Kennedy Krieger Institute
Outpatient Medical Center
Baltimore, Maryland

Katie Sennett - CM

Senior Thesis

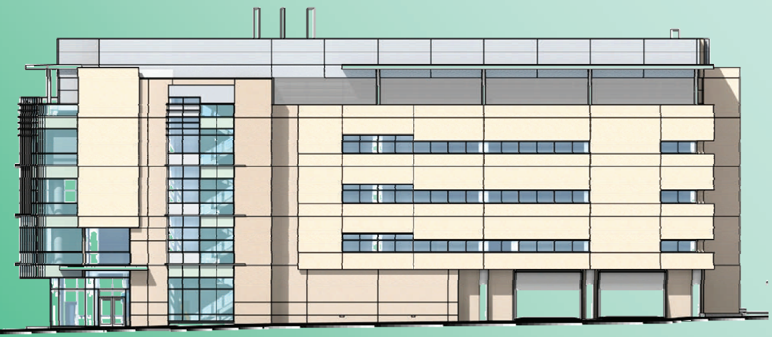
Advisor: Dr. Messner

April 9, 2008

Kennedy Krieger Institute Outpatient Medical Center Baltimore, Maryland

Project Team
- Owner: Kennedy Krieger Institute
- CM: Whiting Turner Contracting
- Architect: Stanley, Beaman, & Sears
- Civil Engineer: RK+K
- Structural: RMF Engineering
- MEP Engineer: RMF Engineering

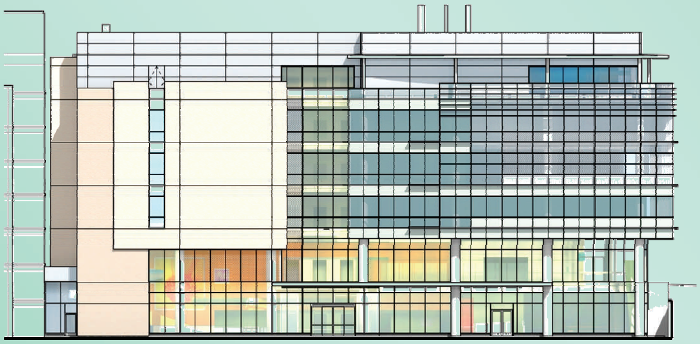
Construction Management
- Estimated Project Cost: $35,000,000
- Size: 115,000 SF
- Number of Stories: 6
- Project Delivery Method: CM @ Risk
- Building Occupancy: Outpatient Medical Center and Developmental Disabilities Center
- Project Start Date: January 22, 2007
- Project End Date: January 20, 2009



Architectural System
- Architectural Precast Concrete Panels
- Cast in Place Concrete over hangs
- Glass Curtain wall
- Outdoor Canopy system
- Interior spaces consist of offices, exam rooms, conference rooms, and a therapy gym and therapy pools.

Structural System
- Cast in placed concrete mat foundation system.
- Cast in place pan and joist floor system and concrete columns.
- Concrete used of building is 4000 psi concrete including the foundation system
- Structural steel column and joist system for 6th floor roof and pent house area.

Mechanical - Electrical - Plumbing
- (3) AHU with 40,000 cfm capacity
- (1) AHU for the Natatorium 5,500 cfm
- (2) Chiller Units with a 245 Ton Capacity
- 277 volt lighting fixtures throughout building
- 1500KVA Transformer
- 2500 Amp Power Source
- (21) 480/270 3 Phase Distribution Switch Boards
- (44) 208/120 3 Phase Distribution Switch Boards
- Standard Fire Protection System



Katie Sennett ~ Construction Management
http://www.engr.psu.edu/ae/thesis/portfolios/2008/kas568/

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Acknowledgements

I would like to thank the following people for their help in assisting me with the development of my senior thesis over past year.

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Dr. Michael Horman
Dr. David Riley
Dr. M Kevin Parfait

Executive Summary

The building that was used for this senior thesis project is the Kennedy Krieger Institute Outpatient Medical Center. The Outpatient Medical Center is a developmental and disabilities center for children and adolescences. It is located in downtown Baltimore next to the Existing Kennedy Krieger Institute and the John Hopkins Medical University. This final report includes alternatives to the existing building structure and systems to try and find improved ways of constructing the building.

The first analysis looks at the structural system. The current structural system is cast in place concrete. The concrete created issues with time because the subcontractors under estimated their schedule. The proposed system was using a structural steel design which created a much shorter schedule and got the building out of the ground 3 months earlier than the original system. The cost of using steel was found to be several hundred thousand dollars cheaper and therefore was found to be a better system when it comes to the cost and schedule of the project.

The second analysis looked at the mechanical system. The original mechanical system included 3 air handling units that required 100% exhaust air. This became of some concern due to the large amount of lost energy through the exhausted air. The proposed solution was to install a heat recovery system into each air handling unit. The best choice for the heat recovery system was an enthalpy wheel. However, the enthalpy wheels turned out to be too expensive even though they saved money on the energy costs. Unfortunately cost savings were outweighed by the cost of the equipment.

The third analysis looked at another critical issue. The critical issue that was researched for this analysis was implementing 3D design coordination and utilizing it for mechanical, electrical, and plumbing clash detection. The overall results from a survey on the topic showed that 3D design is a good system to utilize on projects, though smaller companies still do not have the resources to get involved with it. However, the companies feel that once the demand for 3D design coordination increases more companies will start purchasing and utilizing it.

Project Information and Background

Project Information

The Kennedy Krieger Institute Outpatient Medical Center is a 6 story cast in place structure. It is located in downtown Baltimore on the corner of East Madison Avenue and North Broadway. Also, it is next to the Existing Kennedy Krieger Institute and the John Hopkins Medical University. This building includes 30 exam rooms, 15 treatment rooms, several conference rooms, 54 offices, a physical therapy/occupational therapy gym, a spinal cord gym, and a physical therapy Natatorium which includes two pools varying in size. In order to start excavation and construction, an existing parking lot had to be removed. The Outpatient Medical Center is being constructed beside the Kennedy Krieger Institute Parking Garage which was recently built and it will utilize parking for the two Kennedy Krieger buildings in that location. The project is currently under construction. It is a 24 month long project which began on January 1, 2007 and is schedule to be completed on January 22, 2009.

Client Information

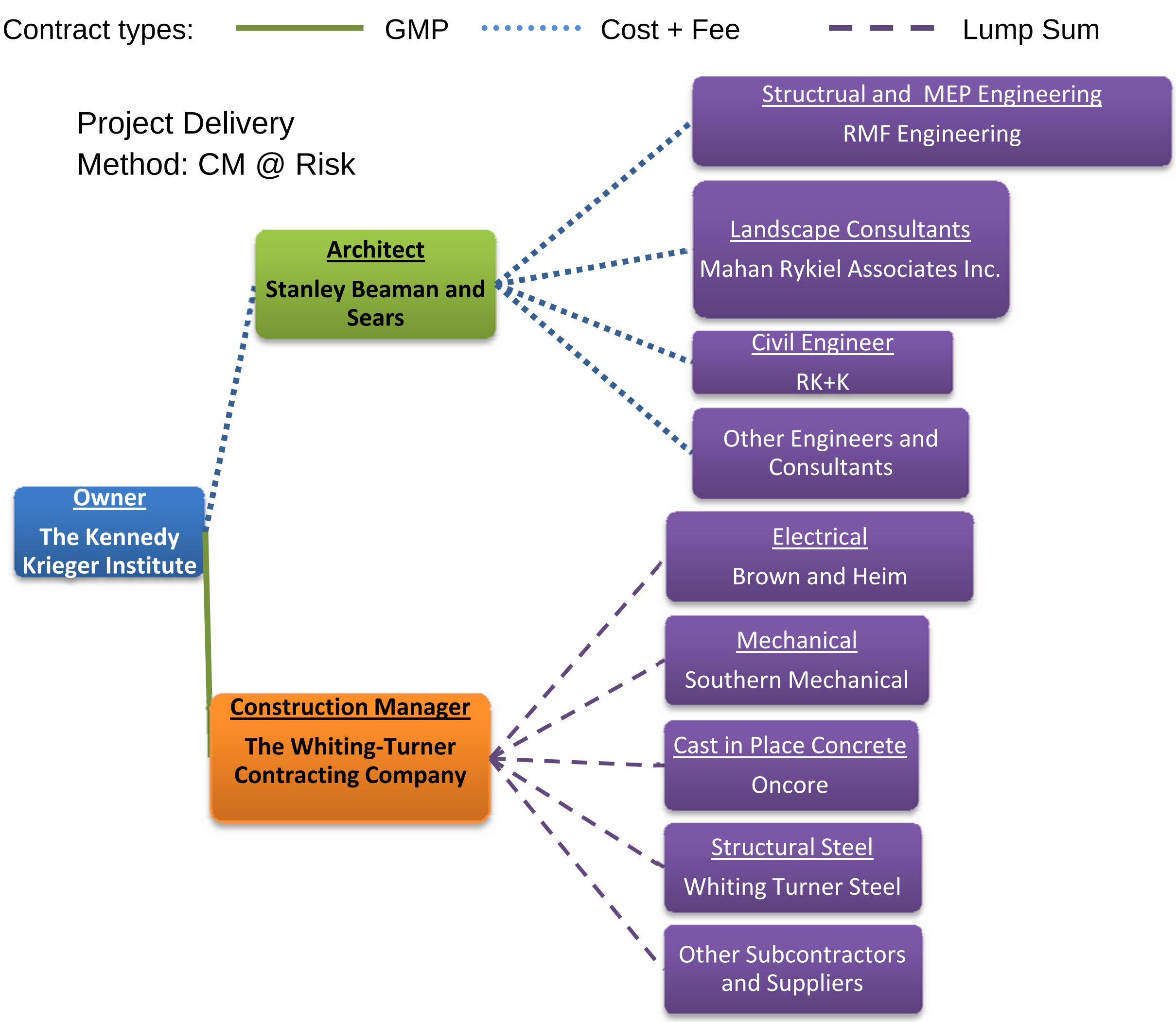
Kennedy Krieger Institute strives to help children and adolescents with development disabilities by providing personal patient care, professional training programs, research, and special education. Kennedy Krieger Institute is internationally known and provides its facilities with some of the world's leading experts in the development disabilities field of study. Kennedy Krieger Institute is located in Baltimore, Maryland. Their mission statement is:

*"We at the Kennedy Krieger Institute dedicate ourselves to helping children and adolescents with disorders of the brain and spinal cord achieve their potential and participate as fully as possible in family, school and community life."**

The Outpatient Medical Center will house the developmental disabilities center. Once the project is complete, the building will have a large physical therapy occupational therapy gymnasium, therapy pools, many treatment and exam rooms, children life area, and a therapy garden that will be located near the entrance of the building. Kennedy Krieger is excited to be able to expand its institution and can't wait to occupy the new facility.

