the most important finishes were that of the lobby where expensive stone was accented by highly stylized and appointed furniture. There haven't been any significant delays in the schedule thus far allowing for timely move-in of the tenants. At this stage in the project, Square 320 has acquired over 85% of tenants and expects to reach 100% before construction has completed.

Project History

The main constructability challenges lie in the historic renovations where information on the existing conditions was lacking at the early stages and new challenges increase as demolition brings them to light. Prior planning and extensive surveying would’ve played a vital role in encouraging the success and overall efficiency of the renovations. Additionally, the close proximity of the Washington METRO forced specific measures to be taken to ensure the excavation support of the western wall opposite from the historical buildings. These concerns were addressed with little prior planning and have been tackled one by one through intentional evaluation.

The project schedule played a weak role in this project and as a result it became very difficult to track the progress of work and inevitably the project fell behind schedule. The leading cause of frustration on the project continues to be the challenges that the teams face with the renovation work. The biggest cause of this delay came from the unforeseen conditions with the renovation work and the continual multiple RFIs that were left open at any given time. Significant schedule time was made up with the creation of leadership meetings that guided the project teams to take the initiative to accelerate the progress of work, the restructuring of the work on the bathrooms as the manpower was doubled and the time was compressed, and the façade restoration work was re-sequenced to take advantage of available personnel and space on site.

The duality of this project, in both the renovation and new construction phases, can be clearly seen in the detailed project schedule. Organized into subcategories, the schedule outlines vital construction items and milestones. Any items that might have significant cost implications are specifically noted, such as construction and removal of the tower crane. While activity durations drive the schedule length, it is these individual milestones that tell the whole story. The project schedule spans a 31 month period in entirety but the construction duration only accounts for 27 of those months. In reference to the structural estimates discussed in this report, the durations of those activities include 111 days for the garage and 170 days for the tower. The project is scheduled for substantial completion in April of 2009 at which point a 90-day punch list period begins.

Project Delivery System

The delivery system used in the Square 320 project most resembles Construction Management Agency at risk. This is based in the fact that Douglas had a plan for what they wanted in the design of the project, sent that out to the architect for design, and then upon completion of the design then pursued builder options. As discussed above, due to the close relationship between Douglas and Davis there was no formal bid process. Instead, once the design had been significantly completed, the two entities met together to discuss the scale of the project, expectations of the budget, cost estimates, and any additional financial constraints. Eventually, Douglas and Davis arrived at an agreement with a Guaranteed Maximum Price contract.

This project is very different than most in that it required the services of three distinct design firms to complete the architectural designs for the full scope of the project. The signature architect on the project was the firm of Pei Cobb Freed & Partners. Their greatest responsibility lied in the design of the high-profile aspects of the building. In order to satisfy the desires of the owner, Pei Cobb Freed designed the very luxurious spaces of the office tower including the highly appointed lobby and executive restrooms. But by far the most significant role of the firm was the design of the tower’s skin and custom curtain wall. The firm of Pei Cobb Freed supplied the name recognition and upper class status that Douglas Development desired from this project. The second architectural firm was that of HKS, P.C. of Washington, DC. They acted as the architect of record and presided over the complete design of the new construction rather than just select building elements. They were inevitably responsible for the integration of work between the different architectural firms throughout the project, significantly supported by their local office. Finally, the architectural firm of Shalomes Baranes Associates was responsible for the restoration and renovation of the buildings on the project. A local firm with extensive historical renovation experience, Shalomes Baranes ensured that the abatement, restoration, and renovation of the Nordlinger, Corcoran, and the B&W Building and Annex were precise and entirely accurate to the buildings’ historical state when it was first built. Having three different architectural firms on one project only blurred the lines of responsibility and added to the stress of the project over time. Especially in terms of RFIs where one firm would be approached with the inquiry but would deny responsibility for it and pass it off to the other firm. Each of the firms played a role in the “run-around” game sending Davis back and forth between firms before eventually getting the necessary response.

Through conversations, it became evident that the specifics of the contractual agreements between the design teams and the owner would not be made available. Rather the assumption will be made that the contractual agreements between Davis and the owner mirror those between Douglas and the various design teams. These firms include Wiles Mensch Corporation for civil consulting, Tadjer-Cohen-Edelson Associates for structural design, Girard Engineering for MEP design, and Cosentini Lighting for lighting design.

Davis’s role in the construction of Square 320 resembles more the role that a general contractor would play rather than solely a construction manager. Davis was selected by Douglas to act as the overall facilitator for the construction on the project and hold the risk associated with it. With the exception of smaller scopes of work, Davis holds the contracts with the subcontractors and responsibility of their work. The owner has held certain contracts throughout the project such as the paint abatement, aspects of site dewatering, selective demolition, and hazmat removal from the site. In addition, the owner is responsible for the Builder’s Risk Insurance. Prior to construction beginning, Douglas met with Davis and came to the joint decision that every subcontract over $200,000 was required to be fully bonded through 100% performance and payment bonds. With the design of the project complete and the scope and schedule of the work sufficiently defined, Davis implemented Lump Sum contracts between all of its specialty and sub contractors. While many of the subcontractors were repeat associates of Davis

over the years, Square 320 was public job that went out for bid and Davis worked to narrow it down to three bids per trade. Then Davis met to evaluate each bid and select the desired contractor.

Local Conditions

The District of Columbia is known for the restrictions placed on the height of all buildings. With the restriction in place, Square 320 was designed to get maximum rentable space by minimizing plenum space and moving towards a cast-in-place concrete design. At specific locations within the tower post-tensioned beams were included to reach the desirable span length without the need of further supports.

The project encompasses the historical renovation of 4 previous buildings on the 11th Street side of the block, the Nordlinger, Corcoran, and the B&W Building and Annex. Great effort was made to ensure the restoration of these buildings to their original condition. Each of the historical buildings had significant abatement and remediation that needed to be accomplished before the renovation could commence but designers wanted to keep the existing structural system intact. Due to the age of the buildings however the floor structure needed to be supported and was down so with the use of structural steel, metal deck, and concrete fill. In addition to renovating the buildings, the owner wanted to create additional rentable space by jacking up the entire B&W building 4.5 feet, excavating it further out under the sidewalk, and then extending the footprint underground and finishing it was basement space.

Throughout the project, proper site management will be crucial seeing as space is the limiting factor. At this point, the Square 320 project has encountered normal waste management conditions that one might expect for commercial construction. At the early stages of construction, dumpster pickups came once every two weeks, and increased in frequency to once a week once the cast-in-place concrete was underway. Finally as expected, with dry-wall and interior finishes going commencing, dumpster tippings are expected to occur 2 to 3 times a week.

The Square 320 project is not seeking a LEED certification therefore does not have a need for various sorting dumpsters for recycling. Furthermore, if there was a need for recycling, it would be worth employing the services of an off-site sorting service that would pick-up the discarded materials and sort them later.

Since the construction site was very limited in space there was absolutely no parking allowed on site. All of the parking was off-site and contractors as well as a Davis' project managers were responsible for finding their own parking. The majority of people used public transportation to get to the site. In fact, having a DC Metro station within a few blocks provided all of the field workers, contractors, and executives with a reliable source of transportation. This bodes well for the convenience of the metro once this project is completed; it is very likely that the majority of tenants will take advantage of the metro system.

Site Information

Washington, DC is a world-class capital city that will guarantee unparalleled opportunities to small and large businesses and organizations. More than a political and cultural center, Washington, DC is also a business capital that is experiencing an unprecedented renaissance as one of the fastest growing and most exciting economies in the country. Choosing to locate your business in DC will ensure advantages that are unmatched by any other city. Over the past few years, DC’s economy has proven to be strong and resilient while major events and cycles have shocked the rest of the nation. DC is a well established hotbed for such industries as business services, nonprofits, law firms, hospitality, technology and an increasingly vibrant retail market. The nation’s capital has the tools, the infrastructure, the workforce, the accessibility, and the climate for businesses to flourish.

Transportation

DC’s public transportation system is highly efficient with the 2nd largest rail network and the 5th largest bus network in the United States. Not only do people rely on the Metro system to commute to work every day, they also use it to explore the city’s many attractions. In 2007, there were a total of 339.4 million trips taken by riders. The average commute time for residents is 29.7 minutes. One of the most exciting features of the Square 320 Project site is its close proximity of the “Metro Center” metro stop just across the street from the north end of the site. This is very attractive to businesses and commuters who like to avoid the long commute into the city from the metropolitan DC area.

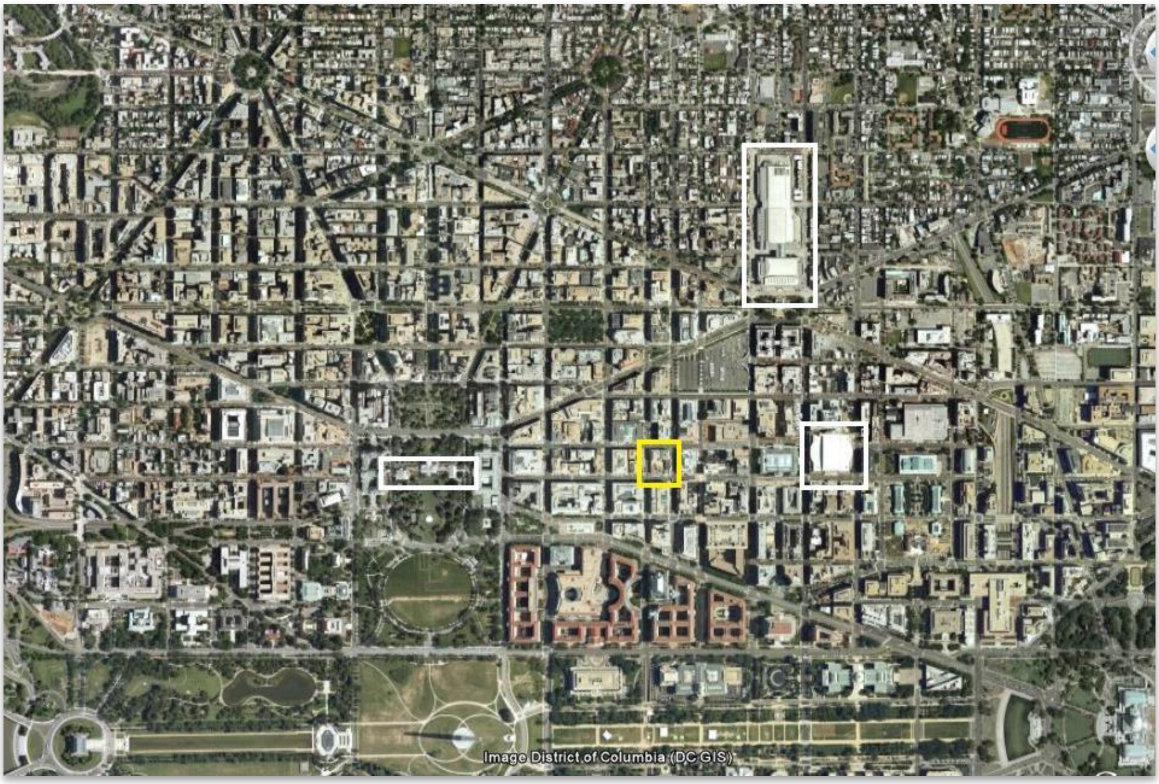


Figure 1 - District of Columbia

Location

Located in the up & coming Northwest district of Washington, Square 320 is strategically located near some of the city's biggest attractions. In the aerial image above, the project site is highlighted in yellow. Just four blocks due west, one can get a tour of the White House and see the most popular site in DC. The first floor shopping is strategically located just a few blocks from places like the ESPNZone, International Spy Museum, and the Verizon Center (highlighted in white to the east). To the south one can walk a few blocks and see a show at either the Warner or the National theatre or keep heading south to the National Mall and visit any of the numerous educational museums the Nation's capital has to offer for free. And if one heads north, it won't be too long before they reach the new Convention Center spanning three city blocks.

Douglas Development knew that site selection was important and when they had the opportunity to take advantage of Square 320's central location they jumped at the chance. There is no question that projects like this one and many others are making great strides to revitalize the NW district with businesses, shopping, and entertainment

Figure 2 - Aerial View of Site

Excavation Support

From above, the Square 320 project occupies nearly two-thirds of the city block. Running north and south are 11th and 12th street from right to left. Running east to west the site borders F St. This project excavated nearly 100 feet below the ground level in order to prepare the way for the 5-story 76,000 SF parking garage that would become the foundation for the 12-story office tower. Before the excavation would be allowed to move forward an extensive dewatering plan had to be created to account for heavy water infiltration into the sight. The dewatering plan consisted of 6 well points along the perimeter of the site continuously discharging directly into the storm sewers in excess of 30,000 GPM. The system was monitored frequently from piezometers on the west and south of the site. Once the system was in place the site was excavated and the support system was built. The supports consisted of a comprehensive system of tiebacks, lagging, tangent piles along 12th street, heavy steel diagonal bracing, and discontinuous underpinning at each level. The majority of the support system was a permanent system with the exception of the large tubular supports that can be seen in the image below.

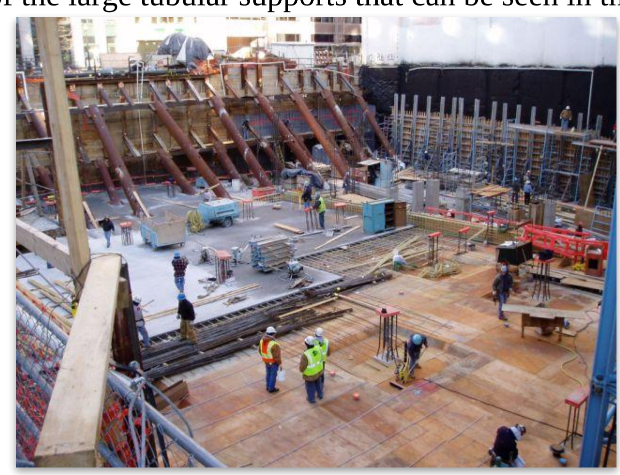


Figure 3 – Excavation Support

Site Layout

Using the combination of the images and the site plans, the organization of the Square 320 project should be rather straightforward. With a tower crane stationed in between the two structures it provided to means to do all the heavy lifting necessary throughout each phase of construction.

Excavation

In these images and in the following site plans it is important to notice the placement of the ramp, where the excavators and dump trucks are required to position, and how the density of the downtown site affects the efficiency to which the work can be done. It is important to make the distinction that although this is not in the photograph, during the excavation phase of construction, the DAVIS field office was housed on the 2nd floor of the B&W building prior to the full demolition of the building. This decision was made to reduce the clutter on the site by not requiring a mobile trailer on site.

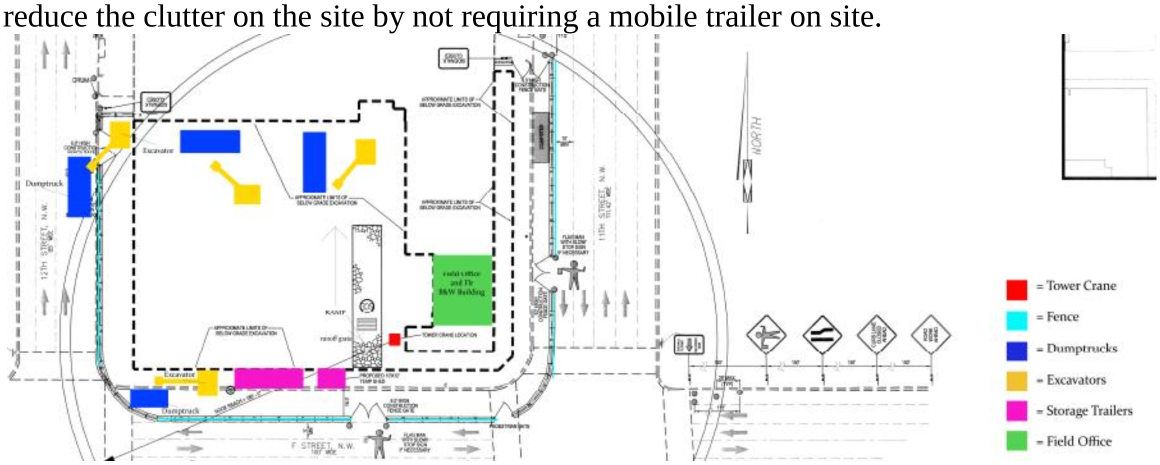


Figure 4 - Site Plan Excavation Phase

Figure 5 - Corner of 12th & F St - Close

Figure 6 - Corner of 12th & F St - Far

Superstructure

Similar to the excavation phase the concrete trucks and pump trucks had very little room to maneuver. At all times during construction hours, a flagman took station at the corner of 11th and F St as trucks were getting in station for their deliveries. Throughout the full duration of the project, one lane of west bound traffic on F St was closed, fenced in, and used for storage or deliveries. At this stage in the construction, as soon as the concrete reached the ground floor the field office transitioned from the B&W building to the ground floor of the tower organized just west of the central elevator and utilities core. Demolition had already begun in the historic buildings and their work was based out of a single mobile trailer stacked on top of two large storage compartments half way up the block on 11th.

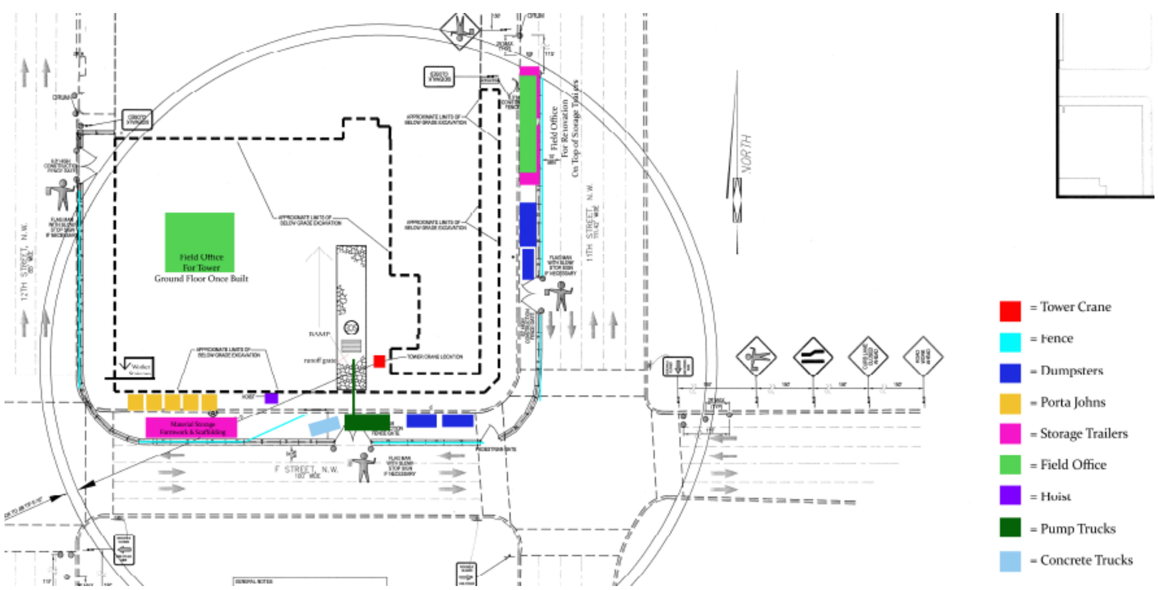


Figure 7 - Site Plan Superstructure Phase

Figure 8 - Corner of 12th & F St

Figure 9 - Corner of 11th & F St

Finishing Phases

As the finishing stages began, the installation of a complex trash chute system was installed along the north wall of the building with the chute leading to two large dumpster staged on the ground floor of the building in the loading dock located at the NW corner of the building. Additionally, a hoist system was installed on the South facade of the building nearly adjacent to the tower crane and continued to be heightened as more floors went up. If necessary, work on the renovation buildings was performed by use of a cherry picker as can be seen in the lower right picture below. This allowed the renovation work to not interfere with the hanging of the curtain wall and the enclosure of the building.

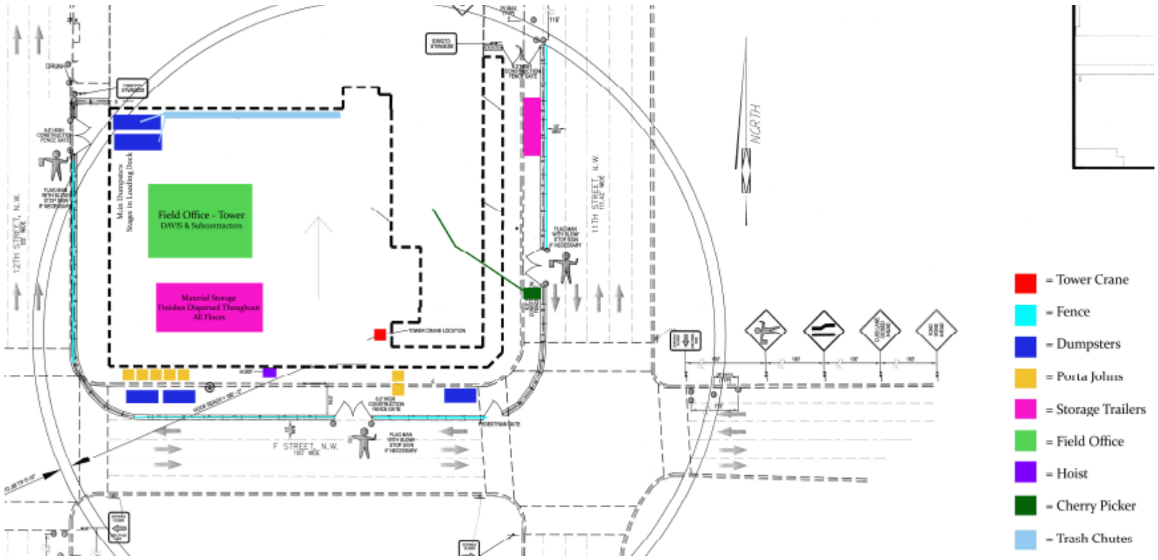


Figure 10 - Site Plan Finishes Phase

Figure 11 - Corner of 11th & F St

Figure 12 – Facing North on 11th St

General Architecture

Square 320's architecture will be best remembered for its elegant curtain wall. Douglas brought in the highly respected architectural firm of Pei Cobb Fried & Associates to design a fully custom, signature curtain wall that would display the building's prominence and high-luxury. Douglas is using this marriage of architecture and luxury to create an office tower iconic with the wealthy tenants. Pei's curtain wall consists of full height glazing panels with architectural bronze and decorative stone. At each concrete floor a sill plate extends out and down creating a lip-like channel for the hooks of the curtain wall system to fall into and transfer weight to. Above and below each of the connections are solid panels of bronze that add the style and color to the curtain wall. The architecture also implements a repeating pattern of masonry separated by two glazing panels on the first two floors and five panels for the remaining levels. Additionally, the design includes high-end appointed stone in the lobby.

