Tech. #2

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[FISK CORPORATE HEADQUARTERS]

Houston, Texas

Executive Summary

The purpose of this technical report is to evaluate the project execution plan implemented on the Fisk Corporate Headquarters project. Careful analysis of key project features such as detailed scheduling, general conditions, systems estimates, and BIM uses offered valuable insight into the project team's execution goals and strategies.

Fisk Electric's new corporate headquarters project is a facility comprised of a two story office building and a single story pre-fabrication shop. The construction costs total approximately 7.3 million dollars with a construction schedule spanning 11 months. It sits on a relatively large site given the size of the two building footprints, allowing the project team an inordinate amount of flexibility regarding their project execution plan.

Fisk Electric currently resides in a fully functional two story office building that has been in their possession for almost 40 years. Due to the lack of pressure to quickly move locations, Fisk's main point of emphasis regarding their overall project schedule was to minimize owner related risk. The project team spent approximately 99 weeks in various stages of design in an effort to ensure the building was fully developed before construction began. The following construction phases were then sequenced in a way that diminished the chance of any major weather or unforeseen delays.

Due to Fisk's ownership by their construction manager and knowledge of construction, they decided it would be beneficial for them as the owner to carry the cost of general conditions. However, Fisk Electric expanded their general conditions to include all of Tutor Perini's pre-construction and jobsite construction management services. In an effort to maintain comparability between this report and the project's actual cost reporting, a similarly styled general conditions estimate was compiled and resulted in a total of $1,122,906 or 15.4% of the construction costs.

Close investigation of the project's building information modeling use plan resulted in the discovery that BIM was not emphasized by the owner. Even though Fisk utilizes BIM for clash detection on all its' major commercial construction projects, they decided the benefits would not outweigh the costs on their own project. This report details ways in which Fisk could have potentially experienced savings had they employed a BIM project plan.

After reporting an inordinately high electrical systems price in Technical Report 1, a detailed division 26 electrical estimate was generated in an effort to gain an understanding as to the source of these expenses. The outcome was an electrical systems cost of $1,245,653 or $23.00 a square foot. Examination of these results attributed the high prices to equipment located within Fisk's facility not normally found in buildings of similar size and function.

The Fisk Corporate Headquarters project team was also contacted regarding the three most imposing constructability challenges that they encountered and the steps the team took to overcome them. It was discerned that the project team managed to overcome each of the three challenges by emphasizing communication, detailing task sequences, and maintaining a high level of cooperation between all pertinent team members. Overall, Fisk and Tutor Perini's combined project execution plan did an excellent job of overcoming obstacles while delivering a high quality product at a low cost.

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Detailed Project Schedule

The Fisk Corporate Headquarters' detailed project schedule begins on February 17, 2010 at the first meeting Fisk had to discuss relocation and finishes with the completed building turnover on October 5, 2012. The project schedule details over 150 different activities pertaining to both the office building and prefabrication shop. The following table gives a summary of the facilities' major design and construction phases:

Table 1: Key Schedule Phase Summary

Detailed Schedule Summary			
Phase Description	Start Date	End Date	Dur. (Wks.)
Design and Pre-Construction	2/17/10	1/10/12	99
Office Building Structure	12/12/11	4/13/12	18
Office Building Enclosure/Roof	4/16/12	8/24/12	19
Office Building Interior			
1st Floor	4/2/12	9/24/12	25
2nd Floor	4/19/12	9/27/12	23
Fab-Shop Structure	1/4/12	3/27/12	12
Fab-Shop Enclosure/Roof	4/24/12	6/6/12	6
Fab-Shop Interior	4/9/12	9/19/12	23
Landscape/Hardscape	4/9/12	9/21/12	24
Final Testing and Closeout	9/24/12	10/5/12	2

Design and Pre-Construction

While the design and pre-construction phase spans the longest time period of the various phases at 99 weeks, it is one of the simplest in terms of activities on the schedule. Once the initial relocation meeting was complete, it took nearly ten months for the design to actually begin. A majority of this time was spent procuring both a construction manager and a capable design consultant team. The three phases of design, schematic, design development, and construction documents, took approximately the same amount of time to develop with the schematic design phase taking slightly longer than the other two due to heavy owner involvement. Upon the completion of the project's construction documents, the design and pre-construction phase came to a close and the project team was able to focus solely on the projects various construction phases.

Another task of note that occurred within the design and pre-construction phase was the geotechnical report that took place during the summer of 2011. It was this geotechnical report that first discerned the unsuitable subsurface conditions investigated in both Technical Report 1 and later in this report.

Office Building Structure

The office building's structural erection phase began at the beginning of the 2012 calendar year and ended in the middle of April of the same year. It started with the drilling and pouring of structural caissons, followed closely by the installation of pier caps and grade beams as detailed on the plans found in Figure 1. Upon completion of the foundation installation, both the MEP underground rough-in and the slab on grade were placed so that the structural steel erection could begin. Luckily, the construction team was able to begin the steel shop drawing and fabrication activities before the foundations even began to be drilled into the soil. This proactive approach allowed for a seamless transition between the foundation installation and steel erection without any available time being wasted. The entire steel superstructure was erected and the metal deck was installed in just under 4 weeks using a single crawler crane.

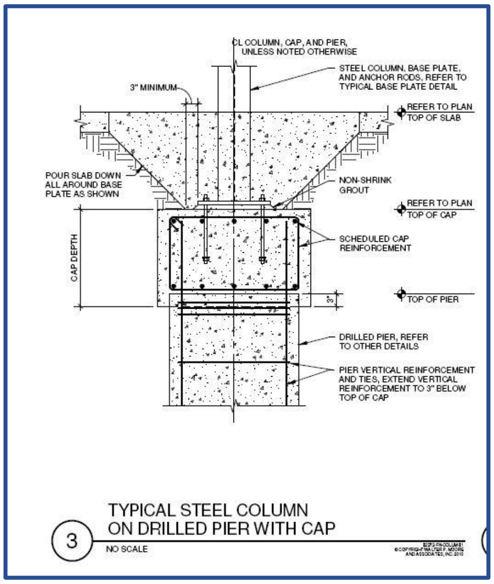


Figure 1: Cap Detail - Provided by Fisk Electric

Office Building Enclosure & Roof

One of the most difficult construction aspects of the Fisk Corporate Headquarters project was the office building's façade system. Comprised of both brick veneer and curtain wall, it quickly became evident to the construction team that careful planning and activity sequencing would be crucial to the success of this phase. Work on the building's façade system began in mid-April shortly after the completion of the building's structural system with the installation of the steel framing system. Due to a lack of scheduling flexibility, the relationship between this steel framing system and the curtain wall panels that were placed within it is investigated later in this report in the section titled Constructability Challenges. Once the framing system was complete, all other aspects of the building enclosure, including the air membrane, brick veneer, and curtain wall system, were installed simultaneously. Through careful coordination and material placement, each trade was able to successfully install its portion of the building envelope without getting into one another's way.

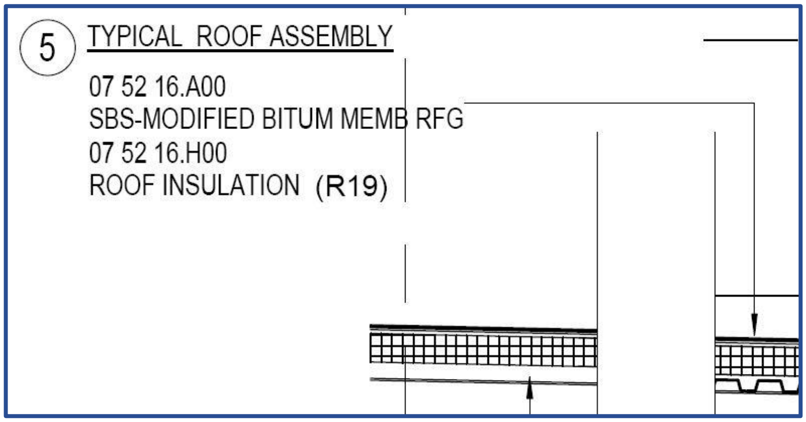


Figure 2: Roof Detail - Provided by Fisk Electric

Due to the simplicity of the roof design as evidenced in Figure 2, the roof was installed at the construction manager's leisure upon the completion of the structural steel. However, it is worth noting that the large mechanical rooftop units needed to be installed before any air could be pumped into the interior sections of the building. This became crucial during the late summer months when the ambient temperature in Houston reaches over 95 degrees on a daily basis. During this time, pumping cool air into the building becomes important not only for the safety of sensitive equipment, but also for the workers who could easily overheat in a confined space under those conditions.

Office Building Interior

The last phase of office building construction is the interior finishes phase. Because it is the most complex of the three main office building construction phases, it has the longest duration and encompasses the largest number of trades working at one time. Tutor Perini decided to implement a fairly traditional top-down approach to the installation of the interior finishes. They began each floor with the major MEP overhead rough-in installation, followed closely by the wall framing. Once the walls were framed, the various MEP wall rough-ins were placed and the walls were closed up. Afterwards, the construction team installed the ceiling grid, MEP ceiling drops, and finally the ceiling tiles themselves. This was followed by the floor and door installation which brought an end to the phase.

It is worth noting that both the first and second floors of the building were constructed at virtually the same time. This was made possible through not only careful scheduling, but also because of the relatively small size of the building coupled with an office building's inherent relative lack of complexity. Tutor Perini utilized the flexibility presented to them from the smaller crew sizes and was able to move the trades efficiently from one area to another without the laborers getting in the way of one another.