*Quote is from the Kennedy Krieger Institute, more information can be found at kennedykrieger.org

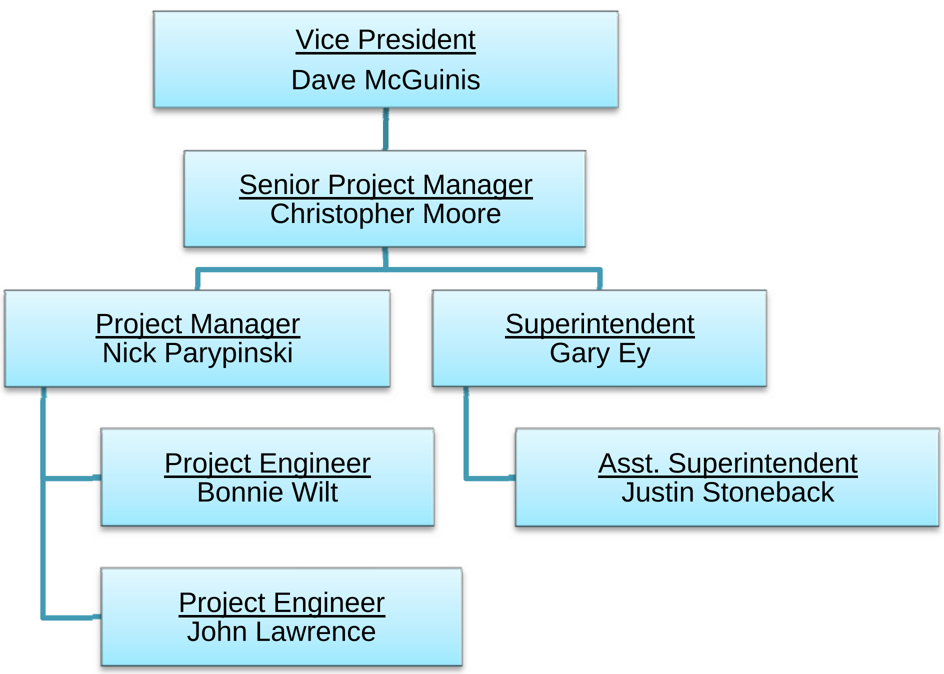
Project Delivery



The above organizational chart shows that Whiting-Turner acts as the CM at risk and holds a GMP contract with the owner. Whiting-Turner has lump sum contracts with all its subcontractors. The owner has a cost, plus a fee contract with the Architect. The Architect also has cost plus a fee with the Engineers. This is the typical AIA standard for a CM at Risk.

Project Team

The organizational chart below shows all people involved with the construction of the Outpatient Medical Center. The Vice President acts as the project executive and spends most of his time working from the main corporate office. The rest of the staff works onsite to ensure construction is being done to the proper specifications according to the architect, engineers, and owner. The Senior Project Manager is responsible for all activities that take place onsite and is responsible for all the employees below him. He is in charge of overseeing the project engineers and the project progress. Each project engineer is given a set of responsibilities, such as overseeing and contracting subcontractors in a variety of trades. All project managers and project engineers are responsible to maintain and update each other on their trades work progress to continue good coordination between trades. This helps to keep the project running smoothly and efficiently. The superintendent and assistant superintendent work onsite and are responsible for keeping track of shipments and supplies as well as ensure that the construction workers and subcontractors are meeting their tasks accurately and safely. They are also in charge of keeping project managers informed of construction issues.



Building Systems Summary

- *Demolition/Excavation*

Demolition was needed to remove an existing parking lot. Once the parking lot was removed, excavation took place. Excavation at the south side was about 50 feet below the street level and the rest was surface grading from the north side toward the area where the foundation system would be installed (at the south end of the site). All site soils that were excavated were permanently removed from site.

- *Structural Steel*

Structural steel is used on the sixth floor penthouse area. Wide flange structural steel is carbon steel, ASTM A992, Grade 50. High strength bolts, nuts, and washers are ASMT 325 and have a mechanically deposited zinc-coating ASTM B695, class 50. Cold formed structural steel tubing is ASTM A500, Grade B material. The Structural steel is for the cooling tower framing, elevator connections, and to enclose the roof area.

- *Cast In Place*

The entire Medical center is cast in place concrete; this includes the foundation mat system, floors, and columns but excludes the 6th floor roof system which consists of structural steel. The foundation system consists of several mat slabs which are placed under the elevators, the columns, and exterior walls. Foundations are approximately 3 feet thick and vary in surface area depending on the item is it supporting. The floors are a pan and joist system with a floor thickness of 6 inches and joist spacing about every 8 inches on center. The columns are an average size of 30 inches in diameter and are located about every 24 feet from north to south and about every 29 feet east to west. Concrete compressive strength used throughout the building is 4000 psi concrete.

- *Precast Concrete*

The exterior façade is made up of architectural precast concrete panels. Panels are made with a minimum of 5000 psi concrete, 28 day strength, and air entrained 5 to 7 percent. Connection devices are all stainless steel, which are connected to embedded plates, and angels. Grout is to be of a minimum strength of 10,000 psi, 28 day strength and will be tinted to coordinate with panels.

- *Mechanical System*

The mechanical system consists of 3 air handling units with 40,000 cfm. There is also 1 air handling unit for the natatorium which has a 5,500 cfm. There are 2 chiller units with a 245 ton capacity. The chiller towers are located in the penthouse. Mechanical rooms are located in the basement and one mechanical room is located on the fifth floor and is for the natatorium units only.

- *Electrical System*

The Outpatient Medical Center uses 2500 amp power source that enters the building at its main switch board. The building also has twenty one 480/270 3 phase distribution switch boards and forty four 208/120 3 phase distribution switch boards and a 1500kVA transformer. The lighting in the building is mainly 277 volt lighting fixtures.

- *Curtain wall*

The curtain wall consists of aluminum frames with vision glazing and glass infill panels at the building's exterior as well as the canopy at the front entrance. The glazing used is one of five different types of glazing, some are tempered and some are filter, all are tinted.

- *Support for excavation*

Standard sheeting and shoring is used, which includes steel wide flange piles, with wood inlay to hold back the ground, and a several wailers to provide more structural support.

Project Costs

Total Building Area = 115,000 SF

- Construction Cost
    - $32,840,888
    - $285.57 / SF

- Total Project Cost
    - $35,156,010
    - $305.70 / SF

- Major Building Systems
    - Electrical
        - $3,382,300
        - $29.41 / SF
    - Structural
        - Concrete: $4,181,700
            - $36.36 / SF
        - Structural Steel: $441,300
            - $3.84 / SF
    - Mechanical
        - $5,658,700
        - $49.20 / SF

General Conditions Estimate

The General Conditions estimate summary is in the following table.

General Conditions Estimate	
Personnel	$1,802,824.00
On-Site Office Trailer	$8,580.00
Field Trailer	$2,860.00
Site Miscellaneous	$3,198,277.00
Total	$5,012,541.00

The GC estimate summary is broke up into four categories: the personnel/staff, the main site trailer, the file trailer, and the rest of the site items. The general conditions cost is about $5 million with a $1.8 million for the staff, which is one reason why the general conditions is $5 million. The site miscellaneous items included are construction tools, safety items, dumpsters demobilizing trailers and so on. For a look at the break down of the general conditions, go to **Appendix A**. For a breakdown of the staffing cost, see table below.

Detailed Project Schedule

The detailed project schedule which can be found in **Appendix B** is a summary of the main construction activities. The project schedule is set up by major activities such as foundation, concrete floor slabs and concrete columns, structural steel, as well as a summary breakdown of each floor rough in and finishes. A majority of the items in the schedule have more than one activity per line. This is because several important of the trade tasks happen at the same time and therefore have been scheduled together. Multiple tasks per line item may not be of the same trade, this is good because it shows where different trades are working respectively beside another trade. This will also show the areas of the schedule where trade coordination will be needed. Once the concrete is placed and cured, mechanical, electrical, and plumbing rough-ins being. These critical activities being in the basement, where the mechanical equipment room is located and where the power enters the building, and continues upward from floor to floor until terminating at the penthouse where the AHU's and HVAC equipment is located. The schedule also divides each floor up into its own group of items. This illustrates the major tasks and their durations throughout the project time period. This division of floors does not happen for the third and fourth floor because they are very similar and therefore the critical items occur at the same time.

To see understand more about the Detailed Project Schedule, go to **Appendix B**.

Site Layout

The site plan depicts the superstructure phase of the project. This is the best phase to illustrate the size of the site with the limitations on available space. A tower crane is located at the center of the site. This works best because of its size and capabilities. It is able to reach most of the site and is used for lifting and moving all items on site. Although the crane is owned and operated by the concrete contractor they, signed a contract allowing other trades to use it when the concrete workers were not using it. The site plan shows a lot going on but one of the most important items is the access to the site. There is only one access to the site and it is located at the north end. Delivery trucks had to be scheduled very closely when materials where to be delivered because of the lack of space and because of the concrete trucks coming and going every twenty to thirty minutes.

Formwork and steel lay down area takes up about fifty percent of the available area. This creates little room to move large equipment around and does not permit construction workers space to park. Parking must be found among the local streets. Site utilities are hard to show on the site plan, because the temporary power was coming directly from the Kennedy Krieger Parking Garage which is located right beside the construction site. This powered the entire site including all site trailers. Temporary water was the only utility needed from the city, because sewer waste was pumped out of the trailer every week. Telecommunications was in the WT trailers only.