The historical buildings are predominantly built with load-bearing masonry which offers a classical image. Ranging from bright tan brick to deep charcoal granite, the building facades are beautiful throwbacks to the turn of the century architecture as can be seen in the picture of the Barry & Whitmore below.

Figure 13 - B&W Building Brick Façade

Due to the height restrictions in the District of Columbia, cast-in-place concrete was used as the structural system for the 12-story office tower. As needed, structural steel was used in the renovation of the historical buildings. With those renovations, great effort was taken to preserve the original terracotta flooring but additional support was required.

I. Information-Time-Money Relationship

Any historical renovation job is going to have a significant amount of unknown variables to it. When you step into a building that was constructed over 100 years ago there are going to be significant differences between what you see and what shows up in the blueprints. Not only were the building structures and techniques drastically different in those days but there were no codes governing construction practices. For that reason, it’s unrealistic to think that an architect or a contractor will have all of the necessary information ahead of time before stepping onto the site of a renovation job. However, with the help of modern technology and a sense of prudence, an owner, architect, and builder can achieve their goals in less time, for less money, and with less frustration.

Each of the historical buildings, the Barry Whitmore, Corcoran, & Nordlinger, had some degree of concealed conditions. In some cases there were beams wrapped in drywall or weakening wooden structures disguised by plaster and lathe. In addition, two of these buildings were built as infill, meaning that they were built between two previous structures with cold joints at both ends but no real free-standing structural support of their own. Naturally, when the project was just starting the owner hired a surveying team to determine the existing conditions of the building before design and construction would begin. Despite the concealed conditions, rough drawings were produced, and architectural designs were based off of them. Even to this day, two years into the project, the design has yet to be finished and there are no complete drawing sets. The renovation work has presented the biggest challenge for the construction team and has been the leading cause of project delay. It was a challenge for all parties involved because both sides felt as though they were at a stalemate. When an issue came up, none of the work could continue and until the design team had time to assess the situation the general conditions costs continued to grow. All of the constructability challenges point towards the design teams for lack of information and in some cases misinformation. Yet, to their defense, without performing an extensive interior demolition of the site, the majority of conditions remained concealed and would not have been uncovered until too late anyway. As the project progressed and the work continued, lack of information became a chronic problem for the entire project and the leading cause for frustration with the Davis team.

The original proposed solution to this challenge incorporated a two phase strategy of selective demolition followed by the 3D Laser scanning of the building’s interior. The accurate surveying of the building’s interior spaces would provide the necessary information and detail in order to facilitate a precise design. This would in turn provide the builder with all of the necessary information to plan properly and perform the scope of work efficiently. No longer would the work be delayed by daily surprises and endless RFIs.

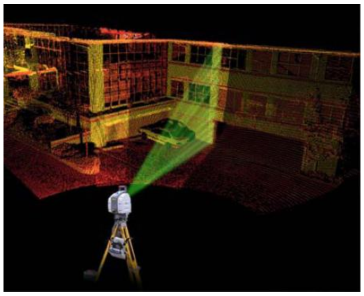


Figure 2 - 3D Laser Scanning In Action

3D Laser Scanning

This relatively new technology has been very successful in recent years. These 3D laser scanning systems measure and capture existing conditions in the built environment. LIDAR (Light Detection and Ranging) Technology is a method of measurement using a Laser pulse without the use of reflectors and generates a real time image. The raw field information is stored and can be used to measure point-to-point distances or for the creation of 3D visualization. In general, the information gathered by a 3D imaging system, in addition to polar or Cartesian coordinates, can also include return pulse intensity and color associated with each coordinate. The color information is usually obtained by an integrated camera or video or an externally mounted camera or video. Once the laser scanning system is set-up in position, it will begin scanning the building and mapping hundreds of thousands of points, which when compiled into a single file creates a 3D point cloud. The point cloud, as seen in the image below, encompasses all of the relative distance data based on one common landmark.

Figure 3 – Ornate Building Facade - Point Cloud

Figure 4 - Building Facade 2 - Point Cloud

In order to scan entire buildings, the equipment can make several scans at different positions, find common locations and use those to triangulate a base coordinate system. From that coordinate system the individual point cloud scans can be combined into a single file. These files, while they resemble 3D designs, still need to be adapted in a computer before they can be used as design tool. But, as seen below, these 3D scans can be joined to have all of the measurements in one single file, precise and accurate to the nearest 1/8th inch.

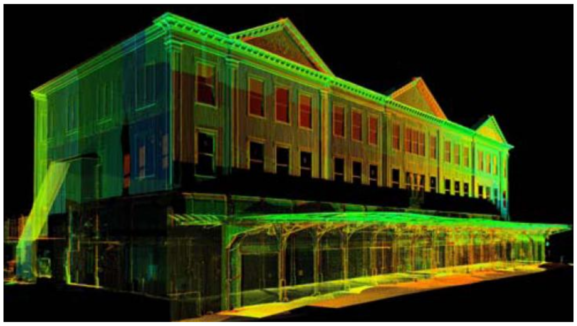


Figure 5 - Pier 17 NYC - Redevelopment Point Cloud

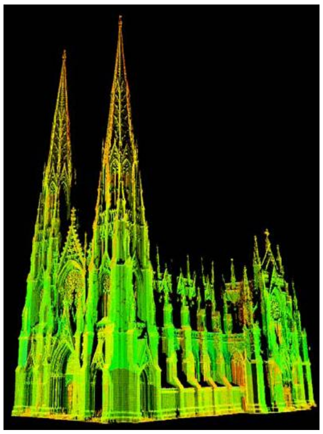


Figure 6 - St. Patrick's Cathedral

In the field of historical renovation work, 3D laser scanning technology has become more desirable because the equipment can collect extremely accurate data in only a matter of hours rather than the traditional weeks. Once these files are created by the surveyor, they can then be offered as deliverables to the owner or designer as a 3D design. Industry research has determined that with historical renovation work, 3D scanning technology can not only reduce field work and improve efficiency but also provide a variety of deliverables like a 3D model or CAD as-built drawings that will significant expedite the design process. All of these reasons encourage the future application of laser scanning to all historical architectural surveying, renovation, and restoration.

Benefits

In a competitive field where time, accuracy, and better informed clients are high priorities, 3D laser scanning offers a perfect solution. According to G. Antova, assistant professor from the University of Architecture in Bulgaria, this ultra fast, high density 3D data is far more beneficial than traditional surveying from both a practical and economical point of view. The higher productivity capability of these systems equates to more time spent developing a good design which in turn leads to quicker project completion. Due to the rapid nature of data collection, the scanner costs become increasingly more cost effective for larger sites. The main cost savings comes from the significantly reduced field time. Additionally, all of the detailed data can be collected without damaging or disrupting the historical building or its aging façade. Once the system is set-up it quickly becomes operator independent. Only a single operator is needed for collecting data which offers a significant reduction in labor costs as well. While the technology is expensive to own and operate, 3D laser scanning offers a cost effective option when considering the significant savings of labor costs on and off-site. The immediate return of a 3D view of the building is also a great benefit in the communication of design ideas to all parties. The high density of data that is collected with 3D scanning ensures a high degree of accuracy and a more effective 3D representation of the space. Finally, the highly accurate information obtained from 3D scanning is invaluable to the building construction and architectural renovation industries.

Would it work?
Mike Cumberland, an engineer with Davis, spent the first few months on the Square 320 Project mainly focused on the initial surveying of the property. When asked about determining if 3D laser scanning would've been the optimum surveying solution in the historical buildings, his response was no. He cited a laundry list of challenges and issues that arose with the project the biggest one being, without demolishing the entire interior of the building, there would be no way to capture the necessary information with the 3D scanning. Additionally, another challenge early one involved the owner's desire to keep the tenants paying rent and in the space as long as possible before construction began. This only impeded the information gathering process.

When pressed, Mike admitted that the scanners would work marvelously on the façade providing very detailed and accurate measurements of the ornate designs but an interior survey would become irrelevant once the demolition began.

Alternative Design
The initial plan to scan the building's interior was a little naive, not fully understanding the extent to which the existing conditions of the historical buildings were hidden. The alternative strategy only came after having the opportunity to visit the site in person and discover firsthand the design challenge that is the Corcoran Stair 3.

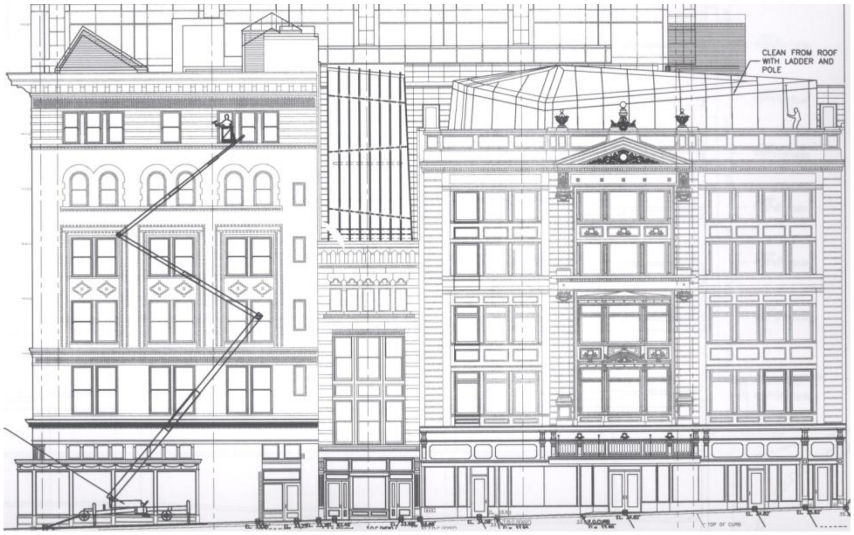


Figure 7 - Historical Elevation – Facing West

The Corcoran building is the narrow building sandwiched in between the BW to the left and the Nordlinger to the right. Since these three buildings all make up the retail space on the eastern side of the block, the buildings are interconnected and require only a single staircase to access each floor. The design placed these stairs in the back end of the Corcoran building because of its narrow width and central positioning in relationship to the other two buildings. The significant challenge associated with this design decision is that not all three buildings share the same elevation and as such not only do these stairs require custom layout and design but a series of ramps need to be installed transfer horizontally from floor to floor.

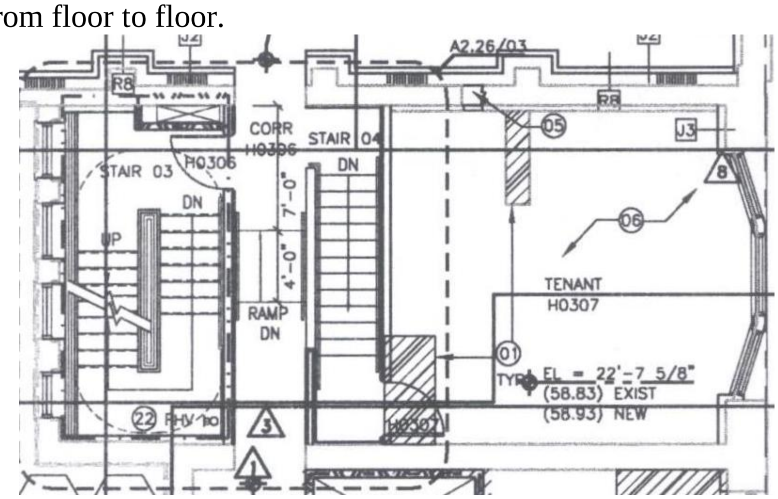


Figure 8 - Corcoran Stair - Plan View

The plan view of the Corcoran stair clearly shows the retail space to the right with the staircase at the back of the building, as seen on the far left. The Corcoran building was so narrow that a standard size stairwell would not fit in the space. Still having to conform to ADA, the stair had to be specially designed with landing elevations required at non-repeating heights and number of risers per floor not being equal. All the while, the design of this stair demanded tight tolerance because of the architectural glass used along

the interior hand rails. The unpredictable floor heights can be easily seen in the following section of stair 3 in the Corcoran building.

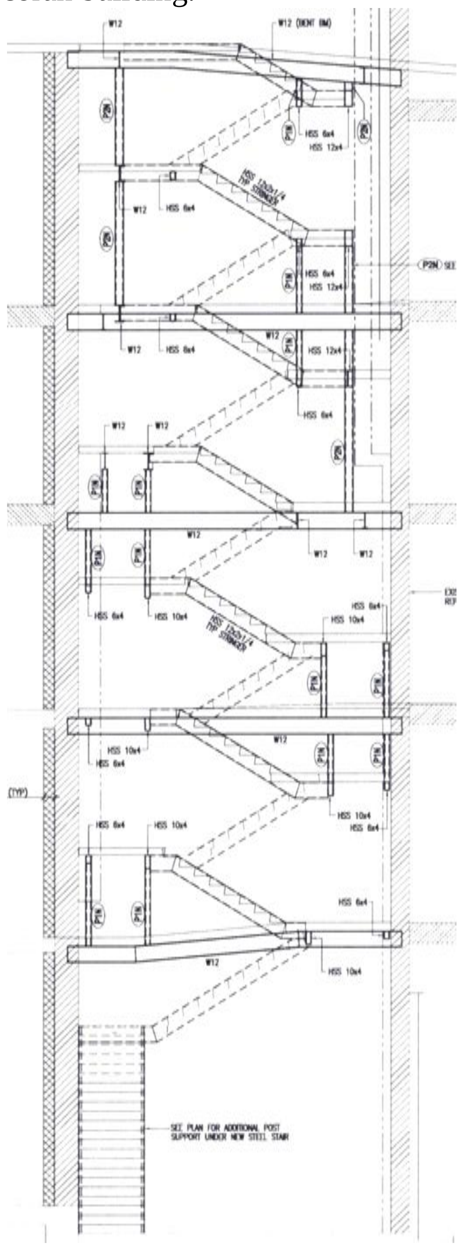


Figure 9 - Stair 3 Section - Facing East

This stair went through multiple redesigns before the final design was completed and eventually built. With as time-intensive as this design was, more detailed information would have significantly expedited the design process and done so by avoiding many of the frustrations and mistakes along the way. The ultimate goal and alternative to the original proposal would be to perform a 3D scan of the vertical space that would house the stair and then use that data to create a 3D model that the custom stair could be designed inside of. All the necessary information would be in the digital form and it could be quickly manipulated to ease the design process and eliminate conflicts that

occurred when the original survey did not accurately show the existing conditions of the site. This 3D scan would be performed by simply traversing up the vertical space creating a scan at each landing and floor while hitting common targets that would allow the scans to be combined into a single point cloud. This alternative proposal would significantly decrease the design time down from the full year it required by traditional means.

Professional Perspective - Cost

While the theory of the application is solid, Mike Cumberland of Davis was quick to outline initial concerns to be aware of. For example, that the wooden floor joists at the time of surveying were sagging and that elevations would vary from floor to floor. Or that the western facade of the Corcoran building had no self-sustaining structure and was neither fully stationary nor plumb at the time of surveying. Lastly, the very expensive and attractive glass handrail in stair 3 had very little tolerances so survey data had to be accurate. While this isn’t the best fit purpose for the tool, in his expert opinion, Mike offered that the best course of action would be to perform a vertical survey with a scan at every level.

Based on his experiences, Rob Duranczyk of Wade Trim in Florida, felt very confident that the 3D surveying of the Corcoran stair would be an effective way to gather the required information. Compared to traditional surveying, cost would likely be equivalent; the field procedure would offer no cost savings. However, the quantity and quality of data far exceeds what would ever be gathered by traditional means. One cannot just look at the price tag of the service alone; they must look at the dollar cost per piece of information or surveying data point. In his opinion, laser scanning isn’t a large cost in the grand scheme of a project. Any owner pays a considerable amount of interest on the project as its schedule is increased. The feasibility conversation must occur with the perspective of time versus money. The average scan could capture enough data in roughly 2 or 3 days. While the laser survey can cost as much as 4 times the price of a conventional survey, the detail is unbeatable and time it takes to manipulate that data into a 3D model still allows for an earlier finish than using traditional methods. If architects or engineers invest in the type of people that can work the specific software, then the surveyor would just need to capture the data for a day or two at a reasonable rate and deliver it to the designers. That whole design process just eliminated nearly 4 or 5 whole weeks. With a general conditions cost of approximately $30K per week, the added first cost of the laser surveying would pay for itself in a matter of days.

Variety of Rough Estimates for Scanning the Corcoran Stair						
Company	**Location**	**Conventional Survey**	**Time**	**Laser Survey**	**Scan Time**	**Data mine**
WadeTrim	FL	$6,000	6 wks	$15,000	1 day	14 days
Langan Engineering	NY	-	-	$5,000	1 day	3-5 days
Darling Surveying	AZ	-	-	$25,000	1 day	7 days
James C. Davis	VA	-	-	-	3 days	10 days

Figure 10 - Corcoran Stair Estimate

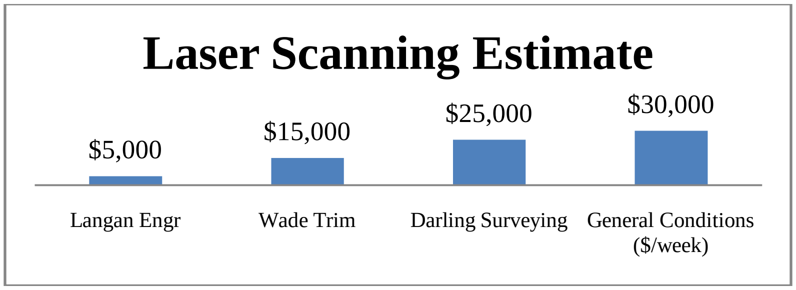


Figure 11 - 3D Surveying Cost VS Gen. Conditions

The average design stage lasts 4 months, and that's assuming architects don't discover problems with their designs. If the use of 3D surveying can shave redesign months off the back end by avoiding them all together, that will equate to considerable savings in design fees and operating costs.

On smaller jobs, there is more inequity in the use of 3D surveying. But, in the case of larger jobs with considerably more square footage, the 3D survey could easily cut the process time in half. According to Rob, if the project was a large industrial facility it would actually cost a significant amount more to use conventional surveying methods than implement 3D scanning. It is vital that the decision maker looks at the entire situation.

Experiencing Synergy Through The Information-Time-Money Relationship

Based on his experiences, Rob Duranczyk of Wade Trim, admits that communication between disciplines is poor. Within the surveying field, those professionals know their lingo and understand their criteria. Part of the problem always seems to be the lack of communication and coordination that is done prior to the start of a project. If an owner were to schedule a kickoff meeting prior to the design stage all parties could be on the same page from the start. Teams could be introduced and as a unit they could discuss where they expect problems to arise from. This is where Rob believes the true cost savings lie; early communication has the most potential for financial gain. This is only further supported by the Cost Influence curve below that shows if the owner waits too late to encourage team work between the various parties involved, then their level of influence drastically diminishes as the projects gains momentum.

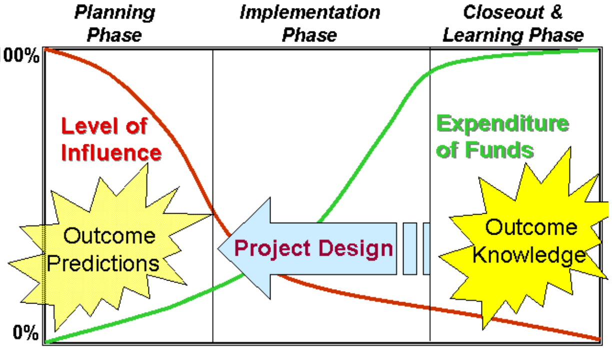


Figure 12 - Level of Influence Curve

In the world of surveying, professionals get to be involved with designers as well as builders. In fact surveyors tend to be well-versed in all the difference disciplines involved on a construction project. The owner is ultimately their client but they’re generally contracted with the CM. For surveyors, communication is key and a little coordination ahead of time can go a long way to save the owner money and expedite the project. If laser scanning can be implemented earlier, then the architects and the civil engineers can be working together sooner ensuring that both parties know the scope of the project and understand exactly what they need to accomplish at each stage in construction. By getting on the same page at first there are no longer assumptions that only one party understands. The technology takes the guesswork out of the job and allows the building’s data to speak for itself.

