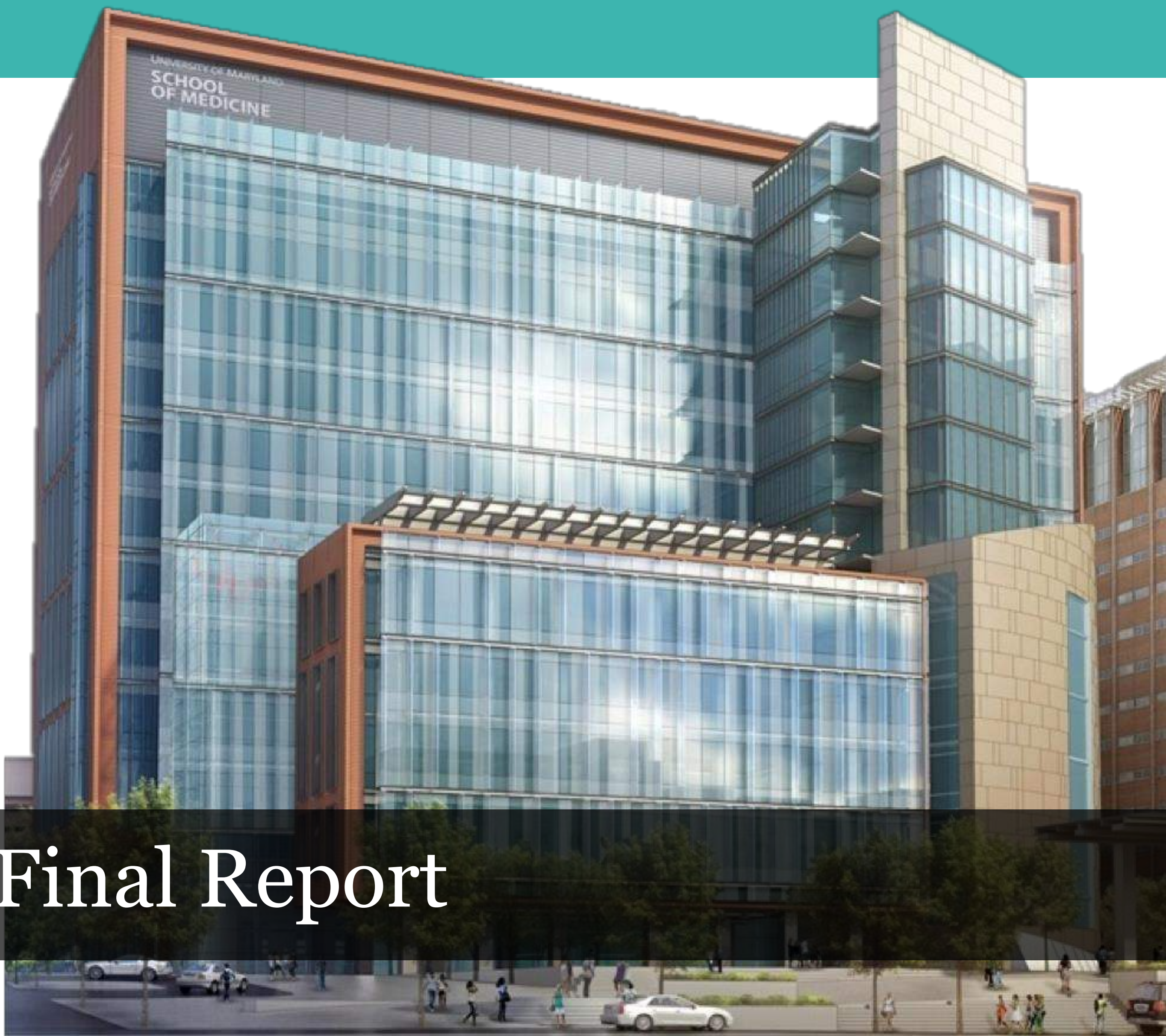

Final Report

Penn State
Construction Management

Advisor: Somayeh Asadi
Health Sciences Facility III
Baltimore, Maryland
April 8, 2015

Executive Summary

This thesis report outlines the research of the construction of Health Sciences Facility III in Baltimore, Maryland. Throughout the year, the building as a whole was analyzed to understand and identify avenues of research in areas like constructability, schedule acceleration, or challenges on the project. These avenues of research developed into specific analyses to investigate based on specific goals in each analysis. All of the analyses cover a wide range of construction topics and are related to understanding value and how to improve value on the project, from the value of a product to the value of time spent performing certain tasks or using certain equipment on a job. This thesis presents the findings of three specific areas of research: alternative support of excavation methods on this project, motivation and its correlation to team performance and resource leveling for cash flow.

Analysis 1: Design of Shoring System

One major challenge on the project included the dewatering system paired with the pile and lagging support of excavation surrounding the site. The project required dry soil in order to both achieve bearing capacity for the pours and to install the waterproofing membrane. Through the investigation of two alternative shoring methods, it was decided that sheet piles would be the best alternative method based on its schedule and overall cost. At $1,640,040 and 90 days of construction, this method is $490,000 cheaper than the pile lagging system and will save 24 days compared to the original system.

Analysis 2: Motivation and Team Performance

Taken from the PACE roundtable, this critical industry research revolves around defining elements that motivate people to do work and how that correlates with team performance on a project. Literature reviews of research done in this area as well as a survey sent to construction managers in the industry paint a picture of how broad of an opinion people have on their motivators to work as well as how their team performance is affected by positive or negative motivators.

Analysis 3: Resource Leveling for Cash Flow

Another challenge on this project involves cash flow. With the project spanning several years, there is only a certain amount of state funding given to the project each fiscal year. Through an analysis of the cash flow for the mechanical trade, a manipulation of the manpower on the project helped move $2.5 million dollars out of fiscal year 2016 into other fiscal years on the project, but it delayed the mechanical rough-in and testing and balancing in the upper floors at least one month. This means that the interior trades that were originally delayed a month could start as originally scheduled and this would accommodate the month delay of the overhead and in-wall installation on the upper floors without compromising the critical path of the project. Overall, it is recommended to use this alternative manpower schedule for the project.

Table of Contents

Acknowledgements

Academic

Advisor: Dr. Somayeh Asadi
Dr. Rob Leicht
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Industry

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Health Sciences Facility III
Baltimore, MD

South Elevation Rendering*

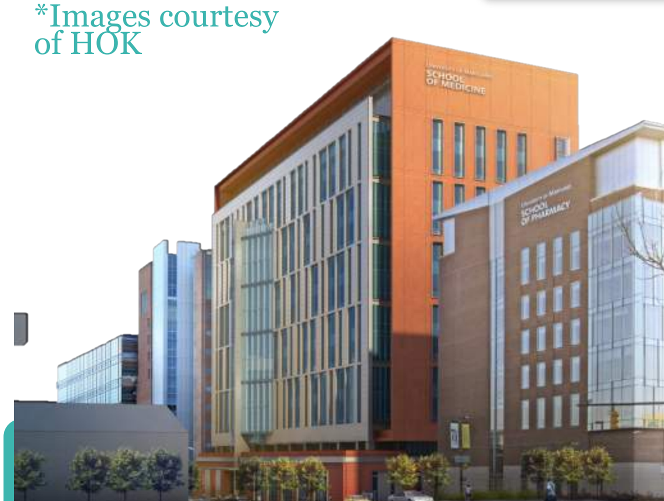
[BUILDING INFORMATION]

Size: 435,000 GSF
Stories: 11 above grade, 2 below
Occupancy: mixed-use lab/office/assembly
Construction Cost: $206 million
Construction: July 2013-Sept 2017
Delivery Method: Fast Track Construction
Contract Type: CM at Risk with GMP

[PROJECT TEAM]

Owner: University of Maryland
Architect: HOK
MEP Engineer: AEI
Structural Engineer: Cagley & Associates
Civil Engineer: Site Resources
Construction Manager: Barton Malow

*Images courtesy of HOK



North Elevation Rendering*

[CONSTRUCTION]

- Placement of concrete is pumped from the foundations to the 5th floor, crane and bucket for the remaining floors
- Tower crane will stay throughout the construction of the superstructure and façade
- Material hoist on west wall will have two cages to transport both material and workers

[ARCHITECTURE]

- Open lab layout to promote collaboration
- Offices mainly along the south wall of each floor
- Primary occupants include the School of Medicine, Pharmacy and Dentistry
- Main exterior façade elements of brick, precast, and curtain wall
- Multiple green roofs located on the atrium and south tower roof
- LEED silver qualified

[STRUCTURE]

- 44” mat foundation
- Concrete superstructure, 5000 psi, 8”-10” elevated slabs
- Steel framing in atrium, hollow tube steel trusses
- Average span of CIP columns is 21 feet

[MECHANICAL]

- Mechanical penthouse holds main equipment
- 100% DOAS AHUs—(4) service labs and (2) service vivariums
- (2) AHUS are 35% outside air to service the office spaces
- All systems have airside economizer controls, reheat coils, chilled beams and VAV units
- Process cooling water system in the lab spaces
- Glycol heat exchangers and cooling towers service the chillers and fin tube radiators around the perimeter

[ELECTRICAL]

- Skylights along atrium roof to promote daylighting
- Main electrical room in basement to receive dual redundant 13.2 KV feeders
- Anticipated load of building is 7,447 KVA
- (4) main switchgears at 100 KAIC, 5000A, 480/277 Wye, two of which are backup switchgears
- (2) electrical rooms per floor to service half of the floor
- Distribution panels are divided into lighting, receptacle, lab, equipment, and emergency panels

Barton Malow
UNIVERSITY of MARYLAND THE FOUNDING CAMPUS

Kathryn Gonzales | Construction Option
Advisor: Dr. Asadi
http://www.engr.psu.edu/ae/thesis/portfolios/2015/keg5247/index.html

Project Information

Project Background

As the third phase in the master plan for the University of Maryland, Baltimore (UMB), Health Sciences Facility III is a ten-story lab and office space that will be constructed on the existing site of Hayden Harris Hall, previously occupied by the Dental school. This building will be used primarily by the School of Medicine to further research developments for the university. At 435,000 GSF, this is the largest project to date that the UMB has undertaken. The guaranteed maximum price contract amounts to $216 million dollars and is expected to finish in September of 2017. One unique element of the design by HOK is the glass atrium that acts as a communal and transition space between distinct areas of the building. The construction manager, Barton Malow, came on board to the project early, around the schematic design phase, and has both the preconstruction and construction contracts. They plan to attain LEED Silver for HSFIII.

Client Information

The University of Maryland, Baltimore chose to move forward with the Health Sciences Facility III building for several reasons. Housing mainly the School of Medicine, it is designed to promote collaboration among researchers across disciplines with an open lab layout. As leaders of research in their fields, this building will allow UMB to grow in research activity and bring more funding to the university. The design has more of a generic layout to accommodate future tenants that the owner has not yet procured. This does not apply to floors 3 and 4, both of which have an identified tenant.

The main drivers of the project are cost and safety, partly because UMB prefers a more traditional method for the construction process. As for safety, the construction manager Barton Malow is working on a partnership with Maryland OSHA that will help improve the safety standards on the project. Another main element that UMB has prioritized throughout design is the facility maintenance. Many systems in the building mimic those in other buildings that they service.

One requirement of the project is to attain 30% MBE participation, with an emphasis on 4% Asian-American participation. Also, this project is moving toward a LEED Silver certification. HSF III is the largest that UMB has undertaken to date, so there are high expectations for the success of this building.

Architecture

Health Sciences Facility III is located in downtown Baltimore, less than a mile from inner harbor. The ten-story facility has a penthouse for mechanical equipment and two levels in the basement that host service spaces as well as special lab spaces such as an MRI suite and radiochemistry lab. All floors accommodate a host of offices, lab spaces, and multi-purpose conference rooms. Most of the lab spaces have an open layout to promote collaboration among students and professors. The offices are mainly along the south wall to take advantage of the direct sunlight into the space. The fifth and sixth floors will be left as a core and shell space. The building is divided up into four main areas, as seen in Figures 1 and 2 below. In the core there are 4 elevators, one of the main mechanical shafts and a stair tower. The south end of the core also holds conference room space up to level 4. The north and south tower include the main program space while the atrium serves as a bridging point between the two towers.

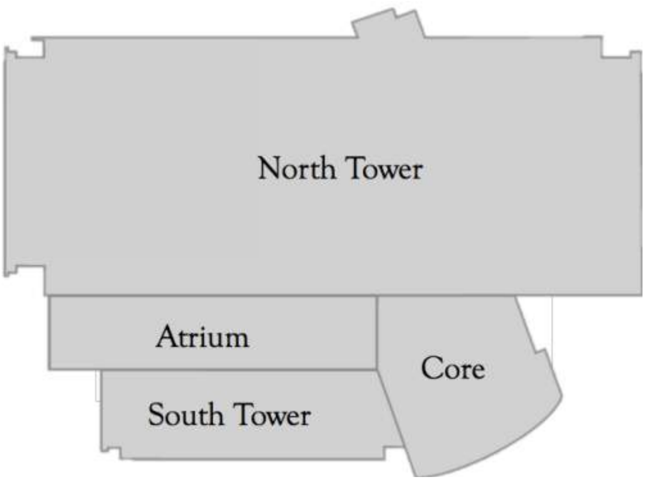


Figure 2: Plan View of Floors 1-6

Figure 1: South view of HSFIII

Structural

HSF III has a mat foundation because of the high water table present on this site. The 44”-60” mat slab acts as a massive weight to anchor the rest of the building to the soil, allowing water to freely pass around it. The waterproof membrane that wraps around the building must be dry when applied, which makes the dewatering efforts critical for this process. This extends all the way up the foundation walls whose forms are built on site with a mix of plywood and reusable forms. There are several shear walls in this building, mostly located near shafts, elevators or stairs, which act as a stiffening agent to the building. The pour schedule of the mat slab is in eight sections and the forms are built in such a way that each joint between pours fits together like a puzzle piece.

The entire superstructure is cast in place concrete that span on average about 21 feet. The elevated slabs are primarily 8” in thickness at 5000 psi with the exception of the 10” slab within the core on all floors. Most of the stairs are made of precast or miscellaneous metal. From the foundations to the 5th floor, the placement method of the concrete will be pumped, while the higher floors will be crane and bucket due to pumping height limitations. It is preferred that many of the major pours will be conducted on a Saturday due to less traffic in the downtown area as well as more availability from the batching plant. Reusable forms will be used on almost all of the columns and shear walls. Re-shoring of the slab is a host of scaffolding to support the weight of the structure while it gains in strength over time.

There is a unique moment of steel framing at the intersection of two curtain walls in the atrium. Hollow metal steel is used to create this horizontal truss to brace the glass, specifically HSS6x4x1/4. A massive HSS6x6 mega column supports each truss in the atrium. There is also a mix of W8x10 and W18x40 steel beams around the atrium skylights on the seventh floor.

Envelope

The design of the envelope for HSF III includes 5 main elements: brick, precast, curtain wall, granite, and punched windows. The roofing system is a mixture of green roof and traditional IRMA roofing, as discussed in the next section. The brick façade located mainly on the east and west walls is intended to blend this building with the existing structures that embody UMB's campus, while the precast on the north elevation, seen in figure 3, also encases the core section of the building. Most of the south façade has curtain wall along with granite surrounding the first floor. The north elevation also has a metal panel fin extending on the bump out.

Figure 3: North Elevation of HSFIII

There is a small relationship between the brick and the precast on the north façade, but the main integration of materials is seen through the curtain-wall and precast on the south façade. Curtain wall takes advantage of the natural sunlight that comes from the south. All of the windows throughout the exterior of the building are made of a low-e insulating glass, and the punched openings will have a louver shading system where needed.

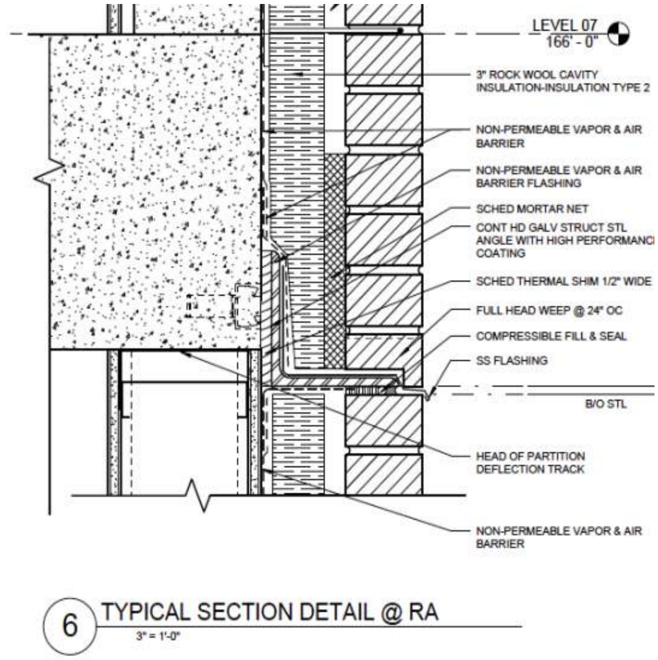


Figure 4 courtesy of the contract documents

The makeup of the brick façade includes the brick, a 2" air barrier, insulation, vapor barrier, sheathing and 6" metal stud backup, shown in figure 4. One noticeable difference of the precast detail compared to the brick wall is its elimination of the air barrier replaced with a cementitious thermal barrier. The precast is also thicker than the brick at 6". Above the roof level, the envelope extends as a parapet forty-three feet to hide the mechanical equipment located on the roof. This is concealed with louvers encased with precast and brick.

Roof

As previously mentioned, there are two types of roofing systems on this building. The main type is an IRMA system that consists of a hot fluid applied asphalt membrane followed by insulation, a fabric mat and ballast stone. The figure below shows an 8" thick slab of concrete that supports the roof.

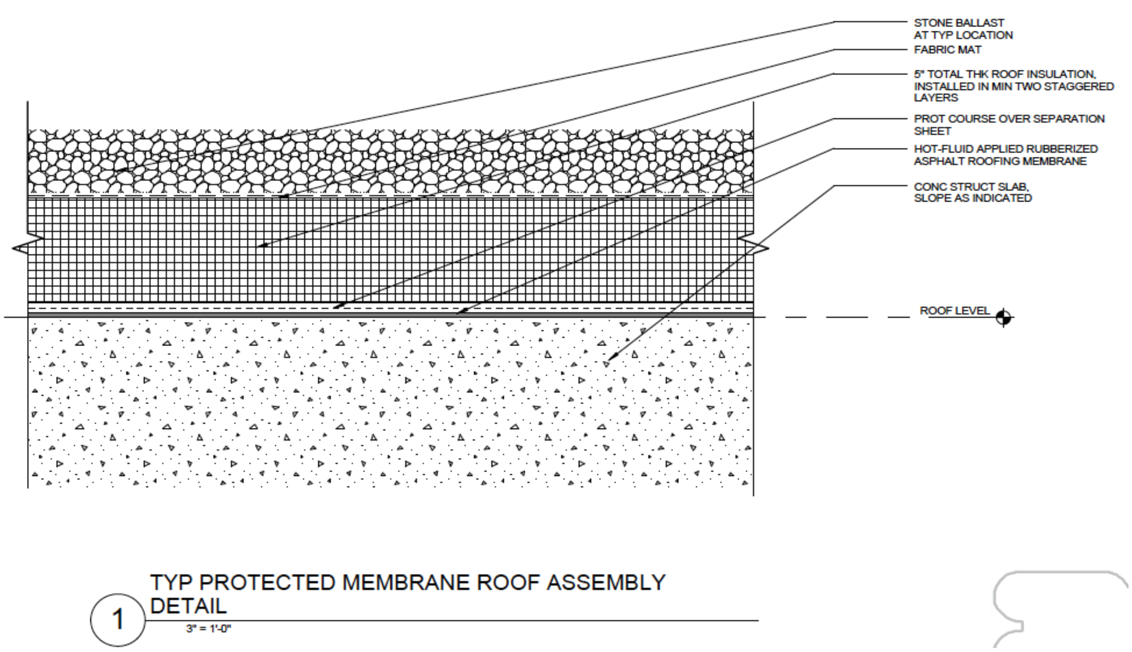


Figure 5: Typical Roof Section

The figure to the right explains the makeup of the green roof. There are multiple locations and levels that this green roof exists such as the south tower, atrium and 7th floor core roof. Its main purpose is to collect rainwater and divert it into the appropriate systems as well as provide thermal insulation. Most of the green roofs have 8" of soil separated by a fabric and a water retention panel. Underneath the retention panel, the roof follows the same makeup as the IRMA roofing system.

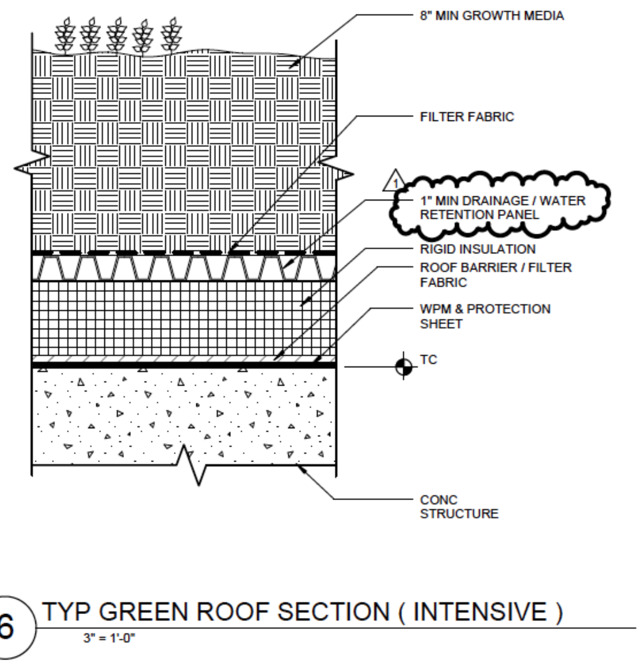


Figure 6: Green Roof Section

Mechanical

There are three major categories for the mechanical systems located in the penthouse of the building. Four air-handling units service the lab spaces with a 100% DOAS system at 64000 CFM. Two air-handling units service the vivarium with the same type of DOAS system that the labs have at 63000 CFM. Finally, the last two air-handling units service the offices space in a mixed air system with 35% outside air at 38000 CFM. All of these systems have airside economizer controls, reheat coils, chilled beams and VAV units. For the vivarium space, the source of energy is a humidification steam generator that also services the booster humidifiers. The existing chilled water system is not sufficient for the capacity of the new building, but the new building will tie into that system as for redundancy and as an emergency loop. The four chilled water systems are electrical driven, water cooled, and variable flow. They service the air-handling units. Due to the program of a lab space, there are several other systems that are involved in the mechanical space. For example, a process cooling water system is used for the water-cooled equipment in the lab spaces in addition to the cold room compressors. For the reheat system, HSFIII has glycol heat exchangers and reheat coils in the fin tube radiators around the perimeter and the chilled beams. Four fiberglass cooling towers on the roof exist to service the chillers and are double cell, counter flow and induced draft.

Electrical

The main electrical room is located in the basement where it receives the dual redundant 13.2KV feeders. For construction related power requirements, a temporary switch on N Fayette will be located. Based on the design information, the anticipated load of the building is 7,447 KVA. There are four main switchgears at 100 KAIC, 5000A and 480/277 wye. Two serve as backup generators and the other two service the entire building. Each distribution panel for the lab spaces has an emergency distribution panel on the same floor. The main distribution of power throughout the building comes from two electrical rooms on each floor. They act somewhat like a shaft up the center of the building on each side that it services.

There are multiple distribution panels on each floor. These panelboards service each of the following items: receptacles, lab receptacles, equipment, lighting, and emergency power. Most of these panels are 100A with the exception of the lab power supply panelboards at 225A and 120/208 wye. For the lighting and the equipment panelboards, their voltage is 480/277 wye.

Lighting

With a high surface area of curtain wall on the south end as well as the use of skylights in the atrium space, natural light is an important feature to the project team at HSFIII. Many of the offices face the south curtain wall and can take advantage of that direct light while the open spaces in the labs are located in the north allow indirect light into the space. Recessed grid mounted fluorescent lights will be used in the open lab spaces because those spaces need a high concentration of light. A typical office space has one pendant hung fluorescent light. The conference rooms match a similar layout to the open lab spaces. Emergency lighting in the space is generally small square recessed fixtures or linear fluorescent fixture mounted on the wall.

Fire Protection

Some of the two hour rated spaces include the shafts, stairs, elevators, and the main switchgear room. Many of these types of spaces span most all the floors and are most likely to spread a fire. One hour rated partitions are for all of the electrical and mechanical rooms, the firs command center in the building, and chemical waste storage. The oil tank room is a hazardous space and requires three hour partitions around it. Within the atrium there are storefront windows that separate the atrium from the north tower. They will be serviced by a water curtain with sprinkler heads spanning no greater than 6 feet. Floors 5 and 6 are shell spaces and will have upright sprinkler heads where the ceiling is exposed all the way up to the metal deck. This is in anticipation of the future use of the space. The lab spaces are considered ordinary hazard, group 2 while the rest fall under the group 1 category, according to NFPA 13. The stairs are a mix of wet and dry standpipes, depending on the location of the stair tower in the building; there is also a dry standpipe at the loading dock. To connect to the water system in the building, the fire department can access connections both at the southwest corner and northeast side. Copper piping and fittings are located in the shielded imaging rooms because these spaces imitate requirements for an MRI suite. An 8" pipe of incoming fire service located on the southwest corner of basement includes a double check backflow preventer on the building side. Standard piping is required at pressure less than 175 psi, while high pressure piping will be used when greater than 175 psi.

Transportation

Figure 7 shows the layout of transportation in the building. There are 6 elevators located in the building and four of them serve as the main core of movement. The two north elevators are the service elevators that access all floors, and the elevator in the southwest corner of the building only stops at the lower basement and the first floor. There are also stairs scattered throughout the building that service all of the floors. There is a difference in elevation at the north entrance of the building, which requires a small set of stairs as well as a wheelchair lift.

Figure 7: Layout of Stairs and Elevators

Telecommunications

All of the data routes back to two IT rooms per floor, each one servicing either the west or east wing of the building. There are plenty of outlets and data connections within all of the office and lab spaces. With the location of the building in downtown Baltimore, the University of Maryland has an on-site security guard that monitors traffic in and out of the building during normal business hours. At all other times the building must be card accessed. There are various security cameras on both the exterior and interior of the building to enhance the safety of the students and faculty. Security closets are on each floor that house the related data and security information. Many of the service rooms in the building as well as lab spaces require card access to those rooms.

Construction Information

Project Delivery System

The main delivery system used in this project is a CM at Risk with a maximum GMP. This type of contract is held with the construction manager as well as 4 design-assist subcontractors. They include the concrete, curtain wall, mechanical and electrical contractors. Barton Malow, the construction manager, was brought on board shortly around the schematic design phase after which the design assist subcontractors soon followed. Their main purpose is to provide expertise on schedule, cost, and constructability at each design stage. They also participate in the coordination of drawings. All other subcontractors for the job are competitively bid.

The design team has a traditional fixed fee contract structure. The project is also considered fast-track construction because the demolition and excavation began before the design was completed. Below is an outline of the contract structure on the project.

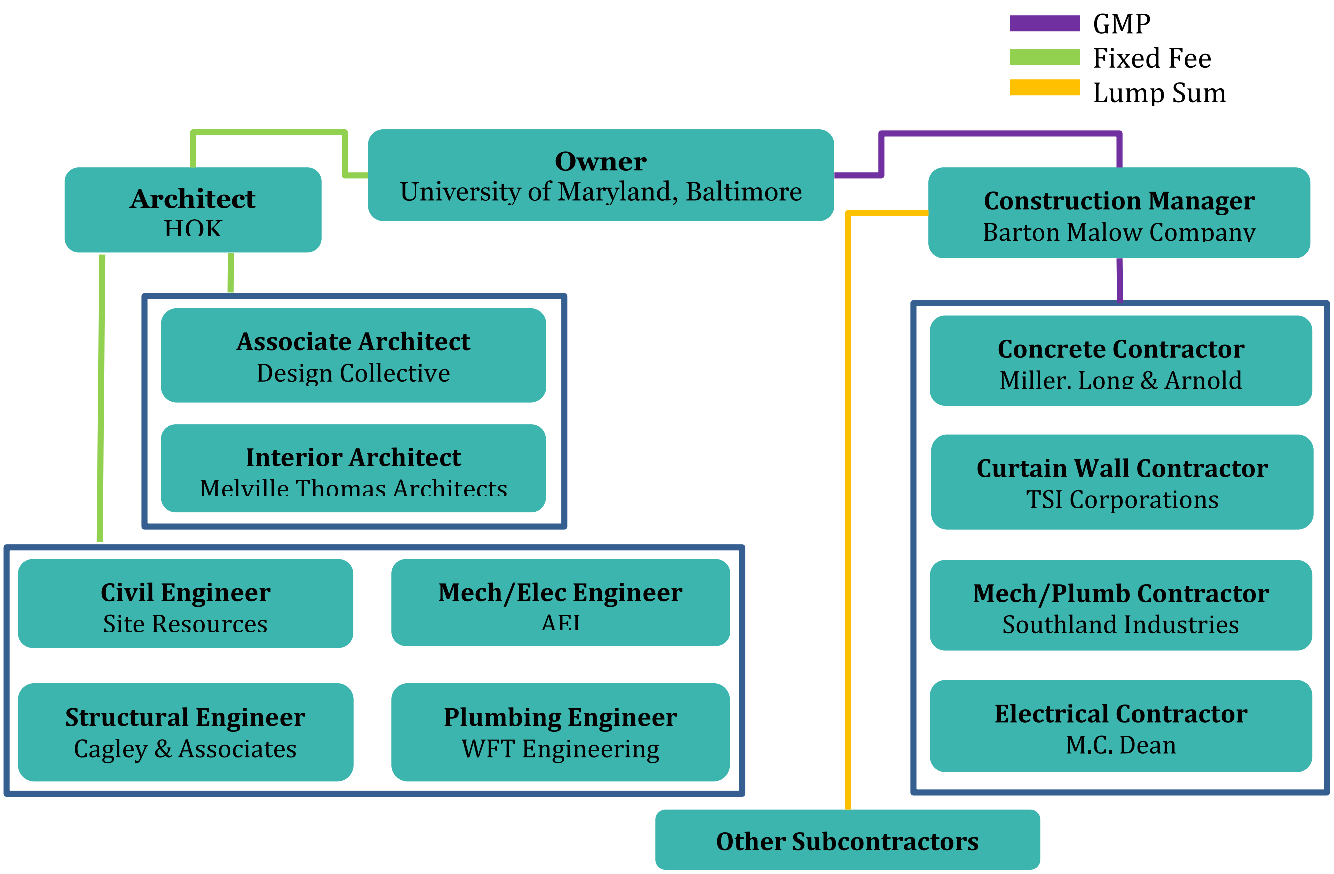


Figure 8: Contract Structure on HSFIII

Staffing Plan

One interesting feature of this project is the colocation of the design assist subcontractors with the CM. The designer representatives and owners also have work spaces available to them at the colocation, which is convenient for when they are attending day long meetings. This promotes collaboration among the various representatives within the company as well as between the contractors. The senior project manager is involved in managing the budget and has a direct relationship with the owner representatives. The second project manager is more responsible for the schedule and some project management work for subcontractors.

There are three project engineers in charge of various subcontractors as well as two superintendents. One of the superintendents oversees the entire site while the other is in charge of the MEP work. The administrative assistant as well as safety coordinator are only on site part-time.

Existing Conditions

A major area of concern is the high water table. With the site approximately one mile from the inner harbor, the dewatering effort is a crucial element to keeping this project on schedule and safe working environment. Based on the geotechnical report, the subsurface conditions are mostly poorly graded sand with silty sand and a layer of silty clay with sand. This plays a large role in what type of dewatering methods can be used. Jet wells work better for the clay layer because it pinpoints the specific location of the water while drilled wells around the perimeter can take care of most of the water before it reaches the site. Due to the tight site shown in figure 9, there is no contractor parking allowed on site. Major utility lines are located on all of the streets surrounding the building site, which means all work must be monitored closely for both marked and potentially unmarked utility lines.

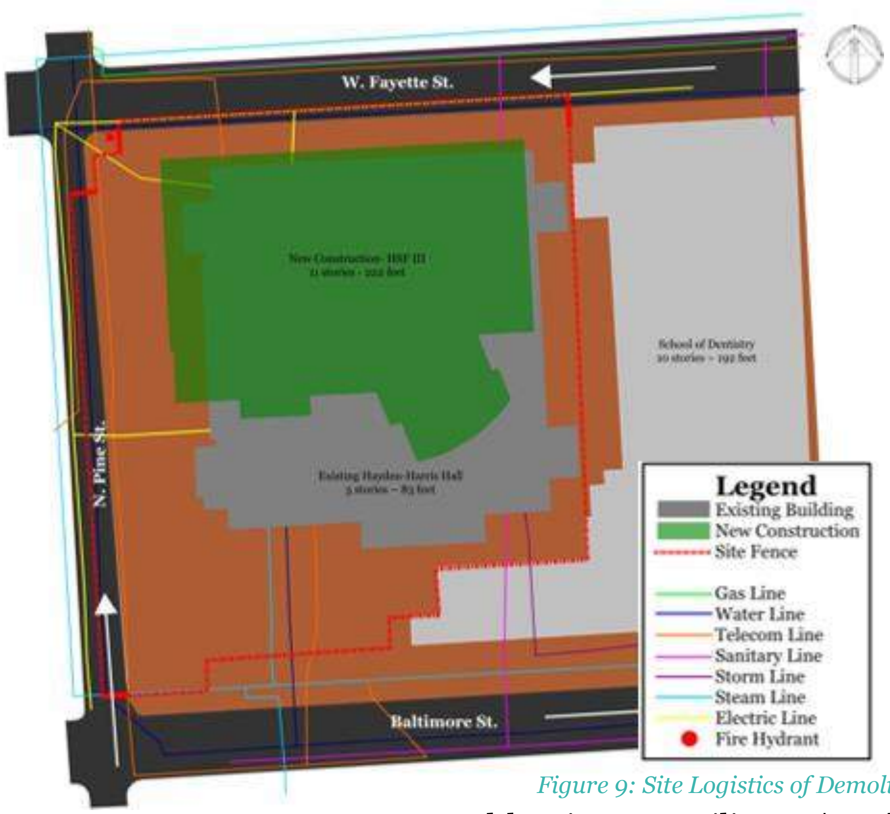


Figure 9: Site Logistics of Demolition

Demolition of the existing building includes the removal of the caissons at least 2 feet past the plan bottom of the new building. Most of the pedestrian traffic is from the University of Maryland and only half of Pine Street was taken for construction to allow access to between W. Fayette and Baltimore St. There is a covered walkway on the south end of the School of Dentistry building to help with the safety of pedestrians at that entrance. Entrances to the site help promote flow within the site for the trucks to easily enter and exit.

Major Equipment

The tower crane is located in the atrium space and fits within the hole of two designated skylights for the space. It is planning on staying in action throughout the erection of the exterior envelope. Once the building reaches the eighth floor, it will have to be raised another eighty feet to reach its final height. During peak times of crane usage, there is potential for two shifts to work with the crane. This plays out when the concrete is using the crane on the upper floors while the precast and curtain wall have started on multiple faces of the building. One material hoist will be located on the west side of the building, obstructing about a third of the façade. There will be a temporary loading dock beside it to allow for material deliveries.

Site Logistics Plan

The first phase of this project includes the demolition of the existing structure, seen in the site logistics plans in appendix A.1. There needs to be as much open space as possible to allow for this movement in dismantling the existing building. With a tight site, the construction management trailer is located 2 blocks off site in the University of Maryland's administrative building. This is a colocation room that is shared with the design assist subcontractors. The subcontractors also have trailers located on site for material and foreman use. The wheel wash stations are crucial to the erosion and sediment control portion of this project that is in an urbanized area. Finally, covered walkways allow for safe access to both entrances to the School of Dentistry that are adjacent to the project boundaries.

The excavation and foundation phase of this project causes more congestion on site due to the large mat foundation and basement. There are two ramp designations because the ramp needs to move at some point in the project to build the lagging behind the ramp area. As the excavation reaches plan bottom, the bottom of the hole can be appropriately used as material storage for the concrete foundation. There needs to be ample space above the hole to accommodate, potentially, multiple cranes during the sequencing of the concrete placement. Port-a-johns are located inside of the building or in the excavation hole. Also, the dewatering station located in the southwest corner of the site will remain there until the building passes the 4th floor and has enough weight to keep the high water table at bay without damage to the structure. Parking is not on site and is the responsibility of the contractor to find parking. The material staging areas will also host the dumpsters because they are in line with the truck path on and off site.

The final stage involves the superstructure, skin and interiors. The main differences in this site logistics plan are the appearance of the material hoist and tower crane. There are more site trailers to account for more subcontractors on site. With more open space for layout of material, there should also be a clear path around the building for cranes and other machinery to move around to perform various tasks.

Cost Evaluation

Although the actual construction cost is $206 million, the table below distinguishes the calculated RS Means cost to the actual construction cost on the project. At $184 million, this number is attributed to the hybrid assemblies and detailed estimate of the MEP systems as well as a detailed quantity takeoff of the structural system.

Table 1: Total Cost Comparison

Actual Building Systems Cost

System	Amount	% Project
Demolition/Excavation	$ 7,616,000	3.69
Structure	$ 21,297,000	10.31
Envelope	$ 34,726,000	16.82
Mechanical/Plumbing	$ 62,903,000	30.46
Electrical	$ 32,357,000	15.67
Fire Protection	$ 1,965,000	0.95
Sitework	$ 2,672,800	1.29
Other	$ 42,956,200	20.80
General Conditions	$ 10,130,300	4.91
Total	**$ 206,493,000**	

RS Means Building Systems Cost

System	Amount	% Project
Demolition/Excavation	$ 5,750,000	3.11
Structure	$ 20,729,700	11.22
Envelope	$ 14,416,100	7.80
Mechanical/Plumbing	$ 54,860,900	29.69
Electrical	$ 22,357,600	12.10
Fire Protection	$ 1,621,400	0.88
Sitework	$ 2,672,800.00	1.45
Other	$ 47,171,200	25.53
General Conditions	$ 15,175,500	8.21
Total	**$ 184,755,200**	

For the detailed structural estimate, every beam, column and shear wall was taken off from the drawings in Bluebeam and input into an original excel file. The slabs are generally repetitive in HSFIII, not including the basement and first floor. A detailed quantity takeoff of the reinforcing in the second floor slab was calculated and then extrapolated from the upper basement to the roof based on the percentage of SF compared to floor 2. The multiple elevations of level 1 called for a multiplier of 1.05 to make up for the added rebar on that floor. The miscellaneous steel in the building is mainly located in shafts, specifically elevator shafts. There is also steel on the atrium roof and a horizontal truss at the joining of the two curtain walls in the atrium that does not have a slab for reinforcement. Appendix A.2 includes the takeoff information as well as overall estimate information.

With a lab and research building, there are multiple mechanical assemblies that RS Means does not cover. Despite this limitation, cost data was acquired from the subcontractors to aid in the understanding of the breakout of the MEP trades and to act as a comparison to the assemblies estimate. For piping, ductwork, wiring and other elements that ran through the entire building, a $/SF value from the contractor was used against the square foot estimate found from a quantity takeoff of the concrete slabs. This also applies to lighting fixtures to accommodate the volume of LED fixtures that are not represented in RS Means. Large equipment from the other systems was determined using the detailed RS Means cost data. This helps account for all of the special systems that come along with this type of building. Overall, all estimates are lower than the actual estimate. This may be partially represented in the lack of temporary facilities quantities in the RS Means estimates because the real MEP estimates include a line item for each subcontractor's contribution to temporary facilities. Also, there is a large volume of miscellaneous smaller equipment not found in RS Means that is in the actual building. Finally, there is no markup, bonding, insurance, escalation, allowances or general conditions within the RS Means estimate that all contribute to the actual building estimate.

The general conditions estimate for the project is considerably higher than the actual estimate. Two drivers to this is the inclusion of temporary facilities and the tower crane in this estimate. The tower crane rental in the actual estimate is divided up by the subcontractors and their frequency of use. Also, the temporary facilities are carried by the subcontractor that installed the work, i.e. the electrical subcontractor carries the pricing for temporary power. Some unknown contingencies and allowances are not included in the RS Means cost but can be seen in the actual estimate. In the staffing plan, not all of the members are full-time or through the whole project. This is specific to the BIM manager and the accountant, who are charged to the job less than 50% of their work week.

Summary Schedule

This lab and research building is a 55 month preconstruction/construction duration with 50 months of construction. There are two core and shell floors whose fit-out portion not in the scope of this project. Preconstruction for the construction manager and the design began in April 2013 and continued through July 2014. During this time, demolition of the existing building began in July 2013. The design reached 100% construction documents while the project was pouring the mat foundation. Table 2 is a summary of the durations of the main project phases and the detailed schedule can be found in appendix A.3.

Table 2: Summary Project Schedule

Health Sciences Facility III Project Summary Schedule

Phase	Begin	End	Duration (Days)
Procurement/Preconstruction	April 15, 2013	October 1, 2015	639
Demolition/Excavation	July 31, 2013	July 11, 2014	245
Substructure	July 4, 2014	September 24, 2014	59
Superstructure	August 25, 2014	February 18, 2016	389
Envelope	February 11, 2015	October 28, 2016	448
Interiors	January 22, 2015	March 7, 2017	554
Sitework	January 11, 2016	July 1, 2016	125
Building Closeout	January 18, 2017	September 29, 2017	183

An abridged version of the critical path can be seen in figure 10. First, the schematic design, site mobilization, demolition and excavation of the project all fall within the critical path. This is a common item within the critical path because the next stages of the project must wait for these steps to be fully complete before initiating sequencing. One exception to this rule is the top-down method, which is not a chosen method on this project. The design and construction of this building is considered fast- track because only 5 months of preconstruction had occurred before the notice to proceed was issued and the contractors broke ground to demolish the existing structure. The fast-track element on this project removes some stages of design from the critical path; however, it could become an issue if the designs were delayed in some way. The beginning of schematic design to the completion of excavation took about four months to complete. Also, the dewatering system needed to be operational until the structure reached at least the fourth floor to sufficiently weigh down the potential uplift and structural problems that would occur from the water infiltration. This led to a decision to provide perimeter wells around the site and jet wells in the most crucial areas with the most water present.

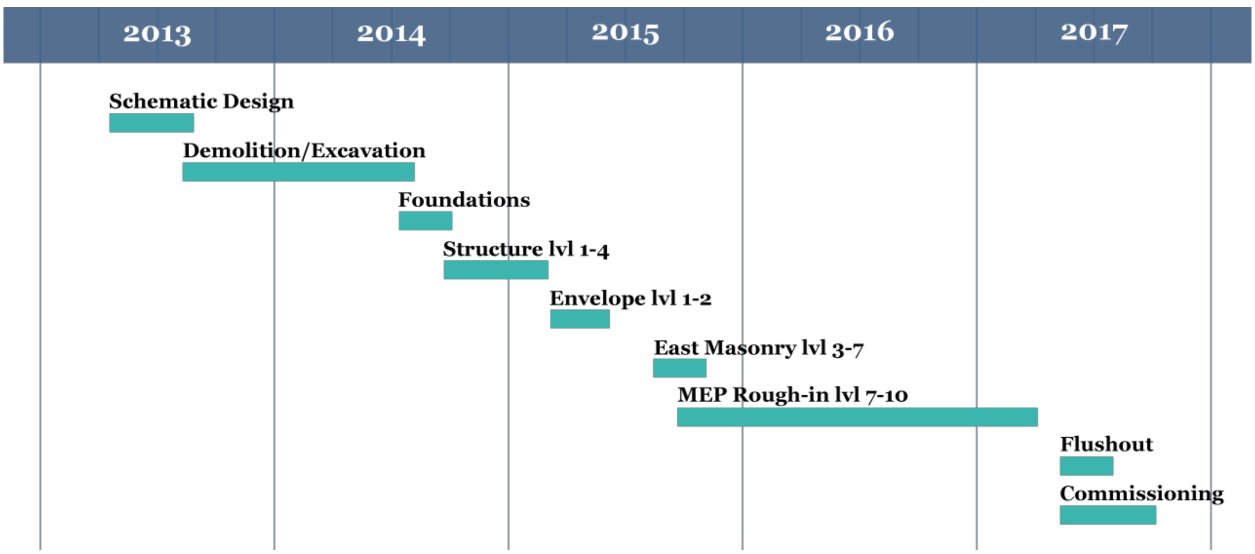


Figure 10 Critical Path of HSFIII

Succeeding the excavation stage in the critical path are the concrete pours for the foundation and structure up to the fourth floor. The entire concrete package is slated to take approximately nineteen months, from foundations to topping out. After the fourth floor, exterior work begins on the first floor. This work must wait until after the fourth floor is poured to both allow the safety nets to be erected on the fourth floor and give sufficient lead-time for the concrete contractor. This ensures that multiple trades are not in the same spaces slowing production. Several parts of the façade on the north tower fall on the critical path. Among those include the first floor granite, the second floor storefront, and the east masonry. This is because the interior finishes must wait for those floors to be dried in to begin installing temperature dependent items. In general, installation of the envelope starts on the west elevation of the north tower where the material hoist is located and works clockwise. The material hoist makes the west elevation the last to be completed, but the east elevation of masonry from floors three through seven is a critical item to close up each floor for the interior work.

The breakout of the interiors for the purpose of this exercise is by floor. Floors 1-10 are highly repeatable, not including the two core and shell floors. The detailed schedule in appendix A.3 captures the main trades and a high level view of the overall duration it will take for a trade to complete one floor. Next on the critical path is the overhead rough-in of floors seven through nine. Generally the MEP overhead rough in is linked from one floor to the next in a start to start fashion with a lag because the MEP trades can sequence themselves so that they are able to be on multiple floors at once. For example, the mechanical piping contractors can be on the fourth floor while the ductwork laborers are working in the same areas on the third and the plumbing contractors on the second, etc. Most of the interior work on the tenth floor also lies on the critical path. Other work in the mechanical spaces have enough float that don't land them on the critical path; this helps with the long lead items and major equipment that needs to be installed for the building commissioning.

Sitework does not fall on the critical path because the interior work and building commissioning have a longer duration both before and after this phase. Also, it is not tied to the interior work and has some freedom as to when it can be performed, preferably in good weather. Although not at the most ideal time, the sitework is to be completed from January 2016 to July 2016. Much of it can be moved around to accommodate weather in this schedule because the project is not complete until September of that following year. The buffer space can be taken advantage of when working on the new utility lines as well as the restoration of the adjacent streets. This type of work is ideally done as close to the end of the project as possible to avoid any damages from construction. Due to the large size of this project, ample time is left for commissioning and flushout of the building. Extra commissioning for the building, including the building envelope, helps with the LEED accreditation process. The building reaches substantial completion at the end of September 2017.

MAE Requirements

All analyses used information from graduate classes to both frame the topics and guide the direction of each analysis. For example, the overarching idea behind this thesis is to investigate what elements provide value on a project and how that can be formed and changed depending on the goals and priorities of the project team. This comes from AE 570, also known as Production Management. This class taught about lean practices and how to create the optimal amount of production based on the resources of the project or team. With this in mind, each analysis looked at how to provide the best value to the project. It also formed the strategies and working patterns throughout the creation of this thesis.

CE 543, better known as Prestressed Concrete helped identify opportunities for a structural breadth and the content used in this class proved to be greatly effective to the steps in design of the alternative shoring systems. Finally, AE 572 on Project Delivery Methods aided greatly in the understanding of the contract structure of this project. Since there are multiple types of contracts on this project as well as a fast-track element, this class helped understand how to identify the different contracts and how that plays into the whole of the project.

Analysis 1: Shoring System

Problem Identification

Over the summer, the excavation phase of the project ran into issues with excessive water in the hole, delaying the project and creating cost over-run in remedial efforts to further dewater the site. This analysis will investigate multiple shoring options to decide on the optimal support of excavation methods for this project. Included in this analysis is a structural breadth that designs the alternative shoring systems.

Background Research

During the excavation phase of HSF III, problems arose with the high water table in the last few feet of excavation to plan bottom. The current pile and lagging shoring method allowed water and mud to ooze from the walls and seep up from the ground. This was problematic to the project because the soil needed adequate bearing to pour the mud mat and the waterproofing required a dry surface during application. The mud that was coming through the walls was a great concern because it caused the shafts between the piles to slowly empty, creating voids behind the lagging. At first, the cranes and other heavy machinery were directed to stay at least ten feet away from the walls as a safety precaution. There were a few occasions where sinkholes formed on the north side between the lagging and the construction fence. This was solved by pouring concrete in the hole to prevent more mud and water from entering the hole. The concrete in these sinkholes was concerning because of the utility lines located in that same general area below grade, making it potentially more difficult to perform the work at a later date.

The dewatering system kept the water table down significantly, but not enough for the bottom of the hole to stay dry. The original documents did not call for any gravel under or surrounding the mat slab and foundation walls, but after several attempts to keep the site dry, gravel was used in some areas of the site to keep the water at bay for the mud mat to be poured. This issue caused delays in the completion of excavation as well as the beginning of the foundation work. Because of this, the first analysis will focus on exploring other shoring methods that could increase the ability to contain the water.

Analysis Goals

The three different shoring systems will be reviewed based on the following parameters:

- Availability
- Constructability
- Cost
- Schedule

While cost and schedule are quantitative values, availability and constructability are qualitative. These will be weighted less than the cost and schedule to install different systems. The following list includes the steps that will be taken to perform this analysis.

1. Research the cost and installation time of the pile and lagging system. Estimate an approximate value for the dewatering system.
2. Research the two alternative systems and evaluate the advantages/disadvantages of both.
3. Design the alternative systems.
4. Compare the three systems based on criteria above.
5. Recommend the most appropriate system for the project.

A design of the alternative systems will help spec a specific product for this analysis and make a more informative decision on the best system to use for this project.

Execution

Each of the three systems will be assessed thoroughly with the four criteria above in mind. With a base understanding of the installation method mentioned, the alternative systems will be designed to satisfy the structural breadth and a there will be a final decision from the research done in this report.

Investigation of Current System

Soldier pile and lagging is arguably the most common type of shoring system used in construction today. Its advantages and disadvantages are shown in figure 11. This is mainly due to the ease of installation, cost effectiveness, and availability of the product. First, the H piles are driven into the ground at specific intervals. In the case of HSFIII, the spacing between piles is 8 feet. Next, the contractor excavates the soil in small lifts of about five feet and installs the lagging boards until the excavation has reached plan bottom.

Advantages	Disadvantages
• Versatile to adjustments in the field	• Difficult to use with high water tables
• Fast to Construct	• Poor backfilling can lead to settlement
• Cheaper installation compared to other systems	• Not as stiff as other shoring methods
• Does not require advanced construction techniques	

Figure 11: Pile and Lagging Advantages and Disadvantages

With the depth of excavation at 32 feet for HSFIII, two lifts tiebacks are used at an interval of 8 feet to help with the static loads induced on the support of excavation. Tieback design will determine the angle to install the tendon, number of tendons, length of tendon, and bond length. A hole is drilled to place the tendon followed by grout to anchor the tendon in the wall. Tiebacks can be designed as temporary or permanent anchors to the foundation wall design. It is important to consider the location of utilities when determining the location of tendons because it could potentially be a major cost to the project if a tieback disturbs a utility line.

At HSFIII, the bottom of excavation for most of the site is at an elevation of +36 feet with a total excavation depth of 32 feet. Two areas of the foundation require a thicker mat foundation slab of 60” instead of the typical 44” slab.

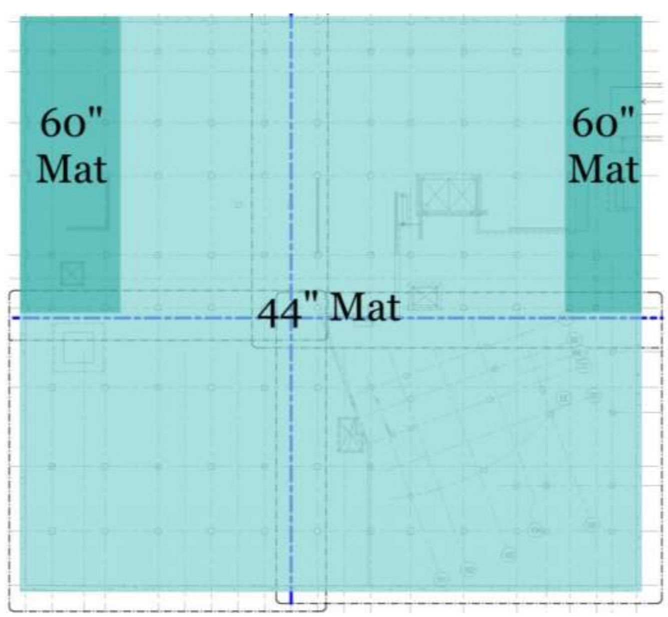


Figure 12: Basement Foundation Plan

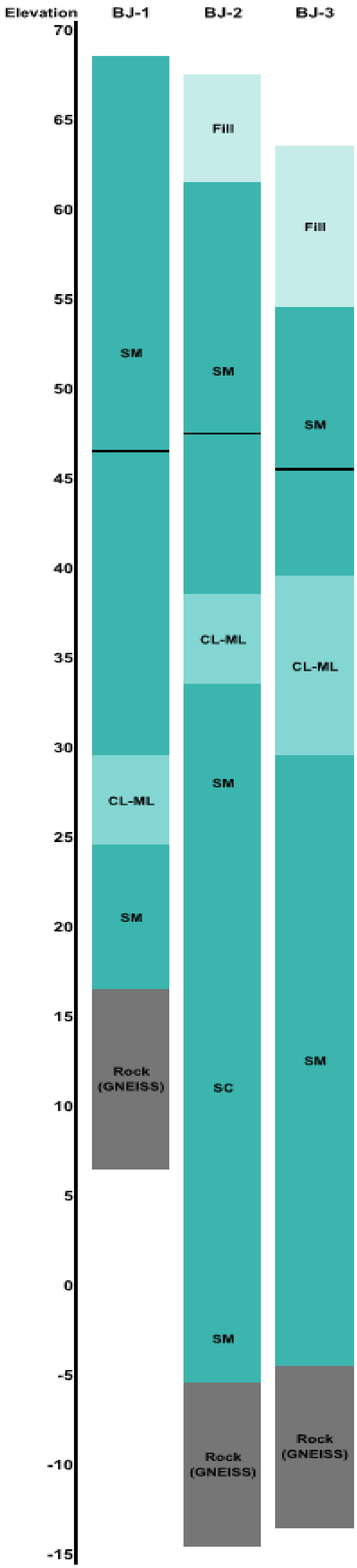


Figure 13: Boring Test Results

Figure 12 on the previous page shows the layout of the mat slab. The foundation design calls for bentonite waterproofing underneath the mat slab to protect the foundation below the water table. Once the soil reaches a bearing capacity of 5000 psf, a mud mat is poured to level out the surface for the waterproofing. Following the mud mat, the waterproofing must be installed on a dry surface to prepare for the mat slab. This is a crucial step to the installation of the foundation system. After the waterproofing, contractors install the bottom rebar, mechanical, plumbing and electrical work. Finally, the completion of the top layer indicates it is time to pour the concrete for the mat slab. It is critical that water does not delay or inhibit this process.

Soil Analysis

Because HSFIII included a complete demolition of the existing building on site, there was limited access for placement of the soil borings. Three boring tests were conducted and analyzed in the geotechnical report[1], seen in figure 13 on the left. The elevation at grade between the north and south borings only differ by five feet, which indicates a small and insignificant difference of grade on the project for the purposes of this soil analysis. Based on the results from the test borings, the majority of the soil is SM, or silty sand. There is a small CL-ML, or silty clay layer, but the bottom of excavation will encounter this layer only in the last few feet of excavation. Figure 14 below shows a comparison between the borings and how they relate to the groundwater found in the boring and the expected plan bottom of excavation.

Figure 14: Location of Boring Tests [1]

Groundwater was found between 19 and 22 feet below the surface level of the boring logs at the time of drilling. The elevation in which groundwater was encountered is consistent among each boring within two feet of one another, but these values can change throughout the project based on rainfall and other related factors. Due to the high groundwater table, the project requires a dewatering system throughout the excavation and foundation stage of the project. The site is located less than one mile from the Baltimore Inner Harbor as seen in the figure below and is less than 100 feet above sea level, indicating that groundwater would be encountered at a shallow depth during excavation.

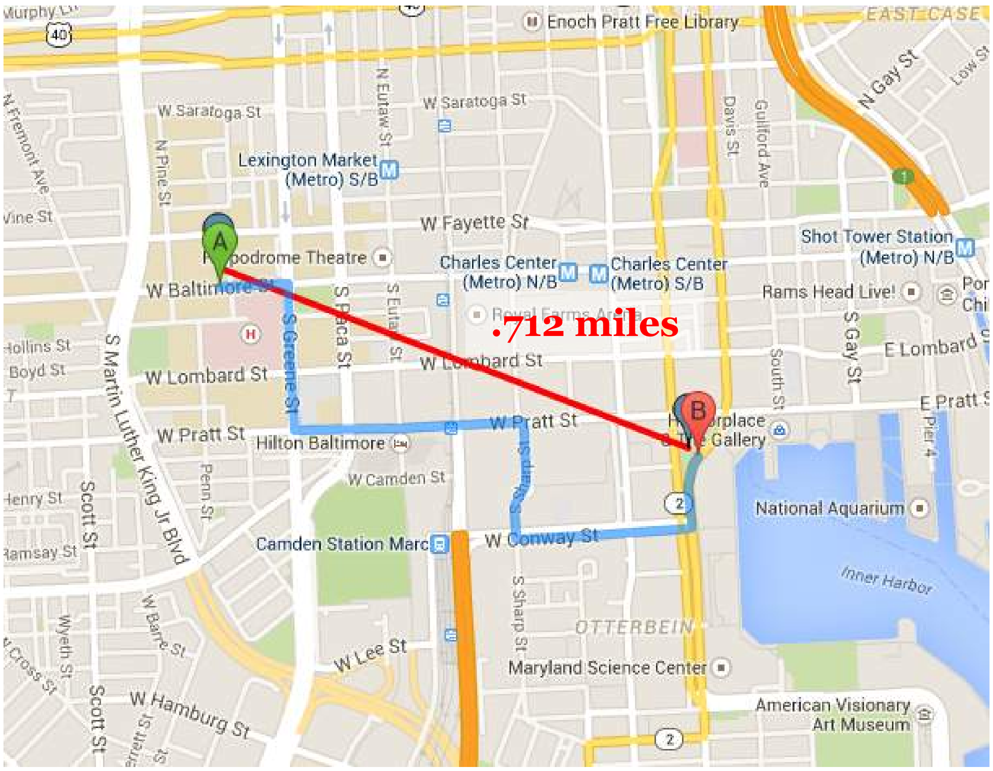


Figure 15: Distance from Site to Inner Harbor[2]

Dewatering Methods

With this knowledge of the high water table on site, a dewatering contractor was brought on board to design a dewatering system capable of handling the heavy amount of water penetrating into the site. Due to the high permeability of the soil, a perimeter deep well system was designed with 19 wells embedded to a depth of 60 feet around the outside of the pile and lagging. All wells are about 60 feet deep and feed into the same header pipe to a discharge station on the southeast corner of the site where the water is filtered and sifted from the soil. Each well is expected to pump about 660 gallons per minute to successfully keep the anticipated water out of the hole.