For public safety a chain linked fence surround the entire perimeter of the site and around the WT trailer, which is locate on median, and a fire hydrate was located at the corner of North Broadway and Ashland. For more site information, please see the site plan on **Appendix C**; note that the site scale is 1” = 40’.

Analysis 1: Structural Analysis

Background and Problem

The Kennedy Krieger Institute Outpatient Medical Center is a cast in place concrete structure with concrete pan and joist flooring system. This system was chosen for this project because at the time of bidding the price of steel was very expensive and the cast in place system would allow the building flexible for future building occupancy. The concrete was scheduled to take 86 days for structural completion. The concrete was completed on time but had scheduling issues during the beginning weeks of construction. Issues that occurred were the following:

- The concrete subcontractors who created the construction schedule were not aware of the actual on site conditions and underestimated the amount of time needed for the construction. This issue was a result of the employees in the office lacking time in the field.

- The first and second floor had complicated sections that needed more attention. There were sections with many cut outs, curves and other sections that varied in floor thickness and elevation.

- Onsite there was one crane which was owned by the concrete subcontractor but was used by all trades during the construction. This would on times interfere with the concrete construction.

These issues did not result in an extended schedule but did cause the concrete subcontractor, the construction workers and a contractor employee to work every Saturday for 2.5 months until they were back on schedule.

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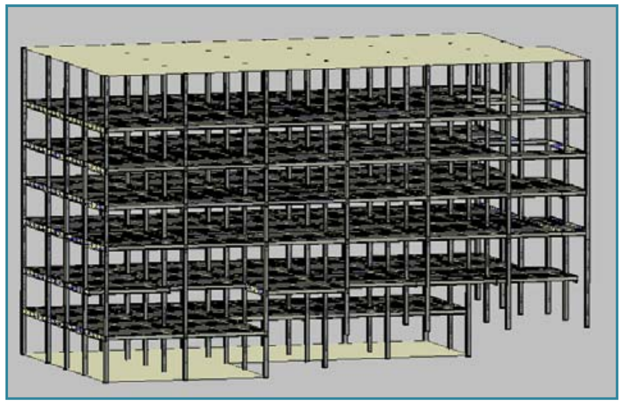
Proposal

The proposed solution to this problem is changing the structural system to structural steel instead of cast in place concrete which is the current structural system for the Outpatient Medical Center.

Current Cast in Place Structural Design



Proposed Structural Steel Design

Goal

The goal of changing the structural system is to get the building out the ground quicker and decrease the cost of the overall project. This would improve the construction schedule, decrease the building cost, and get owners into the building sooner increasing their building profitability.

Analysis: "Structural Breadth"

Please refer to **Appendix D** for the structural steel calculations

The design of the structural steel for the building was done by using a typical bay size of 29' x 29', a metal deck size of 1 ½" with 18 gage intermediate ribs, and 5" in concrete flooring. The books that were used to aid in the design were the Steel Construction Manual, 13th Edition. And the International Building Code 2006.

Step 1: Sizing of the beams and girders

The beam size was found first by calculating the moment on the beam and using that to find the moment of inertia which was 282 in^4. This resulted with a beam size of 16 x 26 with an I=301 in^4 and a ΦMn = 166 kips. Next the Girder was found by the same process. The calculated moment of inertia was 1461 in^4 which gave a girder size of 21 x 68 with I=1480 in^4 and a ΦMn = 600 kips.

Step 2: The total load on the building was found

The next step was calculating the size of the columns. The resulting calculation ended with a total building live load of 246.5 kips and a dead load of 378.1 kips. Using these results the column size was found to be a 14 x 90 wide flange with a ΦPn = 928 kips.

Step 3: Determining Plenum height

Using steel wide flange beams and girders the plenum space was found to be the same depth as the original plans called for. This creates no redesign of the mechanical ductwork, which therefore saves money.

Step 4: Coordination Issues

Now that the plenum height was determined the next issue is coordination of the mechanical, plumbing, and electrical systems in the vertical direction through the building. Areas of concern are, where penetrations through the structural system were located. These areas are the following: 1^{st} – 6^{th} floor between **column lines F-G & 2-4, column line B: 1-2 pipe penetrations**, and **column lines B-C: 3-4.** See Figure below.

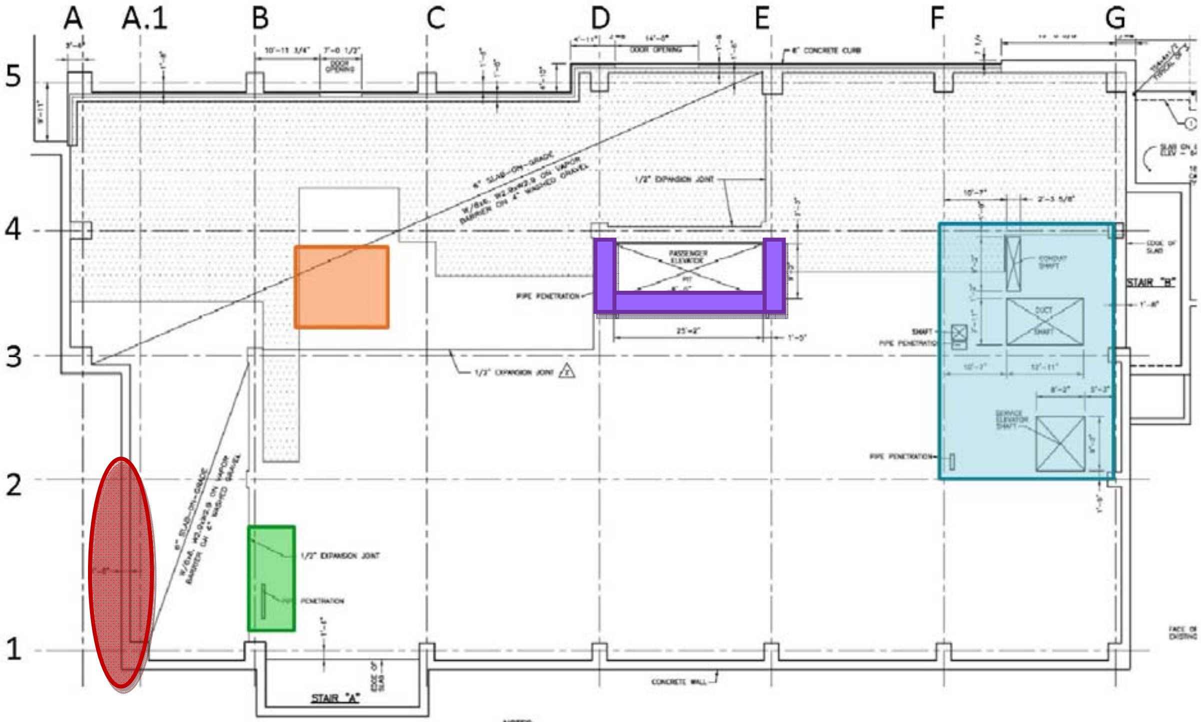


Figure 1.1 Coordination Issues Areas

For these areas the steel beams will need to be removed and steel cross bracing of equal or greater size will be used. This will allow for an equal load bearing capacity without having to change the structural design too much. The girders and columns are not interfered and therefore will not require any changes.

Step 5: Connections

The connections for this structural redesign will be concrete shear walls. Concrete shear walls are more cost effective then moment connections and will be easier to generate. The concrete shear walls will also act as fire protection for the elevator shaft. The shear walls are cast in place concrete and are located at two different locations in the building. The first location is the three sides of the elevator shaft (which can be seen in the above drawing in purple). The shear walls will be 14 inches thick and will rise up through the entire height of the elevator shaft. The second location is at Column A between 1 & 2 (which can be seen in the above drawing in red). This shear wall will be 29 feet long, 14 inches thick and consist of a 30 foot section of wall.

Schedule Comparison

The Outpatient Medical Center's schedule for their original cast in place concrete design was started on June 25, 2007 and was scheduled to take 86 days to complete. This did not include the 15 Saturdays the concrete subcontractor needed to make up for getting behind schedule. Final total for the construction of the super structure was 101 days.

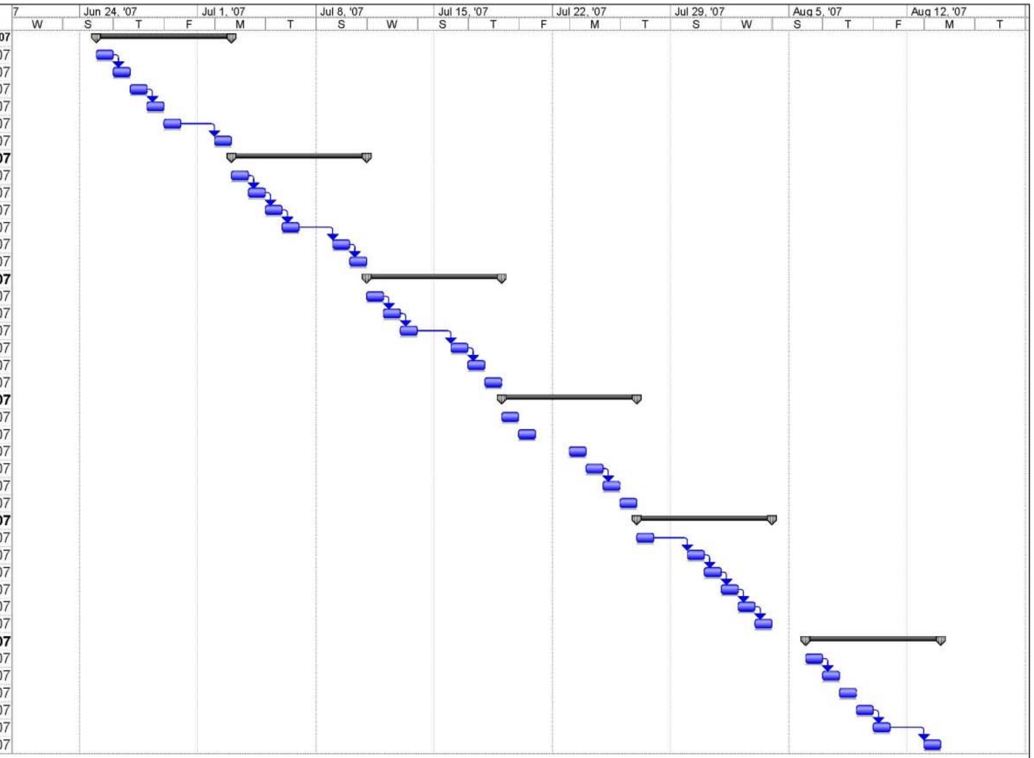
The proposed structural system, which consists of structural steel is also scheduled to start on June 25, 2007 but it will take only 43 days to complete structural construction/erection. This is a total of 58 days less of scheduled work which would get the project finished 3 months earlier.