According to Langan Engineering, the real cost savings comes from having in house professionals that know how to interpret and handle the data that comes from the scanners. The cost of running the laser survey on site is considerably cheaper than the time and labor it takes to turn that information into a workable 3D design file. On one job, Langan built a BIM model directly from their 3D scans that helped virtually identify 3500 minor conflicts and 500 major conflicts on their project without ever stepping on site. All 4000 conflicts were able to be resolved in the virtual realm before the start of construction – each conflict was expected to require $7500 to resolve. Thanks to the implementation of 3D surveying on the project, the owner estimates that they saved over $500,000 from avoiding the onsite coordination struggles. The additional cost of using 3D scanning in lieu of traditional surveying easily paid for itself before the project even finished.

Conclusion

There is an inverse relationship between information and both time and money. The level of information any given team has on the project inversely equates to more efficient production rates and fewer delays from RFIs or hidden conditions. More efficient production rates relate directly to that portion of labor requiring less time for completion. If the job is completed faster, fewer resources need to be dedicated to the work and that aspect of the construction costs less as manpower and resources are used more efficiently.

Therefore, had the initial surveying period implemented the use of 3D scanning technology, there would’ve been much more information for the designers and the builders to work from. Without doubt, that increase in information would’ve brought upon substantial time and money savings that would’ve definitely benefited a project that suffered from endless setbacks.

In order to further optimize the situation, the owner should have engaged all parties at the earliest stage of this project to encourage proper communication, teamwork, and mutual support. As mentioned by Ryan Darling of Darling Surveying in Arizona, in order to utilize 3D mapping in all of its money savings capabilities, everyone must be on board from the beginning. Enabling multiple end-users to interface with the point-cloud early on will accelerate everyone’s work and encourage teamwork from the start. It is evident,

the frequent interaction and communication between all parties involved would have grown into a synergy, having every team take the initiative to expedite the work by encouraging quick and efficient communication at every step of the way. In this situation, each party would benefit from their mutual success leading to an outcome far greater for the whole than the sum of the individual successes reached on their own.

II. Hindsight Perspective on the Basement Expansion

When the design decision was made to maximize the rentable square footage of the building's basement, it meant only one solution: excavate the foundation earth. In order to achieve the required ceiling height, nearly 4.5 ft of earth had to be excavated out from underneath the entire row of historical buildings along 11th Street. The section view below shows the proposed new B1 level as compared to the building's original basement floors.

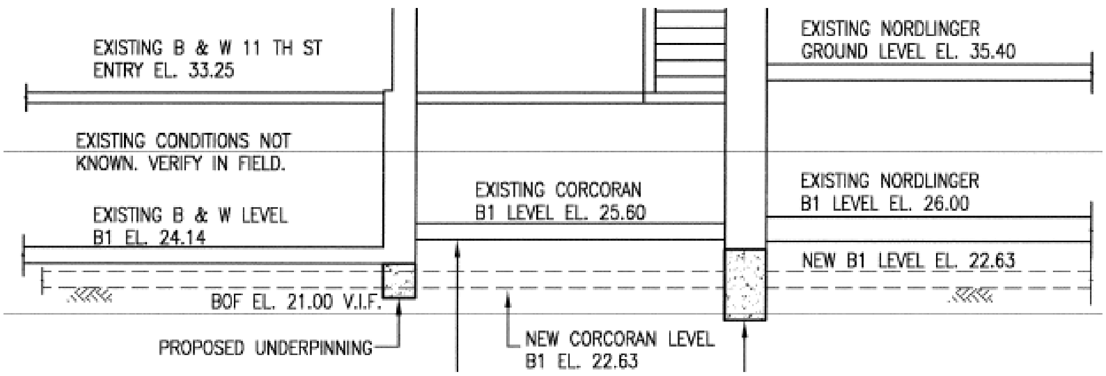


Figure 13 - Basement Section View

In addition, the project took advantage of a portion of the vault space beneath the sidewalks even though it was outside the footprint of the building and brought the basement foundation wall out 9 feet. This basement expansion was a considerable challenge that brought with it extensive challenges and stress to the already challenging renovation work of Square 320.

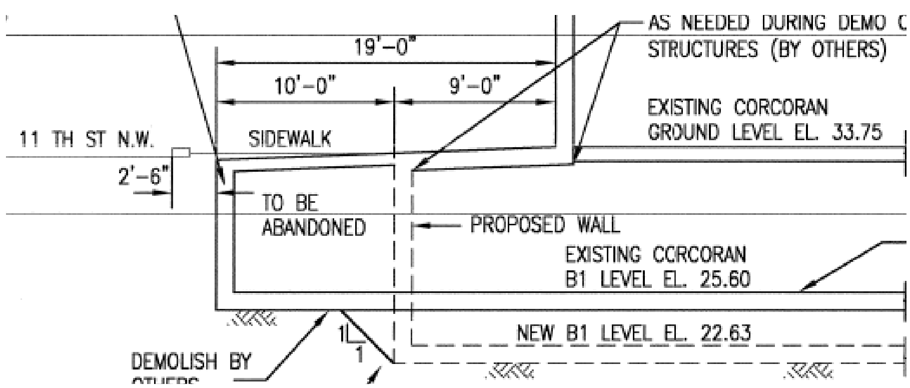


Figure 14 - Corcoran Bldg Section - South

The owner was very willing to go forward despite the challenges and risk that this sort of design decision added to the project. Not only did the work cost a considerable amount of money but it brought with it significant safety risks that hadn't been considered originally. Additionally, due to the age of the historical buildings, there was very limited information concerning the as-built dimension and structural conditions. In some places, load-bearing walls were as far as 3 feet out of place.

Procedure

Davis outsourced a large portion of the work to Clark Foundations, the renowned expert in below grade work. Based on the site conditions and constraints, their team put together a plan for supporting the building load while underpinning the building's foundations and then excavating to the desired elevation. In the image below, notice the footing and underpinning planned along the west wall. Alternative faster strategies could have included tangent piles or basic sheathing and shoring but due to the 12-story tower that came right up to the building's edge, the only Clark had was to install pin piles directly under the foundation of the west wall. Underpinning piles were installed 3 feet wide and 40feet deep, detailed below as a vertical line of circles just barely touching.

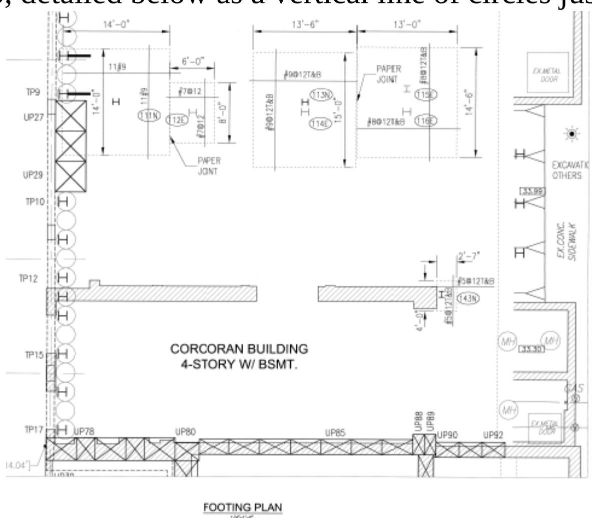


Figure 15 - Pin Piles Along West Wall

In sequence, a man on a rope would go down and dig a hole 40 feet deep. Then it would be filled with concrete and the man would move down the line skipping two and then coming back to them so that the building wasn't upset if too much earth was removed from right adjacent to the last pile. This procedure took an incredible amount of time as each hole needed to be hand dug and excavated by bucket. The next phase of work involved the demolition of the existing slab and excavation of the underpinning pits along each party wall and around each of the columns – these can be seen below denoted as horizontal ovals.

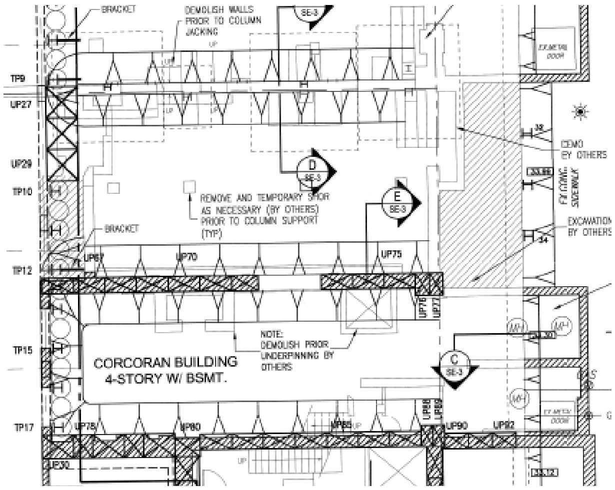


Figure 16 - Underpinning Plan Beneath Party Walls

Once the pits were set, Clark would use their jacking units to support the load of each column while it was excavated underneath and underpinned with concrete. The image below shows the excavation portion of the work prior to the underpinning and the concrete pour.

Figure 17 - Nordlinger Underpinning

As the column loads were supported by the jacking systems, the previous underpinning would be demolished, the earth would be excavated to the planned elevation and then the original column would be extended down to the new footing. Once the footing was ready, the column would be loaded again and the crew would move onto the next column and repeat the process until each column was successfully underpinned and the earth was excavated to the desired elevation.

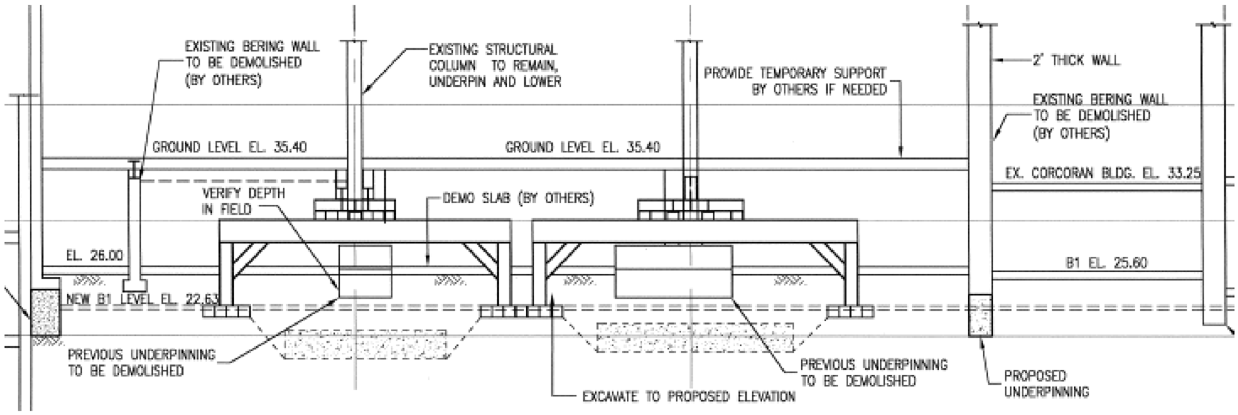


Figure 18 - Section View - Jacking Column Loads

The work was taking a lot longer than originally anticipated, partly because it was very complicated work but also partly because the crew kept discovering existing conditions that were not as they had originally planned. For example, many times the crew would excavate to find a much larger footing than planned or one that was entirely out of place. Then they would have to demolish it in order to excavate down the full 4.5ft in order to re-pour one. This became such a nuisance in the Nordlinger basement that at a certain point the team decided to stop demoing the footing and just excavate around it. The difference between these two concepts can be seen in the image below. On the right side, the footings were demolished and excavated below grade in order to have flat floor space, but on the left the existing footings were so big and too high in elevation so the crew just strengthened them with additional concrete.

Figure 19 - Nordlinger Footing

In short, this design decision to excavate and create rentable square footage led to expensive change orders and months in project delay. After the plan was implemented it became more and more evident that excessive amounts of time, money, and energy were thrown at this problem only to create a moderately pleasing outcome.

So, was this a wise decision? Did the owner and design team make the right call on this? The answers to these questions are pursued further in the following section. The analysis works to answer whether or not this decision was the most lucrative option. Was the decision to move forward and expand the basement the right one? The following analysis explores the financial ramifications and the associated construction challenges that ensued.

Market Conditions

The current condition of the real estate market in Washington DC is a promising one. The office sector within the District remains one of the best performing office markets in the country. All signs point to continued growth and a healthy market future. In fact with rising rental rates and decreasing vacancy rates, DC’s office market is the healthiest it’s been in the last 25 years. As the nation’s capital, one might thing the government owns the majority of the market but that is simply not true. 22 million square feet is occupied by federal offices and GSA affiliates but that only represents a fifth of the 100 million square feet of private office space on the market. In recent years, DC has seen the new construction of an additional 6.2 million square feet. Washington DC continues to offer one of the nation’s best markets for real estate investors in large scale corporate office projects. Furthermore, according to the Association for Foreign Investors in Real Estate, the District is ranked #1 in both national and international investment markets.

As a leader in the national real estate market, the District is always working in a progressive way to grow and expand its opportunities. This past fiscal year brought a total of 115 projects under construction totaling $9.5 billion. And looking forward, DC has over 300 projects planned totaling nearly $35 billion in development. Currently, Washington DC sets a national and global example of how to achieve sustainable development by creating policy and achieving a record number of LEED certified projects. It is an understatement to say that the District is a developing city; DC is by far one of the best locations to be a real estate developer.

Financial Data & Calculations

The purpose of this financial analysis is to determine the legitimacy of the basement expansion and to define in monetary terms whether the design decision was the correct one or not. This will be done in a simple way. Using the CCIM Financial Model created by Gary G Tharp of GT Commercial, this portion of the report will analyze the cost effective nature of the basement expansion. Excluding all other aspects of this project, the goal is to determine when will Douglas, the owner, break even as a result of incurring additional costs in the effort to create more rentable square footage.

The data we use for this analysis will be compiled in the Annual Property Operating Data sheet from the CCIM model. The following is the complete set of the values used for this analysis with each justification immediately following.

Project Cost

This calculation was made by taking into account the additional cost of the change order for this expansion as well as its effect on the project in terms of delays and increases to the general conditions costs. See below the two documents from Davis articulating the financial consequences of the basement expansion plan.

James G. Davis Construction Corp

7-Jun-07

Square 320

Nordlinger Basement Issues (revised)

Item	Description	Cost	Comments
Option A	**If we continue with lowering the Nordlinger Basement**		
1	Excessive Footing Demolition	$ 226,000.00	Unforeseen Conditions, Clark proposal 5/31
1a	Clark GCs	$ 33,000.00	
1b	Davis GCs	$ 180,000.00	2 months, 120000x2x.75
1c	Davis Fee/Ins/Bond	$ 25,000.00	
2	Nordlinger Bump-Out Fix Masonry, Helical Anchors	$ 50,000.00	Budget Price
2a	Davis GCs	$ 120,000.00	1 month
	Davis Fee	$ 8,000.00	
3	Shore and Footings 3 Add. Columns	$ 150,000.00	Budget Price
3a	Clark GCs	$ 30,000.00	
3b	Davis GCs	$ 90,000.00	1 month, 120000x.75
	Davis Fee	$ 14,000.00	
4	Added Work Inside Bump-Out, support 2 added columns	$ 100,000.00	
4a	Clark GCs	$ 30,000.00	
4b	Davis GCs	$ 90,000.00	1 month, 120000x.75
4c	Davis Fee	$ 11,000.00	
5	Add Underpinning Pits	$ 15,000.00	4 Pits at 6' depth
5a	Davis Fee	$ 1,000.00	
	Budgeted Total	**$1,173,000.00**	**4 months added to the schedule**

Figure 20 - Change Order + GC Estimate

RE: Square 320
1199 F Street, NW

Subject: **Nordlinger B1 Level Added Costs**

1.) Davis Summary of Costs (revised) dated 6.07.07
2.) Davis drawings dated 6.07.07 showing conditions not shown
3.) Clark Foundations letter dated 5.31.07

Dear Kevin:

Davis advised your office early this week of additional costs, forwarded to you by email enclosing 3.), involved with the Nordlinger B1 level (NB1). Following this correspondence Davis prepared what was felt to be the cumulative impact of the NB1 potential changes. We presented and discussed the scope of these changes along with the additional time and costs during our meeting held on-site June 7, 2007. The majority of the costs involve concealed conditions found in the Nordlinger B1 level of the project. These conditions are referenced in 2.) and 3.).

The budgeted costs, **$1,139,000.00** and time required, **4 months**, are outlined as Option A which addresses continuing lowering the Nordlinger Basement, reference 1.), are in addition to our contract with Jemal’s Square 320, LLC (JS320).

Figure 21 - Davis Letter to Owner

Based on the documents above, the values were put into this table to calculate the total cost incurred with this addition to the project scope.

Calculating Project Cost				
Change Order ($)	**Delays (wks)**	**GCs ($/wk)**	**GC Fee (+5%)**	**Total Cost**
$1,139,000	16	$30,000.0	$1,500.0	**$1,620,500**

Square Footage
The square footage value used for this analysis is just the additional rentable square footage that was achieved by expanding the basement. The excavation allowed for the floor area to become rentable space. Therefore the square footage of this analysis is the same square footage as the B1 level of the historical buildings. Due to the smaller foot print of these buildings, the final square footage value is 2,300 ft^2.

Vacancy Rate & Expected Rental Rate

Class A Office Space[2]	
Number of Buildings	249
Total Square Feet (RBA)	60,337,743sf
Vacancy Rate	6.9%
Vacancy with Sublet	8.5%
Average Rental Rate (PSF)	$42.31/fs

Figure 22 – Class A Office Space

Based on this data gathered from the Washington DC Economic Partnership, the average vacancy rate in the District is 6.9%. Additionally, the expected rental rate for Class A Office is $42.31/$ft^2$

Real Estate Tax
From the office of Tax and Revenues in the District of Columbia, Real property is taxed based on its classification. Classification is the grouping of properties based on similar use. The tax rate itself is the amount of tax on each $100 of the assessed value of the property.

The amount of tax due is determined by dividing the assessed value of the property by $100, then multiplying that amount by the rate for the class associated with the property. For buildings above $3M you enter into a split rate of $1.65 for the portion less than $3M and then $1.86 for the portion greater than $3M. The table below calculates what the expected tax rate would be for this sub-portion of the project. This calculation assumes that no incentives are granted to Douglas for the project.

Calculating Basement Tax							
Assessed Value ($)	**Rate <$3M**	**Tax Value**	**Rate >$3M**	**Tax Value**	**Total Tax Cost**	**Tax Cost /ft^2**	**Total Basement Tax**
$60,000,000	$1.65	$49,500	$1.86	$1,060,200	$1,109,700	$3.70	**$8,507.70**

Taxes/Worker's Compensation
Additionally, gathered from the Washington DC Economic Partnership publication which can be found in the appendix, once insured, a newly liable employer pays taxes at the rate of 2.7% for their worker's benefits. This is money that is not taxed off of their income but instead comes directly from the employer.

Property Insurance/Off-site Management/ Maintenance Repairs
For each of these items, no information was able to be found during the research process. Therefore, this analysis assumes the standard values from the financial analysis example.

The financial model program used in class has 3.0%, 5.0%, and 0.5% identified as the percentage costs respectfully.

Utilities
In order to determine an appropriate rate of utilities, it had to be calculated based on the average utility rate of a residential property in the District. Based on the research, the average monthly cost of utilities downtown totaled to $320 per residence. Then, we divided that by the average square footage of residences in the district to determine an estimated rate based on square footage. From there the rate was multiplied by the B1 level square footage to determine a monthly estimate of what utilities would cost for the portion of the project that this analysis is covering.

Calculating Rough Utilities Estimate				
Avg Cost ($/month)	**Residential ft^2**	**Rate ($/(month x ft$^{2)}$)**	**Project ft^2**	**Monthly Expenditure**
$320	2000	$0.16	2,300	**$368**

Assumptions
The financial model is limited both in the information that has collected through research and the small nature of the expansion portion in regards to the larger project. Therefore, in order to encourage results that can more easily be interpreted a few assumptions have been made. The first of which involves the method of payment for this work. This analysis assumes that the cost of the project is paid in full at day 1. This enables the analysis to focus on the effective rental income from the B1 lever rather than the significantly high debt-income ratio for this portion. The second assumption is the range of capitalization rates used for comparison. With an estimated income of $97,000 and a cost of $1.6M, the capitalization rate comes to 6.1%, therefore, the values this analysis will cover range from 4-6%. All other values from the CCIM financial model remain as their default values.