Challenges with Excavation

As the project progressed, the excavation continued without delay until the contractor reached the last few feet of excavation. Around elevation +39 feet, the perimeter wells could not successfully keep the water out of the hole. Heavy rain complicated the investigation of the source of the dewatering problem, but it was not the main cause for delay. Wet soil seeped through the lagging boards on the north face of the site, causing voids in the shafts between the two lagging boards and increasing the risk of a cave-in. A sinkhole was discovered on the north end of the site, which led to enhanced monitoring of the shafts and seepage of soil.

In an effort to control the excessive water, many other types of well systems were used on the project. Battered wells were drilled from inside of the hole about halfway down the excavation on the northwest corner to address the heaviest area of water penetration. Also, jetted wells were installed in the same corner below the mat slab once the excavation reached plan bottom to help the soil achieve the proper bearing capacity for the mud mat. The contractor installed a French drain on the northeast corner of the site to avoid the same dewatering issues on the northwest corner. Most of the site was also excavated an additional foot and backfilled with gravel to help control the water.

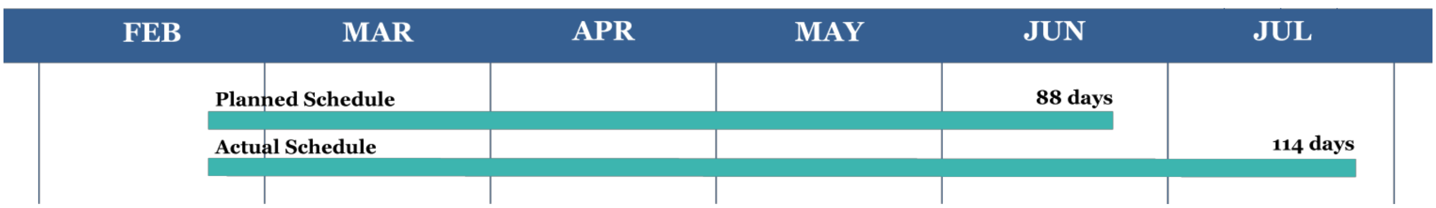


Figure 16: Pile and Lagging Planned vs Actual Duration

Figure 16 above is a comparison of the planned versus actual schedule of the excavation. As seen in the image, the project was delayed 26 days from excessive water on site that caused a variable amount of issues. Not only did the water reduce productivity of removing soil from the site, cost also accrued from the additional gravel and wells required to aid the dewatering problem as well as labor to investigate the issue. This added roughly $650,000 to the base shoring price on the project.

Shoring	$1,480,000
Dewatering Issues	$650,000
New Total	**$2,130,000**

Based on the original price for the shoring system and the delay from dewatering the site, the total cost for the shoring system is $2,130,000. This is a 44% increase from the original contract price. Two alternative systems will be examined based on the criteria previously mentioned to determine the optimal solution for this project. For consistency in the values among the various systems, excavation of the soil is not included. Also, the original dewatering system price of $600,000 is not included because it is assumed that this perimeter well system must stay in place for any shoring system to act as a secondary line of defense against the penetration of water into the hole.

Investigation of Alternative Systems

Based on the given information for the current shoring system on the project, this analysis will investigate sheet piles and a slurry wall system as alternatives mainly due to their common applications in places with high water tables.

Sheet Piles

Traditional sheet piles, shown in the figure below, are manufactured in a Z or U configuration from a variety of materials like aluminum, treated timber, vinyl, fiberglass reinforced polymer, and steel. Among these material choices for sheet piles, the most common material used is steel. While steel may have a higher corrosion and generally weighs more than other materials, they are more cost-effective for the same strength requirements than the other options. The ends of each sheet act as a tongue and groove that interlock multiple sheets together and come in various lengths and strengths. Maximum manufacturing lengths can be upwards of 100 feet depending on the manufacturer. Using the sheet pile design for HSFIII shown later in this report, this shoring method only requires sheet piles between 50 and 60 feet. They can also be used in conjunction with anchors and tiebacks to reduce the overall length of the pile and increase the strength of the system.

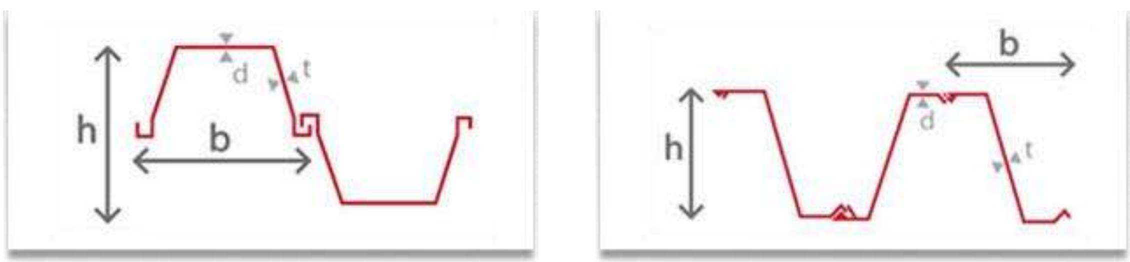


Figure 17: Z and U Sheet Pile Configuration[3]

Typically sheet piles are used as retaining structures in water or to control chemical seepage. This is often seen in the construction of bridges or dams. There are several advantages and disadvantages to using sheet piles as a shoring system for building construction as defined in figure 18. Although HSFIII would use these sheet piles in a permanent application, there are many types of coatings that prevent corrosion to the steel over time. Also, the vibration impact on other buildings is something to consider here in the urban setting of downtown Baltimore.

Advantages	Disadvantages
• High resistance to driving stress • Quick installation • Long service life when properly protected • Can be reused on multiple projects	• Difficult to use in permanent application • Soil type greatly affects the cost and schedule • Installation method could disturb neighboring buildings

Figure 18: Sheet Pile Advantages and Disadvantages

Two main methods to drive sheet piles into the soil is either through impact or vibration. Impact driving uses a machine that performs a series of hammer blows on the sheet piles to successfully dig into the ground. The type of soil determines the most effective equipment needed to drive the piles. For cohesive soils, diesel or drop hammers have fewer strikes per minute to allow for the pressure from the hammer to dissipate in the soil between blows. Generally the hammer is raised to a certain height and freely dropped onto the pile to drive it into the ground. One important thing to consider is the stress induced on the top of the pile from the hammer. A pile cap is commonly used to help reduce this stress, but the hammer force or soil resistance can increase the stress on the top of the pile and potentially damage it. Some tips to consider when driving piles into the ground include:

- Drive with ball end leading to prevent damage to the pile
- Drive pile in stages to help reduce deflection
- Alternate sheets to prevent driving them out of interlock
- Keep sheets plumb

Vibration driving uses counter-rotating eccentric weights with hydraulic motors that translate the vibrations into the pile. They are best used in sandy soil and also have the ability to extract piles if used for temporary shoring. Clamped to the pile, the hammer is set to a specific frequency based on the type of soil uses this frequency to drive the pile into place.

Slurry Wall

A slurry wall, also known as a diaphragm wall, is a non-structural vertical wall that uses a slurry trench installation system. The purpose of this method is to reduce the flow rate of groundwater on site. A variety of mixtures such as soil bentonite, soil-cement-bentonite and cement bentonite are common to this system. A specified narrow trench is excavated while one mixture mentioned above is pumped into the hole to keep the integrity of the soil wall. These mixtures, also called bentonite slurry or just slurry, keep the trench stable from collapsing. They enter the trench in a semi-fluid mix and harden to various strengths depending on the degree of cement present in the mix, seen in the figure below.

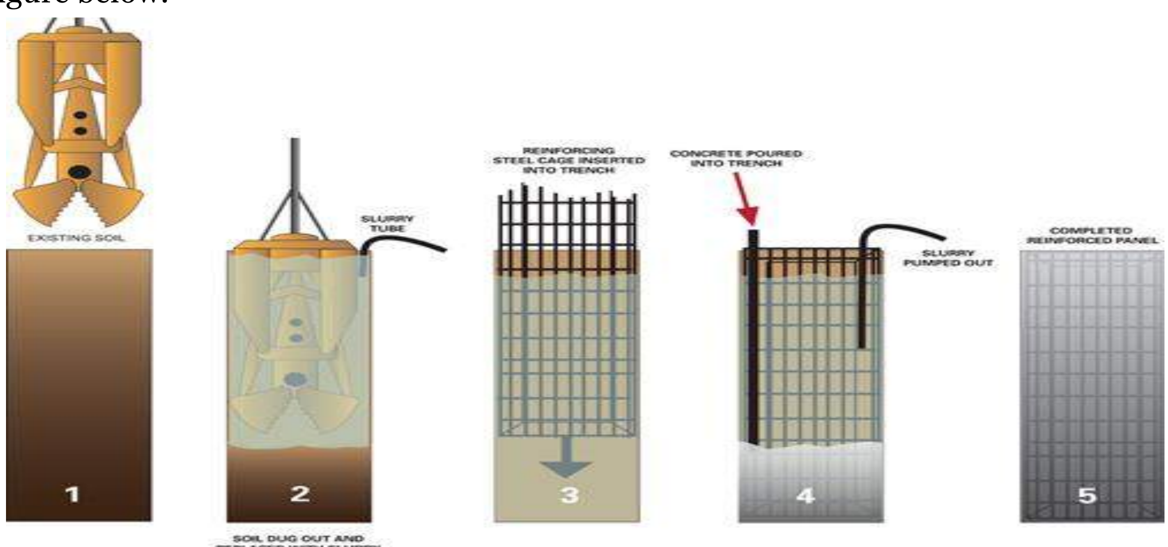


Figure 19: Slurry Wall Sequence[4]

Typically the mixture is prepared on site if there is room for the slurry plant or nearby to the project if the site does not have adequate on-site space. The soil-cement-bentonite mix has the highest strength and stability among the three options. Bentonite is important to this mixture because it absorbs a considerable amount of water and increases the viscosity of the mixture to reduce the amount of water flowing through the wall.

Advantages	Disadvantages
• Good for applications with high water table	• More expensive
• High stiffness	• Requires more working space than other systems
• Does not need backfill	• Longer installation time

Figure 20: Slurry Wall Advantages and Disadvantages

One of the major disadvantages to a slurry wall system is the high mobilization costs, seen in figure 20, making this system one of the most expensive to use. Equipment required to install a slurry wall include a slurry mix plant, pumping equipment to place the slurry in the trench, and an excavator to remove soil from a narrow trench. A clamshell bucket is a smart equipment choice for excavation in a tight site or deep foundation. Other excavators with extended booms work well when there is more room on site to follow the line of excavation. Stop end pipes allow for the trenches to be excavated and poured in sections.

Structural Breadth: Design of Shoring Systems

The purpose of this breadth is to design both a sheet pile and a slurry wall for more accurate cost and schedule information. They both share the same loading properties and can use the same data to determine total depth of wall and maximum shear and moment. The slurry wall requires more design for reinforcement and thickness of the wall. With SM soil and recommendations from the geotechnical report, the following assumptions concerning soil properties that can be made are shown in table 3.

Table 3: Geotechnical Information and Assumptions

Soil Property	**Amount**	**Unit**
Water Table	20	ft
Angle of Friction, ϕ	35	Degrees (°)
Moist Unit Weight, γ	125	pcf
Saturated Unit Weight, γ_{SAT}	145	pcf
`Construction surcharge, q	250	psf
Allowable bearing, q_a	5000	psi
Soil Type	SM	--

This information given above helps fill in other constants required for the completion of a retaining wall design, shown below.

$$\gamma' = \gamma_{SAT} - \gamma_w = 125\text{-}62.4 = 82.6 \text{ pcf}$$

$$Ka = \tan^2\left(45 - \frac{\phi}{2}\right) = \tan^2\left(45 - \frac{35}{2}\right) = .271$$

$$Kp = \tan^2\left(45 + \frac{\phi}{2}\right)$$

$$= \tan^2\left(45 + \frac{35}{2}\right)$$

$$= 3.69$$

The figure on the right shows the distribution of forces on the wall. The water table shown at 20 feet greatly affects the loading on the lower part of the wall above the foundation grade. The rectangular loads 1 and 3 are from the construction surcharge on the top of the wall while the triangular loads 2, 4, 5, and 6 are from the soil or water. Load 6 is where the wall moves from active pressure to passive pressure. With the given information from the depth of excavation, L_1 and L_2 are known while the L_3 and H must be calculated. Below is a list of the resulting forces from the loads described in the image.

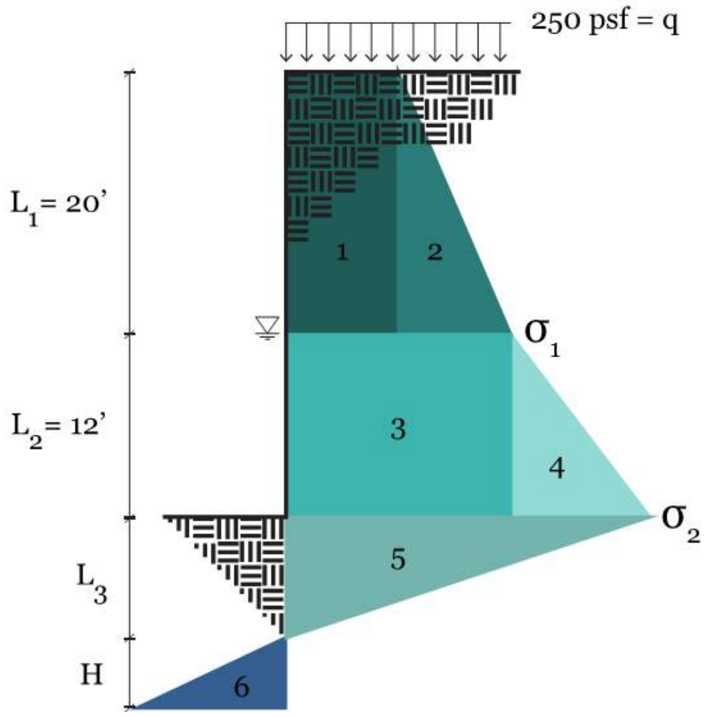


Figure 21: Retaining Wall Load Diagram

Active Forces

$$P_1 = k_a q L_1$$
$$= .271(250)(20) = \mathbf{1355\ lbs}$$

$$P_2 = \frac{1}{2} k_a \gamma L_1^2$$
$$= .5(.271)(125)(20)^2 = \mathbf{6775\ lbs}$$

$$P_3 = k_a(q + \gamma L_1)L_2$$
$$= .271\big(250 + 125(20)\big)12 = \mathbf{8943\ lbs}$$

$$P_4 = \frac{1}{2} k_a(\gamma_{SAT} - \gamma_W)L_2^2 + \frac{1}{2}\gamma_W L_2^2$$
$$= .5(.271)(145 - 62.4)(12)^2 + .5(62.4)(12)^2 = \mathbf{6105\ lbs}$$

The forces that occur from the soil and surcharge up to the bottom of the mat slab help to determine L_3, which ends at the point where the active pressures become passive pressures.

$$L_3 = \frac{\sigma_2}{\gamma'\left(k_p - k_a\right)}$$
$$= \frac{1763}{82.6(3.69 - .271)} = \mathbf{6.24\ ft}$$

$$P_5 = \frac{1}{2}\sigma_2 L_3$$
$$= .5(1763)(6.24) = \mathbf{5501\ lbs}$$

Passive Forces

$$P_6 = \frac{1}{2} k_p \gamma' H^2$$
$$= .5(3.69)(82.6)H^2 = \mathbf{152H^2}$$

Summing moments about the bottom of the retaining wall will get H, the final length needed to determine the total height of the wall. The first calculations do not include the tieback to determine whether or not a tieback is needed.

Sum of Moments (without tieback)

$$\sum M_O = P_1\left(H + L_3 + L_2 + \frac{L_1}{2}\right) + P_2\left(H + L_3 + L_2 + \frac{L_1}{3}\right) + P_3\left(H + L_3 + \frac{L_2}{2}\right) + P_4\left(H + L_3 + \frac{L_2}{3}\right) + P_5\left(H + \frac{2L_3}{3}\right)$$

$$= 1355\left(H + 6.24 + 12 + \frac{20}{2}\right) + 6775\left(H + 6.24 + 12 + \frac{20}{3}\right) + 8943\left(H + 6.24 + \frac{12}{2}\right) + 6105\left(H + 6.24 + \frac{12}{3}\right) + 5501\left(H + \frac{2(6.24)}{3}\right)$$

$$= \mathbf{401869 + 28659}\boldsymbol{H}$$

$$\sum M_R = P_6\frac{H}{3}$$

$$= 152H^2\frac{H}{3} = \mathbf{50.7}\boldsymbol{H^3}$$

$$F.S. = 1.5 \quad --\rightarrow \frac{M_o}{M_R} = 1.5 \quad --\rightarrow M_O = 1.5M_R$$

$M_O = 1.5M_R$
$401869 + 28659H = 1.5(50.7)H^3$
$-76H^3 + 28659H + 401869 = 0$
$\boldsymbol{H = 24.4\ ft}$

Total height = L1 + L2 + L3 + H
=20+12+6.24+24.4=**62.64ft**

Although it is feasible for sheet piles to be manufactured to this length, from a constructability standpoint it makes more sense to add a tieback and reduce the overall length of the member. The length of the sheet piles also affects the transportation method. With this project being located in an urban setting, it is prudent to restrict the transportation of the piles to the length of a truck bed, which is about 53 feet maximum. The following calculations include a tieback at an assumed height of 10 feet from the surface.

Sum of Moments (with tieback)

$$\sum F_X = P_1 + P_2 + P_3 + P_4 + P_5 - P_T - P_6$$
$$= 1355 + 6775 + 8943 + 6105 + 5501 - P_T - 152H^2$$
$$= 28659 - P_T - 152H^2$$
$$P_T = 28659 - 152H^2$$

$$M_T = P_T(H + L_3 + L_2 + L_1 - 10')$$
$$= P_T(H + 6.24 + 12 + 20 - 10)$$
$$= P_T(H + 28.24)$$

$$M_O = M_R - M_T$$
$$401869 + 28659H = 76H^3 - P_T H + P_T 28.24$$
$$401869 + 28659H = 76H^3 - (28659 - 152H^2)H + (28659 - 152H^2)28.24$$
$$H = \mathbf{5.5\ ft}$$

Total height = L1 + L2 + L3 + H
=20+12+6.24+5.5=43.74ft~**44ft**

$$P_T = 28659 - 152(5.5)^2 = 24061\ lbs = \mathbf{24k/ft}$$

These calculations indicate that the length of the shoring system only needs to be a total of 44 feet. Shaving almost 20 feet off the total length is a significant amount to the weight of the system, and decreasing crane size requirements as well as reducing installation time frames.

Using a structural software tool called Risa to find the maximum shear and moment, a factor of 1.64 per LRFD standards was multiplied to get the ultimate shear and moment on the member. Risa software results can be found in appendix B.1.

$M_a = 145.6 ft \cdot k$
$M_u = 1.64 M_a$
$M_u = 1.64(145.6) = \mathbf{239 ft \cdot k}$

$V_a = 14.2k$
$V_u = 1.64 V_a$
$V_u = 1.64(14.2) = \mathbf{23.3k}$

Sheet Pile Design Choice

Using the maximum bending moment, a suitable sheet pile was picked, seen below in figure 22. With grade 50 steel, the bending moment capacity is 259.6 ft·k and exceeds the ultimate moment of 239 ft·k. The perimeter of the shoring is 948 feet with 4 corners which means it only requires 4 bends in the system. More product data for this sheet pile can be found in appendix B.2.

Solution Estimate

SKZ 38

Skyline Steel

Z-Sheet Pile	
name	SKZ 38
units	400
height	44.00 ft
weight per ft	88.95 lb/ft
total weight	782.747 short tons

Summary	
wall height	44.00 ft
target wall length	948.00 ft
actual wall length	950.00 ft
panel quantity	400
pieces to install	400
WADIT® sealant	17,600.00 ft
choose WADIT® sealant	
wall area	41,800.00 ft^2
panel weight	88.95 lb/ft
weight per ft^2	37.45 lb/ft^2
section modulus	62.32 in^3/ft
moment of inertia	560.85 in^4/ft
total weight	782.747 short tons

Figure 22: Sheet Pile Specifications[5]

Slurry Wall Design

A design for the slurry wall can use the maximum shear and moment value from the previous calculations, shown below. Checks for bearing, overturning and sliding are all taken care of in previous calculations.

Assumptions	Value	Notes
h	24”	thickness
d_o	20”	
b	12”	Unit strip method
$f'c$	5000 psi	
Clear cover	3”	

$M_u = 1.64(145.6) = \mathbf{239 ft \cdot k}$ $V_u = 1.64(14.2) = \mathbf{23.3k}$

Calculate Shear on Wall

$\phi V_n = \phi 2\sqrt{f'c}bd$

$\phi V_n = .9 * 2\sqrt{5000}(12)(20)$

$\phi V_n = \mathbf{30.5k} > 23.3k \quad ok$✓

Calculate Moment on Wall

$$a = \frac{A_s * f_y}{.85 f'c\, b}$$

$$a = \frac{A_s * 60}{.85(5)(12)} = 1.18A_s$$

$$\phi M_n = \phi A_s f_y (d - \frac{a}{2})$$

$$239 = .9(A_s)(60)(20 - \frac{1.18A_s}{2})$$

$A_s = 2.90\ in^2$

Use (2 layers) #8 @6” -> $A_s = 3.14\ in^2$

New d = 24"-3"-1"-.5"=19.5”

Check Shear and Moment

$\phi V_n = \mathbf{29.8k} > 23.3k \quad ok$✓

$$\phi M_n = .9(3.14)(60)(19.5 - \frac{1.18 * (3.14)}{2})$$

$\phi M_n = 2992\ in \cdot k = \mathbf{249 ft \cdot k} > \mathbf{239 ft \cdot k} \quad ok$✓

Check Steel

$\beta = .85 - .05(f'c - 4) = .85 - .05(5 - 4) = .80$

$c = \frac{a}{\beta} = \frac{3.71}{.8} = 4.63$

$\varepsilon = \frac{.003}{c}(d - c)$

$\varepsilon = \frac{.003}{4.63}(19.5 - 4.63) = \mathbf{.0096 > .005 \dashrightarrow \phi = 0.9}$

Horizontal Reinforcement

$\rho = \frac{A_s}{bd}$

$A_s = \rho bd = .002(12)(12) = .288$

A_s = (2 layers) #4@12"=.40in^2

A_s = .40>.288 ok✓

Vertical Reinforcement

As seen above:

A_s = (2 layers) #8@6"= 3.14 in^2

$\rho = \frac{A_s}{bd}$

$\rho = \frac{3.14}{(12)(19.5)}$

$= .013 > .0033$ ok✔

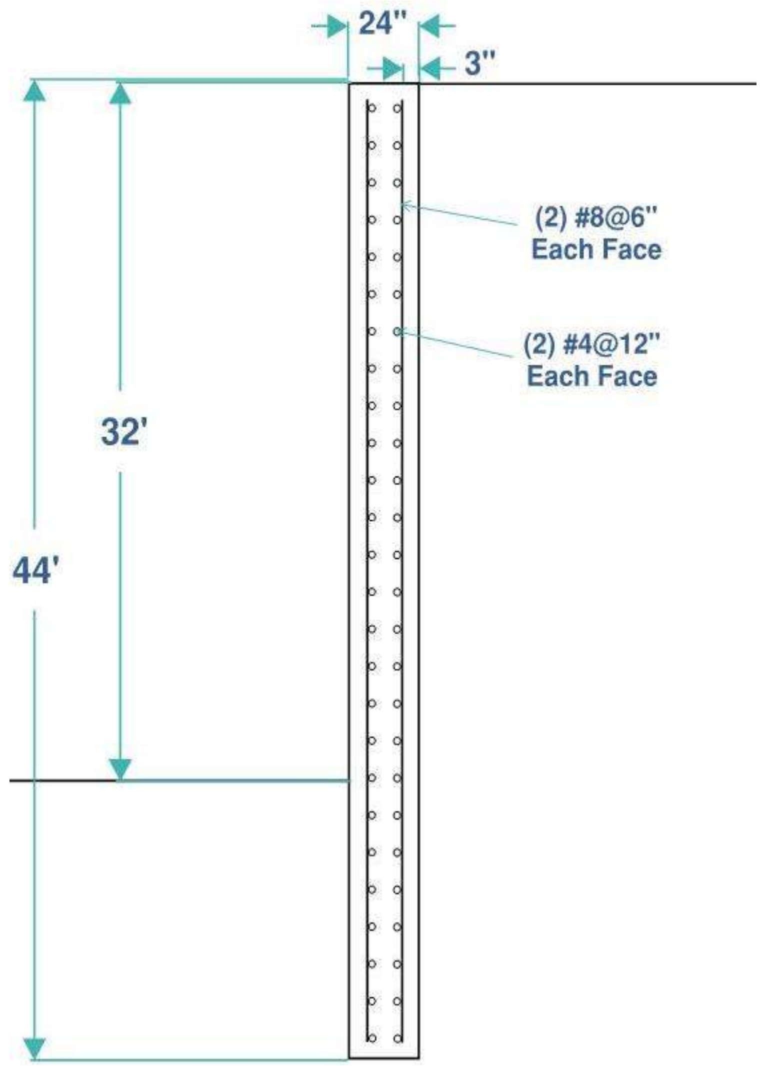


Figure 23: Slurry Wall Detail

Comparison of Three Systems

Looking at all three systems together, the most appropriate system for this application will be decided based on the cost, schedule, availability and constructability of the system.

Availability

The current shoring contractor is capable of installing a pile and lagging system as well as sheet piles, but they do not have experience in slurry walls. This means a slurry wall design would require a different installation contractor. There are at least 3 alternative contractors found with offices within an hour of the site that are capable of installing slurry walls, shown in the figure below.

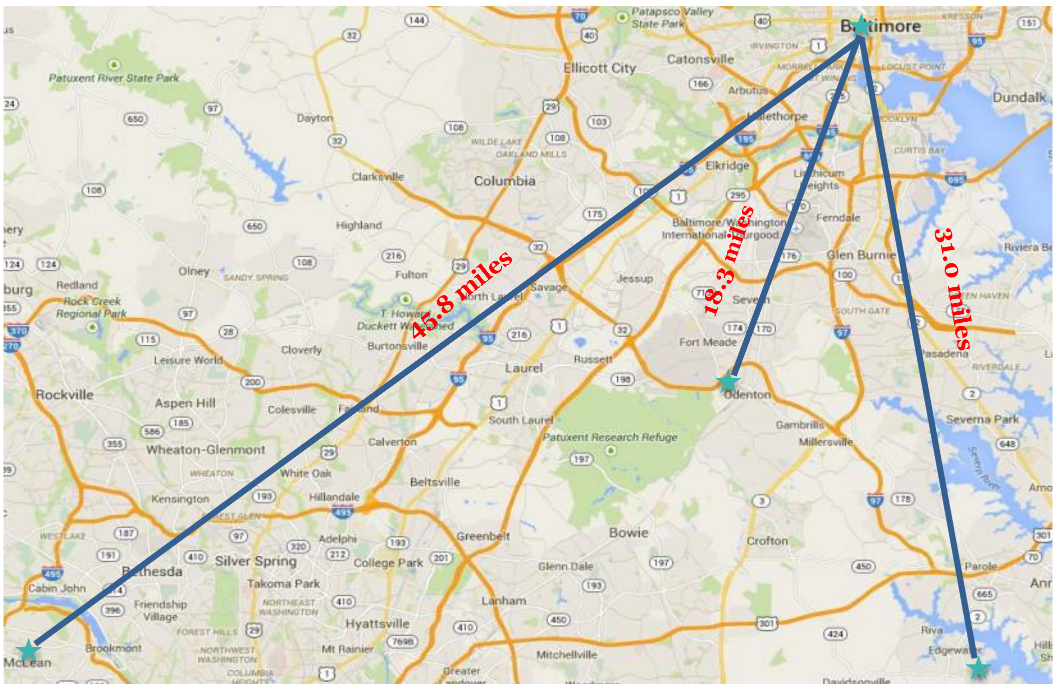


Figure 24: Alternative Shoring Contractor Locations[6]

Potential limitations for the sheet pile installation include the 8 week lead time for the specified product. Luckily, the overall depth of the pile is shorter than the length of a truck bed, which allows for the piles to be easily transported to the site. One location for the manufacturer specified is in Springfield, Virginia, just over an hour away from the job site. This means the specified product is well within driving distance to acquire and install.

Some factors to consider for the slurry wall system are the location of the slurry batch plant and the availability of trenching equipment for the slurry wall. Many projects have a place on site to mix the bentonite slurry mix with the existing soil. This allows for easy reuse of the slurry as the trenching progresses through the site. The size of the batch plant is based on the size of the slurry wall and the speed of installation. There must be enough slurry mix to keep up with the excavation on the leading end of the wall while also waiting for the concrete to be poured on the other end. For HSFIII, there is not enough room on site to keep a slurry plant during installation, so a suitable place near the site is required. This will also create price increases in transportation of materials from the batch plant to the site. Figure 25 shows the limited space on site and the lighter green square is the excavation footprint where the shoring wall surrounds. The east side of the site is inaccessible due to the grade difference from the site fence to the edge of excavation, and the south west corner is used for mobile cranes, material laydown, site trailers and traffic on site.

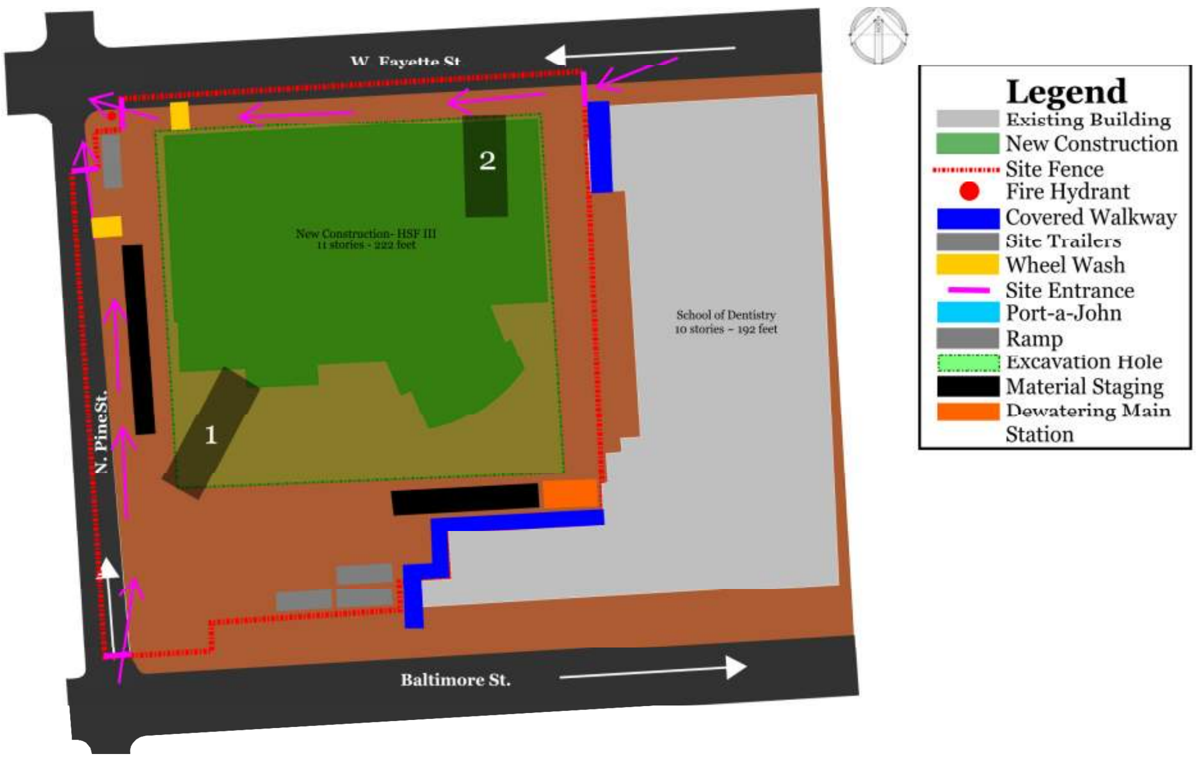


Figure 25: Site Logistics of HSFIII

Constructability

Looking at the constructability of the pile and lagging, the excess water coming into the site compromised the soil in the shafts and the integrity of the lagging boards. Many shafts were replaced with concrete or soil and boards covered with bracing to prevent a blowout. Complications arise when the soil is too hard and cause difficulties in pile driving. Also, the piles should be within driving tolerances.

Sheet pile construction is much like pile and lagging. The sheet pile driving has similar tolerances and limitations to H piles. Two main areas to look at the constructability are the interlocking of the piles and the corners. The method of driving piles into the soil can greatly affect the connection between piles. Too much friction at the interlock of the two piles can cause the two to fuse together. This sometimes happens when the pile is driven with the socket end leading. When the socket end leads, the socket becomes filled with soil and requires the ball joint to force out the extra soil, causing excessive friction on the members. Also, pile caps should be used to reduce warping of the top of the pile and to help the pile to remain straight as it is driven. Finally, the angle in which a pile is driven can affect adjacent piles, so piles driven in at an angle should be corrected immediately. At the corners, there are many types of sheet piles interlocking designs to allow for a change in direction. The final two corners where the driving starts and ends are crucial to meet and cause a tight connection to prevent water from entering the site.

Slurry walls have many more stages throughout the process that need to be monitored compared to the other two systems. First, trenching equipment needs adequate space to excavate the trench, specifically in the corners where the trench changes direction. This is problematic on the site of HSFIII. Second, the slurry mix should be monitored so it is sufficient according to the design specifications. It is important to keep the integrity of the walls to install the rebar cage, remove and slurry and place the concrete. Concrete mixes shall be tested also according to design specifications. Overall, the offsite slurry batch plant and space requirement for a slurry wall does not make this a feasible option from a constructability standpoint.

Cost

As mentioned before, the original pile and lagging price plus the delays to the project amount to $2,130,000. The list below shows the cost comparison between the three systems. The sheet pile and slurry wall cost data came from RS Means 2015. A detailed breakout of the pricing can be found in appendix B.3.

Pile and Lagging	$2,130,000
Sheet Piles	$1,640,040
Slurry Wall	$3,029,810

Without the dewatering issues, pile and lagging would be the cheapest option for HSFIII; however, the other two options are designed to better contain or keep out fluids, reducing the risk of leakage found on the site. Both the sheet piles and slurry wall include a mobilization cost, but the slurry wall mobilization is much higher and more elaborate than the sheet piles. One source found estimated a conservative mobilization and demobilization cost at 5% of the total price, which can be found in the current slurry pricing. As mentioned earlier, these prices do not include excavation of the hole, which was an entirely different contractor on this project.

For the slurry wall pricing, a range of values were investigated from different sources, but most of them only included the materials and did not include equipment, labor and mobilization. This is also true of the early production rates discovered. One source used in this report was a case study in California that happened to be about an average of all the other prices investigated. A comparison of the RS Means values for the slurry wall helps understand where this source falls in pricing. Concerning the sheet piles, RS means helped with the bulk of the pricing and other sources were used for the tiebacks as well as mobilization costs.

Schedule

Using both production information from RS Means as well as contractor pricing, the following durations helped compare the three systems, seen in figure 26.

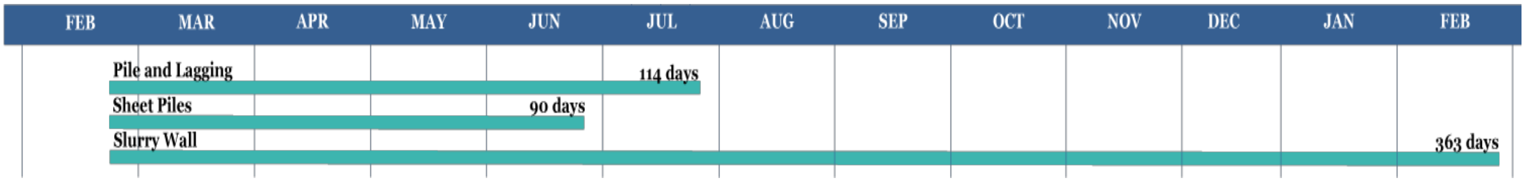


Figure 26: Schedule Matrix

It is obvious that the slurry wall takes the most time to install because there are inherently more steps than the other system options. Slurry walls require digging the trench, placing the slurry, inserting the rebar cage, and then simultaneously pouring the concrete while pumping out the slurry. This requires more equipment such as a clam and shell bucket for excavation, a crane for the rebar cage, a pump for both the slurry and concrete, and a station for the slurry to mix while it is not being used. Compared to the other options of piles that only require pile driving equipment, this is much more extensive and takes longer to install.

If the pile and lagging was not delayed, it would also be an optimal solution, but again the sheet piles takes the gold in its efficiency and ability to keep water out in areas with a high water table. The pile and lagging is technically not complete until the excavation finishes because the lagging boards are installed as the excavators dig deeper into the hole while the sheet piles do not have this restriction, so they should be inherently faster than the pile and lagging system.

Recommendations

The table below outlines the performance of each shoring system and clearly shows that sheet piles is the recommended system to use for HSFIII. Because the pile and lagging was unable to keep the water at bay, it does not receive a check mark in the constructability category. Although there are contractors available to install the slurry wall, it is the most expensive system as well as takes significantly longer than other systems to install, making it the least optimal system to use for HSFIII. The sheet piles satisfy all of the needs of this project, making it the optimal solution.

	Pile and Lagging	**Sheet Piles**	**Slurry Wall**
Availability	✓	✓	✓
Constructability		✓	
Cost	✓	✓	
Schedule	✓	✓	

With sheet piles as the optimum choice, this system would only cost $1,640,040 to install and would take about 90 days. This is not only 24 days faster than the pile and lagging system, but would also cost about $490,000 less than the pile and lagging.

Analysis 2: Motivation and Team Performance

Problem Identification

Motivation is crucial to the overall performance and lifestyle of an individual in all facets of life. This critical industry research will investigate the drivers that motivate individuals and how this affects construction projects.

Background Research

At the PACE roundtable, the most interesting topics were related to innovative design and incentivizing team performance. The first breakout session was about innovative design. The discussion took a different direction than was originally anticipated: it was focused more on how innovation is born and the drivers behind innovation. The second breakout session discussed many types of incentives that contribute to team performance. Among those listed included organizational culture, peer pressure, recognition, personal price and potential for repeat work. Motivations to perform work differ between people, which allow for various methods to have different degrees of success on projects.

These two topics are closely related to how motivation drives performance and innovation. The research topic that sounds the most intriguing to pursue is identifying intrinsic motivators and how they relate to team performance. The construction industry is saturated with challenges and a variety of individuals from the tradesman level up through the owner. They all play a large role in the overall success of the project. Problems arise when the challenges start to negatively affect the performance on the project. This research is intended to outline the drivers of motivation on project and how that correlates to team performance.

Analysis Goals

The major goals of this research fall under two categories: discovering what motivates people to work and how it correlates to team performance. There are several variables that revolve around understanding how people are motivated to work. The audience of this research area will be primarily construction management companies. This is intended to narrow the scope and find consistencies among the research with one specific group within the construction process. A survey will be the main source of information from industry professionals to gather statistically relevant data and better understand how people are currently motivated to perform work. From there, literature review on ways to motivate people to perform work will help understand how motivation relates to team performance. These two avenues of research will help discover the following analysis goals:

1. Evaluate the main drivers of motivation.
2. Investigate the correlation between different drivers of motivation.
3. Identify if there is a relationship between motivation and team performance.
4. Evaluate the effects of negative motivation on a project.
5. Study previous research in the area of motivation and team performance.
6. Compare this research to construction practices and drivers of motivation.

Execution

As mentioned above, the two avenues of this research include literature review and a survey analysis. These are intended to help connect research done in the field of motivation to construction practices to better understand project motivators.

Literature Review

From the seminal research of *Maslow on the Hierarchy of Needs* to the new research findings of What Millennials Want from Work, these four literature reviews give an overview of motivation to understand what motivation is and how this can be applied to construction.

Maslow's Hierarchy of Needs[1]

Abraham Maslow's theory on motivation and the hierarchy of needs has been widely used in the areas of higher education and management training. He suggests five levels of needs that build on each other (seen in figure 27). This means that one level of need must be satisfied in order to advance up the pyramid of needs. He also mentions that the lowest four levels of needs must be met to be satisfied as an individual; meaning if one or more elements were missing it would cause unrest and anxiety. Below is an explanation of each level of need with a relevant example to how these needs can be satisfied.

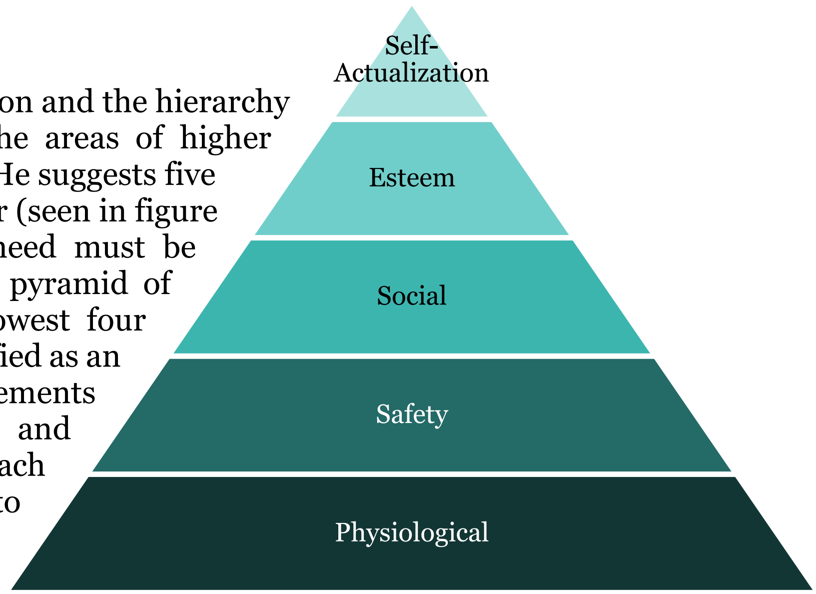


Figure 27: Maslow's Hierarchy of Needs

- *Physiological Needs* relate to basic needs of survival like food, water and shelter. These items provide nourishment to the body and protection from the elements.
- *Safety Needs* refer to areas like finances, health, freedom from fear and others. They provide security and comfort to the individual.
- *Social Needs* stem from the branches of emotions and relationships. It encompasses all types of relationships from work to intimacy and gives the person a sense of belonging.
- *Esteem Needs* focus more on the events and accomplishments of an individual that promote feelings of respect and self-achievement.
- *Self-actualization* is the highest need on the list and is not required for satisfaction; rather it represents the full potential of an individual and the process toward realizing this potential.

The highest level, self-actualization, is dependent on the person, but it is a need that signifies growth in an individual[2]. It may materialize in different ways, like an engineer desiring to invent a life changing device or musician composing a masterpiece. For Maslow, the main purpose is to climb the ladder and reach the self-actualization phase of life.

This relates to motivation because different individuals on a project will be motivated by a variety of factors depending on what level of the pyramid they identify with. The levels are not indicative in the sense that it can predict one's motivation to work to satisfy multiple needs, or have different motivations to satisfy the same need, this structure from Maslow simply helps with a basic understanding of the overall satisfaction of an individual and how it relates to motivation.

Frederick Herzberg- Theory of Motivation[3]

Similarly, Herzberg recommended a two-needs system to successfully promote satisfaction in the workplace. These two are Hygiene Factors and Motivators, as listed below:

Hygiene Factors

- Company Policy
- Supervision
- Relationship with Boss
- Work Conditions
- Salary
- Relationship with Peers

Motivators

- Achievement
- Recognition
- The work itself
- Responsibility
- Advancement
- Growth

While the facilitation of all hygiene factors does not guarantee a cohesive workplace, one or more elements left unfulfilled might cause dysfunction. These, as described by Herzberg, are more important than the motivators because they accomplish the basic physiological needs of the individual. Motivators focus more on the growth and personal development. They will nurture a positive work environment when fulfilled, but they are not primary reasons for dysfunction when unfulfilled.

Compared to Maslow's hierarchy of needs, the hygiene factors relate to the lower four levels of needs while the motivators fall under the self-actualization category. Herzberg weights the categories much differently than Maslow but the ideology behind dissatisfaction if one of more of the elements is not present remain consistent between both theories. Maslow connects motivators to general needs within society while Herzberg specifically mentions motivators within the workplace that could cause dissatisfaction.

One thing that Herzberg concludes from his research on satisfaction is the idea of job enrichment. The company should be providing opportunities and responsibilities that match the employee's full abilities for maximum satisfaction from the employee. Dissatisfaction arises when a person is performing a majority of tasks well below their ability level. This dissatisfaction can lead to a serious problem in motivation because they do not feel adequately challenged in their job.

What Millennials Want from Work, Charted Across the World[4]

A recent study conducted last summer focused on the millennial generation from age 18 to 30 and aimed to understand the goals of the millennial generation and how that is shaped by culture around the world. As the future leaders in construction, this is a pivotal study that is planned to continue annually to understand trends in different cultures. Although it is not focused on construction, this information can easily be translated to the construction millennials. This analysis will focus on the data taken from North America and what that means for motivation in construction. The two sections below are only pieces of this vast study that applies to this research on motivation.

Importance of Leadership and Drivers to Become Leaders

Understanding why millennials want to work will help a team customize the goals of the group to hopefully maximize the motivation of the group. Over 70% of millennials from North America said it was important for them to become leaders, but their reasoning compared to the world was shockingly diverse. According to figure 28, the most important driving factor toward becoming a leader is for the opportunity to influence a company or organization. While this is the highest reason from the pool of participants, other reasons still had high responses. This is potentially a good question to ask on a team to best align the goals of the project to the team or personal goals.

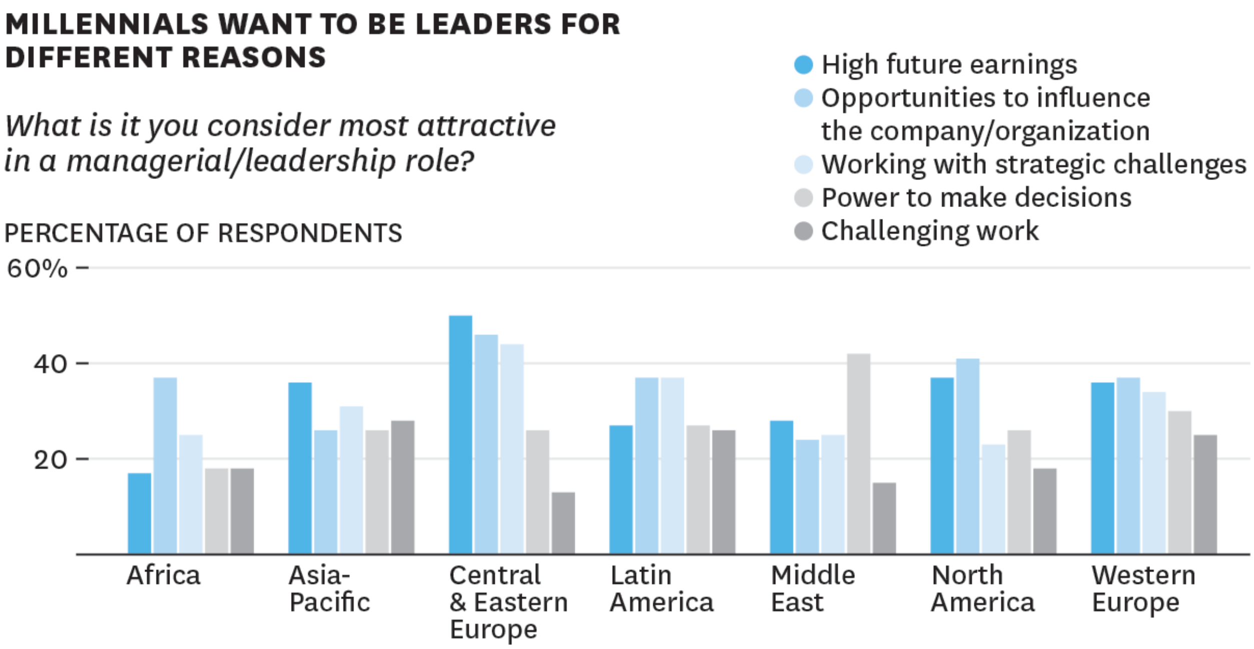


Figure 28: Reasons behind becoming a leader[4]

How Millennials Want to Be Managed

If the majority of millennials are striving to become leaders, then their idea of good management is closely related to their ability to perform and satisfaction in the job. For North America, almost 50% of participants indicated that the most important trait in a manager would be to empower their employees. Universum made a point to note that "Millennials responding to the survey seem to connect the term empowerment with the ability to make independent decisions and chart their own course (based on additional interviews conducted to probe deeper into this topic). This suggests empowerment is less about being empowered in day-to-day work life, and more about having personal freedom and autonomy." Two other ways millennials want in their managers is for them to be experts in their technical field as well as role models to the millennials.

Clear expectations in what millennials want in their leadership can drive decisions in the team goals and approach on the project. This is helpful for managers to use a leadership style that best fits the team and to increase team cohesiveness. Some of the research found in the survey isolates the millennial generation and compares its tendencies to older generations which is an important distinction to understand how the trends and drivers of motivation change with age. Construction is no exception to working in teams and having supervisors that delegate work to their employees, and are historically known to work more than a 40 hour work week; this is what makes this data extremely useful to see the future of a company and how to address the needs of the younger generation.

The Five Dysfunctions of a Team[5]

One of the participants in the open ended survey mentioned the book The Five Dysfunctions of a Team by Patrick Lencioni. When investigating the drivers behind motivation and in what way it correlates to team performance, this is a great resource that outlines five interconnected areas limiting the success of a team. These are as follows:

- *Absence of trust*—unwilling to be vulnerable within the group
- *Fear of conflict*—seeking artificial harmony over constructive passionate debate
- *Lack of commitment*—feigning buy-in for group decision creates ambiguity throughout the organization
- *Avoidance of accountability*—ducking the responsibility to call peers on counterproductive behavior which sets low standards
- *Inattention to results*—focusing on personal success, status and ego before team success[6]

Patrick makes a point to emphasize that these five reasons are not independent from one another. Rather, they build on each other and the absence of one of these characteristics causes a detrimental domino effect of the other characteristics. Figure 29 shows how these traits start from the foundation of trust all the way up to the attention to results. Much like the visual for Maslow's hierarchy of needs, this is an easy way to emphasize that these needs or elements of team cohesiveness are not independent.

Figure 29: 5 Dysfunctions of a Team

Concerning construction managers, this team dysfunction is easily relatable. One of the more obvious roadblocks in the success of a construction project is the lack of trust among the involved parties. When an owner does not trust a construction manager, there is constant tension related to keeping the project on schedule and within budget. A lack of trust easily waterfalls into conflict, causes the team commitment to falter and so forth. When this happens, morale on the team plummets and production on the project visibly reduces. Becoming aware of the importance of trust to the success of the project across all professions is crucial to the satisfaction of the project quality.

Survey Results

The survey prepared was sent to construction managers in the industry and included a mix of open ended responses and Likert scale questions. From a pool of 30 participants, the responses came from a range of experience in the industry as well as varied levels of education. Also, six of the responses came from women, representing 20% of the data. A copy of the survey and the responses can be found in appendix C.1.

Multiple Choice Questions

The likert scale questions had a list of drivers of motivations where participants ranked on a 1 to 5 scale how much they agreed with the reason. The main question asked in the survey was "to what degree does each of these items motivate you" and included the following options:

- A respectable leader
- Formal recognition
- Promotional opportunities
- Time off
- A challenging project
- Money
- A complex project
- Negative consequences
- Team reputation
- Negative feedback
- An unmotivated team leader

The subjects could rank according to the scale of:

Not at All	Very Little	Somewhat	Significantly	Very Significantly

There were a few more questions related to motivation and its connection to team performance. They are included in the correlation analyses. For clarification, the likert scale questions concerning belief in the cause means that the subject feels motivated when they can stand behind the mission of the project, and the team means the subject feels motivated by their team. With a data set of 30 individuals, a correlation analysis used the average of each question to see what drivers were negatively or positively correlated to each other. The correlation between questions can be seen in appendix C.2.

Correlation between Drivers of Motivation

The data shows the top 5 positively correlated drivers in table 4. This means that if a subject considers a complex project to be of greater significance as a driver to motivation, they are more likely to think the same thing of a challenging project. Similarly, if they think that a complex project is little to no significance on a project, they tend to think the same of a challenging project.

Table 4: Positively Correlated Drivers of Motivation

Driver #1	Driver #2	Degree of Correlation
A complex project	A challenging project	.70
When believe in the cause	The team	.58
The team	Motivated leader influences team performance	.54
Formal recognition	Promotional opportunities	.51
Promotional opportunities	Time off	.45

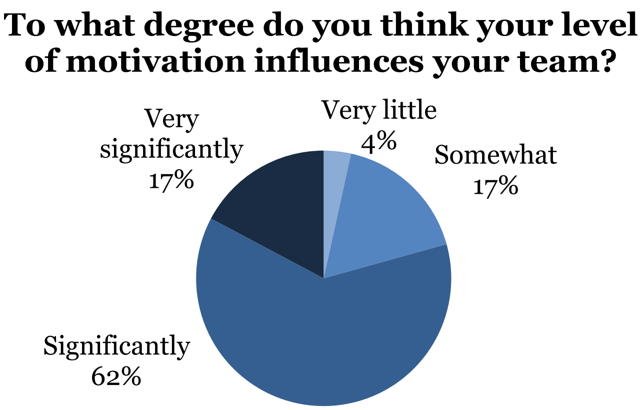
The second highest correlation from this date is between feeling motivated when the subject believes in the cause and by their team. This positive correlation would make sense if teams were put together based on not only their strengths, but their passion to work on specific projects. Thirdly, the participants responded positively toward feeling both motivated by their team as well if a motivated leader influences team performance.

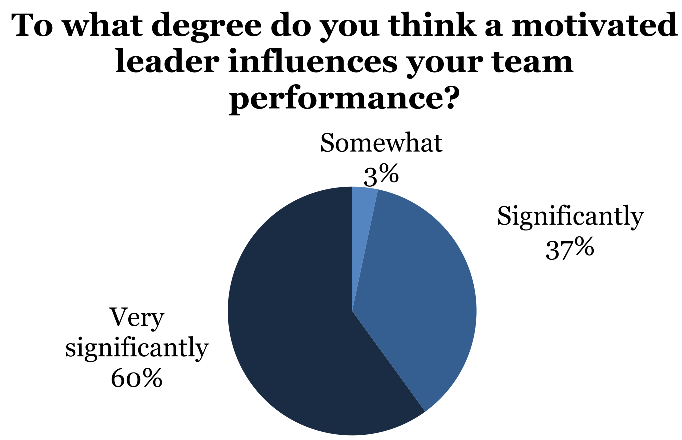
The top 5 negatively correlated drivers are shown in table 5. Money and the questions related to team performance showed up the most in the top selections from this data. This means that if the subjects said that money was less significant as a driver of motivation, then their opinion toward how much motivation relates to team performance was high. Because money is a major part of a construction project, the reasoning why money motivates could definitely be a contributor to this correlation. For example, if money motivates an individual for personal gain, than they would care less about how to motivate the team to perform better.

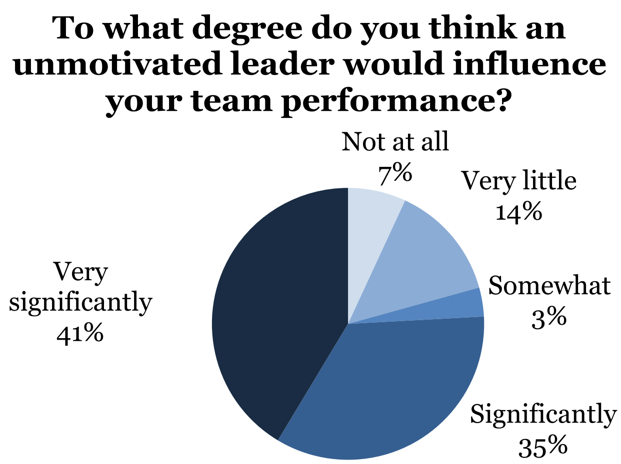
Table 5: Negatively Correlated Drivers of Motivation

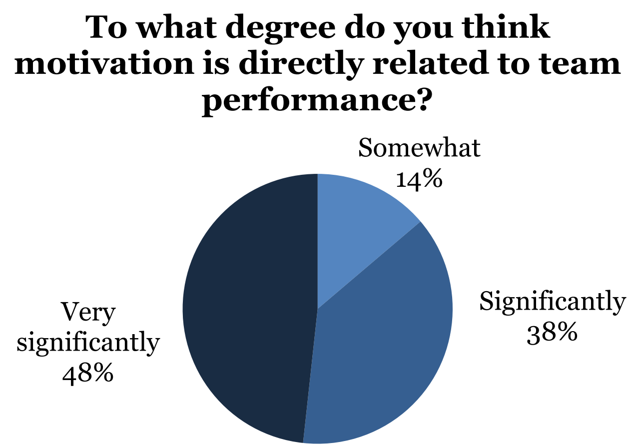
Driver #1	Driver #2	Degree of Correlation
Money	Degree motivation related to team performance	-.44
A complex project	Motivated leader influences team performance	-.43
Money	Assuming a leadership position	-.40
A complex project	Unmotivated leader influences team performance	-.39
Money	Motivated leaders influences team performance	-.38

Relationship between Motivation and Team Performance
A few questions asked about the relation between motivation and team performance. These were more qualitative questions related to participant's perception on the relationship between the two. The four main questions were as follows with their corresponding graphs below:









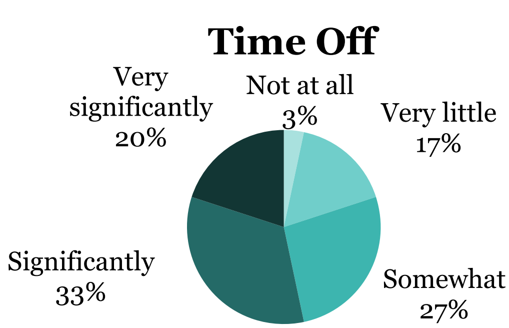
The only question that the participants varied in their opinion was the question on the bottom left chart related to how much an unmotivated leader would influence team performance. This is different than the other questions that had strong opinions on how much motivation and team performance correlated. The data shows the wide scope of how something negative, like lack of motivation from a leader, does not negatively affect everyone. Some people may be able to perform their jobs independent of this leadership while others may have more trouble functioning. Tasks that require multiple participants to complete might have more trouble if their leader is unmotivated. It is common on construction projects to require information and collaboration among multiple parties, and without clear direction, the end goal can be adversely affected.