The schedule that can be found on the next page is broken up into floors and each floor will take about 6 days to complete the steel erection. The floors are then broken up into 6 sections and each section then consists of 4 bays. The sections are made up of 20 to 30 pieces of steel. This allows for each section to be completed in an 8 hour work day. Once the first section is complete, installation of the metal decking and placing of the concrete will take place. (A schedule of this process can be seen below but only shows up to the first section on floor 2.) The concrete will be placed the day after the metal decking and rebar are placed because the concrete will cure better if it is placed in the morning as opposed to mid to late afternoon. This order of work will be consistent throughout each floor. The steel will be scheduled to be delivered the day of its erections to eliminate double picking the steel and to save space on site since it is such a small area with already limited free space.

Section Schedule	25-Jun	26-Jun	27-Jun	28-Jun	29-Jun	2-Jul	3-Jul	4-Jul	5-Jul
Section 1-1	Steel erection	Metal Deck	Concrete						
Section 1-2		Steel erection	Metal Deck	Concrete					
Section 1-3			Steel erection	Metal Deck	Concrete				
Section 1-4				Steel erection	Metal Deck	Concrete			
Section 1-5					Steel erection	Metal Deck	Concrete		
Section 1-6						Steel erection	Metal Deck	Concrete	
Section 2-1							Steel erection	Metal Deck	Concrete

Table 1.1 Detail Construction Schedule

ID	Task Name	Duration	Start	Finish
1	**First Floor**	**6 days**	**Mon 6/25/07**	**Mon 7/2/07**
2	1st Floor Bay Section #1	1 day	Mon 6/25/07	Mon 6/25/07
3	1st Floor Bay Section #2	1 day	Tue 6/26/07	Tue 6/26/07
4	1st Floor Bay Section #3	1 day	Wed 6/27/07	Wed 6/27/07
5	1st Floor Bay Section #4	1 day	Thu 6/28/07	Thu 6/28/07
6	1st Floor Bay Section #5	1 day	Fri 6/29/07	Fri 6/29/07
7	1st Floor Bay Section #6	1 day	Mon 7/2/07	Mon 7/2/07
8	**Second Floor**	**6 days**	**Tue 7/3/07**	**Tue 7/10/07**
9	2nd Floor Bay Section #1	1 day	Tue 7/3/07	Tue 7/3/07
10	2nd Floor Bay Section #2	1 day	Wed 7/4/07	Wed 7/4/07
11	2nd Floor Bay Section #3	1 day	Thu 7/5/07	Thu 7/5/07
12	2nd Floor Bay Section #4	1 day	Fri 7/6/07	Fri 7/6/07
13	3rd Floor Bay Section #5	1 day	Mon 7/9/07	Mon 7/9/07
14	2nd Floor Bay Section #6	1 day	Tue 7/10/07	Tue 7/10/07
15	**Third Floor**	**6 days**	**Wed 7/11/07**	**Wed 7/18/07**
16	3rd Floor Bay Section #1	1 day	Wed 7/11/07	Wed 7/11/07
17	3rd Floor Bay Section #2	1 day	Thu 7/12/07	Thu 7/12/07
18	3rd Floor Bay Section #3	1 day	Fri 7/13/07	Fri 7/13/07
19	3rd Floor Bay Section #4	1 day	Mon 7/16/07	Mon 7/16/07
20	3rd Floor Bay Section #5	1 day	Tue 7/17/07	Tue 7/17/07
21	3rd Floor Bay Section #6	1 day	Wed 7/18/07	Wed 7/18/07
22	**Fourth Floor**	**6 days**	**Thu 7/19/07**	**Thu 7/26/07**
23	4th Floor Bay Section #1	1 day	Thu 7/19/07	Thu 7/19/07
24	4th Floor Bay Section #2	1 day	Fri 7/20/07	Fri 7/20/07
25	4th Floor Bay Section #3	1 day	Mon 7/23/07	Mon 7/23/07
26	4th Floor Bay Section #4	1 day	Tue 7/24/07	Tue 7/24/07
27	4th Floor Bay Section #5	1 day	Wed 7/25/07	Wed 7/25/07
28	4th Floor Bay Section #6	1 day	Thu 7/26/07	Thu 7/26/07
29	**Fifth Floor**	**6 days**	**Fri 7/27/07**	**Fri 8/3/07**
30	5th Floor Bay Section #1	1 day	Fri 7/27/07	Fri 7/27/07
31	5th Floor Bay Section #2	1 day	Mon 7/30/07	Mon 7/30/07
32	5th Floor Bay Section #3	1 day	Tue 7/31/07	Tue 7/31/07
33	5th Floor Bay Section #4	1 day	Wed 8/1/07	Wed 8/1/07
34	5th Floor Bay Section #5	1 day	Thu 8/2/07	Thu 8/2/07
35	5th Floor Bay Section #6	1 day	Fri 8/3/07	Fri 8/3/07
36	**Sixth Floor**	**6 days**	**Mon 8/6/07**	**Mon 8/13/07**
37	6th Floor Bay Section #1	1 day	Mon 8/6/07	Mon 8/6/07
38	6th Floor Bay Section #2	1 day	Tue 8/7/07	Tue 8/7/07
39	6th Floor Bay Section #3	1 day	Wed 8/8/07	Wed 8/8/07
40	6th Floor Bay Section #4	1 day	Thu 8/9/07	Thu 8/9/07
41	6th Floor Bay Section #5	1 day	Fri 8/10/07	Fri 8/10/07
42	6th Floor Bay Section #6	1 day	Mon 8/13/07	Mon 8/13/07



Project: steel schedule
Date: Sat 3/29/08

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Page 1

Figure 1.2 Erection Schedule

Sequencing

The structural steel will be erected differently than the original system. The original system started construction on the east side and worked toward the west, all the way up the building. For the steel erection, the process is going to be reversed. Reason for this is so that the crane will not be passing over the already erected steel sections, permitting concrete subcontractor to work on the flooring system while the steel erection continues on.

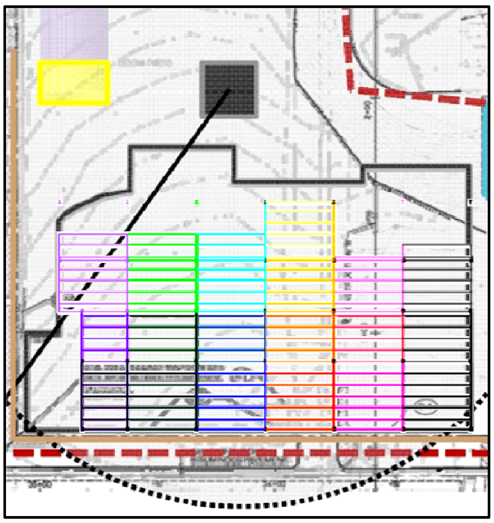


Figure 1.3 Erection Sequencing

The picture on the left (figure 1.2) is the building foot print with the second floor structural design. This image illustrates the erection sequence by color variations. Each section is shown in a different color and each bay is in a different shape of that sections color theme. The erection sequence goes from the darkest shape to the lightest shape of color starting with purple and going east to the black section.

This construction sequence is the best choice to keep construction continuing and keeping a safe working environment for the other trades that will be performing work close by. This sequence does not impact the site set up, although it will determine the path of the crane. The crane path will start out as counterclockwise until the first sections of that particular floor are complete. Then the crane will continue steel erection by a clockwise rotation. This is way the crane will not be passing large pieces of steel over the entire site. This alone will reduce the erection time by several minutes with every piece that is moved into place, creating a smooth safe erection process.

Site Impact

The site is currently a small area where a lot of different activities and trades are all going on at the same time. Because of the tight space, the steel will be delivered the day it is to be erected. This will eliminate the need for a shakeout area. There will be however a small section set aside for steel that may be delivered out of order or early. This area is located near the east side of the site next to the construction fence and next to the area where the trucks will unload the steel. The site plan below shows theses areas.