Fab-Shop

Fisk's new fabrication shop is a simple facility comprised of a structural steel skeleton, masonry wall enclosure, high bay fixtures, and virtually no air conditioning system. Figure 3 shows a detail of the simplicity of the building's façade and structural systems. As a result of this simplicity, Tutor Perini decided to just parallel its tasks with those of a similar nature within the office building. The only difference was that some of fabrication shop's activities were staggered slightly behind those of the office building. This

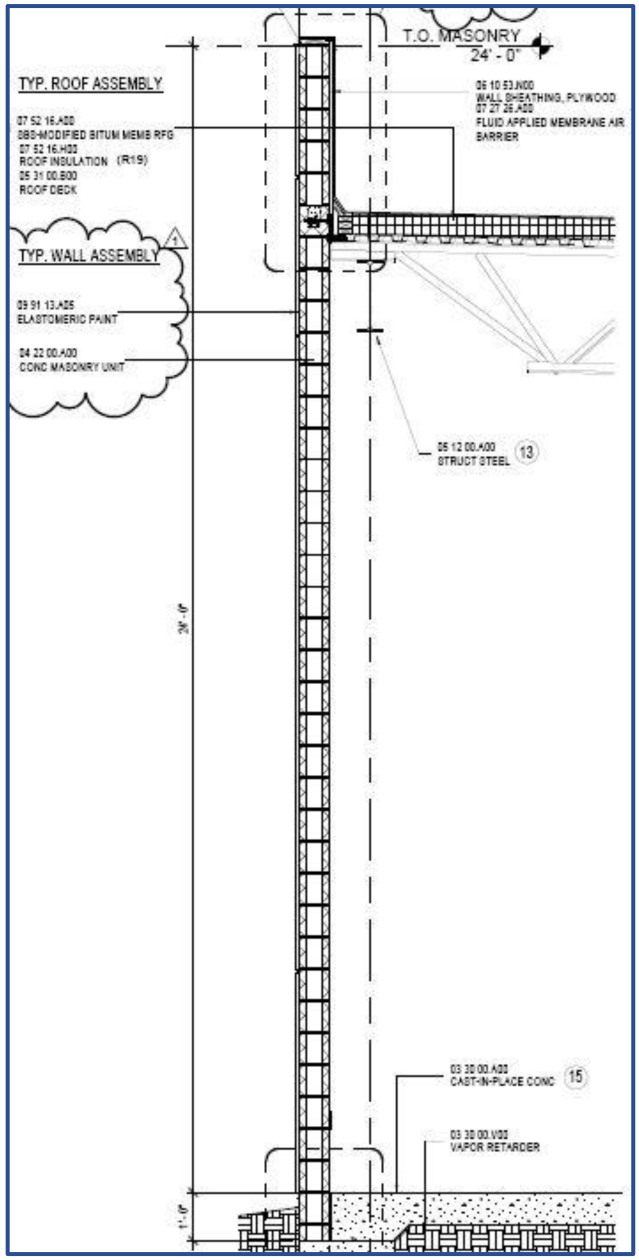


Figure 3: Fab-Shop Detail - Provided by Fisk Electric

allowed the crews to wrap up their tasks on the office building, and then move directly over to the fabrication shop. In some instances, the tasks required of the various crews were so minimal within the fab-shop that they were able to actually complete their assignments within both buildings simultaneously.

Hardscape/Landscape

The only details worth mentioning regarding the project's landscaping phase stem from the unforeseen surface condition of the soil. This condition is responsible for the longevity of the phase and is described in further detail later in this report under the section labeled Constructability Challenges. Once the issue was adequately addressed, the schedule was altered accordingly and the phase was completed without incident.

Final Testing and Closeout

Due to Fisk's knowledge of the various building systems within their new facilities, very little third party testing was completed within the new buildings. A majority of the phase consisted of architectural punch-lists and knowledgeable Fisk representatives checking on the building's equipment and installed systems. The phase only lasted about two weeks.

For the complete detailed project schedule, please reference Appendix A.

Detailed Division 26 Electrical System Estimate

Technical Report 1 reported that the electrical system costs for the Fisk Corporate Headquarters project was substantially higher than other buildings of similar size and composition. A detailed division 26 electrical system estimate was compiled to better understand the reasons behind the high electrical system costs. This estimate was generated using an online, 2012 version of RSMeans that enabled the estimate to be automatically adjusted for construction in Houston, Texas. All electrical components found within specification division 26 were included in this estimate. While specification divisions 27 and 28, which include all the low voltage cabling systems, are electrical in nature, they are typically not completed by the projects' traditional electrical contractor. As such, the components for these various systems were not included in this report's detailed electrical estimate.

Fisk Electric reported the cost for their project's electrical systems to be $1,223,400. This total included not only the traditional division 26 electrical costs, but also all the division 27 and 28 low voltage costs. However, due to their competitive standing within the electrical contracting industry, Fisk decided to keep the various electrical system breakdowns confidential. Fisk was willing to concede that the cost of all division 27 and 28 components combined equated to approximately $400,000. This value was plugged into both the estimated and actual electrical system cost in order to complete an accurate variance analysis. Table 2 depicts the results of the detailed electrical estimate created for this report compared to the actual electrical systems cost incurred on the Fisk project.

Table 2: Generated Electrical Estimate Analysis

Electrical Estimate Comparison		
Description	Estimated Costs	Actual Costs
Division 26	$845,653	$823,400
Low-Voltage Systems	$400,000	$400,000
Total Electrical	**$1,245,653**	**$1,223,400**
Cost per Sq. Ft.	**$23.00**	**$22.59**

As evidenced above, the division 26 estimated costs are slightly higher than those actually incurred on the Fisk Corporate Headquarters project. Even though this estimated discrepancy only equates to a $22,253 dollar, or 3%, increase over the actual costs, the reasons behind this inconsistency were investigated. A discussion with Fisk Electric yielded that the reason for the disparity between the RSMeans generated estimate and the actual costs stemmed from the difference between large electrical contracting and nationalized electrical contracting averages. Simply stated, large commercial firms like Fisk Electric are forced to employ slightly lower component costs in order to maintain their competitive edge.

For the complete division 26 electrical estimate, please reference Appendix B.

Detailed Electrical Estimate Composition

Electrical systems have been traditionally comprised of a relatively large number of components that vary in price and application. However, in the past 30 years these component varieties have swelled in number due to the increasing technological and power requirements within buildings. Below, Figure 4 depicts the Fisk Corporate Headquarters' electrical system composition. It shows the percentage of the total system costs associated with the 7 main electrical component groupings within the building.

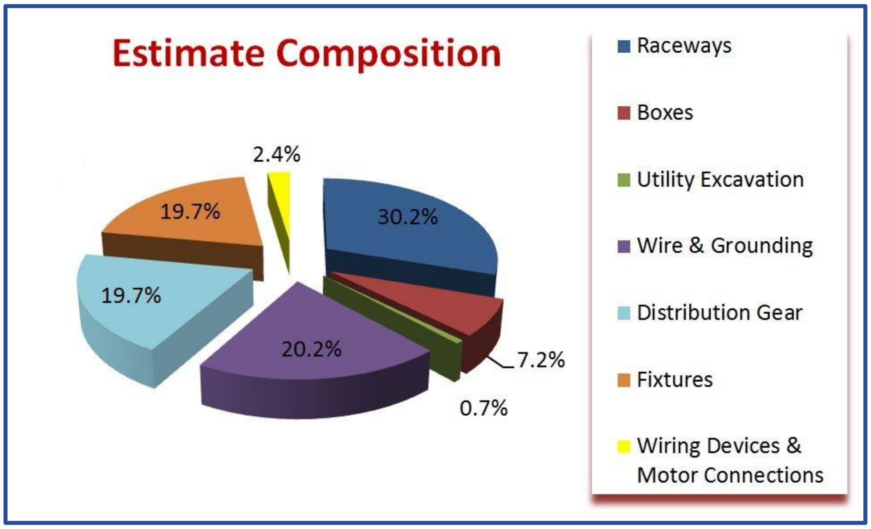


Figure 4: Electrical Component Composition

Raceways

At $226,717, raceways make up the most expensive group of electrical components found in the Fisk Corporate Headquarters project. It accounts for over 40,000 linear feet of conduit of various diameter sizes and includes the raceways for not only division 26 wiring, but also those required for all the division 27 and 28 low voltage systems. For the purpose of this report, it was assumed that all small branch circuits would be placed in ¾" conduit. This grouping also includes all the connectors, couplings, hangers, and elbows that are required to connect these conduits together and to their various termination locations.

Boxes & Wiring Devices

Boxes and wiring devices account for approximately 9.6% of the total electrical system costs. The systems' over 1,100 required boxes cost $53,960. These boxes are used primarily to house the building's various wiring devices and are also the locations of all wire splices. Wiring devices are any terminal device that distributes either power or control to the building's inhabitants and include all receptacles, switches, and sensors found within the building.

This section also included the money required for all the building's motor terminations. Typically this can be accomplished with a small piece of flexible conduit and some time to land the required wires on the appropriate locations within the various motors.

Utility Excavation

While the money required for utility excavation is minor compared to the electrical system as a whole, this phase of electrical construction can have large, negative cost ramifications if done incorrectly. Once the structural slabs are installed in a building, it becomes cost prohibitive to move or to install new underground utility feeds. This grouping also includes all the underground branch trenching required for site lighting and other small conduit requirements.

Distribution Gear

Traditionally, some of the more expensive components in an electrical estimate are the panel boards and transformers required by the building. These items, commonly referred to as the distribution gear, on the Fisk Headquarters project were estimated to cost just under $150,000. However, this number would have been much higher had Fisk decided not to save roughly $60,000 by simply moving their existing generator from their previous facility instead of purchasing a new one. Also included within this component grouping are all safety switches, overcurrent protection devices, and VFDs.

One of the more expensive components found within this category is the building's 75 kVA UPS and associated battery bank system. During the design process, Fisk Electric concluded that they would benefit from having an on-site data center to store information in their new facility. In order to insure the safety of this stored information, a UPS system estimated to be worth over $60,000 needed to be installed to provide uninterrupted power to the data center in the time that elapses between an outage and the generator startup.

Wire & Grounding

Another expensive group of electrical components found on any jobsite are the current carrying copper wires and grounding rods. Copper has a fantastic resale value and will often times be stolen from a jobsite if protective measures are not taken. It is also a component whose price is constantly in flux due to manufacturing cost relying heavily upon the price of copper by the pound. On the Fisk Headquarters Project, the estimated cost of all required copper wire and grounding components was $151,665. This report assumed that all branch wiring over 100 feet in length needed to be upsized in order to compensate for voltage drop.

Figure 5: Type A3 – Courtesy of Pinnacle Lighting

Fixtures

Encompassing just under 20% of the total electrical systems' estimated value, the last major component found within the Fisk Corporate Headquarters project is the building's fixtures. Fixtures are notorious on jobsites for being problematic due to their long lead times, expensive costs, and relative frailty. Figure 5 shows an example of one of the types of fixtures found within a majority of the individual office spaces. Also included in this grouping are the required fixture whips and exterior light poles.

General Conditions Estimate

The general conditions estimate for the Fisk Corporate Headquarters project is unique in that the general conditions were actually carried by the owner rather than the general contractor. As a typical rule of thumb, general conditions are usually around six percent of the total contract value and are carried by the general contractor. However, Tutor Perini has no presence in the Houston construction market even though they own Fisk Electric. This truth, coupled with Fisk's vast knowledge of Houston's construction market, led both parties to the decision to have Fisk Electric carry the general conditions. This unique situation led for the general conditions estimate to be slightly skewed compared to normal general conditions costs. The normally distinct lines between owner costs and general contractor costs are blurred to the point it becomes difficult to differentiate between the two.

Because Tutor Perini, not Fisk Electric, is actually staffing the job, it became easier for Fisk to expand their general conditions to include all their costs incurred directly from Tutor Perini, minus Tutor Perini's fee. These costs included, but were not limited to, jobsite management staffing costs, scheduling costs, and preconstruction services. Fisk then added these expenses to the typical general conditions costs found on a project to produce one total general conditions total.