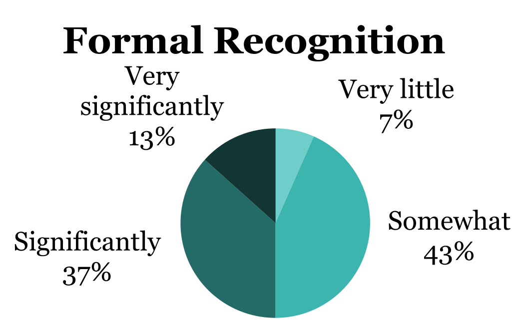
Degree of Significance for each Driver of Motivation
In conjunction with the correlation analysis from the drivers of motivation, the responses were ranked to see how significant or insignificant they perceived a specific driver to be. This ranking is shown below in table 6. The percent significant includes both people that responded very significant and significant while the percent insignificant includes those that responded very little to not at all on the likert scale. It is not surprising that these two tables are opposite of one another; the only factor that would change this data around is the percentage of participants who responded 'somewhat' to any question because that is not represented in this table.

Table 6: Drivers of motivation and their levels of significance

Driver	% Significant	Driver	% Insignificant
Believe in Cause	100	Unmotivated Team Member	60
Respectable Leader	97	Negative Consequences	43
A Challenging Project	83	Negative Feedback	27
Team reputation	80	Time Off	20
Assuming Leadership Position	77	Formal Recognition	7
A Complex Project	73	Promotional Opportunities	7
The Team	63	Team Reputation	7
Promotional Opportunities	60	Money	3
Money	57	A Complex Project	3
Time Off	53	The Team	3
Formal Recognition	50	Respectable Leader	0
Negative Consequences	37	A Challenging Project	0
Negative Feedback	27	Assuming Leadership Position	0
Unmotivated Team Member	10	Believe in Cause	0

Not unlike the question related to how an unmotivated leader affects team performance, respondents answered that over 60% of individuals thought an unmotivated team member motivates them very little or not at all. This is due to the teamwork heavy nature of construction. There is only a small level of autonomy



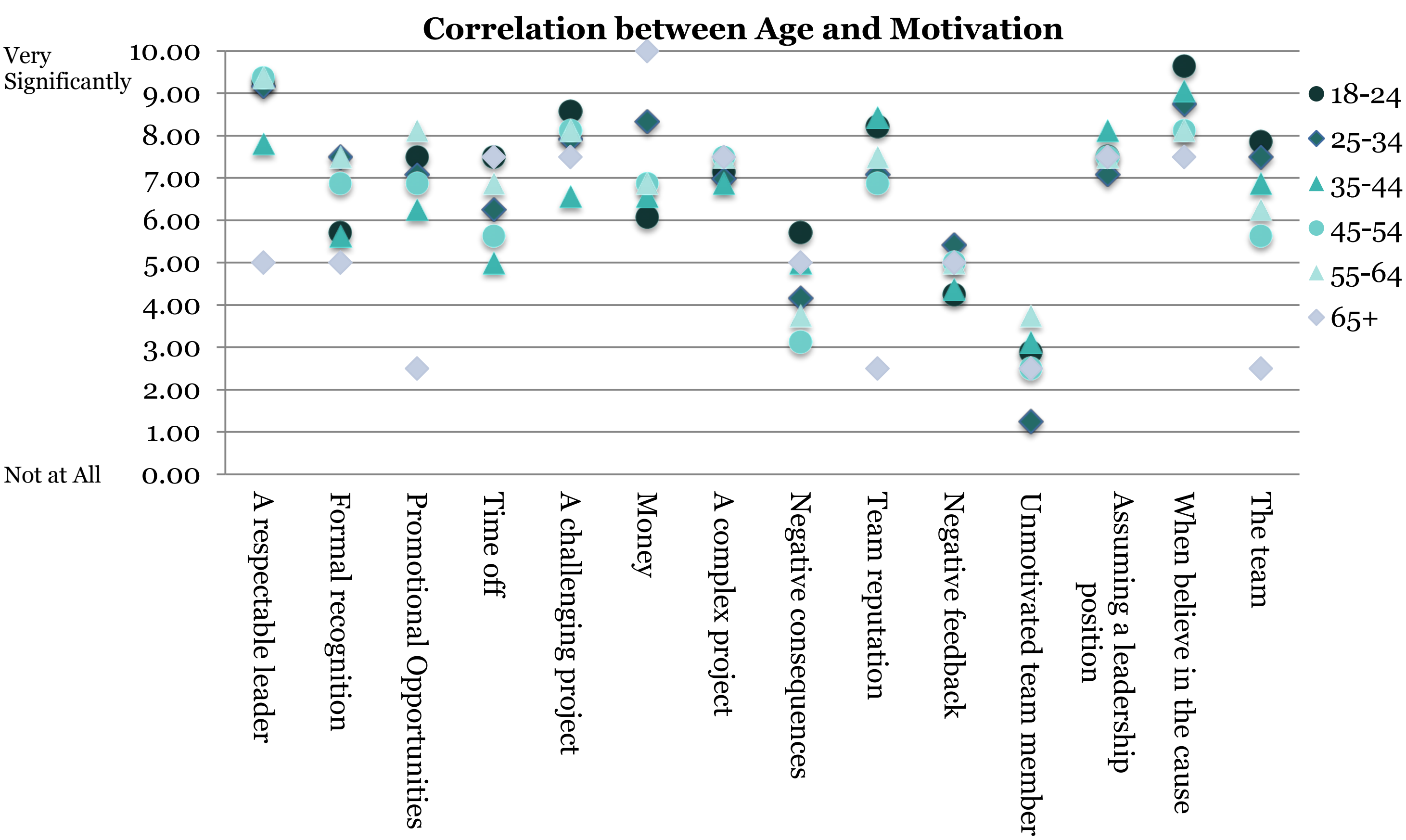


because many challenges and problems require multiple to participate in. Not surprisingly, subjects were less likely to be motivated by negative experiences like feedback and consequences. Some of the questions such as formal recognition and time off had a larger degrees of influence on the subject's motivation, seen in the graphs below.

Correlation between Age and Motivation

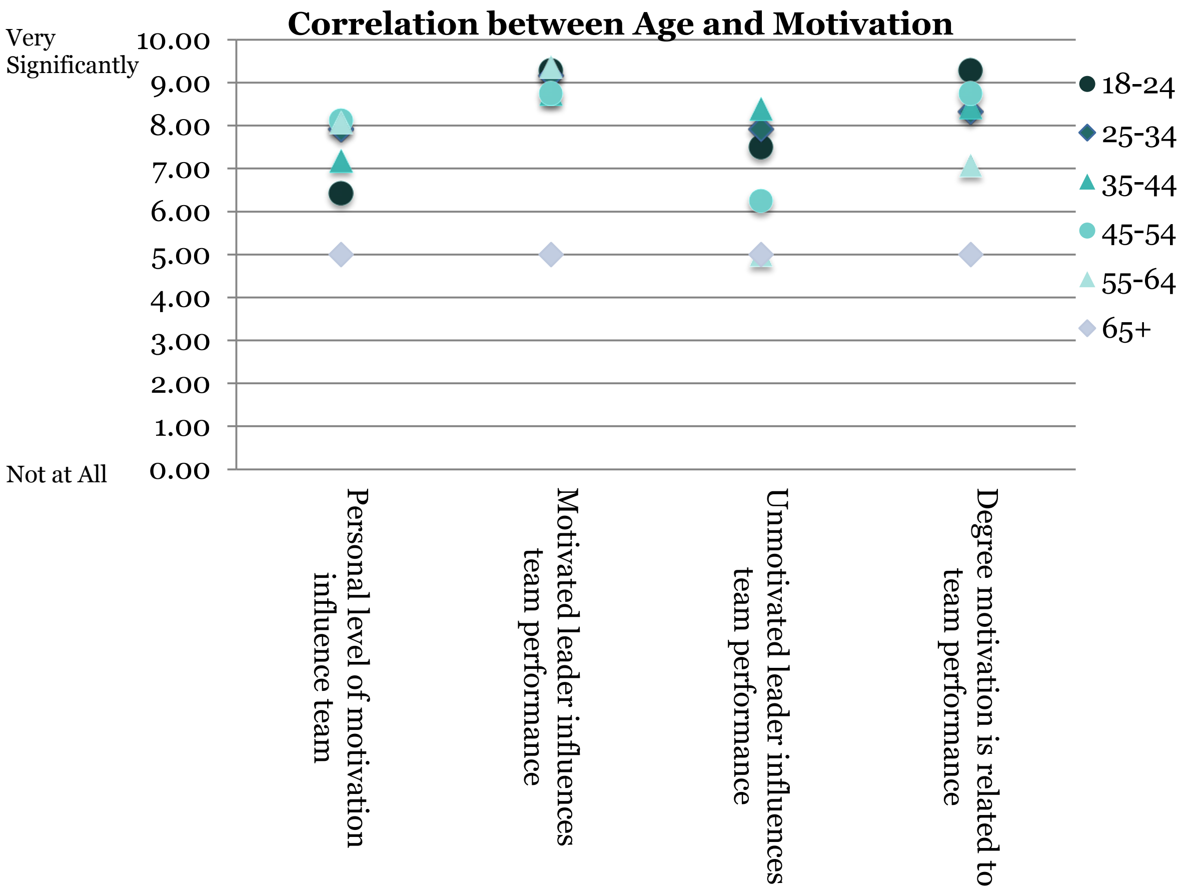
Another analysis done with this survey was to see if age affected how significantly the participant's felt motivated. The table on the right shows the number of responses per age group from the thirty participants. The age group least represented is 65+, so this data in the graph below is slightly skewed based on one response. The written responses were turned into numerical values, seen on the left of the graph. Then an average for each age group was calculated and plotted against the other age groups. The lighter colors on the chart indicate an increase in age.

Age Range	# Responses
18-24	7
25-34	6
35-44	8
45-54	4
55-64	4
65+	1



These questions above relate to the drivers of motivation. One of the more obvious drivers of motivation that changes with age is the how much the team affects personal motivation as seen in the last question on the right. This may potentially be the case because employees that are younger and with less experience rely on the team more for wisdom and direction while more seasoned members of the team have a better understanding of their roles and are more autonomous. Two drivers that seem to have little impact with age is a complex project and assuming a leadership position. The subjects generally ranked these two items in the significant (7.5) range, meaning they find these two to be significant in their personal motivation on a job, but the opinion does not seem to change with age. One of the questions that was across the board depending on age is formal recognition. This implies that not only is the driver of formal recognition not affected by age, but people have varying opinions on how much that personally motivates them.

The next questions below follow the same format as the graph above, but these questions relate to team performance. Based on this information, it looks like the degree that a motivated team leader affects team performance does not vary significantly with age, but the degree motivation is related to team performance does.



Its level of influence decreases as age or experience increases.

The survey included not only likert style questions, but a series of open ended questions as well. This was intended to better understand the reasoning why participants ranked the drivers or questions about team performance a certain way. The next section of this report gives an overview of those responses.

Open Ended Questions

The most fruitful information from this survey was the open-ended questions. They ranged from asking about personal experiences of motivated or unmotivated teams to what the most effective way to motivate the team is. This report walks through those questions and comments on their responses.

What type of project did you work on that particularly motivated you?
There was a wide interpretation of this question from naming specific types of projects to the type of people that were the most motivating. People felt most motivated by leadership, a motivated owner, a challenging project, responsibility, or a team desire to deliver a quality product. As seen in other questions, these reasons continued throughout the responses. This question prompted answers highly related to specific people on the project, including the owner, the team and the contractors; even those responses that named specific projects were more related to repeat work through a specific owner.

What type of project were you on that you did not feel motivated to work? Explain what did not work.
While some people may be motivated by strict deadlines or challenging projects, the interpretation of the word challenging greatly changes the perspective of motivation. If the participant saw challenging as an ability to use problem solving skills with the team to improve the quality of the project, then they felt more motivated. If different teams or people on the project proved to be challenging or difficult to work with, then their idea of motivation decreased. This is seen through this question where multiple subjects explained situations involving people that caused them to not feel motivated to work. Some of those responses included answers such as a specific unmotivated leader, negative relations to an owner, lack of trust between multiple parties. Many responses mentioned the importance of a leader and how their attitude greatly affects motivation. Animosity, disrespect, negative critique, and a lack of acknowledgement of work all contributed to the participants' loss of motivation.

What do you think is the most effective way to motivate your team?
The most common answer to this question was communication. Some answers layered communication with other responses, but it was clear that many individuals found this to be the most important way to motivate the team. Good communication is the backbone that makes the other reasons to motivate the team effective. Other reasons included respect, positive reinforcement, clear goals, working hard, accountability and leading by example. A few people also mentioned including the team to solve problems and being part of the solution. These forms of motivation seem to break down when there is a miscommunication somewhere in the chain.

What do you think is the least effective way to motivate your team?
These responses were similarly aligned to the question that asked about an experience where the participant did not feel motivated. Many of the same answers such as disrespect, criticism, negative feedback, unprofessional actions and a lack of

communication came up in this section. While the last question like this one prompted answers that focused more on the team and the project, this one elicited answers much more focused on specific individuals on a team such as the manager. Some of these individual focused answers include poor incentives, not recognizing unique strengths in people, poor conflict management, laziness and a negative attitude.

What makes an effective/efficient team?
This is the first question where trust was mentioned among one of the reasons behind an effective or efficient team. There was also an emphasis on work-life balance as well as identifying and building on the strengths of individual team members. Some of the same answers such as clear goals, communication and accountability also popped up in these answers. This is also an area where personal motivation was mentioned to making an effective team.

Do you think team or personal motivation affects overall job quality? Explain.
There was a resounding yes to this question. This shows the significance on how much motivation relates to job satisfaction and the overall quality of a product. One participant specifically mentioned that "Construction is a people business. Unmotivated people do a poor job and this affects quality." A few mentioned that personal motivation has a higher effect on job quality than team motivation.

How does conflict affect motivation or team performance?
Compared to the last question, this response had varied results. Although there was a heavy emphasis that conflict has a negative effect on motivation, a few participants actually felt more motivated to resolve the conflict. One response specifically clarified that constructive conflict is a good thing on a project, but when this spirals out of control it reduces team performance. Another mentioned that conflict is healthy and helps team members "get aligned when working together to develop the most effect solution. There are two parts to this question. Based on the responses here, one could argue that conflict overall slows team performance because it detracts from the normal tasks at hand, but it varies on how it affects the motivation of the team members. This might be due to how they personally feel motivated or handle different types of conflict.

Would you consider yourself client driven, cost driven, team driven, or other?
The purpose of this question was to see if there was an array of answers among construction managers and whether they prioritized different aspects of construction. The majority of the answers actually discussed the significance of having a balance of all three drivers and a few people mentioned other drivers such as time or personal reasoning.

It is evident through the participant's responses that leadership style is essential to the level of motivation of the team. Not only is it the responsibility of the construction manager to lead the efforts in conflict management between different parties on the project, but the project managers also have a responsibility to effectively manage their team and motivate them to work. A better understanding of how their team is personally motivated will help maximize their potential and build them up as an individual.

Without quantifying the degree in which motivation relates to team performance, these responses indicate that a correlation exists between the two. There were multiple instances in which participants explained a perceived lower performance on a project from a mismanagement of conflict or an inability for leaders to communicate their goals clearly.

Participants mentioned several items correlative to the literature reviews. For example, the Five Dysfunctions of a Team were saturated in the individual responses. This shows a strong correlation between the importance of building trust and communication within a team to improve the success of a team. Also, Frederick Herzberg's motivational factors of achievement, recognition, the work itself, responsibility, advancement and growth were mentioned at least once in all of the questions asked in the survey. There is definite correlation between Frederick's study and the responses from construction managers.

Recommendations

Also this research is more qualitative, some conclusions based on the survey can be drawn. First, the survey participants most strongly agreed with each other on their opinion of how much the two drivers of belief in the cause and a respectable leader affects motivation. They were much more varied on their opinion of negative motivators such as negative feedback or and unmotivated leader. Some drivers of motivation showed a correlation between age and their responses like how much the team affects personal motivation while others like assuming a leadership position did not have a correlation to age.

Based on the questions relating to team performance, there was a similar reaction among the participants of their strong agreement that a motivated leader affects team performance as well as a varied response on how much an unmotivated leader affects team performance. This shows that there is a correlation, but the extent of its correlation greatly depends on varied factors such as leadership style and satisfaction of employees.

The open ended responses greatly showed how much the literature review related to the participant's responses. Two of the most prominent responses revolved around trust and communication on a project and how much that greatly influences motivation and team performance. This directly correlates with the *5 Dysfunctions of a Team* research which states that the most important element in a team environment is trust and that trust is the foundation of success on a team.

Overall, it was found that not only is there was a correlation between motivation and team performance, but these drivers behind motivation can change with age, roles and responsibilities in life, and with the team dynamic. It is recommended to try and understand these motivators on a job to best craft the team's goals and responsibilities.

Analysis 3: Resource Leveling for Cash Flow

Problem Identification

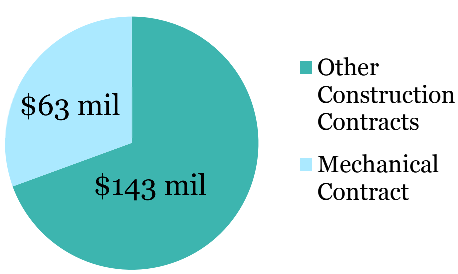
The construction portion of this project spans multiple years and with some state funding involved in the project and there are limitations concerning the amount of money awarded to the project per year. This analysis will look at the mechanical budget and investigate how much a manipulation of manpower affects the overall project schedule.

Background Research

Construction spans 50 months from July 2013 to September 2017, a lengthy project in which a project manager must manage cash flow. Because this building is a laboratory for the University of Maryland, Baltimore, state funding is heavily involved in the project budget. This limits the amount of funding awarded each year from the state. The table on the right shows this funding breakout based on the fiscal year from July to June. This limitation presents cash flow challengers with this project.

Fiscal Year	Funding (million)
FY 2014	$18
FY 2015	$59
FY 2016	$91.5
FY 2017	$53
FY 2018	$9.5
Total	$231

The total funding during this time period amounts to $231 million. With the construction budget at $206 million and the project total budget at $216 million, this means there is $15 million dollars from the state allocated elsewhere and are not within the scope of this analysis. This state funding restriction requires the project to carefully look at how cash is distributed throughout tendency of this project. To accommodate this cash flow limitation, the project team delayed some purchasing of major equipment as well as the start of interior work to push off major expenses into a fiscal year with more funding.



This analysis will look at the cash flow of the mechanical contractor due to their duration on site and contract size. An attempt to level out the manpower from the mechanical trade on the project will help create a steady flow of production and delay some funding to later fiscal years. The mechanical and plumbing contracts were awarded to the same contractor; combined, they amount to $63 million of the $206 million budget. As seen in the graph on the left, this is about 31% of the entire budget. As the largest trade contract on the project, the mechanical trade also spends the longest amount of time on site compared to other trades. Figure 30 shows the

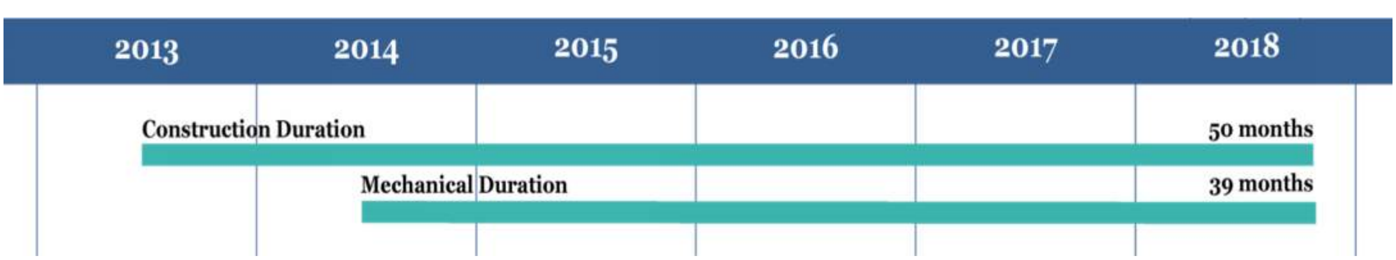


Figure 30: Construction Durations

overall time frame of the project and how long the mechanical contractor will remain on site. With this longevity on site, there is opportunity to manipulate the cash flow in the mechanical trade and make a large financial impact on the project.

Analysis Goals

With the project in a unique position of being not interested in accelerating the project schedule, the purpose of this analysis is to see how the manipulation of manpower on the project affects the mechanical schedule. Below is a list of goals for this analysis to better understand this situation.

- Research the funding on the project
- Understand the relationship between the current schedule and the monthly manpower allocation
- Review first assumptions with the mechanical contractor
- Manipulate the manpower for a more consistent number of crews across the length of the project
- Assess the schedule implications with this shift in manpower
- Assess the change in monthly billing due to this change
- Assess how this affects the critical path of the project

Ultimately, it is assumed that leveling the manpower will delay some of the floors, but hopefully it will not delay the entire project.

Execution

Based on the information from the original cost and schedule data provided by the project team, the cash flow was initially assessed to understand the mechanical billing on the project. From there, a preliminary man-loaded schedule helped illustrate how the monthly billing for labor related to the schedule of different mechanical and plumbing tasks. This original schedule was reviewed by the mechanical contractor and corrected with the most current information. The contractor corrected some outlier assumptions made in the first pass and added missing information into the schedule. Finally, this updated schedule was used to level the manpower curve and assess the impacts on both the mechanical and overall project schedules.

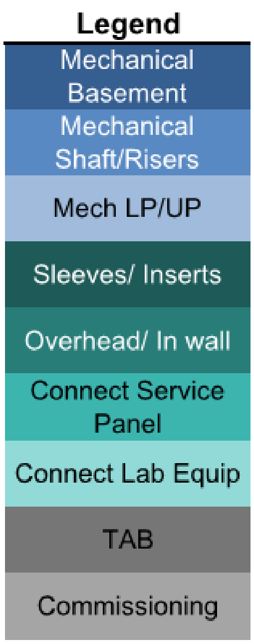


Figure 31: Schedule Legend

Study of Original Cash Flow

Using the original project schedule given at the beginning of the year, a high level mechanical schedule was created to understand the relationship between the cash flow and the schedule items. A Gantt chart style mechanical schedule for all iterations of this analysis can be found in appendix D.1 and a summary of major tasks is shown in figure 32 below. One important difference to distinguish is between repeatable tasks and non-repeatable tasks. For example, the basement and penthouse equipment is unique compared to the installation of ductwork on every floor. For the man-loaded schedule, it was important to include both types of tasks because of the crews allocated across all types of tasks in a given week. The color coordination in the schedule follows the same format as the man-loaded schedule. On the left, figure 31 shows the breakout of each major task on the project. The shades of blue tasks are unique to the space and the teal or gray indicate work that repeats throughout the building.

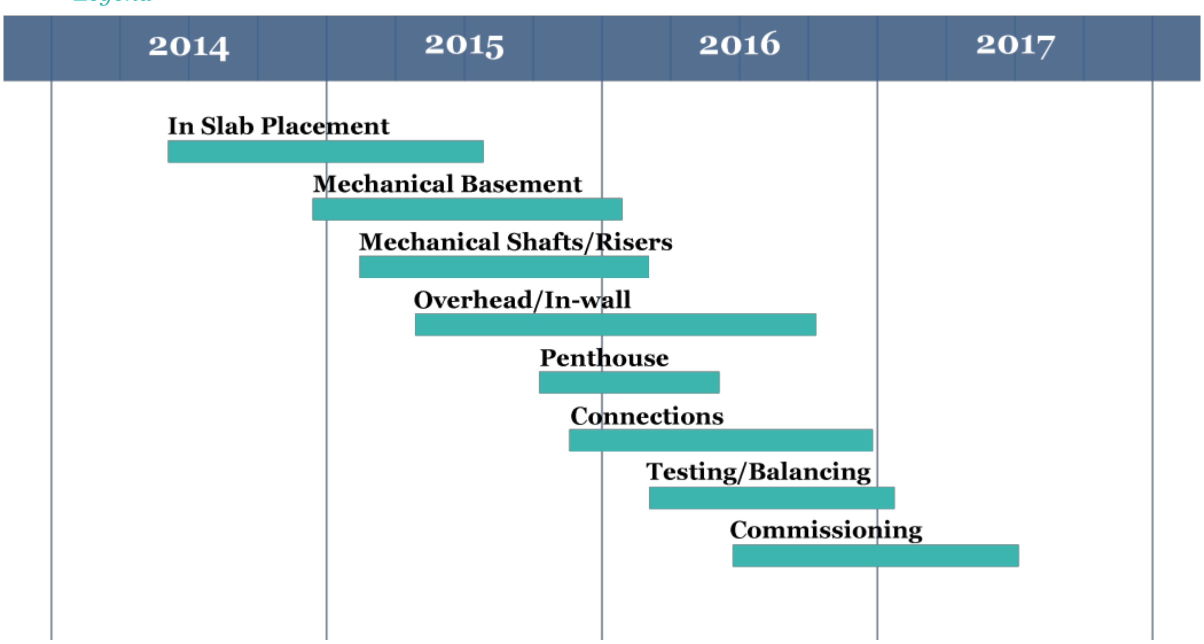
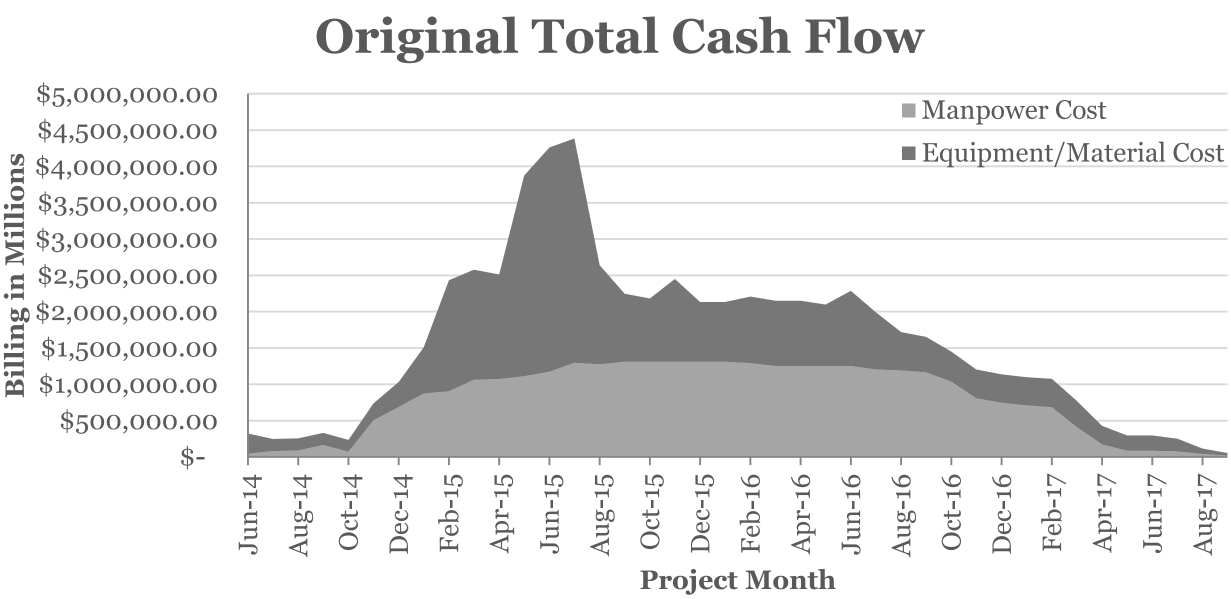


Figure 32: Mechanical Summary Schedule

Levels 5 and 6 are currently designed as core and shell spaces, so the duration for these floors is considerably shorter than the other floors. This is why the logic of starting a new floor every two months jumps from floor 4 to 7. As the mechanical work in the risers and the basement end, both floors 7 and 8 start at the same time; this is done in the same way for floors 9 and 10.

The first attempt to understand how the manpower is divided through the project closely aligned with the planned schedule of major activities. For example, it was noticed that from December 2014 to January 2015 there was the first jump in the number of crews on site. This directly correlates to the start of work in the basement. Also, the repeatable elements for the most part were able to have a consistent crew size per month, which also translated to each floor. There is a line item designated for miscellaneous crews. This pertains to work that is not indicated on the list such as utility work or performance mockups. With the projected monthly billing information, this was broken into two sections: labor and materials/equipment. This breakout identifies where the big equipment purchases occur and how that affects the monthly billing. With the labor billing as a separate item, the iterations identify how the manipulation of manpower changes the monthly billing. These findings are shown in the graph below.



The bulk of equipment purchases occur between fiscal years 2015 and 2016. This correlates to state funding of $59 million in FY2015 and $91.5 million in FY 2016. At that stage in construction, the mechanical trade is in the middle of work in the basement, mechanical shafts, first floor overhead and second floor overhead. With at least three months before the mechanical penthouse starts, this is an opportunity to purchase long lead items such as the air handling units and cooling towers located on the roof.

As mentioned previously, the information given on number of crews per month helped create a man-loaded schedule. A snapshot of this can be found in figure 33, while the entire schedule is located in appendix D.2. The line between the blue tasks and teal or gray tasks separate the unique work from the repeatable work on different floors. One important thing to note is that the number of crews only changes monthly to help with the simplicity of the exercise. For a smaller project size, it would be wiser to break out this work by week or even day. To read this table, 18 in the box under April-15 and the mechanical basement indicates that for the month of April 2015, there will be 18 crews working per day. Realistically, the number of crews from day to day will vary, but this average helps calculate a monthly estimate of work to bill to the owner.

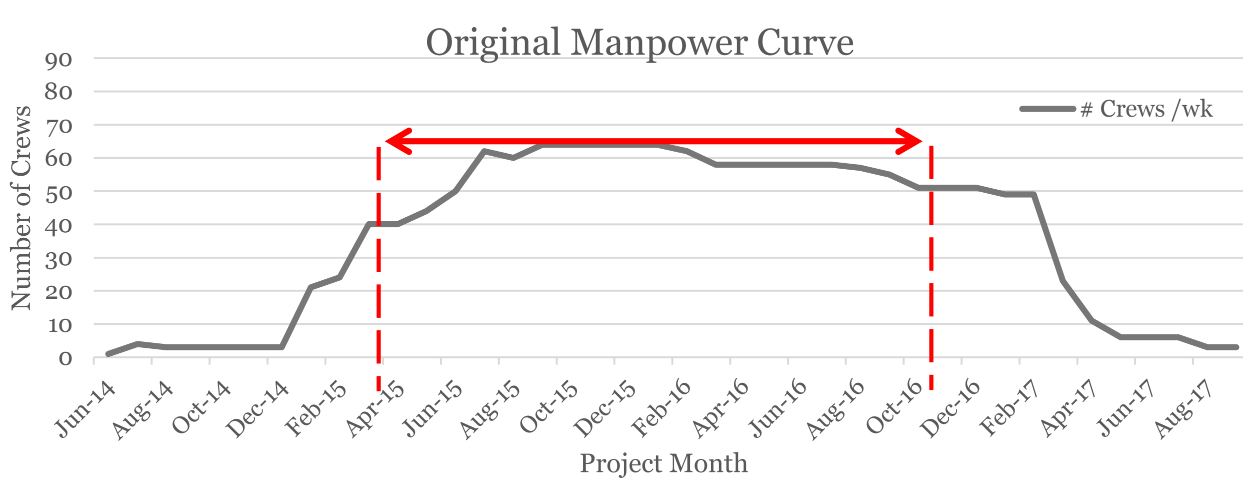
Legend

- Mechanical Basement
- Mechanical Shaft/Risers
- Mech LP/UP
- Sleeves/ Inserts
- Overhead/ In wall
- Connect Service Panel
- Connect Lab Equip
- TAB
- Commissioning

Original Man-Loaded Schedule	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16
Mechanical Basement	18	12	18	20	20	20	18	15												
Mechanical Shafts/Risers	19	19	19	19	19	19	19	19	19	19	19									
Mechanical Penthouse/Roof							7	7	15											
Basement																		10	10	
Level 1		10	10	10	10	10									5		10	10	10	
Level 2				10	11	10	10	10								5		10	10	10
Level 3						5	10	10	15	10						5	10	10	10	
Level 4								3	15	15	10	10						5	5	10
Level 5													10	5					6	10
Level 6														5	10					10
Level 7										10	10	10	10	10						5
Level 8	3									10	10	10	10	10						
Level 9		2										10	10	10	10	10	10			
Level 10		1										10	10	10	10	10	10			
Penthouse			3										4	4	9	9				
Roof				3									4	4	9	9				
Miscellaneous											13	8			5	10	17	10		6
Total Number of Crews	40	44	50	62	60	64	64	64	64	64	62	58	58	58	58	58	57	55	51	51
	40	44	50	62	60	64	64	64	64	64	62	58	58	58	58	58	57	55	51	51
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

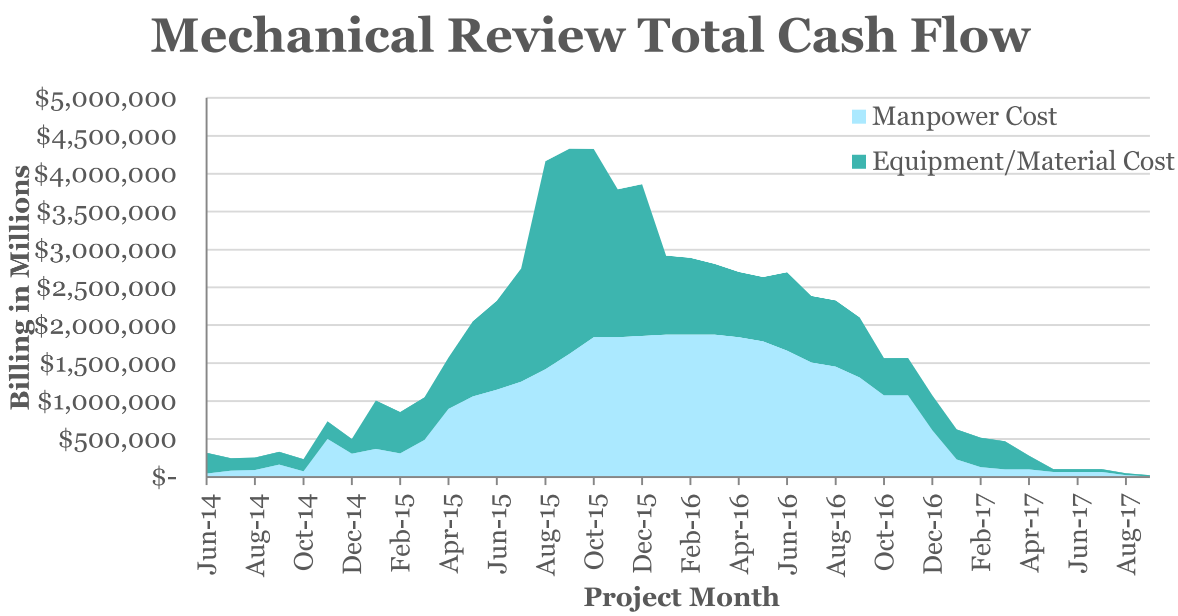
Figure 33: Snapshot of Original Man-loaded Schedule

At the bottom of the table, there is a line for the total number of crews. This is done by adding all of the crews in a given column. A crew size in this exercise is considered one laborer, whether a journeyman or apprentice. An average price per laborer is used for the monthly billing process. From there, the number of supervisors on site is dependent on the number of crews working. They are not counted for in the man-loaded schedule but they are included in the overall manpower price per month. Below is a graphical representation of the total number of crews per month. Highlighted is the focus time seen in the man-loaded schedule.

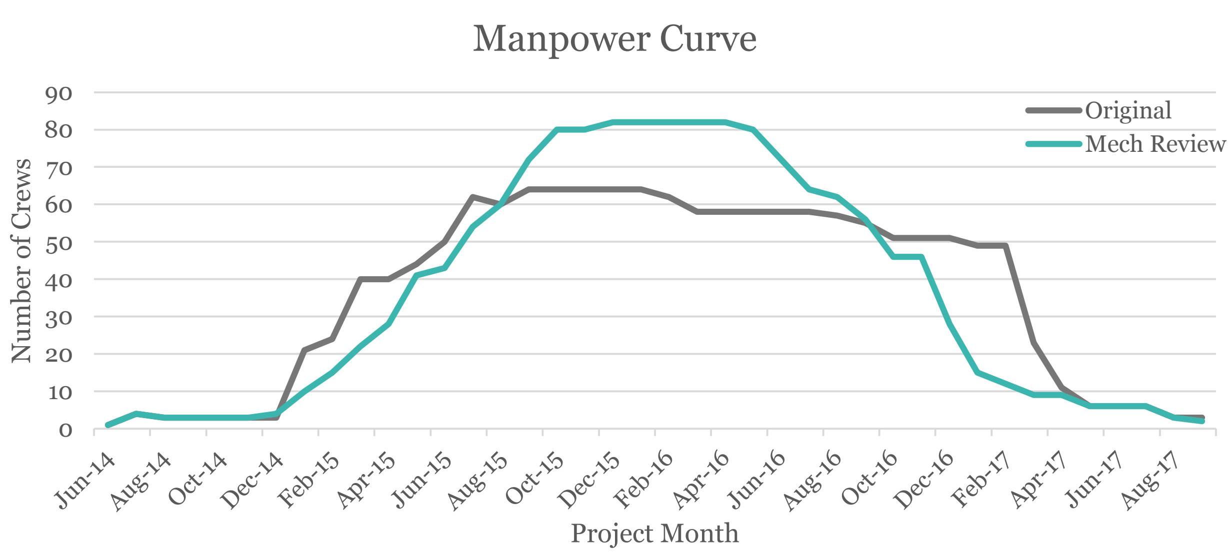


Mechanical Review of Cash Flow

This original man-loaded schedule was discussed with the mechanical contractor and the feedback given gave more accurate assumptions and billing information. After this meeting, the updated cash flow became the new baseline of information to manipulate and modify. In this new graph below, the manpower curve is noticeably larger. Also, the peak equipment billing occurs over a larger span of months rather than sharply dropping off after July 2015. The information given from the contractor also shows an increase in contract price from $63 million to $64.4 million. The reasoning behind this change in price is not necessary to understand to continue through this analysis, so a new baseline of $64.4 million was used in further modifications.



Peak manpower from the original assumptions to the schedule review grew from 64 crews to 82, seen in the teal line on the graph below. This is due to a more accurate analysis of the manpower demands on the project between the original receiving of information in August to this review in March.



The two figures below show the same schedule snapshot from April 2015 to November 2016 to emphasize minor changes made in the man-loaded schedule. For example, the original assumptions for overhead installation were shorter than the true project schedule. This longer duration accounts for plumbing tasks previously missed in the first pass at the schedule. Also, the work in the penthouse and roof is slated to last longer than anticipated. Finally, the crew sizes for the mechanical shafts and commissioning were inflated. This new man-loaded schedule looks much more repeatable and accurate. From here, the new baseline was used to modify the schedule and investigate how the leveling of manpower on a project affects the schedule.

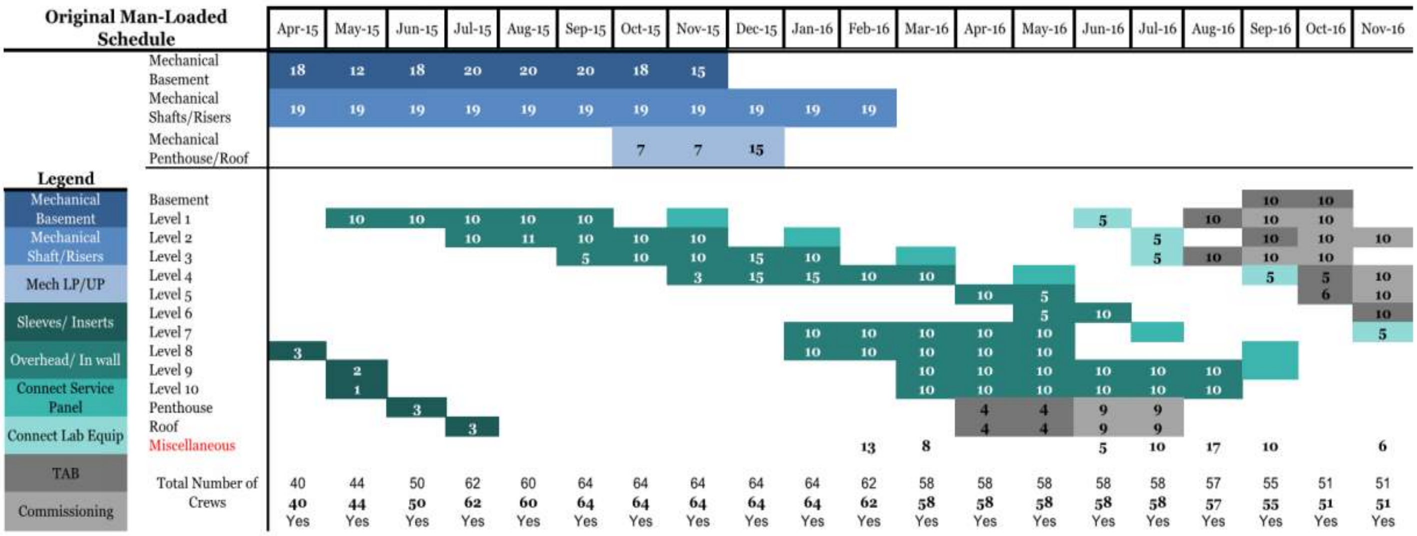


Figure 34: Snapshot of Original Man-Loaded Schedule

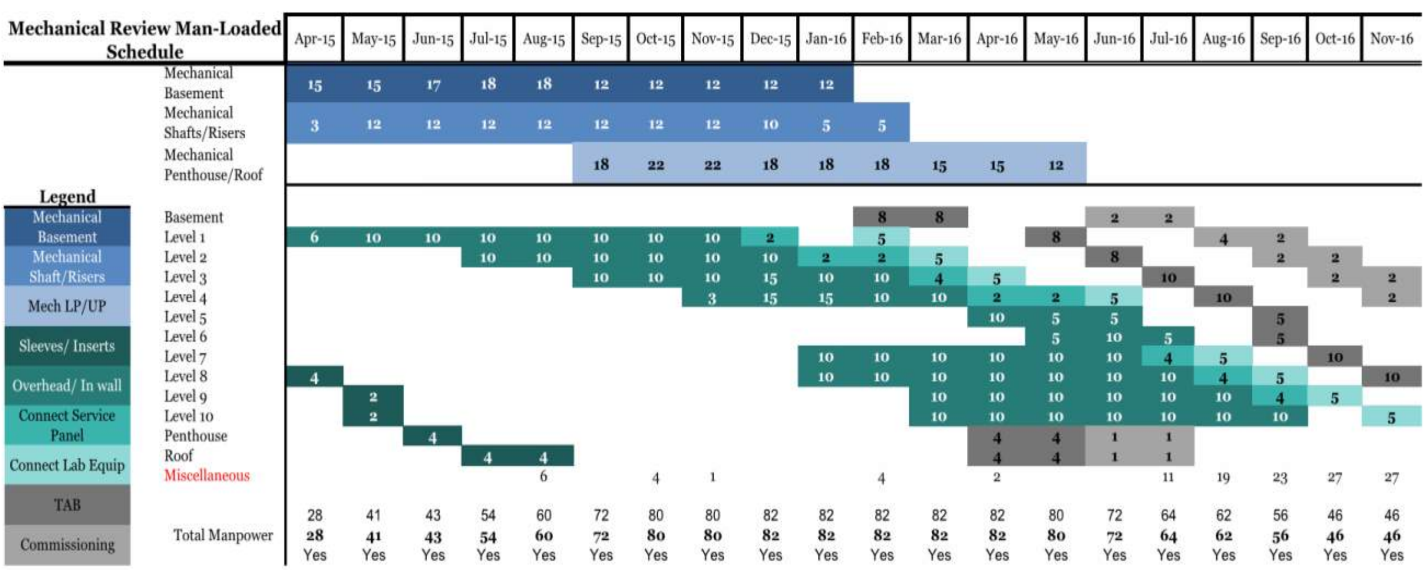
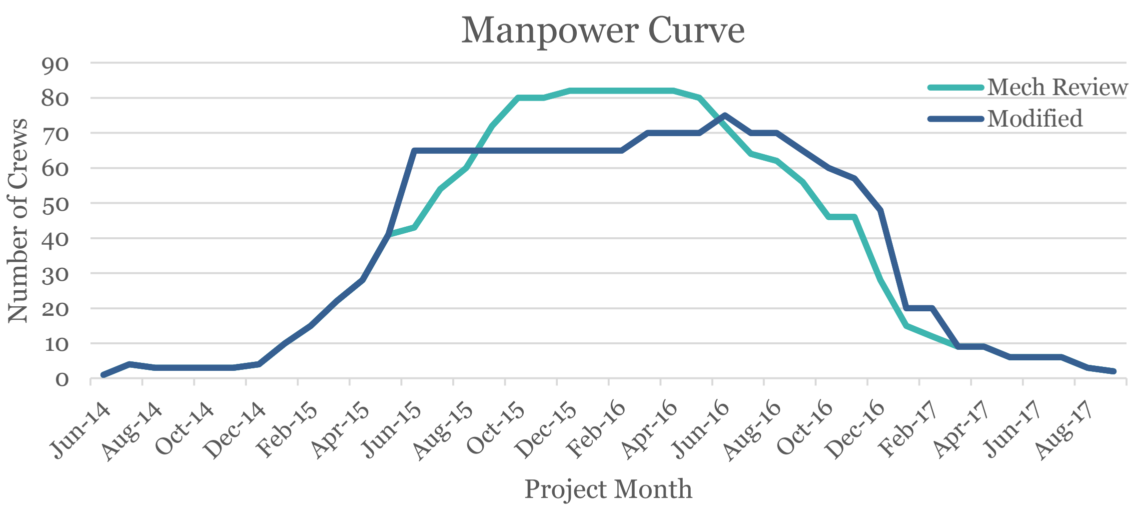


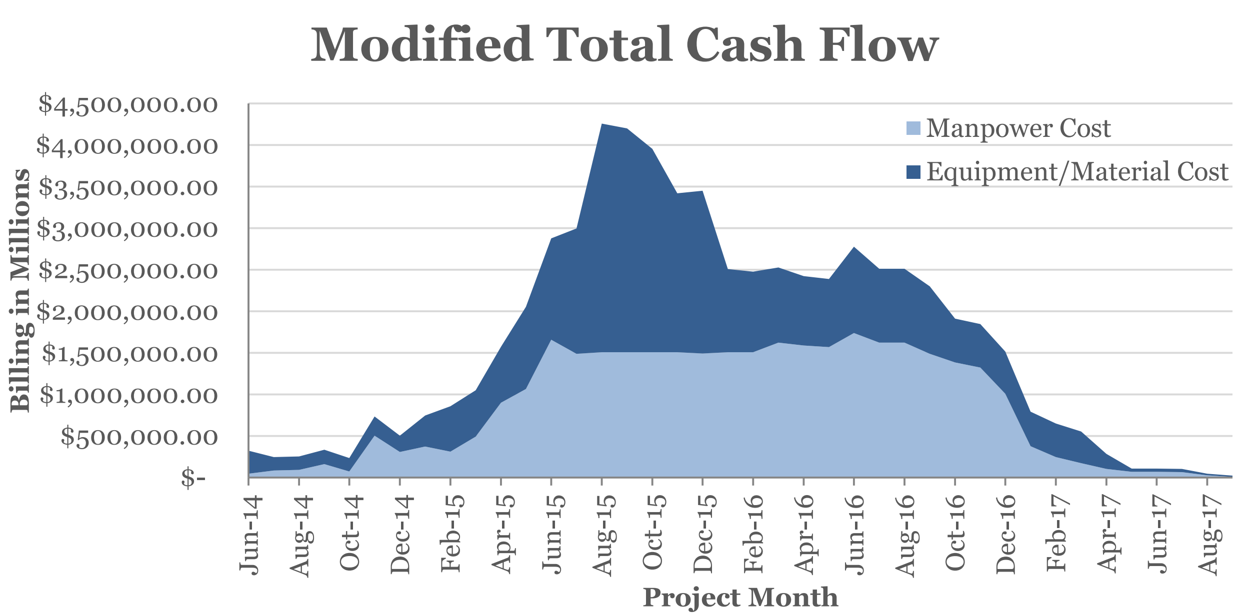
Figure 35: Snapshot of Mechanical Review Man-loaded Schedule

Modified Cash Flow

Armed with the new cost information, the man-loaded schedule was manipulated to show a more consistent crew size for more months. First, the total number of crews per month was adjusted, shown in the graph below. The peak manpower on the project reduced from 82 crews to 75; however, the months from June 2015 to February 2016 consistently have 65 crews per month. This adjusted crew distribution translates to the total monthly cost data in the second graph on the bottom of the page. It took several iterations to balance the total number of crews with a reasonable distribution of crews across different tasks per month.



In order to successfully level this manpower, it was assumed that a total number of crews across the job would stay the same no matter what month they landed because the scope of the job remained the same from the new baseline to the modified version. Once the total number of crews across the project was calculated, then they were divided up based on the goal of reducing the peak manpower and being aware of the schedule affects and major milestones on the project. The following graph translates this leveling information paired with the equipment and material monthly cost.



Looking at the critical path compared to this man-loaded schedule reviewed by the contractor, the mechanical items on the critical path include overhead installation for levels 7-9, all installation for level 10 and commissioning. Because of this, most of the commissioning crew sizes and durations were not moved. Also, the overhead/in wall line item in the man-loaded schedule includes tasks for both plumbing and mechanical. This means in order to meet the critical path on the project, those crew sizes for the mechanical overhead should stay the same while the other tasks in this line item such as in-wall rough-in for mechanical and plumbing should adjust accordingly. Figures 36 and 37 show the alterations from the new baseline to the modified schedule.

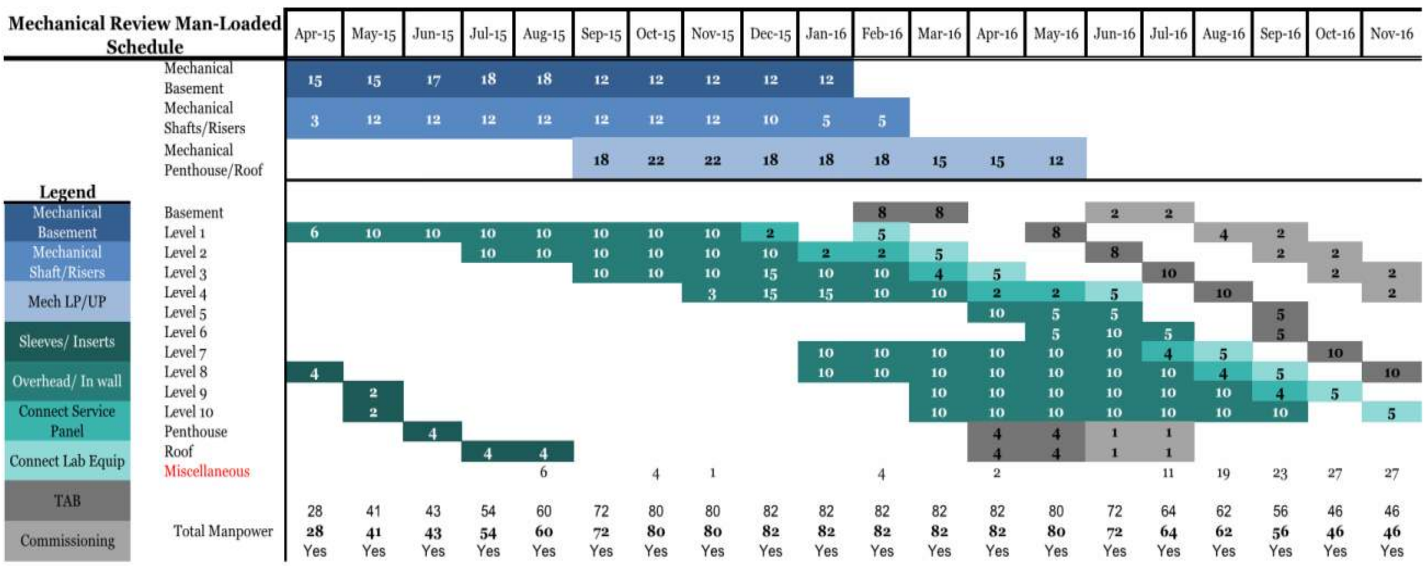


Figure 36: Snapshot of Mechanical Review Man-Loaded Schedule

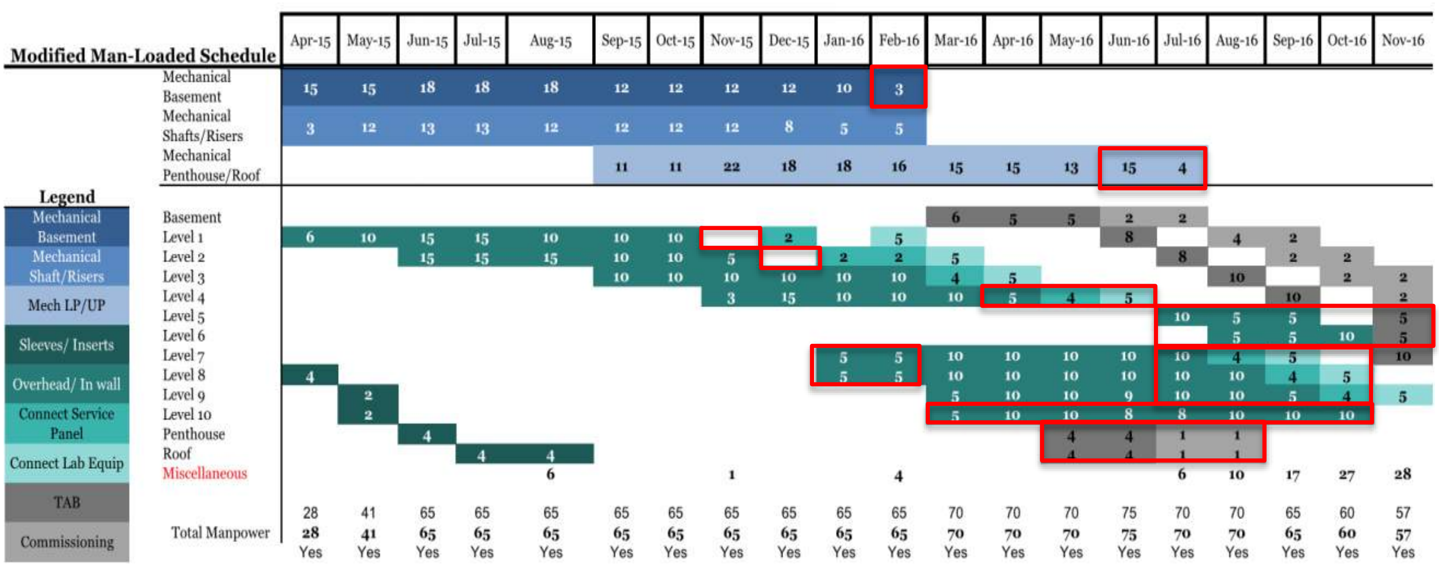


Figure 37: Snapshot of Modified Man-Loaded Schedule

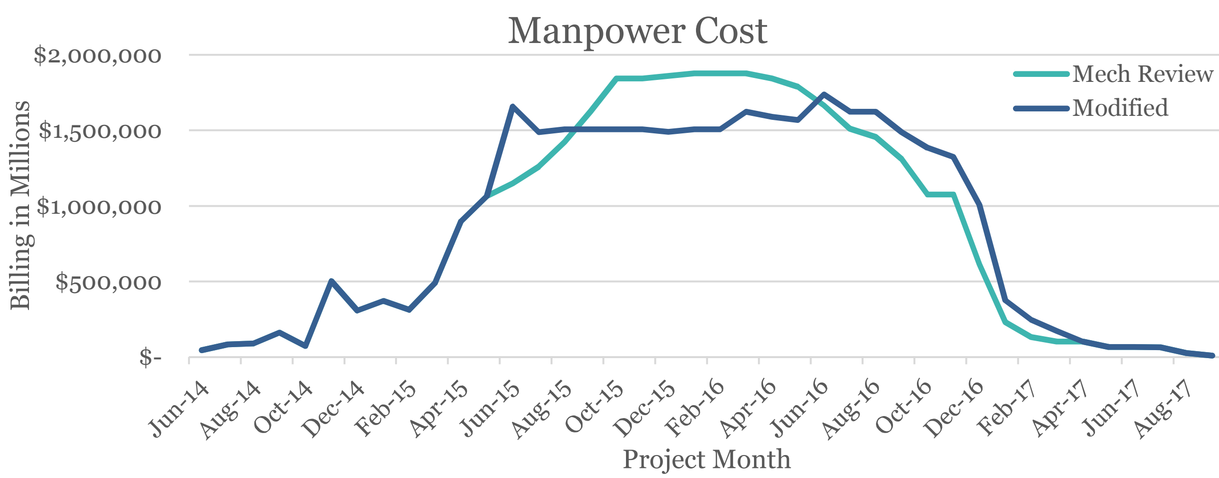
Shown in the snapshot on the previous page, testing and balancing for most of the floors were pushed back one month and the commissioning for the penthouse and roof was also delayed one month. The only main tasks following testing and balancing is punchlist items, building flushout and commissioning. There is 100 days for building flushout, giving some wiggle room for both testing and balancing as well as punchlist items. The work for levels 5 and 6 were delayed 3 months since they serve as core and shell spaces. Levels 7 through 10 extended one month in the overhead line item, pushing back the connections line items one month. Again, a Gantt chart of the original, mechanical review and modified versions of the mechanical schedule can be found in appendices D.1 and D.2.

Cumulatively, this manipulation of the manpower saved at most $400,000 per month in the months of December 2015-February 2016. This is a significant amount of money that can be used for things such as purchasing long lead items at critical times to keep the project moving. Below is table 7 describing the overall change per fiscal year and how that relates to funding on the project. A comparison of the manpower cost monthly is shown in the graph at the bottom of the page.

Table 7: Fiscal Cost Comparison

Fiscal Year	Funding	Mechanical Review Billing	Modified Billing	Difference from Baseline
FY 2014	$18,000,000	$ 321,700	$321,700	--
FY 2015	$59,000,000	$10,910,600	$11,463,500	$552,900
FY 2016	$91,500,000	$39,874,100	$37,377,100	($2,497,000)
FY 2017	$53,000,000	$13,141,800	$15,086,200	$1,944,500
FY 2018	$9,500,000	$173,900	$174,000	$100

There is a variance of about $500 between the reviewed and modified total project price; this is from rounding in the labor excel file used to move around the manpower crews and determine monthly billings. Fiscal year 2016 is where the majority of the savings is realized. This is also the source of the most funding in a fiscal year for the project. Over an entire year, this is a significant amount of money that could be allocated to other equipment purchases or to start other trades sooner on the project like the exterior façade. If the building becomes dried in faster, the interior work could start earlier and at a more constant pace throughout the building. This money saved in fiscal year 2016 amounts to 4% of the total mechanical contract of $64.4 million.