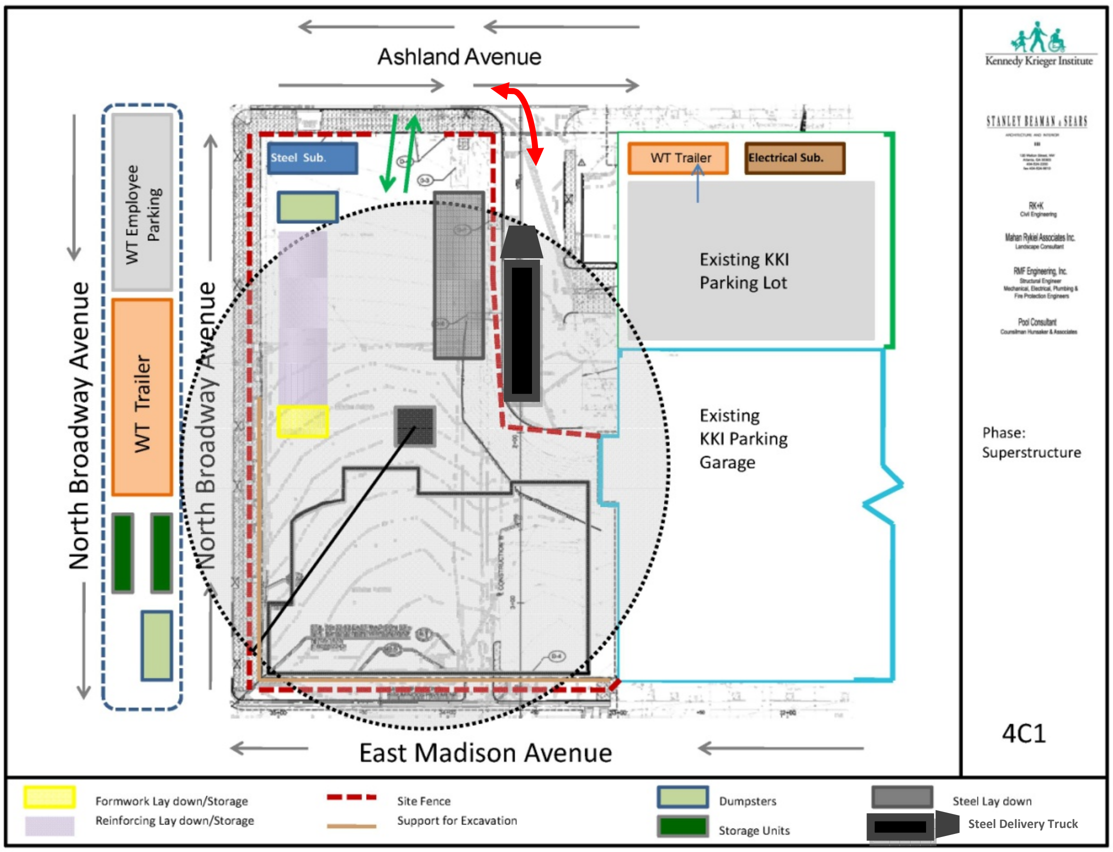


Figure 1.4 Site Layout

The only entrance to the site is located at the north end of the site. This area is small so this is why the steel deliveries will be dropped off next to the site as shown. The reinforcing, metal deck and formwork for the concrete floor will be stored on the west side of the site. These areas are shown on the site in yellow and purple sections. These are the only major changes to the original site plan.

Cost Comparison

The original cost for the cast in place concrete structural system cost a total of $4,181,700. This includes the price of the foundation system which was $580,800. The costs of the re-design to structural steel are as followed:

The cost estimate of the structural steel construction totals $3,517,972. This total also includes the $580,800 needed for the foundation system. This amount for the steel is $663,738 less than the cost of the cast in place concrete.

Description	Cost
Foundation system	580,800
Structural Steel	1,899,951
Concrete Shear Walls	388,292
Concrete Flooring	406,350
Fire Proofing	173,179
Tower Crane	69,400
Total	**$3,517,972**

Table 1.2 Cost Comparisons

Total cost savings = $663,738

For a more detailed cost breakdown of the different systems listed above please refer to **Appendix E**.

Conclusion

The proposed solution to the structural system has many benefits. The first benefit is the amount of time needed to construct the super structure is reduced by three months, completing the project by Oct. 20th 2008 instead of Jan. 20th, 2009. This schedule change will save money by getting the building out of the ground quicker. The second benefit is the amount of money saved by using steel. Over half a million dollars would be saved which could be used for more specialized equipment and research for the developmental disabilities in adolescents and children. This proposal seems like a good idea to reduce cost and the schedule, resulting in happier owners.

Analysis 2: Mechanical System

Background and problem

The Kennedy Krieger Institute Outpatient Medical center is a medical center for children and adolescences with developmental disabilities. It therefore requires the building to have a 100% exhaust air system. The building has three Air Handling Units that require a 40,000 cfm capacity. The air handling units are on a need basis with AHU 1 being the primary unit. When needed the AHU 2 and AHU 3 will work in conjunction to AHU 1. With the AHU's 100% exhaust air system, this creates a great loss of energy which will therefore increase the energy costs to run the building.

Proposal

The proposed solution to prevent this enormous amount of lost energy is to install a heat recovery system, which in this case is an enthalpy wheel. The enthalpy wheel is made up of aluminum coil that capture the hot/cold exhaust air. The Enthalpy wheel is installed and works in conjunction with the air handling units. The enthalpy wheels will have an exhaust duct system attached to it to prevent contamination of the supply air.

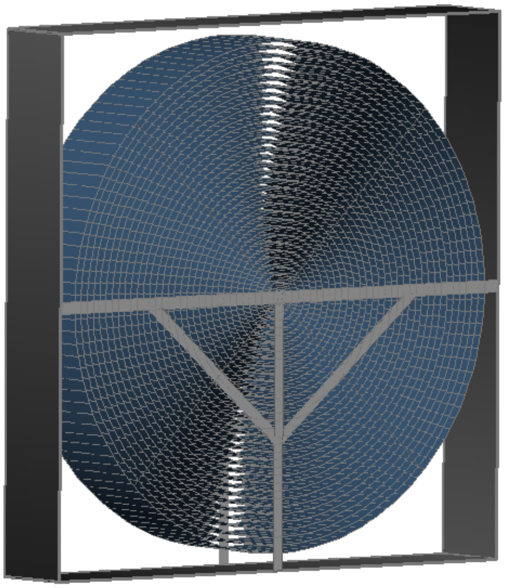


Figure 2.1 by Katie Sennett in AutoCAD.

On the left is an image of the enthalpy wheel that will be used for this analysis. It is a 10 foot diameter wheel that is housed in an 11 foot by 11 foot frame. The wheel coils are made of durable aluminum. The heat recovery system will have three of these enthalpy wheels.

Goal

The goal is to install enthalpy wheels into each air handling unit. The Enthalpy wheel will take the exhaust air and use it to pre condition the outdoor air. The purpose is to save energy from heating/cooling the supply air by using the exhaust air to preheat/pre-cool the supply air. The second goal of this system is to maintain a clean air system but removing any contaminations through an exhaust duct system that is located near the side of the spinning wheel and removes the contaminates through the exhaust air duct.

Analysis:

The enthalpy wheel for the recovery system was designed to be a 10 foot diameter wheel with an 11 foot by 11 foot framing unit. This unit has a nominal cfm of 40,000 and will be adequate to work with the mechanical system.

Step 1: Structural System Impact

The total weight of each wheel is about 3,000 lbs. This is a good bit of weight but will not change the structural system by much because the three systems are relatively spaced apart. This allows for better distribution of weight on the flooring system. However, the only major change would be a slight increase to the size of the beams and girders with a decrease in the spacing of the beams. No structural calculations where done here, because the wheels did not seem to effect the structure enough to go into deep analysis.

Step: 2 Calculating the Energy Efficiency

To determine the energy efficiency of the enthalpy wheel the following information about the building was determined. See table below, (Figure 2.1) for design conditions. For mechanical breadth analysis information, please see **Appendix F**.

	1st Floor	2nd Floor	3rd Floor	4th Floor	5th Floor	6th Floor
Occupancy Type	Exam Rm/Enterance	Offices	Treatment/Gym	Gym/Exam Rm	Offices	Pool and Penthouse
Floor area	16704 sf	16705 sf	16706 sf	16707 sf	16708 sf	16709 sf
Floor Height	16ft	18ft	13ft	13ft	14ft	18ft
Max Occ. # per floor	50	25	35	45	75	5
Linear Ftage. Of exterior walls	540ft	540ft	540ft	540ft	540ft	540ft
R-values	See Below					
% Glass walls /U-values Glass	South 20%/2.8 W/m^2k^2	North 85%/2.8 W/m^2k^2		West 70%/ 2.8 W/m^2k^2	East 2%/2.8 W/m^2k^2	
Supply Air Temp/Room Temp Seasons	Cool 67 degrees/ Heat 70 degrees					
What floor AHU service	AHU 1 runs all floors until AHU 2 and AHU 3 are needed. They work as needed.					
Utility rate nat. gas.	#0.94 /Thermo Natural Gas					
Location	Baltimore, Maryland					

R-Values			
Precast Concrete	Rigid Insulation	Batt Insulation	GWB
6"	2"	6"	(2) 5/8"
R-0.48	R- 9.1	R-8.7	R-5

Table 2.1 Design Information

Mechanical Impact:

The enthalpy wheels will be part of the air handling units. Therefore, the units will need to be modified to be able to house the wheels. The image below shows a section view of what the new system will look like once the enthalpy wheels are installed.

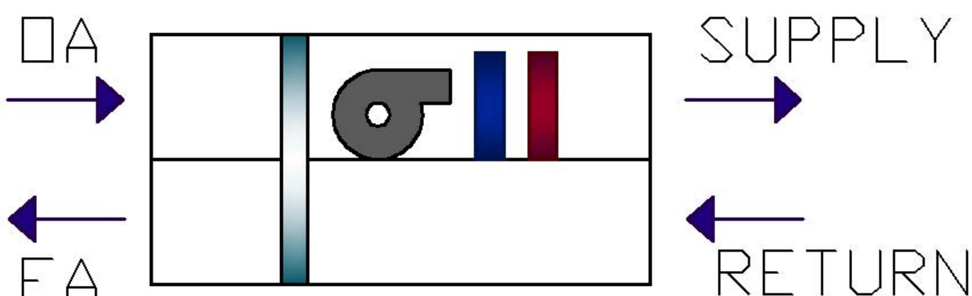


Figure 2.2 (by Katie Sennett in AutoCAD)

Figure 2.2 is a section view of the AHU with the enthalpy wheel. The enthalpy wheel works by capturing the cold air/ hot air from the exhaust air. This cold/hot energy that is captured on the spinning enthalpy wheel is then used to precondition the outdoor air. The air then travels through the fan which pushes the preconditioned air through the heating/cooling coils for the correct supply air temperature. This supply air is then distributed throughout the building.

Schedule:

The enthalpy wheel is a large piece of equipment and requires a long lead time between 3 to 6 months prior to installation. It takes approximately 6.6 days to install one enthalpy wheel. This will take a total of 20 days to install all three units into the air handling units. This installation will take place around the same time that the air handling units are installed.