The general conditions estimate generated in this report followed the same format as the one adopted by Fisk Electric on the actual project. It was created using a blend of both actual costs provided by Fisk Electric and RSMeans. The estimate was created with a construction schedule of 47 weeks or 11 months in mind depending on the item's unit in question. The results can be seen in Table 3 below:

Table 3: General Conditions Summary

General Conditions Estimate Summary		
Description	Cost $	% of Construction
Tutor Perini Services	$729,030.20	10.0%
Typical GC Costs	$393,875.69	5.4%
Total GC Costs	**$1,122,906**	**15.4%**

As previously stated, the blending between construction management services and typical general conditions caused the total general conditions estimate to be much larger than the typical 6% found on most jobs. However, when the typical general conditions costs are isolated from the construction management services, the 5.4% of the total project costs become much more reasonable, even though they do not include the construction manager's staffing fees.

The staffing costs were developed using the staffing plan found in Technical Report 1 and equal 44% of the total general conditions estimate. While many of the individuals only consulted the project periodically, their combined time was found to equal one slightly overpaid project manager working the entire length of the project.

Insurance and bonds account for roughly 19% of the total general conditions estimate. 17% of the total general conditions estimate is comprised of typical general conditions items such as temporary utilities, waste removal, temporary fencing, and temporary facilities. The remaining costs come from the scheduling and preconstruction services that were included within the general conditions estimate.

For the full General Conditions Estimate, please reference Appendix C.

BIM Use Evaluation

Building Information Modeling, or BIM, is a relatively new construction technology that has become mandatory on large commercial projects over the past ten years. Fisk Electric first began adopting BIM practices in 2004 when they were asked to take part in a 3D MEP coordination model on a large national laboratory. Since then, Fisk has helped to build a MEP coordination model on every large commercial job on which they were contracted. However, having experienced firsthand many of the benefits gained from the use of BIM, Fisk still ultimately decided on their own job that the paybacks of requiring BIM would not outweigh the costs associated with widespread BIM use.

BIM Uses

Even though Fisk did not require or pay for BIM to be implemented on their headquarters jobsite, some firms decided to use BIM tools to aide in their respective project roles. The BIM use summary on the Fisk Corporate Headquarters project can be seen in Table 4 below.

Table 4: BIM Use Summary

Actual BIM Use							
X	Plan	X	Design	X	Construct	X	Operate
	Programming	X	Design Authoring		Site Utilization Planning		Building Maintenance Scheduling
	Site Analysis	X	Design Reviews		Construction System Design		Building System Analysis
			3D Coordination		3D Coordination		Asset Management
		X	Structural Analysis		Digital Fabrication		Space Management / Tracking
			Lighting Analysis		3D Control and Planning		Disaster Planning
			Energy Analysis				Record Modeling
			Mechanical Analysis				
			Other Eng. Analysis				
			Sustainability (LEED) Evaluation				
			Code Validation				
	Phase Planning (4D Modeling)		Phase Planning (4D Modeling)		Phase Planning (4D Modeling)		Phase Planning (4D Modeling)
	Cost Estimation		Cost Estimation		Cost Estimation		Cost Estimation
	Existing Conditions Modeling		Existing Conditions Modeling		Existing Conditions Modeling		Existing Conditions Modeling

Both the Architectural and Structural Engineering firms, Gensler and Walter P. Moore, decided that even though they would not get paid for creating a 3D model, they would benefit greatly from using the model to aide in their design. Apart from using their models individually for their respective design work, the models were also used by the two firms to make sure their designs complemented one another without any clashes or major design flaws. Once created, the firms were able to use the models to portray and sell their ideas and design to Fisk Electric and Tutor Perini. Upon design completion, the models were then given to Fisk Electric for their potential use during the construction phase. However, Fisk ultimately decided to not use these models during construction.

Although Fisk decided not to implement any sort of BIM technology during the construction phase of the project, there are ways that BIM could have been implemented that might have resulted in project savings. The proposed construction BIM uses detailed in this report can be seen in Table 5 below.

Table 5: Proposed BIM Use Summary

Proposed BIM Use							
X	**Plan**	**X**	**Design**	**X**	**Construct**	**X**	**Operate**
	Programming	X	Design Authoring	X	Site Utilization Planning		Building Maintenance Scheduling
	Site Analysis	X	Design Reviews	X	Construction System Design		Building System Analysis
			3D Coordination	X	3D Coordination		Asset Management
		X	Structural Analysis		Digital Fabrication		Space Management / Tracking
			Lighting Analysis		3D Control and Planning		Disaster Planning
			Energy Analysis				Record Modeling
			Mechanical Analysis				
			Other Eng. Analysis				
			Sustainability (LEED) Evaluation				
			Code Validation				
	Phase Planning (4D Modeling)		Phase Planning (4D Modeling)		Phase Planning (4D Modeling)		Phase Planning (4D Modeling)
	Cost Estimation		Cost Estimation		Cost Estimation		Cost Estimation
	Existing Conditions Modeling		Existing Conditions Modeling		Existing Conditions Modeling		Existing Conditions Modeling

Even though the Fisk Corporate Headquarters project is relatively small, it would still benefit from the use of 3D MEP coordination model. While the building's MEP systems are not complex enough to require the model for clash detection, all MEP tradesmen would save valuable time by not having to perform any field layouts. Also, considering the completeness of the drawings at the start of construction, the model could be completed long before the MEP tradesmen began any interior overhead work.

As stated in Technical Report 1, one area in which the Fisk Corporate Headquarters project suffered in terms of efficiency was the site utilization plan. In an effort to eliminate loss of efficiency, the construction team could use the architectural Revit model as a baseline for the general site layout. They could then place simple representative objects around the building in an organized fashion to designate material laydown and storage areas. This organizational tool would cut down on the time lost by laborers being forced to move materials periodically when they got in the way of other trades and also having to travel long distances away from their work areas to gather the necessary materials to complete their tasks.

The last way BIM could have been effectively used by the construction team is through the design of the curtain wall's "two dimensions". As detailed later in this report, one of the biggest constructability challenges the team faced was the coordination between the glazing and structural steel contractors. Instead of addressing the problem in the traditional manner, the team could have utilized BIM to design the exact dimensions of the system virtually. Once designed, both contractors could have extrapolated their dimensions from the model and constructed their systems independently.

BIM Process Maps

In an effort to gain further comprehension regarding the flow of information from one entity to another via BIM, a representative, detailed process map was created. The following figure graphically depicts the flow of BIM information used on the Fisk Corporate Headquarters project by the design team.

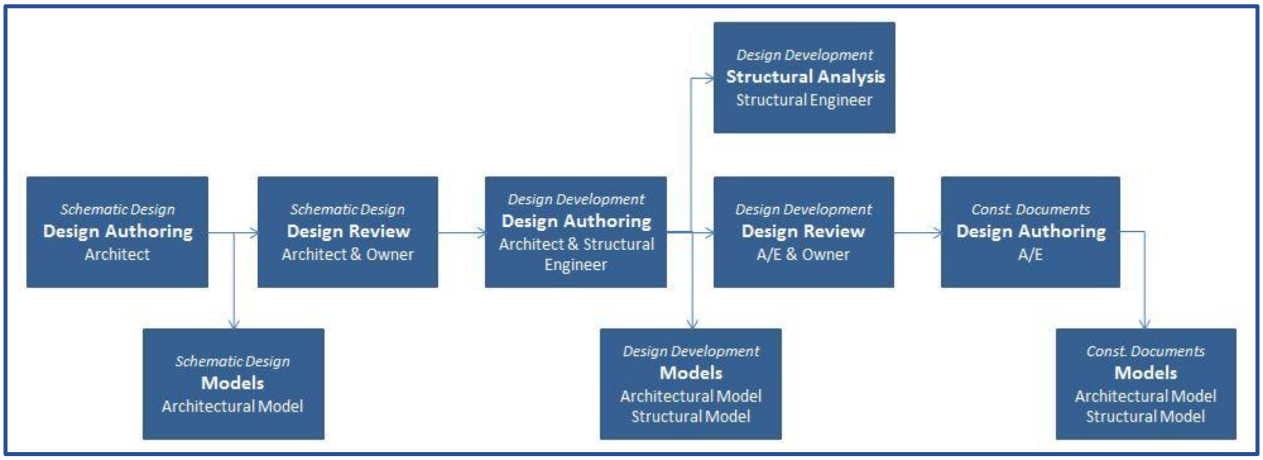


Figure 6: Actual BIM Process Map

Careful study of the process map shows that while the process employed on the project does effectively use BIM to aide in design, virtually no BIM information was transferred to the construction team.

Figure 7 depicts how the process map would have been altered if the project team had implemented the BIM uses detailed in the previous section. Information could have seamlessly moved from design directly into the construction phase.

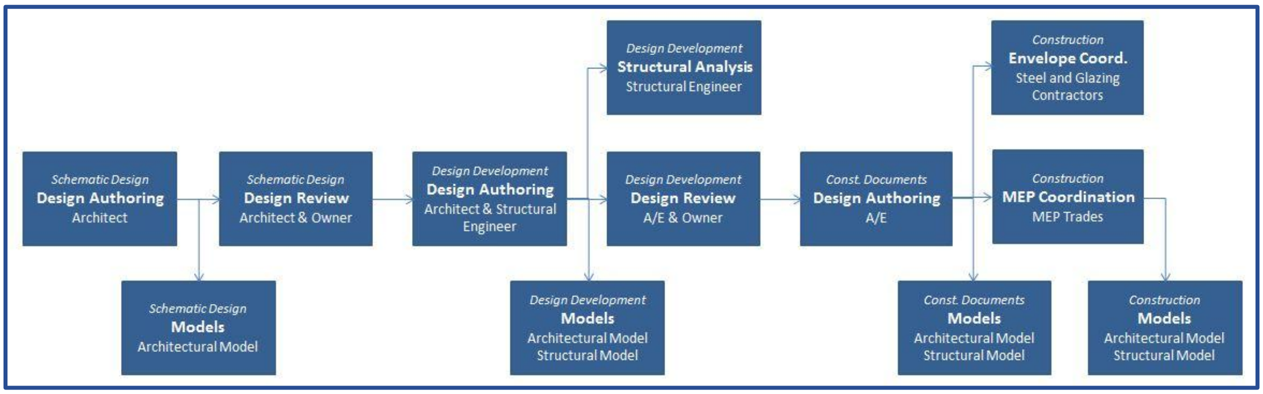


Figure 7: Proposed BIM Process Map

BIM Critique

Even though BIM was used sparingly on the Fisk Corporate Headquarters project, every instance where it was implemented was done both efficiently and effectively. Both the architect and structural engineer saw the value in using BIM to aide in their respective design disciplines. Figure 8 shows a screenshot of the structural model created by the Walter P. Moore engineer. However, the project team did not take full advantage of the tools available to them. While the implementation of BIM would have increased the project's initial costs, the payback in labor savings would have more than offset those costs. Through effective use of the MEP coordination model, site utilization plans, and curtain wall layout, the construction team could have reaped the benefits of BIM in the same manner experienced by the various participating design entities.