Recommendations

This exercise of manipulating the manpower in hopes of transferring cost into other fiscal years was valuable because it helped define how much a reduction of manpower affects not only the mechanical trade itself but other trades that depend on the completion of mechanical work as well. Based on moving solely manpower, this project transferred almost $2.5 million dollars out of fiscal year 2016 where the most funding as well as the most work is happening. This comes at the risk of delaying the top floors from 7 to 10 an entire month as well as delaying testing and balancing one month. Although there is some buffer room in the building flushout phase of the project, it is a risk to delay this work and sandwich other phases on the critical path. If the situation on this project required more money in fiscal year 2016, Because this project planned on delaying the interior work one month, they could use this new manpower schedule and start the interior trades at the original intended start date without detrimentally affecting the tasks on the critical path later in the project. With this in mind, it is recommended to suggest this modified cash flow system for the mechanical trade and the success of the project.

Architectural Breadth

Problem Identification

Originally this breadth was embedded in the fourth analysis, discussed in the next section; however, it was decided to keep this breadth but remove that analysis from the scope of this thesis. This architectural breadth acknowledges that the east side of the precast on the north elevation cannot be installed with a tower crane because the precast is either too heavy or the tower crane cannot reach the last few panels on the east side. Because of this issue, the precast contractor plans to bring in a mobile crane to install about half of the precast panels on the north elevation. This architectural breadth will analyze how an alternative material may change the appearance of the building but reduce the amount of time needed for a secondary crane to assemble the precast installation. This analysis will also comment on the material change's potential impacts on other systems.

Execution

First, a model of the original building was created to analyze the current architectural north façade. There are many materials on this façade. Figures 38 and 39 below give both a large scale perspective of the current materials and a close up perspective as a person would encounter the building. Since this building is so massive, the material choice makes a bold statement in how it interacts both with the other materials on this building but also the surrounding structures.

Figure 38: North View of HSFIII

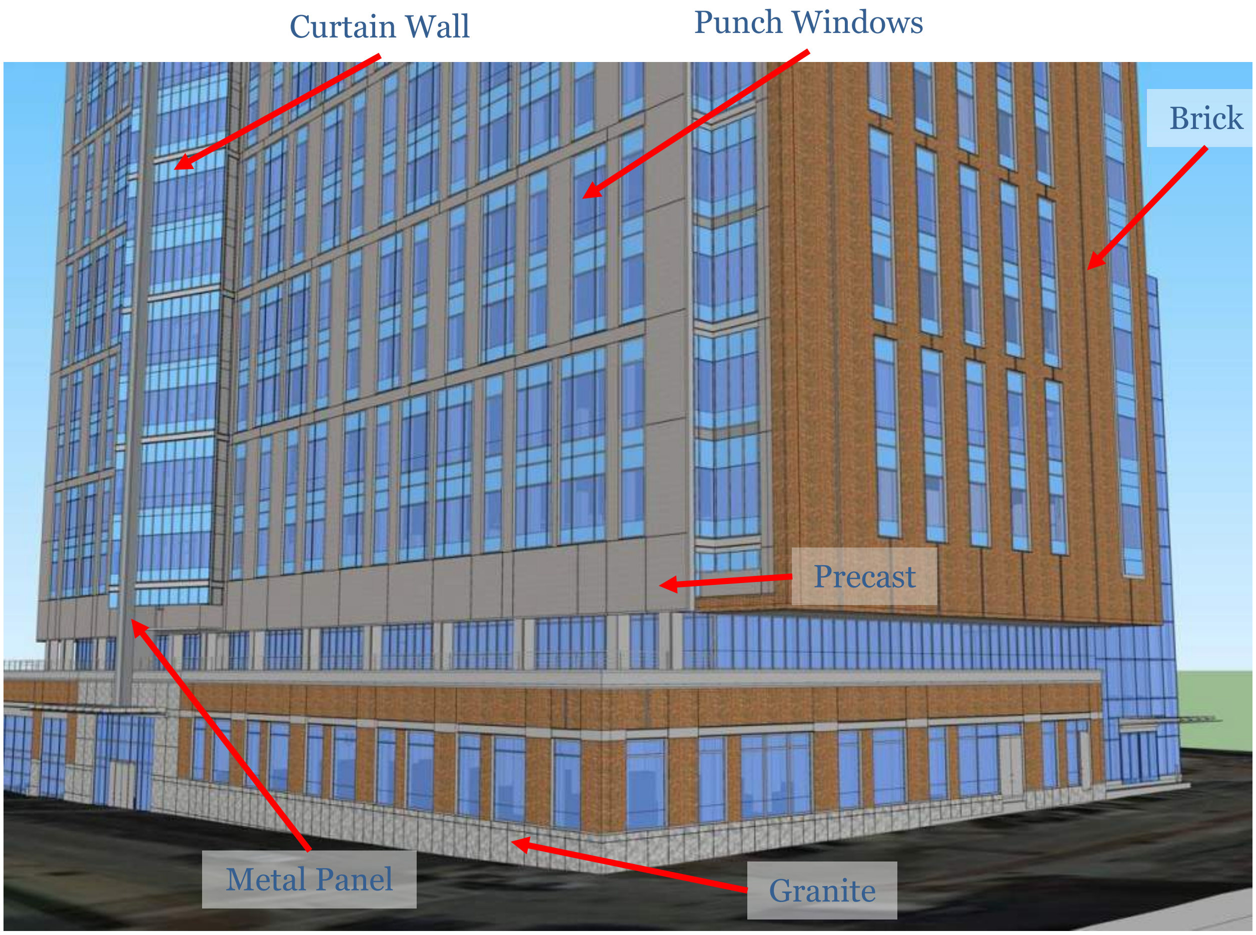
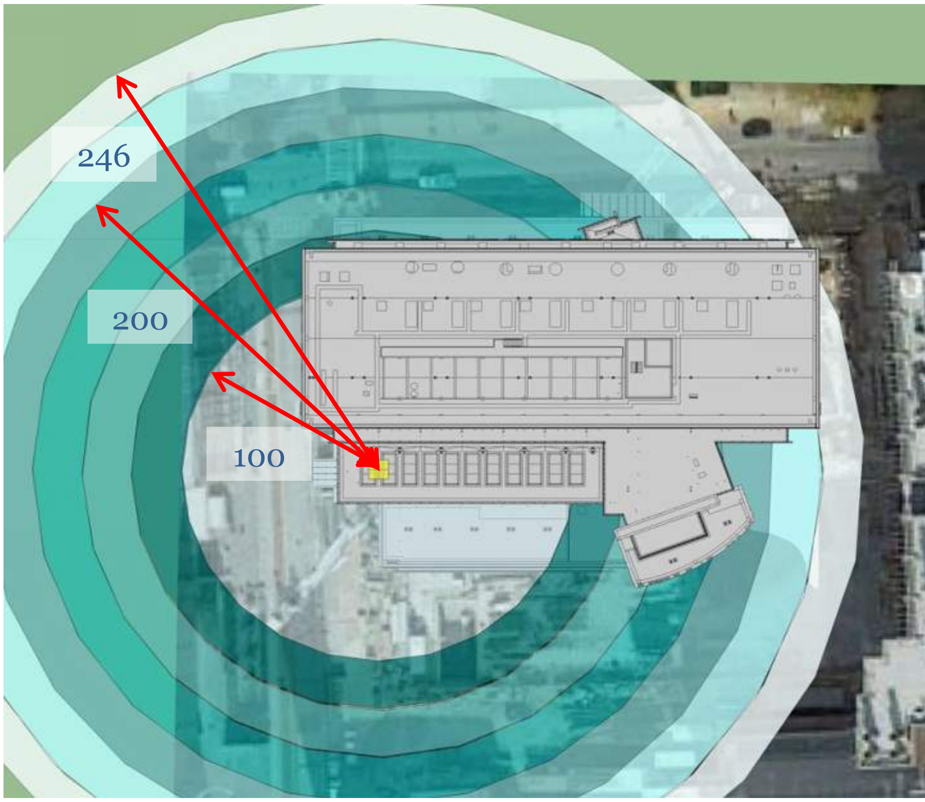


Figure 39: Close up of HSFIII

The image above identifies the main components of the façade system in the building. This closer view shows more of their interactions with each other. The store front on the second floor acts as a divider between the first floor program and the upper levels that have labs and offices. Also, the bump out on the north façade is designated as the collaboration tower and hosts collaboration or meeting spaces on every other floor.

The panels are deceptively large. The middle precast panels next to the punch windows span two levels, about 27 feet. On the east side, the heaviest panel falls just east of the collaboration tower and weighs approximately 16,000 pounds. The easternmost panels where the tower crane barely reaches average at about 8000-9000 pounds, which exceeds the capacity of the tower crane at that distance. Figures 40 and 41 on the next page show the tower crane capacity as the distances increases from the base and how that interacts with the precast system.



Distance from Base (feet)	**Capacity (kips)**
100	22
125	17
150	13.5
175	11.3
200	9.5
225	8
246	7

Figure 40: Tower Crane Load Capacity

Precast panels located 175 feet to 246 feet away from the tower crane base exceed the load capacity of the tower crane and require a mobile crane for installation. This breadth will investigate a new material that will keep the integrity of the design while simultaneously designing a lighter system for the tower crane to install.

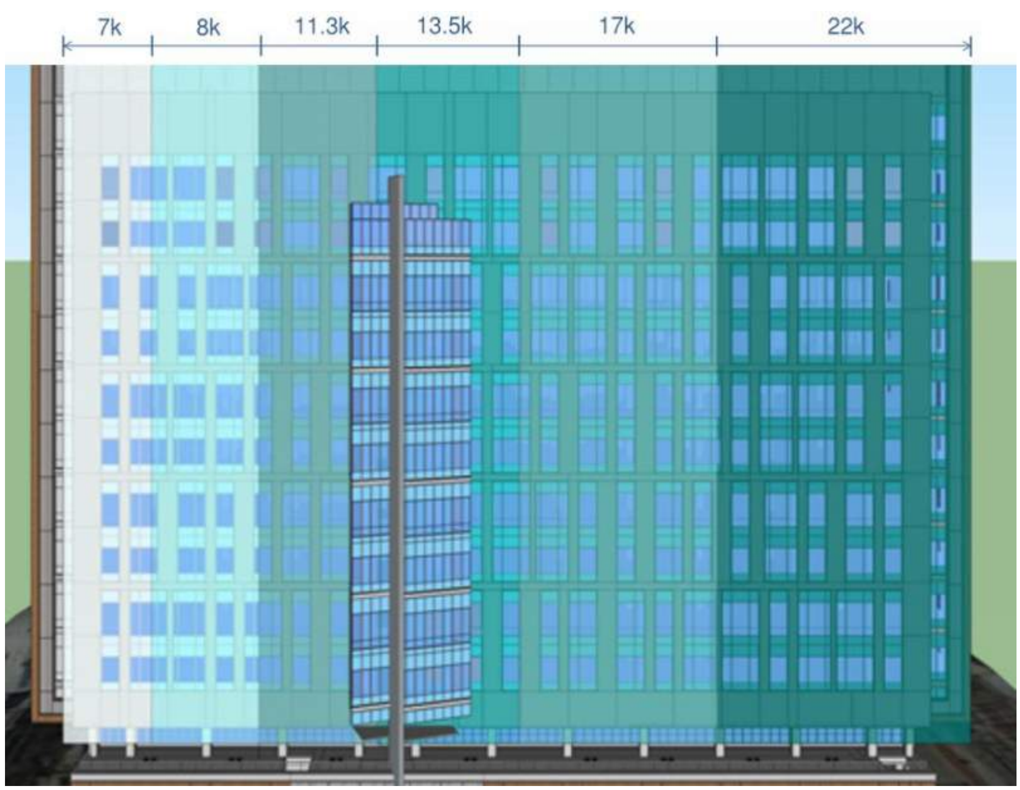
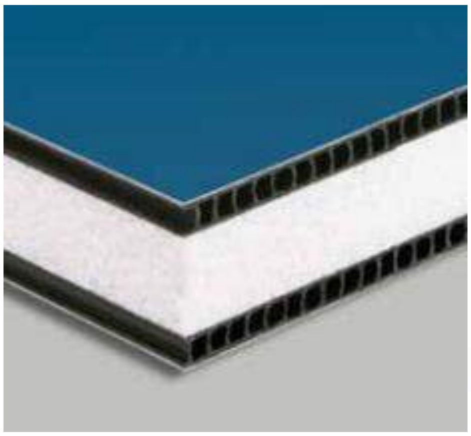


Figure 41: North Elevation of Tower Crane Load Capacity

Material Selection

When looking at material choices, the 6” of precast at 75 psf is one of the heavier façade systems. Metal panel is the strong contender for alternative material selection. It is already located on the fin on the north collaboration tower, so the same manufacturer could be used for this material change. Below is some product information for the existing metal panel on the fin. This product comes from the manufacturer Laminators Inc, seen in appendix E.1.

Thermolite™



Energy-saving insulating properties and a great look rolled into one—that's the magic of our Thermolite panels used for exterior wall applications.

- Constructed of an insulating foam core sandwiched between two corrugated polyallomer stabilizers and finished aluminum sheets
- Water-resistant, virtually maintenance-free for up to 20 years
- Available in smooth or stucco-embossed finishes
- Fit into standard 1 in. insulating glass and glazing pockets and storefront extrusions

Another product from the same manufacturer is better suited for the precast replacement based on its color options and typical applications, seen below.

Omega-Lite®

When you're looking for a highly decorative yet durable solution for exterior wall surfaces, choose Omega-Lite panels—they will not rot, swell, corrode, or delaminate. Best of all, with our installation systems they make total installed costs extremely competitive.

- Composed of a polyallomer corrugated core between two finished aluminum sheets
- Non-absorbent, water-resistant, and easy to maintain
- Custom color panels and caulks available to meet any corporate need

Two limitations with this manufacturer are that one dimension can be no wider than 60”, and it only comes in certain colors. This champagne color fortunately comes in this dimension and is being used on the fin for the collaboration tower. It has a metallic look that compliments the color. Because of this width restriction, the panel sizes need to be reconfigured into smaller units. The panels themselves are only .99lb/sf, making them significanly lighter than precast. A comparison of the old and new layout can be found on the next page.

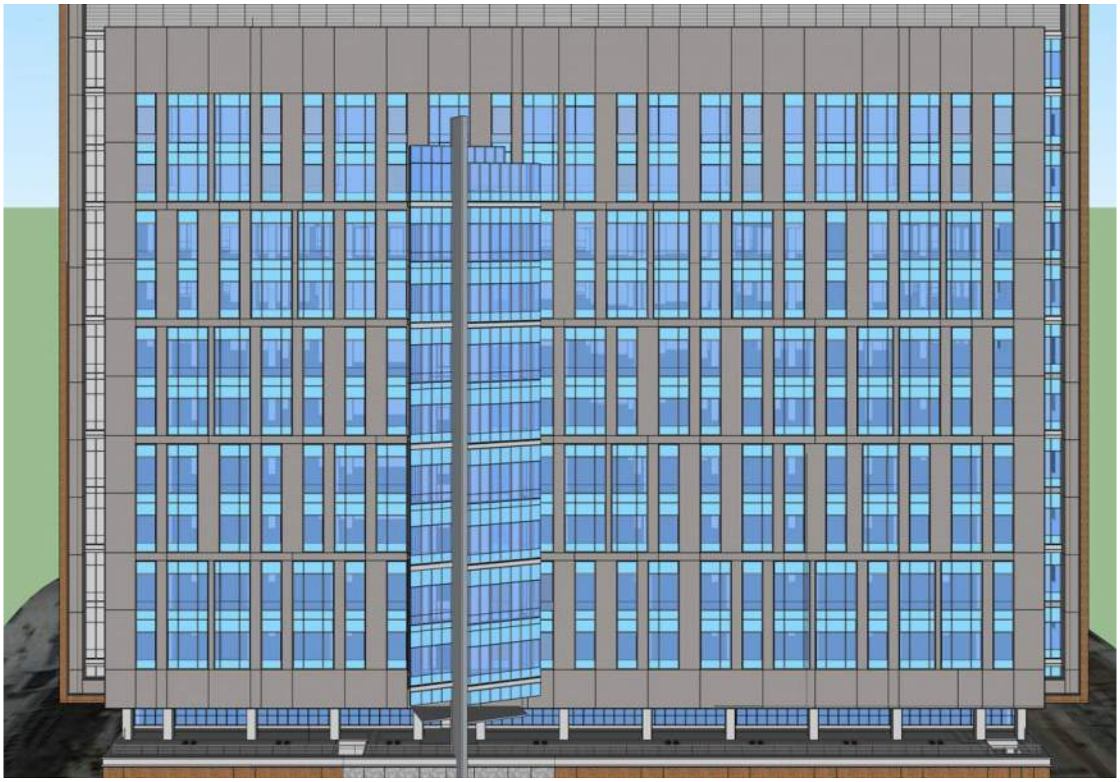


Figure 43: Original Precast Layout

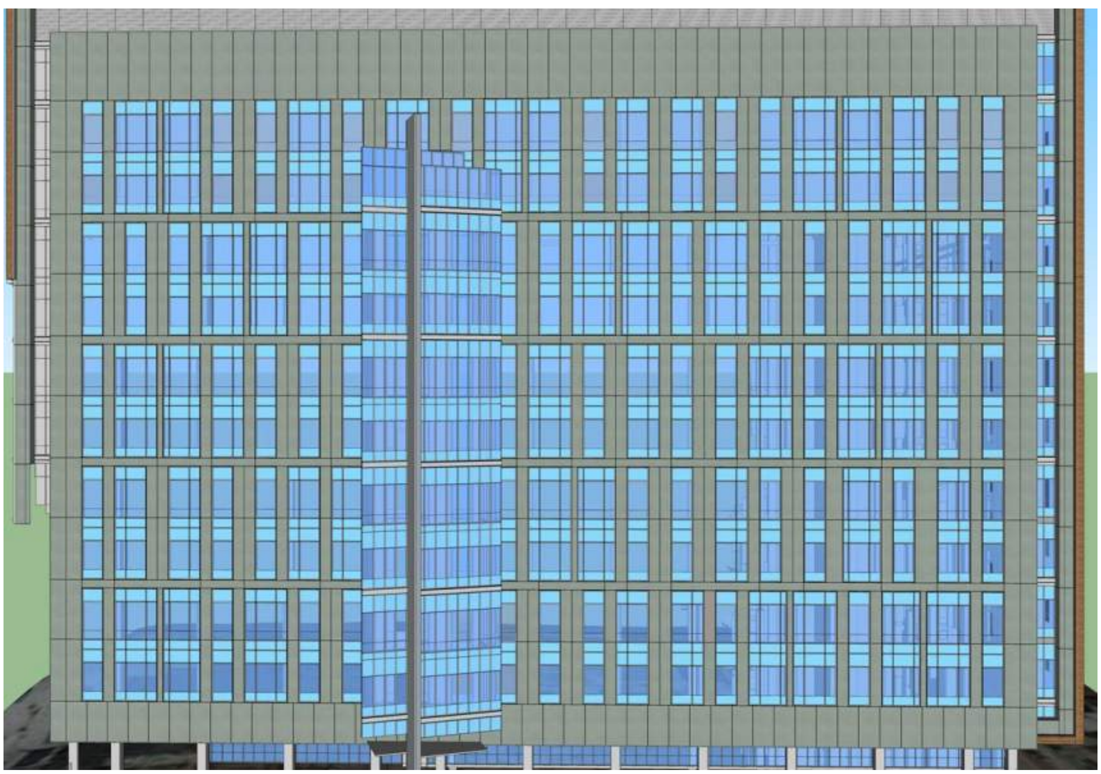


Figure 42: Modified Metal Panel Layout

The most noticeable place where the metal panel differs from the precast is in the north and south precast that frames the building. Here, uniform panels accommodate the width restriction of 60”. Also, the widest panels woven in between the windows were over 60” which prompted a redesign of these panels. Although the redesign is small, the texture from the precast to the metal panel is significant and greatly changes the impression of the building.

Effect on Other Systems

With a lighter facade, one major system affected is the mechanical system. The new metal panel has an R-value of 2.63, surprisingly higher than 6” precast which has an R-value of about 1.22[1]. This means that the other components of the wall such as the insulation and air barrier can be adjusted accordingly to get the same heating and cooling on the spaces in the building. Secondly, the structural system is greatly affected by this new system. This specific metal panel is significantly smaller than the precast, weighing in at .99lb/sf rather than the 6” precast at 75 lb/sf. This means that the structural backing for the system can be greatly reduced, similar to the curtain wall loading requirements.

Cost Analysis

The metal panels are also significantly cheaper than the precast. Based on existing cost information from the glazing and precast contractor, the table below shows the average cost per square foot for each system, indicating that the metal panel is less than half the cost of precast per square foot. A detailed takeoff of the precast and existing metal panel to obtain this cost information can be found in appendix E.2.

Precast	$103/SF
Metal Panel	$44/SF

Recommendations

With a higher R-value, a cheaper cost per square foot and similar panel layout to the current system, it is recommended to switch the precast to a metal panel system.

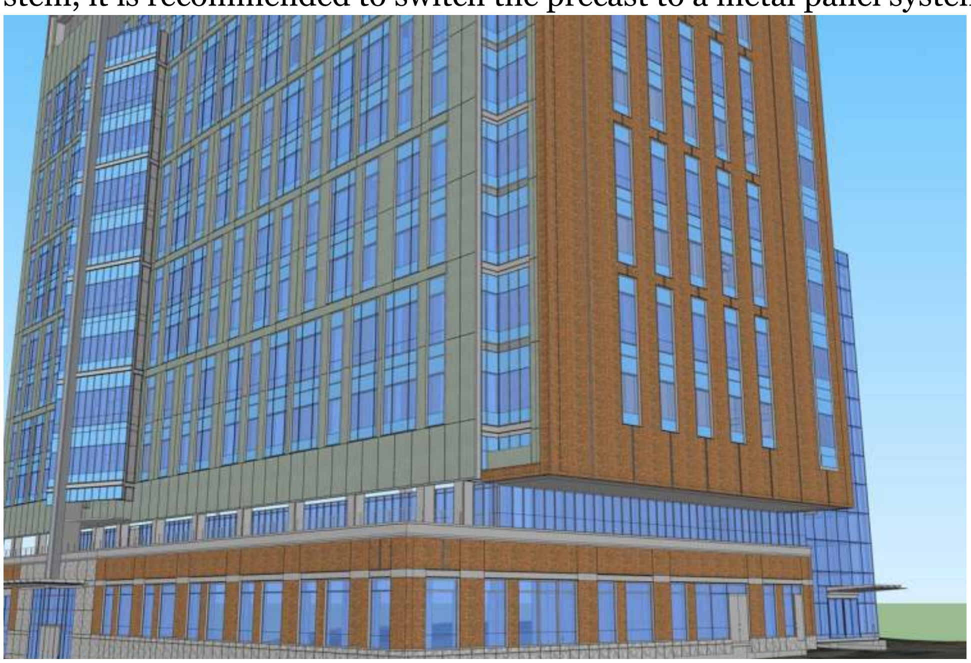


Figure 44: Closeup of Metal Panel System

Analysis 4: Remarks on Tower Crane Optimization

Problem Identification

There are multiple times during the installation of the exterior façade where the tower crane will be at its peak usage. This analysis was originally intended to investigate alternative solutions to help with the tower crane usage.

Background Research

Some of the first discussions over the summer concerning this tower crane included using the crane in two shifts to be used by different trades. The only trade that does not need the tower crane is the masonry contractor and they only have the east and west façade to erect. Apart from that, the concrete, windows, curtain wall, and precast contractor all require use of the tower crane.

With no interest in accelerating the schedule, this analysis will focus on how the re-sequencing of the exterior façade will affect the project schedule and the overall construction cost. The curtain wall and the precast will be the two major trades bargaining for crane usage throughout their time on site, and they each have a substantial amount of work that spans all of the floors.

When the first two floors of the façade begin, there is more structural concrete to pour on the upper floors. This overlap means the façade needs to be aware of the pathway that the crane is taking to transport concrete up to the top floors. The concrete has a high chance of spilling out of the bucket and could potentially damage the façade, specifically the storefront windows on the second floor. Also, the concrete contractor requires the tower crane for erection.

One important element to consider in this is how the interior trades are affected by this façade re-sequencing. If it is drawn out too long, then there will be potential delays in the interior work which will not benefit the project. 4D modeling such as Synchro will be used to help visualize and understand this relationship between the structure, exterior façade contractors, and interior trades.

Potential Solutions

With the tower crane as the element that limits production on the project, the following potential solutions will address how to best use the tower crane. Overall, the design variables that will help make the decision include the tower crane, the manpower, and the cost of installation.

The first option is to remove the two shifts of the precast and curtain wall. The overtime of the tower crane operator would not be necessary here. This option will investigate how this affects the overall project schedule. Also, with the assumed additional cranes that will be on site when the tower crane is at its peak usage, this solution will evaluate the cost of the additional cranes and the best balance between double shifts and multiple cranes on site. The mindset behind removing the two shifts is to potentially flatten out the cash flow curve in this year, since the funding for the project comes in certain amounts every year.

Second, this analysis could investigate supplementary equipment to aid the tower crane in the erection of the façade. For example, a gantry could be used to erect the punch windows and other smaller elements, which would free up the tower crane. Also, there might be some other equipment that could erect the curtain wall or precast. This may take the responsibility of erection off the tower crane, but the cost of the equipment and impact on the schedule and other trades will be evaluated.

Finally, the third potential solution could consider sequencing the project in sections rather than clockwise. The building is broken into four sections, the north tower, south tower, atrium, and core, seen in the figure on the right. They are disproportionally sized, but it might help with the tower crane production. This could free up those areas inside to perform interior work sooner in areas like the atrium or south tower. If the interior trades start earlier and with a smaller sized manpower, they might be able to better level out the fluctuations of manpower throughout the project. This will also allow the tower crane to focus on specific areas and specific trades at a time.

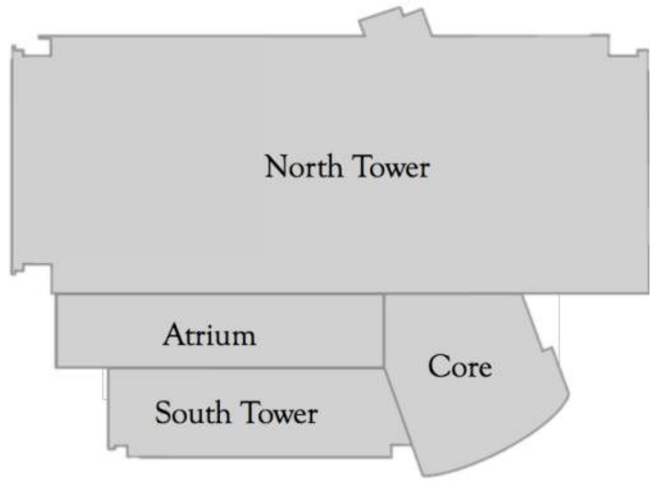


Figure 45: Breakout of HSF III

Remarks

After puzzling through this analysis and discussions with the construction manager, it was decided to remove the tower crane analysis from this thesis. By the time the conversation took place with the construction manager, many of the things originally proposed in this thesis were either shot down or implemented on the project. Below is a recap of the potential solutions I planned to investigate:

Option 1: double shift removal (based on assumption that they were moving forward with two shifts for precast/concrete or precast/curtain wall)
Option 2: supplementary equipment
Option 3: re-sequencing the project

The discussion with the project engineer outlined their current plan with the façade. Since the relationship between the precast and concrete is the most crucial to requiring the tower crane, this is where the most time was spent in solving how to use the tower crane. The concrete contractor has priority over the tower crane for its last pours on the upper floors, so the precast will be using a mobile crane to erect floors 1 through 4. This limitation is also because of the safety nets surrounding the concrete on levels 4 and 7. These must come down before the precast can use the tower crane. Once the nets are gone, the precast will use the tower crane during a night shift while it is used for other purposes during the day. The tower crane cannot set the northeast precast due to weight limits on the crane, so it will be erected completely by a mobile crane. There is some precast in the southeast that will also be erected during off-hour shifts.

Concerning the other façade types, the masonry never needed the crane and will be using a hydraulic lift to build the masonry façade. The curtain wall on the south end as well as any punch windows plan to use a deck crane, which is a small crane set up on the 9th floor that can move around the floor and hang the panels as needed. The tower crane will only be used in this case to stock the deck crane of material during off hours. Both the storefront and metal panel will be stick built on site, while the granite on the first floor will be hung by from the scaffolding.

With this new information, the use of a mobile crane and a deck crane used many of the potential solutions I intended to look into. This made the analysis obsolete and I did not think it was a wise use of time to research the same potential solutions implemented on site. Because the final presentation only required three analyses, I chose to spend my time focusing intently on the first three for the presentation. I plan to keep the architectural breadth originally connected to this thesis in order to fulfill the requirement of having two breadths for my thesis.

Conclusion

Each analysis in this thesis is intended to research and better understand construction issues while utilizing the resources and knowledge gained through the pursuits of an architectural engineering degree. The breadths are designed to showcase the talents and knowledge of other disciplines that take this program to the next level. All three analysis investigated value and its effect on construction, from the value of motivation and team performance to deciding on the best value in a shoring system to understanding the value of manpower's effect on the cost and schedule of a project.

Analysis 1 considered multiple shoring systems for the project and proved that although pile and lagging is a better system when there are no complications, it is more advantageous to the project to pick sheet piles as the support of excavation method. This would greatly reduce the amount of dewatering issues on the site and is cheaper for the project at $1,640,040, about $490,000 less than the final pile and lagging price. It will also take 24 days less than the delayed pile and lagging system. The structural breadth for this analysis designed the alternative systems to give better content in the decision making process.

Analysis 2 researched motivation and team performance within construction managers on a construction project. Overall, it was found that not only is there was a correlation between motivation and team performance, but these drivers behind motivation can change with age, roles and responsibilities in life, and with the team dynamic. It is recommended to try and understand these motivators on a job to best craft the team's goals and responsibilities. The literature review greatly helped identify and categorize the responses of the individuals on how they perceived motivation and team performance.

Analysis 3 focused on cash flow of the mechanical trade and manipulated the manpower crew sizes throughout the project to understand how it affected cash flow on a project. It was discovered that the reduction in peak manpower saves almost $2.5 million dollars in fiscal year 2016. This means that the interior trades that were originally delayed a month could start as originally scheduled and this would accommodate the month delay of the overhead and in-wall installation on the upper floors without compromising the critical path of the project.

Finally, the architectural breadth that was not woven into any analysis examined an alternative material to the precast on the north elevation based on the tower crane load capacity. With a higher R-value and a lighter system, it was recommended to use metal panel as a substitute to the precast on the north.

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Analysis 1: Shoring System

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Analysis 2: Internal Motivators

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Architectural Breadth

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Appendix B

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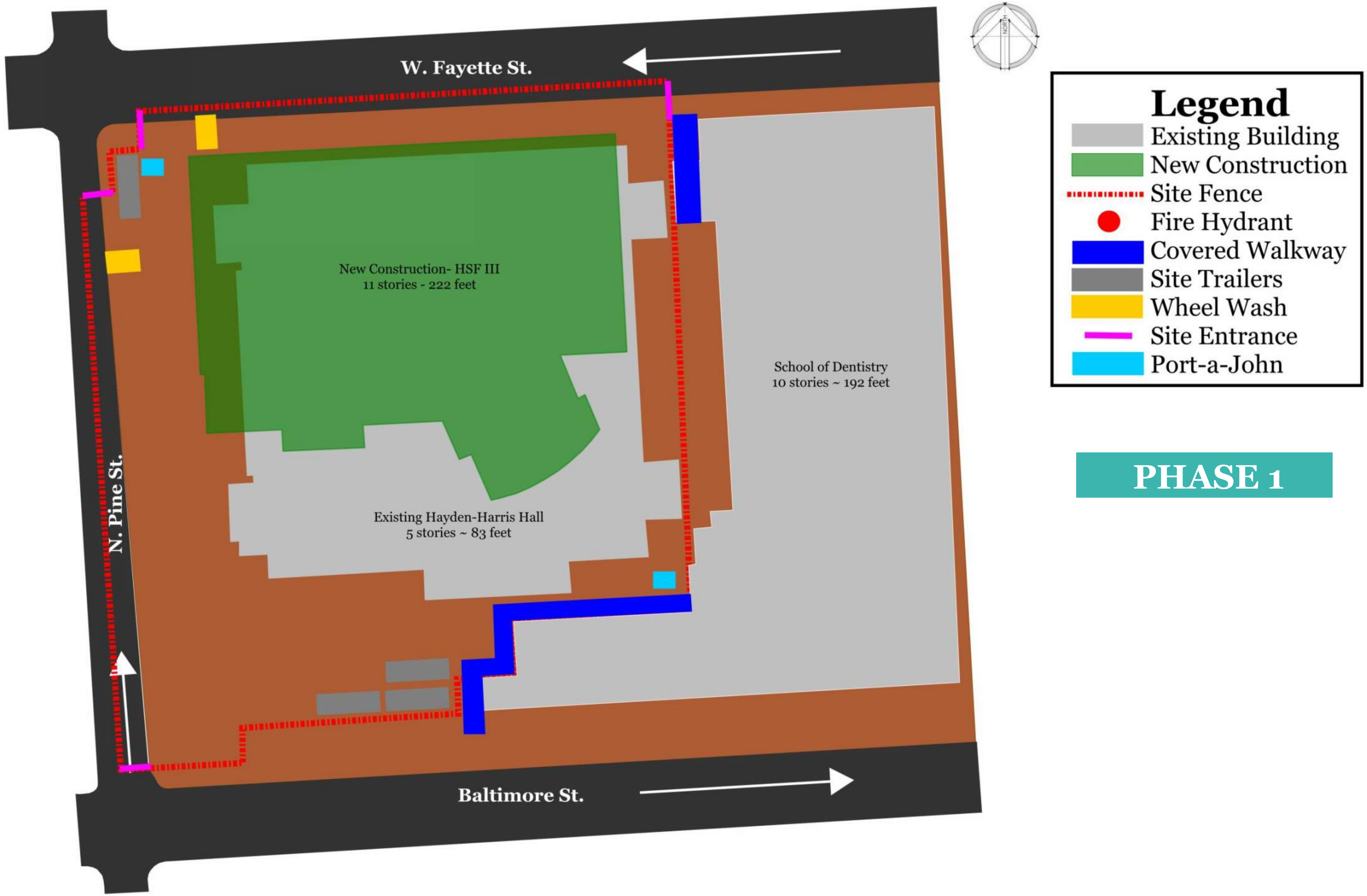
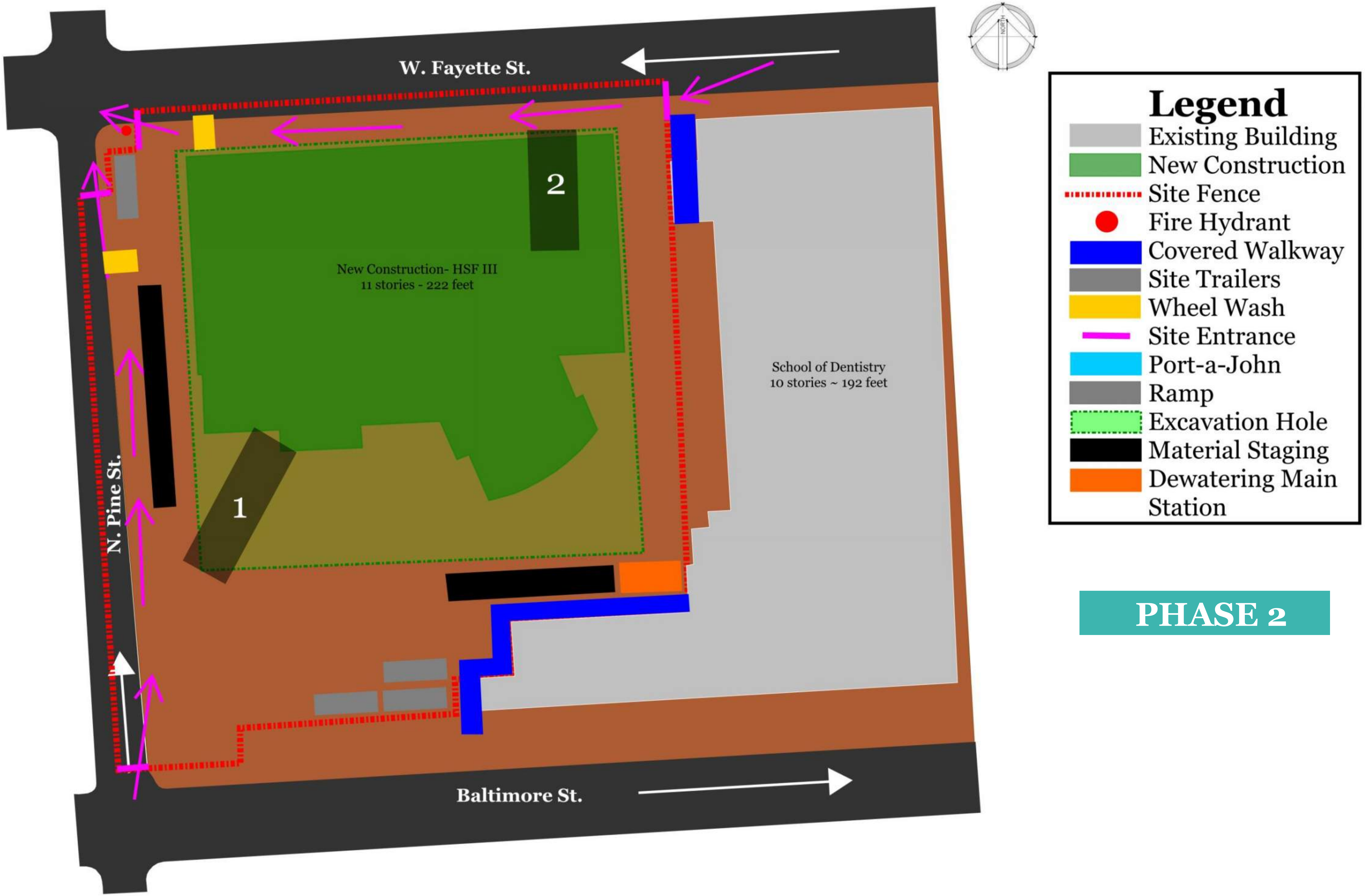
Appendix A.1

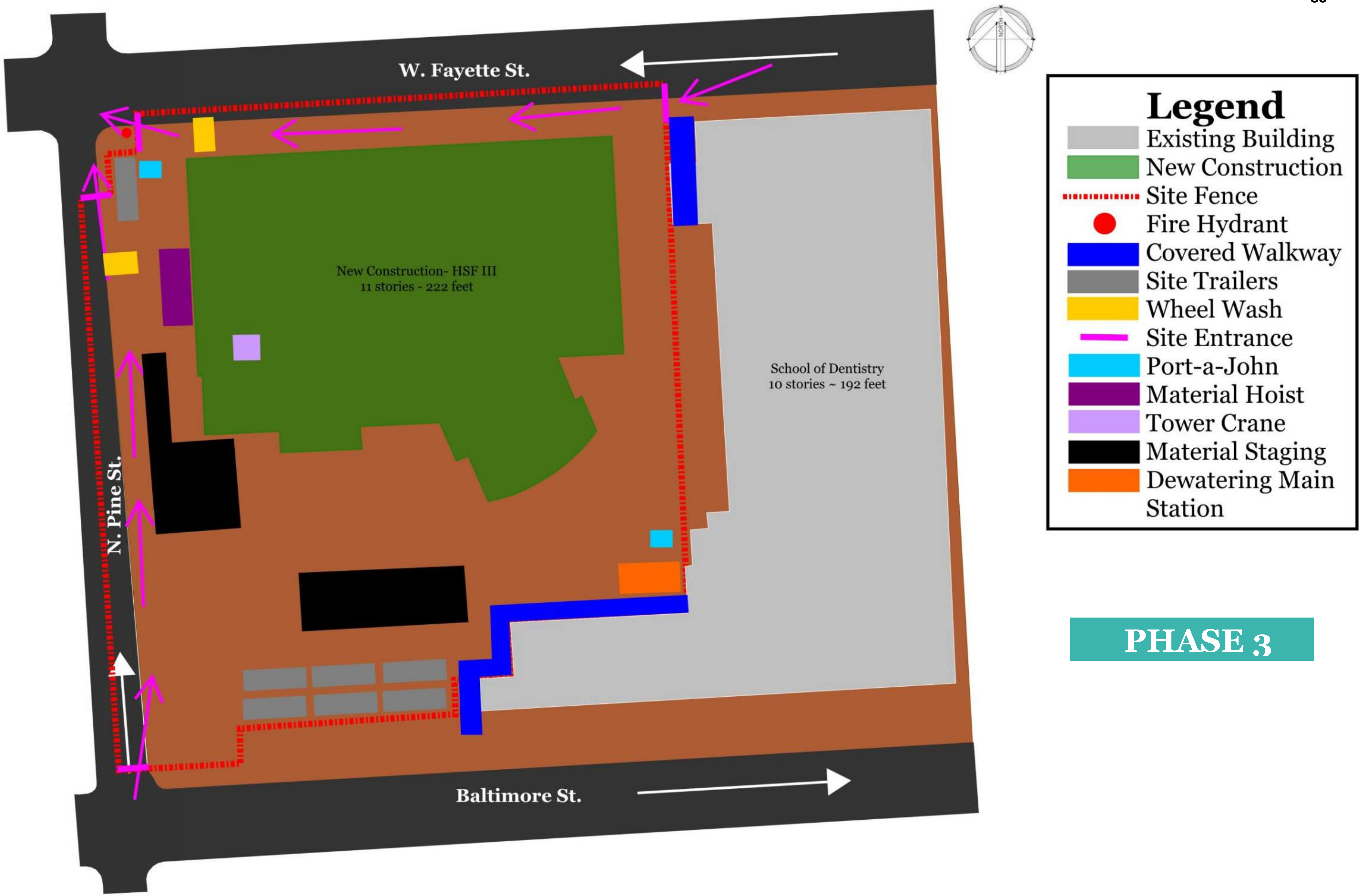
Site Logistics Plans


W. Fayette St.
N. Pine St.
Baltimore St.
New Construction- HSF III
11 stories - 222 feet
Existing Hayden-Harris Hall
5 stories ~ 83 feet
School of Dentistry
10 stories ~ 192 feet
Legend
Existing Building
New Construction
Site Fence
Fire Hydrant
Covered Walkway
Site Trailers
Wheel Wash
Site Entrance
Port-a-John

PHASE 1


W. Fayette St.
N. Pine St.
Baltimore St.
New Construction- HSF III
11 stories - 222 feet
School of Dentistry
10 stories ~ 192 feet
1
2
NORTH
Legend
Existing Building
New Construction
Site Fence
Fire Hydrant
Covered Walkway
Site Trailers
Wheel Wash
Site Entrance
Port-a-John
Ramp
Excavation Hole
Material Staging
Dewatering Main Station

PHASE 2


W. Fayette St.
N. Pine St.
Baltimore St.
NORTH
New Construction- HSF III
11 stories - 222 feet
School of Dentistry
10 stories ~ 192 feet
Legend
Existing Building
New Construction
Site Fence
Fire Hydrant
Covered Walkway
Site Trailers
Wheel Wash
Site Entrance
Port-a-John
Material Hoist
Tower Crane
Material Staging
Dewatering Main Station
PHASE 3

Appendix A.2

Cost Estimate and Takeoff

		UNT	AMT	MAT/UNT	MAT	LAB/UNT	LABOR	EQP/UNT	EQP	TOT
A.0 Demolition/Excavation (Square Foot)										
	Demolition	EA	1							848,000
	Excavation	EA	1							4,901,993
									Subtotal:	5,750,000
A.1 Substructure (Detailed)										
	FORMWORK									
03 11 13.45 0020	Wall footing, 4 use	SFCA	26,502	2.03	53,799	2.87	76,061		-	129,860
03 11 13.55 0120	Mat Foundation, 4 use	SFCA	60,236.67	0.65	39,154	6.10	367,444		-	406,598
	CONCRETE (includes formwork, formwork is for reference above)									
03 30 53.40 1900	Elevated Slab, 20' span	CY	244.22	256	62,521	249	60,811	19.30	4,713.49	128,046
03 30 53.40 4050	Foundation Mat, over 20CY	CY	8,105.21	178	1,442,727	87	705,153	10	81,052.10	2,228,933
03 30 53.40 4500	Foundation wall, 28' tall	CY	1,963.11	155	304,282	187	367,102	15.25	29,937.44	701,321
	REINFORCEMENT									
03 21 11.60 0700	walls, #3-#7	TON	117.93	1,000	117,926	540	63,680		-	181,607
03 21 11.60 0750	wall, #8-#18	TON	187.01	1,000	187,009	405	75,739		-	262,748
03 21 11.60 0550	Mat foundation rebar (footings, #8-#18)	TON	428.02	1,000	428,019	450.00	192,608		-	620,627
07 17 13.10 0100	Waterproofing, bentonite, rolls, 3/8" thick	SF	83,248	1.50	124,872	0.57	47,451		-	172,323
07 17 13.10 0625	Drain board, 2" with filter fabric	SF	26,502	0.54	14,311	0.15	3,975		-	18,286
									Subtotal:	4,313,900
B Shell: Superstructure (Detailed)										
	FORMWORK									
03 11 13.20 1550	Beams and girders, exterior spandrel, 24" wide, 2 use	SFCA	37,725.63	1.4	52,816	7.40	279,170		-	331,986
03 11 13.20 3500	Beams and girders, bottom only, 30" wide, 1 use	SFCA	16,666.33	3.98	66,332	9.30	154,997		-	221,329
03 11 13.20 2050	Beams and girders, interior beam, 12" wide, 2 use	SFCA	5,265.63	1.7	8,952	6.30	33,173		-	42,125
03 11 13.20 4000	Beams and girders, vertical, 36" wide, 1 use	SFCA	31,163.67	5.10	158,935	6.40	199,447		-	358,382
03 11 13.25 7750	Columns, steel framed plywood, 24"x24"	SFCA	170,862.33	0.78	133,273	3.17	541,634		-	674,906
03 11 13.25 1150	Elevated Slabs, plywood, 4 use	SF	413,103	1.18	487,462	3.83	1,582,184		-	2,069,646
03 11 13.25 2150	Elevated Slabs, drop panel, plywood, 4 use	SF	57,882.23	1.68	97,242	4.03	233,265		-	330,508
	CONCRETE (includes formwork, formwork is for reference above)									
03 30 53.40 0350	Beams, 25' span	CY	3,270	335	1,095,450	495	1,618,650	40.0	130,800	2,844,900
03 30 53.40 0940	Columns, square, 24"x24", over 3% reinforcing	CY	3,132.43	680	2,130,049	650	2,036,076	52.5	164,452.33	4,330,578
03 30 53.40 1900	Elevated Slab, 20' span	CY	12,195.51	256	3,122,051	249	3,036,682	19.3	235,373.37	6,394,107
03 30 53.40 4270	Shear Wall, 14' tall	CY	1,349.14	152	205,069	228	307,604	18.6	25,093.99	537,767
03 30 53.40 6800	Stairs	LF Nose	788	5.40	4,255	26	20,488	40.0	31,520	56,263
	REINFORCEMENT	TON								
03 21 11.60 0700	walls, #3-#7	TON	85	1,000	85,401	540	46,117		-	131,518
03 21 11.60 0750	wall, #8-#18	TON	4.02	1,000	4,015	405	1,626		-	5,641
03 21 11.60 0400	Elevated Slab, #3-#7	TON	679.32	1,000	679,324	560	380,421		-	1,059,745
03 21 11.60 0100	Beams and girders, #3-#7	TON	63.19	1,000	63,192	1,025	64,772		-	127,964
03 21 11.60 0150	Beams and girders, #8-#18	TON	270.17	1,000	270,171	600	162,102		-	432,273
	STEEL									
05 12 23.75 0300	W8x10	LF	127	14.60	1,854	4.68	594	2.55	323.85	2,772
05 12 23.75 0320	W8x15	LF	2,084.50	22	45,859	4.68	9,755	2.55	5,315.48	60,930
05 12 23.75 0600	W10x12	LF	24.50	17.50	429	4.68	115	2.55	62.48	606
05 12 23.75 0620	W10x15	LF	89.25	22	1,964	4.68	418	2.55	227.59	2,609
05 12 23.75 1100	W12x16	LF	32	23.50	752	3.19	102	1.74	55.68	910
05 12 23.75 1300	W12x22	LF	98	32	3,136	3.19	313	1.74	170.52	3,619
05 12 23.75 1900	W14x22	LF	34	38	1,292	2.84	97	1.54	52.36	1,441
05 12 23.75 2700	W16x26	LF	38.75	38	1,473	2.81	109	1.53	59.29	1,641
05 12 23.75 3300	W18x35	LF	1,852.50	51	94,478	4.22	7,818	1.74	3,223.35	105,518
05 12 23.75 3500	W18x40	LF	1,216.0	58.50	71,136	4.22	5,132	1.74	2,115.84	78,383
05 12 23.75 3700	W18x50	LF	32.0	73	2,336	4.44	142	1.83	58.56	2,537
05 12 23.75 3900	W18x55	LF	56.25	80	4,500	4.44	250	1.83	102.94	4,853
05 12 23.75 3920	W18x65	LF	32	94.50	3,024	4.50	144	1.86	59.52	3,228
05 12 23.75 1300	C4x4.5, lightweight framing	LF	29.50	4.29	127	18.85	556	2.15	63.43	746
05 12 23.75 1300	C8x11.5, lightweight framing	LF	1,218.50	9.15	11,149	34.50	42,038	3.95	4,813.08	58,001

		UNT	AMT	MAT/UNT	MAT	LAB/UNT	LABOR	EQP/UNT	EQP	TOT
Manufacturer	HSS3x2x1/4	LF	169	8.89	1,502		-		-	1,502
Manufacturer	HSS4x4x5/16	LF	42	13.35	561		-		-	561
Manufacturer	HSS5x5x1/4	LF	4.50	14.06	63		-		-	63
Manufacturer	HSS5x5x5/16	LF	1,056	17.17	18,134		-		-	18,134
Manufacturer	HSS6x4x1/4	LF	520	16.27	8,461		-		-	8,461
Manufacturer	HSS6x4x5/16	LF	192	23.85	4,579		-		-	4,579
Manufacturer	HSS6x6x1/4	LF	102	17.12	1,746		-		-	1,746
Manufacturer	HSS6x6x5/16	LF	472.20	21.01	9,919		-		-	9,919
Manufacturer	HSS6x6x3/8	LF	406.12	24.73	10,044		-		-	10,044
Manufacturer	HSS6x6x5/8	LF	14.67	31.72	465		-		-	465
Manufacturer	HSS8x4x5/16	LF	154.50	34.35	5,307		-		-	5,307
Manufacturer	HSS8x6x3/8	LF	120.67	40.71	4,912		-		-	4,912
Manufacturer	HSS8x8x5/16	LF	494.75	53.39	26,414		-		-	26,414
Manufacturer	HSS10x6x1/4	LF	13	32.28	420		-		-	420
Manufacturer	HSS10x10x5/16	LF	214	72.63	15,543		-		-	15,543
Manufacturer	HSS10x10x1/2	LF	175	56.21	9,837		-		-	9,837
Manufacturer	HSS14x6x3/8	LF	234	51.11	11,960		-		-	11,960
	Steel Connections (10% of steel)			0.10	37,337		-		-	37,337
									Subtotal:	16,415,800
B Shell: Enclosure (Square Foot)										
	Base Price	EA	1.00							10,224,155
	Curtain Wall Percentage Increase	%	0.25							2,556,039
	Precast Percentage Increase	%	0.16							1,635,865
									Subtotal:	14,416,100
D Plumbing (Assemblies)										
	PIPING									
Contractor	Storm, cast iron	SF	420,864	2.65	1,115,290		-		-	1,115,290
Contractor	Natural gas, medical air, medical vacuum	SF	420,864	1.64	690,217		-		-	690,217
Contractor	Domestic Water	SF	420,864	3.20	1,346,765		-		-	1,346,765
Contractor	Laboratory water, gas, air, vacuum	SF	420,864	9.14	3,846,697		-		-	3,846,697
Contractor	Animal Water	SF	420,864	0.52	218,849		-		-	218,849
Contractor	RO/DI Water	SF	420,864	1.61	677,591		-		-	677,591
Contractor	Sanitary, Waste, Vent, Acid	SF	420,864	4.15	1,746,586		-		-	1,746,586
	FIXTURES									
D2010 120 3000	Water closet, wall hung, back to back	EA	155	3,525	546,375	1,150	178,250		-	724,625
D2010 210 2000	Urinal, wall hung	EA	10	620	6,200	825	8,250		-	14,450
D2010 310 2040	Lavatory vanity top, 18"x15"	EA	105	960	100,800	815	85,575		-	186,375
D2010 430 1600	Laboratory sink, stainless steel, single bowl	EA	300	2,125	637,500	1,025	307,500		-	945,000
D2010 810 1920	Drinking Fountain, non recessed, stainless steel	EA	42	1,650	69,300	485	20,370		-	89,670
22 14 26.13 4680	Roof Drain, 8"	EA	50	3,025	151,250	1,975	98,750		-	250,000
	EQUIPMENT									
23 21 20.46 2390	Expansion Tank, 200 gal	EA	2	8,100	16,200	420	840		-	17,040
24 21 20.46 2390	Expansion Tank, 80 gal	EA	2	4,050	8,100	280	560		-	8,660
22 31 13.10 6070	Water Softener, 60 kgrains	EA	4	2,525	10,100	230	920		-	11,020
Contractor	Rainwater Reclamation System	EA	1	-	-		-		-	178,000
Contractor	Reverse Osmosis/Deionized Water	SF	420,864	0.40	168,346		-		-	168,346
22 11 23.13 0500	Booster Pump, 30HP	EA	1	26,400.0	26,400	2,880	2,880		-	29,280
D2020 250 2260	Water heater, gas fired, 600 MBH input	EA	6	25,000.0	150,000	3,975	23,850		-	173,850
22 12 21.13 2070	Water Storage Tank, 12,000 gallon capacity	EA	3	17,400.0	52,200	1,050	3,150	440	1320	56,670
22 62 19.70 0130	Vacuum system for medical facilities, triplex 180 SFCM	EA	1	49,600.0	49,600	1,075	1,500		-	51,100
22 13 29.14 3100	Sump Pump, 174 GPM (average)	EA	12	3,075.0	36,900	920	11,040		-	47,940
23 21 23.13 4300	Water Pumps, 3HP	EA	6	3,375.0	20,250	460	2,760		-	23,010
Contractor	Meters and Valves	SF	420,864	0.65	273,562		-		-	273,562
Contractor	Miscellaneous Medical Equipment	SF	420,864	1.76	740,721		-		-	740,721
Contractor	Miscellaneous Laboratory Equipment	SF	420,864	0.59	248,310		-		-	248,310
									Subtotal:	13,879,600

		UNT	AMT	MAT/UNT	MAT	LAB/UNT	LABOR	EQP/UNT	EQP	TOT
D HVAC (Assemblies)										
	PIPING									
Contractor	Insulation	SF	420,864	12.71	5,349,181		-		-	5,349,181
Contractor	Hot Water Piping	SF	420,864	9.91	4,170,762		-		-	4,170,762
Contractor	Fuel Oil Piping	SF	420,864	1.27	534,497		-		-	534,497
Contractor	Chilled Water Piping	SF	420,864	15.72	6,615,982		-		-	6,615,982
Contractor	Condensate Piping	SF	420,864	9.80	4,124,467		-		-	4,124,467
Contractor	Heat Pump Piping	SF	420,864	2.87	1,207,880		-		-	1,207,880
	AIR DISTRIBUTION									
Contractor	Ductwork, supply, return, exhaust, dampers, sound attenuators	SF	420,864	25.34	10,664,694		-		-	10,664,694
23 34 16.10 0240	Fans, exhaust, 400 CFM	EA	3	1,250	3,750	335	1,005		-	4,755
23 34 16.10 5560	Fans, exhaust, 5,000 CFM	EA	6	4,725	28,350	555	3,330		-	31,680
23 34 16.10 0350	Fans, exhaust, 10,000 CFM	EA	3	2,925	8,775	1,550	4,650		-	13,425
23 34 16.10 4080	Fans, exhaust, 15,000 CFM	EA	4	6,025	24,100	395	1,580		-	25,680
23 34 16.10 4120	Fans, exhaust, 30,000 CFM	EA	6	11,900	71,400	490	2,940		-	74,340
23 34 16.10 4140	Fans, exhaust, 38,000 CFM	EA	2	15,800	31,600	565	1,130		-	32,730
23 34 16.10 4140	Fans, exhaust, 46,500 CFM	EA	2	15,800	31,600	565	1,130		-	32,730
23 34 16.10 4160	Fans, exhaust, 57,000 CFM	EA	5	20,100	100,500	985	4,925		-	105,425
Contractor	VFDs	SF	420,864	1.65	694,426		-		-	694,426
	HEATING/COOLING EQUIPMENT									
23 57 19.16 1120	Heat Exchanger, 98 GPM, liquid to liquid shell type	EA	6	13,700	82,200	600	3,600		-	85,800
23 57 19.16 3140	Heat Exchanger, 1200 GPM, liquid to liquid	EA	2	91,500	183,000	5,250	10,500		-	193,500
23 57 19.16 0300	Heat Exchanger, 700 GPM, liquid to liquid shell type	EA	2	25,000	50,000	1,875	3,750		-	53,750
23 22 23.10 2150	Pumps, duplex	EA	2	10,400	20,800	830	1,660		-	22,460
23 21 23.13 4190	Pumps, in line	EA	18	2,950	53,100	415	7,470		-	60,570
22 11 23.10 4130	Pumos, single stage	EA	14	18,900	264,600	3,225	45,150		-	309,750
22 13 26.10 0360	Blow down separator, 16"	EA	3	9,500	28,500	660	1,980		-	30,480
Contractor	Steam generator	EA	1		-		-		-	36,860
46 25 13.20 0100	Water Filter, side stream filter	EA	3	22,300	66,900	340	1,020	49	147	68,067
Assumption	Glycol System	EA	1	10,000	10,000		-		-	10,000
23 21 20.10 0380	Air Separator	EA	3	6,075	18,225	595	1,785		-	20,010
23 64 16.10 0330	Centrifugal Chiller, 1200 ton	EA	3	523,000	1,569,000	22,000	66,000		-	1,635,000
23 65 13.10 2596	Cooling Tower	EA	3	119,000	357,000	10,100	30,300		-	387,300
Contractor	BTU meter	EA	1		-		-		-	5,000
23 21 20.46 2390	Expansion Tank,1300 gal	EA	2	8,100	16,200	315	630		-	16,830
23 21 20.46 2390	Expansion Tank,900 gal	EA	2	6,750	13,500	280	560		-	14,060
23 21 20.46 2390	Expansion Tank,300 gal	EA	1	4,050	4,050	280	280		-	4,330
23 21 20.46 2390	Expansion Tank,600 gal	EA	2	4,725	9,450	315	630		-	10,080
23 73 13.10 0990	AHU, dbl wall, VFD,economizer, sound attenuator, 38000CFM	EA	2	50,500	101,000	3,275	6,550		-	107,550
23 73 13.10 0990	AHU, dbl wall, VFD, heat pipe, 64000CFM	EA	6	210,000	1,260,000	19,000	114,000		-	1,374,000
23 73 13.20 1550	AHU, packaged, 10000CFM	EA	9	25,300	227,700	2,425	21,825		-	249,525
Contractor	Filter House	EA	1		-		-		-	92,000
Contractor	Air Terminal Units	SF	420,864	4.78	2,011,730		-		-	2,011,730
Contractor	Testing and Balancing	EA	1		-		-		-	500,000
Contractor	Commissioning	EA	1		-		-		-	155,000
								Subtotal:		40,981,300
D Fire Protection (Assemblies)										
D4010 410 1080	Wet Sprinkler, ordinary hazard, 10,000 SF	SF	39,594	1.95	77,208	2.60	102,944		-	180,153
D4010 410 1220	Each additional floor, 10,000SF	SF	381,270	1.35	514,715	2.43	926,486		-	1,441,201
								Subtotal:		1,621,400
D Electrical (Assemblies)										
D5010 130 1250	Underground Electric Service, 1200A, w/ groundfault switchboard	EA	1	47,900	47,900	1,500	1,500		-	49,400
D5010 240 0620	Substation, 5000A	EA	5	82,000	410,000	18,000	90,000		-	500,000
D5010 240 0580	Switchboard, 1200A	EA		24,400	-	7,950	-		-	-
D5010 250 4060	Distribution Board, 480/277V, 100A	EA	67	3,000	201,000	1,850	123,950		-	324,950
D5010 250 5040	Distribution Board, 480/277V, 225A	EA	7	8,125	56,875	5,375	37,625		-	94,500