Cost Savings:

The amount of energy that the enthalpy wheel saves is a total cost savings of $2,898 a year. However, initial cost of the enthalpy wheel is $39,550 for just one wheel. For three wheels, the cost would be $118,650 dollars. It would 41 years to pay off the equipment which does not include early maintenance or replacing of the entire wheel. This replacement of the wheel could increase the price greatly because the roof system would need to be removed to remove and replace a new wheel. This is an issue because architects do not design buildings to have an easily removable roof system.

	Electric	**Gas**	**Total Cost**
	$/yr	$/yr	yr
Existing System	$122,824	$3,774	$126,598
Redesign	$120,098	$3,602	$123,700
		Total Savings =	**$2,898**

Table 2.2 Cost Savings

Conclusion:

Saving money on energy costs is becoming more of a standard rather than an option in new construction. However, not every building design can be changed in a way to save money by reducing energy costs. For a building with 100% exhaust air, a heat recovery system would be a great way to reduce that energy costs. However for the outpatient medical center the initial cost of such a system outweighs the amount of savings. Therefore, the enthalpy wheel would not be a good system to use for the project.

3D Design Coordination (Critical Issues Research)

Introduction:

The Outpatient Medical Center is currently coordinating mechanical, electrical, and plumbing systems through bi-weekly coordination meetings and the sharing of a single set of construction documents. However, being an Intern on this project and getting the opportunity to be a part of and overseeing these coordination meetings a few issues were found. The first issue was the lack of organization of each subcontractor and their idea who they thought had the most important construction element when it came to inserting their design/plans on to the set of construction documents. This created an environment of arguing and confusion for what items needed to go where on the drawings. The second issue was the lack of communication in and outside of the meetings when it came to clashes and mechanical equipment being relocated. The bi-weekly meeting seemed be timely and very unproductive.

Proposal:

The proposed solution to this mechanical, electrical, and plumbing coordination issue is utilizing 3D design coordination software with clash detection. With 3D design coordination software becoming increasingly popular in the construction industry, the use of it on a project like the Outpatient Medical Center could greatly benefit the quality of the overall project.

Goal:

The goal to this analysis is to identify the use of 3D design coordination with the mechanical, electrical, and plumbing clash detection and implementing it during construction. Getting all project team members and trades involved is sometimes a difficult challenge. This analysis will develop research on how to implement it in the industry and what is needed to get contractors, subcontractors and owners all on the same page with using 3D design coordination on projects.

Research:

Step 1: What it costs to implement

3D Design coordination involves computer software and technical knowledge of the systems and software. This can cost a lot of money for a small subcontractor because not only does the software need to be purchased but the schooling behind how the programs works will also be needed. The following tables show the different types of 3D design programs there are and how much they cost to purchase and to get trained in it.

Software	Price
AutoCAD	$3,970
Revit MEP	$2,536
Revit Structural	$3,103
NavisWorks	$8,000

Autodesk
Corporate Classroom Training
3-Day (27hrs) = $2,350
5-Day (45hrs) = $3,950
Corporate On-Site Training
3-Day (27hrs) = $1,950
5-Day (45hrs) = $3,250

Table 3.1 Cost Comparison

Step 2: Surveying the subcontractors and engineers

Why was 3D design coordination not used on the Outpatient Medical Center? This step of the research will look at the reasons why the subcontractors and engineers are not using 3D design coordination on this project and what their thoughts are on the topic. A breakdown of survey questions with the answers of 5 subcontractors and engineers working on the Outpatient Medical Center can be found below. Please see **Appendix G** for a sample survey.

1. Does your company use 3D design coordination programs?
    - No
        - The company does not currently own any such programs
        - Because the CAD company that performs the coordinated drawings for the Mechanical contractor has the ability to do 3D drawings and do not need to use it ourselves.

    - We do not use the 3D design ourselves. We subcontract the 3D design work out to people who are knowledgeable and competent in using it.
- Yes
    - The company does own and utilize the 2008 LT version of AutoCAD
    - The company is currently in the process of purchasing 3D design programs

2. If your company does not use 3D design coordination, what do you see in the future for your company?
    - As construction starts to move away from paper documents to digital ones, the company will eventually need 3D CAD software in order to conduct business properly.
    - In the future the company will ultimately be forced into utilizing 3D design programs as the call for coordination drawings become more frequently used in construction.

3. If your company does use 3D design coordination, what does it take to implement it on projects?
    - Close coordination with other subcontractor, but in from design engineer and release for drawings.
    - The need for the project to require the 3D software.

4. What are the difficulties of using 3D design coordination?
    - Cost and training.

- It is not easily used by everyone. A lot of the time you need to look at it on the computer to see certain things and every project manager may not have the knowledge to operate the system.
- Difficult for smaller businesses to fund the training for employees that lack computer literacy.
- Coordinating with other contract because not every contractor has the capability.

5. If your company has the capability of incorporating 3D design coordination into you productivity, what types of buildings or spaces is it used on.
    - Existing buildings of tight mechanical room spaces.
    - On most projects but it all depends on size of the project and the direction of the engineer.
    - Health care facilities
    - Government project

6. Is it difficult to get other subcontractors on board with using 3D design coordination and if so why?
    - Yes
        - The cost
        - Smaller contractors do not have the funds to do 2D CAD design let alone the expense of a 3D design. Many people feel that the 3D design coordination is also a waste of time because no matter how many coordination drawings are done it always seems to change in the field.

7. What are the steps needed to implement 3D design coordination with MEP systems for clash detection?
    - Buy in from the design engineer, getting the client to understand the additional cost, and making sure all subs have the technology.

8. What would you say to a small company who was looking into implementing 3D design coordination on their project?
    - The costs are high but the rewards for correct coordination and being able to see the conflicts are very beneficial.
    - It is only as good as the information that you put on it.
    - Make sure that all the other subcontractors that you work with will be able to use the 3D system to work with you.
    - If the financial ability is there, hire someone.

9. What would you say are the advantages to using 3D design coordination?
    - It allows users to view the project in a 3rd dimension before it is constructed. It can also help detect problems before material has been ordered and duct has been built.
    - Installation of equipment and materials run smoother and is more accurate.
    - Being able to visually see the conflicts before they become major problems.
    - It does an excellent job of detecting area of conflict, which allows for changes to be implanted prior to installation. This is its self lowers the cost of rework to the owner.

10. What would you say are the disadvantages to using 3D design coordination?

- The costs associated with the program and the amount of training time needed.
- Many times areas are so congested that all problems can not be identified. Also, things are always changing on the project and you may put a great deal of effort into the 3D design coordination and feel that you have all the areas of conflict identified then with one change order this may all go to waste.
- If drawings are not followed accurately it can cause difficulties in the coordination of the installation of equipment and materials.
- Sometimes coordination drawings take too long to produce and construction schedules override.

Conclusion

3D design coordination has so many benefits such as creating better visuals for design and being able to find clashes in MEP systems. However, as great as 3D design may seem, it appears that most companies today still do not have the resources to implement it. Implementing 3D design involves the funds to, not only to purchase the software products, but it requires the right equipment and the knowledge to learn how to use it. And this is just too much money for the contractors to be putting out there and not knowing how much it will even be used. Because in order for the 3D design coordination to work properly, everyone on the project team must have the resources to be able to work with and use the 3D design. This is one of the key issues for companies when it comes to using 3D design coordination programs.

Engineers and subcontractor that lack the resources to implement 3D design have to subcontract it out to people who specialize in it. This is how the engineers and subcontractor on the Outpatient Medical Center project are using and creating their construction documents. This works, although it is somewhat difficult to coordinated MEP drawings when outside people are creating the drawings. This involves many more coordination meetings and communication, which takes more time and money which could have been resolved by each contractor having and using the 3D design coordination programs.

3D design coordination has it benefits and its down falls, but overall, engineers and subcontractors see that in the future the construction industry will rely solely on the computer images instead of paper copies. Contractors may not be able to afford it now, but feel that in some time they will be starting to get more motivated to spend the extra money when the demand of 3D design coordination beings to increase.