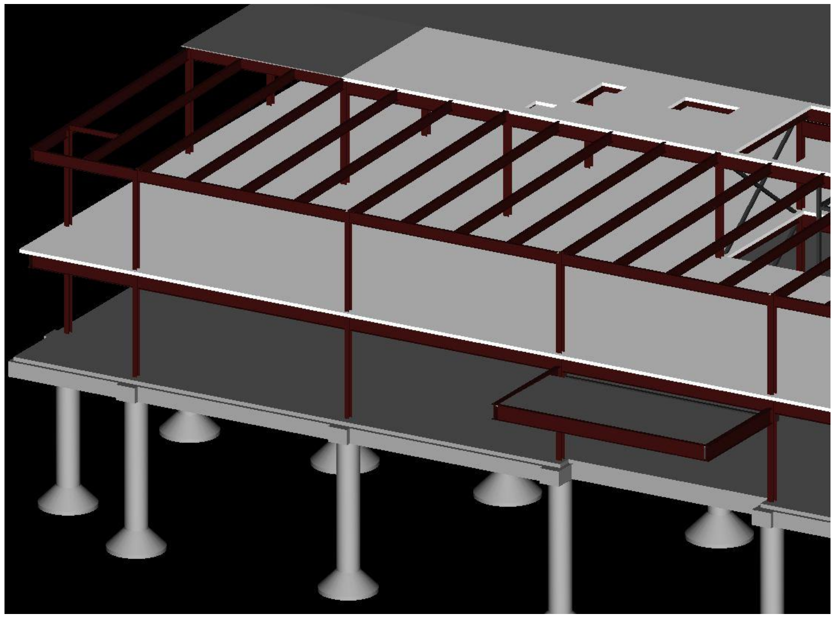


Figure 8: Structural Revit Model - Courtesy of Walter P. Moore

Constructability Challenges

The Fisk Corporate Headquarters project presented multiple unique constructability challenges to the construction team over the lifetime of the project. Three of the most distinctive challenges the project team had to overcome were the coordination between the curtain wall and steel framing systems, the structural unsuitability of both structure's subgrade conditions, and the unforeseen soil surface conditions. As with any jobsite trial, it fell to the project team to devise an intelligent plan of attack to overcome each challenge. While each issue was isolated and unique, all three were overcome using thorough communication, detailed sequence scheduling, and cooperation between all pertinent team members.

Curtain Wall to Steel Framing Coordination

The most crucial constructability concern in terms of a scheduling impact on the Fisk Corporate Headquarters project was the coordination between the curtain wall and structural steel framing systems. In a typical construction sequence, the steel erectors would install the secondary structural steel for the brick ledge, leaving out a roughly sized framed area for the curtain wall panels. Tutor Perini and a majority of the construction world designate this framed area outlined in Figure 9 as the "two dimensions". Once the "two dimensions" are established, the glazing contractor then manufactures his curtain wall panels to fit snugly within them.

Figure 9: "Two Dimensions"

However, as a result of a tight building envelope schedule stemming from late design changes, the project team was forced to work backwards on the Fisk Corporate Headquarters project. Due to long manufacturing lead times, the glazing contractor was instructed to design and begin fabrication of the curtain wall panels before the "two dimensions" were realized by the steel contractor. Upon design completion, the glazing contractor gave the steel contractor the "two dimensions" in a timely manner. The steel contractor then framed the "two dimensions" via steel studs according to the glazing contractor's specifications.

Other than the discomfort caused by being forced to work backwards felt by both involved contractors, the main difficultly with this construction solution was the different tolerances that both trades are used to working within. Ironworkers typically work within much larger tolerances than glazing craftsmen. As such, forcing the ironworkers to install their secondary framing system with the same precision that glazing contractors are accustomed proved difficult. These differences in work styles forced Tutor Perini to take measures to ensure the two systems would be installed correctly and bond to form one cohesive enclosure. Tutor Perini began by making sure the ironworkers utilized technologically advanced layout equipment, such as the Dewalt Self Leveling 3 Beam Line Laser found in Figure 10, prior to laying out

Figure 10: Dewalt Laser - Courtesy of Dewalt

their "two dimensions". They also required mandatory field tolerance quality checks to be done on all completed framing locations. Finally, through smart management techniques and frequent meetings, Tutor Perini was able to provide the two contractors with enough means of communication to accomplish their respective tasks cooperatively. This enhanced communication, coupled with field installation tolerance quality checks and advanced layout equipment, allowed the two systems to be installed accurately and within each other's tolerances.

Unsuitable Structural Subgrade

The second unique constructability concern encountered on the Fisk Corporate Headquarters project was the unsuitable condition of the subgrade to support the structural system required by both building structures. Because of this, the construction team was forced to excavate between 5 to 10 feet beneath each building footprint and then backfill and compact each location with a specified structural fill. Technical report 1 detailed some of the scheduling and costs impacts the team had to endure due to these conditions, but did not specifically address the construction management techniques employed in order to minimize these impacts.

Houston, Texas is a relatively warm, wet climate located just inland from the Gulf of Mexico. While not known as a dreary or rainy place, Houston is susceptible to randomly receive high volume, sometimes even violent, downpours in short periods of time. If the jobsite received one of these intense downpours during either the excavation or backfill process, the construction manager would be forced to push back critical path activities, negatively impacting the schedule and costing the owner and builder more money. Since the Fisk Corporate Headquarters project the owner and builder were virtually the same entity, damages incurred due to scheduling deficiencies would become too costly to be tolerated.

Keeping this in mind, Tutor Perini decided to employ a highly coordinated, intelligently sequenced process between the different subcontractors in order to minimize the excavation's unprotected exposure to Houston's quickly changing climate. They accomplished this by creating a detailed schedule that illustrated each step in the earthwork sequence and the responsibilities of everyone involved. Once distributed to the appropriate parties, individual parties knew their window within which they would be allowed to complete their task. By instituting this highly organized form of coordination between each event in the sequence, Tutor Perini was able to excavate, backfill, and compact in rapid succession. Similar to the previous constructability issue, emphasis was placed on the importance of constant communication between all involved team members throughout this detailed sequencing process. Without the communication and cooperation of all the involved entities, the entire process would have taken longer, been more susceptible to weather delays, and potentially could have caused irreversible damages to the project schedule.

Unforeseen Soil Surface Conditions

Unforeseen conditions are always a major constructability concern on any jobsite. Depending on the severity of the condition, the project team could be forced to make significant scheduling adjustments or accept extra costs to overcome the situation. In the case of the Fisk Corporate Headquarters project, the project team was unaware when construction began as to the condition of the external topsoil layer.

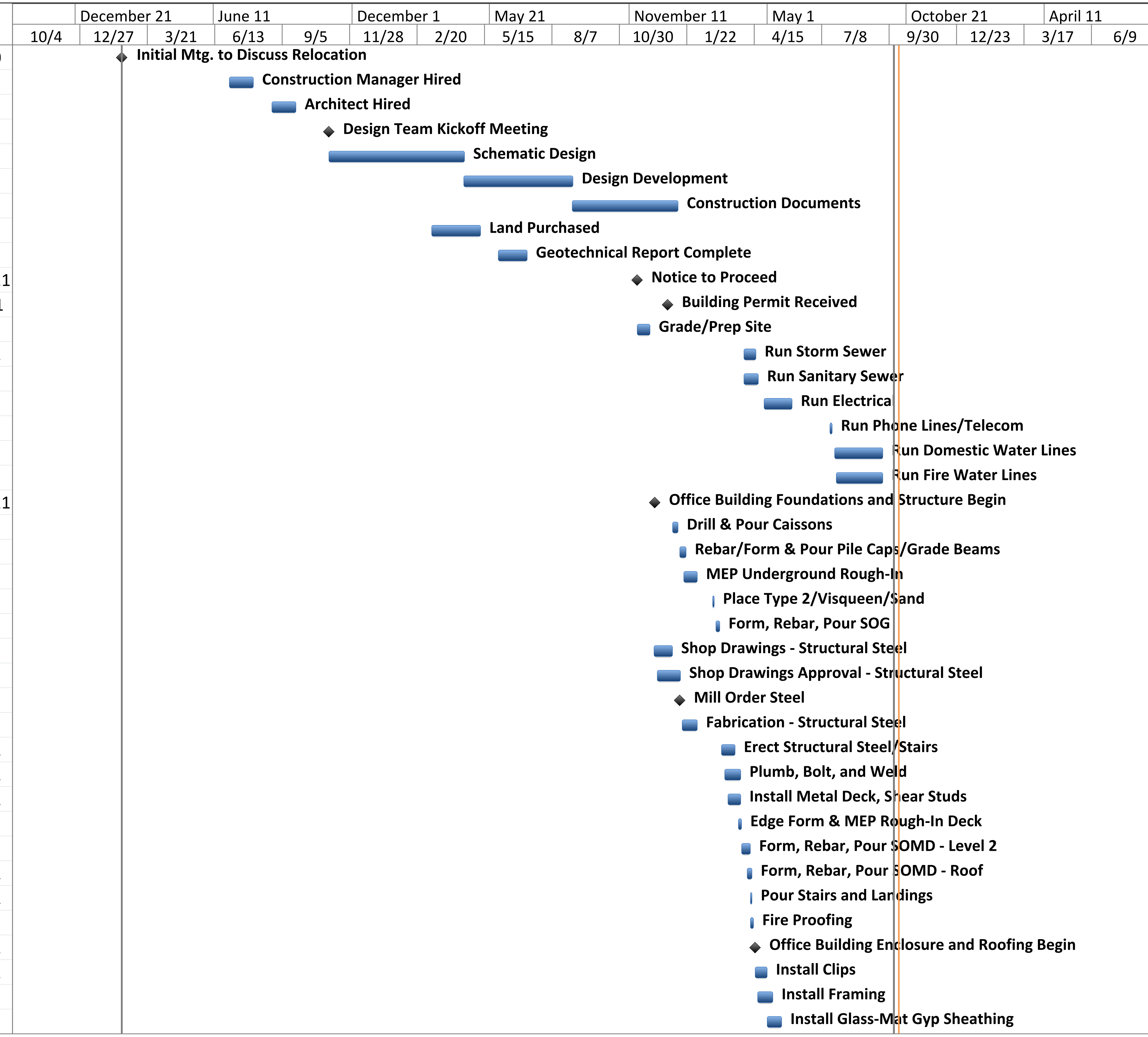
The site for the Fisk project was previously inhabited by a concrete producing facility before it was torn down and sold to Fisk Electric. Due to the nature of concrete production, bits of limestone, small aggregates, and concrete solutions from the previous facility seeped into the topsoil. Over time, these objects and solutions hardened into the topsoil layer, leaving behind them an incredibly hard, difficult to break exterior surface layer. Tutor Perini and the construction team quickly discovered that the original surface was so hard that conventional dozers and excavating equipment could not be used to dig into the topsoil layer.