Results

Annual Property Operating Data

Name	Square 320 - Historic Basement		
Location	1199 F Street Wash DC, NW		
Type of Property	Class A Office	Purchase Price	$1,620,500.00
Size of Property	2,300 (Sq. Ft./Units)	Acquisition Costs	
		Loan Points	
Purpose		Down Payment	1,620,500

Assessed/Appraised Values			Existing	Balance	Payment	#Pmts. /Yr.	Interest
Land			1st				
Improvements			2nd				
Personal Property							
Total			Potential				
			1st				
Adjusted Basis as of	3-Apr-09	$1,620,500	2nd				

	ALL FIGURES ARE ANNUAL	$/SQ FT or $/Unit	% of GOI			COMMENTS/FOOTNOTES
1	**POTENTIAL RENTAL INCOME**	$42.31			97,313.00	
2	Plus: Other Income (affected by vaca					
3	Less: Vacancy & Cr. Losses		(6.9%	of 97,313)	6,715	
4	**EFFECTIVE RENTAL INCOME**				90,598	
5	Plus: Other Income (not affected by vacancy)					
6	**GROSS OPERATING INCOME**				90,598	
	OPERATING EXPENSES:					
7	Real Estate Taxes			$8,507.70		
8	Personal Property Taxes					
9	Property Insurance		3.0%	$2,718		
10	Off Site Management		5.0%	$4,530		
11	Payroll					
12	Expenses/Benefits					
13	Taxes/Worker's Compensation		2.7%	$2,628		
14	Repairs and Maintenance		0.5%	$453		
	Utilities:			$368		
29	TOTAL OPERATING EXPENSES				19,205	
30	**NET OPERATING INCOME**				71,394	
31	Less: Annual Debt Service					
32	Less: Funded Reserves					
33	Less: Leasing Commissions					
34	Less: Capital Additions					
35	**CASH FLOW BEFORE TAXES**				$71,394	

Figure 23 - CCIM Financial Model

INTERNAL RATES OF RETURN

BEFORE TAX

n	Alternative 1 $	n	Alternative 2 $	n	Alternative 3 $
	(1,620,500)		(1,620,500)		(1,620,500)
1	71,394	1	71,394	1	71,394
2	73,536	2	73,536	2	73,536
3	75,742	3	75,742	3	75,742
4	78,014	4	78,014	4	78,014
5	2,004,641	5	1,619,784	5	1,363,212
IRR= 7.86%		IRR= 3.74%		IRR= 0.56%	

AFTER TAX

n	Alternative 1 $	n	Alternative 2 $	n	Alternative 3 $
	(1,620,500)		(1,620,500)		(1,620,500)
1	45,692	1	45,692	1	45,692
2	47,063	2	47,063	2	47,063
3	48,475	3	48,475	3	48,475
4	49,929	4	49,929	4	49,929
5	1,914,956	5	1,607,070	5	1,401,813
IRR= 5.86%		IRR= 2.22%		IRR= -0.36%	

INTERNAL RATES OF RETURN

Figure 24 - Rates of Return

The financial model in Figure 4 clearly shows that the B1 level only represents 2300 square feet of rentable space which at most brings in a gross income of $97K. Based on a price tag of $1.6M, nearly 200% of the income, this design decision does not make a lot of sense. Only with the adjusted assumptions of lower capitalization rates did the model even provide an IRR value. At first the values were all undefined or extremely negative. Even in the best condition, before tax, the IRR = %7.86 which is considerably low. For the other pre-tax alternatives the IRR equals 3.74% and 0.56%. These values are below

the standard and would be reason to reconsider building the project if this analysis were done before construction.

Discussion

At first look, the IRR are less than promising for this work. But due to the nature of the analysis, this does not tell the whole picture and therefore cannot be the only information used to make an informed decision. If you look at the bigger scope of the project, this is not only area of construction that can be analyzed. In a broader scope, the rest of the project offers more financial gain in terms of its cost. For example, the tower portion will provide more than 250,000ft^2 of rentable space nearly 100 times that of the basement while only incurring approximately 30 times the cost. Looking towards the future, it will take Square 320 a considerable amount of time before the project begins break even and make a profit for the owner. With that considered, it will be the income from tower's rented space that will likely cover the added cost of the basement expansion. The basement expansion only represents 2.6% of the cost incurred for the project and in hindsight it adds a significant amount of value to the building knowing that the basement is usable and rentable, not just below grade storage space.

Business Proposition

After visiting the space in person in March, I was instantly struck with how rough and stark this floor felt. As an office space this is likely to provide nothing more than a mailroom or an intern work station. However, with the interesting use of the basement vault space (Fig.6) and the exciting look of the rough brick (Fig. 7) this space might have a purpose after all.

Figure 25 - BW Bldg - B1 Level - Southern View

If there were a way to turn this basement into a bar or lounge, the odd architecture in combination with the lower ceilings and darker walls would really create a sense of comfort. One could put low track lighting in the ceiling, and put booth seating along the narrow vault space (Fig. 6) and there is no question that a folks would want to come downstairs for a drink, conversation, or a game of pool for happy hour at the end of the work day.

Figure 26 - BW Bldg - B1 Level - East View

While that goes beyond the scope of research or analysis, it is just one perspective on how to take a rather unusual space and optimize it for the best financial outcome. And, in case there is interest in further examples of money-saving alternatives, perhaps the following examples will provide insight into additional opportunities to make the most out of the situation.

Exploring Alternative Solutions To Recovering That Loss

A. Redesign of the Structural Jacking Support Systems - *Structural Breadth*

As discussed above, Clark Foundations carried out the majority if the work for the basement excavation. Their plan incorporated a very complicated structural jacking system to take the load off of each existing column before they could be safely underpinned and then re-supported with their new footings. Below, in Figure 14, the typical structural jacking system is built-up around an existing column. The system rests on footings that are installed prior to jacking. Once the load is supported by the jack the proposed footing will be completed, the existing steel column will be extended to reach the footing, and the jack will be unloaded.

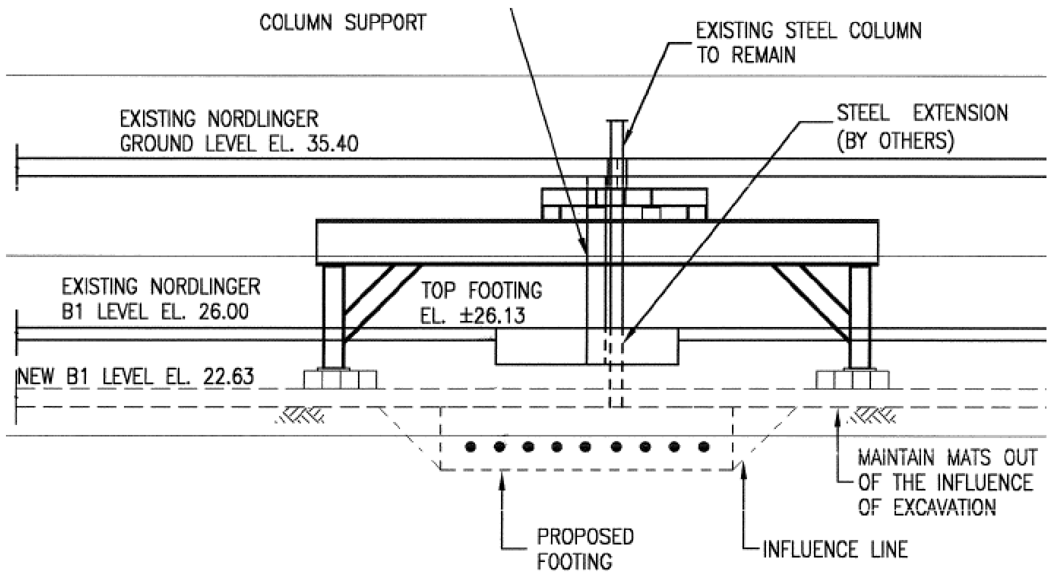


Figure 14 - Typical Jacking System Set-Up

The layout of the jacking support systems can be seen in the basement plan view of the historical B1 level below. The columns will not be unloaded simultaneously, but rather will be worked on one at a time.

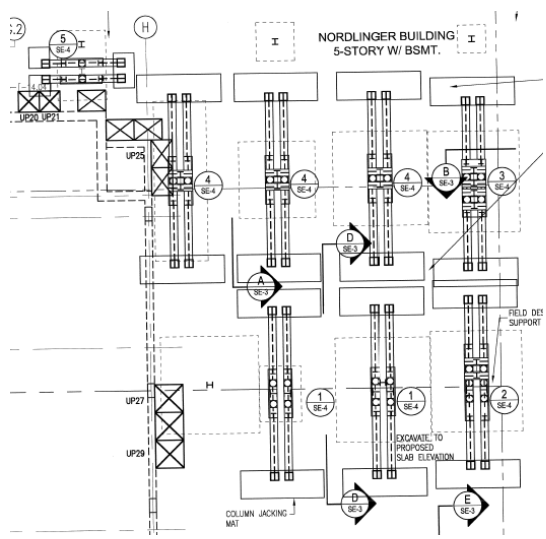


Figure 27 - Jacking Plan View

The typical jacking system design can be seen below and consists of two steel beams supported on four steel posts. The two beams share the column load and transfer it down to a steel post at each end. The posts then transfer the load directly onto the temporary footings.

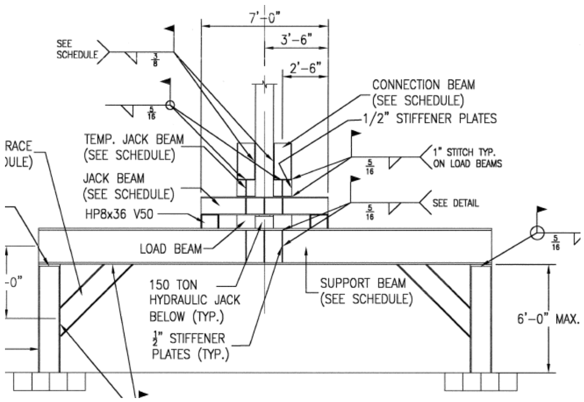


Figure 28 – Typical Jack – Section View

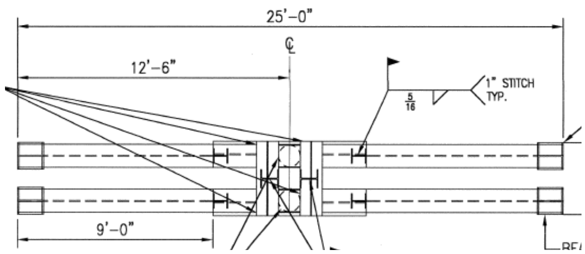


Figure 29 - Typical Jack - Plan View

The steel beams span an average of 25 feet and are laterally unsupported. Based on the load values from the Clark Foundations construction documents *(see appendix)* it appears as though there is potential for substantial savings with the economical re-design of the typical jack systems. Even though the design decision to expand the basement incurred an additional $1.6M, there are ways to get some of that money back. This portion of the report proposes that a substantial portion of the contract with Clark for the completion of this work could be reduced with an alternative design for the jacking system. The ultimate goal of this structural breadth is to save money by calculating the loads on the current jack support systems and redesign them with more economical steel members.

Economical Re-Design of the Steel Jacking System

Using the information below, the scope of the structural analysis was the redesign of the structural support jacking system. Table displays the calculated loads on each of the columns in the historical basement footprint of the Nordlinger building. The original versions of these tables can be found in the Clark Foundation scope of work documents in the appendix. Please see the document for additional notes and details.

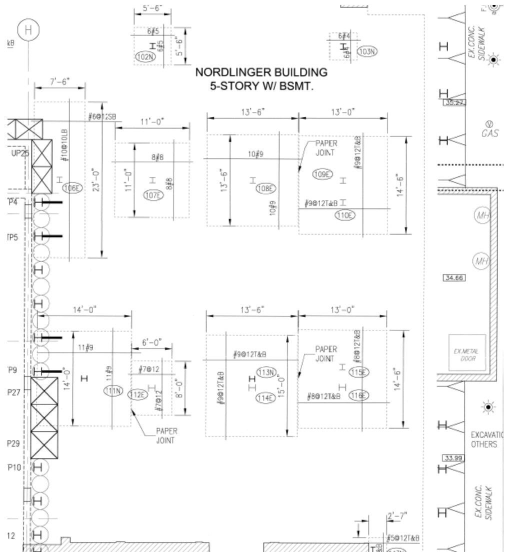


Figure 30 - Nordlinger Bldg Column Plan

	Calculated Load (kips)	Proposed Load (kips)
Existing		
104	125	120
106	306	425
107	260	294
108	333	455
109	337	390
110	218	45
112	340	114
114	114	113
115	251	185
116	243	275
New		
113	355	360
111	none	444

Table 4 – Building Column Loads

Column Support #1				
Member Number	Qty	Section	F_y (ksi)	Length (ft)
Support Beam	2	W24x131	50	25
Jack Beam	2	HP14x73	50	9
Support Posts	4	HP14x102	50	6
Support Post Braces	4	HP12x53	50	4
Connection Beam	2	HP12x53	50	2
Stiffener Plates	12	2" Plate	50	14
Stiffener Plates	12	2" Plate	50	24
Temp Supports	4	HP8X36	50	1

Column Support #2				
Member Number	Qty	Section	F_y (ksi)	Length (ft)
Support Beam	2	W24x131	50	25

Jack Beam	2	HP12x53	50	13
Temp Jack Beams	2	HP12x53	50	4
Support Posts	4	HP14x102	50	6
Support Post Braces	4	HP12x53	50	4
Connection Beam	2	HP12x53	50	2
Stiffener Plates	28	2" Plate	50	14
Stiffener Plates	20	2" Plate	50	24
Temp Supports	4	HP8X36	50	1

Column Support #3				
Member Number	Qty	Section	F_y (ksi)	Length (ft)
Support Beam	2	W24x131	50	25
Jack Beam	2	HP12x53	50	7
Temp Jack Beams	2	HP14x73	50	4
Support Posts	4	HP14x117	50	6
Support Post Braces	4	HP12x53	50	4
Connection Beam	2	HP12x53	50	2
Stiffener Plates	32	2" Plate	50	14
Stiffener Plates	24	2" Plate	50	24
Temp Supports	4	HP8X36	50	1

Column Support #4				
Member Number	Qty	Section	F_y (ksi)	Length (ft)
Support Beam	2	W24x131	50	25
Jack Beam	2	HP14x73	50	7
Temp Jack Beams	2	HP14x73	50	4
Support Posts	4	HP14x102	50	6
Support Post Braces	4	HP12x53	50	4
Connection Beam	2	HP12x53	50	2
Stiffener Plates	16	2" Plate	50	14
Stiffener Plates	12	2" Plate	50	24
Temp Supports	4	HP8X36	50	1

Column Support #5				
Member Number	Qty	Section	F_y (ksi)	Length (ft)
Support Beam	2	HP14x73	50	12
Jack Beam	2	HP10x42	50	6
Support Posts	4	HP10x42	50	6
Connection Beam	2	HP10x42	50	2
Stiffener Plates	16	2" Plate	50	14
Stiffener Plates	12	2" Plate	50	14
Temp Supports	4	HP8X36	50	1

Table 2 - Jacking System Details

The redesign of the structural jacking system begins by taking the column load values, calculating the load on the beams and the maximum moments. These calculations follow the guidelines from Table 3-23 on page 3-212 of the *AISC Steel Construction Manual*:

Simple Beam – Uniform Load Partially Distributed

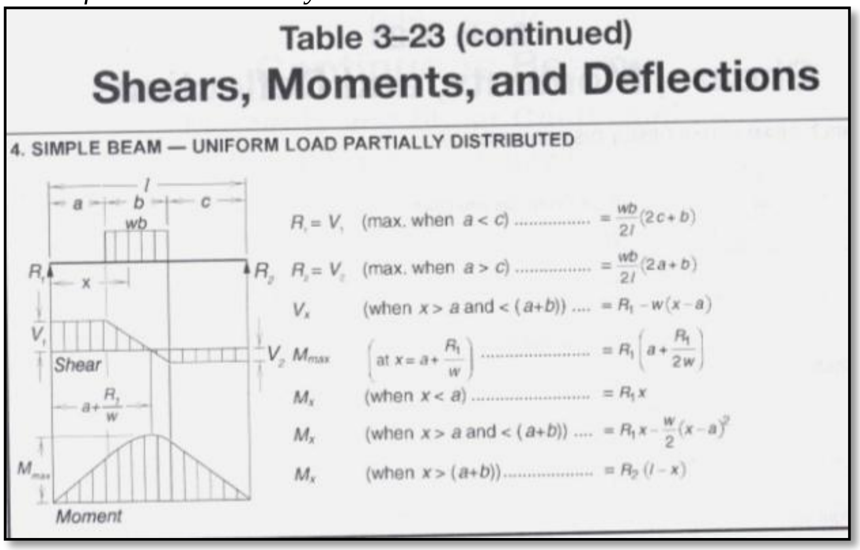


Table 3–23 (continued)

Shears, Moments, and Deflections

4. SIMPLE BEAM — UNIFORM LOAD PARTIALLY DISTRIBUTED

$R_1 = V_1$ (max. when $a < c$) .... $= \frac{wb}{2l}(2c+b)$

$R_2 = V_2$ (max. when $a > c$) .... $= \frac{wb}{2l}(2a+b)$

V_x (when $x > a$ and $< (a+b)$) .... $= R_1 - w(x-a)$

M_{max} $\left(\text{at } x = a + \frac{R_1}{w}\right)$ .... $= R_1\left(a + \frac{R_1}{2w}\right)$

M_x (when $x < a$) .... $= R_1 x$

M_x (when $x > a$ and $< (a+b)$) .... $= R_1 x - \frac{w}{2}(x-a)^2$

M_x (when $x > (a+b)$) .... $= R_2(l-x)$

Figure 31 - Table 3-23 AISC Steel Manual

NOTE: As noted in previous section, the column load is supported by two identical beams and then transferred to the ground by two steel posts. Therefore, the column load values in Table 1 are divided in half before being entered in as loads on the beam in Table 3-23. From there, when the calculated loads are displayed in Table 4 they have been subsequently divided into a quarter of the original load on that specific column.

Using the equations from Table 3-23 above, this analysis treated the jack system as a simple beam with a uniform load partially distributed. Based on that assumption, the calculations from the table below determine the maximum moment on the beam. This information is necessary to determine whether the beams are at risk of Lateral Torsional Buckling due to their unbraced length.

Deflection

It is also important to understand how the beams react to the loads specifically in terms of deflection. In order to simplify the calculation, we assume a simple beam with a single point load at mid-span. Each beams maximum displacement was calculated using the equation below:

$E = 29{,}000\ ksi$

$I = 4020\ in^4$

$$\Delta = \frac{Pl^3}{48EI}$$

General serviceability standards call for a maximum deflection of span/360. In this case, since we are not concerned with user comfort as our serviceability factor, the specific displacement value doesn't necessarily need to be less than span/360 but it at least provides this calculation with a way to compare it to standard deflection values. Based on a 25 foot span, the acceptable displacement value becomes 25ft x 12in, or 300/360 = 0.8 inches deflection. As the excel table below shows, only two of the systems as they are currently designed with satisfy that serviceability requirement.

AISC Steel Manual - Table 3-23 - Uniform Load Partially Distributed											
Determine Maximum Moment											
Support System	**Column**	**Length** (ft)	**Dist. Load** (kips/ft)	**Load** (kips)	**A** (ft)	**B** (ft)	**C** (ft)	**R_1**	**M_{max}**	**Def.**	**D < 0.8**
System #1	112	25	18.89	170	8.5	9	8.5	88.4	958.2	0.82	N
"	114	25	6.33	57	8.5	9	8.5	29.64	321.3	0.28	Y
System #2	115/6	25	22.45	247	7	11	7	123.5	1204.1	1.19	N
System #3	109/10	26	34.69	277.5	9	8	9	138.8	1526.25	1.51	N
System #4	106	25	21.86	153	9	7	9	76.5	822.38	0.74	N
"	107	25	18.57	130	9	7	9	65	698.75	0.63	N
"	108	25	23.79	166.5	9	7	9	83.25	894.94	0.80	N
System #5	104	12	10.42	62.5	3	6	3	31.25	140.63	0.18	Y

With the maximum moment values calculated, you can proceed to the next step in determining whether the steel beams of the column support system are at risk of Lateral Torsional Buckling. The following is an initial calculation of the current support beam system. The first step is to determine the values for the nominal moment, M_n, and based on these values we can compare it with the maximum moment, M_{max}, the beam will experience to determine if the system is in threat of buckling. The structural calculations below are modeled after the following sections of professor Geschwindner’s text “Unified Design of Steel Structures”.

Design of Compact Laterally Unsupported Wide Flange Beams

6.4.1 Lateral Torsional Buckling (in LRFD)

$L_b = unbraced\ length\ of\ the\ compression\ flange$

$L_p = maximum\ unbraced\ length\ before\ reaching\ plastic\ moment\ strength$

$r_y = radius\ of\ gyration\ for\ the\ shape\ about\ the\ y-axis$

$\quad = 2.97 in\ \ (from\ Table\ 1-1)$

$F_y = 50\ ksi$

$$L_b \leq L_p = 1.76 r_y \sqrt{\frac{E}{F_y}}$$

$$L_b \leq L_p = 1.76\left(\frac{2.97}{12}\right)\sqrt{\frac{29{,}000}{50}}$$

$$L_b \leq L_p = 125.88\ ft$$
$$L_b = 25$$

$$\underline{25\ ft \leq 125.88\ ft}$$

$\Phi = 0.9$

$M_n = nominal\ Moment$

M_p $= maximum\ available\ flexural\ strength\ for\ noncompact\ shapes$
$BF = flexural\ strength\ factor$

$$\Phi M_n = \Phi M_p - BF(L_b - L_p)$$

$$0.9M_n = (0.9)1916.51 - 24.5(25 - 125.9)$$

$$\underline{M_n = 4388.26\ kips}$$

Design of Compact Laterally Unsupported Wide Flange Beams											
Lateral Torsional Buckling											
System	Shape	F_y (ksi)	I (in^4)	E	Φ	L_b (ft)	L_p (ft)	r_y (in)	BF	$M_{max} = M_p$	M_n (kips)
#1	W24x131	50	4020	29000	0.9	25	125.89	2.97	24.5	958.26	3430.00
#1	W24x131	50	4020	29000	0.9	25	125.89	2.97	24.5	321.30	2793.04
#2	W24x131	50	4020	29000	0.9	25	125.89	2.97	24.5	1204.13	3675.87
#3	W24x131	50	4020	29000	0.9	26	125.89	2.97	24.5	1526.25	3973.50
#4	W24x131	50	4020	29000	0.9	25	125.89	2.97	24.5	822.38	3294.12
#4	W24x131	50	4020	29000	0.9	25	125.89	2.97	24.5	698.75	3170.50
#4	W24x131	50	4020	29000	0.9	25	125.89	2.97	24.5	894.94	3366.68
#5	HP14x73	50	729	29000	0.9	12	147.93	3.49	*8.03*	140.63	1232.13

Determining Critical Buckling Load – Steel Posts
Using the equations below, these calculations were done to analyze the current strength of the column supports on the jacking system to determine if they were over-designed and whether or not the members can be downsized and redesigned economically.