		UNT	AMT	MAT/UNT	MAT	LAB/UNT	LABOR	EQP/UNT	EQP	TOT
D5010 250 6020	Distribution Board, 480/277V, 400A	EA	4	12,300	49,200	8,575	34,300		-	83,500
D5010 250 7000	Distribution Board, 480/277V, 600A	EA	5	21,400	107,000	12,700	63,500		-	170,500
D5010 240 0540	Distribution Board, 480/277V, 800A	EA	10	18,100	181,000	6,400	64,000		-	245,000
D5010 240 0560	Distribution Board, 480/277V, 1000A	EA	5	22,500	112,500	7,100	35,500		-	148,000
D5010 250 1040	Distribution Board, 120/208V, 50A	EA	5	2,475	12,375	3,075	15,375		-	27,750
D5010 250 1040	Distribution Board, 120/208V, 60A	EA	7	2,475	17,325	3,075	21,525		-	38,850
D5010 250 1040	Distribution Board, 120/208V, 100A	EA	20	2,475	49,500	3,075	61,500		-	111,000
D5010 250 1040	Distribution Board, 120/208V, 125A	EA	32	2,475	79,200	3,075	98,400		-	177,600
D5010 250 1040	Distribution Board, 120/208V, 150A	EA	21	2,475	51,975	3,075	64,575		-	116,550
D5010 250 2020	Distribution Board, 120/208V, 175A	EA	2	6,025	12,050	4,900	9,800		-	21,850
D5010 250 2020	Distribution Board, 120/208V, 225A	EA	72	6,025	433,800	4,900	352,800		-	786,600
D5010 250 2020	Distribution Board, 120/208V, 250A	EA	20	6,025	120,500	4,900	98,000		-	218,500
D5010 250 3000	Distribution Board, 120/208V, 400A	EA	28	8,475	237,300	7,725	216,300		-	453,600
D5010 250 3000	Distribution Board, 120/208V, 500A	EA	1	8,475	8,475	7,725	7,725		-	16,200
D5020 110 0480	Receptacles, 8 per 1000SF, with transformer	SF	420,864	0.74	311,439	2.41	1,014,282		-	1,325,722
D5020 130 0320	Wall Switches: 2.5 per 1000 SF	SF	420,864	0.12	50,504	0.47	197,806		-	248,310
D5020 175 1420	Motor and Starter, 75 HP AHU	EA	13	8,600	111,800	1,950	25,350		-	137,150
D5020 175 1180	Motor and Starter, 30 HP Booster Pump	EA	12	3,325	39,900	975	11,700		-	51,600
D5020 175 1480	Motor and Starter, 100 HP Chilled Water	EA	14	9,725	136,150	2,125	29,750		-	165,900
D5020 175 1300	Motor and Starter, 50 HP Chilled Water	EA	27	5,050	136,350	1,475	39,825		-	176,175
	Chiller	EA			-		-		-	-
D5020 175 0240	Motor and Starter, 1 HP	EA	177	680	120,360	325	57,525		-	177,885
D5020 175 0720	Motor and Starter, 5 HP	EA	23	1,300	29,900	540	12,420		-	42,320
D5020 175 0880	Motor and Starter, 7.5 HP	EA	12	1,325	15,900	730	8,760		-	24,660
D5020 175 1600	Motor and Starter, 150 HP	EA	5	28,600	143,000	2,675	13,375		-	156,375
D5020 175 0960	Motor and Starter, 10 HP	EA	21	1,700	35,700	740	15,540		-	51,240
Contractor	Connections	SF	420,864	3.25	1,367,808		-		-	1,367,808
Contractor	Interior Lighting	SF	420,864	14.59	6,140,406		-		-	6,140,406
Contractor	Data Comm	SF	420,864	4.56	1,919,140		-		-	1,919,140
Contractor	Security	SF	420,864	3.52	1,481,441		-		-	1,481,441
Contractor	Fire Alarm	SF	420,864	3.01	1,266,801		-		-	1,266,801
Contractor	Site Lighting	SF	420,864	1.88	791,224		-		-	791,224
Contractor	Branch Wiring	SF	420,864	5.05	2,125,363		-		-	2,125,363
Contractor	Motor and Equipment Wiring	SF	420,864	2.67	1,123,707		-		-	1,123,707
									Subtotal:	22,357,600
G Building Sitework and Landscape (Square Foot)										
									Subtotal:	2,672,800
Other (Square Foot)										
									Subtotal:	47,171,200

SUBTOTAL	169,579,700
General Conditions	15,175,484
GRAND TOTAL	**184,755,200**

BEAM CONCRETE								BOTTOM BAR (LF)				TOP BAR/ LE &RE (LF)					STIRRUP (LF)		
Name	W (in)	H (in)	L (FT)	Perim	SFCA	CF	CY	#8	#9	#10	#11	#7	#8	#9	#10	#11	#4	#5	#6
B-1,73	24	40	76.42	10.67	560.39	509.44	18.87		305.67					401.67			879.11		
B-2,109	24	14	104.50	6.33	539.92	243.83	9.03			627.00				385.50			699.83		
B-3	30	30	876.00	10.00	6,570.00	5,475.00	202.78		5,256.00				4,272.00				9,240.00		
B-4,14	36	32	171.00	11.33	1,482.00	1,368.00	50.67			855.00					1,560.00		2,368.67		
B-4A	27	40	131.50	11.17	1,030.08	986.25	36.53		526.00						747.50		1,652.67		
B-6,15,15A,16	30	32	325.80	10.33	2,497.80	2,172.00	80.44		1,954.80					155.68	1,591.20		4,213.52		
B-7	24	18	396.67	7.00	2,181.67	1,190.00	44.07	1,586.67						1,550.00			4,340.00		
B-8,10,19,24,29,35, 47,61,62,63,64,65, 66,100-103	24	24	2,040.17	8.00	12,241.00	8,160.67	302.25		8,160.67					12,630.83			20,492.80		
B-9,27	12	24	1,766.17	6.00	7,064.67	3,532.33	130.83	3,532.33					4,132.33				13,196.40		
B-11	24	22	38.00	7.67	221.67	139.33	5.16		190.00						250.00		591.87		
B-12,34	24	28	202.33	8.67	1,281.44	944.22	34.97			1,011.67					1,191.67		2,260.27		
B-13	24	20	36.25	7.33	205.42	120.83	4.48		108.75					126.75			329.27		
B-14A	23	40	29.67	10.50	212.61	189.54	7.02		148.33						249.67		388.50		
B-17	16	32	229.00	8.00	1,221.33	814.22	30.16		687.00					795.00			1,904.00		
B-18	18	24	190.00	7.00	950.00	570.00	21.11			760.00			1,000.00				1,435.00		
B-18A	18	28	28.50	7.67	152.00	99.75	3.69			114.00			354.00				333.50		
B-20,93,94	24	46	146.00	11.67	1,143.67	1,119.33	41.46			1,022.00				776.00			1,843.33		
B-21	36	48	36.00	14.00	360.00	432.00	16.00			216.00					210.00		525.00		
B-22,50	48	48	49.50	16.00	594.00	792.00	29.33			693.00					430.50		1,228.00		
B-23,51,52,55,56	36	48	113.00	14.00	1,130.00	1,356.00	50.22		565.00						572.00			1,687.00	
B-25,31,106	12	36	332.92	8.00	1,664.58	998.75	36.99		1,331.67						1,451.67		2,927.33		
B-28,41,42,53,54	48	60	192.17	18.00	2,498.17	3,843.33	142.35			1,537.33					1,921.33			3,675.00	
B-30,105	18	36	190.17	9.00	1,141.00	855.75	31.69			760.67					452.33		1,792.50		
B-32	24	52	35.50	12.67	295.83	307.67	11.40				355.00					207.50		468.67	
B-33	21	36	19.67	9.50	127.83	103.25	3.82				98.33			102.67			237.50		
B-36-37,74,104	24	36	122.25	10.00	855.75	733.50	27.17			611.25				585.00				1,523.00	
B-38-40,43,44,45	36	30	97.00	11.00	824.50	727.50	26.94		388.00					532.00			1,149.50		
B-46,67,68,71,72	24	42	78.33	11.00	587.50	548.33	20.31		313.33					433.33				1,095.60	
B-48	30	36	15.00	11.00	120.00	112.50	4.17				90.00				84.00		231.00		
B-49	27	24	17.83	8.50	115.92	80.25	2.97		71.33					95.33			229.50		
B-57-58	30	48	68.00	13.00	612.00	680.00	25.19				408.00					320.00		1,097.20	
B-59	30	60	12.67	15.00	126.67	158.33	5.86		63.33					93.33				249.00	
B-60,82,108	24	48	82.50	12.00	660.00	660.00	24.44			412.50					562.50		1,080.00		
B-69,86,87,88	24	54	67.00	13.00	569.50	603.00	22.33		268.00					364.00			1,118.00		
B-70	24	78	17.00	17.00	178.50	221.00	8.19		85.00				92.00				314.50		
B-75-77	24	60	58.83	14.00	529.50	588.33	21.79	235.33					153.67				886.67		
B-78	12	28	39.67	6.67	171.89	92.56	3.43	79.33				103.33					307.88		
B-79-80,81	24	90	65.25	19.00	750.38	978.75	36.25			261.00				272.50			1,325.25		
B-83	24	30	10.00	9.00	65.00	50.00	1.85	40.00						32.00			120.60		
B-84	24	32	19.75	9.33	131.67	105.33	3.90		79.00			103.00					234.27		
B-89	12	90	16.33	17.00	155.17	122.50	4.54		49.00					44.67			303.17		
B-90	12	24	19.17	6.00	76.67	38.33	1.42		76.67					50.33			146.40		
B-91-92	18	24	61.00	7.00	305.00	183.00	6.78	244.00					316.00				666.75		
B-95	16	21	59.92	6.17	264.63	139.81	5.18		179.75				233.75				577.35		
B-96	24	21	19.25	7.50	110.69	67.38	2.50			57.75			75.75				183.75		
B-97	12	21	19.25	5.50	72.19	33.69	1.25			57.75			75.75				165.69		
B-110	16	65	36.00	13.50	291.00	260.00	9.63	144.00					120.00				567.00		
B-111	12	18	44.83	5.00	156.92	67.25	2.49	134.50				125.67					463.33		
RB-1,2,3,4,5,6,7, 17,28	48	36	1,114.92	14	12,264.08	13,379.00	495.52		6,689.50					12,713.50			19,397.00		
RB-8,9,10,11,18,20	24	36	322.25	10	2,255.75	1,933.50	71.61		1,289.00					1,768.50			3,329.38		
RB-12,13,14,15	60	36	105.08	16	1,366.08	1,576.25	58.38		630.50					774.50			2,794.00		
RB-16	84	36	51.00	20	867.00	1,071.00	39.67		1,020.00					456.00			1,042.86		
RB-19	16	36	223.75	9	1,267.92	895.00	33.15		671.25					887.25			2,013.38		
RB-21,22	24	30	54.00	9	351.00	270.00	10.00	216.00				312.00					526.50		
RB-23	18	38	36.25	9	223.54	172.19	6.38	145.00					84.50				352.33		
RB-24	30	30	268.00	10	2,010.00	1,675	62			1,608.00				1,264.00			2,800.00		

BEAM CONCRETE								BOTTOM BAR (LF)				TOP BAR/ LE &RE (LF)					STIRRUP (LF)		
Name	W (in)	H (in)	L (FT)	Perim	SFCA	CF	CY	#8	#9	#10	#11	#7	#8	#9	#10	#11	#4	#5	#6
RB-25,26,27	30	28	112.33	10	823.78	655	24			898.67				755.33	210		1,542.80		
RB-29,30,31	42	32	91.25	12	882.08	852	32		456.25				655.50				1,242.58		
RB-32	24	40	21.25	11	155.83	142	5		85.00					109.00			242.67		
PHB-1	30	18	409.00	8	2,658.50	1,534	57	1,636.00				1,924.00					5,028.00		
TG-1	42	96	50.75	23	761.25	1,421	53				913.50					808.47		1,432.90	
TG-2	60	96	50.75	26	913.50	2,030	75				1,218.00					1,249.46			1,619.80
TG-3	66	96	50.75	27	964.25	2,233	83				1,319.50					2,083.96			1,682.10
TG-4	48	96	50.75	24	812.00	1,624	60				1,015.00					1,693.22			1,857.00
TG-5	42	96	50.75	23	761.25	1,421	53				812.00					661.48		1,432.90	
TG-6	42	96	50.75	23	761.25	1,421	53				913.50					808.47		1,432.90	
TG-7	60	96	50.75	26	913.50	2,030	75				1,218.00					1,249.46			1,619.80
TG-8	66	96	50.75	27	964.25	2,233	83				1,319.50					2,083.96			1,682.10
TG-9	48	96	50.75	24	812.00	1,624	60				1,015.00					1,693.22			1,857.00
TG-10	42	96	50.75	23	761.25	1,421	53				812.00					661.48		1,432.90	
TG-11	30	98	39.50	21	520.08	806	30				632.00			260.21				1,706.67	
TG-12	18	102	39.50	20	454.25	504	19				395.00			182.00					1,210.00
TG-13	30	90	39.50	20	493.75	741	27				632.00					195.04		1,210.00	
TG-14	30	72	21.25	17	233.75	319	12				170.00					143.26		563.13	
TG-15	48	60	36.25	18	471.25	725	27				797.50					338.00			1,001.25

TOTALS	CY		
5000 psi	3,270		
	LF	LBS	Ton
#4	123,261	82,585	41.29
#5	19,007	19,767	9.88
#6	12,529	18,794	9.40
#7	2,568	5,239	2.62
#8	19,558	52,221	26.11
#9	70,246	238,835	119.42
#10	22,988	98,848	49.42
#11	28,331	150,437	75.22

General Conditions Cost Estimate

RS Means Cost Code	Description	UNT	QTY	Hrly Rate	$/UNT	COST ($)
	PROJECT MANAGEMENT TEAM					
Construction Manager	Senior Project Manager	WK	216.325	95	3800	822,035.00
Construction Manager	Project Manager	WK	192.725	90	3600	693,810.00
Construction Manager	Site/Structure/Enclosure Superintendent	WK	216.325	120	4800	1,038,360.00
Construction Manager	MEP Superintendent	WK	194.75	80	3200	623,200.00
Construction Manager	Interiors Superintendent	WK	94.775	80	3200	303,280.00
Construction Manager	BIM Manager	WK	43.65	75	3000	130,950.00
Construction Manager	Administrative Assistant	WK	145.525	40	1600	232,840.00
Construction Manager	Senior Project Engineer	WK	145.525	60	2400	349,260.00
Construction Manager	Project Engineer-Structure/Skin	WK	145.525	50	2000	291,050.00
Construction Manager	Project Engineer-MEP	WK	192.725	50	2000	385,450.00
Construction Manager	Project Engineer-Interiors	WK	145.525	50	2000	291,050.00
Construction Manager	Field Accountant	WK	52.9	50	2000	105,800.00
					Subtotal	***5,161,285.00***
	SITE CONDITIONS					
Contractor	Temporary Heat	EA				330,000.00
Contractor	Temporary Power	EA				87,000.00
01 51 13.80 0700	Temporary Water	MO	50		68	3,400.00
01 52 13.40 0140	Temporary phone & Data	MO	50		89	4,450.00
01 56 26.50 0020	Temporary Fencing	LF	2000		7.2	14,400.00
01 74 13.20 0100	Final Cleaning	MSF	420.864		564	237,367.30
Assumption	Temporary Restrooms	EA	14		300	4,200.00
01 58 13.50 0020	Temporary Signage	SF	450		29.5	13,275.00
Assumption	Dumpsters	MO	45		1800	81,000.00
					Subtotal	***775,092.30***
	FIELD OFFICE SUPPLIES					
01 52 13.20 0300	Field Office & Furnishings	EA	1		15200	15,200.00
01 52 13.40 0100	Office Equipment	MO	50		600	30,000.00
01 52 13.40 0120	General Office Supplies	MO	50		300	15,000.00
01 52 13.40 0160	Lights and HVAC	MO	50		167	8,350.00
Assumption	Drawings and Specs	EA	25		300	7,500.00
Assumption	Mobile Phones	EA	8		200	1,600.00
Assumption	Office Water Cooler	EA	1		500	500.00
01 31 13.40 0130	Main Office Expense	Job	20000000		0.10%	20,000.00
					Subtotal	***98,150.00***
	CONSTRUCTION SUPPLIES					
01 54 19.50 0500	Tower Crane	MO	18		320000	5,760,000.00
01 54 36.50 0020	Mobilization/Demobilization	EA	2		300000	600,000.00
01 54 39.70 0020	Small Tools	EA	1		750,000	750,000.00
01 45 23.50 0100	Testing and Inspecting	EA	1		250000	250,000.00
					Subtotal	***7,360,000.00***
	SAFETY					
Assumption	PPE's	MO	50		50	2,500.00
Assumption	First Aid + Monthly Upkeep	MO	50		50	2,500.00
Assumption	Fall Protection	EA	8		200	1,600.00
Assumption	Safety Program and Training	MO	50		80	4,000.00
Assumption	Fire Extinguishers	EA	25		90	2,250.00
01 54 09.60 00340	Safety Net	LF	1832		1.15	2,106.80
					Subtotal	***14,956.80***
	MISCELLANEOUS					
01 41 26.50 0020	Bonding	%	1			1,766,000.00
	Insurance	%	1			1,766,000.00
					GRAND TOTAL	**15,175,484.10**

H (ft)	SLABS (SF)		Roof (SF)		Slab Breakout (SF)												Drop Panels			Slab Rebar (LF)					
					H (in)	SF	CF	PSI	H (in)	SF	CF	PSI	H (in)	SF	CF	PSI	SF	CF	CY	#4	#5	#6	#8	#9	#11
14	LB	56,746			44	48,667	178,446	Below	60	8,079	40,395	6,000	5	15,115	6,298	3,500	-	-	-	-	-	-	-	240,319	7,336
14	UB	9,891			8	9,891	6,594	5,000									-	-	-	15,085	15,497	6,640	23	103	21
20	1	39,594			Specific Breakout below												6,470	2,747	101.72	63,404	65,136	27,908	98	431	89
17.33	2	33,616	lvl 2 Roof	4,492	8	29,347	19,565	5,000	10	4,269	3,558	5,000	10	4,492	3,743	5,000	5,493	2,922	108.20	51,268	52,668	22,566	80	349	72
14.67	3	35,758			8	31,489	20,993	5,000	10	4,269	3,558	5,000					5,843	2,918	108.08	54,535	56,024	24,004	85	371	77
14.67	4	35,718			8	31,449	20,966	5,000	10	4,269	3,558	5,000					5,836	2,922	108.20	54,474	55,962	23,978	84	371	77
14.67	5	35,758			8	31,489	20,993	5,000	10	4,269	3,558	5,000					5,843	2,547	94.33	54,535	56,024	24,004	85	371	77
14.67	6	31,173	lvl 6 Roof	4,545	8	26,904	17,936	5,000	10	4,269	3,558	5,000	10	4,545	3,788	5,000	5,094	2,115	78.32	47,542	48,841	20,926	74	323	67
14.67	7	25,881	lvl 7 Roof	5,292	8	21,612	14,408	5,000	10	4,269	3,558	5,000	Composite Metal deck, see S127W				4,229	2,115	78.32	39,471	40,549	17,374	61	269	55
14.67	8	25,881			8	23,025	15,350	5,000	10	2,856	2,380	5,000					4,229	2,115	78.32	39,471	40,549	17,374	61	269	55
14.67	9	25,881			8	23,025	15,350	5,000	10	2,856	2,380	5,000					4,229	2,115	78.32	39,471	40,549	17,374	61	269	55
18	10	25,881			8	23,025	15,350	5,000	10	2,856	2,380	5,000					4,229	2,115	78.32	39,471	40,549	17,374	61	269	55
16	LP	25,881			9	23,025	17,269	5,000	10	2,856	2,380	5,000					4,229	2,115	78.32	39,471	40,549	17,374	61	269	55
24	UP	13,205			8	10,349	6,899	5,000	10	2,856	2,380	5,000					2,158	1,079	39.96	20,139	20,689	8,865	31	137	28
27.33	Parapet ht.		Roof	25,881	8	18,680	12,453	5,000	9	3,490	2,618	5,000	11	3,711	3,402	5,000		TOTAL	LF	558,336	573,588	245,762	866	3,798	784
																			LBS	374,085.32	596,531.05	368,642.32	2,311.69	12,913.50	4,163.69
																			TON	187.04	298.27	184.32	1.16	6.46	2.08

Total SF	420,864
(no roof)	

Slab/Wall Totals			
TOTALS	CF	CY	
3500	11,716	434	
5000	654,269	24,232	
6000	127,918	4,738	
7000	865.58	32	
	LF	LBS	Ton
#4	700,839	469,562	235
#5	726,376	755,431	378
#6	270,302	405,453	203
#7	56,602	115,468	58
#8	142,883	381,498	191
#9	244,959	832,859	416
#11	8,120	43,118	22

Level 1 Slab Breakout (SF)											
H (in)	SF	CF	PSI	H (in)	SF	CF	PSI	H (in)	SF	CF	PSI
8	19,522	13,015	5,000	54	168	756	3500				
10	9,423	7,853	5,000	Topping slabs				Topping slab			
12	24,548	24,548	5,000	6	3,401	1,701	3500	48	497	1,988	3500
								24	487	974	3500

Mat Slab PSI		CF
6000	22,731.25	83,348
5000	25,935.75	95,098

X/12		Rebar	
1	0.083	#4	0.67
2	0.167	#5	1.04
3	0.250	#6	1.5
4	0.333	#7	2.04
5	0.417	#8	2.67
6	0.500	#9	3.4
7	0.583	#10	4.3
8	0.667	#11	5.31
9	0.750		
10	0.833		
11	0.917		

	Slab Rebar Level 2 Breakout (LF)					
	#4	#5	#6	#8	#9	#11
Bottom Mat	51,268	13,325				
Extra Bottom		480	2,452		288	
		133	2,219			
		7,075	1,201			
		776	1,594			
			138			
Top Bar		2,120	4,532			72
			5,995			
		2,207	319			
		3,053	2,102			
		2,227	1,144			
		5,826	289			
		1,439	583			
		1,314				
		1,489				
		5,918				
		2,613				
		2,459				
		216				
Mid Bar				80	61	
TOTALS (LF)	51,268	52,668	22,566	80	349	72

Shear Walls													
	PSI	H (ft)	W (ft)	L (ft)	Openings (CF)	CF	CY	Rebar (LF)					
								#4	#5	#6	#7	#8	#9
SW-1	6000	28	1	16.33	-	457.33	16.94						
	5000	198	1	16.33	-	3,234	119.78	12,448	3,962	5,175	891	912	
SW-2	6000	28	1	19.50	-	546	20.22						
	5000	158	1	19.50	92.15	2,988.85	110.70	12,407	2,448			128	128
SW-3	6000	28	1	29.33	-	821.33	30.42						
	5000	158	1	29.33	124.88	4,509.79	167.03	19,432	3,392	3,344			144
SW-4	6000	28	1	25.00	-	700.00	25.93						
	5000	174	1	25.00	26.67	4,323.33	160.12						
	5000	37	1	19.75	-	730.75	27.06	27,412		4,288			
SW-5	6000	28	1	24.00	-	672.00	24.89						
	5000	198	1	24.00	26.67	4,725.33	175.01						
	5000	11.33	1	20.00	-	226.67	8.40	22,712	3,712	2,144			
SW-6	7000	28	1.5	26.00	226.42	865.58	32.06						
	5000	20	1.5	26.00	226.42	553.58	20.50						
	5000	138	1	26.00	-	3,588	132.89						
	5000	64	1	22.50	63.56	1,376.44	50.98	16,483	7,076	2,485	6,493	895	570
SW-7	6000	28	1	12.67	-	354.67	13.14						
	5000	158	1	12.67	-	2,001.33	74.12	10,609	1,959	3,552			
SW-8	6000	28	1	23.00	20.25	623.75	23.10						
	5000	20	1	23.00	-	460	17.04						
	5000	138	1	19.33	-	2,668	98.81	21,000		3,552			
						TOTAL	LF	142,502	22,550	24,541	7,384	1,935	842
							LBS	95,476.56	23451.5	36811	15063.4	5167.34	2862.8
							TON	47.74	11.73	18.41	7.53	2.58	1.43

	Mat Slab Rebar	
	#9	#11
Btm/Top Mat	223,896	
Extra Bar Vert	10,105	468
Extra Bar Horiz	6,318	6,868
TOTAL LF	240,319	7,336
LBS	817,082.90	38,954.16
TON	408.54	19.48

Foundation Walls								
PSI	H (ft)	W (ft)	L (ft)	CF	CY	Rebar (LF)		
						#5	#7	#8
5000	28	2	946.5	53004	1963.11	130,238	49,218	140,082
				TOTAL	LBS	135,447.94	100,404.72	374,018.94
					TON	67.72	50.20	187.01

Location	Type	Weight (PLF	Length	LBS	TONS
	Wide Flange				
UB Catwalk	W8x15	15	571.8	8,576.25	4.29
	W12x22	22	98.0	2,156.00	1.08
SE1-2	W10x15	15	89.3	1,338.75	0.67
	W8x10	10	10.0	100.00	0.05
Atrium Roof	W18x65	65	32.0	2,080.00	1.04
	W16x26	26	38.8	1,007.50	0.50
	W18x50	50	32.0	1,600.00	0.80
	W12x16	16	32.0	512.00	0.26
	W14x22	22	34.0	748.00	0.37
	W10x12	12	24.5	294.00	0.15
	W18x40	40	576.0	23,040.00	11.52
	W8x10	10	117.0	1,170.00	0.59
	W18x55	55	56.3	3,093.75	1.55
	W18x35	35	1,852.5	64,837.50	32.42
	W8x15	15	1,512.8	22,691.25	11.35
	W18x40	40	640.0	25,600.00	12.80
	Channels				
Stair 1	C8x11.5	11.5	115.5	1,328.25	0.66
SW3	C8x11.5	11.5	416.5	4,789.75	2.39
2nd N Collab	C4x4.5	4.5	29.5	132.75	0.07
	C8x11.5	11.5	29.5	339.25	0.17
SW8	C8x11.5	11.5	40.5	465.75	0.23
Elev 3-6	C8x11.5	11.5	180.0	2,070.00	1.04
Elev 1-2	C8x11.5	11.5	436.5	5,019.75	2.51
	HSS Tubes				
Elev. 1-2	HSS8x4x5/16	23.34	106.0	2,474.04	1.24
UB	HSS8x4x5/16	23.34	32.0	746.88	0.37
UB	HSS4x4x5/16	14.83	42.0	622.86	0.31
Tower Crane	HSS6x6x1/4	19.02	80.0	1,521.60	0.76
	HSS6x6x5/16	23.34	40.0	933.60	0.47
Elev. 3-6	HSS8x4x5/16	23.34	16.5	385.11	0.19
Atrium	HSS6x4x1/4	15.62	520.0	8,122.40	4.06
	HSS6x6x5/16	23.34	192.0	4,481.28	2.24
	HSS5x5x5/16	19.08	96.0	1,831.68	0.92
Vestibule	HSS3x2x1/4	5.59	169.0	944.71	0.47
	HSS10x6x1/4	25.82	13.0	335.66	0.17
	HSS6x6x1/4	19.02	22.0	418.44	0.21
Walkway	HSS14x6x3/8	47.9	234.0	11,208.60	5.60
Elev 3-6	HSS6x4x5/16	19.08	192.0	3,663.36	1.83
N Collab Twr	HSS6x6x3/8	27.48	33.8	927.45	0.46
	HSS8x6x3/8	32.58	120.7	3,931.32	1.97
	HSS6x6x3/8	27.48	196.0	5,386.08	2.69
Floor 6	HSS6x6x5/8	42.3	14.7	620.54	0.31
	HSS6x6x5/16	23.34	240.2	5,606.27	2.80
	HSS6x6x3/8	27.48	15.0	412.20	0.21
Atrium Roof	HSS6x6x3/8	27.48	161.4	4,434.45	2.22
UP	HSS10x10x1/2	62.46	175.0	10,930.50	5.47
	HSS10x10x5/16	40.35	214.0	8,634.90	4.32
	HSS5x5x1/4	15.62	4.5	70.29	0.04
	HSS8x8x5/16	31.84	494.8	15,752.84	7.88
	HSS5x5x5/16	19.08	960.0	18,316.80	9.16

STEEL SUMMARY

Type	LF	LBS	TONS
Wide Flange			
W8x10	127.00	1,270	0.64
W8x15	2,084.50	31,268	15.63
W10x12	24.50	294	0.15
W10x15	89.25	1,339	0.67
W12x16	32.00	512	0.26
W12x22	98.00	2,156	1.08
W14x22	34.00	748	0.37
W16x26	38.75	1,008	0.50
W18x35	1,852.50	64,838	32.42
W18x40	1,216.00	48,640	24.32
W18x50	32.00	1,600	0.80
W18x55	56.25	3,094	1.55
W18x65	32.00	2,080	1.04
Channels		LBS	TONS
C4x4.5	29.50	133	0.07
C8x11.5	1,218.50	14,013	7.01
HSS Tubes		LBS	TONS
HSS3x2x1/4	169.00	945	0.47
HSS4x4x5/16	42.00	623	0.31
HSS5x5x1/4	4.50	70	0.04
HSS5x5x5/16	1,056.00	20,148	10.07
HSS6x4x1/4	520.00	8,122	4.06
HSS6x4x5/16	192.00	3,663	1.83
HSS6x6x1/4	102.00	1,940	0.97
HSS6x6x5/16	472.20	11,021	5.51
HSS6x6x3/8	406.12	11,160	5.58
HSS6x6x5/8	14.67	621	0.31
HSS8x4x5/16	154.50	3,606	1.80
HSS8x6x3/8	120.67	3,931	1.97
HSS8x8x5/16	494.75	15,753	7.88
HSS10x6x1/4	13.00	336	0.17
HSS10x10x5/16	214.00	8,635	4.32
HSS10x10x1/2	175.00	10,931	5.47
HSS14x6x3/8	234.00	11,209	5.60

Columns (LF)									Column Rebar			Stirrup
Name	Floors	f'c (psi)	L	W	H	SFCA	Perim	TOT CF	#8 LF	#11 LF	#10 LF	#4 LF
A1.5	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
A2	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
A3	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
A4	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
A5	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
A6	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
A7	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
A7.5	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
A8	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
A9	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
A10	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
A11.5	LB-1	5,000	2	2	48	384	8	192	384	-	-	432
B1.5	LB-UP	5,000	2	2	226	1,808	8	904	1,872	576	-	2,712
B2	LB-UB	6,000	2	2	28	224	8	112	1,872	576	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
B3	LB-UB	6,000	2	2	28	224	8	112	1,552	1,296	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
B4	LB-UB	6,000	2	2	28	224	8	112	1,392	1,296	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
B5	LB-UB	6,000	2	2	28	224	8	112	1,392	1,296	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
B6	LB-UB	6,000	2	2	28	224	8	112	1,392	1,296	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
B7	LB-UB	6,000	2	2	28	224	8	112	1,392	1,296	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
B7.5	LB-UB	6,000	2	2.33	28	243	9	131	1,477	1,296	-	476
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
B8	LB-UB	6,000	2	2.33	28	243	9	131	1,221	1,552	-	476
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
B9	LB-1	6,000	2.67	2.00	48	448	9	256	1,392	1,728	-	912
	2-UP	5,000	2	2	178	1,424	8	712			-	1,602
B10	LB-1	6,000	2.33	2.67	48	480	10	299	1,296	1,792	-	936
	2-UP	5,000	2	2	178	1,424	8	712			-	1,602
B11	LB-UB	6,000	2	2	28	224	8	112	720	576	-	336
	2-UP	5,000	2	2	178	1,424	8	712			-	1,602
B11.5	LB-UB	6,000	2	2	28	224	8	112	1,931	976	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
B1-1.5	LB-2	5,000	2	2	65	523	8	261		976	-	784
B1-2	parapet	5,000	2	2	27	219	8	109	251	-	-	246
B1-3	parapet	5,000	2	2	27	219	8	109	251	-	-	246
B1-4	parapet	5,000	2	2	27	219	8	109	251	-	-	246
B1-5	parapet	5,000	2	2	27	219	8	109	251	-	-	246
B1-6	parapet	5,000	2	2	27	219	8	109	251	-	-	246
B1-7	parapet	5,000	2	2	27	219	8	109	251	-	-	246
B1-7.5	parapet	5,000	2	2	27	219	8	109	251	-	-	246
B1-8	parapet	5,000	2	2	27	219	8	109	251	-	-	246
B1-9	parapet	5,000	2	2	27	219	8	109	251	-	-	246
B1-10	parapet	5,000	2	2	27	219	8	109	251	-	-	246
B1-11	parapet	5,000	2	2	27	219	8	109	251	-	-	246
B1-11.5	LB-UB	6,000	2.33	2	28	243	9	131	-	976	-	476
	1-2	5,000	2.33	2	37	324	9	174			-	635
B1-12	3-Par	5,000	2	2	188	1,504	8	752	1,931	-	-	1,692
C1	3-Par	5,000	2	2	188	1,504	8	752	1,931	-	-	1,692
C1.5	LB-2	7,000	4	2.33	65	828	13	610	-	1,789	-	1,895
C2	LB-UB	6,000	2	2	28	224	8	112	1,867	224	-	336
	1,3-10	5,000	2	2	141	1,125	8	563			-	1,266

Columns (LF)									Column Rebar			Stirrup
Name	Floors	f'c (psi)	L	W	H	SFCA	Perim	TOT CF	#8 LF	#11 LF	#10 LF	#4 LF
C3	LB-UB	6,000	2.33	2	28	243	9	131	1,707	1,200	-	476
	1-10	5,000	2	2	158	1,264	8	632			-	1,422
C4	LB-UB	6,000	2.33	2	28	243	9	131	1,296	976	-	476
	1-10	5,000	2	2	158	1,264	8	632			-	1,422
C5	LB-UB	6,000	2.33	2	28	243	9	131	1,296	976	-	476
	1-10	5,000	2	2	158	1,264	8	632			-	1,422
C6	LB-UB	6,000	2.33	2	28	243	9	131	1,296	976	-	476
	1-10	5,000	2	2	158	1,264	8	632			-	1,422
C7	LB-UB	6,000	2.33	2	28	243	9	131	1,296	976	-	476
	1-10	5,000	2	2	158	1,264	8	632			-	1,422
C7.5	LB-UB	6,000	2	2	28	224	8	112	1,477	720	-	336
	1-10	5,000	2	2	158	1,264	8	632			-	1,422
C8	LB-UB	6,000	2.33	2	28	243	9	131	1,477	720	-	476
	1-10	5,000	2	2	158	1,264	8	632			-	1,422
C9	LB-UB	6,000	2.33	2	28	243	9	131	1,296	976	-	476
	1-10	5,000	2	2	158	1,264	8	632			-	1,422
C10	LB-1	6,000	2.33	2	48	416	9	224	1,072	1,200	-	816
	2-10	5,000	2	2	138	1,104	8	552			-	1,242
C11	LB-UB	6,000	2	2	28	224	8	112	1,355	243	-	336
	3-10	5,000	2	2	121	965	8	483			-	1,086
C11.5	LB-2	7,000	4	2.33	65	828	13	610		1,789	-	1,895
C12	3-Par	5,000	2	2	188	1,504	8	752	1,931	-	-	1,692
D1	3-Par	5,000	2	2	188	1,504	8	752	2,005	-	-	1,692
D1.5	LB-2	7,000	4	2.33	65	828	13	610	-	1,789	-	1,895
D2	LB-1	6,000	2	2	48	384	8	192	1,493	1,323	-	576
	3	5,000	2.33	2	15	127	9	68			-	249
	4-UP	5,000	2	2	146	1,168	8	584			-	1,314
D3	LB-UB	6,000	2	2.58	28	257	9	145	2,088	1,296	-	518
	1-UP	5,000	2	2.58	198	1,815	9	1,023			-	3,663
D4	LB-1	6,000	2.33	2.33	48	448	9	261	1,573	1,749	-	672
	2-3	5,000	2.33	2	32	277	9	149			-	312
	4-UP	5,000	2	2	146	1,168	8	584			-	1,314
D5	LB-1	6,000	2.33	2.33	48	448	9	261	1,573	1,568	-	672
	2-3	5,000	2.33	2	32	277	9	149			-	544
	4-UP	5,000	2	2	146	1,168	8	584			-	1,314
D6	LB-UB	6,000	2	2	28	224	8	112	2,053	720	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	2,376
D7	LB-UB	6,000	2.33	2	28	243	9	131	1,573	1,824	-	476
	1-3	5,000	2.33	2	52	451	9	243			-	884
	4-UP	5,000	2	2	146	1,168	8	584			-	1,314
D7.5	LB-UB	6,000	2	2.33	28	243	9	131	1,531	1,344	-	476
	2-3	5,000	3	2.33	32	341	11	224			-	688
	4-UP	5,000	2	2	146	1,168	8	584			-	1,314
D8.2	LB-UB	6,000	1	2	28	168	6	56	2,256	-	-	378
	1-UP	5,000	1	2	198	1,188	6	396			-	2,673
D9.2	LB-UB	6,000	1	2	28	168	6	56	2,304	-	-	378
	1-10	5,000	1	2	158	948	6	316			-	2,133
	LP-UP	5,000	1.5	1.5	40	240	8	90			-	420
D10	LB-UB	6,000	2	2	28	224	8	112	1,936	720	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
D11	LB-UB	6,000	2	2	28	224	8	112	2,144	672	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
D11.5	LB-2	7,000	4	2.33	65	828	13	610	-	1,789	-	1,895
D12	3-Par	5,000	2	2	188	1,504	8	752	1,419	448	-	1,692
D.5-5.5	LB-UB	6,000	2	2	28	224	8	112	1,872	-	-	336
	1-2	5,000	1.33	2	37	249	7	100			-	523
	3-10	5,000	1	2	121	724	6	241			-	1,629
D.5-6.5	LB-UB	6,000	2	2	28	224	8	112	1,872	-	-	336
	1-2	5,000	1.33	2	37	249	7	100			-	523
	3-10	5,000	1	2	121	724	6	241			-	1,629
E1	3-Par	5,000	2	2	188	1,504	8	752	2,005	-	-	1,692

Columns (LF)									Column Rebar			Stirrup
Name	Floors	f'c (psi)	L	W	H	SFCA	Perim	TOT CF	#8 LF	#11 LF	#10 LF	#4 LF
E1.5	LB-2	7,000	3	2	65	653	10	392		1,627	-	1,372
E2	LB-UB	6,000	2	2	28	224	8	112	2,587		-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
E3	LB-UB	6,000	2	2	28	224	8	112	1,717	976	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
E4	LB-1	6,000	2.33	2.33	48	448	9	261	1,269	1,888	-	672
	2-3	5,000	2.33	2.33	32	299	9	174			-	448
	4-UP	5,000	2	2	146	1,168	8	584			-	1,314
E5	LB-1	6,000	2.33	2.33	48	448	9	261	1,269	1,888	-	672
	2-3	5,000	2.33	2.33	29	274	9	160			-	411
	4-UP	5,000	2	2	146	1,168	8	584			-	1,314
E6	LB-UB	6,000	2	2	28	224	8	112	1,973	720	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
E7	LB-UB	6,000	2.33	2.33	28	261	9	152	1,493	1,664	-	392
	1-3	5,000	2.33	2	52	451	9	243			-	884
	4-UP	5,000	2	2	146	1,168	8	584			-	1,314
E7.5	LB-UB	6,000	2.33	2.33	28	261	9	152	1,493	1,424	-	392
	1-3	5,000	2.33	2	52	451	9	243			-	884
	4-UP	5,000	2	2	146	1,168	8	584			-	1,314
E8	LB-UB	6,000	2	2	28	224	8	112	2,085	720	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
E9	LB-UB	6,000	2	2	28	224	8	112	1,973	720	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
E10	LB-UB	6,000	2	2	28	224	8	112	1,717	976	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
E11	LB-UB	6,000	2	2	28	224	8	112	2,587	-	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
E11.5	LB-2	7,000	4	2	65	784	12	523	-	1,627	-	1,176
E12	3-Par	5,000	2	2	188	1,504	8	752	2,005	-	-	1,692
E.5-1	3-Par	5,000	2	2	188	1,504	8	752	2,005	-	-	1,692
E.5-1.5	LB-2	5,000	2	2	65	523	8	261	-	976	-	784
E.5-2	parapet	5,000	2	2	27	219	8	109	251	-	-	246
E.5-3	parapet	5,000	2	2	27	219	8	109	251	-	-	246
E.5-4	parapet	5,000	2	2	27	219	8	109	251	-	-	246
E.5-5	parapet	5,000	2	2	27	219	8	109	251	-	-	246
E.5-6	parapet	5,000	2	2	27	219	8	109	251	-	-	246
E.5-7	parapet	5,000	2	2	27	219	8	109	251	-	-	246
E.5-7.5	parapet	5,000	2	2	27	219	8	109	251	-	-	246
E.5-8	parapet	5,000	2	2	27	219	8	109	251	-	-	246
E.5-9	parapet	5,000	2	2	27	219	8	109	251	-	-	246
E.5-10	parapet	5,000	2	2	27	219	8	109	251	-	-	246
E.5-11	parapet	5,000	2	2	27	219	8	109	251	-	-	246
E.5-11.5	LB-2	6,000	2	2	65	523	8	261	-	976	-	784
E.5-12	3-Par	5,000	2	2	188	1,504	8	752	1,931	-	-	1,692
F1.5	LB-UP	5,000	2	2	226	1,808	8	904	2,256	-	-	2,034
F2	LB-UB	6,000	2	2	28	224	8	112	2,368	-	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
F3	LB-UB	6,000	2.33	2	28	243	9	131	2,400	-	-	476
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
F4	LB-UB	6,000	2.33	2	28	243	9	131	2,400	-	-	476
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
F5	LB-UB	6,000	2.33	2	28	243	9	131	2,400	-	-	476
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
F6	LB-UB	6,000	2.33	2	28	243	9	131	2,400	-	-	476
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
F7	LB-UB	6,000	2.33	2	28	243	9	131	2,400	-	-	476
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
F7.5	LB-UB	6,000	2.33	2.33	28	261	9	152	1,381	1,424	-	392
	1-2	5,000	2.33	2	37	324	9	174			-	635
	3-UP	5,000	2	2	161	1,285	8	643			-	1,446

Columns (LF)									Column Rebar			Stirrup
Name	Floors	f'c (psi)	L	W	H	SFCA	Perim	TOT CF	#8 LF	#11 LF	#10 LF	#4 LF
F8	LB-UB	6,000	2.33	2.33	28	261	9	152	1,531	1,200	-	392
	1	5,000	2.33	2	20	173	9	93			-	340
	2-UP	5,000	2	2	178	1,424	8	712			-	1,602
F9	LB-UB	6,000	2.33	2.33	28	261	9	152	1,531	1,200	-	392
	1	5,000	2.33	2	20	173	9	93			-	340
	2-UP	5,000	2	2	178	1,424	8	712			-	1,602
F10	LB-UB	6,000	2.33	2.33	28	261	9	152	1,531	1,200	-	392
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
F11	LB-UB	6,000	2	2	28	224	8	112	1,392	720	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
F11.5	LB-UB	6,000	2	2	28	224	8	112	1,392	720	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
G2	LB-UB	6,000	2.33	2.17	28	252	9	142	288	-	-	483
G3	LB-UB	6,000	2.33	2	28	243	9	131	1,216	432	-	476
	1-5	5,000	2	2	81	651	8	325			-	732
G4	LB-UB	6,000	2	2	28	224	8	112	432	-	-	336
G4.5	1-5	5,000	2	2	81	651	8	325	1,216	-	-	732
G5	LB-UB	6,000	2.33	2	28	243	9	131	-	432	-	476
G5.5	1-5	5,000	2	2	81	651	8	325	811	-	-	732
G6	LB-UB	6,000	2	2	28	224	8	112	432	-	-	336
G7	LB-UB	6,000	2.33	2	28	243	9	131	811	432	-	476
	1-5	5,000	2	2	81	651	8	325			-	732
G7.5	LB-UB	6,000	2	2	28	224	8	112	1,605	976	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
F.6-11.8	LB-UB	6,000	2	2	28	224	8	112	432	-	-	336
G3-11.8	LB-UB	6,000	2	2	28	224	8	112	432	-	-	336
H2	LB-UB	6,000	2.33	2.17	28	252	9	142	-	-	288	483
H3	LB-UB	6,000	2.33	2	28	243	9	131	1,216	432	-	476
	1-5	5,000	2	2	81	651	8	325			-	732
H4	LB-UB	6,000	2	2	28	224	8	112	432	-	-	336
H4.5	1-5	5,000	2	2	81	651	8	325	1,216	-	-	732
H5	LB-UB	6,000	2.33	2	28	243	9	131	-	432	-	476
H5.5	1-5	5,000	2	2	81	651	8	325	1,216	-	-	732
H6	LB-UB	6,000	2	2	28	224	8	112	432	-	-	336
H7	LB-UB	6,000	2.33	2	28	243	9	131	811	432	-	476
	1-5	5,000	2	2	81	651	8	325			-	732
H7.5	LB-UB	6,000	2	2	28	224	8	112	1,605	-	-	336
	1-UP	5,000	2	2	198	1,584	8	792			-	1,782
H.2-10	LB-UB	6,000	2	2	28	224	8	112	288		-	336
H.2-10.5	LB-UB	6,000	2	2	28	224	8	112		432	-	336
H.2-11.8	LB-UB	6,000	2	2	28	224	8	112	432		-	336
I2	LB-UB	6,000	2.33	2.17	28	252	9	142	-	-	288	483
I3	LB-UB	6,000	2	2	28	224	8	112	-	432	-	336
I4	LB-UB	6,000	2.33	2	28	243	9	131	-	432	-	476
I5	LB-UB	6,000	2.33	2	28	243	9	131	-	432	-	476
I6	LB-UB	6,000	2.33	2	28	243	9	131	-	432	-	476
I7	LB-UB	6,000	2.33	2	28	243	9	131	-	576	-	476
I7.5	LB-UB	6,000	2.33	2	28	243	9	131	-	576	-	476
I8	LB-UB	6,000	2.33	2	28	243	9	131	-	576	-	476
I9	LB-UB	6,000	2.33	2	28	243	9	131	-	432	-	476
I10	LB-UB	6,000	2	2	28	224	8	112	-	432	-	336
I11.8	LB-UB	6,000	2	2	28	224	8	112	432	-	-	336
I10.5	LB-UB	6,000	2	2	28	224	8	112	288	-	-	336
AA102	LB-UB	6,000	2	2	28	224	8	112	2,208	240	-	336
	1	5,000	1.33	2.33	20	147	7	62			-	320
	2-UP	5,000	1	2	178	1,068	6	356			-	1,202
AA103	1	5,000	1.17	2	20	127	6	47	2,016	-	-	275
	2-UP	5,000	1	2	178	1,068	6	356			-	1,202
AA104	LB-UB	6,000	2	2	28	224	8	112	1,776	672	-	336
	1	5,000	1.33	2.33	20	147	7	62			-	320
	2-UP	5,000	1	2	178	1,068	6	356			-	2,403

Columns (LF)									Column Rebar			Stirrup
Name	Floors	f'c (psi)	L	W	H	SFCA	Perim	TOT CF	#8 LF	#11 LF	#10 LF	#4 LF
BB102	LB-UB	6,000	2	2	28	224	8	112	2,496	-	-	336
	1	5,000	1.17	2	20	127	6	47			-	275
	2-UP	5,000	1	2	178	1,068	6	356			-	2,403
BB103	1-UP	5,000	1	2	198	1,188	6	396	1,968	-	-	2,673
BB104	LB-UB	6,000	2	2	28	224	8	112	2,400	-	-	336
	1-2	5,000	1.33	2	37	249	7	100			-	523
	3-UP	5,000	1	2	161	964	6	321			-	2,169
CC101	LB-UB	6,000	2	2	28	224	8	112	2,507	-	-	336
	1-6	5,000	2	2	96	768	8	384			-	864
	7-Par	5,000	1.67	2	129	948	7	431			-	1,875
CC102	LB-UB	6,000	2	2	28	224	8	112	2,400	-	-	336
	1-2	5,000	1.33	2	37	249	7	100			-	523
	3-UP	5,000	1	2	161	964	6	321			-	2,169
CC103	1	5,000	1.33	2	20	133	7	53	1,968	-	-	280
	2-7	5,000	1.17	2	91	574	6	212			-	1,247
	8-UP	5,000	1	2	87	524	6	175			-	1,179
CC104	LB-UB	6,000	2	2	28	224	8	112	2,400	-	-	336
	1-2	5,000	1.33	2	37	249	7	100			-	523
	3-Par	5,000	1	2	188	1,128	6	376			-	2,538
CC105	LB-UB	6,000	2.33	2	28	243	9	131	1,109	432	-	476
	1-7	5,000	2	2	111	885	8	443			-	996
DD102	7-LP	5,000	1.5	2	78	546	7	234	468	-	-	1,112
DD103	7-LP	5,000	1.5	3	78	702	9	351	468	-	-	1,580
EE101	LB-UB	6,000	2	2	28	224	8	112	1,365	432	224	336
	1-7	5,000	2	2	111	885	8	443				996
EE103	LB-UB	6,000	2.33	2	28	243	9	131	821	720	480	476
	1-7	5,000	2	2	111	885	8	443				996
EE105	LB-UB	6,000	2	2	28	224	8	112	1,797	-	224	336
	1-7	5,000	2	2	111	885	8	443				996

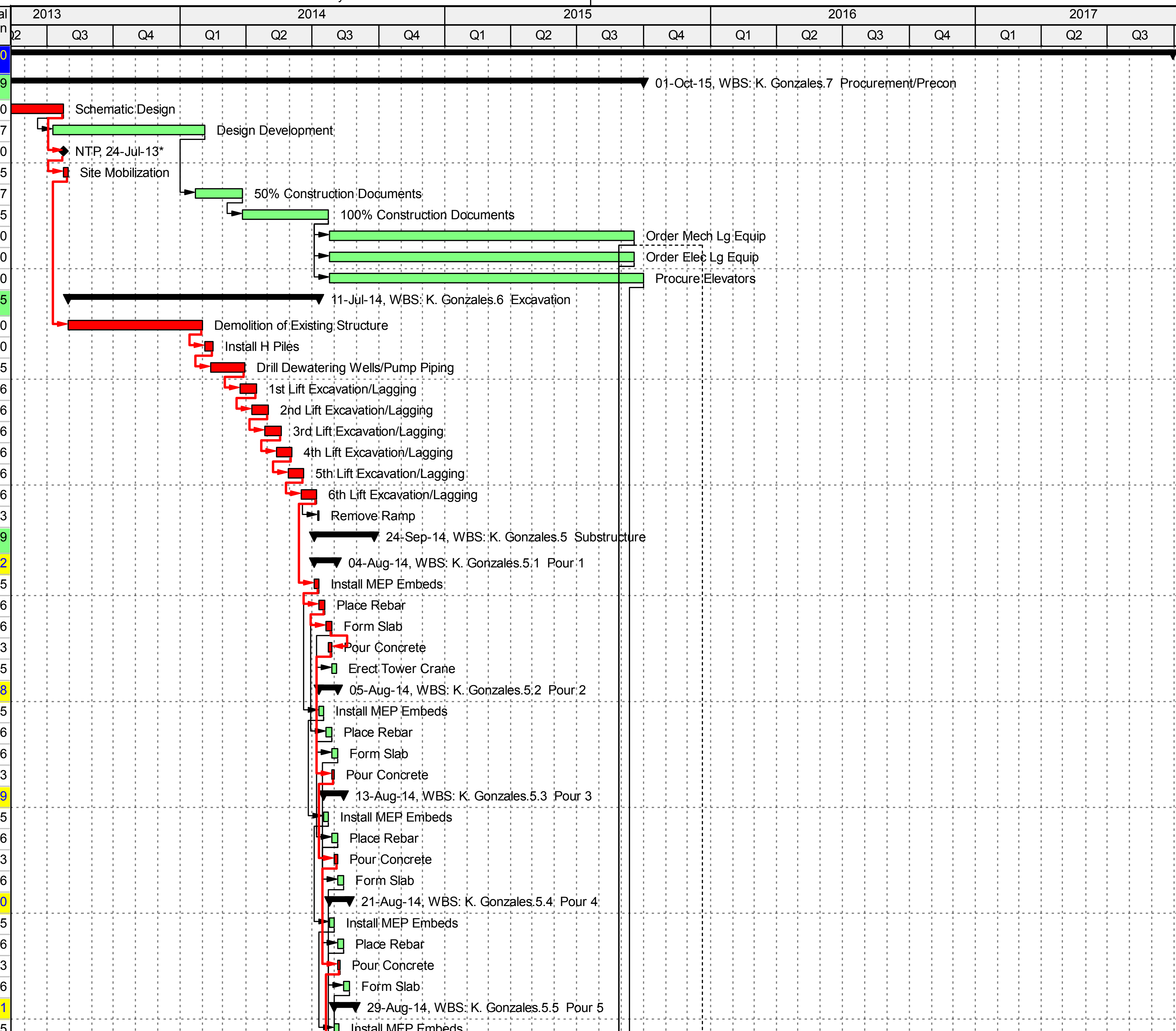
TOTALS	CF	CY	
5000	67,567	2,502	
6000	13,655	506	
7000	3,354	124	
	LF	LBS	Ton
#8	175,648	468,980	234
#11	78,973	419,348	210
#10	1,504	6,467	3
#4	234,327	156,999	78

Appendix A.3

Detailed Schedule

HSFIII — Classic Schedule Layout — 17-Oct-14 07:44

Activity ID	Activity Name	Start	Finish	Original Duration
Project: K. Gonzales HSFIII		15-Apr-13	29-Sep-17	1160
WBS: K. Gonzales.7 Procurement/Precon		15-Apr-13	01-Oct-15	639
A4010	Schematic Design	15-Apr-13	23-Jul-13	70
A4020	Design Development	10-Jul-13	04-Feb-14	147
A4030	NTP	24-Jul-13*		0
A4040	Site Mobilization	24-Jul-13	30-Jul-13	5
A4050	50% Construction Documents	22-Jan-14	27-Mar-14	47
A4060	100% Construction Documents	28-Mar-14	24-Jul-14	85
A3930	Order Mech Lg Equip	25-Jul-14	17-Sep-15	300
A3940	Order Elec Lg Equip	25-Jul-14	17-Sep-15	300
A4070	Procure Elevators	25-Jul-14	01-Oct-15	310
WBS: K. Gonzales.6 Excavation		31-Jul-13	11-Jul-14	245
A1000	Demolition of Existing Structure	31-Jul-13	31-Jan-14	130
A1010	Install H Piles	03-Feb-14	14-Feb-14	10
A1020	Drill Dewatering Wells/Pump Piping	11-Feb-14	31-Mar-14	35
A1030	1st Lift Excavation/Lagging	25-Mar-14	15-Apr-14	16
A1040	2nd Lift Excavation/Lagging	10-Apr-14	01-May-14	16
A1050	3rd Lift Excavation/Lagging	28-Apr-14	19-May-14	16
A1060	4th Lift Excavation/Lagging	14-May-14	04-Jun-14	16
A1070	5th Lift Excavation/Lagging	30-May-14	20-Jun-14	16
A1080	6th Lift Excavation/Lagging	17-Jun-14	08-Jul-14	16
A1090	Remove Ramp	09-Jul-14	11-Jul-14	3
WBS: K. Gonzales.5 Substructure		04-Jul-14	24-Sep-14	59
WBS: K. Gonzales.5.1 Pour 1		04-Jul-14	04-Aug-14	22
A1100	Install MEP Embeds	04-Jul-14	10-Jul-14	5
A1120	Place Rebar	11-Jul-14	18-Jul-14	6
A1110	Form Slab	21-Jul-14	28-Jul-14	6
A1130	Pour Concrete	24-Jul-14	28-Jul-14	3
A3770	Erect Tower Crane	29-Jul-14	04-Aug-14	5
WBS: K. Gonzales.5.2 Pour 2		11-Jul-14	05-Aug-14	18
A1140	Install MEP Embeds	11-Jul-14	17-Jul-14	5
A1160	Place Rebar	21-Jul-14	28-Jul-14	6
A1150	Form Slab	29-Jul-14	05-Aug-14	6
A1170	Pour Concrete	29-Jul-14	31-Jul-14	3
WBS: K. Gonzales.5.3 Pour 3		18-Jul-14	13-Aug-14	19
A1180	Install MEP Embeds	18-Jul-14	24-Jul-14	5
A1200	Place Rebar	29-Jul-14	05-Aug-14	6
A1210	Pour Concrete	01-Aug-14	05-Aug-14	3
A1190	Form Slab	06-Aug-14	13-Aug-14	6
WBS: K. Gonzales.5.4 Pour 4		25-Jul-14	21-Aug-14	20
A1260	Install MEP Embeds	25-Jul-14	31-Jul-14	5
A1280	Place Rebar	06-Aug-14	13-Aug-14	6
A1290	Pour Concrete	06-Aug-14	08-Aug-14	3
A1270	Form Slab	14-Aug-14	21-Aug-14	6
WBS: K. Gonzales.5.5 Pour 5		01-Aug-14	29-Aug-14	21
A1300	Install MEP Embeds	01-Aug-14	07-Aug-14	5