Appendix A

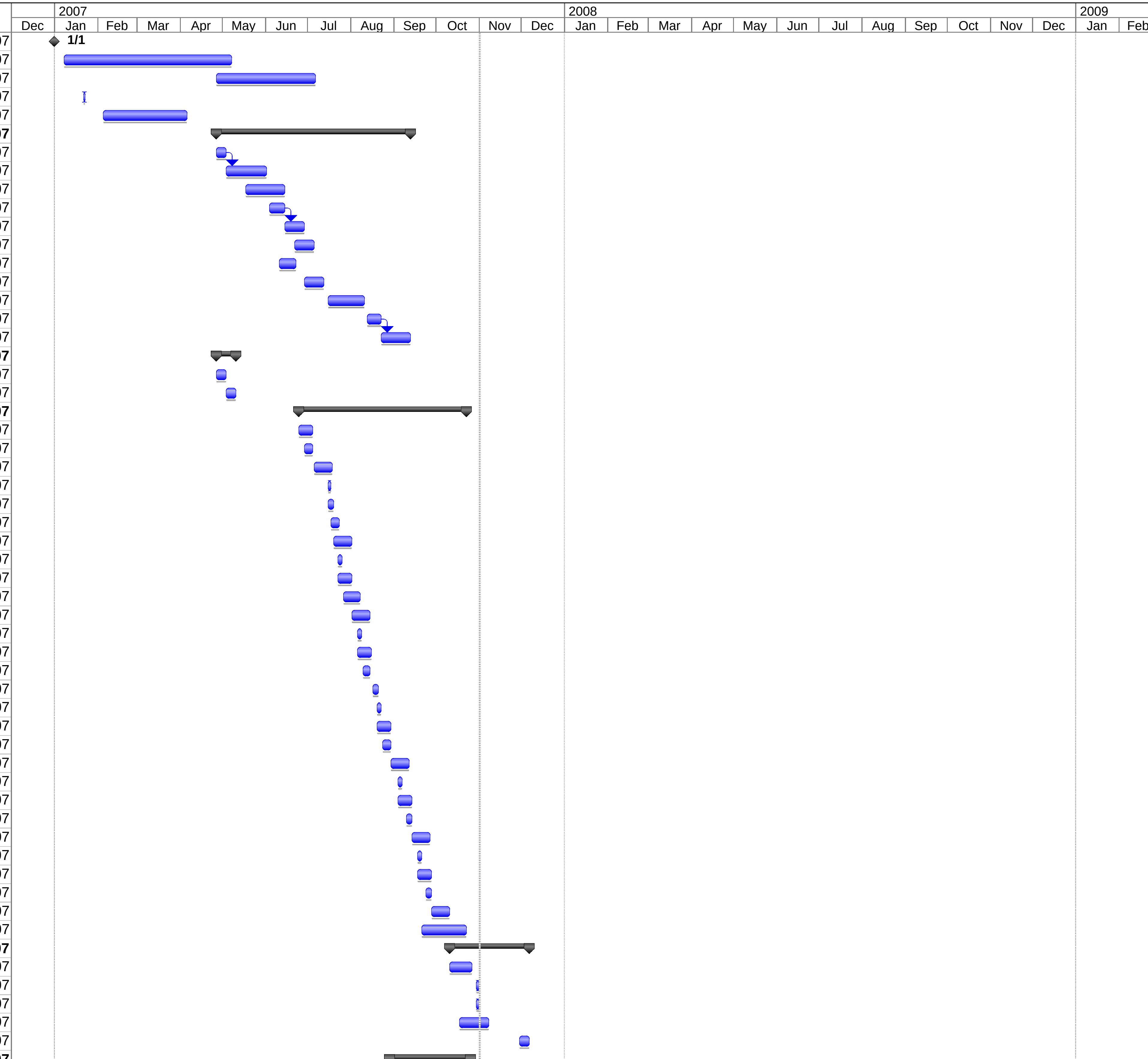
General Condition Estimate

Description	Unit	Price	Amount
Personnel	MO	$69,339	$1,802,824
Site Trailer	MO	$330.00	$8,580
Field Trailer	MO	$110.00	$2,860
Building Demolition	MO	$480.77	$12,500
Overhead Protection	MO	$1,421.38	$36,956
Shoring & Underpinning	MO	$23,967.31	$623,150
Site Development	MO	$56,097.31	$1,458,530
Temporary Electric	MO	$1,539.00	$40,000
Electric Usage	MO	$6,923.00	$180,000
Temporary Water	MO	$385.00	$10,000
Utilities	MO	$14,769.23	$384,000
Foundation Drain - Site	MO	$454.04	$11,805
Parking Equipment	MO	$384.62	$10,000
Landscaping - Base	MO	$3,716.35	$96,625
Landscaping - Garden	MO	$0.00	$0
Construction Fence	MO	$214.62	$5,580
Construction Fence	MO	$1,153.85	$30,000
Pest Control	MO	$196.96	$5,121
Dumpster	MO	$3,699.23	$96,180
Demobilize Trailers	MO	$1,153.85	$30,000
Layouts and Grades	MO	$1,230.77	$32,000
Site Maintenance	MO	$1,538.46	$40,000
Site Maintenance	MO	$293.46	$7,630
Trash Chutes	MO	$484.62	$12,600
Hoisting/Access	MO	$2,076.92	$54,000
Misc. Supplies	YR	$10,000	$21,600
		Total	$5,012,541

Appendix B

Detailed Project Schedule

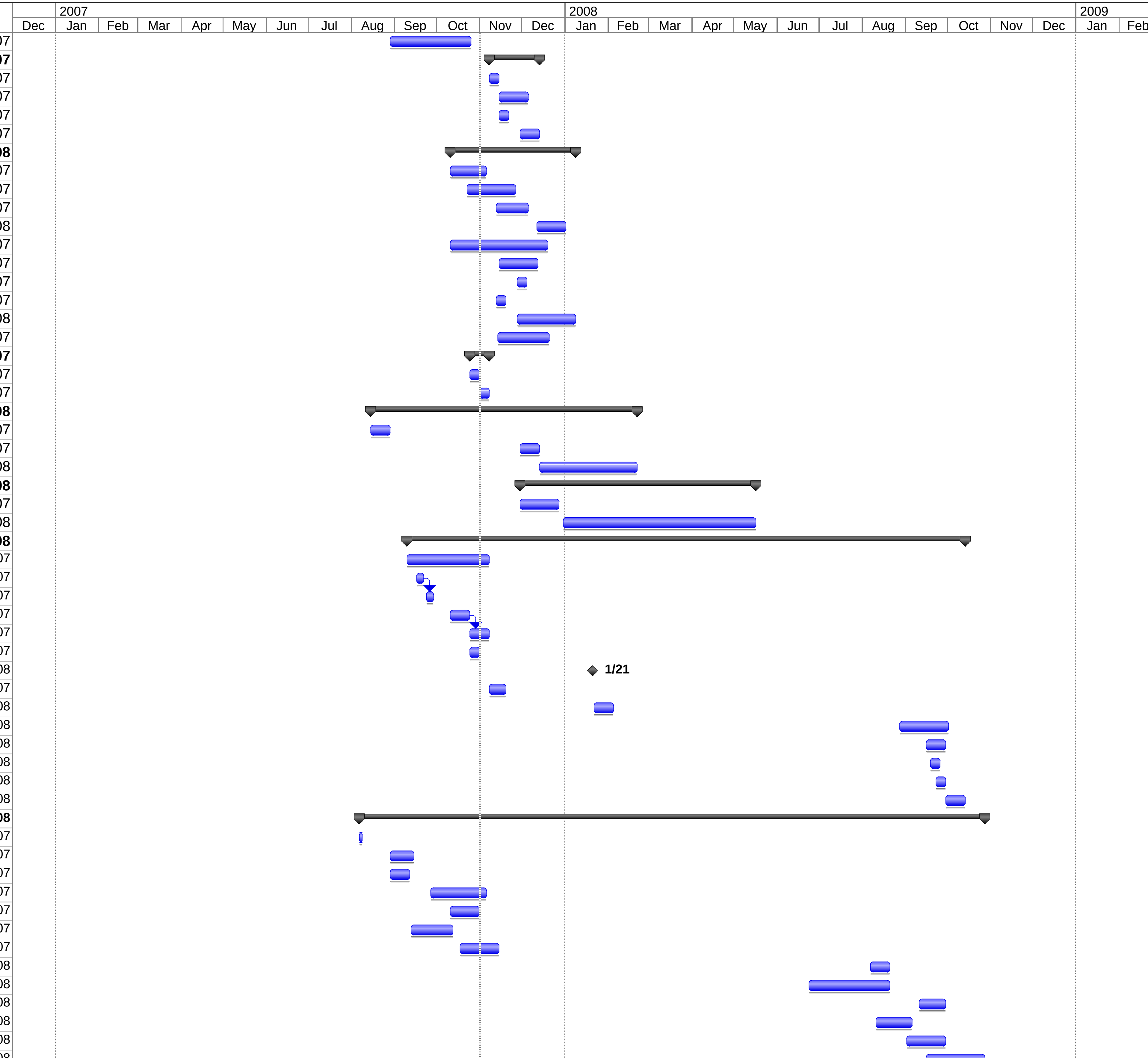
ID	Task Name	Duration	Start	Finish
1	Notice to Proceed	0 days	Mon 1/1/07	Mon 1/1/07
2	Procurement of Construction	86 days	Mon 1/8/07	Mon 5/7/07
3	Procurment of Accessories	51 days	Fri 4/27/07	Fri 7/6/07
4	Site Preparation	1 day	Mon 1/22/07	Mon 1/22/07
5	Excavation	44 days	Mon 2/5/07	Thu 4/5/07
6	**Foundation/SOG/Backfill**	**99 days**	**Fri 4/27/07**	**Wed 9/12/07**
7	Foundation Mobilize Concrete Operation	5 days	Fri 4/27/07	Thu 5/3/07
8	Basement Footing	21 days	Fri 5/4/07	Fri 6/1/07
9	1st Lift Basement Walls & Coulmns	20 days	Fri 5/18/07	Thu 6/14/07
10	Brace, Waterproof, Backfill Int Bsmt Walls	9 days	Mon 6/4/07	Thu 6/14/07
11	Footings 1st Level	10 days	Fri 6/15/07	Thu 6/28/07
12	Walls & Columns 1st Level 2nd Lift	10 days	Fri 6/22/07	Thu 7/5/07
13	Basement Slab	10 days	Mon 6/11/07	Fri 6/22/07
14	First floor slab on grade	10 days	Fri 6/29/07	Thu 7/12/07
15	Waterproof Exterior Foundation Walls	20 days	Mon 7/16/07	Fri 8/10/07
16	Permieter Foundation Drains	8 days	Mon 8/13/07	Wed 8/22/07
17	Backfill Foundation	15 days	Thu 8/23/07	Wed 9/12/07
18	**Tower Cane**	**10 days**	**Fri 4/27/07**	**Thu 5/10/07**
19	Tower Crane Foundation	5 days	Fri 4/27/07	Thu 5/3/07
20	Mobilize Tower Crane	5 days	Fri 5/4/07	Thu 5/10/07
21	**Concrete Floor Slabs/Columns (Floors 1-6)**	**86 days**	**Mon 6/25/07**	**Mon 10/22/07**
22	1st Floor Shore & Frame Slab	8 days	Mon 6/25/07	Wed 7/4/07
23	1st Floor Plumbing & Electrical Rough-In	4 days	Fri 6/29/07	Wed 7/4/07
24	1st FL. Place Concrete - Cure/Strip Reshore	9 days	Fri 7/6/07	Wed 7/18/07
25	2nd FL Prep/Pour#1 Columns	2 days	Mon 7/16/07	Tue 7/17/07
26	2nd Fl. Shore & Frame Slab	4 days	Mon 7/16/07	Thu 7/19/07
27	2nd FL Plumbing & Electrical Rough-In	4 days	Wed 7/18/07	Mon 7/23/07
28	2nd Fl Place Concrete - Cure/Strip Reshore	9 days	Fri 7/20/07	Wed 8/1/07
29	2nd Fl Prep/Pour #2	3 days	Mon 7/23/07	Wed 7/25/07
30	2nd Fl. Shore & Frame Slab	8 days	Mon 7/23/07	Wed 8/1/07
31	2nd FL Plumbing & Electrical Rough-In	8 days	Fri 7/27/07	Tue 8/7/07
32	2nd Fl Place Concrete - Cure/Strip Reshore	9 days	Thu 8/2/07	Tue 8/14/07
33	3rd Fl Prep/Pour Columns	3 days	Mon 8/6/07	Wed 8/8/07
34	3rd Fl Shore & Frame Slab	8 days	Mon 8/6/07	Wed 8/15/07
35	3rd Fl Plumbing & Electrical Rough-In	3 days	Fri 8/10/07	Tue 8/14/07
36	3rd Fl Place Concrete - Cure/Strip Reshore	2 days	Fri 8/17/07	Mon 8/20/07
37	4th Fl Prep/Pour Columns	3 days	Mon 8/20/07	Wed 8/22/07
38	4thFl Shore & Frame Slab	8 days	Mon 8/20/07	Wed 8/29/07
39	4thFl Plumbing & Electrical Rough-In	4 days	Fri 8/24/07	Wed 8/29/07
40	4thFl Place Concrete - Cure/Strip Reshore	9 days	Thu 8/30/07	Tue 9/11/07
41	5th Fl Prep/Pour Columns	3 days	Tue 9/4/07	Thu 9/6/07
42	5thFl Shore & Frame Slab	8 days	Tue 9/4/07	Thu 9/13/07
43	5thFl Plumbing & Electrical Rough-In	4 days	Mon 9/10/07	Thu 9/13/07
44	5thFl Place Concrete - Cure/Strip Reshore	9 days	Fri 9/14/07	Wed 9/26/07
45	6th Fl Prep/Pour Columns	3 days	Tue 9/18/07	Thu 9/20/07
46	6thFl Shore & Frame Slab	8 days	Tue 9/18/07	Thu 9/27/07
47	6thFl Plumbing & Electrical Rough-In	4 days	Mon 9/24/07	Thu 9/27/07
48	6thFl Place Concrete - Cure/Strip Reshore	9 days	Fri 9/28/07	Wed 10/10/07
49	6th Fl form/Pour Pool structure & Cure/Strip	22 days	Fri 9/21/07	Mon 10/22/07
50	**Structural Steel**	**41 days**	**Thu 10/11/07**	**Thu 12/6/07**
51	Mobilize & Erect Structural Steel Level 6	12 days	Thu 10/11/07	Fri 10/26/07
52	Set Cooling Towers, AHU's, & Set Pools/Protect	2 days	Tue 10/30/07	Wed 10/31/07
53	Set Elevator Machines/Protect	2 days	Tue 10/30/07	Wed 10/31/07
54	Deck Plumbing and Bolt Level 6	15 days	Thu 10/18/07	Wed 11/7/07
55	Spray on Fireproofing	5 days	Fri 11/30/07	Thu 12/6/07
56	**Stairs A & B**	**42 days**	**Wed 8/29/07**	**Thu 10/25/07**