The initial step was to calculate the critical buckling load, P_{cr}, of each steel post. This was completed by using the equation below and getting values from the ASIC Steel Construction Manual based on the members in question.

$$P_{cr} = \frac{\pi^2 E I_y}{L^2}$$

The second step was to calculate the maximum load strength, P_y, of each current steel post. Using the equation below, the table shows the maximum load value for each post. Additionally, in the table below it is clear that due to such a minimal steel post height, $P_y \leq P_{cr}$; therefore P_y is the limiting design factor.

$F_y = 50\ ksi$
$A_s = from\ AISC\ Table\ (4-2)$

$$P_y = F_y A_s$$

Design of Column Support For Jacking System								
Determine Steel Post Strength								
Support System	**Shape**	**Height** (ft)	**I_y** (in^4)	**A_s** (in^2)	**P_{cr}** (kips)	**P_y** (kips)	**P_{calc}** (kips)	**min I_y** (in^4)
System #1	HP14x102	6	380	30	20,981	1500	85	1.54

"	HP14x102	6	380	30	[redacted]		28.5	0.52
System #2	HP14x102	6	380	30	20,981	1500	123.5	2.24
System #3	HP14x117	6	443	34.4	24,459	1720	138.75	2.51
System #4	HP14x102	6	380	30	20,981	1500	76.5	1.39
"	HP14x102	6	380	30	[redacted]		65	1.18
"	HP14x102	6	380	30	[redacted]		83.25	1.51
System #5	HP10x42	6	71.7	12.4	3,959	620	31.25	0.57

Table 5 - Economic Design of Steel Posts

Economic Redesign

After determining the steel post strength for the structures the calculations show that the steel has been overdesigned. In fact, the minimum I_y value acceptable determines the smallest HP steel member that will be structurally sufficient for this use. As the calculations show the range of these values go from 0.52 to 2.51. Therefore, seeing as the smallest HP member has a value for I_y of $40.3in^4$, substituting the **HP8x36** will result in a cost savings while maintaining the highest standards of structural integrity.

Determining Critical Bending Moment – Steel Beams

In this section of the analysis, the goal is to select the least-weight wide flange member for the loading conditions calculated above. The beam design below is based on LRFD.

$F_y = 50\ ksi$
$Z = plastic\ section\ modulus\ (Table\ 3-2)$

$$M_{max} = F_y Z$$

Rearranging the equation so we can solve for Z, we get the following. Now we can compare the different values of Z in Table 3-2 of the AISC Steel Construction Manual to determine if a more economical steel beam can be designed for this system. The required moment must be less than the available moment, $M_u \le \Phi M_n = \Phi F_y Z$, therefore:

$$Z_{req} = \frac{M_u}{\Phi F_y}$$

Economic Redesign

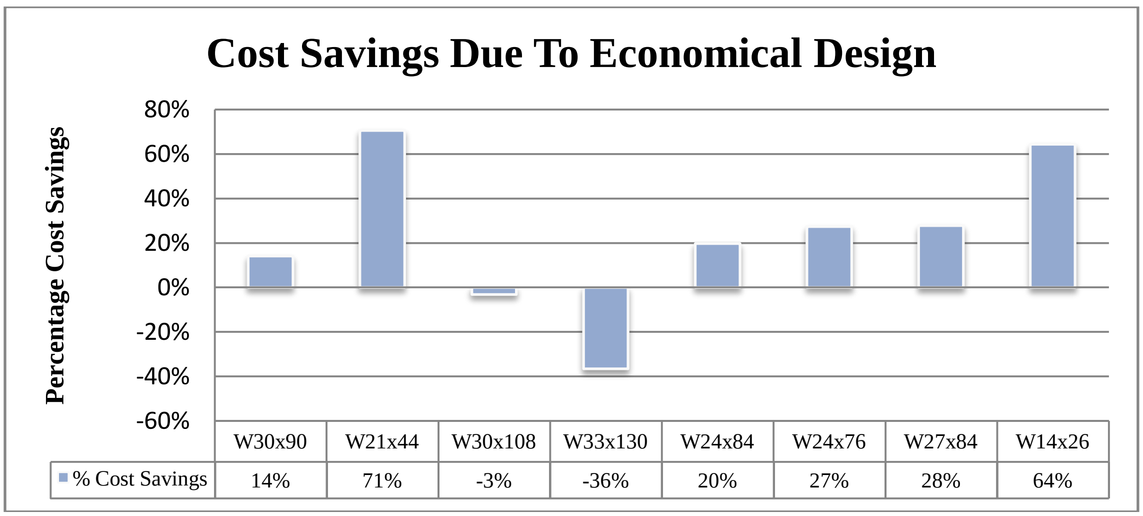
Using the required plastic section modulus select the minimum weight W-shape from the plastic section modulus economy table 3-2 of the AISC Steel Construction Manual. Start at the bottom of the Z column and move up until a shape in bold is found with a Z_x value equaling at least what was calculated below in the table.

Design of Beam For Jacking System					
Determine Beam Strength					
Support	**Shape**	**F_y** (ksi)	**M_{max}** (ft-kips)	**Z_{req}** (in^3)	**Economical Shape**
System #1	W24x131	50	958.3	256	W30x90
"	W24x131	50	321.3	86	W21x44
System #2	W24x131	50	1204.1	321	W30x108
System #3	W24x131	50	1526.3	407	W33x130
System #4	W24x131	50	822.4	219	W24x84

"	W24x131	50	698.9	186	W24x76
"	W24x131	50	894.9	239	W27x84
System #5	HP14x73	50	140.6	38	W14x26

Conclusions

Based on the graph below the majority of the beams can definitely be downsized but a few remain that will provide similar strength to the economic alternative. Based on the tonnage per foot values for each of the redesigned members the chart below shows the cost savings due to the economical design of each beam. Considering the 5th support system, based on the column loads supported by the jacking system, the steel beam can be redesigned from a W24x131 to W14x26 member. The economical downsizing will result in a %64 cost savings. Therefore, with the exception of the W30x108 and the W33x130 members, an economical beam redesign has the potential of producing considerable cost savings.



B. Performing a Mechanical Tenant-Fit-Out (TFO) – Structural Proposal

As-Built Mechanical System

The original mechanical system is built upon a series of variable volume (V-VAV) self contained water cooled AC units, one on each floor. Next in line are two plate and frame heat exchangers leading to the HVAC penthouse on the roof. There, two inducted draft propeller fan cooling towers rest integrated into the green roof, each weighing 28,000 lbs and capable of pushing 1800GPM and 149,090 CFM. In addition, on each floor a series of traditional ductwork transfers the treated air throughout the spaces. It is evident that the mechanical design considered maximum building height as a serious constraint. This can be easily seen in the design and selection of the supply and return air ductwork with sizes in the order of 120”x7” where are the aspect ratios are well

outside of acceptable design practices. Each floor has limited plenum space ranging from 9" at its tightest point and 18" at its widest point. Therefore one of the challenges that the system has to account for is coordination in that space with other trades.

Advantages of Alternative System

Within the recent years, Southland Industries, located in the Northern Virginia area, designed a brand new type of mechanical system. The Fan-Powered Induction Units (FPIU) consists of two boxes, one large and one small. The large box acts as the mixing zone where the indoor air meets the outdoor supply air after being filtered and passed through the cooling coil. The mixed air in the large box is then drawn into the small box where it is discharged back into the space via the ECM motor. Generally fans are energy hogs and inefficient, however, this system utilizes an ECM (Electronically Commutated Motor) motor. The ECM is an ultra high efficient programmable brushless DC motor utilizing a permanent magnet rotor and built-in inverter. Due to noise considerations, most traditional PSC fans operate at efficiency range of 12-45% whereas the ECM motor in contrast maintains a high efficiency of 65-75% at any speed. Below you can see a schematic of the system and the way in which the air is circulated.

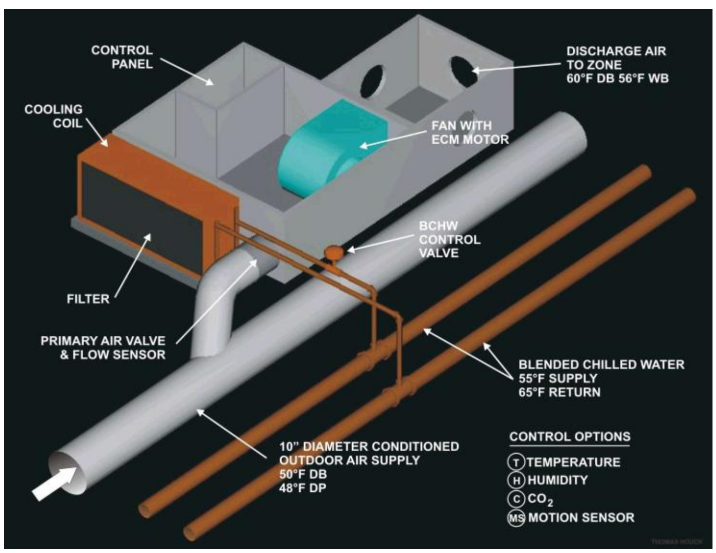


Figure 32 - Fan Powered Induction Unit Schematic

The beauty of this system is that all of the conditioning and mixing happens on the spot, not in the mechanical space a significant distance away. In addition, there is no need for return air duct because the indoor air is circulated locally with the outdoor air that is supplied to each unit. Due to the location of the cooling coil in each unit, there needs to be supply and return chilled water as well as hot water. This is an added cost but it is quickly outweighed in comparison to the cost savings associated with not requiring return duct. Additionally, this design no longer requires a V-VAV unit on each floor and due to a significant decrease in load, there root-top AHU gets significantly smaller.

The FPIU represents a considerable first-cost savings because so much of the previously designed equipment is no longer required. There is an additional energy usage due to the constant use of the ECM motor but by utilizing an enthalpy wheel, the energy is recycled and the potential for increased energy usage becomes a ‘wash’.

Designing with the FPIU system is extremely flexible, because the only requirement is that a box is located to serve an area of space between 400 to 800ft^2. Additionally, this system is great for a Tenant-Fit-Out (TFO) because they can design to number and location of the units to precisely the needed amount. The plan view below displays how these FPIUs are generally arranged in a long column.

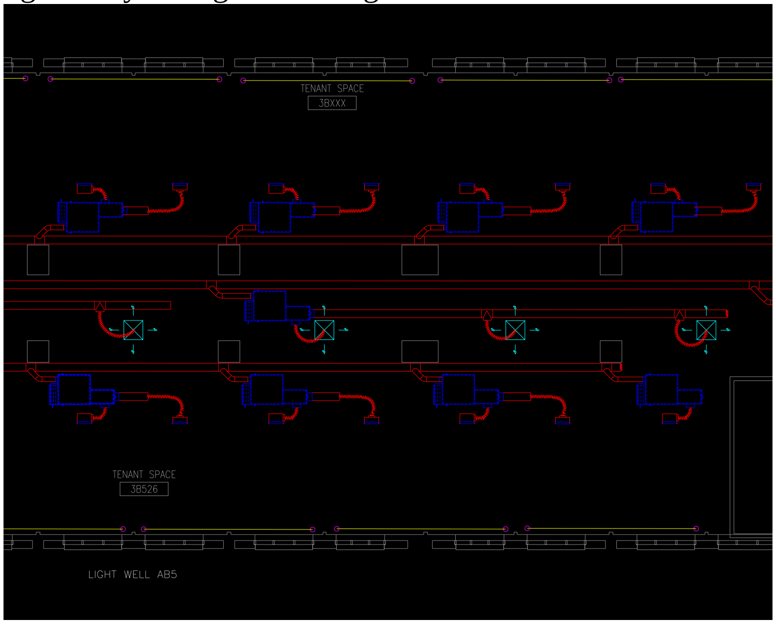


Figure 33 - FPIU Layout Example

Due the lack of return duct, there is a significant volume of ceiling plenum space that can be recaptured for architectural design. Each unit measures 30” wide, roughly 5ft long, but only hangs down 18” from the ceiling. With the creation of a vertical bulkhead along the outside edge of the units, the air can be supplied into the room without requiring row of ductwork. Fig 24 below shows the plenum diagram for the as-built VAV traditional system. The whole mechanical design revolved around the necessity to create the largest ceiling height as possible, which resulted in being 9 ft high.

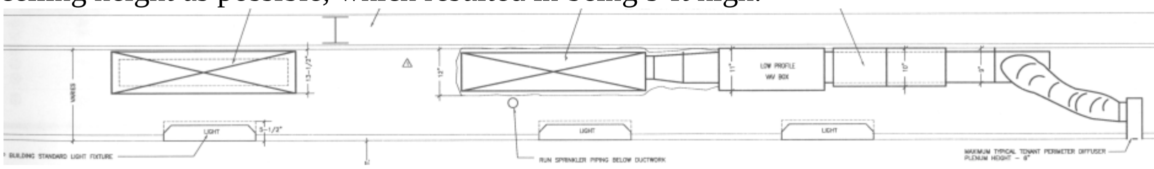


Figure 34 - As Built Plenum Diagram

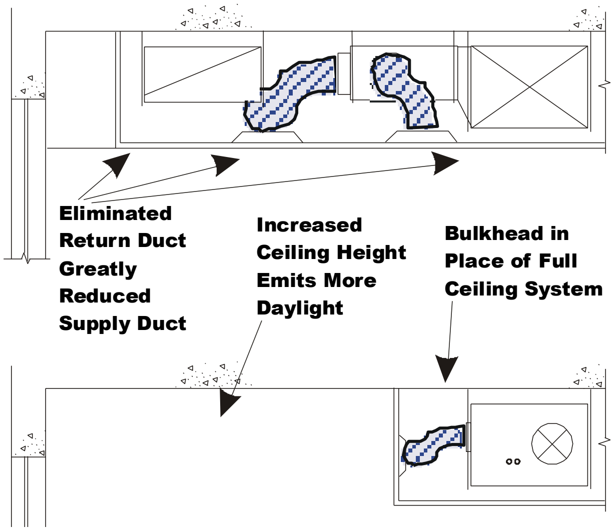


Figure 35 – FPIU System Plenum Diagram

In comparing the two diagrams, the former requires a 9ft ceiling height throughout the entire floor to provide space for the comprehensive duct work and lighting systems. The latter clearly shows that the majority of the plenum space can be recaptured an opened up to allow an additional 18-24" of ceiling height in the regions void of an FPIU unit. All of the plenum space that was being used to house duct work in the original design can be opened up to provide higher ceiling heights, added day lighting, and a more pleasing architectural ambiance. In the images below, this bulkhead can be seen running in a column down the center of this building's wing. On either side of the bulkhead the ceiling height is raised providing the feeling of more open space coupled with additional daylighting.

Figure 36 - Bulkhead Housing FPIUs (1)

Figure 37 - Bulkhead Housing FPIUs (2)

Figure 38 - Bulkhead Housing FPIUs (3)

Federal Building Case Study

The joint research of professors D. Riley & M. Horman took an in-depth look into the effect a lean-green fit-out system like the FPIU could have on a large scale project. That case study provides an example of how enabling design-build mechanical processes and competencies can help to efficiently achieve high performance objectives. The FPIU system was used in Phase II of the renovation, eliminating the use of return air duct and allowing the induction units to locally mix supply air. This resulted in higher ceiling heights and drastic improvement on daylight penetration into the interior space. The FPIU system reduced the number of mechanical rooms from 118 to nine. Installation of this system was streamlined resulting in a 20% cost savings compared to the initial phase. Based on their research, over the life of the system, the owner will save 9% on energy costs. Furthermore, when HVAC systems are designed “lean” and not over-sized, all of the equipment such as fans and chillers benefit from running in higher ranges of their operating efficiency, resulting in lower energy costs. The more tangible cost savings

associated with this system is the significant reduction in piping and ductwork sizes. This has the secondary effect of speeding construction processes and reducing the labor demand on the project. In the case of this federal building, the engineering benefits that resulted from utilizing the FPIU system translated directly into cost savings and dramatic improvements in the efficiency of the architectural design.

Benefits

While the original VAV design satisfies the demands of the project, it provides Square 320 with little benefit in the long run in terms of energy savings over time. Additionally, the move to away from the V-VAV units equates into a significant first-cost reduction as well. The FPIU units offer a wealth of added benefits without any real negatives for the project. From the construction management perspective there is significant cost savings in equipment & duct, energy savings with better performance, simplified coordination of the plenum space between different trades, and higher ceilings with added day lighting just to name a few. In addition, from the mechanical perspective, this system provides high velocity supply air with high Indoor Air Quality, increased ventilation effectiveness, and all the manufactures are local and easily interchangeable.

There is good reason to believe that making the design switch from the traditional VAV system to Southland Industries' FPIU units greatly benefit the Square 320 project and potentially provide an opportunity to recapture a portion of the $1.6M added cost that resulted from the basement expansion.

Fan Powered Induction Unit (FPIU) Mechanical Redesign

In order to earn cost savings through efficient and lean design, the following section logs the load calculations and designing of an alternative mechanical system for a typical floor of both the Tower and the Historical buildings.

The first step in the schematic redesign of the mechanical system is to determine the total square foot area per floor that is served by the outdoor air (OA) shaft. Due to the repetitive floor plan of the 12-story tower, the mechanical design is for a typical floor and as a result the values can be multiplied by each floor for a whole building estimate. The FPIU boxes work locally, therefore there needs to be a single unit located within a zone determined by square footage. On the floor plans below you will see the schematic design of the system with the units in each of their given zones. For units placed along the perimeter of the building shell, the rule of thumb is 400 ft^2/zone, for those positioned within the interior of the building; the zone area is doubled to 800 ft^2/zone. We assume typical office occupancy for entire floor area even though a small portion of each floor will be corridor. The square footage of the floor is then multiplied by the density value from the table 6-1 in the ASHRAE standard 62.1-2007 below.