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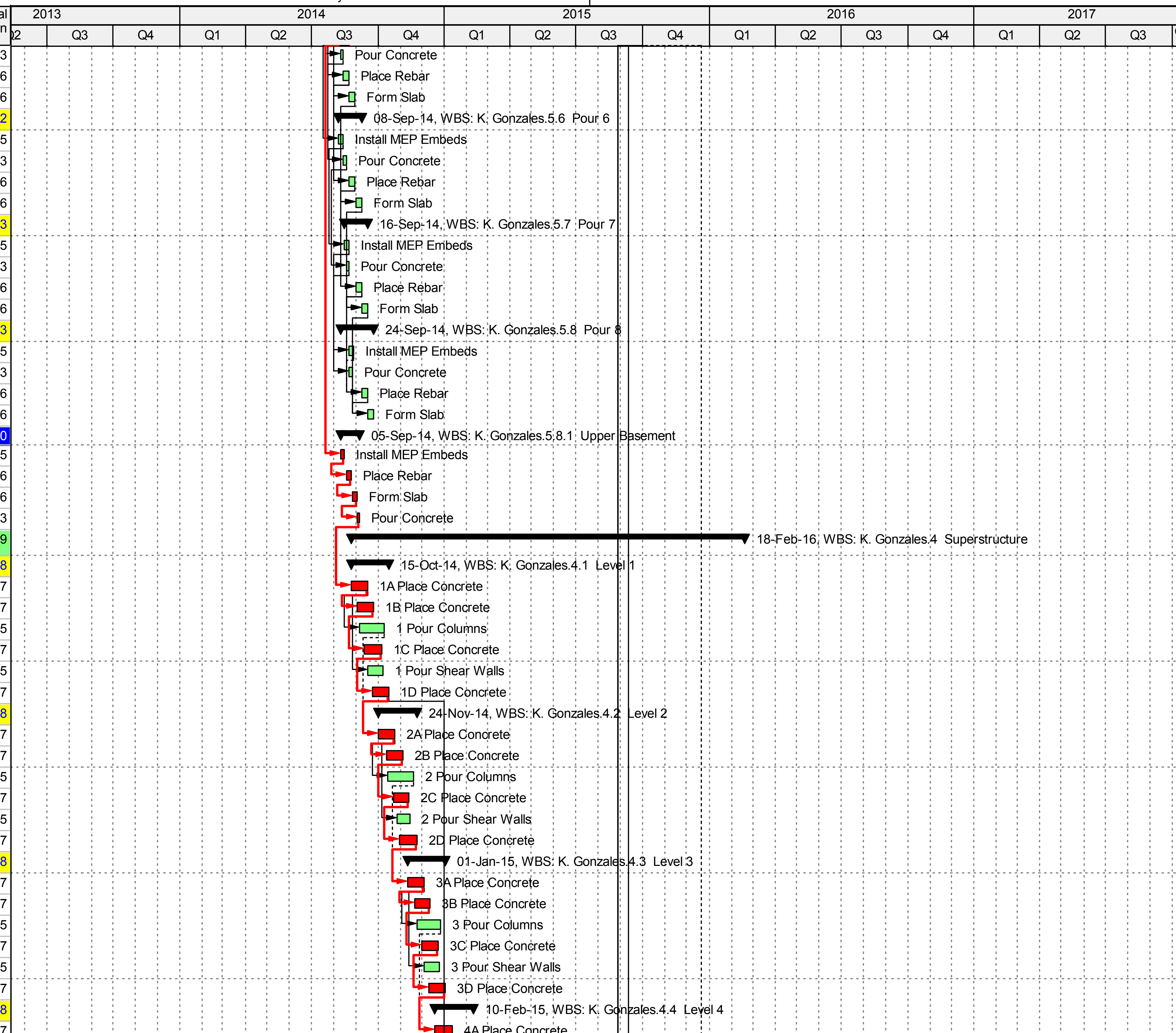
HSFIII | Classic Schedule Layout | 17-Oct-14 07:44

Activity ID	Activity Name	Start	Finish	Original Duration
A1330	Pour Concrete	11-Aug-14	13-Aug-14	3
A1320	Place Rebar	14-Aug-14	21-Aug-14	6
A1310	Form Slab	22-Aug-14	29-Aug-14	6
WBS: K. Gonzales.5.6 Pour 6		08-Aug-14	08-Sep-14	22
A1340	Install MEP Embeds	08-Aug-14	14-Aug-14	5
A1370	Pour Concrete	14-Aug-14	18-Aug-14	3
A1360	Place Rebar	22-Aug-14	29-Aug-14	6
A1350	Form Slab	01-Sep-14	08-Sep-14	6
WBS: K. Gonzales.5.7 Pour 7		15-Aug-14	16-Sep-14	23
A1380	Install MEP Embeds	15-Aug-14	21-Aug-14	5
A1410	Pour Concrete	19-Aug-14	21-Aug-14	3
A1400	Place Rebar	01-Sep-14	08-Sep-14	6
A1390	Form Slab	09-Sep-14	16-Sep-14	6
WBS: K. Gonzales.5.8 Pour 8		11-Aug-14	24-Sep-14	33
A1220	Install MEP Embeds	22-Aug-14	28-Aug-14	5
A1250	Pour Concrete	22-Aug-14	26-Aug-14	3
A1240	Place Rebar	09-Sep-14	16-Sep-14	6
A1230	Form Slab	17-Sep-14	24-Sep-14	6
WBS: K. Gonzales.5.8.1 Upper Basement		11-Aug-14	05-Sep-14	20
A1	Install MEP Embeds	11-Aug-14	15-Aug-14	5
A1	Place Rebar	18-Aug-14	25-Aug-14	6
A1	Form Slab	26-Aug-14	02-Sep-14	6
A1	Pour Concrete	03-Sep-14	05-Sep-14	3
WBS: K. Gonzales.4 Superstructure		25-Aug-14	18-Feb-16	389
WBS: K. Gonzales.4.1 Level 1		25-Aug-14	15-Oct-14	38
A1460	1A Place Concrete	25-Aug-14	16-Sep-14	17
A1470	1B Place Concrete	03-Sep-14	25-Sep-14	17
A3010	1 Pour Columns	05-Sep-14	09-Oct-14	25
A1480	1C Place Concrete	12-Sep-14	06-Oct-14	17
A3020	1 Pour Shear Walls	17-Sep-14	07-Oct-14	15
A1490	1D Place Concrete	23-Sep-14	15-Oct-14	17
WBS: K. Gonzales.4.2 Level 2		02-Oct-14	24-Nov-14	38
A1500	2A Place Concrete	02-Oct-14	24-Oct-14	17
A1510	2B Place Concrete	13-Oct-14	04-Nov-14	17
A4140	2 Pour Columns	15-Oct-14	18-Nov-14	25
A1520	2C Place Concrete	22-Oct-14	13-Nov-14	17
A4150	2 Pour Shear Walls	27-Oct-14	14-Nov-14	15
A1530	2D Place Concrete	31-Oct-14	24-Nov-14	17
WBS: K. Gonzales.4.3 Level 3		11-Nov-14	01-Jan-15	38
A1540	3A Place Concrete	11-Nov-14	03-Dec-14	17
A1550	3B Place Concrete	20-Nov-14	12-Dec-14	17
A4160	3 Pour Columns	24-Nov-14	26-Dec-14	25
A1560	3C Place Concrete	01-Dec-14	23-Dec-14	17
A4170	3 Pour Shear Walls	04-Dec-14	24-Dec-14	15
A1570	3D Place Concrete	10-Dec-14	01-Jan-15	17
WBS: K. Gonzales.4.4 Level 4		19-Dec-14	10-Feb-15	38
A1580	4A Place Concrete	19-Dec-14	12-Jan-15	17



Actual Level of Effort | Remaining Work | Milestone
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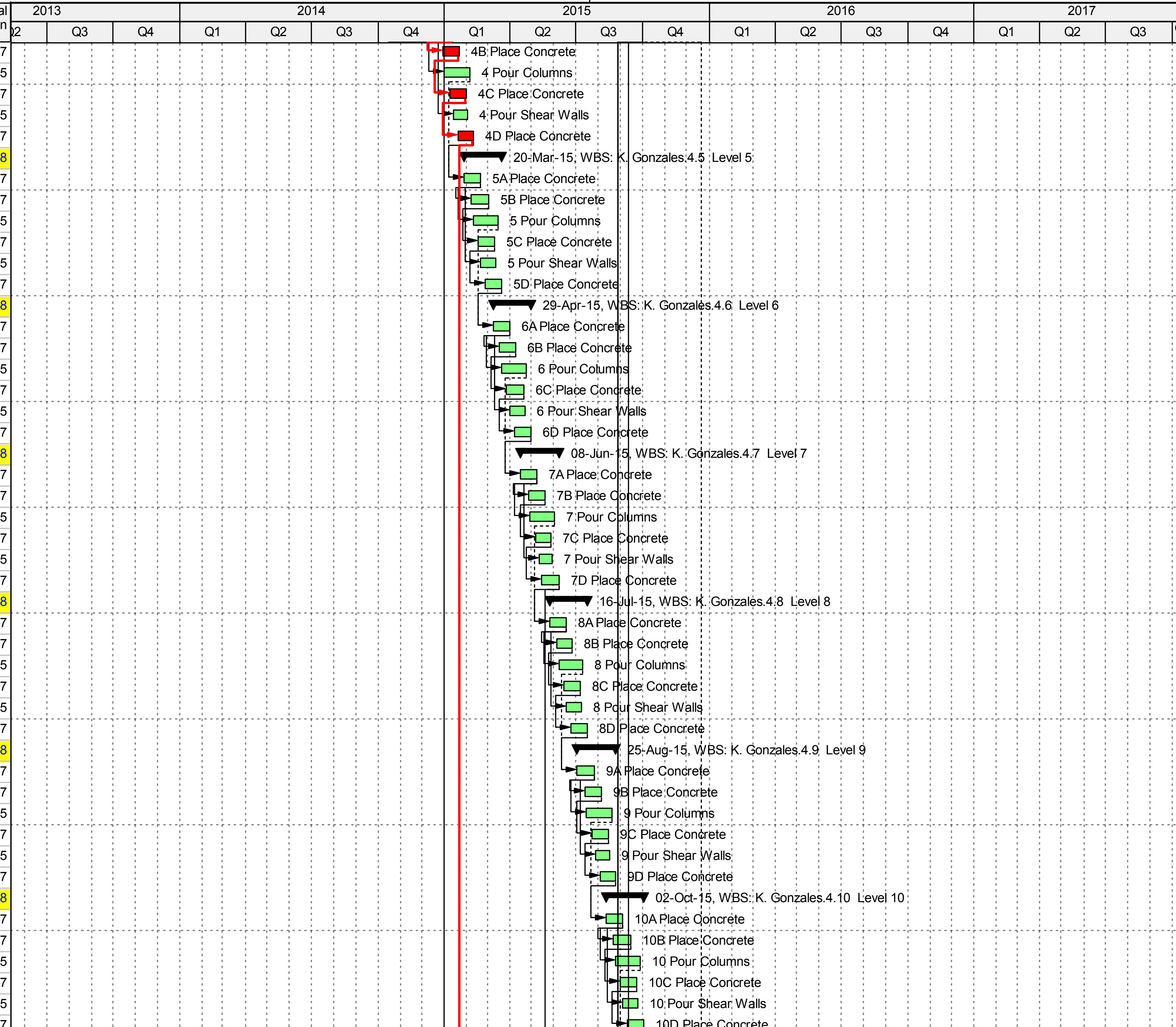
Activity ID	Activity Name	Start	Finish	Original Duration
A1590	4B Place Concrete	30-Dec-14	21-Jan-15	17
A4180	4 Pour Columns	01-Jan-15	04-Feb-15	25
A1600	4C Place Concrete	08-Jan-15	30-Jan-15	17
A4190	4 Pour Shear Walls	13-Jan-15	02-Feb-15	15
A1610	4D Place Concrete	19-Jan-15	10-Feb-15	17
WBS: K. Gonzales.4.5 Level 5		**28-Jan-15**	**20-Mar-15**	**38**
A1620	5A Place Concrete	28-Jan-15	19-Feb-15	17
A1630	5B Place Concrete	06-Feb-15	02-Mar-15	17
A4200	5 Pour Columns	10-Feb-15	16-Mar-15	25
A1640	5C Place Concrete	17-Feb-15	11-Mar-15	17
A4210	5 Pour Shear Walls	20-Feb-15	12-Mar-15	15
A1650	5D Place Concrete	26-Feb-15	20-Mar-15	17
WBS: K. Gonzales.4.6 Level 6		**09-Mar-15**	**29-Apr-15**	**38**
A1660	6A Place Concrete	09-Mar-15	31-Mar-15	17
A1670	6B Place Concrete	18-Mar-15	09-Apr-15	17
A4220	6 Pour Columns	20-Mar-15	23-Apr-15	25
A1680	6C Place Concrete	27-Mar-15	20-Apr-15	17
A4230	6 Pour Shear Walls	01-Apr-15	21-Apr-15	15
A1690	6D Place Concrete	07-Apr-15	29-Apr-15	17
WBS: K. Gonzales.4.7 Level 7		**16-Apr-15**	**08-Jun-15**	**38**
A1700	7A Place Concrete	16-Apr-15	08-May-15	17
A1710	7B Place Concrete	27-Apr-15	19-May-15	17
A4240	7 Pour Columns	29-Apr-15	02-Jun-15	25
A1720	7C Place Concrete	06-May-15	28-May-15	17
A4250	7 Pour Shear Walls	11-May-15	29-May-15	15
A1730	7D Place Concrete	15-May-15	08-Jun-15	17
WBS: K. Gonzales.4.8 Level 8		**26-May-15**	**16-Jul-15**	**38**
A1740	8A Place Concrete	26-May-15	17-Jun-15	17
A1750	8B Place Concrete	04-Jun-15	26-Jun-15	17
A4260	8 Pour Columns	08-Jun-15	10-Jul-15	25
A1760	8C Place Concrete	15-Jun-15	07-Jul-15	17
A4270	8 Pour Shear Walls	18-Jun-15	08-Jul-15	15
A1770	8D Place Concrete	24-Jun-15	16-Jul-15	17
WBS: K. Gonzales.4.9 Level 9		**03-Jul-15**	**25-Aug-15**	**38**
A1780	9A Place Concrete	03-Jul-15	27-Jul-15	17
A1790	9B Place Concrete	14-Jul-15	05-Aug-15	17
A4280	9 Pour Columns	16-Jul-15	19-Aug-15	25
A1800	9C Place Concrete	23-Jul-15	14-Aug-15	17
A4290	9 Pour Shear Walls	28-Jul-15	17-Aug-15	15
A1810	9D Place Concrete	03-Aug-15	25-Aug-15	17
WBS: K. Gonzales.4.10 Level 10		**12-Aug-15**	**02-Oct-15**	**38**
A1820	10A Place Concrete	12-Aug-15	03-Sep-15	17
A1830	10B Place Concrete	21-Aug-15	14-Sep-15	17
A4300	10 Pour Columns	25-Aug-15	28-Sep-15	25
A1840	10C Place Concrete	01-Sep-15	23-Sep-15	17
A4310	10 Pour Shear Walls	04-Sep-15	24-Sep-15	15
A1850	10D Place Concrete	10-Sep-15	02-Oct-15	17



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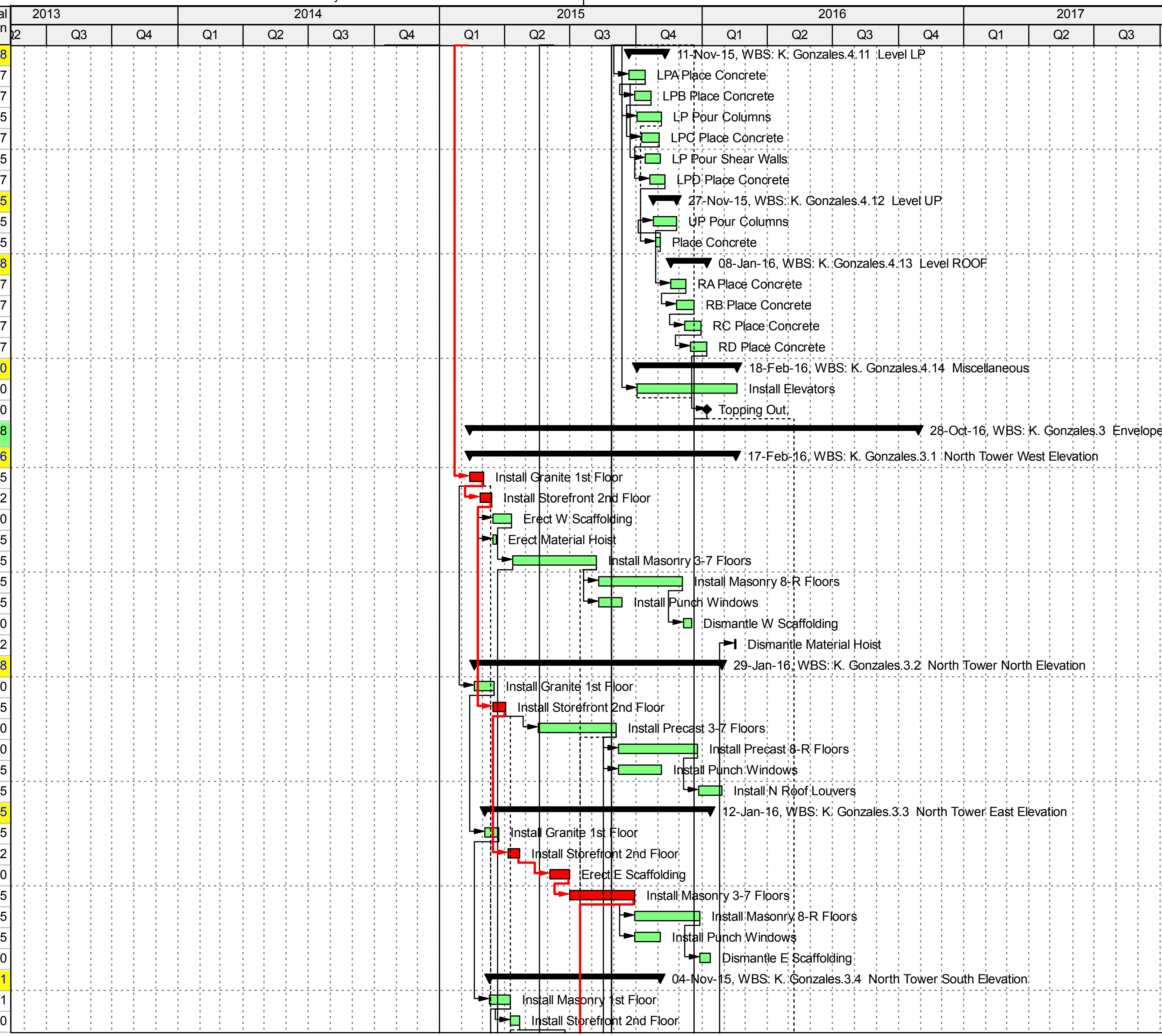
HSFIII					Classic Schedule Layout	17-Oct-14 07:44
Activity ID	Activity Name	Start	Finish	Original Duration		
WBS: K. Gonzales.4.11 Level LP		21-Sep-15	11-Nov-15	38		
A1860	LPA Place Concrete	21-Sep-15	13-Oct-15	17		
A1870	LPB Place Concrete	30-Sep-15	22-Oct-15	17		
A4320	LP Pour Columns	02-Oct-15	05-Nov-15	25		
A1880	LPC Place Concrete	09-Oct-15	02-Nov-15	17		
A4330	LP Pour Shear Walls	14-Oct-15	03-Nov-15	15		
A1890	LPD Place Concrete	20-Oct-15	11-Nov-15	17		
WBS: K. Gonzales.4.12 Level UP		26-Oct-15	27-Nov-15	25		
A4340	UP Pour Columns	26-Oct-15	27-Nov-15	25		
A1900	Place Concrete	29-Oct-15	04-Nov-15	5		
WBS: K. Gonzales.4.13 Level ROOF		18-Nov-15	08-Jan-16	38		
A1910	RA Place Concrete	18-Nov-15	10-Dec-15	17		
A1920	RB Place Concrete	27-Nov-15	21-Dec-15	17		
A1930	RC Place Concrete	08-Dec-15	30-Dec-15	17		
A1940	RD Place Concrete	17-Dec-15	08-Jan-16	17		
WBS: K. Gonzales.4.14 Miscellaneous		02-Oct-15	18-Feb-16	100		
A3950	Install Elevators	02-Oct-15	18-Feb-16	100		
A4080	Topping Out		08-Jan-16	0		
WBS: K. Gonzales.3 Envelope		11-Feb-15	28-Oct-16	448		
WBS: K. Gonzales.3.1 North Tower West Elevation		11-Feb-15	17-Feb-16	266		
A1950	Install Granite 1st Floor	11-Feb-15	03-Mar-15	15		
A1960	Install Storefront 2nd Floor	26-Feb-15	13-Mar-15	12		
A1970	Erect W Scaffolding	16-Mar-15	10-Apr-15	20		
A3960	Erect Material Hoist	16-Mar-15	20-Mar-15	5		
A1980	Install Masonry 3-7 Floors	13-Apr-15	07-Aug-15	85		
A1990	Install Masonry 8-R Floors	10-Aug-15	04-Dec-15	85		
A2000	Install Punch Windows	10-Aug-15	11-Sep-15	25		
A2010	Dismantle W Scaffolding	07-Dec-15	18-Dec-15	10		
A3970	Dismantle Material Hoist	16-Feb-16	17-Feb-16	2		
WBS: K. Gonzales.3.2 North Tower North Elevation		18-Feb-15	29-Jan-16	248		
A2090	Install Granite 1st Floor	18-Feb-15	17-Mar-15	20		
A2100	Install Storefront 2nd Floor	16-Mar-15	03-Apr-15	15		
A2110	Install Precast 3-7 Floors	18-May-15	04-Sep-15	80		
A2120	Install Precast 8-R Floors	07-Sep-15	25-Dec-15	80		
A2130	Install Punch Windows	07-Sep-15	06-Nov-15	45		
A2140	Install N Roof Louvers	28-Dec-15	29-Jan-16	25		
WBS: K. Gonzales.3.3 North Tower East Elevation		04-Mar-15	12-Jan-16	225		
A2020	Install Granite 1st Floor	04-Mar-15	24-Mar-15	15		
A2030	Install Storefront 2nd Floor	06-Apr-15	21-Apr-15	12		
A2040	Erect E Scaffolding	03-Jun-15	30-Jun-15	20		
A2050	Install Masonry 3-7 Floors	01-Jul-15	29-Sep-15	65		
A2060	Install Masonry 8-R Floors	30-Sep-15	29-Dec-15	65		
A2070	Install Punch Windows	30-Sep-15	03-Nov-15	25		
A2080	Dismantle E Scaffolding	30-Dec-15	12-Jan-16	10		
WBS: K. Gonzales.3.4 North Tower South Elevatioi		11-Mar-15	04-Nov-15	171		
A2150	Install Masonry 1st Floor	11-Mar-15	08-Apr-15	21		
A2160	Install Storefront 2nd Floor	09-Apr-15	22-Apr-15	10		



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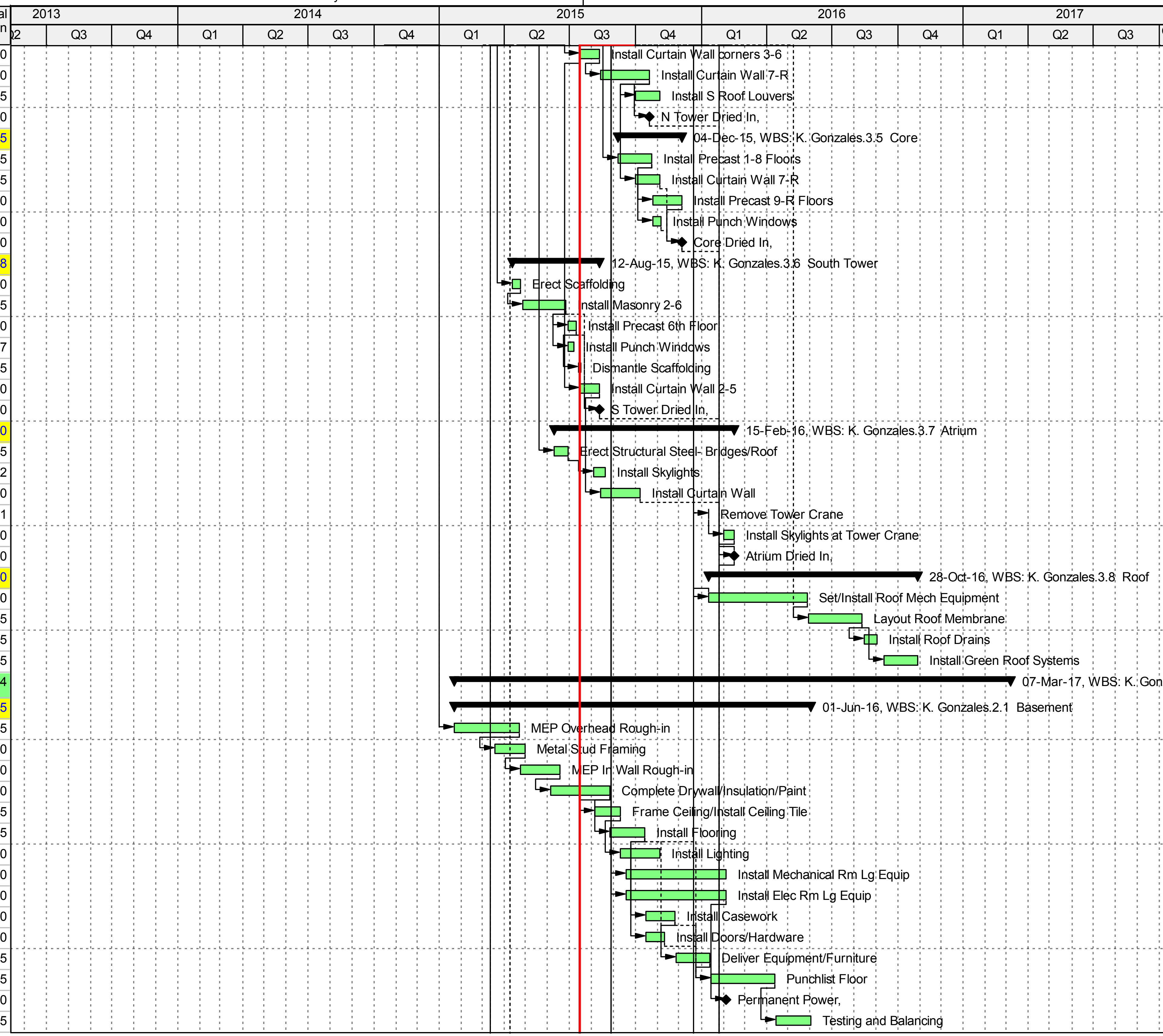
Activity ID	Activity Name	Start	Finish	Original Duration
A2180	Install Curtain Wall corners 3-6	16-Jul-15	12-Aug-15	20
A2170	Install Curtain Wall 7-R	13-Aug-15	21-Oct-15	50
A2190	Install S Roof Louvers	01-Oct-15	04-Nov-15	25
A3800	N Tower Dried In		21-Oct-15	0
WBS: K. Gonzales.3.5 Core		07-Sep-15	04-Dec-15	65
A2200	Install Precast 1-8 Floors	07-Sep-15	23-Oct-15	35
A2230	Install Curtain Wall 7-R	01-Oct-15	04-Nov-15	25
A2210	Install Precast 9-R Floors	26-Oct-15	04-Dec-15	30
A2220	Install Punch Windows	26-Oct-15	06-Nov-15	10
A4100	Core Dried In		04-Dec-15	0
WBS: K. Gonzales.3.6 South Tower		13-Apr-15	12-Aug-15	88
A2240	Erect Scaffolding	13-Apr-15	24-Apr-15	10
A2250	Install Masonry 2-6	27-Apr-15	26-Jun-15	45
A2270	Install Precast 6th Floor	29-Jun-15	10-Jul-15	10
A2280	Install Punch Windows	29-Jun-15	07-Jul-15	7
A2290	Dismantle Scaffolding	13-Jul-15	17-Jul-15	5
A2260	Install Curtain Wall 2-5	16-Jul-15	12-Aug-15	20
A4110	S Tower Dried In		12-Aug-15	0
WBS: K. Gonzales.3.7 Atrium		09-Jun-15	15-Feb-16	180
A2300	Erect Structural Steel- Bridges/Roof	09-Jun-15	29-Jun-15	15
A2310	Install Skylights	04-Aug-15	19-Aug-15	12
A2320	Install Curtain Wall	13-Aug-15	07-Oct-15	40
A2330	Remove Tower Crane	11-Jan-16	11-Jan-16	1
A2340	Install Skylights at Tower Crane	02-Feb-16	15-Feb-16	10
A4120	Atrium Dried In		15-Feb-16	0
WBS: K. Gonzales.3.8 Roof		11-Jan-16	28-Oct-16	210
A3790	Set/Install Roof Mech Equipment	11-Jan-16	27-May-16	100
A2350	Layout Roof Membrane	30-May-16	12-Aug-16	55
A2370	Install Roof Drains	15-Aug-16	02-Sep-16	15
A2360	Install Green Roof Systems	12-Sep-16	28-Oct-16	35
WBS: K. Gonzales.2 Interiors		22-Jan-15	07-Mar-17	554
WBS: K. Gonzales.2.1 Basement		22-Jan-15	01-Jun-16	355
A2400	MEP Overhead Rough-in	22-Jan-15	22-Apr-15	65
A2410	Metal Stud Framing	19-Mar-15	29-Apr-15	30
A2420	MEP In Wall Rough-in	23-Apr-15	17-Jun-15	40
A2430	Complete Drywall/Insulation/Paint	04-Jun-15	26-Aug-15	60
A2450	Frame Ceiling/Install Ceiling Tile	06-Aug-15	09-Sep-15	25
A2460	Install Flooring	27-Aug-15	14-Oct-15	35
A2440	Install Lighting	10-Sep-15	04-Nov-15	40
A2380	Install Mechanical Rm Lg Equip	18-Sep-15	04-Feb-16	100
A2390	Install Elec Rm Lg Equip	18-Sep-15	04-Feb-16	100
A2470	Install Casework	15-Oct-15	25-Nov-15	30
A2490	Install Doors/Hardware	15-Oct-15	11-Nov-15	20
A2480	Deliver Equipment/Furniture	26-Nov-15	13-Jan-16	35
A2510	Punchlist Floor	14-Jan-16	13-Apr-16	65
A4090	Permanent Power		04-Feb-16	0
A2500	Testing and Balancing	14-Apr-16	01-Jun-16	35



Actual Level of Effort | Remaining Work | ◆ ◆ Milestone
Actual Work | Critical Remaining Work | summary

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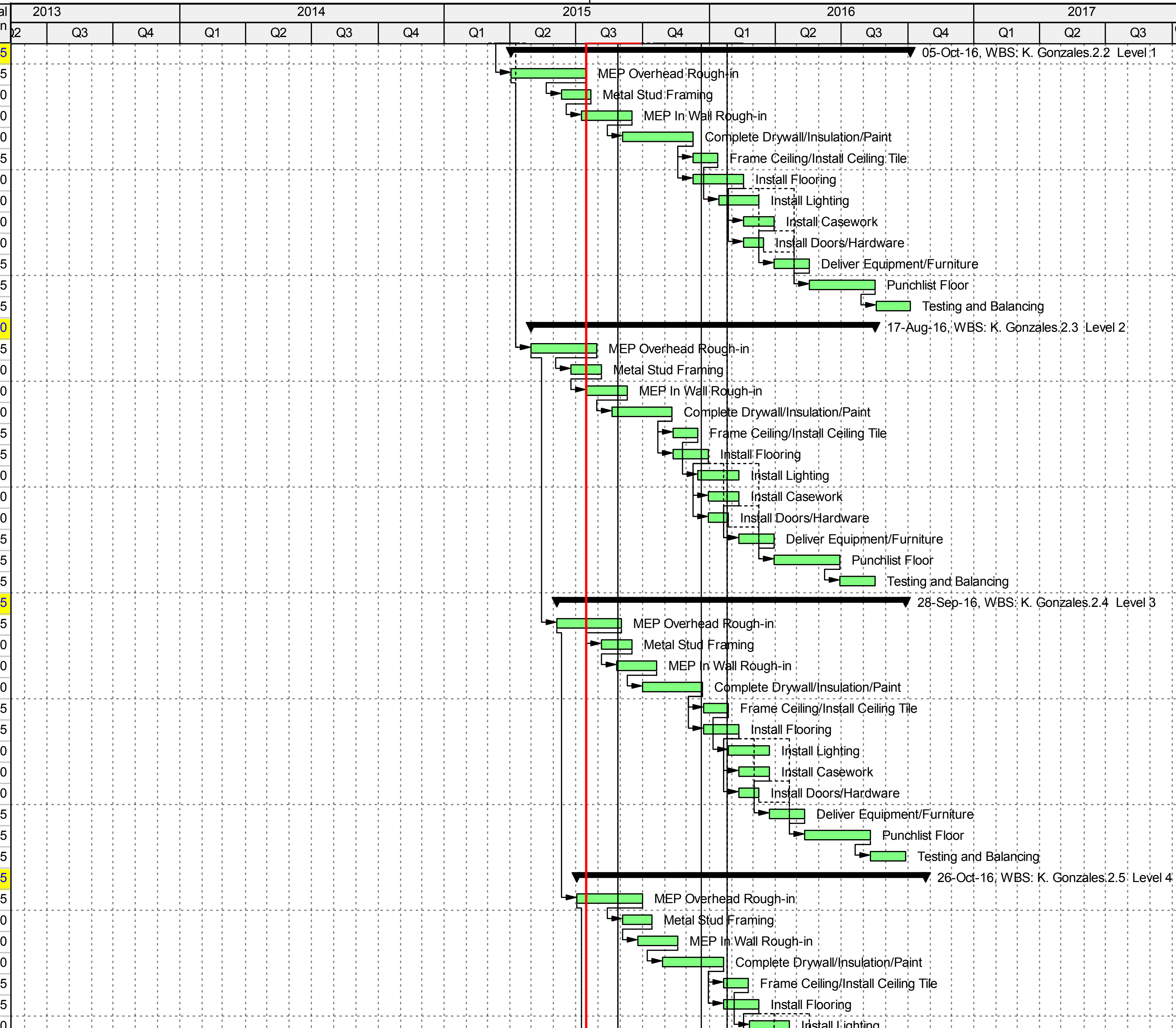
TASK filter: All Activities

HSFIII | Classic Schedule Layout | 17-Oct-14 07:44

Activity ID	Activity Name	Start	Finish	Original Duration
WBS: K. Gonzales.2.2 Level 1		02-Apr-15	05-Oct-16	395
A2520	MEP Overhead Rough-in	02-Apr-15	15-Jul-15	75
A2530	Metal Stud Framing	11-Jun-15	22-Jul-15	30
A2540	MEP In Wall Rough-in	09-Jul-15	16-Sep-15	50
A2550	Complete Drywall/Insulation/Paint	03-Sep-15	09-Dec-15	70
A2570	Frame Ceiling/Install Ceiling Tile	10-Dec-15	13-Jan-16	25
A2580	Install Flooring	10-Dec-15	17-Feb-16	50
A2560	Install Lighting	14-Jan-16	09-Mar-16	40
A2590	Install Casework	18-Feb-16	30-Mar-16	30
A2610	Install Doors/Hardware	18-Feb-16	16-Mar-16	20
A2600	Deliver Equipment/Furniture	31-Mar-16	18-May-16	35
A2630	Punchlist Floor	19-May-16	17-Aug-16	65
A2620	Testing and Balancing	18-Aug-16	05-Oct-16	35
WBS: K. Gonzales.2.3 Level 2		30-Apr-15	17-Aug-16	340
A2640	MEP Overhead Rough-in	30-Apr-15	29-Jul-15	65
A2650	Metal Stud Framing	25-Jun-15	05-Aug-15	30
A2660	MEP In Wall Rough-in	16-Jul-15	09-Sep-15	40
A2670	Complete Drywall/Insulation/Paint	20-Aug-15	11-Nov-15	60
A2690	Frame Ceiling/Install Ceiling Tile	12-Nov-15	16-Dec-15	25
A2700	Install Flooring	12-Nov-15	30-Dec-15	35
A2680	Install Lighting	17-Dec-15	10-Feb-16	40
A2710	Install Casework	31-Dec-15	10-Feb-16	30
A2730	Install Doors/Hardware	31-Dec-15	27-Jan-16	20
A2720	Deliver Equipment/Furniture	11-Feb-16	30-Mar-16	35
A2750	Punchlist Floor	31-Mar-16	29-Jun-16	65
A2740	Testing and Balancing	30-Jun-16	17-Aug-16	35
WBS: K. Gonzales.2.4 Level 3		04-Jun-15	28-Sep-16	345
A2760	MEP Overhead Rough-in	04-Jun-15	02-Sep-15	65
A2770	Metal Stud Framing	06-Aug-15	16-Sep-15	30
A2780	MEP In Wall Rough-in	27-Aug-15	21-Oct-15	40
A2790	Complete Drywall/Insulation/Paint	01-Oct-15	23-Dec-15	60
A2810	Frame Ceiling/Install Ceiling Tile	24-Dec-15	27-Jan-16	25
A2820	Install Flooring	24-Dec-15	10-Feb-16	35
A2800	Install Lighting	28-Jan-16	23-Mar-16	40
A2830	Install Casework	11-Feb-16	23-Mar-16	30
A2850	Install Doors/Hardware	11-Feb-16	09-Mar-16	20
A2840	Deliver Equipment/Furniture	24-Mar-16	11-May-16	35
A2870	Punchlist Floor	12-May-16	10-Aug-16	65
A2860	Testing and Balancing	11-Aug-16	28-Sep-16	35
WBS: K. Gonzales.2.5 Level 4		02-Jul-15	26-Oct-16	345
A2880	MEP Overhead Rough-in	02-Jul-15	30-Sep-15	65
A2890	Metal Stud Framing	03-Sep-15	14-Oct-15	30
A2900	MEP In Wall Rough-in	24-Sep-15	18-Nov-15	40
A2910	Complete Drywall/Insulation/Paint	29-Oct-15	20-Jan-16	60
A2930	Frame Ceiling/Install Ceiling Tile	21-Jan-16	24-Feb-16	25
A2940	Install Flooring	21-Jan-16	09-Mar-16	35
A2920	Install Lighting	25-Feb-16	20-Apr-16	40

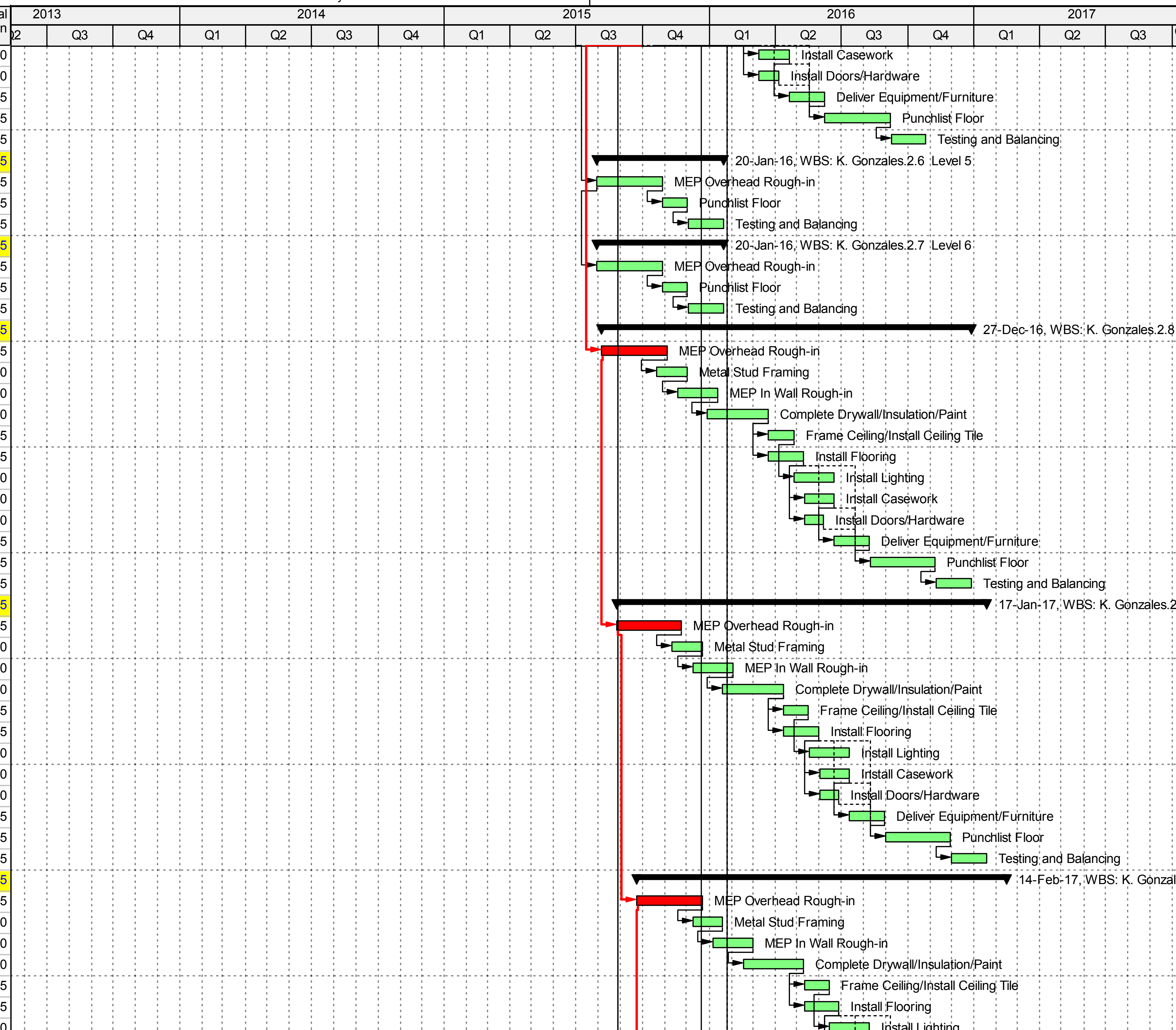


Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

HSFIII | Classic Schedule Layout | 17-Oct-14 07:44

Activity ID	Activity Name	Start	Finish	Original Duration
A2950	Install Casework	10-Mar-16	20-Apr-16	30
A2970	Install Doors/Hardware	10-Mar-16	06-Apr-16	20
A2960	Deliver Equipment/Furniture	21-Apr-16	08-Jun-16	35
A2990	Punchlist Floor	09-Jun-16	07-Sep-16	65
A2980	Testing and Balancing	08-Sep-16	26-Oct-16	35
WBS: K. Gonzales.2.6 Level 5		**30-Jul-15**	**20-Jan-16**	**125**
A3000	MEP Overhead Rough-in	30-Jul-15	28-Oct-15	65
A3110	Punchlist Floor	29-Oct-15	02-Dec-15	25
A4130	Testing and Balancing	03-Dec-15	20-Jan-16	35
WBS: K. Gonzales.2.7 Level 6		**30-Jul-15**	**20-Jan-16**	**125**
A3120	MEP Overhead Rough-in	30-Jul-15	28-Oct-15	65
A3230	Punchlist Floor	29-Oct-15	02-Dec-15	25
A3220	Testing and Balancing	03-Dec-15	20-Jan-16	35
WBS: K. Gonzales.2.8 Level 7		**05-Aug-15**	**27-Dec-16**	**365**
A3240	MEP Overhead Rough-in	05-Aug-15	03-Nov-15	65
A3250	Metal Stud Framing	21-Oct-15	01-Dec-15	30
A3260	MEP In Wall Rough-in	18-Nov-15	12-Jan-16	40
A3270	Complete Drywall/Insulation/Paint	30-Dec-15	22-Mar-16	60
A3290	Frame Ceiling/Install Ceiling Tile	23-Mar-16	26-Apr-16	25
A3300	Install Flooring	23-Mar-16	10-May-16	35
A3280	Install Lighting	27-Apr-16	21-Jun-16	40
A3310	Install Casework	11-May-16	21-Jun-16	30
A3330	Install Doors/Hardware	11-May-16	07-Jun-16	20
A3320	Deliver Equipment/Furniture	22-Jun-16	09-Aug-16	35
A3350	Punchlist Floor	10-Aug-16	08-Nov-16	65
A3340	Testing and Balancing	09-Nov-16	27-Dec-16	35
WBS: K. Gonzales.2.9 Level 8		**26-Aug-15**	**17-Jan-17**	**365**
A3360	MEP Overhead Rough-in	26-Aug-15	24-Nov-15	65
A3370	Metal Stud Framing	11-Nov-15	22-Dec-15	30
A3380	MEP In Wall Rough-in	09-Dec-15	02-Feb-16	40
A3390	Complete Drywall/Insulation/Paint	20-Jan-16	12-Apr-16	60
A3410	Frame Ceiling/Install Ceiling Tile	13-Apr-16	17-May-16	25
A3420	Install Flooring	13-Apr-16	31-May-16	35
A3400	Install Lighting	18-May-16	12-Jul-16	40
A3430	Install Casework	01-Jun-16	12-Jul-16	30
A3450	Install Doors/Hardware	01-Jun-16	28-Jun-16	20
A3440	Deliver Equipment/Furniture	13-Jul-16	30-Aug-16	35
A3470	Punchlist Floor	31-Aug-16	29-Nov-16	65
A3460	Testing and Balancing	30-Nov-16	17-Jan-17	35
WBS: K. Gonzales.2.10 Level 9		**23-Sep-15**	**14-Feb-17**	**365**
A3480	MEP Overhead Rough-in	23-Sep-15	22-Dec-15	65
A3490	Metal Stud Framing	09-Dec-15	19-Jan-16	30
A3500	MEP In Wall Rough-in	06-Jan-16	01-Mar-16	40
A3510	Complete Drywall/Insulation/Paint	17-Feb-16	10-May-16	60
A3530	Frame Ceiling/Install Ceiling Tile	11-May-16	14-Jun-16	25
A3540	Install Flooring	11-May-16	28-Jun-16	35
A3520	Install Lighting	15-Jun-16	09-Aug-16	40



Actual Level of Effort | Remaining Work | ◆ Milestone
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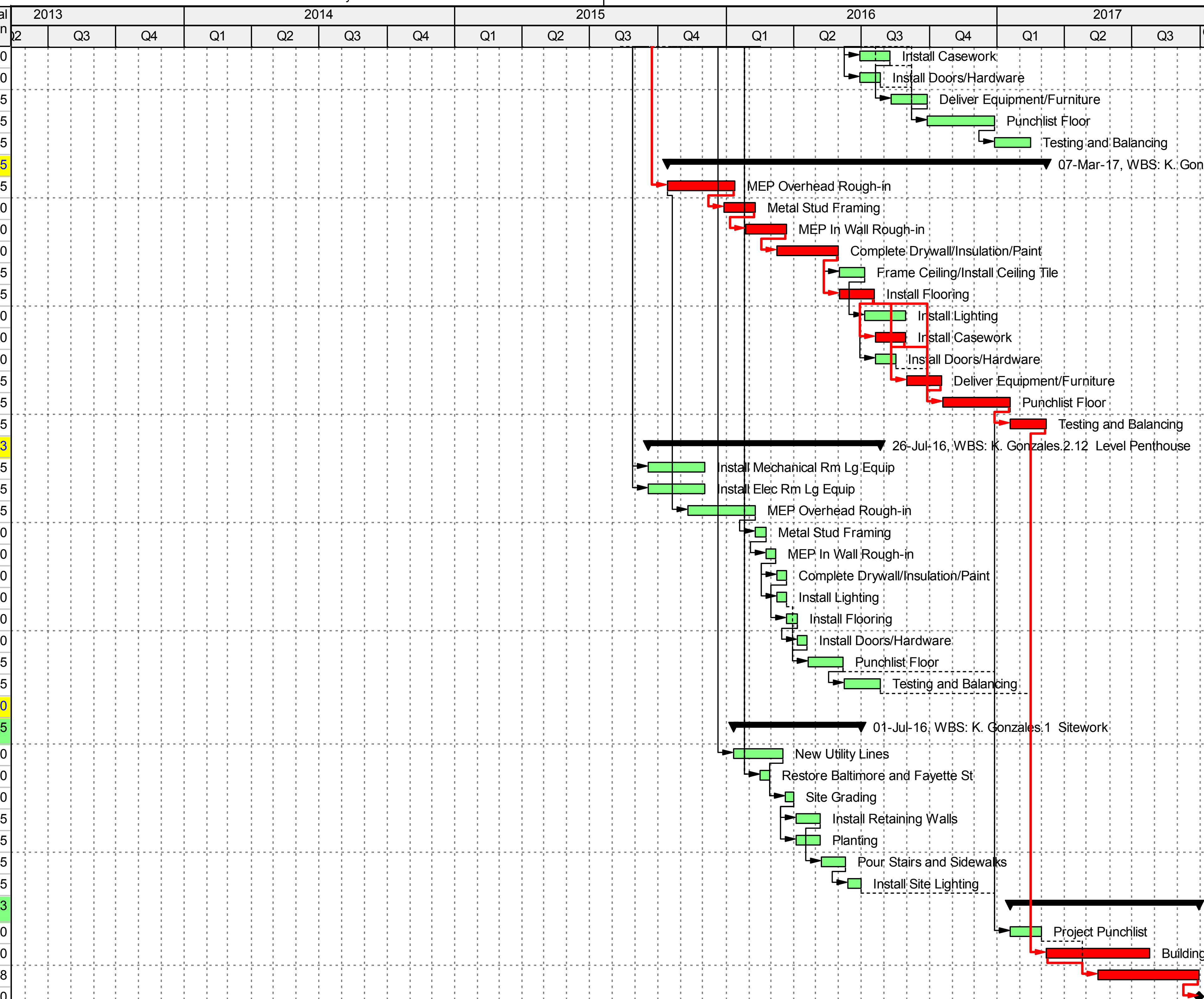
TASK filter: All Activities

HSFIII					Classic Schedule Layout	17-Oct-14 07:44
Activity ID	Activity Name	Start	Finish	Original Duration		
A3550	Install Casework	29-Jun-16	09-Aug-16	30		
A3570	Install Doors/Hardware	29-Jun-16	26-Jul-16	20		
A3560	Deliver Equipment/Furniture	10-Aug-16	27-Sep-16	35		
A3590	Punchlist Floor	28-Sep-16	27-Dec-16	65		
A3580	Testing and Balancing	28-Dec-16	14-Feb-17	35		
WBS: K. Gonzales.2.11 Level 10		14-Oct-15	07-Mar-17	365		
A3600	MEP Overhead Rough-in	14-Oct-15	12-Jan-16	65		
A3610	Metal Stud Framing	30-Dec-15	09-Feb-16	30		
A3620	MEP In Wall Rough-in	27-Jan-16	22-Mar-16	40		
A3630	Complete Drywall/Insulation/Paint	09-Mar-16	31-May-16	60		
A3650	Frame Ceiling/Install Ceiling Tile	01-Jun-16	05-Jul-16	25		
A3660	Install Flooring	01-Jun-16	19-Jul-16	35		
A3640	Install Lighting	06-Jul-16	30-Aug-16	40		
A3670	Install Casework	20-Jul-16	30-Aug-16	30		
A3690	Install Doors/Hardware	20-Jul-16	16-Aug-16	20		
A3680	Deliver Equipment/Furniture	31-Aug-16	18-Oct-16	35		
A3710	Punchlist Floor	19-Oct-16	17-Jan-17	65		
A3700	Testing and Balancing	18-Jan-17	07-Mar-17	35		
WBS: K. Gonzales.2.12 Level Penthouse		18-Sep-15	26-Jul-16	223		
A3840	Install Mechanical Rm Lg Equip	18-Sep-15	03-Dec-15	55		
A3850	Install Elec Rm Lg Equip	18-Sep-15	03-Dec-15	55		
A3720	MEP Overhead Rough-in	11-Nov-15	09-Feb-16	65		
A3730	Metal Stud Framing	10-Feb-16	23-Feb-16	10		
A3740	MEP In Wall Rough-in	24-Feb-16	08-Mar-16	10		
A3750	Complete Drywall/Insulation/Paint	09-Mar-16	22-Mar-16	10		
A3760	Install Lighting	09-Mar-16	22-Mar-16	10		
A3780	Install Flooring	23-Mar-16	05-Apr-16	10		
A3810	Install Doors/Hardware	06-Apr-16	19-Apr-16	10		
A3830	Punchlist Floor	20-Apr-16	07-Jun-16	35		
A3820	Testing and Balancing	08-Jun-16	26-Jul-16	35		
WBS: K. Gonzales.2.13 Level Roof				0		
WBS: K. Gonzales.1 Sitework		11-Jan-16	01-Jul-16	125		
A3860	New Utility Lines	11-Jan-16	18-Mar-16	50		
A3870	Restore Baltimore and Fayette St	16-Feb-16	29-Feb-16	10		
A3880	Site Grading	21-Mar-16	01-Apr-16	10		
A3890	Install Retaining Walls	04-Apr-16	06-May-16	25		
A3910	Planting	04-Apr-16	06-May-16	25		
A3900	Pour Stairs and Sidewalks	09-May-16	10-Jun-16	25		
A3920	Install Site Lighting	13-Jun-16	01-Jul-16	15		
WBS: K. Gonzales.8 Building Closeout		18-Jan-17	29-Sep-17	183		
A3990	Project Punchlist	18-Jan-17	28-Feb-17	30		
A3980	Building Flushout	08-Mar-17	25-Jul-17	100		
A4000	Final Building Commissioning	17-May-17	29-Sep-17	98		
A4350	Substantial Completion		29-Sep-17	0		



Actual Level of Effort	Remaining Work	Milestone	Page 8 of 8	TASK filter: All Activities
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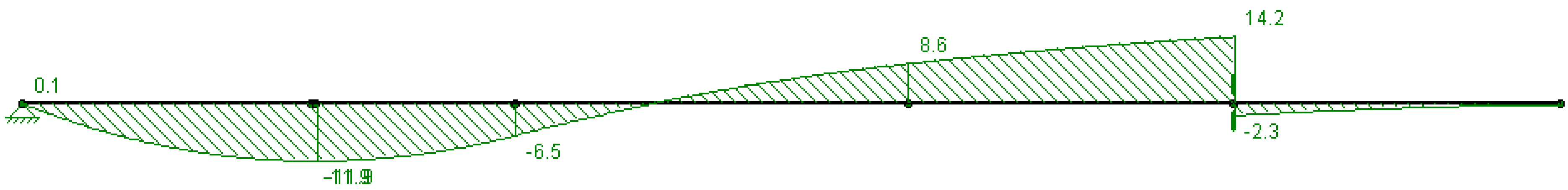
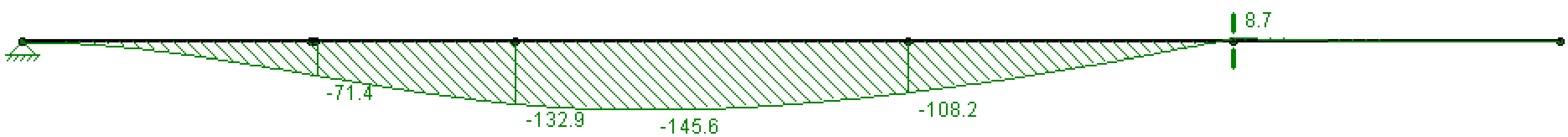
Appendix B.1