To account for this unforeseen condition, Tutor Perini had to employ a breaker, similar to the Komatsu Hydraulic Breaker found in Figure 11, to come to the site and crack through the topsoil layer in all areas of the site where subsurface work was required. Even areas where simple asphalt roads or landscaping such as trees or shrubbery needed to be installed had to be broken up beforehand. This complication forced the construction team to attempt to alter their scheduled activities around when they were able to procure the use of the breaker. Once again the team's communication and cooperation allowed them to come up with and implement a plan that enabled them to adapt to the situation without any major scheduling impacts.

Figure 11: Hydraulic Breaker - Courtesy of Komatsu

Appendix A: Detailed Project Schedule

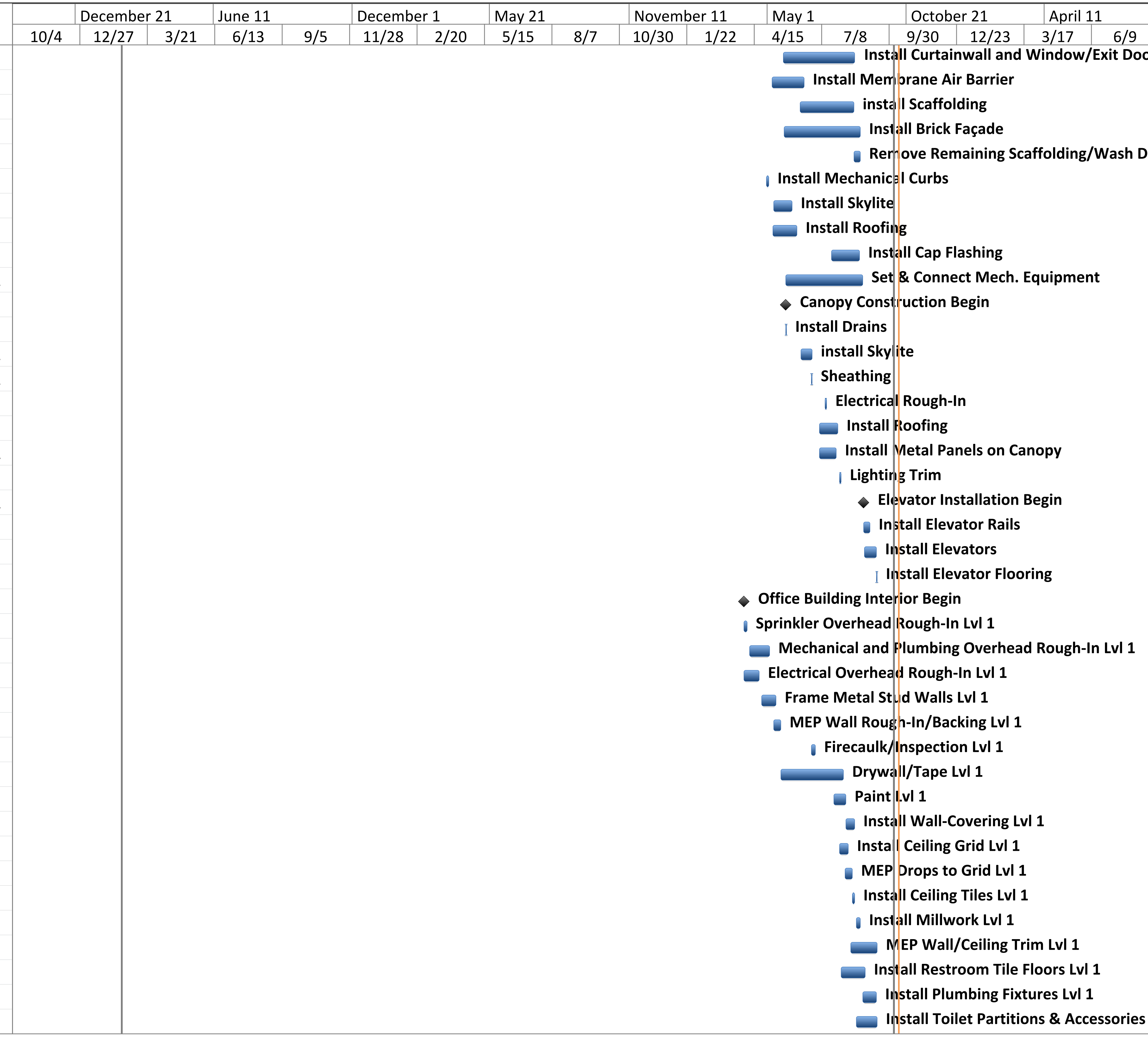
ID	Task Name	Duration	Start	Finish
1	Initial Mtg. to Discuss Relocation	0 days	Wed 2/17/10	Wed 2/17/10
2	Construction Manager Hired	22 days	Thu 7/1/10	Fri 7/30/10
3	Architect Hired	22 days	Mon 8/23/10	Tue 9/21/10
4	Design Team Kickoff Meeting	0 days	Tue 11/2/10	Tue 11/2/10
5	Schematic Design	121 days	Tue 11/2/10	Tue 4/19/11
6	Design Development	98 days	Tue 4/19/11	Thu 9/1/11
7	Construction Documents	94 days	Thu 9/1/11	Tue 1/10/12
8	Land Purchased	43 days	Thu 3/10/11	Mon 5/9/11
9	Geotechnical Report Complete	26 days	Wed 6/1/11	Wed 7/6/11
10	Notice to Proceed	0 days	Mon 11/21/11	Mon 11/21/11
11	Building Permit Received	0 days	Thu 12/29/11	Thu 12/29/11
12	Grade/Prep Site	12 days	Mon 11/21/11	Tue 12/6/11
13	Run Storm Sewer	11 days	Mon 4/2/12	Mon 4/16/12
14	Run Sanitary Sewer	14 days	Mon 4/2/12	Thu 4/19/12
15	Run Electrical	25 days	Fri 4/27/12	Thu 5/31/12
16	Run Phone Lines/Telecom	3 days	Wed 7/18/12	Fri 7/20/12
17	Run Domestic Water Lines	44 days	Tue 7/24/12	Fri 9/21/12
18	Run Fire Water Lines	42 days	Thu 7/26/12	Fri 9/21/12
19	Office Building Foundations and Structure Begin	0 days	Mon 12/12/11	Mon 12/12/11
20	Drill & Pour Caissons	5 days	Wed 1/4/12	Tue 1/10/12
21	Rebar/Form & Pour Pile Caps/Grade Beams	6 days	Fri 1/13/12	Fri 1/20/12
22	MEP Underground Rough-In	13 days	Wed 1/18/12	Fri 2/3/12
23	Place Type 2/Visqueen/Sand	2 days	Thu 2/23/12	Fri 2/24/12
24	Form, Rebar, Pour SOG	5 days	Mon 2/27/12	Fri 3/2/12
25	Shop Drawings - Structural Steel	17 days	Mon 12/12/11	Tue 1/3/12
26	Shop Drawings Approval - Structural Steel	21 days	Fri 12/16/11	Fri 1/13/12
27	Mill Order Steel	0 days	Fri 1/13/12	Fri 1/13/12
28	Fabrication - Structural Steel	15 days	Mon 1/16/12	Fri 2/3/12
29	Erect Structural Steel/Stairs	13 days	Mon 3/5/12	Wed 3/21/12
30	Plumb, Bolt, and Weld	14 days	Fri 3/9/12	Wed 3/28/12
31	Install Metal Deck, Shear Studs	12 days	Tue 3/13/12	Wed 3/28/12
32	Edge Form & MEP Rough-In Deck	4 days	Mon 3/26/12	Thu 3/29/12
33	Form, Rebar, Pour SOMD - Level 2	7 days	Fri 3/30/12	Mon 4/9/12
34	Form, Rebar, Pour SOMD - Roof	4 days	Fri 4/6/12	Wed 4/11/12
35	Pour Stairs and Landings	2 days	Tue 4/10/12	Wed 4/11/12
36	Fire Proofing	4 days	Tue 4/10/12	Fri 4/13/12
37	Office Building Enclosure and Roofing Begin	0 days	Mon 4/16/12	Mon 4/16/12
38	Install Clips	11 days	Mon 4/16/12	Mon 4/30/12
39	Install Framing	13 days	Thu 4/19/12	Mon 5/7/12
40	Install Glass-Mat Gyp Sheathing	14 days	Tue 5/1/12	Fri 5/18/12