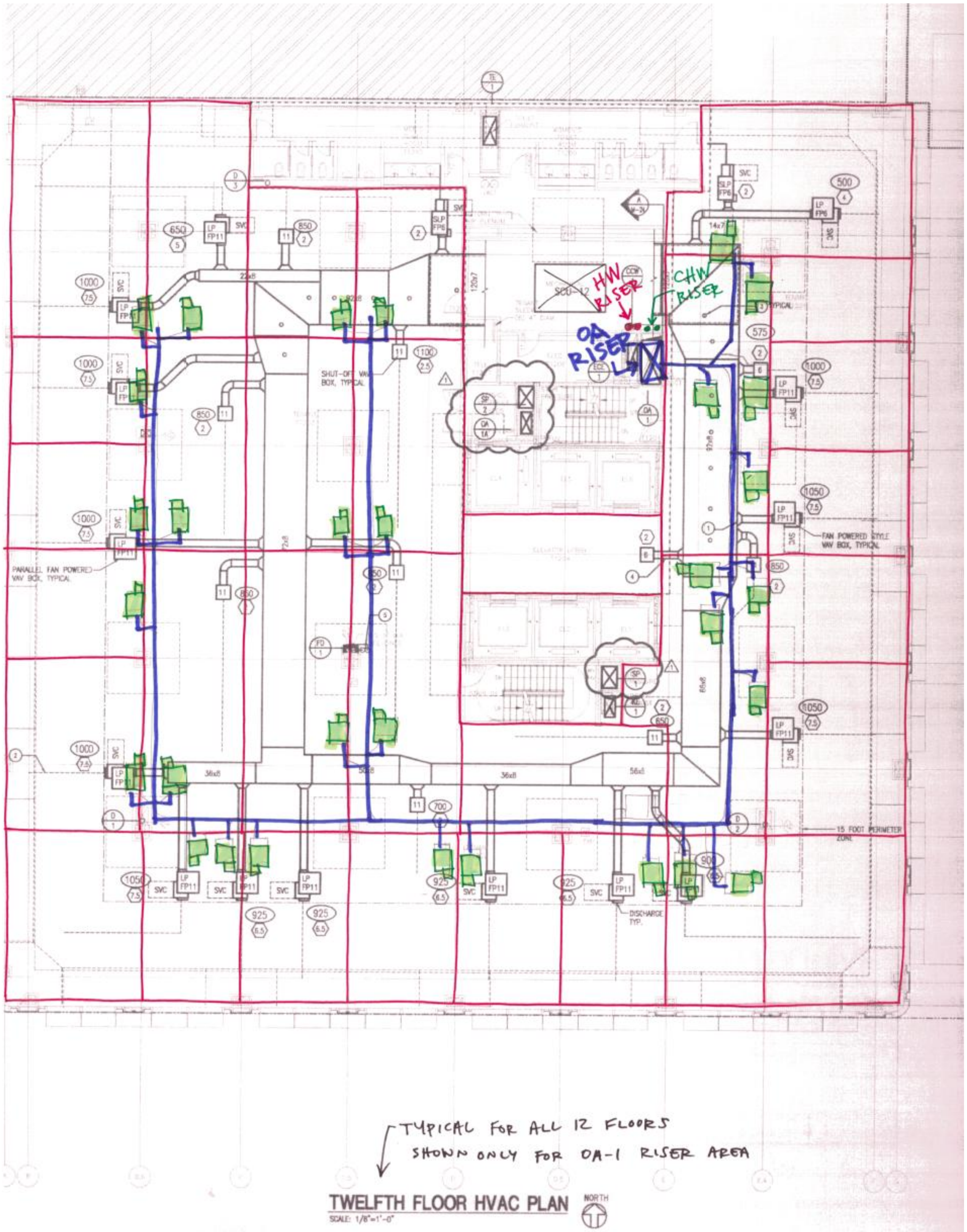


Figure 39 - Schematic FPIU – Tower

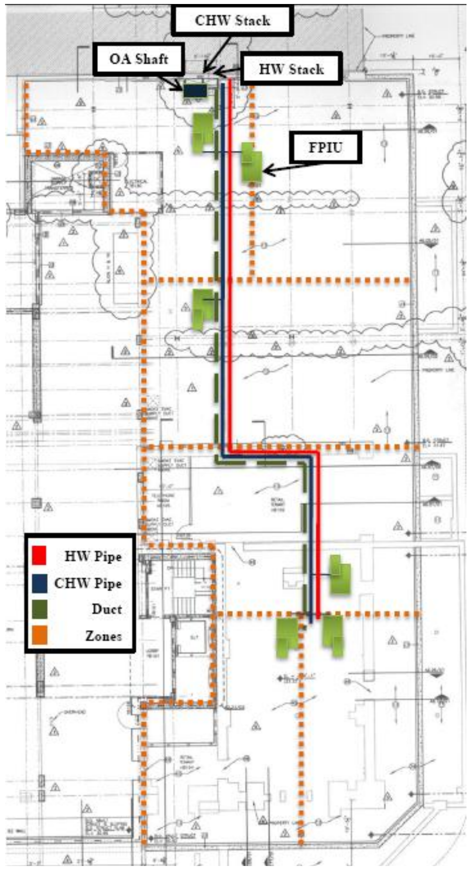


Figure 40 - FPIU Schematic - Historic

TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE *(continued)*
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values: Occupant Density (see Note 4)	Default Values: Combined Outdoor Air Rate (see Note 5)		Air Class
	cfm/person	L/s·person	cfm/ft²	L/s·m²		#/1000 ft² or #/100 m²	cfm/person	L/s·person	
Office Buildings									
Office space	5	2.5	0.06	0.3		5	17	8.5	1
Reception areas	5	2.5	0.06	0.3		30	7	3.5	1
Telephone/data entry	5	2.5	0.06	0.3		60	6	3.0	1
Main entry lobbies	5	2.5	0.06	0.3		10	11	5.5	1

Figure 41 - Occupant Density Table

Since this project is only concerned with the buildings shell, we are not aware of the expected occupancy. We need to use the #/1000ft^2 value, divide the floor square footage by that value, and determine how many people will be in each space. After we have an estimate of occupants we can use the standard rate of 20 cfm/person to determine the total Outdoor Air (OA) demand on the typical floor. According to industry standards and common practices, 1800 fpm is the correct value used to size the ductwork because it is considered medium pressure. The typical tower floor demands 1900cfm and divided by 1800fpm, we get a required duct cross-sectional area of approximately 1 ft^2. Therefore,

all of the branch ductwork bringing OA to each FPIU will be sized at 12”x12”. The B1 level of the historical buildings demands 1100cfm and when divided by 1800fpm, the required duct cross-sectional area of approximately 0.6 ft^2. Therefore, in the schematic design of the historical basement all of the branch ductwork will be sized at 12”x8”. In addition to the branch ductwork, we need to size the shaft ductwork. The shaft needs to transfer 1800 fpm, which in turn becomes 1800 in^2. Based on standard sizes, the shaft ductwork should be sized at 36”x50”. The shaft demand is 25% that of the typical tower shaft, therefore we expect to require only 25% of the cross sectional area. As a result, the shaft ductwork is sized to be 20”x22”.

Determining Basic Outdoor Air Loads					
Floor	**# Flrs**	**Area** (ft^2)	**Density** (#/1000ft)	**Outdoor Air** (cfm)	**Bldg OA** (cfm)
Tower			*rate: 5 ppl/1000ft*	*rate: 20 cfm/person*	*Total Shaft*
Typical Floor	12	19000	95	1900	**22800**
Historical - B1					
B&W	6	2115	11	212	1269
B&W Annex	6	1080	5	108	648
Corcoran	4	1235	6	124	494
Nordlinger	5	6460	32	646	3230
Vault Space - B&W	1	110	1	11	11
Total		**11000**	**55**	**1100**	**5652**

Every FPIU requires CHW (chilled water) piping (supply and return) to serve the CHW coil in the unit. Each perimeter FPIU requires a HW (hot water) coil and piping (supply and return). In the schematic designs on both the tower and basement floor plans this is clearly marked. However, it is not enough just to mark them; they must be sized as well.

Sizing CHW Pipe Based On Flowrates for Typical Floor			
Floor	**# Units**	**CHW Flowrate** (gpm)	**HW Flowrate** (gpm)
Tower - Typical Floor		*rate: 3 gpm/unit*	*rate: 0.5 gpm/unit*
Perimeter FPIU	19	57	9.5
Internal FPIU	13	39	-
TOTAL	32	96	9.5
x 12 Floors	**384**	**1152**	**114**
Historical - B1			
Perimeter FPIU	6	18	3.0
Internal FPIU	0	-	-
TOTAL	6	18	3
x 6 Floors	**36**	**108**	**18**

There are two sets of chilled water pipes that need to be sized. For both the chilled water and hot water we must size the pipe by floor (horizontal distribution) and then by building (for vertical distribution). Looking at the Tower, a typical floor requires just below 100gpm. This is best met with a 3.5” or 4” pipe. For the sake of efficiency and

savings, we'll select a 3.5" diameter pipe. In terms of the vertical stack, the total CHW load comes to 1152. Based on standard chilled water pipe sizing, 1152 gpm requires a pipe no smaller in diameter than 10", but similar to before, a 12" pipe is perfectly acceptable as well. The hot water pipe load totals to just less than 10 gpm which requires a 1.5" pipe. For the vertical stack, the total HW load totals 112 gpm. This is only slightly more than the CHW load on a single floor. As we did for that portion, we select a 3.5" diameter pipe.

Looking at the historic buildings, a typical floor requires only 18 gpm of chilled water. This can be handled with a smaller pipe; the 2" diameter pipe is the best fit. For the hot water distribution pipe, a load of only 3 gpm can easily be handled by a ¾" pipe. In terms of the vertical stack, the total CHW load comes to 108 gpm. Based on our assumptions above, 108 gpm can be assumed to be the same as the CHW load of a typical floor in the tower and as such requires a pipe no smaller in diameter than 3.5. The hot water stack happens to be the same as the chilled water pipe from a single floor. This load of 18 gpm can be handled with the same size pipe, 2" diameter.

With the pipes sized, lastly we need to size the equipment that will be responding the calculated loads above. In terms of sizing the chiller, we will use the following equation: $Q = 500 \times gpm \times \Delta T$. Due to having the supply CHW at 55F and the return at 65F, we must use a ΔT value of 10. The second we'll need is the total gpm, which comes from the table above: 1152gpm for the Tower and 108gpm for the historical buildings.

Determining Chilled Water Load To Size Chiller				
Q = 500 x Gpm x ΔT (BTU/Hr)				
Floor	**Gpm**	**ΔT (F)**	**Q** (BTU/Hr)	**Q** (Tons)
Tower - Typical Floor	1152	10	5760000	**480**
Historical - B1	108	10	540000	**45**

The procedure is very similar for sizing the boiler. In this case, due to the need of higher temperatures, the ΔT value grows significantly to 60 as the water is supplied at 180F but only returned at 120F. The equation is nearly identical except for the 500 in the equation above becoming 450 in the sizing of the boiler.

Determining Hot Water Load To Size Boiler				
Q = 450 x Gpm x ΔT (BTU/Hr)				
Floor	**Gpm**	**ΔT (F)**	**Q** (BTU/Hr)	**Q** (MBTU/Hr)
Tower - Typical Floor	114	10	570000	**570**
Historical - B1	18	10	90000	**90**

Picking Equipment – Chiller

TRANE: EarthWise™ CenTraVac™ Water-Cooled Liquid Chillers

Tower - CVHG — 3-Stage Single Compressor — 50 Hz 450 – 1200 ton

Historic - CVHE — 3-Stage Single Compressor — 50/60 Hz - 170 – 500 ton

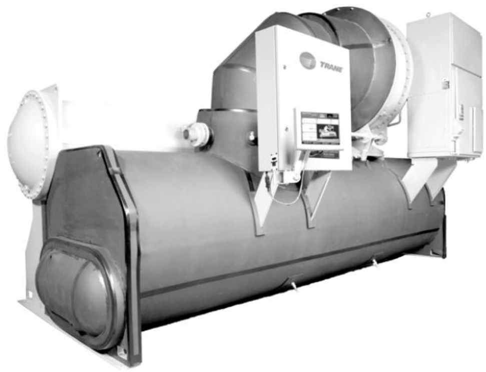


Figure 42 - EarthWise CenTraVac Chiller

Trane has always had a reputation of developing trusted products. With the Square 320 project, specifically in regards to the FPIU redesign, the desired outcome is to significantly reduce energy costs by investing in more energy efficient equipment and systems at the first-costs stage. These TRANE EarthWise™ CenTraVac™ chillers utilize free cooling which allows reduced operating costs. These CenTraVac™ chillers can provide up to 45% of the nominal chiller capacity without operating the compressor. This will bring upon significant energy and cost savings. The free cooling operation is based on the principle that refrigerant migrates to the area of lowest temperature. When condenser water is available at temperatures lower than the required leaving chilled-water temperature, typically 50°F to 55°F (10°C to 12.8°C), the unit control panel starts the free cooling cycle automatically. When the free cooling cycle can no longer provide sufficient capacity to meet cooling requirements, mechanical cooling is restarted automatically by the unit control panel.

Bottom line, free cooling can provide up to 45 percent of nominal chiller capacity without operation of the compressor. This means that payback can easily occur in less than a year. For example, DC is in a geographical region that experiences all four seasons. Located in a climate with cold winters, this building has a relatively high internal cooling load. Therefore, it is possible to cool the building exclusively with free cooling three to six months of the year!

Picking Equipment – Boiler
Buderus Hydronic Systems: SB & GB Series Super High Efficiency Boilers
Tower – SB615: 240 Model – 94.8% Thermal Efficiency – 750 MBTU/Hr
Historic – GB312: 90 Model – 92.8% Thermal Efficiency – 265 MBTU/Hr

Figure 43 - Buderus GB312:90

Buderus is known for the importance it places on low-cost, high efficiency, exceptional performance equipment. Their boilers offer innovative technology in a compact form with features like exemplary energy efficiency and ease of handling. Everything about the GB312 is designed for greater simplicity and economy, including ease of operation and installation. Additionally, the GB312 delivers a lot but takes up remarkably little space. Its compact design makes it an ideal choice for minimal space in the B1 basement level. The GB312 is a high performance, compact condensing boiler which provides a high combustion rating of 92.8-94.8%.

Comparison of As-Built vs FPIU Ductwork Designs – Cost Estimates

The following section is a collection of cost estimates performed on the ductwork in both the office tower and the historical buildings. The first estimate is performed on the supply air ductwork on a typical floor as originally designed using the VAV units on each floor. The estimate is then compared to that of the required duct work based on the FPIU mechanical system redesign.

Job Name: Tower - Typical Floor Date of Estimate: 4/2/2009
Job Number: 001
Duct Type: Bare Metal Estimate by: Michael Webb

Width	Height	Length	Sections	SQFT	Lbs	Gauge
120	7	16	4	342.0	737.4	18
92	8	30	7.5	506.3	1091.5	18
72	8	26	6.5	352.1	583.0	20
66	8	14	3.5	175.6	290.8	20
56	8	8	2	87.0	144.1	20
50	8	8	2	79.0	111.1	22
36	8	18	4.5	135.8	190.9	22
Totals		120.0	30.0	1677.8	3148.8	

Summary

Waste Factor =	2.0 % Adjustment	
Metal =	3211.8 Adjusted Lbs	
Hanger Straps =	40 @ 6 ft Centers	
Drives =	61 Ft	
Slips =	402 Ft	
Unit Price =	$4.00 Per Lb.	Bare Metal
Duct Price =	**$12,847.10**	

Figure 44 - Tower Typical Floor (As-Is) Duct Estimate

Job Name: Tower - FPIU Ductwork Date of Estimate: 4/2/2009
Job Number: 002
Duct Type: Bare Metal Estimate by: Michael Webb

Width	Height	Length	Sections	SQFT	Lbs	Gauge
12	12	152	38	639.7	579.5	26
Totals		152.0	38.0	639.7	579.5	

Summary

Waste Factor =	2.0 % Adjustment	
Metal =	591.1 Adjusted Lbs	
Hanger Straps =	51 @ 6 ft Centers	
Drives =	103 Ft	
Slips =	103 Ft	
Unit Price =	$4.00 Per Lb.	Bare Metal
Duct Price =	**$2,364.36**	

Figure 45 - Tower FPIU Duct Estimate

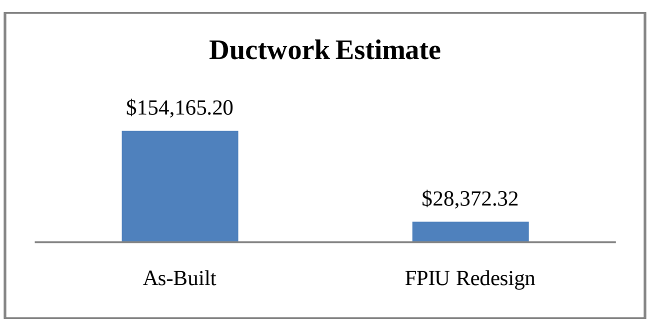


Figure 46 - Estimate Comparison

If the Square 320 project were to switch to the FPIU mechanical system redesign, the owner would save nearly $125,000, a cost-reduction of 82%.

This next estimate is performed on the supply air ductwork on the B1 Level of the historical building. This estimate is then compared to that of the required duct work based on the FPIU mechanical system redesign.

Job Name: Historic - Typical Duct Date of Estimate: 4/2/2009
Job Number: 003
Duct Type: Bare Metal Estimate by: Michael Webb

Width	Height	Length	Sections	SQFT	Lbs	Gauge
40	12	14	3.5	124.3	174.7	22
38	9	14	3.5	112.6	158.3	22
30	9	4	1	26.8	31.0	24
24	12	10	2.5	62.1	71.8	24
24	9	8	2	45.7	52.8	24
16	8	8	2	33.7	38.9	24
14	9	40	10	161.7	186.9	24
16	8	8	2	33.7	38.9	24
Totals		106.0	26.5	600.6	753.3	

Summary

Waste Factor =	2.0 % Adjustment	
Metal =	768.4 Adjusted Lbs	
Hanger Straps =	35 @ 6 ft Centers	
Drives =	61 Ft	
Slips =	123 Ft	
Unit Price =	$4.00 Per Lb.	Bare Metal
Duct Price =	**$3,073.46**	

Figure 47 - Historical As-Designed Duct Estimate

Job Name: Historic - FPIU Duct Date of Estimate: 4/3/2009
Job Number: 004
Duct Type: Bare Metal Estimate by: Michael Webb

Width	Height	Length	Sections	SQFT	Lbs	Gauge
12	8	66	16.5	233.8	211.8	26
Totals		66.0	16.5	233.8	211.8	

Summary

Waste Factor =	2.0 % Adjustment	
Metal =	216.0 Adjusted Lbs	
Hanger Straps =	22 @ 6 ft Centers	
Drives =	34 Ft	
Slips =	45 Ft	
Unit Price =	$4.00 Per Lb.	Bare Metal
Duct Price =	**$864.14**	

Figure 2 - Historical FPIU Redesigned Duct Estimate

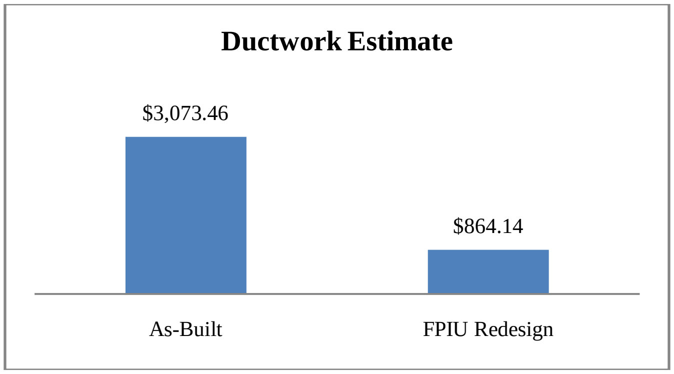


Figure 3 - Cost Comparison of Historical Duct

If the Square 320 project were to switch to the FPIU mechanical system redesign in the historical buildings, the owner would save $2210 and reduce cost by 73%.

This next estimate is performed on the vertical shaft ductwork required in the historical building. This estimate is then compared to that of the required duct work based on the FPIU mechanical system redesign.

Job Name: Historic - FPIU Stack Date of Estimate: 4/3/2009
Job Number: 004
Duct Type: Bare Metal Estimate by: Michael Webb

	Width	Height	Length	Sections	SQFT	Lbs	Gauge
	44	20	84	21	913.5	1284.4	22
	44	18	84	21	885.5	1245.0	22
	40	14	84	21	773.5	1087.5	22
	40	12	84	21	745.5	1048.2	22
Totals			336.0	84.0	3318.0	4665.1	

Summary

Waste Factor =	2.0 % Adjustment	
Metal =	4758.4 Adjusted Lbs	
Hanger Straps =	112 @ 6 ft Centers	
Drives =	286 Ft	
Slips =	657 Ft	
Unit Price =	$4.00 Per Lb.	Bare Metal
Duct Price =	**$19,033.61**	

Figure 4 - Historical As-Design Vertical Shaft

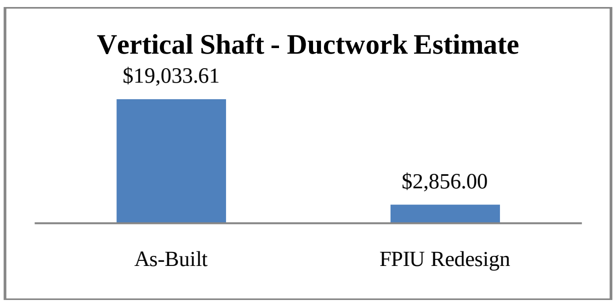
Job Name: Historic - FPIU Stack Date of Estimate: 4/3/2009
Job Number: 004
Duct Type: Bare Metal Estimate by: Michael Webb

	Width	Height	Length	Sections	SQFT	Lbs	Gauge
	22	20	84	21	605.5	700.0	24
Totals			84.0	21.0	605.5	700.0	

Summary

Waste Factor =	2.0 % Adjustment	
Metal =	714.0 Adjusted Lbs	
Hanger Straps =	28 @ 6 ft Centers	
Drives =	86 Ft	
Slips =	93 Ft	
Unit Price =	$4.00 Per Lb.	Bare Metal
Duct Price =	**$2,856.00**	

Figure 4 - Historical FPIU Redesigned Vertical Shaft



If the Square 320 project were to switch to the FPIU mechanical system redesign in the historical buildings, the owner would save $16177 on ductwork for the vertical shaft and cost costs by 85%.

Overall, excluding all other opportunities for cost savings, the savings that can be achieved in minimizing ductwork alone is still very impressive. This estimate calculates the as-built supply air and return air ductwork as required by a VAV system. It then compares it to the required outdoor air ductwork designed for the FPIU system. Due to the fact that the FPIU system doesn’t require return air ductwork, there is room for considerable cost savings. There are many other ways that the FPIU systems can save the owner and CM tome and money but ductwork savings was the extent to what these calculations covered. Even as only one cost saving benefit, FPIU’s have the potential to save upwards of $144,000 per floor with the possibility of over $1.5M for the whole project.

Potential Cost Savings From Duct		
Tower - Horizontal	**Historic - Horizontal**	**Historic - Vertical Shaft**
$125,792.88	$2,209.32	$16,177.61
	Total	$144,179.81
x 12 Floors	*x 6 Floors*	
$1,509,514.56	$13,255.92	$16,177.61
	Total	**$1,538,948**

The next section with conclude what exactly has been calculated in the above analysis and will offer additional ways that utilizing a FPIU system in Square 320 could save even more money.

Conclusions

There are many benefits to this type of system, many of which have already been covered. But specifically with the redesign of the Tower and Historical floors, the FPIU can give back a considerable amount of the lost plenum space taken up by the previous design. Higher ceilings are especially important in the Washington, DC area where building heights are strictly monitored but having more ceiling to floor height is a considerable architectural advantage for to the tenants; there's even a good chance that the owner might charge a premium for the office space, especially when it feels spacious.