Risa Output

Shear Diagram

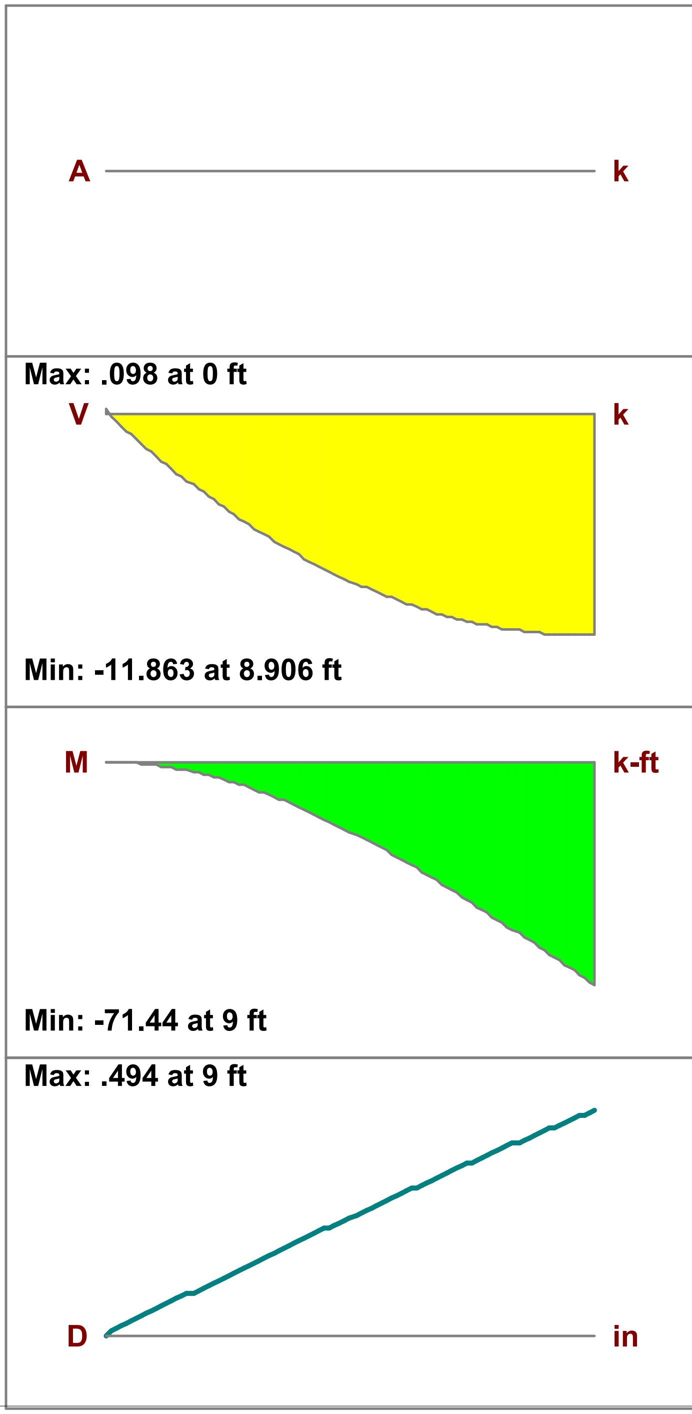


Moment Diagram



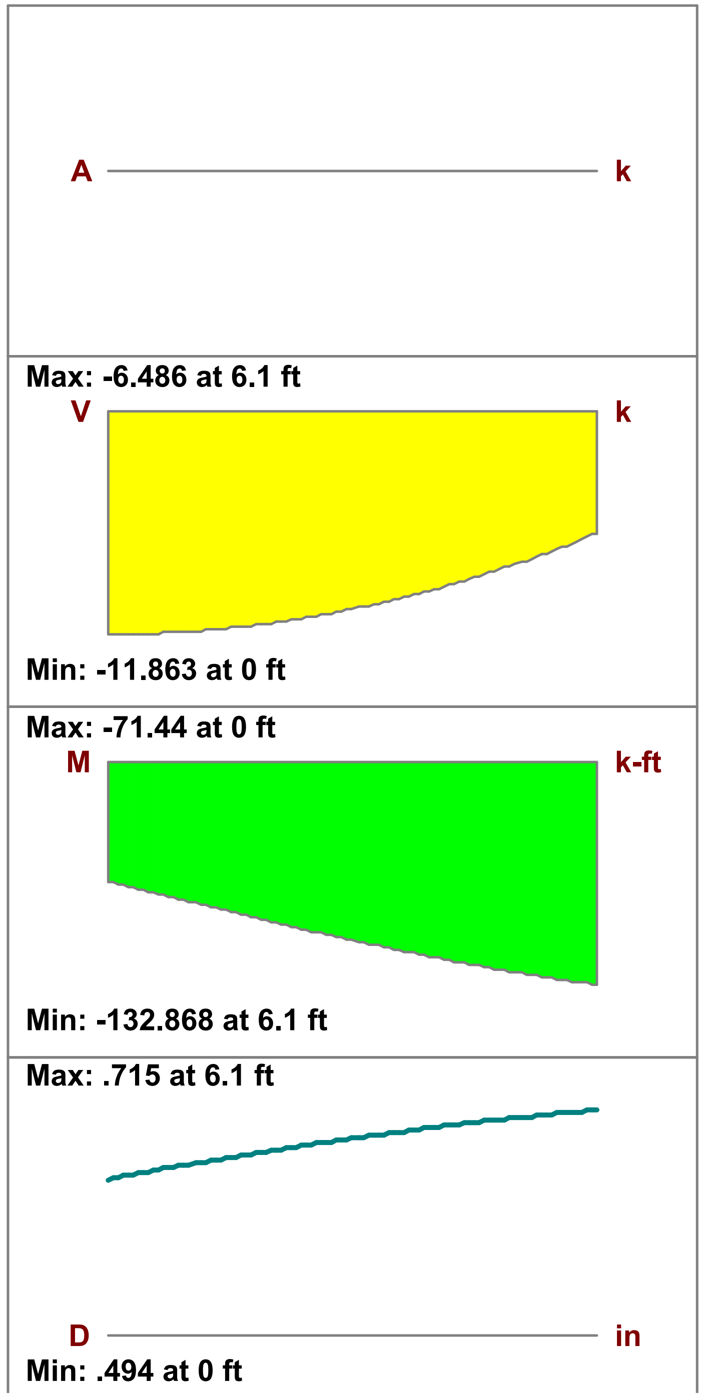
Member: ***M1***

Length: **9 ft**
I Joint: **N1**
J Joint: **N7**



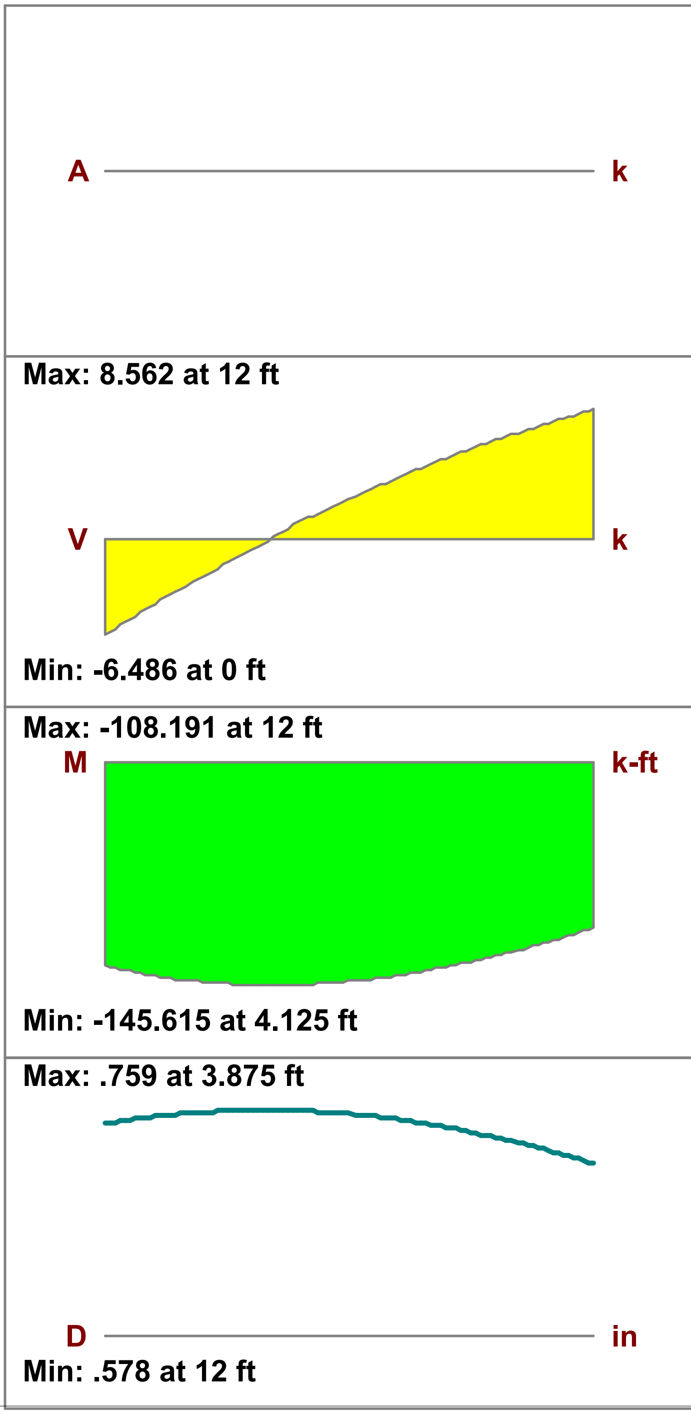
Member: ***M2***

Length: **6.1 ft**
I Joint: **N7**
J Joint: **N3**



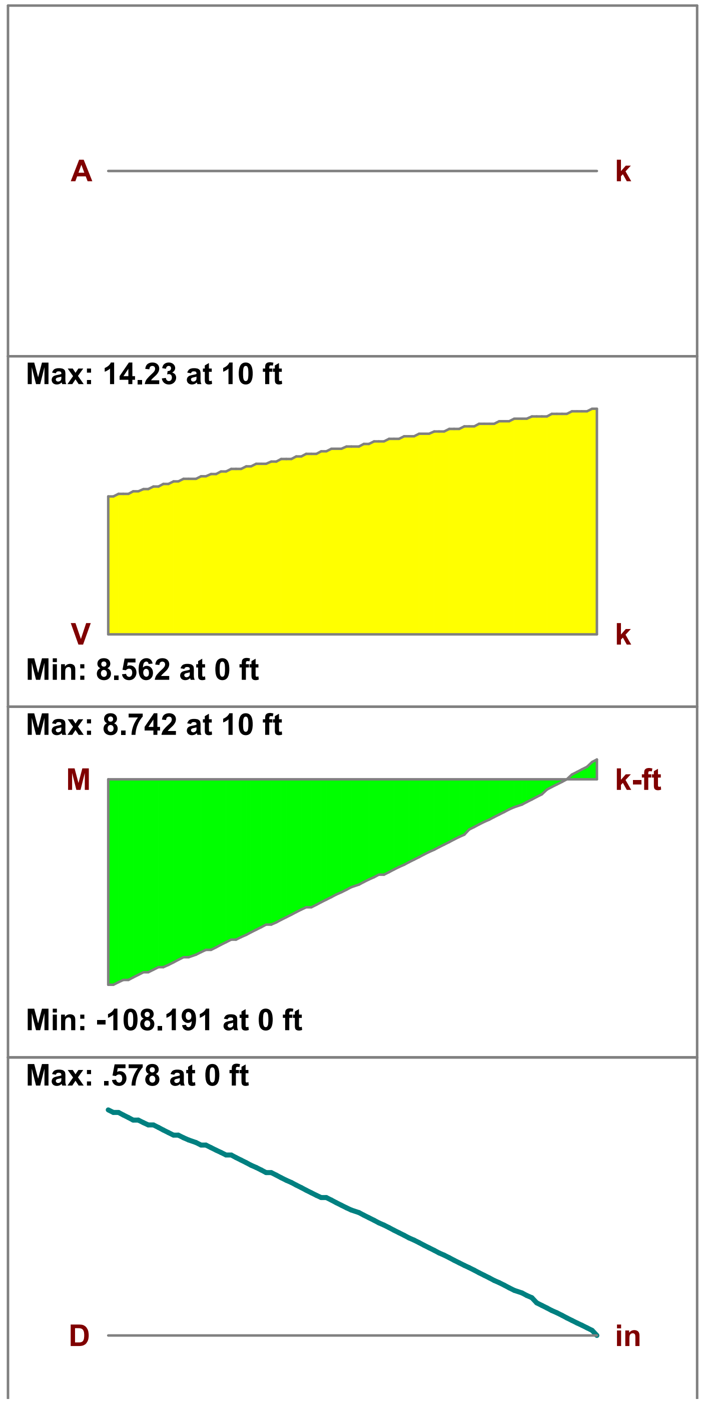
Member: ***M3***

Length: **12 ft**
I Joint: **N3**
J Joint: **N4**



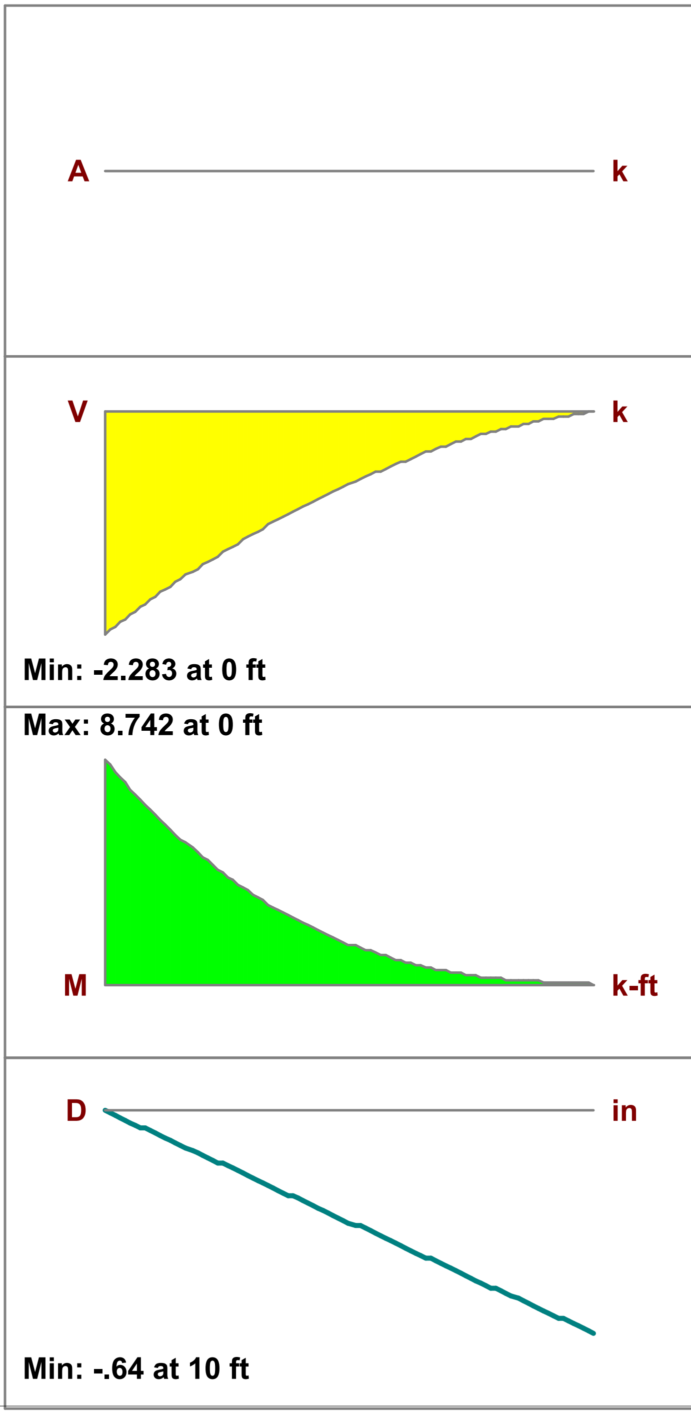
Member: ***M4***

Length: **10 ft**
I Joint: **N4**
J Joint: **N5**



Member: *M5*

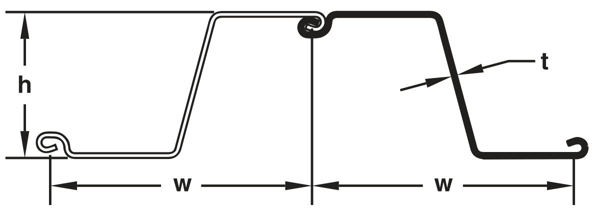
Length: **10 ft**
I Joint: **N5**
J Joint: **N6**



Appendix B.2

Sheet Pile Product Data

SCZ/SKZ Cold Formed Steel Sheet Pile



SECTION	Width (w) in (mm)	Height (h) in (mm)	Thickness (t) in (mm)	Cross Sectional Area in²/ft (cm²/m)	WEIGHT: Pile lb/ft (kg/m)	WEIGHT: Wall lb/ft² (kg/m²)	SECTION MODULUS: Elastic in³/ft (cm³/m)	SECTION MODULUS: Plastic in³/ft (cm³/m)	Moment of Inertia in⁴/ft (cm⁴/m)	COATING AREA: Both Sides ft²/ft (m²/m)	COATING AREA: Coating Area ft²/ft² (m²/m²)
SCZ 14	28.50 723.9	10.00 254.0	0.250 6.4	4.18 88.48	33.81 50.31	14.23 69.50	14.36 772	16.32 877.4	71.82 9808	6.10 1.86	1.28 1.28
SCZ 16	28.50 723.9	10.00 254.0	0.276 7.0	4.62 97.79	37.37 55.61	15.73 76.82	15.75 847	17.97 965.9	78.73 10751	6.10 1.86	1.28 1.28
SCZ 17N	28.50 723.9	10.00 254.0	0.295 7.5	4.95 104.78	40.03 59.58	16.86 82.32	16.87 907	19.21 1033	84.35 11519	6.10 1.86	1.28 1.28
SCZ 18N	28.50 723.9	10.00 254.0	0.317 8.1	5.31 112.39	42.94 63.91	18.08 88.28	18.10 973	20.61 1108	90.48 12356	6.10 1.86	1.28 1.28
SCZ 21N	28.50 723.9	10.00 254.0	0.375 9.5	6.29 133.06	50.84 75.66	21.41 104.54	21.43 1152	24.40 1312	107.13 14629	6.10 1.86	1.28 1.28
SKZ 20	28.50 723.9	16.00 406.4	0.315 8.0	6.00 136.20	48.24 71.79	20.31 99.17	31.69 1704	36.66 1970.97	253.51 34618	7.60 2.32	1.60 1.60
SKZ 22	28.50 723.9	16.00 406.4	0.335 8.5	6.30 145.40	51.30 76.34	21.60 105.46	33.43 1797	38.94 2093.55	267.40 36515	7.60 2.32	1.60 1.60
SKZ 23	28.50 723.9	16.00 406.4	0.354 9.0	6.70 162.50	54.20 80.66	22.82 111.42	35.61 1915	41.12 2210.75	284.90 38905	7.60 2.32	1.60 1.60
SKZ 24	28.50 723.9	16.00 406.4	0.375 9.5	7.10 179.50	57.43 85.47	24.18 118.06	37.73 2028	43.52 2339.78	301.80 41213	7.60 2.32	1.60 1.60
SKZ 25	28.50 723.9	16.00 406.4	0.399 10.1	7.60 188.00	61.10 90.93	25.73 125.61	40.14 2158	46.24 2486.02	321.12 43851	7.60 2.32	1.60 1.60
SKZ 31	28.50 723.9	18.00 457.2	0.450 11.4	9.07 192.04	73.82 109.85	31.08 151.75	51.56 2772	60.51 3253.29	464.05 63369	8.06 2.46	1.70 1.70
SKZ 33	28.50 723.9	18.00 457.2	0.475 12.1	9.40 198.97	77.64 115.54	32.69 159.61	54.89 2951	63.57 3417.68	494.03 67462	8.06 2.46	1.70 1.70
SKZ 34	28.50 723.9	18.00 457.2	0.500 12.7	9.89 209.25	81.42 121.17	34.28 167.38	57.62 3098	66.86 3594.60	518.62 70821	8.06 2.46	1.70 1.70
SKZ 36	28.50 723.9	18.00 457.2	0.535 13.6	10.78 228.10	86.81 129.19	36.55 178.46	60.71 3264	71.58 3848.17	546.43 74619	8.06 2.46	1.70 1.70
SKZ 38	28.50 723.9	18.00 457.2	0.550 14.0	11.07 234.42	88.95 132.37	37.45 182.85	62.32 3350	73.52 3952.44	560.85 76588	8.06 2.46	1.70 1.70

Interlock Compatibility

	SCZ 14	SCZ 16	SCZ 17N	SCZ 18N	SCZ 21N	SKZ 20	SKZ 22	SKZ 23	SKZ 24	SKZ 25	SKZ 31	SKZ 33	SKZ 34	SKZ 36	SKZ 38
SCZ 14	●	●	●	●	●	●	●	●	●	●	○	○	○	○	○
SCZ 16	●	●	●	●	●	●	●	●	●	●	○	○	○	○	○
SCZ 17N	●	●	●	●	●	●	●	●	●	●	○	○	○	○	○
SCZ 18N	●	●	●	●	●	●	●	●	●	●	○	○	○	○	○
SCZ 21N	●	●	●	●	●	●	●	●	●	●	○	○	○	○	○
SKZ 20	●	●	●	●	●	●	●	●	●	●	○	○	○	○	○
SKZ 22	●	●	●	●	●	●	●	●	●	●	○	○	○	○	○
SKZ 23	●	●	●	●	●	●	●	●	●	●	○	○	○	○	○
SKZ 24	●	●	●	●	●	●	●	●	●	●	○	○	○	○	○
SKZ 25	●	●	●	●	●	●	●	●	●	●	○	○	○	○	○
SKZ 31	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●
SKZ 33	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●
SKZ 34	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●
SKZ 36	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●
SKZ 38	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●

● Interlock compatible ○ Interlock not compatible

SCZ/SKZ

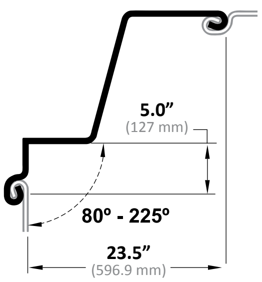
SCZ/SKZ Cold Formed Steel Sheet Pile

Available Steel Grades					
ASTM	YIELD STRENGTH		ASTM	YIELD STRENGTH	
	(ksi)	(MPa)		(ksi)	(MPa)
A 572 Grade 50	50	345	A 572 Grade 65 (Mod)**	80	555
A 572 Grade 55	55	380	A 588	50	345
A 572 Grade 60	60	415	A 690	50	345
A 572 Grade 65*	65	450			

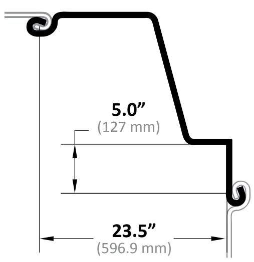
*Not available for thicknesses ≥ 0.375" (9.525mm). **Not available for thicknesses > 0.276" (7.0mm).

Corner Piles

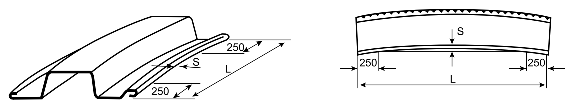
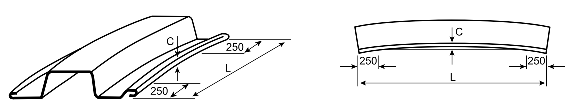
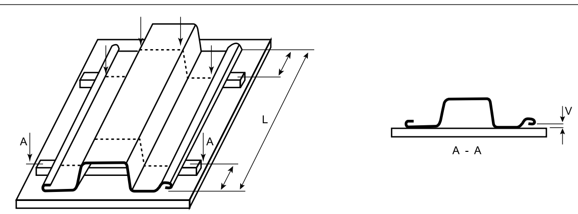
B2 Corner Pile



B3 Corner Pile



Delivery Conditions & Tolerances

	ASTM A6		EN 10249-2	
Mass	± 2.5%		± 7%	
Length	+ 5 inches	– 0 inches	± 50 mm	
Straightness				
Bending (S)			0.25% of the length	
Curving (C)			0.25% of the length	
Twisting (V)			2% of the length	

Maximum Rolled Lengths*

SCZ/SKZ	70 feet	(21.3 m)

* Longer lengths may be possible upon request.

Health Sciences Facility III | Kathryn Gonzales

Appendix B.3

Shoring Systems Cost and Schedule

		UNT	AMT	MAT/UNT	MAT	LAB/UNT	LABOR	EQP/UNT	EQP	TOTAL	COST/ SF
Pile & Lagging											
	Pile and Lagging Contract Price				$ -		$ -		$ -	$ 1,480,000.00	
	Dewatering Issues				$ -		$ -		$ -	$ 650,000.00	
									Subtotal	**$ 2,130,000.00**	**$ 47.81**
Sheet Piles											
31 41 16.10 0900	40' deep excavation, 38 psf, left in place	Ton	668.67	$ 1,600.00	$ 1,069,870.40	$ 144.00	$ 96,288.34	$ 177.00	$ 118,354.41	$ 1,284,513.15	
31 41 16.10 2500	Wales, connections, struts, 2/3 salvage	Ton	668.67	$ 480.00	$ 320,961.12					$ 320,961.12	
http://assets.isheetp	Mobilization	EA	1							$ 22,000.00	
https://itd.idaho.gov	Tieback Anchors, grouted	EA	190.00	$ 66.15	$ 12,568.50					$ 12,568.50	
									Subtotal	**$ 1,640,042.77**	**$ 36.81**
Slurry Wall											
31 56 23.20 0500	Reinforced slurry trench, minimum	SF	44,556.00	$ 11.30	$ 503,482.80	$ 13.45	$ 599,278.20	$ 16.40	$ 730,718.40	$ 1,833,479.40	$ 41.15
	Average	SF	44,556.00	$ 24.40	$ 1,087,166.40	$ 23.98	$ 1,068,230.10	$ 29.20	$ 1,301,035.20	$ 3,456,431.70	$ 77.58
31 56 23.20 0600	Reinforced slurry trench, maximum	SF	44,556.00	$ 37.50	$ 1,670,850.00	$ 34.50	$ 1,537,182.00	$ 42.00	$ 1,871,352.00	$ 5,079,384.00	$ 114.00
http://yosemite.epa.g	**Slurry 1250 L x 65' deep example, construction cost only**	**SF**	**44,556.00**	**$ 68.00**	**$ 3,029,808.00**				**Subtotal**	**$ 3,029,808.00**	**$ 68.00**

	DAILY OUTPUT	UNT	AMT	TTL DURATION
Pile & Lagging				
Original	506	SF		88.00
Delay				26.00
			Total	114.00
Sheet Piles				
Sheet Piles	500	SF	44556	90.00
Slurry Wall				
RS Means (average)	123	SF	44556	363.00

Appendix C.1

Motivation Survey and Responses

AE Senior Thesis Survey on Motivation

The purpose of this survey is to understand what motivates people to work and how it correlates with team performance.

1. **To what degree do each of these items motivate you:**
   Mark only one oval per row.

	Not at all	Very little	Somewhat	Significantly	Very significantly
A respectable leader					
Formal recognition					
Promotional opportunities					
Time off					
A challenging project					
Money					
A complex project					
Negative consequences					
Team reputation					
Negative feedback					
An unmotivated team member					

2. **To what degree does assuming a leadership position motivate you?**
   Mark only one oval.

   - Not at all
   - Very little
   - Somewhat
   - Significantly
   - Very significantly

3. **To what degree do you feel motivated to do the work when you believe in the cause?**
   Mark only one oval.

   - Not at all
   - Very little
   - Somewhat
   - Significantly
   - Very significantly

4. **To what degree does your team motivate you to work?**
   Mark only one oval.

   - Not at all
   - Very little
   - Somewhat
   - Significantly
   - Very significantly

5. **To what degree do you think your level of motivation influences your team?**
   Mark only one oval.

   - Not at all
   - Very little
   - Somewhat
   - Significantly
   - Very significantly

6. **To what degree do you think a motivated leader influences your team performance?**
   Mark only one oval.

   - Not at all
   - Very little
   - Somewhat
   - Significantly
   - Very significantly

7. **To what degree do you think an unmotivated leader would influence your team performance?**
   Mark only one oval.

   - Not at all
   - Very little
   - Somewhat
   - Significantly
   - Very significantly

8. **To what degree do you think motivation is directly related to team performance?**
Mark only one oval.

- Not at all
- Very little
- Somewhat
- Significantly
- Very significantly

9. **What type of project did you work on that particularly motivated you?**

10. **What type of project were you on that you did not feel motivated to work? Explain what did not work.**

11. **What do you think is the most effective way to motivate your team?**

12. **What do you think is the least effective way to motivate your team?**

13. **What makes an effective/efficient team?**

14. **Do you think team or personal motivation affects overall job quality? Explain.**

15. **How does conflict affect your motivation? Team performance?**

16. **Would you consider yourself client driven, cost driven, team driven, or other? Explain.**

17. **What is your gender?**
Mark only one oval.

- Male
- Female
- Prefer not to answer

18. **What is your age?**
Mark only one oval.

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65+

19. **How many years industry experience do you have?**
Mark only one oval.

- 0-4
- 5-9
- 10-14
- 15-19
- 20-24
- 25-29
- 30+

20. **Education: What is the highest degree or level of school you have completed? If currently enrolled, highest degree received.**
Mark only one oval.

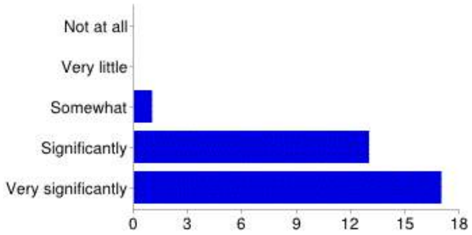
- No schooling completed
- Nursery school to 8th grade
- Some high school, no diploma
- High school graduate, diploma or the equivalent (for example: GED)
- Some college credit, no degree
- Trade/technical/vocational training
- Associate degree
- Bachelor's degree
- Master's degree
- Professional degree
- Doctorate degree

kgonzales6123@gmail.com
Edit this form

View all responses Publish analytics

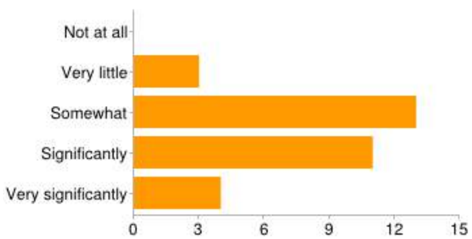
Summary

A respectable leader [To what degree do each of these items motivate you:]



Not at all	**0**	0%
Very little	**0**	0%
Somewhat	**1**	3.1%
Significantly	**13**	40.6%
Very significantly	**17**	53.1%

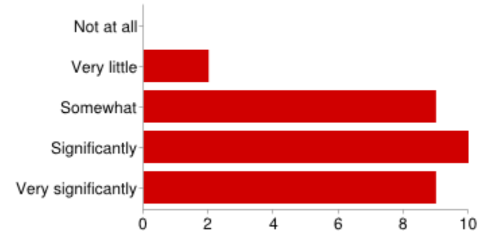
Formal recognition [To what degree do each of these items motivate you:]



Not at all	**0**	0%
Very little	**3**	9.4%
Somewhat	**13**	40.6%

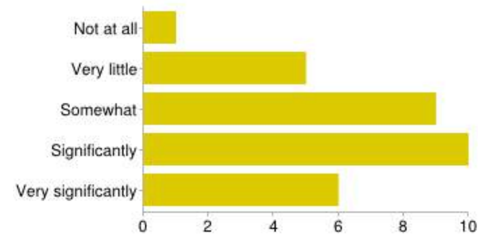
Significantly	**11**	34.4%
Very significantly	**4**	12.5%

Promotional opportunities [To what degree do each of these items motivate you:]



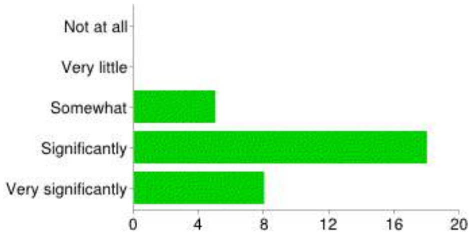
Not at all	**0**	0%
Very little	**2**	6.3%
Somewhat	**9**	28.1%
Significantly	**10**	31.3%
Very significantly	**9**	28.1%

Time off [To what degree do each of these items motivate you:]



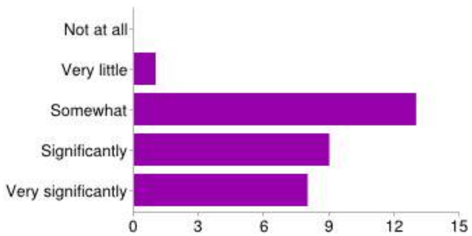
Not at all	**1**	3.1%
Very little	**5**	15.6%
Somewhat	**9**	28.1%
Significantly	**10**	31.3%
Very significantly	**6**	18.8%

A challenging project [To what degree do each of these items motivate you:]



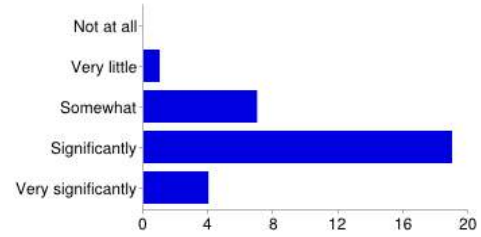
Not at all	**0**	0%
Very little	**0**	0%
Somewhat	**5**	15.6%
Significantly	**18**	56.3%
Very significantly	**8**	25%

Money [To what degree do each of these items motivate you:]



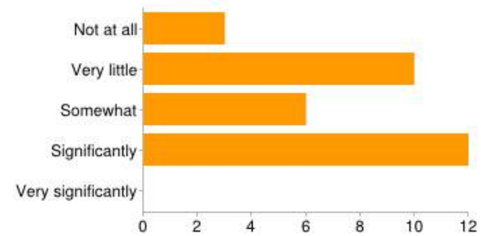
Not at all	**0**	0%
Very little	**1**	3.1%
Somewhat	**13**	40.6%
Significantly	**9**	28.1%
Very significantly	**8**	25%

A complex project [To what degree do each of these items motivate you:]



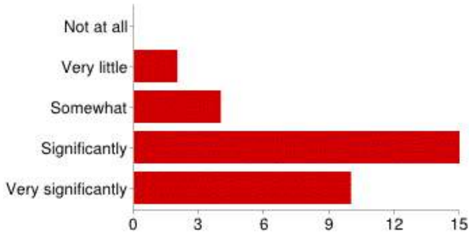
Not at all	**0**	0%
Very little	**1**	3.1%
Somewhat	**7**	21.9%
Significantly	**19**	59.4%
Very significantly	**4**	12.5%

Negative consequences [To what degree do each of these items motivate you:]



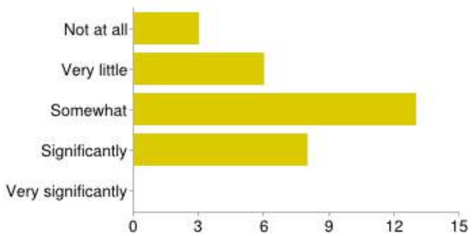
Not at all	**3**	9.4%
Very little	**10**	31.3%
Somewhat	**6**	18.8%
Significantly	**12**	37.5%
Very significantly	**0**	0%

Team reputation [To what degree do each of these items motivate you:]



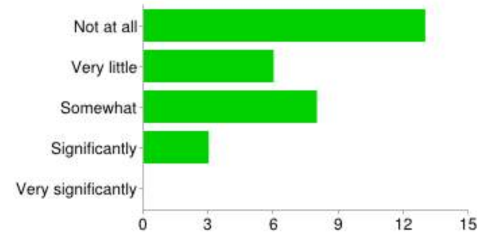
Not at all	**0**	0%
Very little	**2**	6.3%
Somewhat	**4**	12.5%
Significantly	**15**	46.9%
Very significantly	**10**	31.3%

Negative feedback [To what degree do each of these items motivate you:]



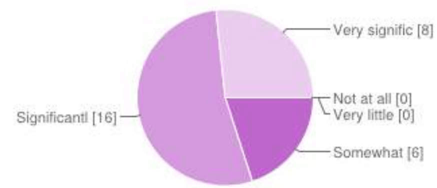
Not at all	**3**	9.4%
Very little	**6**	18.8%
Somewhat	**13**	40.6%
Significantly	**8**	25%
Very significantly	**0**	0%

An unmotivated team member [To what degree do each of these items motivate you:]



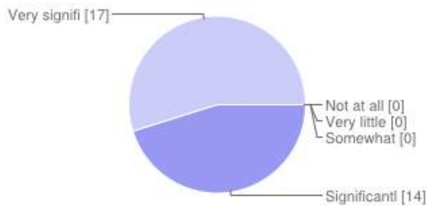
Not at all	**13**	40.6%
Very little	**6**	18.8%
Somewhat	**8**	25%
Significantly	**3**	9.4%
Very significantly	**0**	0%

To what degree does assuming a leadership position motivate you?



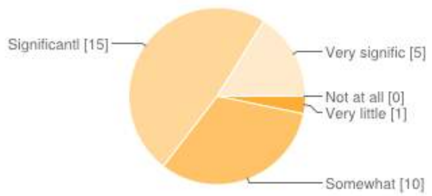
Not at all	**0**	0%
Very little	**0**	0%
Somewhat	**6**	18.8%
Significantly	**16**	50%
Very significantly	**8**	25%

To what degree do you feel motivated to do the work when you believe in the cause?



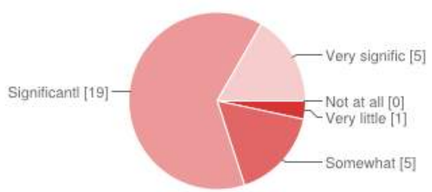
Not at all	**0**	0%
Very little	**0**	0%
Somewhat	**0**	0%
Significantly	**14**	43.8%
Very significantly	**17**	53.1%

To what degree does your team motivate you to work?



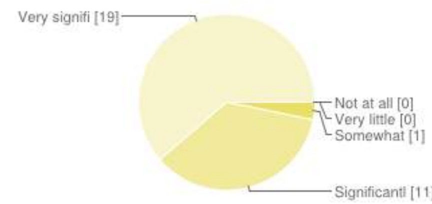
Not at all	**0**	0%
Very little	**1**	3.1%
Somewhat	**10**	31.3%
Significantly	**15**	46.9%
Very significantly	**5**	15.6%

To what degree do you think your level of motivation influences your team?



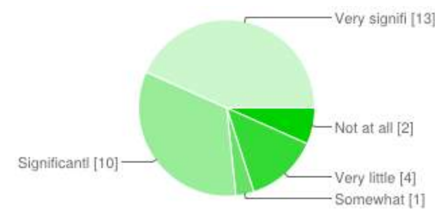
Not at all	**0**	0%
Very little	**1**	3.1%
Somewhat	**5**	15.6%
Significantly	**19**	59.4%
Very significantly	**5**	15.6%

To what degree do you think a motivated leader influences your team performance?



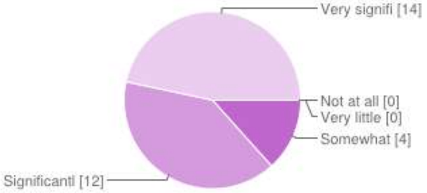
Not at all	**0**	0%
Very little	**0**	0%
Somewhat	**1**	3.1%
Significantly	**11**	34.4%
Very significantly	**19**	59.4%

To what degree do you think an unmotivated leader would influence your team performance?



Not at all	**2**	6.3%
Very little	**4**	12.5%
Somewhat	**1**	3.1%
Significantly	**10**	31.3%
Very significantly	**13**	40.6%

To what degree do you think motivation is directly related to team performance?



Not at all	**0**	0%
Very little	**0**	0%
Somewhat	**4**	12.5%
Significantly	**12**	37.5%
Very significantly	**14**	43.8%

What type of project did you work on that particularly motivated you?

Any project with great project leadership.

Two-Story overbuild on top of an existing hospital for a new Labor/Delivery unit and Ambulatory Surgery Center.

Any project where the team members are motivated and put time and effort into their work helps motivate me. Doesn't have to be a specific type of project -- more so the people who are working on it that affects motivation.

I was most motivated when I knew that the work of the team was respected and appreciated by the Owner. I put a significant amount of myself into my work and if treated respectfully and acknowledged for expertise I am more apt to internalize the project goals.

Complex, fast track renovation project.

Sports and Disney

Large, complex, high profile projects. Typically involve best players from all parties (sophisticated Owner, top-tier design firms, A-team CM and contractors)

Any projects where the team directly depends on me. Most school projects do not motivate me in this way because they are too abstract and most of it is truly done on my own. However, when I can directly see that my motivation directly and immediately affects my team's performance, I feel particularly motivated. For example, when I was a freshman we had a week-long exercise called RAP week. This exercise usually ran from 430am to 7am and was based around physical training (i.e. running, carrying heavy objects, etc.) with checks on knowledge throughout. Throughout the week, the testers

ensured we learned one lesson: if you do something wrong, the team gets punished; if you get it right, you MAY finish early. My actions and mistakes directly helped or hurt the team during this and motivated me to try my best and not let them down.

Disney-motivated Owner, motivated team which in turn fed to the field personnel

A well planned schedule & effective leadership.

Complex, challenging project

Close Out. Strict deadlines.

not sure

Daytona International Speedway

Sports

Complex, fast paced sports stadium requiring quick decisions daily. Ability to provide meaningful contributions daily.

Fast paced, complicated

Being in the Safety world when the team works together is a beautiful thing. Safety is every ones responsibility to include Superintendent, Project Manger, Project Engineer, Foreman, Workers and Safety Managers.

The National Aquarium in Baltimore, MD. The project was highly complicated and provided a great learning experience.

Internships/ jobs where I really felt as if I were influential and part of the team.

Design/Build project with my classmates where we had a real client

Higher Education and University Work

Pittsburgh Children's Hospital

The project that I am currently on has motivated me to want to learn more about all aspects of the construction we do. The team here at the DIS FR are very skilled and knowledgeable and share a desire to deliver a quality product to our client.

Mine train

Troubled project

What type of project were you on that you did not feel motivated to work? Explain what did not work.

The Kitchen renovation at the US Naval Academy in Annapolis, MD. While it was an interesting project there was an excess of high ranking team members that pulled the project in too many directions and failed to provide clear direction to the rest of the team.

Previous company working as an Account Manager. Uneducated and unprofessional owner and management. Technically good products but with poor business practices in hiring, accounting and fair labor.

Low bid K-12 school renovation. Typically bottom of the barrel for contractors, designers, and other team members.

Self motivation has always been critical

When myself and the team were treated as 'contractors' in lieu of partners. I am less apt to look out for the best interests of the Owner at the espense of my time if the Owner treats my like a 'cheat'.

The projects that have motivated me the least usually involved either an unmotivated team or an unmotivated teacher/leader. I think specifically of assignments in school where teachers seem very lax and uncaring about the assignments they give us.

Generally, interior renovations of any kind. They just don't appeal to me. However, there is a sense of motivation if the renovations are in an occupied facility, where you have the potential for disruptions and overall dissatisfaction of the Owner.

A project where team members are not motivated will make others less motivated to do work as well. Especially if the leader is unmotivated or does not help when help is requested. This will have a negative effect on subordinates. If there are no incentives, this will affect motivation as well.

A negative relationship with the projects owners rep.

An Energy project. Poor management and large loss of profit made morale sink.

A new grocery store. Did not want to be there (Texas) and it was an uninspiring project.

None

Working in a pizza shop i n High School

Iconic, my leaders take every opportunity to make me feel unworthy. Talk down to myself and others in front of others. Pass me over for things I was promised and that others in the same position have.

One where the PM was critical of management and corporate.

Negative, most of the team gave up. I got to the project half way through it and the owner was always changing things so the drawing were not complete and people could not see the end of the tunnel.

Animosity among the team members is a job killer!!!!!!

Slow paced with little to no engineering issues. Unorganized, disrespectful leader who provided no growth for leadership.

I have not been on enough projects to really give feed back as far as it goes with this company. I did work for an organization where the gentleman in charge never affirmed anything that we as a team did. Our efforts were constantly corrected and criticized which made it very difficult to appreciate what we were doing.

I do not feel motivated to work for any project where the management does not care to create a unified team, and I do not have the ability/need to step into a role of management. If the team is not cohesive with a clear understanding of what is supposed to go on and what the end goal is, then the job is not efficiently completed if ever completed at all.

Minimal staff and minimal input from supervisor.

Any project with crummy project leadership.

One that was so far behind schedule we had LD's evoked. Trying to make up time on one shift 6 days a week, when we should have been working 2 shifts 7 days a week.

Negative environment, losing money, bad leadership

Power plant, unmotivated team, lack of leadership, money problems.

mine train.some of the leadership

What do you think is the most effective way to motivate your team?

Positive reinsurance in the safety world is the only way to go.

Communication

Formal recognition, bonuses, promotions, and advancement

work with them

Making it a "family community". We all win or we all loose, but in the end were here to have fun and do the job.

Team interaction and working together to resolve issues.

Good leadership that manages but also takes the time to put in some time of physical labor

Communication, it does have to be positive, just honest

Treat us respectfully and show appreciation for our efforts.

Treat others as you want to be treated, admit your mistakes. And do not take out your frustrations on others. I am only @ 50% when I am treated this way. I can never grow with someone's foot in my neck.

Support & leadership during tough times and good times.

what seems to work for me is the random acts of appreciation that our leadership shows here. Whether it be a luncheon or a meeting after work or just the affirmation they offer when a job is done well. I like the fact that when something is being done wrong they work with you in deciding a solution rather than just criticizing and walking away leaving you to figure it out by yourself.

Team building events.

Listen to what they have to say & hold them accountable.

Positive recognition, end-goal in mind, team meetings

Clearly communicate project goals, personal expectations, and importance of each person's role to the success of the project. Set a good example.

Work harder than anyone else. Be the first to arrive and the last one to leave. Have a positive and constantly optimistic attitude.

Work hard with a good attitude.

By being accountable and showing an interest towards the work you are completing. Also, participating in problems they may have and helping them resolve them instead of telling them to figure it out on their own. Acting as a team and helping each other out is important to motivation. Respect for one another is also important.

By my own passionate example of highly motivated behavior.

Open and active communication top to bottom and bottom to top.

Have them take ownership of their piece of the project no matter how small

By example. The more motivation you exude, and the harder you work, the team will follow suit.

I feel that the best way to motivate people is by example. By working hard and offering assistance and support in the assignments that you set for the team, you will be able to demonstrate key characteristics that lead to success.

The most effective way to motivate a team is to know and understand how every individual gets motivated, motivated individuals make for a motivated team.

The most effective way to motivate a team is provide a clear goal, purpose, and a method to accomplish them. The carrot and stick method is definitely a method that works, but even that can lose its power if used too often. Most times, if the subordinates understand the purpose of the mission, believe in it, and trust the leader they will bend over backwards to get the job done.

Get along side of them and recognize their work habits, skill set and motivators then challenge them to the task(s).

What do you think is the least effective way to motivate your team?

doing whatever is in your best intrest

Disrespect to team members does not motivate them to keep working. Not helping them with issues they need help resolving. Having them work longer hours or given more responsibilities with no reward.

Assuming they all think and feel the same, cant motivate a team if you dont know each member.

Constant criticism and lack of true leadership with all issues.

Grumble and complain all the time

Providing negative feedback towards their work and/or not providing suggestions or insight for how to improve the end results.

negativity

Threatening and scare tactics are the lease motivational method.

Asking for something to be done without providing the bigger picture of how the task affects the total success of the project.

With threats and talking to grown adults like a dictator.

Undue criticism.

Not be an integral team member and not communicate with team members.

Incentives that mean nothing or that you would get anyway.

The least effective way for me is the feeling that you are just a pawn to help someone else achieve their vision while your needs and goals are not valued.

When you ask them to do as you say, and not as you do. The team will follow your lead, good or bad.

Not help them understand where their piece fits in

Be self centered and self absorbed with unprofessional work place characteristics.

Power trips

Brow beating and reprimanding

Intimidation & putting one employee against the other, causing friction among the team.

Assign jobs but never take the time to check-in with how they're doing or if the project is even being completed

Using phrases "because I said so" or anything else of this nature. It does not communicate purpose, commander's intent, or even a clear understanding of why the project needs to occur. Does the subordinate always need to understand everything that is going on? No; but if time allows for it, it is important that they understand why they are doing what they are doing.

Yelling, passive agressiveness, inappropriate communication

A negative attitude/atmosphere. Confrontational relationships within the project team.

The opposite of above. Show up late, leave early, don't carry your wright, procrastinate on assignments... display negative energy.

Constant negative feedback.

By my own laziness.

What makes an effective/efficient team?

coordination, communication and willingness to work with and around each others individual schedules and support each other as a team.

A positive atmosphere in which ideas can be shared and discussed leading to end results that make everyone feel proud of the end results.

Alignment and focus on a common goal.

Cohesion/trust, flexibility, and focus. If the team bickers and argues all the time, nothing gets done and no one will respect each other. I'm not saying that everyone has to be friends by the end of the project, but it is important that everyone gets along and puts their best effort towards it. I once heard someone use the word "flexecute" meaning ~ being flexible and cooperative for the greater good of accomplishing the mission. No plan is perfect and something will always go wrong. In terms of focus, if everyone is distracted, nothing will get done.

The leaders recognize and acknowledges the talents and efforts of everyone. Optimism is contagious. Having positive energy and squelching the negative. An effective team celebrates even the little team victories every day.

Proper motivation, communication, understand that employees have a family and a life that they want to enjoy.

One that every member takes the initiative and does not wait to be directed. Also when the team members acknowledge their strenghts and weaknesses openly so the team can be organized effectively.

Cohesiveness, communication

Communication, honesty and respect.

Trust. Conflict. Commitment. Accountability. Focus on desired results. (Lencioni's Five Dysfunctions of a Tema)

A team that works together, talks to each other and takes ownership of work or problems, when needed

Trust and individual motivation.

Respect for one another. Accountability and holding each other accountable for the work they are responsible for managing and completing. Trust between coworkers.

Group involvement, communication between team members, support from fellow team members not criticism. Appreciation for contributions of each team member individually and as a team. A sincere desire to see teammates succeed and exceed expectations.

Leader to communicate team goals, roles and responsibilities up front, and then facilitate the opportunity for good communication throughout the process. Creating a collaborative environment.

team work

Having multiple different types of thinkers to allow a problem to be looked at in a broad spectrum of ways.

Teamwork. Regular meetings.

cooperation

Open communication & accountability.

Everybody understands their role, and is able to effectively communicate and work together to meet goals, schedule, etc.

Communication is the biggest thing in team work.

Knowing their piece of the project and knowing how to get it to fit when things run into a road block

Ability to communicate effectively and efficiently

People who are unselfish, hard-workers, and emotionally intelligent.

Good management, clear communication, and a whole team understanding and

agreement of standards and goals

Do you think team or personal motivation affects overall job quality? Explain.

yes beacause everyone shares the same desire and passion for the quality of the product in winch they are producing.

Yes, I think team/personal motivation affects overall job quality. If a person is unmotivated, then their responsibilities will not be completed to the best of their abilities. If a person is held unaccountable for not completing their tasks, due to their lack of motivation, then the work will be given to another subordinate who is not supposed to be working on those tasks. This will cause them to be slightly unmotivated since another coworker now has less responsibilities and the other team member now has additional work. This is why accountability is important in motivating teams.

It affects it directly. Construction is a people business, unmotivated people do a poor job, and this affects quality.

Yes. The more motivation or excitement surrounding the project, the more creative the team will be and the more willing the team will be to put forth a quality effort in completing the work or solving the problems.

Absolutely. If you are not personally motivated your team will notice and then proceed to not trust you.

Yes. Because it makes everyone really care.

I am personally driven to do my part for the team. If the team does not care about the job at all, my motivation lacks, but I still do my part so I know I did what as much as I could. If the project has a client, I will work for the client and not the team if need be. If the project is for a grade and not a client, I will do my part to get the grade I need, but I will not carry an unmotivated team if their input won't affect my grade.

Absolutely. If there is one bad egg, it affects the whole party.

yes

Yes, if employees are unhappy they will not go the extra mile to do ensure quality work.

Low motivation lower project quality

Absolutely. If you are not interested in what you're doing, your attention is split between it and what you want to be doing.

Team motivation is important and to accomplish this, all members of the team must have a certain level of drive to be sucessful personally.

Personal. No matter how motivated a team, if one person is not motivated they can sink a project.

Both affect overall job quality

Yes, teammates that are motivated learn to work smart, working faster without compromising quality and accomplishing a greater amount of productivity. Motivation and pride in a job well done seems to go hand in hand with being pleasant and even fun to work with and around.

Both, they can bring you up or down

Team work in the safety world.

Yes, a team who doesn't care or just wants to get the job done will put forth a lesser product than the team who wants to do the best they possibly can. This comparison can be seen in many ways, such as, the time it takes to execute, the thoroughness of the plan, materials used, etc.

Team motivation with everyone held accountable for their piece of the puzzle.

Absolutely, negative motivation/attitude will bring down those around yout

Of course, positive always leeds to productive a result.

A job can get done with or without a motivated team or individuals. The level of quality may be slightly better with motivation, but the level of personal satisfaction is always exponentially higher.

Yes.

Yes, motivated people take pride in their work.

Team Motivation While personal motivations vary from person to person, I believe most people want to work in a place they enjoy and can achieve satisfaction for their work. The success of the project team can provide these things and can be a great motivation to work hard towards the common goal.

Both but team can control quality more eyes the more individual views.

How does conflict affect your motivation? Team performance?

Conflict can either decrease motivation or increase it as a need to prove oneself. However, conflict almost always has a negative effect on team performance.

As long as it not personnel little to know affect. It is just business

It lowers it.

Conflict can slow team performance and motivation, but with management that I respect then it's easier to listen to him/her as an ultimate decision maker

Conflict deflates motivation and detracts from team performance. Conflict draws attention away from the project goal and focuses on the conflict itself which gets a life of it's own and less work gets done on the project. Conflict may also add or fuel an adversarial relationship with another team member(s) limiting the normal communication lines.

Conflict has a tendency to motivate me to push harder, and stake my position on the high road. If handled well, conflict can become a rallying point for a team. If handled poorly it can cause members to revert into their personal bad habits.

Dealing with conflicts effectively is one of the hallmarks of great leaders because it

motivates people to be undaunted in the face of adversity.

It is a lot harder to accomplish goals within the project if you are doing it by yourself. When you look at the responsibility one has especially on a project of this size it can become very overwhelming if you dont have support and understanding from your team.

It significantly reduces motivation.

Conflict is healthy during certain topics however can be very problematic when constant. It is required for constant development of the team but the leader must be cautious to not create conflict for the sake of being right.

Conflict is just part of the job when it comes to the safety world it's knowing how to handle it. Communication is the main thing when it comes to team performance and trying to reach a common goal.

Degrading on both personal and team motivation and performance. Nobody likes conflict. But, the leader should help teach the team how to eliminate, reduce or diffuse conflict.

This tends to close individuals down from group and lead to a "best for me" attitude. This type of attitude can dramatically impact the success of a team as others may hold back their best efforts once they see that others are not contributing as they once were.

It makes you want to avoid the person, which creates road bumps in the goal you are trying to accomplish.

Constructive conflict is very productive/motivating. It allows you to debate ideas and develop creative solutions. I find that through disagreeing/debating an issue with my Superintedent we tend to find the optimum solution that balances the outcome (budget/Work Execution).

it divides you

If there is conflict, the individual motivation and team performance decrease, especially if the conflict drags on. It creates a loss of focus on the overall goal and people will be more concerned about fixing the conflict than doing the job.

cant think straight

By nature, people avoid conflict, hence a problematic environment will make individuals dont want to be part of the team, affecting performance directly.

By 50%, loss of full focus. Fairness is a must among grown adults.

in extreme case it can undermine the entire job, lessen the confidence in coworkers

Solid commitment and real accountability cannot be achieved with first a healthy dose of conflict. In this sense, conflict is a prerequisite for real motivation and ultimately team performance.

I am highly unmotivated by conflict.

Conflict is healthy and helps team members get aligned when working together to develop the most effective solution.

Conflict affects motivation because it has a negative vibe. Humans will not want to do something that they do not feel comfortable doing or if conflict exists between people. Team performance will be affected if conflict exists because the team will not trust each other and it will hinder communication between the two parties.

It kills the motivation & drags the performance down.

Would you consider yourself client driven, cost driven, team driven, or other? Explain.

All of the above. Having been in business for myself I have come full circle with all of the above.

All of the above. Balance is essential and all of the above are equally important.

I would consider myself team driven at this point because I have been fortunate enough to have been placed with some very intelligent leadership. It is helpful for me while I am still learning so much to have the support from my team and their insight and intellect to see me through when I am faced with situations that i do not know how to handle.

Client and team driven

It's a 3-legged stool - you can't not have all 3 with some reasonable balance. For business development purposes we must be client driven. For internal survival we must be cost driven. For day-to-day effectiveness and enjoyment we must be team driven.

There is definitely some of all of these, and many others, that are a part of my own personal drive. The one that stands out the most for me though, is client driven. The reason I say this is that being client driven can lead to success in the other areas. A happy and satisfied client can provide more work, positive personal/team/company reviews and recommendations to other potential clients. This is the one that I feel can have the greatest overall impact to everyone.

self, team and client

All of the above. You have to be well-rounded to succeed.

Can't really be just one, and I don't think you have to be, or should be. All of these and more should be motivational factors in how you conduct your business as a leader.

Team driven, a good team will overcome any adversity.

yes

Client and cost driven above team driven. I've found that taking care of client needs usually builds the trust that makes the job progess more smoothy. Cost is the typical driver of Owner satisfaction. Taking care of these aspects usually leads to a smoother project which reduces stress on the team - a positive side-effect.

I consider myself personally client driven. Happy clients mean repeat work. Repeat works means more opportunities.

Team driven. When my team wins, our Company wins, and our clients win.

Obviously, I'm not in the industry, but couldn't a person/company be all three? In my head, I'm imagining a ven-diagram in which all three overlap

Team driven. If you're coming to work everyday, you want a positive environment to produce sucessful work and if you have a cohesive team, the team will work together to create success in the areas of cost, schedule, and cliet relations.

I must be all of those things because they are equally important.

All of these are important but the challenge of getting multiple people focused on a common goal and constantly working together excites me so I am team driven.

I am driven by my desire to finish a project on time and on budget. I continue to find motivation in the meaningful contribution to the overall team and ability to assist in a variety of tasks.

1.) Client Driven: If a client is trusting me with their money, time, and project then I do not want to let them down in any of those areas. 2.) Other, Personal-time Driven: If I am inefficient then projects will surely cut into my personal time. If I do my best to be efficient and lead the team to efficiency then we have a chance for more personal time.

Team driven. Having a good, respectful, trustworthy, accountable team is very motivating to make sure we are all working together to achieve the goals set to be successful.

Mostly team driven with a little bit of cost. You have to have fun with the team, but in the end it has to be financially worth it.

Schedule . Way too many problems if you do not finish on or before completion date.

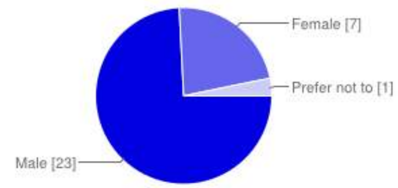
Client driven, if they are satisfied you may have an opportunity to do additional projects w/them.

task driven and team driven

Cost driven/team driven.

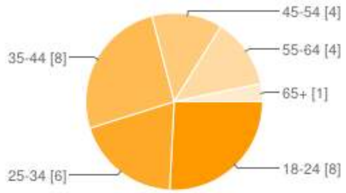
Team Driven "Safety is all about team work!"

What is your gender?



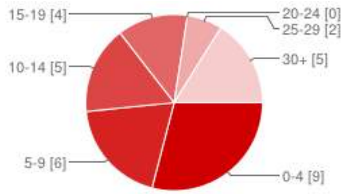
Male	**23**	71.9%
Female	**7**	21.9%
Prefer not to answer	**1**	3.1%

What is your age?



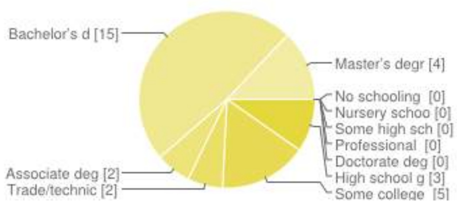
18-24	**8**	25%
25-34	**6**	18.8%
35-44	**8**	25%
45-54	**4**	12.5%
55-64	**4**	12.5%
65+	**1**	3.1%

How many years industry experience do you have?



0-4	**9**	28.1%
5-9	**6**	18.8%
10-14	**5**	15.6%
15-19	**4**	12.5%
20-24	**0**	0%
25-29	**2**	6.3%
30+	**5**	15.6%

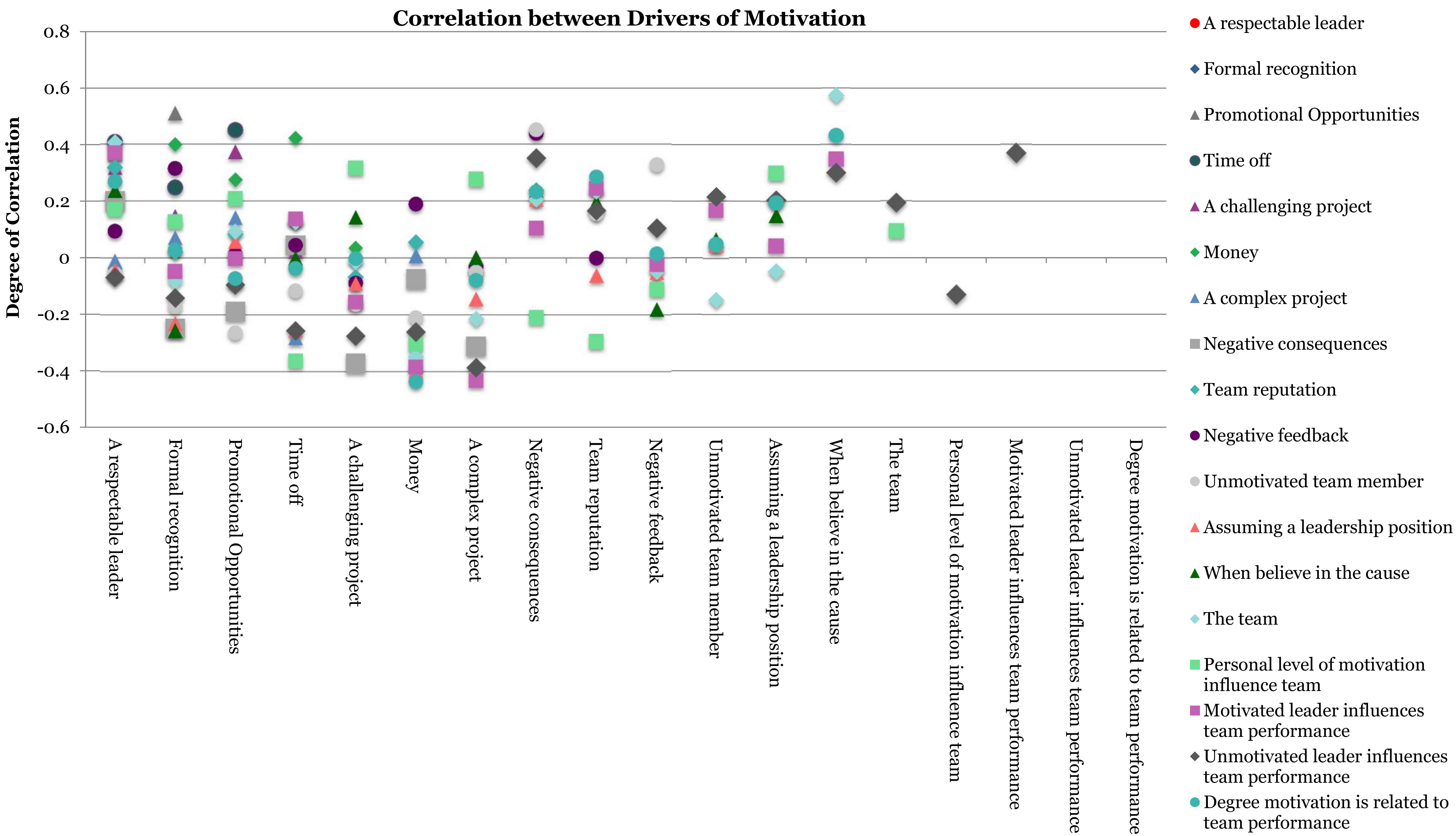
Education: What is the highest degree or level of school you have completed? If currently enrolled, highest degree received.