Project: Fisk Corporate Headquar
Date: Sun 10/7/12

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

ID	Task Name	Duration	Start	Finish
41	Install Curtainwall and Window/Exit Doors	65 days	Mon 5/21/12	Fri 8/17/12
42	Install Membrane Air Barrier	30 days	Mon 5/7/12	Fri 6/15/12
43	install Scaffolding	49 days	Mon 6/11/12	Thu 8/16/12
44	Install Brick Façade	69 days	Tue 5/22/12	Fri 8/24/12
45	Remove Remaining Scaffolding/Wash Down	6 days	Fri 8/17/12	Fri 8/24/12
46	Install Mechanical Curbs	3 days	Mon 4/30/12	Wed 5/2/12
47	Install Skylite	17 days	Wed 5/9/12	Thu 5/31/12
48	Install Roofing	22 days	Tue 5/8/12	Wed 6/6/12
49	Install Cap Flashing	25 days	Fri 7/20/12	Thu 8/23/12
50	Set & Connect Mech. Equipment	68 days	Thu 5/24/12	Mon 8/27/12
51	Canopy Construction Begin	0 days	Thu 5/24/12	Thu 5/24/12
52	Install Drains	1 day	Thu 5/24/12	Thu 5/24/12
53	install Skylite	10 days	Tue 6/12/12	Mon 6/25/12
54	Sheathing	1 day	Mon 6/25/12	Mon 6/25/12
55	Electrical Rough-In	2 days	Thu 7/12/12	Fri 7/13/12
56	Install Roofing	17 days	Thu 7/5/12	Fri 7/27/12
57	Install Metal Panels on Canopy	15 days	Thu 7/5/12	Wed 7/25/12
58	Lighting Trim	2 days	Mon 7/30/12	Tue 7/31/12
59	Elevator Installation Begin	0 days	Wed 8/29/12	Wed 8/29/12
60	Install Elevator Rails	6 days	Wed 8/29/12	Wed 9/5/12
61	Install Elevators	11 days	Thu 8/30/12	Thu 9/13/12
62	Install Elevator Flooring	1 day	Fri 9/14/12	Fri 9/14/12
63	Office Building Interior Begin	0 days	Mon 4/2/12	Mon 4/2/12
64	Sprinkler Overhead Rough-In Lvl 1	4 days	Mon 4/2/12	Thu 4/5/12
65	Mechanical and Plumbing Overhead Rough-In Lvl 1	19 days	Mon 4/9/12	Thu 5/3/12
66	Electrical Overhead Rough-In Lvl 1	15 days	Mon 4/2/12	Fri 4/20/12
67	Frame Metal Stud Walls Lvl 1	14 days	Tue 4/24/12	Fri 5/11/12
68	MEP Wall Rough-In/Backing Lvl 1	7 days	Wed 5/9/12	Thu 5/17/12
69	Firecaulk/Inspection Lvl 1	5 days	Mon 6/25/12	Fri 6/29/12
70	Drywall/Tape Lvl 1	56 days	Fri 5/18/12	Fri 8/3/12
71	Paint Lvl 1	11 days	Mon 7/23/12	Mon 8/6/12
72	Install Wall-Covering Lvl 1	9 days	Tue 8/7/12	Fri 8/17/12
73	Install Ceiling Grid Lvl 1	9 days	Mon 7/30/12	Thu 8/9/12
74	MEP Drops to Grid Lvl 1	7 days	Mon 8/6/12	Tue 8/14/12
75	Install Ceiling Tiles Lvl 1	3 days	Wed 8/15/12	Fri 8/17/12
76	Install Millwork Lvl 1	5 days	Mon 8/20/12	Fri 8/24/12
77	MEP Wall/Ceiling Trim Lvl 1	25 days	Mon 8/13/12	Fri 9/14/12
78	Install Restroom Tile Floors Lvl 1	22 days	Wed 8/1/12	Thu 8/30/12
79	Install Plumbing Fixtures Lvl 1	13 days	Tue 8/28/12	Thu 9/13/12
80	Install Toilet Partitions & Accessories Lvl 1	20 days	Mon 8/20/12	Fri 9/14/12



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

ID	Task Name	Duration	Start	Finish
81	Install Carpet & Base Lvl 1	7 days	Thu 8/16/12	Fri 8/24/12
82	Hang Doors & Hardware Lvl 1	7 days	Thu 9/6/12	Fri 9/14/12
83	Install & Hook-Up Office Partitions Lvl 1	10 days	Tue 9/4/12	Mon 9/17/12
84	Final Clean Lvl 1	5 days	Mon 9/17/12	Fri 9/21/12
85	Punch List Lvl 1	5 days	Tue 9/18/12	Mon 9/24/12
86	Sprinkler Overhead Rough-In Lvl 2	6 days	Thu 4/19/12	Thu 4/26/12
87	Mechanical and Plumbing Overhead Rough-In Lvl 2	25 days	Mon 4/23/12	Fri 5/25/12
88	Electrical Overhead Rough-In Lvl 2	15 days	Thu 4/19/12	Wed 5/9/12
89	Frame Metal Stud Walls Lvl 2	16 days	Fri 4/27/12	Fri 5/18/12
90	MEP Wall Rough-In/Backing Lvl 2	15 days	Mon 5/7/12	Fri 5/25/12
91	Firecaulk/Inspection Lvl 2	5 days	Mon 6/25/12	Fri 6/29/12
92	Drywall/Tape Lvl 2	56 days	Mon 5/21/12	Mon 8/6/12
93	Paint Lvl 2	12 days	Wed 7/25/12	Thu 8/9/12
94	Install Wall-Covering Lvl 2	8 days	Fri 8/10/12	Tue 8/21/12
95	Install Ceiling Grid Lvl 2	7 days	Fri 8/10/12	Mon 8/20/12
96	MEP Drops to Grid Lvl 2	8 days	Mon 8/13/12	Wed 8/22/12
97	Install Ceiling Tiles Lvl 2	3 days	Thu 8/23/12	Mon 8/27/12
98	Install Millwork Lvl 2	18 days	Wed 8/29/12	Fri 9/21/12
99	MEP Wall/Ceiling Trim Lvl 2	15 days	Mon 8/27/12	Fri 9/14/12
100	Install Restroom Tile Floors Lvl 2	19 days	Mon 8/6/12	Thu 8/30/12
101	Install Plumbing Fixtures Lvl 2	16 days	Thu 8/23/12	Thu 9/13/12
102	Install Toilet Partitions & Accessories Lvl 2	14 days	Tue 8/28/12	Fri 9/14/12
103	Install Carpet & Base Lvl 2	10 days	Mon 8/27/12	Fri 9/7/12
104	Hang Doors & Hardware Lvl 2	5 days	Mon 9/10/12	Fri 9/14/12
105	Install and Hook-Up Office Partitions Lvl 2	10 days	Tue 9/4/12	Mon 9/17/12
106	Final Clean Lvl 2	5 days	Thu 9/20/12	Wed 9/26/12
107	Punch List Lvl 2	5 days	Fri 9/21/12	Thu 9/27/12
108	Fab-Shop Foundations and Structure Begin	0 days	Wed 1/4/12	Wed 1/4/12
109	Drill & Pour Caissons	5 days	Wed 1/4/12	Tue 1/10/12
110	Rebar/Form & Pour Pile Caps/Grade Beams	6 days	Thu 1/5/12	Thu 1/12/12
111	MEP Underground Rough-In	6 days	Tue 1/17/12	Tue 1/24/12
112	Place Type 2/Visqueen/Sand	5 days	Mon 1/23/12	Fri 1/27/12
113	Form, Rebar, Pour Slab on Grade	5 days	Mon 1/23/12	Fri 1/27/12
114	Form, Rebar, Pour Dock Ramp, Walls, and Slab	10 days	Wed 5/2/12	Tue 5/15/12
115	Erect Structural Steel	2 days	Tue 3/13/12	Wed 3/14/12
116	Plumb, Bolt, and Weld	7 days	Mon 3/19/12	Tue 3/27/12
117	Install Metal Deck	5 days	Wed 3/21/12	Tue 3/27/12
118	Fab-Shop Enclosure and Roofing Begin	0 days	Tue 4/24/12	Tue 4/24/12
119	Install Scaffolding	23 days	Tue 4/24/12	Thu 5/24/12
120	Install Masonry Walls	32 days	Mon 4/23/12	Tue 6/5/12

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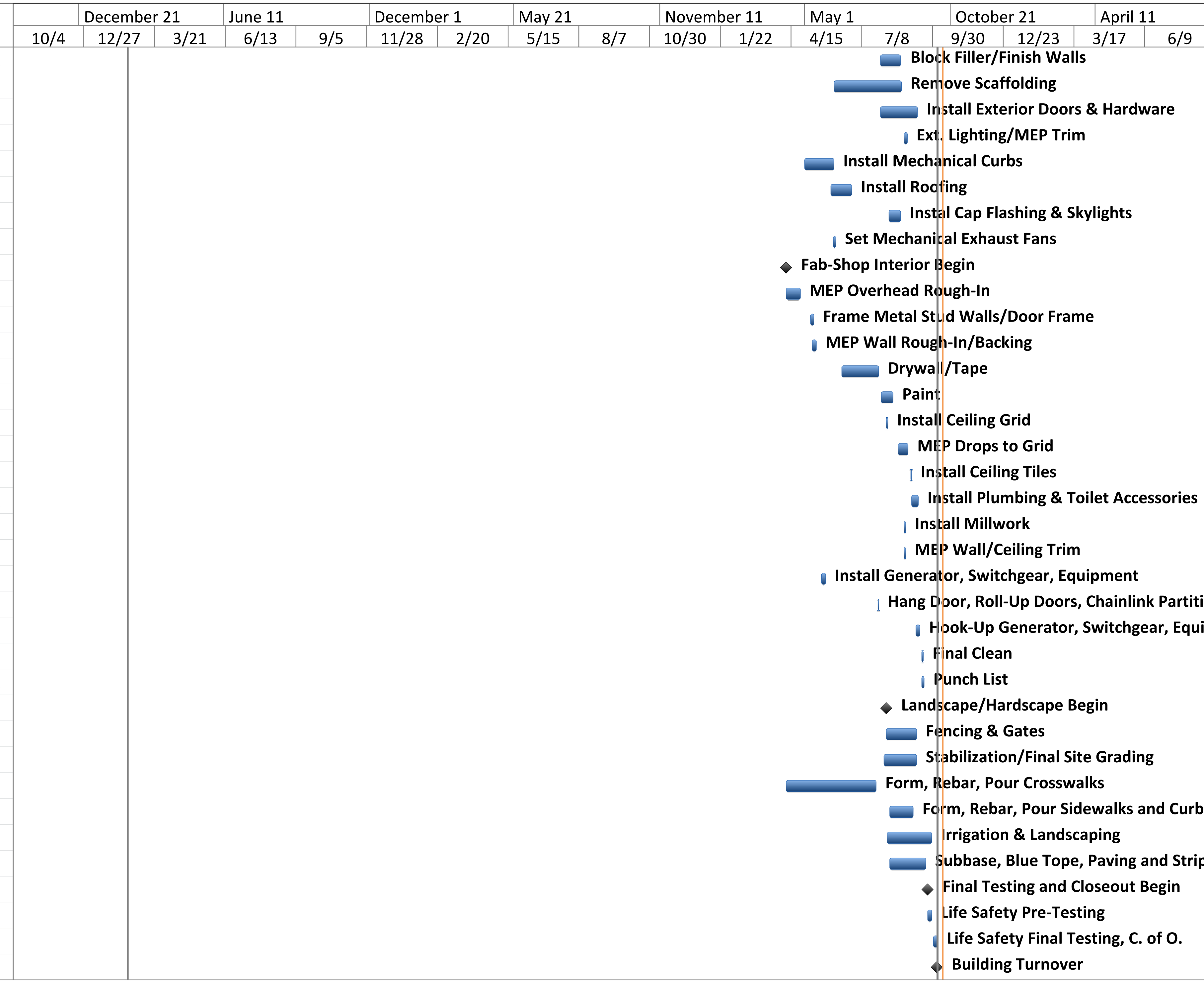
Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress

ID	Task Name	Duration	Start	Finish
121	Block Filler/Finish Walls	18 days	Mon 7/30/12	Wed 8/22/12
122	Remove Scaffolding	58 days	Tue 6/5/12	Thu 8/23/12
123	Install Exterior Doors & Hardware	32 days	Mon 7/30/12	Tue 9/11/12
124	Ext. Lighting/MEP Trim	4 days	Mon 8/27/12	Thu 8/30/12
125	Install Mechanical Curbs	25 days	Tue 5/1/12	Mon 6/4/12
126	Install Roofing	17 days	Fri 6/1/12	Mon 6/25/12
127	Instal Cap Flashing & Skylights	10 days	Thu 8/9/12	Wed 8/22/12
128	Set Mechanical Exhaust Fans	3 days	Mon 6/4/12	Wed 6/6/12
129	Fab-Shop Interior Begin	0 days	Mon 4/9/12	Mon 4/9/12
130	MEP Overhead Rough-In	13 days	Mon 4/9/12	Wed 4/25/12
131	Frame Metal Stud Walls/Door Frame	4 days	Tue 5/8/12	Fri 5/11/12
132	MEP Wall Rough-In/Backing	3 days	Thu 5/10/12	Mon 5/14/12
133	Drywall/Tape	32 days	Thu 6/14/12	Fri 7/27/12
134	Paint	10 days	Tue 7/31/12	Mon 8/13/12
135	Install Ceiling Grid	2 days	Mon 8/6/12	Tue 8/7/12
136	MEP Drops to Grid	10 days	Mon 8/20/12	Fri 8/31/12
137	Install Ceiling Tiles	1 day	Tue 9/4/12	Tue 9/4/12
138	Install Plumbing & Toilet Accessories	6 days	Wed 9/5/12	Wed 9/12/12
139	Install Millwork	2 days	Mon 8/27/12	Tue 8/28/12
140	MEP Wall/Ceiling Trim	2 days	Mon 8/27/12	Tue 8/28/12
141	Install Generator, Switchgear, Equipment	5 days	Mon 5/21/12	Fri 5/25/12
142	Hang Door, Roll-Up Doors, Chainlink Partitions	1 day	Fri 7/27/12	Fri 7/27/12
143	Hook-Up Generator, Switchgear, Equipment	5 days	Mon 9/10/12	Fri 9/14/12
144	Final Clean	2 days	Mon 9/17/12	Tue 9/18/12
145	Punch List	3 days	Mon 9/17/12	Wed 9/19/12
146	Landscape/Hardscape Begin	0 days	Mon 8/6/12	Mon 8/6/12
147	Fencing & Gates	26 days	Mon 8/6/12	Mon 9/10/12
148	Stabilization/Final Site Grading	27 days	Fri 8/3/12	Mon 9/10/12
149	Form, Rebar, Pour Crosswalks	77 days	Mon 4/9/12	Tue 7/24/12
150	Form, Rebar, Pour Sidewalks and Curbs	20 days	Fri 8/10/12	Thu 9/6/12
151	Irrigation & Landscaping	39 days	Tue 8/7/12	Fri 9/28/12
152	Subbase, Blue Tope, Paving and Striping	31 days	Fri 8/10/12	Fri 9/21/12
153	Final Testing and Closeout Begin	0 days	Mon 9/24/12	Mon 9/24/12
154	Life Safety Pre-Testing	5 days	Mon 9/24/12	Fri 9/28/12
155	Life Safety Final Testing, C. of O.	5 days	Mon 10/1/12	Fri 10/5/12
156	Building Turnover	0 days	Fri 10/5/12	Fri 10/5/12



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Appendix B: Detailed Electrical Estimate

Conduit/Raceway Takeoff								
Code	**Description**	**Quantity**	**Unit**	**Mat./Unit**	**Mat. Tot.**	**Lab./Equip.**	**L/E Tot.**	**Total $**
260533135020	3/4" EMT Conduit	32000	L.F.	$1.08	$34,560	$2.14	$68,480	$103,040
260533136220	3/4" EMT Coupling	3200	EA	$3.06	$9,792			$9,792
260533136520	3/4" EMT Conduit Conn	2640	EA	$2.53	$6,679	$2.53	$6,679	$13,358
260533132030	3/4" GRC Elbow	66	EA	$10.95	$723	$9.96	$657	$1,380
260533152580	3/4" GRC Nipple	37	EA	$4.92	$182	$10.29	$381	$563
260533139470	3/4" PVC Adapter	26	EA	$0.66	$17	$6.62	$172	$189
260533139110	3/4" PVC Conduit	3290	L.F.	$1.30	$4,277	$1.92	$6,317	$10,594
260533350200	3/4" Steel Flex	198	L.F.	$1.04	$206	$1.74	$345	$550
260533350440	3/4" Steel Flex Conn	132	L.F.	$4.10	$541	$3.98	$525	$1,067
260533135040	1" EMT Conduit	502	L.F.	$1.87	$939	$2.42	$1,215	$2,154
260533136240	1" EMT Coupling	50	EA	$4.97	$249			$249
260533136540	1" EMT Conduit Conn	84	EA	$4.79	$402	$3.09	$260	$662
260533139480	1" PVC Adapter	24	EA	$0.88	$21	$7.32	$176	$197
260533139120	1" PVC Conduit	1200	L.F.	$2.22	$2,664	$2.23	$2,676	$5,340
260533135060	1 1/4" EMT Conduit	25	L.F.	$3.11	$78	$2.78	$70	$147
260533136560	1 1/4" EMT Conduit Conn	4	EA	$9.31	$37	$3.98	$16	$53
260533135720	1 1/4" EMT Elbow	1	EA	$10.47	$10	$8.71	$ 9	$19
260533350300	1 1/4" Steel Flex	136	L.F.	$2.45	$333	$3.98	$541	$874
260533350452	1 1/4" Steel Flex Conn	30	EA	$10.62	$319	$6.18	$185	$504
260533135080	1 1/2" EMT Conduit	495	L.F.	$4.07	$2,012	$3.09	$1,530	$3,542
260533136280	1 1/2" EMT Coupling	49	EA	$15.05	$737			$737
260533136580	1 1/2" EMT Conduit Conn	14	EA	$13.46	$188	$4.62	$65	$253
260533135740	1 1/2" EMT Elbow	56	EA	$12.16	$681	$11.61	$650	$1,331
260533139510	2" PVC Adapter	6	EA	$1.92	$12	$10.29	$62	$73
260533139150	2" PVC Conduit	1350	L.F.	$4.17	$5,630	$3.09	$4,172	$9,801
260533139270	2" PVC Elbow	6	EA	$5.65	$34	$17.55	$105	$139
260533135120	2 1/2" EMT Conduit	50	L.F.	$12.59	$630	$4.62	$231	$861
260533136320	2 1/2" EMT Coupling	5	EA	$58.38	$292			$292
260533136620	2 1/2" EMT Conduit Conn	8	EA	$65.14	$521	$7.73	$62	$583
260533135780	2 1/2" EMT Elbow	16	EA	$43.43	$695	$23.29	$373	$1,068
260533135180	4 " EMT Conduit	70	L.F.	$20.75	$1,453	$6.95	$487	$1,939
260533136380	4" EMT Coupling	7	EA	$79.13	$554			$554
260533136700	4 " EMT Conduit Conn	18	EA	$121.59	$2,189	$17.55	$316	$2,505
260533135840	4" EMT Elbow	4	EA	$102.29	$409	$46.24	$185	$594
260533131970	4" GRC Conduit	60	L.F.	$30.40	$1,824	$13.84	$830	$ 2,654
260533132470	4" GRC Coupling	6	EA	$41.98	$252			$252
260533132220	4" GRC Elbow	4	EA	$192.04	$768	$69.53	$278	$1,046
260533139550	4" PVC Adapter	20	EA	$8.25	$165	$25.31	$506	$671
260533139190	4" PVC Conduit	2475	L.F.	$12.55	$31,061	$6.18	$15,296	$46,357
260533139310	4" PVC Elbow	10	EA	$27.02	$270	$46.24	$462	$733

Box Takeoff								
Code	**Description**	**Quantity**	**Unit**	**Mat./Unit**	**Mat. Tot.**	**Lab./Equip.**	**L/E Tot.**	**Total $**
260533160370	4 x 1 1/2" Sq. Box	293	EA	$21.86	$6,405	$19.11	$5,599	$12,004
260533160370	4 x 2 1/8" Sq. Box	785	EA	$15.05	$11,814	$19.11	$15,001	$26,816
260533180220	12 x 12 x4" Screw Cvr Box	4	EA	$34.74	$139	$42.86	$171	$310
260533161150	2G Floor Box	11	EA	$180.46	$1,985	$69.53	$765	$2,750
Estimated	T-Bar Hanger	15	EA	$5.00	$75	$19.11	$287	$362
260533182600	Utility Pullbox	16	EA	$569.35	$9,110	$185.63	$2,970	$12,080

Utility Excavation Takeoff								
Code	**Description**	**Quantity**	**Unit**	**Mat./Unit**	**Mat. Tot.**	**Lab./Equip.**	**L/E Tot.**	**Total $**
312316143100	16" W by 24" D Excavation	1450	L.F.			$0.88	$1,276	$1,276
312316140100	Machine Trench	4100	L.F.			$0.46	$1,886	$1,886
33053403825	Red Concrete	11	C. Y.	$157.35	$1,731	$42.62	$469	$2,200

Wire & Grounding Takeoff

Code	Description	Quantity	Unit	Mat./Unit	Mat. Tot.	Lab./Equip.	L/E Tot.	Total $
260519901000	#14 Control Cable	220	C.L.F	$9.02	$20	$21.26	$47	$67
260519900940	#12 THHN	120470	C.L.F	$11.97	$14,420	$25.31	$30,491	$44,911
260519900960	#10 THHN	24693	C.L.F	$18.87	$4,660	$27.68	$ 6,836	$11,496
260519901300	#8 THHN	4710	C.L.F	$32.33	$1,523	$34.76	$1,637	$3,160
260519901350	#6 THHN	635	C.L.F	$55.49	$352	$42.86	$272	$625
260526800400	#6 Bare Copper	210	C.L.F	$54.52	$114	$27.68	$58	$173
260519901400	#4 THHN	230	C.L.F	$86.85	$200	$52.65	$121	$321
260519901450	#3 THHN	140	C.L.F	$110.01	$154	$55.69	$78	$232
260519901500	#2 THHN	35	C.L.F	$138.00	$48	$61.76	$22	$70
260519901550	#1 THHN	445	C.L.F	$180.16	$802	$69.53	$309	$1,111
260519901600	#1/0 THHN	2450	C.L.F	$218.09	$5,343	$84.38	$2,067	$7,411
260526800700	#1/0 Bare Copper	200	C.L.F	$203.62	$407	$69.53	$139	$546
260519901700	#3/0 THHN	355	C.L.F	$342.58	$1,216	$111.38	$395	$1,612
260519902000	#4/0 THHN	395	C.L.F	$429.43	$1,696	$126.23	$499	$2,195
260519902200	#250 MCM	80	C.L.F	$511.45	$409	$139.05	$111	$520
260519902800	#600 MCM	5665	C.L.F	$1,114.58	$63,141	$191.57	$10,852	$73,993
260519351780	#8 Crimp Lug	12	EA	$2.54	$30	$7.73	$93	$123
260519351800	#6 Crimp Lug	4	EA	$3.34	$13	$9.28	$37	$50
260519352000	#4 Crimp Lug	14	EA	$4.54	$64	$10.29	$144	$208
260519352400	#1 Crimp Lug	10	EA	$7.33	$73	$13.84	$138	$212
260519352500	#1/0 Crimp Lug	7	EA	$7.82	$55	$15.86	$111	$166
260519352800	#3/0 Crimp Lug	4	EA	$10.71	$43	$23.29	$93	$136
260519353200	#250 Crimp Lug	10	EA	$14.04	$140	$31.05	$311	$451
260526800100	Grounding Rod - 10' Long	16	EA	$37.15	$594	$63.11	$1010	$1604
260526800250	Grounding Clamp - 3/4" Dia.	16	EA	$8.44	$135	$8.71	$139	$274