Additional opportunities for cost savings in regards to this specific project would be with the elimination of 12 SCUs where one is on each of the tower floors. Those big pieces of equipment are no longer necessary because all of the air-mixing, heating, and cooling occurs inside each of the FPIUs. This will save you the first cost of the equipment, paying the utilities to run it, and last but not least, you will get back some additional rentable space on each level. More floor space means more income for the owner.

In terms of the as-built mechanical design, more in-depth research was done looking into the design of the ductwork alone, and there were considerable concerns that many industry professionals mentioned in terms of the ductwork design. The sizing and design of the ductwork doesn't seem like it will work very well. This is due to the bizarre series of ductwork aspect ratios (duct width divided by duct depth) that are absolutely awful. For example, with 92x8 duct, the aspect ratio is 11.5:1. For 72x8 it's 9:1. And for 50x8, it's 6:1. The general rule of thumb, as passed on to me from industry professionals, is the ideal aspect ratio is 1:1. For this reason, Southland uses round duct in these situations as their standard. This is also partially due to the fact that round duct is easier to install in the field, too. The max aspect ratio one should ever use is 4:1. As the estimates and typical floor plans show, a lot of the big duct mains are a lot worse than that. The goal of the original design was obviously to use as little depth as possible, but in turn their design greatly affects airflow for the worse. It restricts it first of all, and it will probably end up "starving" the boxes since there's a good chance they won't get enough air flow at all. Additionally, with duct sizes as large as 120x7, the entire coordination process becomes extremely challenging when you are trying to install conduit, lighting, data cables but you can't because you can barely work behind the 10ft wide duct. While I'm not the expert, I know enough to say the as-built duct design is really poor. The FPIU system only requires a single line of ductwork, open air, and as noted above, the ductwork from the design is no bigger than 12"x12". For that reason and the many that precede it, the FPIU system is the best alternative for a poorly designed VAV system.

III. Emotional Intelligence’s Monitoring Role

In the construction industry, as developing technologies play bigger roles in the success of projects, one might be quick to forget the fact that managing and taking care of your people is still the most valuable job one can do. Construction has always been a successful (job) because of the increasing need for team and collaboration kills. However, if the industry allows itself to become too dependent on upcoming technology and doesn’t focus on taking care of its workers, it’s doing the industry a disservice.

Emotional intelligence has been selected to assess individual and team performance because it has been successfully used in the construction industry. The success of an individual is not limited to their IQ or technical skills but rather it is dependent on their emotional intelligence or EQ. As defined by Daniel Goleman in his book *Working with Emotional Intelligence,* Emotional Intelligence is the capacity to recognize one’s feelings and those of others, for motivating ourselves, and managing our own emotions and emotions within our relationships. Figure # clearly shows that Emotional Intelligence covers five areas of our personalities that are then broken down into the following subcategories:

Intrapersonal

Self-regard: “ability to respect and accept oneself as basically good”
Emotional self-awareness: Ability to recognize one’s feelings and share them appropriately

Assertiveness: Ability to express feelings, beliefs, thoughts and to defend one’s rights in a constructive manner

Independence: Ability to be self directed and free from emotional dependency
Self-actualization: Ability for one to realize their potential and to be generally satisfied with their life

Adaptability

Reality Testing: Ability to see the real situation, not being overly optimistic or pessimistic
Flexibility: Ability to adjust one’s emotions, thoughts and behavior as a situation changes

Problem Solving: Ability to identify and solve problems and implement effective solutions

Interpersonal

Empathy: To be aware of, understand and appreciate the feelings of others
Social responsibility: To be a cooperative, contributing, and constructive member of a group

Interpersonal Relationships: “Ability to establish and maintain mutually stratifying relationships”

Stress Management

Stress Tolerance: Ability to not fall apart when adverse and stressful situations occur

Impulse Control: Ability to resist or delay an impulse, drive or temptation to act

General Mood

Optimism: Ability to look on the bright side, maintain a positive attitude, even when faced with adversity
Happiness: Ability to feel satisfied with life, to enjoy oneself and others, to have fun

Figure 48 - EQ Core Competencies

Why is emotional intelligence especially poignant in the construction industry? In a technical industry like construction, workers and managers alike will not always be able to understand or even articulate all the inherent details and specifics of the job. This is where teamwork and healthy communication are vital to the success of the project. If

members of the team were to have significant challenges with deficiencies in specific EQ areas, this would become evident in their communication and would hinder their progress. As Brent Darnell says in his book, *The People-Profit Connection*, the people who excel are the ones with higher levels of emotional intelligence. Technical skills are referred to as the 'price of entry' but emotional intelligence is vital for ongoing success.

In a similar way, the EQ assessment, if taken by an entire team, can brings to light the current conditions of a project like the working relationships or the current challenges and issues the project is facing. It is for this reason especially, that EQ can be a very effective managing tool in the industry and on the job site. Some of the challenges with working relationships on a jobsite are not easily noticed at first and potentially can lead to significant delays with financial implications. The power of the EQ assessments come to play in that a routine retesting of a construction team and can first gauge the condition of the relationships and second the progress of those individuals to strengthen the relationships. In this way, the EQ assessment can become a monitoring tool keeping a figure on the 'pulse' of a project based on what kinds of feedback the tests are providing. Based on the research of C.J. Butler, P.S. Chinowsky, and R.Y. Sunindijo, construction industry professionals with higher EQ scores tend to be better communicators, more proactive leaders, and stronger delegators. These are very valuable traits that help to drive the progress of a construction project. If intentionally monitored and developed, possessing these traits brings upon significant potential for a project's growth and success en route to experiencing synergy.

Research methodology - EQ Assessment Survey
EQ is most accurately quantified through the Bar-On EQ-i validated, self-perception instrument that measures the five main areas. Results are then compared to a large pool of over one million results and scored against a mean score of 100. Due to financial and time constraints, an alternative to the full 130 question test had to be used to get a snapshot look at an individual's score. The exact EQ survey used in the research for this report can be found at the back in the appendix section. Unlike IQ, emotional intelligence is an inherent set of skills that can be learned and improved over time. Taking the test and learning about your EQ skills is meant to identify areas that can be improved on in the efforts of better individuals and as a result the team as a whole. Generally, scores will typically increase with age as the individual matures.

The specific EQ survey used in this research was a 40 question snapshot at an individual's score showing relative strengths and weaknesses on a 1-15 scale. The feedback was all very strong, with the average values falling between 12-14 but in some cases there was a significant relative difference in one category's score displaying an individual's need to focus and develop that area.

Organizational Structure
Due to the duration and magnitude of the project, there were certain limitations on the scope of the EQ research. In order to focus in on one area and get valuable data, the survey was limited to the CM team of James C. Davis Construction Corporation. The organizational structure of DAVIS on this project equated to two parallel chain structures, the first being on-site in the field, and the second being at the home office.

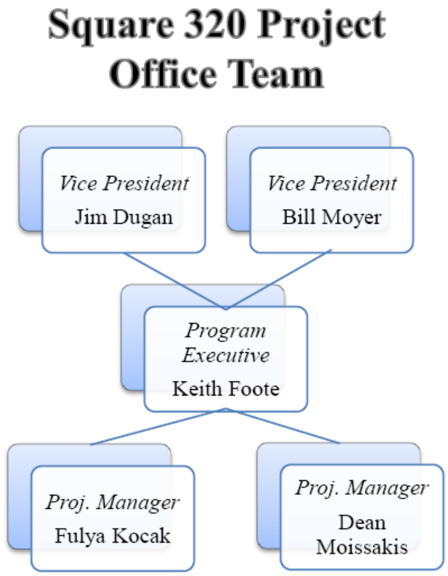


Figure 49 - Organizational Structure - Office

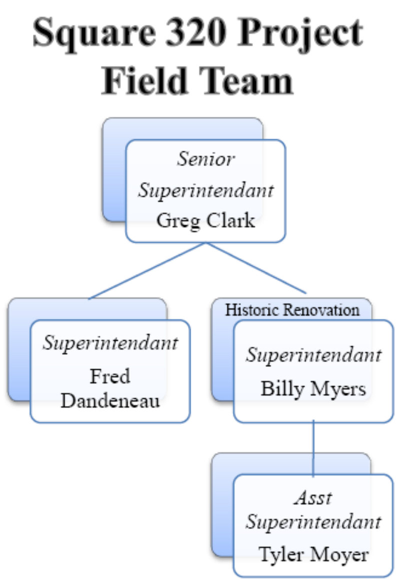


Figure 50 - Organizational Structure - Field

Office
Since 1990, DAVIS has been led by three primary leaders, Jim Davis, Dennis Cotter, and Bill Moyer. For the Square 320 Project, Jim Davis is designated as the Principle-in-Charge and he

carries the ultimate responsibility for the success of the venture. Additionally, Bill Moyer was brought in after the project began and worked the leaders of the project to increase the momentum and stay on schedule. Keith Foote, the Project Executive, has been working on this project from day 1 and is considered the one overall responsible for the project at the working level. While part of the office staff, his time is split between both on and off-site while in at this late stage of the project the majority of his time is spent on site overseeing the progress of the entire project. From there the remaining responsibility and work is divided among two project managers whose time is all spent at the office.

Field

On the field side, Greg Clark, the Senior Superintendant leads the team and carries the on-site responsibility of the work getting accomplished. Again, due to the magnitude and duality of the project, there are two superintendants assigned to the job, one handling the new construction portion of the work, Fred, while the other was brought in to focus on the historical renovations, Billy. Bill was brought in to focus on the renovation work so that the other superintendant could handle the new construction with the assistant superintendant being the relay in between. Those two superintendants encourage and verify that the work is done promptly and correctly. Lastly, the assistant superintendent Tyler Moyer, whose job can be rather dynamic, has been focusing his attention on the finishes of the historical buildings and their storefronts.

Standard Construction Industry Profile

Before analyzing the survey responses and discussing the results, it is important to understand where the majority of construction managers lie on the graphical representation of their EQ. *The People-Profit Connection* comments on how construction managers tend to have medium to high levels of specialized knowledge, but average to low emotional intelligence and even lower interpersonal skills. Thanks to the work of Brent Darnell and his research, a definite pattern or standard EQ profile has emerged for construction managers.

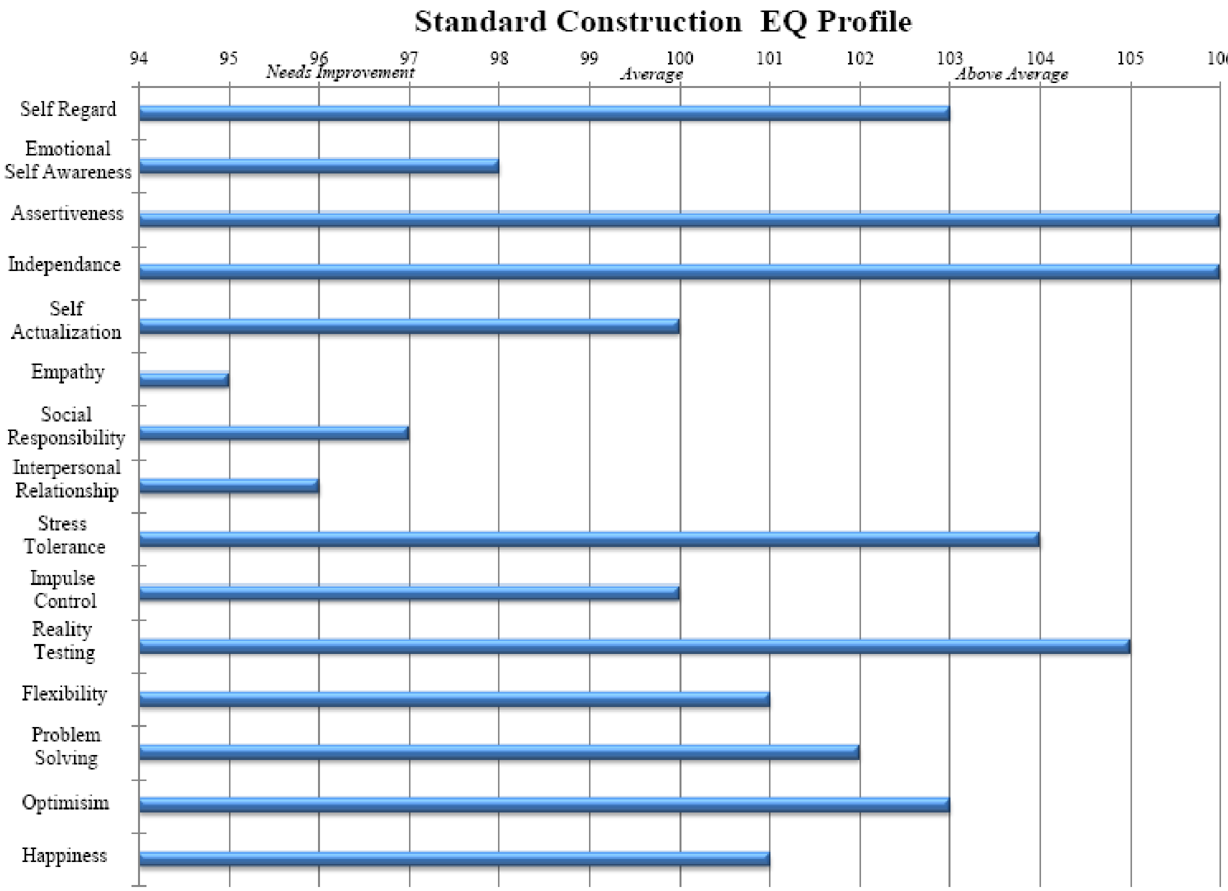


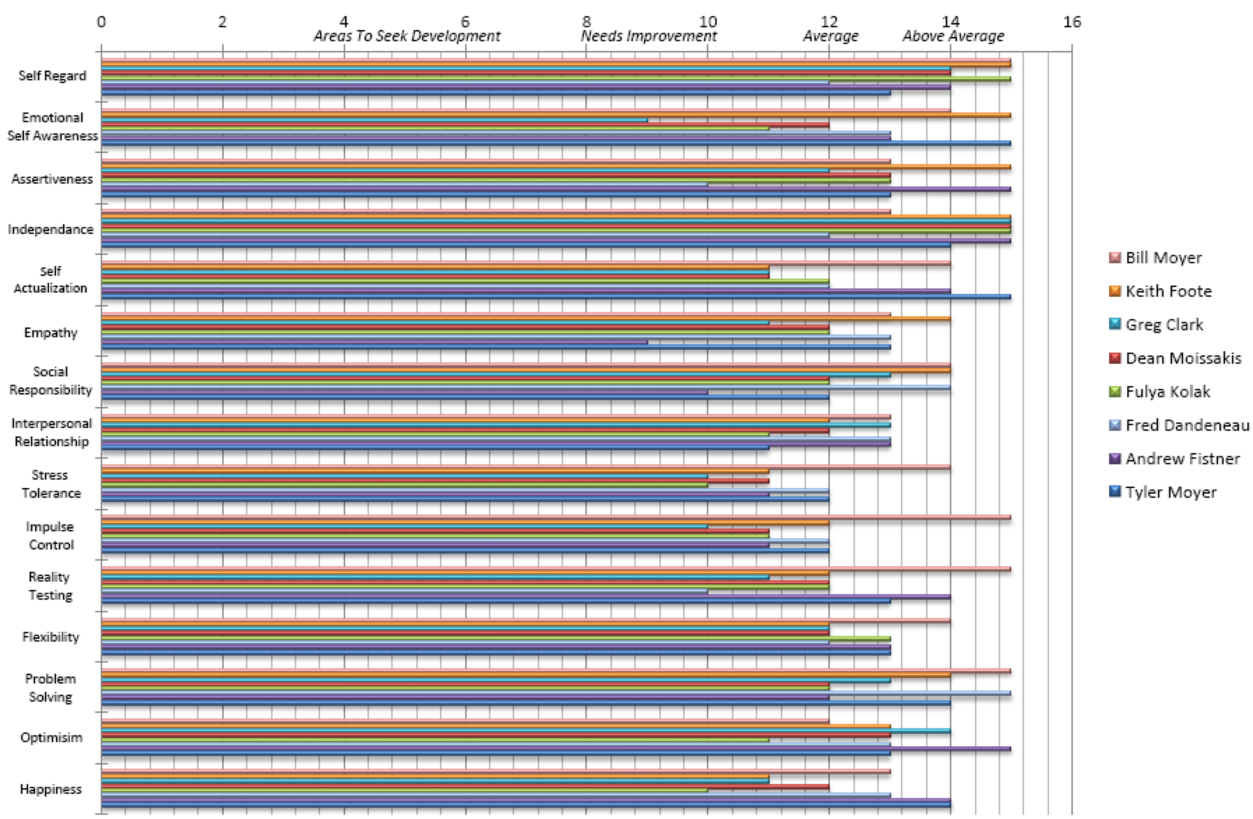
Figure 51 - B. Darnell's Standard CM Profile

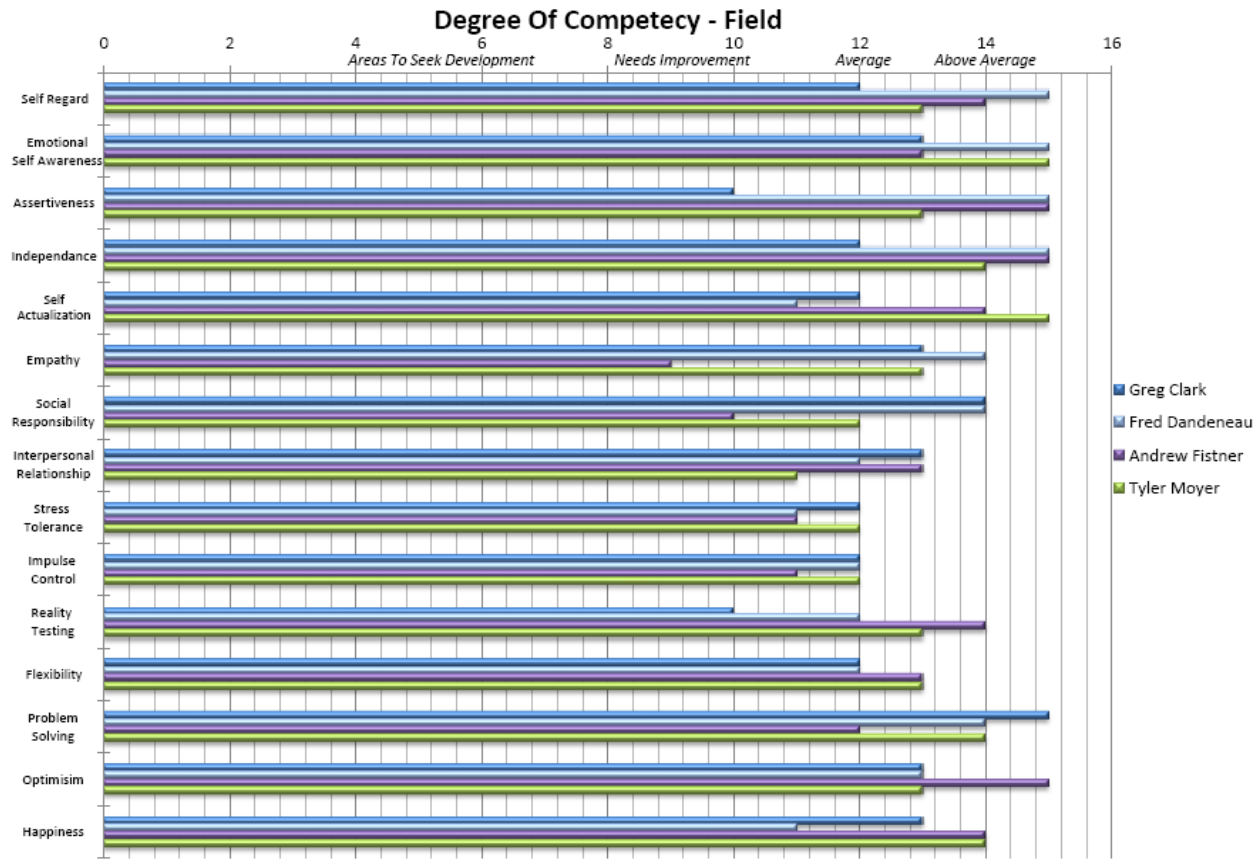
What tends to stand out quickly is the relatively low score in emotional self-awareness, a crucial element to emotional management. Interestingly, the standard profile also shows high scores in assertiveness, independence, and self-regard that contrast the relatively low scores in areas of interpersonal skills such as low empathy, low social responsibility, and low interpersonal relationship skills. These scores are tight to one another when compared to the x-axis, but focus on the relative distance the scores are away from each other and that is how the scores are best interpreted. Notice also that the CM group combines a high stress tolerance with a low impulse control. Brent Darnell deems this the “chaos” profile where managers react to situations and go from crisis to crisis. This group scores high in reality testing which correlates to a being neither optimisitic nor pessimistic and handling situations black & white. With this typical profile, most CMs are interpreted to be aggressive and independent to the extreme where they no longer ask for help, listen to others’ input, or involve people in the decision making. Additionally, without the interpersonal skills to counteract their aggressive and assertive nature, these strengths can quickly counteract their progress and hinder their success. The goal for anyone is to have a balance across the board without a lot of relative differences that stick out among the rest.