No schooling completed	**0**	0%
Nursery school to 8th grade	**0**	0%
Some high school, no diploma	**0**	0%
High school graduate, diploma or the equivalent (for example: GED)	**3**	9.4%
Some college credit, no degree	**5**	15.6%
Trade/technical/vocational training	**2**	6.3%
Associate degree	**2**	6.3%
Bachelor's degree	**15**	46.9%
Master's degree	**4**	12.5%
Professional degree	**0**	0%
Doctorate degree	**0**	0%

Appendix C.2

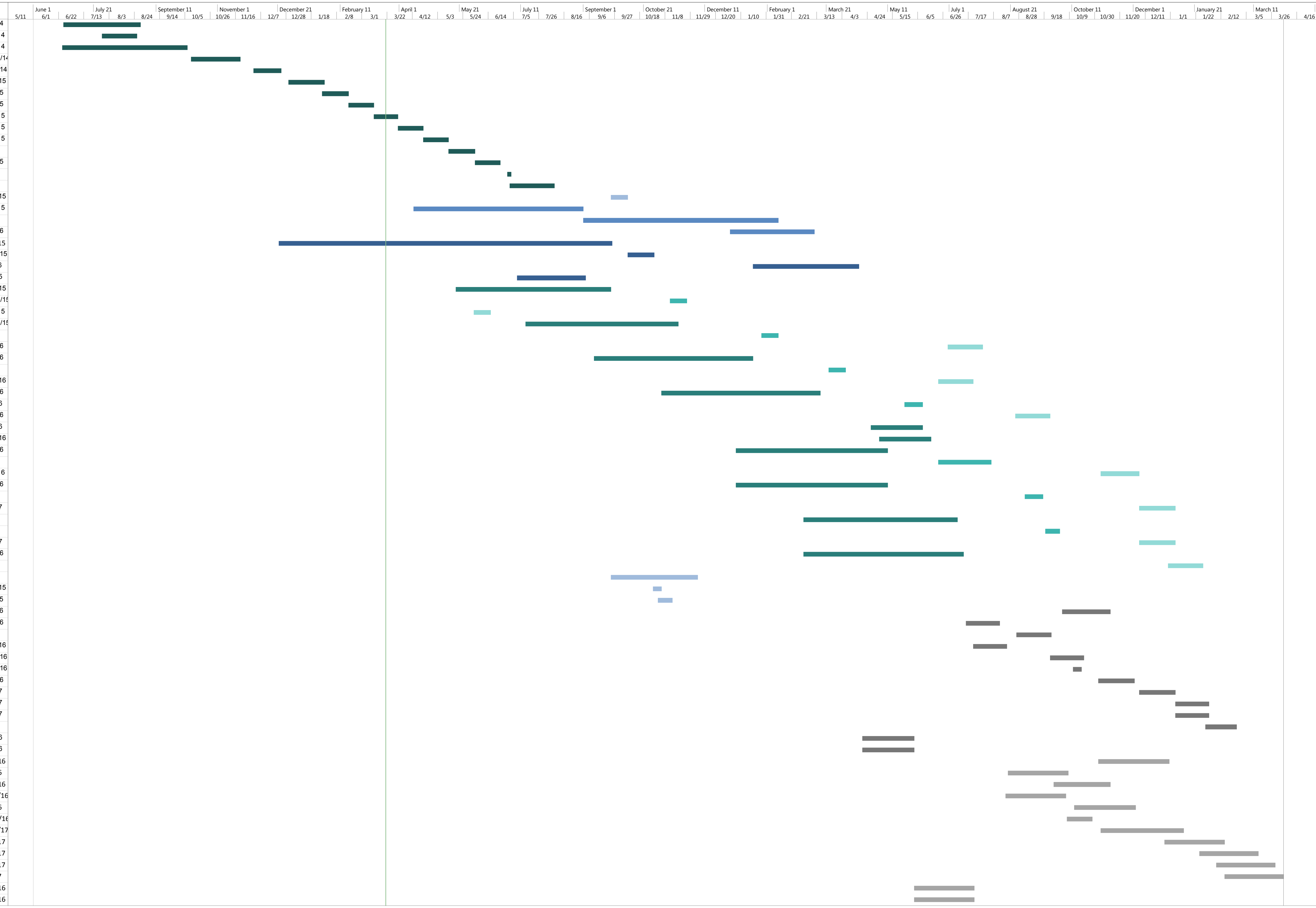
Motivation Correlation Graph


Correlation between Drivers of Motivation
Degree of Correlation
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
A respectable leader
Formal recognition
Promotional Opportunities
Time off
A challenging project
Money
A complex project
Negative consequences
Team reputation
Negative feedback
Unmotivated team member
Assuming a leadership position
When believe in the cause
The team
Personal level of motivation influence team
Motivated leader influences team performance
Unmotivated leader influences team performance
Degree motivation is related to team performance
A respectable leader
Formal recognition
Promotional Opportunities
Time off
A challenging project
Money
A complex project
Negative consequences
Team reputation
Negative feedback
Unmotivated team member
Assuming a leadership position
When believe in the cause
The team
Personal level of motivation influence team
Motivated leader influences team performance
Unmotivated leader influences team performance
Degree motivation is related to team performance

Appendix D.1

Mechanical Gantt Schedule

ID	Task Mode	Task Name	Duration	Start	Finish
1		In Slab Placement- Mat Slab	46 days	Thu 6/26/14	Thu 8/28/14
2		In Slab Placement- UB Slab	21 days	Mon 7/28/14	Mon 8/25/14
3		In Slab Placement- Level 1	74 days	Wed 6/25/14	Mon 10/6/14
4		In Slab Placement- Level 2	29 days	Fri 10/10/14	Wed 11/19/14
5		In Slab Placement- Level 3	17 days	Mon 12/1/14	Tue 12/23/14
6		In Slab Placement- Level 4	22 days	Tue 12/30/14	Wed 1/28/15
7		In Slab Placement- Level 5	16 days	Tue 1/27/15	Tue 2/17/15
8		In Slab Placement- Level 6	15 days	Wed 2/18/15	Tue 3/10/15
9		In Slab Placement- Level 7	14 days	Wed 3/11/15	Mon 3/30/15
10		In Slab Placement- Level 8	15 days	Tue 3/31/15	Mon 4/20/15
11		In Slab Placement- Level 9	15 days	Tue 4/21/15	Mon 5/11/15
12		In Slab Placement- Level 10	16 days	Tue 5/12/15	Tue 6/2/15
13		In Slab Placement- Level LP	15 days	Wed 6/3/15	Tue 6/23/15
14		In Slab Placement- Level UP	3 days	Tue 6/30/15	Thu 7/2/15
15		In Slab Placement- Level Roof	27 days	Thu 7/2/15	Fri 8/7/15
16		Set Mech Equip on Roof	10 days	Thu 9/24/15	Wed 10/7/15
17		Mechanical Shafts lvl LB-2	101 days	Mon 4/13/15	Mon 8/31/15
18		Mechanical Shafts lvl 3-6	116 days	Tue 9/1/15	Tue 2/9/16
19		Mechanical Shafts lvl 7-R	50 days	Fri 1/1/16	Thu 3/10/16
20		Install Mechanical LB	199 days	Mon 12/22/1	Thu 9/24/15
21		Set Mech Equip Basement	16 days	Thu 10/8/15	Thu 10/29/15
22		Connect Mech Equip Basement	64 days	Wed 1/20/16	Sat 4/16/16
23		Mechanical Level UB	41 days	Wed 7/8/15	Wed 9/2/15
24		L1 Overhead/In Wall	93 days	Mon 5/18/15	Wed 9/23/15
25		L1 Connections Service Panels	10 days	Thu 11/12/15	Wed 11/25/15
26		L1 Connections Lab Equip	10 days	Tue 6/2/15	Mon 6/15/15
27		L2 Overhead/In Wall	91 days	Wed 7/15/15	Wed 11/18/15
28		L2 Connections Service Panels	10 days	Wed 1/27/16	Tue 2/9/16
29		L2 Connections Lab Equip	21 days	Thu 6/30/16	Thu 7/28/16
30		L3 Overhead/In Wall	94 days	Thu 9/10/15	Tue 1/19/16
31		L3 Connections Service Panels	10 days	Wed 3/23/16	Tue 4/5/16
32		L3 Connections Lab Equip	21 days	Wed 6/22/16	Wed 7/20/16
33		L4 Overhead/In Wall	94 days	Thu 11/5/15	Tue 3/15/16
34		L4 Connections Service Panels	11 days	Wed 5/25/16	Wed 6/8/16
35		L4 Connections Lab Equip	21 days	Thu 8/25/16	Thu 9/22/16
36		L5 Overhead/In Wall	31 days	Wed 4/27/16	Wed 6/8/16
37		L6 Overhead/In Wall	31 days	Wed 5/4/16	Wed 6/15/16
38		L7 Overhead/In Wall	90 days	Wed 1/6/16	Tue 5/10/16
39		L7 Connections Service Panels	32 days	Wed 6/22/16	Thu 8/4/16
40		L7 Connections Lab Equip	22 days	Fri 11/4/16	Mon 12/5/16
41		L8 Overhead/In Wall	90 days	Wed 1/6/16	Tue 5/10/16
42		L8 Connections Service Panels	11 days	Fri 9/2/16	Fri 9/16/16
43		L8 Connections Lab Equip	22 days	Tue 12/6/16	Wed 1/4/17
44		L9 Overhead/In Wall	92 days	Wed 3/2/16	Thu 7/7/16
45		L9 Connections Service Panels	10 days	Mon 9/19/16	Fri 9/30/16
46		L9 Connections Lab Equip	22 days	Tue 12/6/16	Wed 1/4/17
47		L10 Overhead/In Wall	95 days	Wed 3/2/16	Tue 7/12/16
48		L10 Connections Lab Equip	21 days	Fri 12/30/16	Fri 1/27/17
49		LP/UP Mechanical	52 days	Thu 9/24/15	Fri 12/4/15
50		Set LP UP Mech Equip	5 days	Thu 10/29/15	Wed 11/4/15
51		Set Roof Equipment	10 days	Mon 11/2/15	Fri 11/13/15
52		TAB LB-UB	30 days	Mon 10/3/16	Fri 11/11/16
53		TAB L1	20 days	Fri 7/15/16	Thu 8/11/16
54		TAB L2	21 days	Fri 8/26/16	Fri 9/23/16
55		TAB L3	20 days	Thu 7/21/16	Wed 8/17/16
56		TAB L4	20 days	Fri 9/23/16	Thu 10/20/16
57		TAB L5	5 days	Wed 10/12/1	Tue 10/18/16
58		TAB L6	22 days	Wed 11/2/16	Thu 12/1/16
59		TAB L7	22 days	Tue 12/6/16	Wed 1/4/17
60		TAB L8	20 days	Thu 1/5/17	Wed 2/1/17
61		TAB L9	20 days	Thu 1/5/17	Wed 2/1/17
62		TAB L10	20 days	Mon 1/30/17	Fri 2/24/17
63		TAB LP-UP	31 days	Wed 4/20/16	Wed 6/1/16
64		TAB Roof	31 days	Wed 4/20/16	Wed 6/1/16
65		Commissioning Basement	43 days	Wed 11/2/1	Fri 12/30/16
66		Commissioning L1	36 days	Fri 8/19/16	Fri 10/7/16
67		Commissioning L2	35 days	Mon 9/26/1	Fri 11/11/16
68		Commissioning L3	36 days	Wed 8/17/1	Wed 10/5/16
69		Commissioning L4	37 days	Thu 10/13/1	Fri 12/2/16
70		Commissioning L5	15 days	Fri 10/7/16	Thu 10/27/16
71		Commissioning L6	49 days	Fri 11/4/16	Wed 1/11/17
72		Commissioning L7	36 days	Tue 12/27/1	Tue 2/14/17
73		Commissioning L8	35 days	Wed 1/25/17	Tue 3/14/17
74		Commissioning L9	35 days	Wed 2/8/17	Tue 3/28/17
75		Commissioning L10	35 days	Wed 2/15/17	Tue 4/4/17
76		Commissioning LP/UP	36 days	Thu 6/2/16	Thu 7/21/16
77		Commissioning Roof	36 days	Thu 6/2/16	Thu 7/21/16



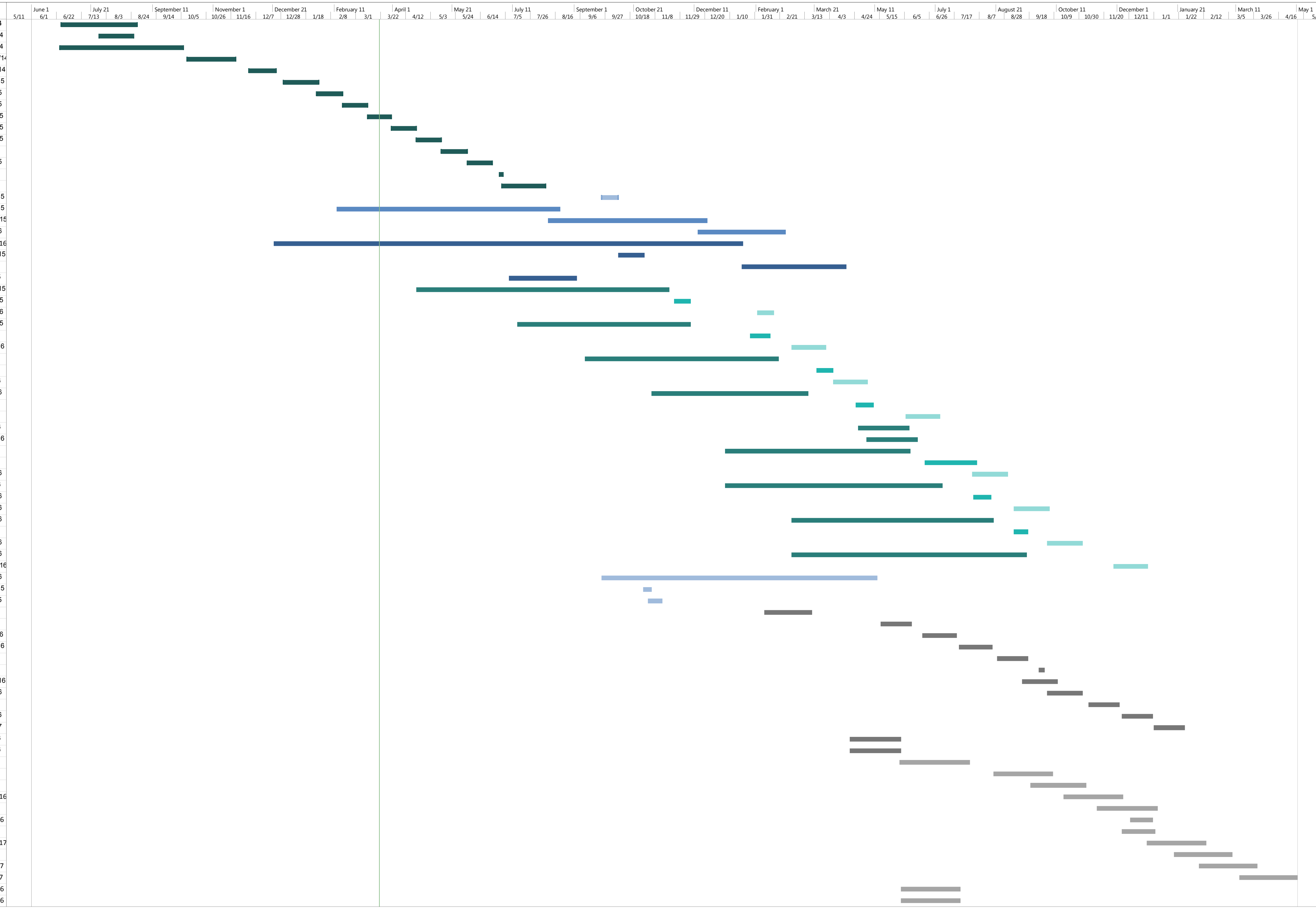
Original Schedule

Project: Schedule with Commiss
Date: Sat 3/21/15

Task	Milestone	Project Summary	Inactive Milestone	Manual Task	Manual Summary Rollup	Start-only	External Tasks	Deadline	Manual Progress		
Split	Summary	Inactive Task	Inactive Summary	Duration-only	Manual Summary	Finish-only	External Milestone	Progress			

Page 1

ID		Task Mode	Task Name	Duration	Start	Finish
1			In Slab Placement- Mat Slab	46 days	Thu 6/26/14	Thu 8/28/14
2			In Slab Placement- UB Slab	21 days	Mon 7/28/14	Mon 8/25/14
3			In Slab Placement- Level 1	74 days	Wed 6/25/14	Mon 10/6/14
4			In Slab Placement- Level 2	29 days	Fri 10/10/14	Wed 11/19/14
5			In Slab Placement- Level 3	17 days	Mon 12/1/14	Tue 12/23/14
6			In Slab Placement- Level 4	22 days	Tue 12/30/14	Wed 1/28/15
7			In Slab Placement- Level 5	16 days	Tue 1/27/15	Tue 2/17/15
8			In Slab Placement- Level 6	15 days	Wed 2/18/15	Tue 3/10/15
9			In Slab Placement- Level 7	14 days	Wed 3/11/15	Mon 3/30/15
10			In Slab Placement- Level 8	15 days	Tue 3/31/15	Mon 4/20/15
11			In Slab Placement- Level 9	15 days	Tue 4/21/15	Mon 5/11/15
12			In Slab Placement- Level 10	16 days	Tue 5/12/15	Tue 6/2/15
13			In Slab Placement- Level LP	15 days	Wed 6/3/15	Tue 6/23/15
14			In Slab Placement- Level UP	3 days	Tue 6/30/15	Thu 7/2/15
15			In Slab Placement- Level Roof	27 days	Thu 7/2/15	Fri 8/7/15
16			Set Mech Equip on Roof	10 days	Thu 9/24/15	Wed 10/7/15
17			Mechanical Shafts lvl LB-2	134 days	Fri 2/13/15	Wed 8/19/15
18			Mechanical Shafts lvl 3-6	96 days	Mon 8/10/15	Mon 12/21/15
19			Mechanical Shafts lvl 7-R	54 days	Mon 12/14/15	Thu 2/25/16
20			Install Mechanical LB	283 days	Mon 12/22/1	Wed 1/20/16
21			Set Mech Equip Basement	16 days	Thu 10/8/15	Thu 10/29/15
22			Connect Mech Equip Basement	64 days	Wed 1/20/16	Sat 4/16/16
23			Mechanical Level UB	41 days	Wed 7/8/15	Wed 9/2/15
24			L1 Overhead/In Wall	153 days	Tue 4/21/15	Thu 11/19/15
25			L1 Connections Service Panels	10 days	Tue 11/24/15	Mon 12/7/15
26			L1 Connections Lab Equip	10 days	Tue 2/2/16	Mon 2/15/16
27			L2 Overhead/In Wall	104 days	Wed 7/15/15	Mon 12/7/15
28			L2 Connections Service Panels	13 days	Wed 1/27/16	Fri 2/12/16
29			L2 Connections Lab Equip	21 days	Wed 3/2/16	Wed 3/30/16
30			L3 Overhead/In Wall	117 days	Thu 9/10/15	Fri 2/19/16
31			L3 Connections Service Panels	10 days	Wed 3/23/16	Tue 4/5/16
32			L3 Connections Lab Equip	21 days	Wed 4/6/16	Wed 5/4/16
33			L4 Overhead/In Wall	94 days	Thu 11/5/15	Tue 3/15/16
34			L4 Connections Service Panels	11 days	Mon 4/25/16	Mon 5/9/16
35			L4 Connections Lab Equip	21 days	Mon 6/6/16	Mon 7/4/16
36			L5 Overhead/In Wall	31 days	Wed 4/27/16	Wed 6/8/16
37			L6 Overhead/In Wall	31 days	Wed 5/4/16	Wed 6/15/16
38			L7 Overhead/In Wall	112 days	Wed 1/6/16	Thu 6/9/16
39			L7 Connections Service Panels	32 days	Wed 6/22/16	Thu 8/4/16
40			L7 Connections Lab Equip	22 days	Mon 8/1/16	Tue 8/30/16
41			L8 Overhead/In Wall	131 days	Wed 1/6/16	Wed 7/6/16
42			L8 Connections Service Panels	11 days	Tue 8/2/16	Tue 8/16/16
43			L8 Connections Lab Equip	22 days	Mon 9/5/16	Tue 10/4/16
44			L9 Overhead/In Wall	122 days	Wed 3/2/16	Thu 8/18/16
45			L9 Connections Service Panels	10 days	Mon 9/5/16	Fri 9/16/16
46			L9 Connections Lab Equip	22 days	Mon 10/3/16	Tue 11/1/16
47			L10 Overhead/In Wall	142 days	Wed 3/2/16	Thu 9/15/16
48			L10 Connections Lab Equip	21 days	Mon 11/28/16	Mon 12/26/16
49			LP/UP Mechanical	166 days	Thu 9/24/15	Thu 5/12/16
50			Set LP UP Mech Equip	5 days	Thu 10/29/15	Wed 11/4/15
51			Set Roof Equipment	10 days	Mon 11/2/15	Fri 11/13/15
52			TAB LB-UB	30 days	Mon 2/8/16	Fri 3/18/16
53			TAB L1	20 days	Mon 5/16/16	Fri 6/10/16
54			TAB L2	21 days	Mon 6/20/16	Mon 7/18/16
55			TAB L3	20 days	Thu 7/21/16	Wed 8/17/16
56			TAB L4	20 days	Mon 8/22/16	Fri 9/16/16
57			TAB L5	5 days	Mon 9/26/16	Fri 9/30/16
58			TAB L6	22 days	Mon 9/12/16	Tue 10/11/16
59			TAB L7	22 days	Mon 10/3/16	Tue 11/1/16
60			TAB L8	20 days	Mon 11/7/16	Fri 12/2/16
61			TAB L9	20 days	Mon 12/5/16	Fri 12/30/16
62			TAB L10	20 days	Sun 1/1/17	Thu 1/26/17
63			TAB LP-UP	31 days	Wed 4/20/16	Wed 6/1/16
64			TAB Roof	31 days	Wed 4/20/16	Wed 6/1/16
65			Commissioning Basement	43 days	Wed 6/1/16	Fri 7/29/16
66			Commissioning L1	36 days	Fri 8/19/16	Fri 10/7/16
67			Commissioning L2	35 days	Mon 9/19/16	Fri 11/4/16
68			Commissioning L3	36 days	Mon 10/17/1	Mon 12/5/16
69			Commissioning L4	37 days	Mon 11/14/1	Tue 1/3/17
70			Commissioning L5	15 days	Mon 12/12/1	Fri 12/30/16
71			Commissioning L6	21 days	Mon 12/5/16	Sun 1/1/17
72			Commissioning L7	36 days	Mon 12/26/1	Mon 2/13/17
73			Commissioning L8	35 days	Wed 1/18/17	Tue 3/7/17
74			Commissioning L9	35 days	Wed 2/8/17	Tue 3/28/17
75			Commissioning L10	35 days	Tue 3/14/17	Mon 5/1/17
76			Commissioning LP/UP	36 days	Thu 6/2/16	Thu 7/21/16
77			Commissioning Roof	36 days	Thu 6/2/16	Thu 7/21/16

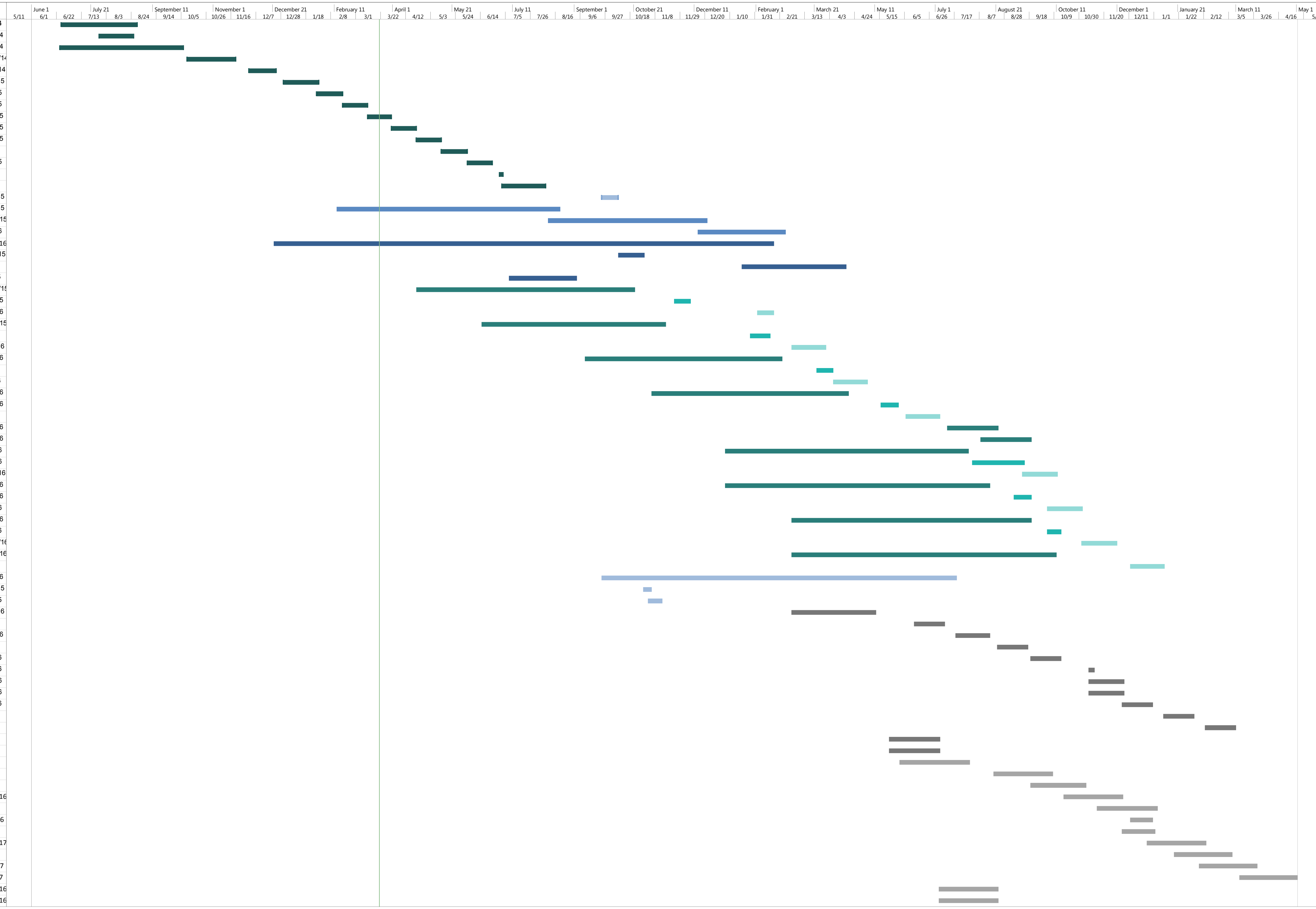


Mechanical Review Schedule

Project: Mech Review Schedule
Date: Sat 3/21/15

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

ID	Task Mode	Task Name	Duration	Start	Finish
1		In Slab Placement- Mat Slab	46 days	Thu 6/26/14	Thu 8/28/14
2		In Slab Placement- UB Slab	21 days	Mon 7/28/14	Mon 8/25/14
3		In Slab Placement- Level 1	74 days	Wed 6/25/14	Mon 10/6/14
4		In Slab Placement- Level 2	29 days	Fri 10/10/14	Wed 11/19/14
5		In Slab Placement- Level 3	17 days	Mon 12/1/14	Tue 12/23/14
6		In Slab Placement- Level 4	22 days	Tue 12/30/14	Wed 1/28/15
7		In Slab Placement- Level 5	16 days	Tue 1/27/15	Tue 2/17/15
8		In Slab Placement- Level 6	15 days	Wed 2/18/15	Tue 3/10/15
9		In Slab Placement- Level 7	14 days	Wed 3/11/15	Mon 3/30/15
10		In Slab Placement- Level 8	15 days	Tue 3/31/15	Mon 4/20/15
11		In Slab Placement- Level 9	15 days	Tue 4/21/15	Mon 5/11/15
12		In Slab Placement- Level 10	16 days	Tue 5/12/15	Tue 6/2/15
13		In Slab Placement- Level LP	15 days	Wed 6/3/15	Tue 6/23/15
14		In Slab Placement- Level UP	3 days	Tue 6/30/15	Thu 7/2/15
15		In Slab Placement- Level Roof	27 days	Thu 7/2/15	Fri 8/7/15
16		Set Mech Equip on Roof	10 days	Thu 9/24/15	Wed 10/7/15
17		Mechanical Shafts lvl LB-2	134 days	Fri 2/13/15	Wed 8/19/15
18		Mechanical Shafts lvl 3-6	96 days	Mon 8/10/15	Mon 12/21/15
19		Mechanical Shafts lvl 7-R	54 days	Mon 12/14/15	Thu 2/25/16
20		Install Mechanical LB	301 days	Mon 12/22/1	Mon 2/15/16
21		Set Mech Equip Basement	16 days	Thu 10/8/15	Thu 10/29/15
22		Connect Mech Equip Basement	64 days	Wed 1/20/16	Sat 4/16/16
23		Mechanical Level UB	41 days	Wed 7/8/15	Wed 9/2/15
24		L1 Overhead/In Wall	132 days	Tue 4/21/15	Wed 10/21/15
25		L1 Connections Service Panels	10 days	Tue 11/24/15	Mon 12/7/15
26		L1 Connections Lab Equip	10 days	Tue 2/2/16	Mon 2/15/16
27		L2 Overhead/In Wall	111 days	Mon 6/15/15	Mon 11/16/15
28		L2 Connections Service Panels	13 days	Wed 1/27/16	Fri 2/12/16
29		L2 Connections Lab Equip	21 days	Wed 3/2/16	Wed 3/30/16
30		L3 Overhead/In Wall	118 days	Thu 9/10/15	Mon 2/22/16
31		L3 Connections Service Panels	10 days	Wed 3/23/16	Tue 4/5/16
32		L3 Connections Lab Equip	21 days	Wed 4/6/16	Wed 5/4/16
33		L4 Overhead/In Wall	118 days	Thu 11/5/15	Mon 4/18/16
34		L4 Connections Service Panels	11 days	Mon 5/16/16	Mon 5/30/16
35		L4 Connections Lab Equip	21 days	Mon 6/6/16	Mon 7/4/16
36		L5 Overhead/In Wall	31 days	Mon 7/11/16	Mon 8/22/16
37		L6 Overhead/In Wall	31 days	Mon 8/8/16	Mon 9/19/16
38		L7 Overhead/In Wall	147 days	Wed 1/6/16	Thu 7/28/16
39		L7 Connections Service Panels	32 days	Mon 8/1/16	Tue 9/13/16
40		L7 Connections Lab Equip	22 days	Mon 9/12/16	Tue 10/11/16
41		L8 Overhead/In Wall	159 days	Wed 1/6/16	Mon 8/15/16
42		L8 Connections Service Panels	11 days	Mon 9/5/16	Mon 9/19/16
43		L8 Connections Lab Equip	22 days	Mon 10/3/16	Tue 11/1/16
44		L9 Overhead/In Wall	144 days	Wed 3/2/16	Mon 9/19/16
45		L9 Connections Service Panels	10 days	Mon 10/3/16	Fri 10/14/16
46		L9 Connections Lab Equip	22 days	Tue 11/1/16	Wed 11/30/16
47		L10 Overhead/In Wall	159 days	Wed 3/2/16	Mon 10/10/16
48		L10 Connections Lab Equip	21 days	Mon 12/12/16	Mon 1/9/17
49		LP/UP Mechanical	213 days	Thu 9/24/15	Mon 7/18/16
50		Set LP UP Mech Equip	5 days	Thu 10/29/15	Wed 11/4/15
51		Set Roof Equipment	10 days	Mon 11/2/15	Fri 11/13/15
52		TAB LB-UB	51 days	Wed 3/2/16	Wed 5/11/16
53		TAB L1	20 days	Mon 6/13/16	Fri 7/8/16
54		TAB L2	21 days	Mon 7/18/16	Mon 8/15/16
55		TAB L3	20 days	Mon 8/22/16	Fri 9/16/16
56		TAB L4	20 days	Mon 9/19/16	Fri 10/14/16
57		TAB L5	5 days	Mon 11/7/16	Fri 11/11/16
58		TAB L6	22 days	Mon 11/7/16	Tue 12/6/16
59		TAB L7	22 days	Mon 11/7/16	Tue 12/6/16
60		TAB L8	20 days	Mon 12/5/16	Fri 12/30/16
61		TAB L9	20 days	Mon 1/9/17	Fri 2/3/17
62		TAB L10	20 days	Mon 2/13/17	Fri 3/10/17
63		TAB LP-UP	31 days	Mon 5/23/16	Mon 7/4/16
64		TAB Roof	31 days	Mon 5/23/16	Mon 7/4/16
65		Commissioning Basement	43 days	Wed 6/1/16	Fri 7/29/16
66		Commissioning L1	36 days	Fri 8/19/16	Fri 10/7/16
67		Commissioning L2	35 days	Mon 9/19/16	Fri 11/4/16
68		Commissioning L3	36 days	Mon 10/17/1	Mon 12/5/16
69		Commissioning L4	37 days	Mon 11/14/1	Tue 1/3/17
70		Commissioning L5	15 days	Mon 12/12/1	Fri 12/30/16
71		Commissioning L6	21 days	Mon 12/5/16	Sun 1/1/17
72		Commissioning L7	36 days	Mon 12/26/1	Mon 2/13/17
73		Commissioning L8	35 days	Wed 1/18/17	Tue 3/7/17
74		Commissioning L9	35 days	Wed 2/8/17	Tue 3/28/17
75		Commissioning L10	35 days	Tue 3/14/17	Mon 5/1/17
76		Commissioning LP/UP	36 days	Mon 7/4/16	Mon 8/22/16
77		Commissioning Roof	36 days	Mon 7/4/16	Mon 8/22/16



Modified Schedule

Project: Modified Schedule.mpp
Date: Sat 3/21/15

Task · Split · Milestone · Summary · Project Summary · Inactive Task · Inactive Milestone · Inactive Summary · Manual Task · Duration-only · Manual Summary Rollup · Manual Summary · Start-only · Finish-only · External Tasks · External Milestone · Deadline · Progress · Manual Progress

Appendix D.2

Mechanical Man-loaded Schedule

Original Schedule

Original Man-Loaded Schedule

Original Man-Loaded Schedule	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15
Mechanical Basement								18	18	18
Mechanical Shafts/Risers									3	19
Mechanical Penthouse/Roof										
Basement	1	2	1							
Level 1		2	2	3						
Level 2					3	3				
Level 3							3			
Level 4								3		
Level 5									3	
Level 6										2
Level 7										1
Level 8										
Level 9										
Level 10										
Penthouse										
Roof										
Miscellaneous										
Total Number of Crews	1	4	3	3	3	3	3	21	24	40
	1	4	3	3	3	3	3	21	24	40
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Original Man-Loaded Schedule	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16
Mechanical Basement	18	12	18	20	20	20	18	15		
Mechanical Shafts/Risers	19	19	19	19	19	19	19	19	19	19
Mechanical Penthouse/Roof							7	7	15	
Basement										
Level 1		10	10	10	10	10				
Level 2				10	11	10	10	10		
Level 3						5	10	10	15	10
Level 4								3	15	15
Level 5										
Level 6										
Level 7										10
Level 8	3									10
Level 9		2								
Level 10		1								
Penthouse			3							
Roof				3						
Miscellaneous										
Total Number of Crews	40	44	50	62	60	64	64	64	64	64
	40	44	50	62	60	64	64	64	64	64
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Original Man-Loaded Schedule	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16
Mechanical Basement										
Mechanical Shafts/Risers	19									
Mechanical Penthouse/Roof										
Basement								10	10	
Level 1					5		10	10	10	
Level 2						5		10	10	10
Level 3						5	10	10	10	
Level 4	10	10						5	5	10
Level 5			10	5					6	10
Level 6				5	10					10
Level 7	10	10	10	10						5
Level 8	10	10	10	10						
Level 9		10	10	10	10	10	10			
Level 10		10	10	10	10	10	10			
Penthouse			4	4	9	9				
Roof			4	4	9	9				
Miscellaneous	13	8			5	10	17	10		6
Total Number of Crews	62	58	58	58	58	58	57	55	51	51
	62	58	58	58	58	58	57	55	51	51
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Original Man-Loaded Schedule	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17
Mechanical Basement										
Mechanical Shafts/Risers										
Mechanical Penthouse/Roof										
Basement										
Level 1										
Level 2										
Level 3										
Level 4	10									
Level 5										
Level 6	10									
Level 7	10	10	10							
Level 8	5	10	10	8						
Level 9	5	10	10	8						
Level 10		5	10	7	11					
Penthouse										
Roof										
Miscellaneous	11	14	9			6	6	6	3	3
Total Number of Crews	51	49	49	23	11	6	6	6	3	3
	51	49	49	23	11	6	6	6	3	3
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Legend

- Mechanical Basement
- Mechanical Shaft/Risers
- Mech LP/UP
- Sleeves/ Inserts
- Overhead/ In wall
- Connect Service Panel
- Connect Lab Equip
- TAB
- Commissioning

Mechanical Review Schedule

Mechanical Review Man-Loaded Schedule

	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16
Mechanical Basement								6	8	15	15	15	17	18	18	12	12	12	12	12
Mechanical Shafts/Risers									3	3	3	12	12	12	12	12	12	12	10	5
Mechanical Penthouse/Roof																18	22	22	18	18
Basement	1	2	1																	
Level 1		2	2	3							6	10	10	10	10	10	10	10	2	
Level 2					3	3								10	10	10	10	10	10	2
Level 3							4									10	10	10	15	10
Level 4								4										3	15	15
Level 5									4											
Level 6										2										
Level 7										2										10
Level 8											4									10
Level 9												2								
Level 10												2								
Penthouse													4							
Roof														4	4					
Miscellaneous															6		4	1		
	1	4	3	3	3	3	4	10	15	22	28	41	43	54	60	72	80	80	82	82
Total Manpower	**1**	**4**	**3**	**3**	**3**	**3**	**4**	**10**	**15**	**22**	**28**	**41**	**43**	**54**	**60**	**72**	**80**	**80**	**82**	**82**
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17
Mechanical Basement																				
Mechanical Shafts/Risers	5																			
Mechanical Penthouse/Roof	18	15	15	12																
Basement	8	8			2	2														
Level 1	5			8			4	2												
Level 2	2	5			8			2	2											
Level 3	10	4	5			10			2	2										
Level 4	10	10	2	2	5		10			2	2									
Level 5			10	5	5			5			1									
Level 6				5	10	5		5			1									
Level 7	10	10	10	10	10	4	5		10			2								
Level 8	10	10	10	10	10	10	4	5		10		2	2							
Level 9		10	10	10	10	10	10	4	5		10		2							
Level 10		10	10	10	10	10	10	10		5		10		4						
Penthouse			4	4	1	1									4					
Roof			4	4	1	1														
Miscellaneous	4		2			11	19	23	27	27	14	1	8	5	5	6	6	6	3	2
	82	82	82	80	72	64	62	56	46	46	28	15	12	9	9	6	6	6	3	2
Total Manpower	**82**	**82**	**82**	**80**	**72**	**64**	**62**	**56**	**46**	**46**	**28**	**15**	**12**	**9**	**9**	**6**	**6**	**6**	**3**	**2**
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Legend

- Mechanical Basement
- Mechanical Shaft/Risers
- Mech LP/UP
- Sleeves/ Inserts
- Overhead/ In wall
- Connect Service Panel
- Connect Lab Equip
- TAB
- Commissioning

Modified Schedule

Modified Man-Loaded Schedule

	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16
Mechanical Basement								6	8	15	15	15	18	18	18	12	12	12	12	10
Mechanical Shafts/Risers									3	3	3	12	13	13	12	12	12	12	8	5
Mechanical Penthouse/Roof																11	11	22	18	18
Basement	1	2	1																	
Level 1		2	2	3							6	10	15	15	10	10	10		2	
Level 2					3	3							15	15	15	10	10	5		2
Level 3							4									10	10	10	10	10
Level 4								4										3	15	10
Level 5									4											
Level 6										2										
Level 7										2										5
Level 8											4									5
Level 9												2								
Level 10												2								
Penthouse													4							
Roof														4	4					
Miscellaneous															6			1		
	1	4	3	3	3	3	4	10	15	22	28	41	65	65	65	65	65	65	65	65
Total Manpower	**1**	**4**	**3**	**3**	**3**	**3**	**4**	**10**	**15**	**22**	**28**	**41**	**65**	**65**	**65**	**65**	**65**	**65**	**65**	**65**
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17
Mechanical Basement	3																			
Mechanical Shafts/Risers	5																			
Mechanical Penthouse/Roof	16	15	15	13	15	4														
Basement		6	5	5	2	2														
Level 1	5				8		4	2												
Level 2	2	5				8		2	2											
Level 3	10	4	5				10		2	2										
Level 4	10	10	5	4	5			10		2	2									
Level 5						10	5	5		5	2									
Level 6							5	5	10	5	2									
Level 7	5	10	10	10	10	10	4	5		10		2								
Level 8	5	10	10	10	10	10	10	4	5		10	2	2							
Level 9		5	10	10	9	10	10	5	4	5		10	2							
Level 10		5	10	10	8	8	10	10	10		5		10	4						
Penthouse				4	4	1	1								4					
Roof				4	4	1	1													
Miscellaneous	4					6	10	17	27	28	27	6	6	5	5	6	6	6	3	2
	65	70	70	70	75	70	70	65	60	57	48	20	20	9	9	6	6	6	3	2
Total Manpower	**65**	**70**	**70**	**70**	**75**	**70**	**70**	**65**	**60**	**57**	**48**	**20**	**20**	**9**	**9**	**6**	**6**	**6**	**3**	**2**
	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

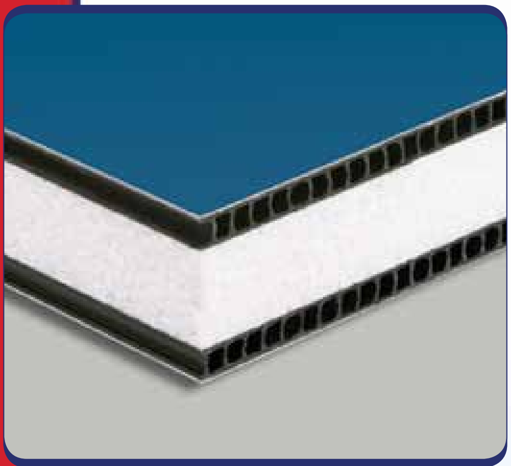
Legend

- Mechanical Basement
- Mechanical Shaft/Risers
- Mech LP/UP
- Sleeves/ Inserts
- Overhead/ In wall
- Connect Service Panel
- Connect Lab Equip
- TAB
- Commissioning

Appendix E.1

Metal Panel Product Data

THERMOLITE™



Panels are water-resistant, featuring an insulating core of Polyisocyanurate (ISO) or Expanded Polystyrene (EPS) foam. Corrugated polyallomer stabilizers are designed for optimal strength with minimal weight. Prefinished aluminum panels can be ordered in a smooth or stucco-embossed finish in 3/4 in. to 3-1/2 in. overall thickness.

Energy-saving insulating properties and a great look rolled into one—that's the magic of our Thermolite panels used for exterior wall applications.

- Constructed of an insulating foam core sandwiched between two corrugated polyallomer stabilizers and finished aluminum sheets
- Water-resistant, virtually maintenance-free for up to 20 years
- Available in smooth or stucco-embossed finishes
- Fit into standard 1 in. insulating glass and glazing pockets and storefront extrusions

TYPICAL APPLICATIONS

- Curtain Walls
- In-Fill Panels
- Partitions
- Opaque Glazing
- Spandrels
- Sunrooms
- Storefronts
- Soffits

THERMOLITE™ TECHNICAL DATA

CONSTRUCTION OF THERMOLITE PANELS

Sizes*	Core	Backer	Face Thickness	Surface Face Finish	Colors
4 ft. x 8 ft. 4 ft. x 10 ft. 4 ft. x 12 ft.	**Stabilizers:** Corrugated Polyallomer **Insulating Core:** EPS or ISO Foam	Painted 0.013 in. aluminum sheet or same surface as face depending on application	0.028 or 0.032 in.	Smooth and/or stucco-embossed aluminum	Kynar 500®, Designer Series, and custom colors
			0.024 in.	Smooth and/or stucco-embossed aluminum	Standard and Natural Series
			0.013 in.	Stucco-embossed aluminum only	Standard

Styrene foam melts at 167°F. Thermal studies by your engineer/architect should determine usability in high thermal load areas.
**5 ft. widths also available in select colors.*
Refer to Architectural Color Chart for specific size and finish availability.

SPECIFICATIONS (Based on 1 in. thick panel with 0.032 in. face and 0.013 in. backer.)

Thickness	Width	Length	Weight	Tolerances	R-Value	Stability	Stiffness	Load
Nominal: 1 in. fits 1 in. glass and glazing pockets **Actual:** 15/16 in. ±1/16 in. thick Thicknesses from 3/4 in. to 3-1/2 in. can be ordered	48 in. or cut-to-size 60 in. in select colors	96 in. 120 in. 144 in. or cut-to-size	1.40 lb./ft.^{2}	**Length and Width:** ±1/16 in. **Squareness:** Diagonals equal within 1/8 in. **Thickness:** ±5/64 in.	**ISO Core:** R-7.77 hr. ft.^{2} °F/BTU **EPS Core:** R-7.13 hr. ft.^{2} °F/BTU (R-Value increases as panel thickness increases)	**Temp:** 2.42 x 10^{-5} in./in. °F **Moisture:** 4.4 x 10^{-4} in./ft. at 50 to 90% RH	1.54 x 10^6 psi/ft. – width (EI)	71 lb./ft.^{2}, 48 in. span AAMA L/175 limit

Fire Rating: Based on ASTM E84: Class A, under 25 Flame Spread

Bond Test: Based on ASTM C481 Cyclic Aging: Pass

Wind Load Rating: Based on ASTM E330 static load: 260 mph, 48 in. O.C., Architectural Testing Inc., limited by AAMA L/175 deflection

Approvals: City of New York Department of Buildings MEA 1-02-M

REFERENCES & TESTING

AAMA 2605 – Voluntary Specification for High-Performance Organic Coatings on Architectural Extrusions and Panels; applicable to Kynar (PVDF) only

AAMA TIR-A11 – Maximum Allowable Deflection of Framing Systems for Building Cladding Components at Design Wind Loads

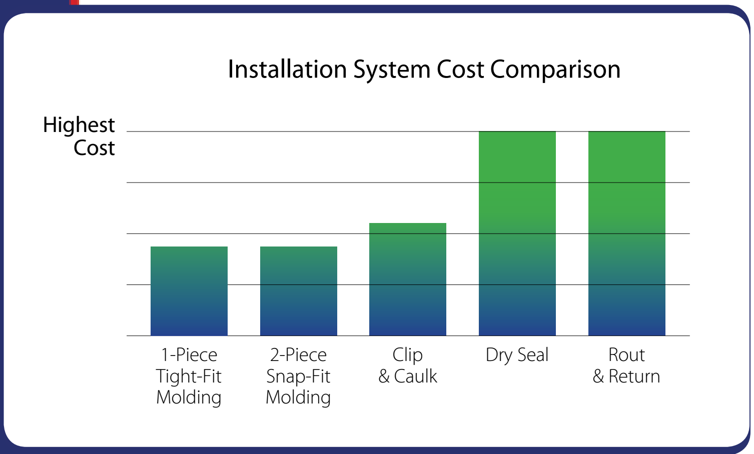
ASTM B209 – Aluminum and Aluminum-Alloy Sheet and Plate

ASTM C481 – Laboratory Aging of Sandwich Constructions

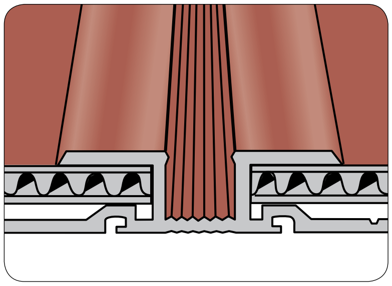
ASTM E84 – Surface Burning Characteristics of Building Materials

ASTM E330 – Structural Performance of Exterior Windows, Curtain Walls, and Doors by Uniform Static Air Pressure Difference

INSTALLATION SYSTEMS

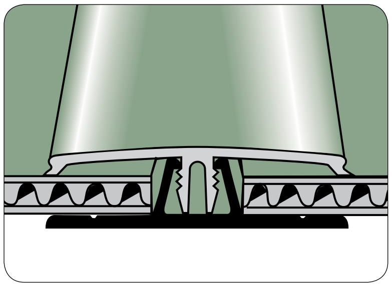


Laminators offers five different panel installation systems to give you the look you need at the budgeted cost you require. Panels can be measured and cut at the job site…no prefabrication or comprehensive shop drawings are necessary. Special panel lengths can be ordered to minimize waste and reduce labor and materials expenses.



1-PIECE TIGHT-FIT MOLDING

Panel installation is easy using Laminators' durable 1-piece moldings. A traditional yet high-tech appearance is obtained at an affordable cost. Both "H" and "reveal H" moldings are available. Unique effects can be obtained by combining our various installation systems.

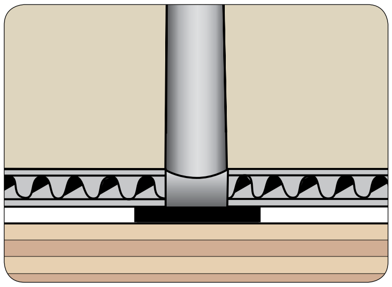


2-PIECE SNAP-FIT MOLDING

You'll like the contemporary look and the ease of "snap-fit" installation. Color-matched or contrasted aluminum molding snaps into place covering fastener heads and caulk beads. Both flat and reveal effects are easily obtained to give you the appearance you need at low cost.

All molding bases can be attached to a wall surface prior to panel placement, compared to other systems that require installation of molding for one panel at a time. 2-piece moldings are easily combined with other systems to provide a variety of design options.

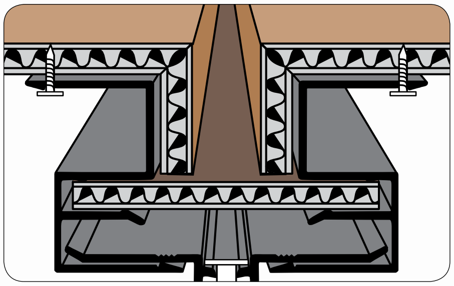
CLIP & CAULK™



Laminators has developed our unique Clip & Caulk system that greatly reduces the total installed cost for ACM panels. This easy, field-proven method is the choice of architects and installers who are looking for a very flat look without visible fasteners. Panels can be cut onsite with few peripheral accessories needed for installation. .

Color-matched caulk gives a beautiful monochromatic look; contrasting caulk can be used with eye-pleasing results.

Use Clip & Caulk in combination with masonry, glass, 1-piece, or 2-piece extruded molding systems or by itself. You'll be pleased with the flexibility, the appearance, and especially the cost.



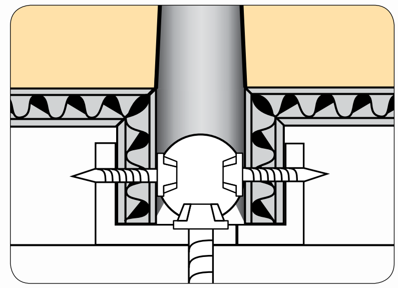
DRY SEAL

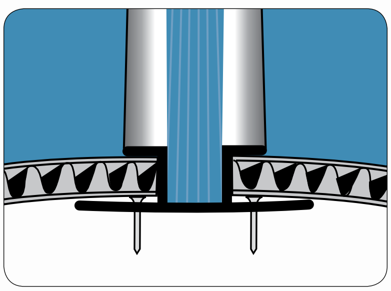
Featuring a "deep reveal" look without caulk at the joints, Laminators' dry seal installation is ideal for installing our Omega-Lite® panels and creates a high-performance, pressure-equalized wall system that compartmentalizes the air cavity and allows for drainage and ventilation. This system reduces moisture-related issues within the wall cavity.

ROUT & RETURN

You get a sophisticated, high-tech look with this installation system.

Excellent strength and a "deep-reveal" appearance are obtained for commercial and institutional installations. Rout & Return can be combined with other installation systems for a more economical, total installed cost. Panels can be panned onsite using standard carpentry tools to give a solid, finished appearance.





OMEGA-FLEX™ CURVE TREATMENT

Typically, radial panel installations require costly engineering, shop fabrication, and difficult installation. Omega-Flex panels make such applications easy and inexpensive without sacrificing beauty; however, special panel configurations are required. Flex panels will conform to the curved shape of the structural support system without costly off-site roll-forming. Omega-Flex panels must be installed with 1-piece, tight-fit moldings.

COLORS AND FINISHES

Vivid colors add new dimension to great architectural design. The right colors create visual interest, enhance beauty, and promote a sense of balance. Laminators Incorporated offers **more than 40 stunning color choices** to complement your design, covering a range of aesthetics and applications. We can also create or match custom colors to your specifications, making it easy to maintain consistency in corporate identity projects.

In addition to the wide range of color choices, aluminum composite architectural panels are now available in nine new finishes ranging from smooth wood grains to bright metallic hues. For a full list of colors and finishes, please visit **LaminatorsInc.com** to download the Architectural Color Chart. Metal color chips and samples are also available by request.

DESIGNER SERIES

Seven new designer finishes add polish to any project. Choose from natural-looking wood grain and stone façades for interior and exterior architectural jobs that require a subtle, sophisticated touch. These finishes can be used on any Laminators architectural panel product.

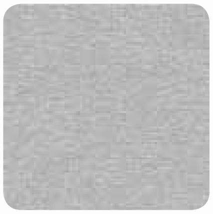
Wood Grain

Warm Cherry

Honey Oak

Dark Walnut

Metal



Brushed ZInc

Stone

Grey Slate

Green Slate

Spanish Stone

Visit our Architectural Color Chart for a full list of colors and finishes

NATURAL SERIES

Two distinctive new finishes make interior and exterior design projects pop. Add visual interest to storefronts, canopies, schools, sunrooms, and more with durable, flexible panels and cool, metallic hues. All finishes are UV stable and will not fade with direct exposure to sunlight.

Clear Matte

Dark Bronze

Additional colors and patterns available by special order.

ARCHITECTURAL SERVICES

Let Laminators handle your architectural services needs. As manufacturers and fabricators of architectural panels, we understand all the nuances of performing take-offs, fabricating for time- and cost-efficiency, and more.

TAKE-OFFS

To save you the time and guesswork involved with performing take-offs, Laminators can provide you with an itemized list of estimated materials with pricing required for your project based on the architectural plans. Having us provide the take-off ensures a more accurate interpretation of what's required on the job. Our experienced project estimators have years of design experience, pay close attention to detail, and will provide the most efficient assembly for your aluminum composite wall panel system.

FABRICATION

Save on time and labor costs by having Laminators fabricate your aluminum composite panels. We'll cut, rout, and bend the panels to the exact specifications needed for the project. Because the panels are being fabricated by the same company that manufactures them, we understand the best way to provide superior looking, ready-to-install panels each and every time.

PANNED EDGES

Let Laminators save you the hassle of panning the panel edges for use in glass and glazing applications. For your convenience, we can provide our Thermolite™ insulated panels with metal wrapped edges cut to your specifications for butt-glazing applications. It's the perfect solution for fitting installation-ready panels into your 1 in. glass curtain walls and storefront extruded molding systems.

FIELD TRAINING

Time is money, so why not let Laminators help you achieve maximum efficiency during your installations. Our field training specialists have a decade of experience in the manufacturing, fabrication, and installation of Laminators' aluminum composite panels and can show you various methods and tricks of the trade to provide a high-quality installation on every project. Whether you're a first-time installer or a long-time veteran, spending time with our field training specialists will help you increase efficiency, decrease your installation time, and save you money.

To speak with an architectural panel representative, please call **800.523.2347**.

Appendix E.2

Precast Takeoff

Width		Height		Number	Area		
Feet	Inches	Feet	Inches				
235	9	15	10	1	3732.71		
7	10.5	141	46.75	2	2282.11		
235	9	9	11.25	1	2342.77		
224	0	1	11	4	1717.33		
2	7.5	27	3.75	38	71.70		
1	3.75	27	3.75	9	35.85		
5	3	27	3.75	32	143.39		
3	11.25	27	3.75	1	107.54		
2	7.5	27	3	10	71.53		
1	3.75	27	3	3	35.77		
5	3	27	3	7	143.06		
10	8.75	3	3.75	2	35.54		
3	4	195	2.25	2	650.63		
250	9.5	5	1.75	1	1290.53	North	12660
6	0	119	4	2	716.00	South	15192
7	0.38	83	11.5	1	590.33		
55	3.75	31	8.125	1	1752.14		
11	5.5	83	11.5	1	962.02		
26	11.75	3	8	1	98.92		
32	3	13	3.75	1	429.33		
11	6.25	81	11.5	1	944.23		
44	18.25	15	3.75	1	697.04		
-6	-8	66	0	1	-440.00		
20	0.5	114	0	1	2284.75		
3	3.25	114	0	1	372.88		
11	4.5	98	7.25	1	1121.62		
11	4.5	14	4.25	1	163.28		
21	4.25	98	7.25	1	2105.61		
21	4.25	12	3	1	261.59		
-10	-6.25	88	4	1	-929.34		
18	9.5	98	7.25	1	1852.94		
18	9.5	8	9	1	164.43		
19	9	98	7.25	1	1947.43		
19	9	4	10	1	95.46		
				Total	**27852**	**SF**	

	Weight of Panels			
Weight Concrete	Width	Height	Thickness	Weight (lbs)
150	5.25	27.31	0.50	10754
	13.06	16.65	0.50	16308
	14.38	16.65	0.50	17946
	7.85	14.67	0.50	8640