Distribution Gear Takeoff

Code	Description	Quantity	Unit	Mat./Unit	Mat. Tot.	Lab./Equip.	L/E Tot.	Total $
262816204350	600V 30A Disc.	4	EA	$313.63	$1,255	$87.08	$348	$1,603
262816204380	600V 60A Disc.	2	EA	$381.18	$762	$120.83	$242	$1,004
262923100150	VFD 20 HP Motor Starter	2	EA	$2,436.63	$4,873	$624.38	$1,249	$6,122
262413300300	800A Distribution Board	2	EA	$2,822.63	$5,645	$631.13	$1,262	$6,908
262816101000	800A MCB	2	EA	$4,921.5	$9,843	$590.63	$1,181	$11,024
262816100600	SWBD BKR 125A	1	EA	$1,519.88	$1,520	$185.63	$186	$1,706
262816100600	SWBD BKR 150A	3	EA	$1,519.88	$4,560	$185.63	$557	$5,117
262816100600	SWBD BKR 225A	2	EA	$1,519.88	$3,040	$185.63	$371	$3,411
262816100700	BKR 400A Gen.	1	EA	$2,605.5	$2,606	$347.63	$348	$2,953
262416301300	Panel 480V 20 Ckts	2	EA	$1,712.88	$3,426	$462.38	$925	$4,351
262416301450	Panel 480V 36 Ckts	2	EA	$2,702	$5,404	$776.25	$1,553	$6,957
262416300600	Panel 208V 12 Ckts	1	EA	$617.6	$618	$276.75	$277	$894
262416300650	Panel 208V 16 Ckts	3	EA	$709.28	$2,128	$371.25	$1,114	$3,242
262416300800	Panel 208V 30 Ckts	1	EA	$1,013.25	$1,013	$526.5	$527	$1,540
262416300950	Panel 208V 36 Ckts	1	EA	$1,182.13	$1,182	$691.88	$692	$1,874
262416301000	Panel 208V 42 Ckts	1	EA	$1,326.88	$1,327	$826.88	$827	$2,154
263353100262	75kVA UPS	1	EA	$46,609.5	$46,610	$3628.13	$3,628	$50,238
263353100400	120V DC Battery Bank	3	EA	$12,159	$36,477	$961.88	$2,886	$39,363
262213103300	30 kVA Xfmer	2	EA	$1,254.5	$2,509	$617.63	$1,235	$3,744
262213103700	75 kVA Xfmer	2	EA	$2,267.75	$4,536	$793.13	$1,586	$6,122
263213132800	250 kW Generator	1	EA	Owned Prior		$2,986.88	$2,987	$2,987
263623100900	800A ATS	1	EA	$9,601.75	$9,602	$691.88	$692	$10,294
263623101700	Adjustable Time Delay	1	EA	$193.97	$194	$0	$0	$194
263623102200	Pilot Light Normal	1	EA	$78.65	$79	$0	$0	$79
263623102100	Pilot Light Emergency	1	EA	$78.65	$79	$0	$0	$79
263623102300	Auxiliary Contact	1	EA	$91.19	$91	$0	$0	$91

Fixture Takeoff								
Code	Description	Quantity	Unit	Mat./Unit	Mat. Tot.	Lab./Equip.	L/E Tot.	Total $
265113500400	Type A1 2 x 4 Fluorescent	57	EA	$55.97	$3,190	$52.65	$3,001	$6,191
265113500400	Type A1-D 2 x 4 Fluorescent	18	EA	$55.97	$1,007	$52.65	$948	$1,955
265113500300	Type A2 2x2 Fluorescent	277	EA	$57.42	$15,905	$48.94	$13,556	$29,462
265113500300	Type A3 2x2 Fluorescent	146	EA	$57.42	$8,383	$48.94	$7,145	$15,529
265113503535	Type B Fluorescent D.L.	54	EA	$106.15	$5,732	$34.76	$1,877	$7,609
265113503540	Type C Wall Washer	28	EA	$106.15	$2,972	$34.76	$973	$3,945
265113502310	Type D3 3' Strip	32	EA	$66.1	$2,115	$34.76	$1,112	$3,228
265113502310	Type D4 4' Strip	16	EA	$66.1	$1,058	$34.76	$556	$1,614
265113503420	Type F Chain Hung Strip	24	EA	$151.51	$3,636	$55.69	$1,337	$4,973
265113500910	Type G4 Linear Fluorescent	6	EA	$64.66	$388	$48.94	$294	$682
265113500910	Type G6 Linear Fluorescent	8	EA	$64.66	$517	$48.94	$392	$909
265113500940	Type H4 2x4 Fluorescent	7	EA	$69.96	$490	$52.65	$369	$858
265113500940	Type H8 2x4 Fluorescent	2	EA	$69.96	$140	$52.65	$105	$245
265113500940	Type H9 2x4 Fluorescent	1	EA	$69.96	$70	$52.65	$53	$123
265113401500	Type I Metal Halide D.L.	8	EA	$414.95	$3,320	$81.68	$653	$3,973
265113503535	Type J Sconce	12	EA	$106.15	$1,274	$34.76	$417	$1,691
265113502950	Type K High Bay Fluorescent	38	EA	$216.16	$8,214	$62.44	$2,373	$10,587
265113401500	Type L MH Down light	12	EA	$414.95	$4,979	$81.68	$980	$5,960
265619209100	Type M LED Parking Light	14	EA	$554.88	$7,768	$103.28	$1,446	$9,214
265619209100	Type M2 LED Parking Light	7	EA	$554.88	$3,884	$103.28	$723	$4,607
265113401980	Type O-CMH Wall Washer	6	EA	$506.63	$3,040	$95.85	$575	$3,615
265313100100	Exit Fixture	20	EA	$36.67	$733	$41.51	$830	$1,564
266113300360	Fixture Whip	86	EA	$14.841	$1,276	$8.71	$749	$2,025
265613103200	30' Aluminum Pole	14	EA	$1592.26	$22,292	$313.43	$4,388	$26,680
265613105400	Bracket Arms - 1 Arm	7	EA	$117.73	$824	$34.76	$243	$1,067

Wiring Devices								
Code	Description	Quantity	Unit	Mat./Unit	Mat. Tot.	Lab./Equip.	L/E Tot.	Total $
262726200500	20A Single Pole Switch	15	EA	$7.33	$110	$10.29	$154	$264
266113100150	Occupancy Sensor Switch	60	EA	$63.21	$3,793	$11.61	$697	$4,489
262726202460	Duplex Receptacles	316	EA	$10.57	$3,340	$10.29	$3,252	$6,592
262726202482	GFI Receptacles	13	EA	$38.12	$496	$10.29	$134	$629
266113100100	24W Sensor	11	EA	$107.12	$1,178	$39.83	$438	$1,616
266113100200	24V Power Pack	18	EA	$35.22	$634	$27.68	$498	$1,132

Motor Connections								
Code	Description	Quantity	Unit	Mat./Unit	Mat. Tot.	Lab./Equip.	L/E Tot.	Total $
260580100020	1 HP and less Motor Conn.	61	EA	$9.94	$606	$34.76	$2,120	$2,727
260580100050	2 HP Motor Conn.	3	EA	$10.18	$31	$42.86	$129	$159
260580102015	20 HP Motor Conn.	2	EA	$30.4	$61	$46.24	$92	$153

Estimate Summary						
Item		Material $		Labor/Equip. $		Total $
Subtotal		$477,833.40		$274,103.10		$751,936.50
Misc. Material (5%)		$23,891.67				$23,891.67
O & P (9%)		$45,155.26		$24,669.28		$69,824.54
Grand Total		$546,880.33		$298,772.38		**$845,653**

Appendix C: General Conditions Estimate

General Conditions Estimate				
Description	Quantity	Unit	Cost/Unit	Total $
Preconstruction Services	1	LS	$90,000	$90,000
Project Manager	47	Wks	$3,100	$145,700
Project Manager	47	Wks	$2,625	$123,375
Superintendent	47	Wks	$2,250	$105,750
Laborer/Flagger	47	Wks	$1,375	$64,625
Timekeeper	47	Wks	$1,150	$54,050
CPM Scheduling	7,276,510	Job	2%	$145,530
Permit	1	LS	$38799	$38,799
Jobsite Trailer	11	Mo	$627.81	$6,906
Temporary Storage	11	Mo	$93.15	$1,025
Office Equipment	11	Mo	$272.33	$2,996
Small Tools	7,276,510	Job	.05%	$3,638
Temporary Fencing	1985	L.F.	$4.57	$9,071
Project Drawings	1	LS	$5,000	$5,000
Continuous Clean	47	Wks	$570	$26,790
Final Cleaning	1	LS	$15,000	$15,000
Waste Removal	47	Wks	$375	$17,625
Job Signs	70	S.F	$33.69	$2,358
Temporary Power	11	Mo	$1,000	$11,000
Temporary Water	11	Mo	$1,000	$11,000
Equip. Insurance/Repairs	11	Mo	$1,000	$11,000
Testing	1	Job	$4,072.95	$4,073
Drug Testing	40	EA	$100	$4,000
Job Photos	4	Set	$525.23	$2,101
Temporary Toilets	11	Mo	$900	$9,900
Fire Marshall Inspection	5	EA	$250	$1,250
Survey	4	Day	$492.09	$1,968
Safety Supplies	11	Mo	$24.28	$267
Liability Insurance	7,276,510	Job	2.02%	$146,986
Builder's Risk	7,276,510	LS	0.24%	$17,464
Subcontractor Bonds	7,276,510	LS	0.60%	$43,659
Grand Total				**$1,122,906**