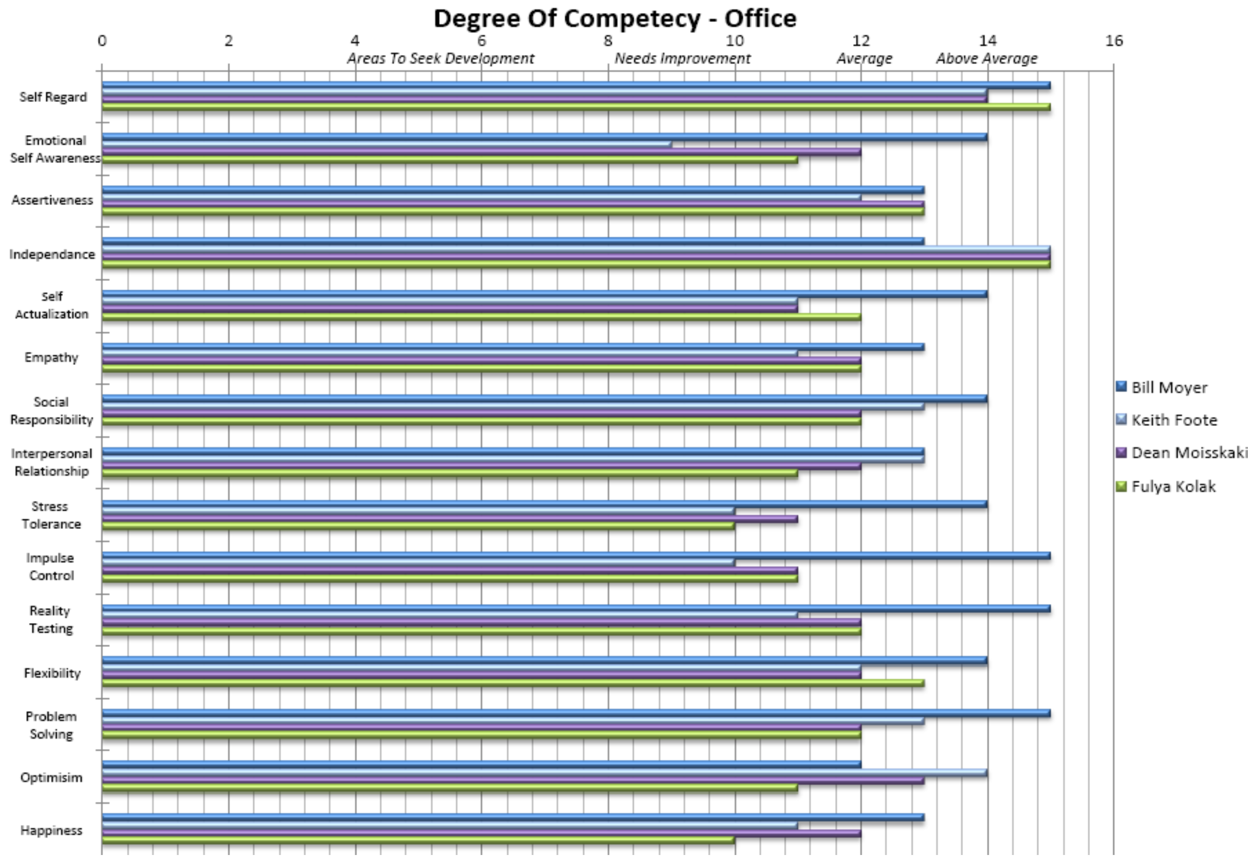
Results

After a total of 8 surveys were completed and returned to me, the data was compiled into a spreadsheet and the results were graphed to display the degree of competency that each individual showed in each of the 15 areas. The results are stacked in order of their seniority within Davis. The first thing one should notice without having to look too hard is the clear resemblance to the standard CM EQ profile with high values of self-regard and independence countered with low values of stress tolerance, empathy, or interpersonal relationships. Additionally, the graph below was split into two based on the individuals being in either the office or the field hierarchy.

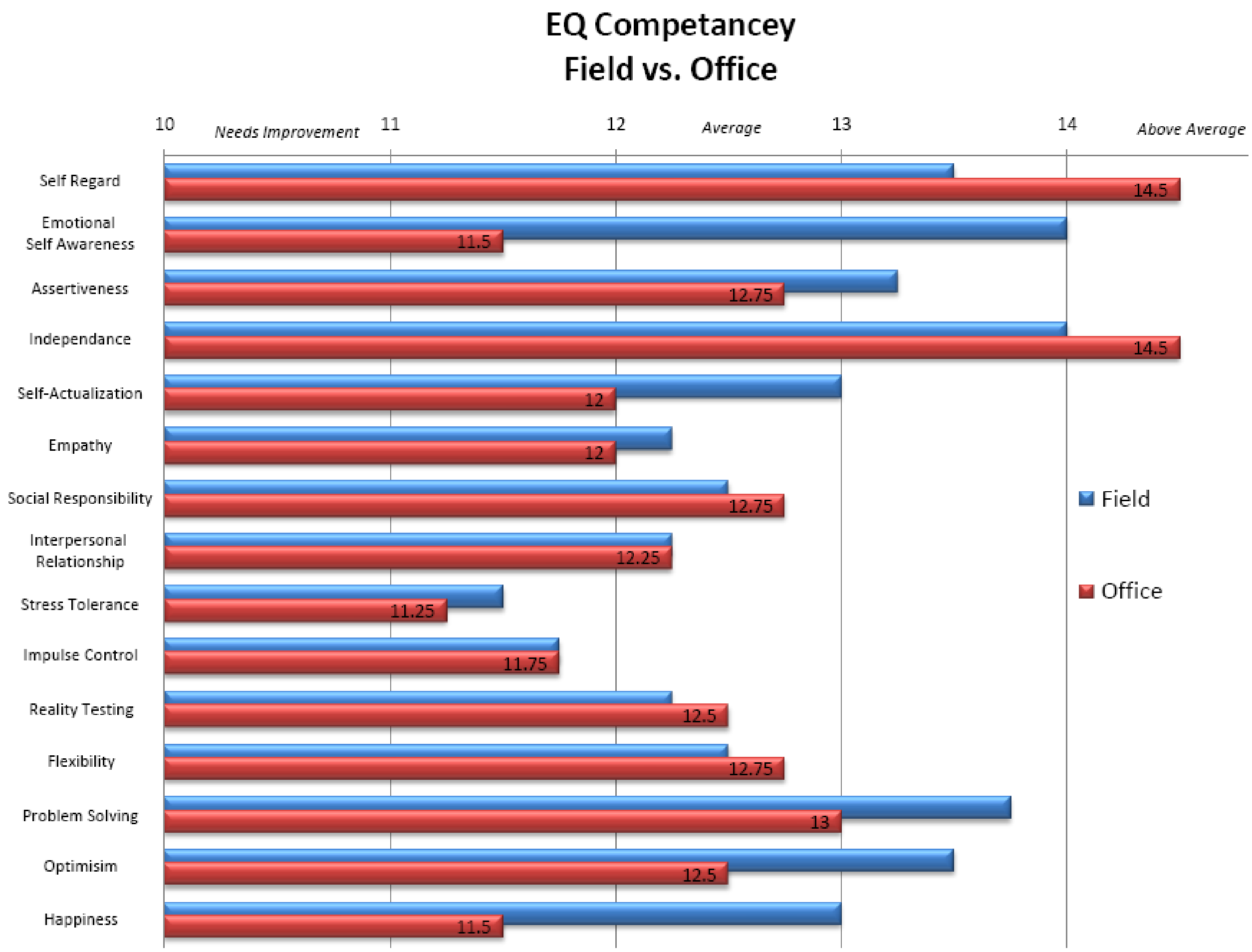
Degree of Competency




Degree Of Competecy - Field
0
2
4
6
8
10
12
14
16
Areas To Seek Development
Needs Improvement
Average
Above Average
Self Regard
Emotional Self Awareness
Assertiveness
Independance
Self Actualization
Empathy
Social Responsibility
Interpersonal Relationship
Stress Tolerance
Impulse Control
Reality Testing
Flexibility
Problem Solving
Optimisim
Happiness
Greg Clark
Fred Dandeneau
Andrew Fistner
Tyler Moyer



In addition to the original EQ survey, where individuals were asked to score 1-5 on how much they agree with each of the 45 EQ statements, there were a few short answer questions giving opportunity for their input. Almost each participant kept coming back to the challenges they faced in communications between the field and the office teams. No matter how much they tried, and even once senior leadership organized weekly management meetings, the challenges with communication sill plagued the project. After learning of this, I decided to reorganize the data in the form of a rough comparison between the field and the office teams. After taking an average of both groups, the resulting numbers were graphed below.



Summary of Findings

Overall, based on the written response portion of the surveys, the first obvious side-effect from the Square 320 project is the existence of strained working relationships contrasted with the concurring feeling that all parties were very proud of their work and of the project. That speaks a lot about the industry, that individuals expect projects to be hard and troublesome even though working on construction projects doesn’t have to be.

What tends to be most interesting is that as a group, the combination of the low stress tolerance, low impulse control, with the lower optimism and lower self-actualization clearly shows the burnout profile. The results indicate that the people involved on this project are tired and worn-out with only a slight difference between the field and office teams, being that those on site show a relatively higher sense of self-actualization and optimism than the other team. Now, one must keep in mind that this remains a simple evaluation. Only a small sampling of 8 people was surveyed and as a result the data cannot possibly be statistically verifiable. Additionally, the survey is not as in-depth as the 130+ Bar-On EQ-I survey used in most research. However, there is still value in the relative differences that the results display, even though they are not absolute numbers.

What’s most important is that the relative values show the individual what they should pay attention and where they have room to develop.

High self-regard, independence, and self-awareness, when combined with lower empathy and interpersonal relationship skills tends to be a recipe disaster. While the results are just a relative distance on the 1-15 scale, the general overview stands that same, that as a team, these professionals are not very strong in their relationship skills. This can be especially seen with the office team where their average empathy, self-awareness, and happiness scores are considerably lower than those of the field team. It is evident in the scores that the office team is strained, frustrated and tired. This is very typical of the Construction Management community in many ways. It is also worth mentioning that the more senior members, at least with the office team, tend to have much more balanced profiles. As discussed earlier from *The People-Profit Connection*, as professionals gain more experience and mature in the industry, their EQ profile gets stronger with age, especially in the weaker areas.

Unlike other testing whether it is IQ or Myers-Brigs, the EQ test is a reflection of the present time. It is a reflection of the project at the moment the survey is taken and the results of each individual can potentially be swayed significantly in many ways. For example, if an individual was currently working on a part of the project that required the help of a few people and the supervision of one, this person would show a very low score for independence. That same person, if put on a smaller task alone, would see their independence score take a significant jump up. As a result, by collecting the data and interpreting the results, we tend to get a very honest look into the general mood and attitude of the project at that moment in time. Furthermore, the other varying aspect is what is going on outside of the work in the lives of each of the individuals. There’s no possible way to know that for sure but one can surmise and there’s always room for conjecture.

It appears as though the field is in a better position for success and enjoyment on this project. It’s difficult to place exactly why but perhaps the field individuals just feel as though they can handle the pressures better. Both groups have low stress tolerance but those in the field appear more optimistic and more self-aware of themselves so they know better how to deal with the stress. Perhaps the office guys are just too bogged down with handling the communication and relationship problems the project faces and now that they are a couple months away from completion they are just burnt out. Additionally, to some extent the field team might feel like they’ve been ‘thrown to the wolves’, forced into a challenging project with limited information and bad communication.

Backing Up The Data

One way to be more certain if the conjecture is true is to ask some of these questions directly of someone from each side and see how they respond. And as such, a follow-up interview was scheduled with a member from each team to get an even further look into the many variables surrounding this project and the validity of these observations.

Office Perspective

Based on the responses from a member of the office team it became evident that being away from the job site did add significant strain on the relationships and ability to communicate with the field. There was the benefit, however, of not having your work interrupted and bothered randomly throughout the day. The working relationships between the field and office were described as good with the exception of those stressful interactions. When asked about the different personalities on the project, this individual admitted to their differences but also commented on the challenges the teams faced with the turnover of manpower as so many people came in and out of the project team throughout the past 2.5 years. After working on a project so so long, this individual agreed that it is easy to get burnt out because it feels like it's never going to end, especially in the closing stages of the project. One of the biggest challenges the office team faced was the length of time to which the RFIs were open. The field team would want to get a job done but the office team would be waiting on an RFI for more than 100 days at some instances. Both parties felt like the design team as a whole didn't coordinate well or even take the time for the necessary planning at times. Lastly, when asked about their enjoyment on the project, this individual responded by admitting that at least it has been a great learning experience, and regardless of the project, this person loves their job and wouldn't ever want to find another; where else can you find such a dynamic, challenging, and adventurous job.

Field Perspective

On site the problems were different. As a whole, from one's perspective, the project was managed poorly. Knowing ahead of time, especially in terms of the renovation work, that this project would bring unknown challenges and frustrations should have empowered someone to boldly take a step back and stop the failing approach in efforts to pursue an alternative. Perhaps one of the reasons communication between the two teams was difficult was because the roles of each person's job weren't clearly defined. As a result, some members of the field team did not feel particularly self-actualized at first. In general, the challenges facing the field team revolved around the taking ownership of one's job, of the project, and in holding people accountable for their work, their actions, or the lack thereof. It appears as though there was a lack of follow-through and execution. Perhaps the breakdown in communication came with a task would need to be completed but it might never have been delegated or prioritized and before you know it, the item is forgotten about. Additionally, significant frustration came into play when the architect would fail to respond to the field team for 100+ days. But perhaps, this is the sort of situation where the senior leadership needs to give everyone the authority to make decisions on the spot in order to get the job accomplished. Perhaps the team needed to be more empowered to make these sorts of judgment calls and decisions. As far as the direct relationships between the office and the field, there weren't any significant conflicts but some mentioned the challenge that comes into play with differences in personalities and even culture or backgrounds. The general experiences of the field team in regards to whether they felt burnt out from the project came back to simple mindset that one prepares them self to accomplish the task ahead of them without letting the

surrounding challenges get at you. At some point, everyone just needs to realize that some things are out of their hands and that it’s only worth worrying about the aspects of the job one can change. Lastly, when asked about their enjoyment on the project, this individual spoke on their love to solve problems and cultivate strong team camaraderie and the fact that these values can only grow when the work is delegated and people feel self-actualized. In the case of Square 320, perhaps initially the lack of delegation led to frustration, but in time as that was figured out, the level of happiness climbed. That might explain why the field had relatively higher values for their happiness, optimism, problem-solving, and self-actualization scores. In the end, as the project progressed it appears as though a lot of the initial ‘wrinkles’ within the operation of the field team began to work themselves out and as a whole the team enjoyed working more and more each day. That doesn’t mean the jobs weren’t taxing, because at points the field has been described as the ideal setting for an all-new reality-tv show, but perhaps more satisfaction comes from seeing the fruits of your labor day-in and day-out.

Recommendations

From the interviews and discussion above, it is evident that there is a lot of value in the accuracy of an EQ assessment, both in providing individuals the opportunity to self-monitor their development, as well as monitoring the working relationships and interactions on the job at that point in time. Many professionals use the EQ-I testing as an annual evaluation of their growth and maturation. What this report shows and what the research proposes, is that there is significant potential for gain in terms of striving to better the working conditions on site through the periodic monitoring of EQ assessments. In the same way that progress reports give a snapshot of how much work has been completed, the EQ can monitors the health of the team and the degree to which the various parts of the ‘body’ are working as a whole. In essence, there is significant potential for a project’s growth and potential for success when a team can reach a level of synergy. This synergy refers to the combined effort of individuals as participants of the team when their collaboration produces results that are greater than the sum of their parts. This can be accomplished but only when intentional efforts are made to hold every member of the team accountable to their work and the vested interest in they have in the success of the project.

Conclusions

As fewer new construction projects get financed there will be a continued growth of renovation projects that get priority. For James C. Davis Construction Company, historical renovation work is a rising market and a strategic effort should be made to get involved in these projects and gain significant experience. This report has clearly shown that there are three aspects of renovation work that have significant potential in encouraging high performance and team success.

Before projects are started, the construction manager needs to meet with the various members of his or her team in order to adequately prepare for the tasks ahead. The first task should be searching for the effective methods, based on the specific project that can potentially unlock greater team success and synergy. In terms of the Square 320 project, had the initial surveying period implemented the use of 3D scanning technology, there would've been much more information for the designers and the builders to work from. Without doubt, that increase in information would've brought upon substantial time and money savings that would've definitely benefited a project that suffered from endless setbacks. This is the first of many ways that various parties on the construction site can team together, work for a common goal and discover that their effort and labor pays off; that their smaller victories when shared together are greater than the sum of its parts. Additionally, the owner must bring members of the construction team together early in the project to take full advantage of the cost-influence curve and the team's collaboration. It is evident, the frequent interaction and communication between all parties involved will go a long way in making sure every team takes the initiative to expedite the work by encouraging quick and efficient communication at every step of the way. In this situation, each party will benefit from their mutual success.

The Square 320 project evaluated these multiple yet distinct areas that should be intentionally addressed on every renovation project. These areas will being hope in terms of significant cost savings, schedule acceleration, and more effective collaboration. At every step of the way, the design and construction team must be innovative and forward-thinking. Only at that point can renovation projects begin to reach their potential success. Finally, by monitoring the growth and development of a group's working relationships, a broadened perspective can be reached in an effort to strengthen the interpersonal skills of the whole. Not only does it promote the benefits of the individual, but when all parts are working their highest efficiency, then the whole benefits as much. The Square 320 project provides many examples of how renovation work, when approached correctly, can be the source of great financial gain and team achievement.

This research also helped so show in particular that there's an inverse relationship between information and both time and money. The level of information any given team has on the project inversely equates to more efficient production rates and fewer delays from RFIs or hidden conditions. More efficient production rates relate directly to that portion of labor requiring less time for completion. If the job is completed faster, fewer resources need to be dedicated to the work and that aspect of the team.

In terms of the basement expansion, the research should show that in hindsight, it wasn't the wisest decision to encourage the expansion of the basement and spend $1.6M in the process. However, that activity spurred on the attempt to redesign both the structural and mechanical systems. As a result the report confirmed that the mechanical redesign is more than capable to cut costs and make up for the added expenditure of the basement expansion. The frustrating financial challenges of that portion of the project all quickly become a moot point. It can definitely be said that the FPIU system makes a great HVAC choice regardless of the project or building type, combining efficient operation with decreased first-costs. In the end, pursuing energy efficiency and pursuing a lean and green option, resulted in the project achieving a sense of synergy in that different agendas and strategies overlapped and resulted in significant savings and exciting results.

Last but not least we discovered the inherent value in using the self-assessed EQ test as a monitoring tool, both for your individual growth and as a method for keeping one’s figure on the pulse of the project and the interteam dynamic. In the same way that progress reports give a snapshot of how much work has been completed, the EQ can monitors the health of the team and the degree to which the various parts of the ‘body’ are working as a whole. In essence, there is significant potential for a project’s growth and potential for success when a team can reach a level of synergy. This synergy refers to the combined effort of individuals as participants of the team when their collaboration produces results that are greater than the sum of their parts. This can be accomplished but only when intentional efforts are made to hold every member of the team accountable to their work and the vested interest in they have in the success of the project.

Credits / Acknowledgement

I have to give thanks and praise to my Father in heaven for the continued blessing that has been bestowed upon me. Every step of the way, God has guided my path and prepared the way ahead of me. That is all the more evident now as my college career comes to a close and I head off soon to the next adventure of my life as a Naval Aviator. With Him, nothing is possible

My deepest love and regards go out to my mother and father, **T. Ladson and Kristin Webb** for being both my biggest fans and harshest critics as the same time. You continue to empower me to grow, develop, and show myself that I yet to reach the extent to what I can achieve. Your unfailing love and support is a model that I hope to embody for the rest of my life and with my future family.

To **Jonathan Dougherty, Bill Moyer, Keith Foote, Tyler Moyer**, and the DAVIS team. You were a model of gracious hospitality to me whenever I called, e-mailed or visited the site. I can say that I've enjoyed this thesis experience as much as I have because of my interactions and conversations with each of you. I hope that this report can be of some benefit to all of you and the organization as a whole. All I can do is offer my perspective after hearing countless testimonies and surveys. But, please take warning to the fact that this report is worth just about as much as you paid for it! Just a few thoughts, from a college kid with no tangible work experience.

To **Nate & Julie Patrick** and **Southland Industries**, you single handedly saved my report and directed me on the path to success. When I made that first call it was evident that I didn't know where I was going but you had patience, took time out of your work day, and have played a crucial role in the success of this project. For that I greatly appreciate everything!

To my **Professors**, I owe you an apology; I should've gotten out of AE a long time ago and not taken up space in your classes. I still could've gotten to flight school as an English major. But all joking aside, I thank you for your faith in me and continued support. I know there were times where I seemed to be removed from my studies but I think that was my way of trying to keep a healthy balance between academics, military training, and service to the University.

To my fellow **WHOs**, you make me laugh, smile, and be the ridiculous person I truly am instead of trying to hold that inside disguised by military bearing. You continue to humble me and teach me so much about how much any single person can accomplish when they have passion for what they do.

To my fellow **Paws** and residents of 419 Old Main, this year has seen so many trials for all of us, yet somehow the glue that keeps us together continues to give us 'strength the pride of her friends'. If there's anything that you all helped to contribute to my thesis work, it's that you forced me to learn first had that Sleep Is for the Weak. But, in all seriousness, y'all are the one part of Penn State that I can take with me where ever I go, whether it be the hot sands of Iraq, the mountainous of Afghanistan, or endless blue of the seven seas. Thank you for your grace, patience, and understanding. MIER.

APPENDIX