Project: Tech2 -Project Schedule
Date: Thu 11/1/07

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

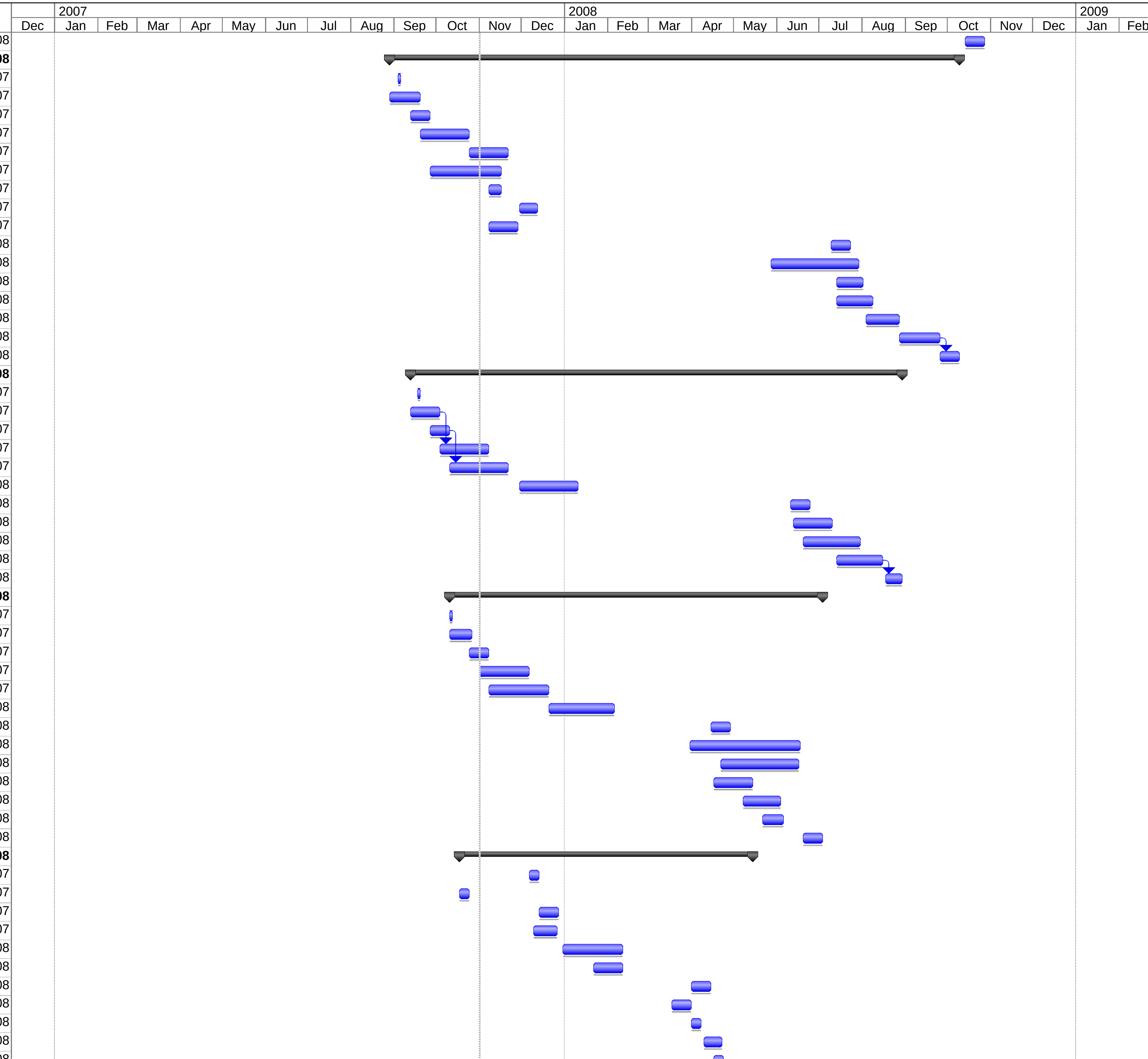
ID	Task Name	Duration	Start	Finish
57	Stairs A & B, Levels 1 thru 6.	42 days	Wed 8/29/07	Thu 10/25/07
58	**Roofing**	**26 days**	**Thu 11/8/07**	**Thu 12/13/07**
59	Main Roof Curbs, Blocking, & Drains	5 days	Thu 11/8/07	Wed 11/14/07
60	Main Roof Accessories, Coping & Flashing	15 days	Thu 11/15/07	Wed 12/5/07
61	Low Roof & Drains	5 days	Thu 11/15/07	Wed 11/21/07
62	Low Roof Accessories, Coping & Flashing	10 days	Fri 11/30/07	Thu 12/13/07
63	**Building Enclosure**	**64 days**	**Thu 10/11/07**	**Tue 1/8/08**
64	Precast - North	18 days	Thu 10/11/07	Mon 11/5/07
65	Precast - South	25 days	Tue 10/23/07	Mon 11/26/07
66	Precast - West	17 days	Tue 11/13/07	Wed 12/5/07
67	Precast - Caulking/Sealant	15 days	Wed 12/12/07	Tue 1/1/08
68	Curtain Wall - North	50 days	Thu 10/11/07	Wed 12/19/07
69	Curtain Wall - West	20 days	Thu 11/15/07	Wed 12/12/07
70	Curtain Wall - Stair A	5 days	Wed 11/28/07	Tue 12/4/07
71	Strip Wondows - South	5 days	Tue 11/13/07	Mon 11/19/07
72	Curtain Wall - Caulking/Sealant	30 days	Wed 11/28/07	Tue 1/8/08
73	Doors, Windows, and Accessories	27 days	Wed 11/14/07	Thu 12/20/07
74	**Tower Crane**	**10 days**	**Thu 10/25/07**	**Wed 11/7/07**
75	Demobilize Tower Crane	5 days	Thu 10/25/07	Wed 10/31/07
76	Reconfigure Temp Power for Freight Elevator	5 days	Thu 11/1/07	Wed 11/7/07
77	**Frieght Elevator**	**137 days**	**Wed 8/15/07**	**Thu 2/21/08**
78	Shaft - Masonry	10 days	Wed 8/15/07	Tue 8/28/07
79	Shaft - Drywall	10 days	Fri 11/30/07	Thu 12/13/07
80	Install Elevator	50 days	Fri 12/14/07	Thu 2/21/08
81	**Passenger Elevators**	**121 days**	**Fri 11/30/07**	**Fri 5/16/08**
82	Drywall shaft	20 days	Fri 11/30/07	Thu 12/27/07
83	Install Elevators	100 days	Mon 12/31/07	Fri 5/16/08
84	**Basement**	**286 days**	**Mon 9/10/07**	**Mon 10/13/08**
85	MEP Rough-In	43 days	Mon 9/10/07	Wed 11/7/07
86	Electrical Power Service	5 days	Mon 9/17/07	Fri 9/21/07
87	Fire Alarm Rough-In	5 days	Mon 9/24/07	Fri 9/28/07
88	CMU Partitions	10 days	Thu 10/11/07	Wed 10/24/07
89	Electrical Hook Up to HVAC Equipment	10 days	Thu 10/25/07	Wed 11/7/07
90	Studs/Drywall Partitions	5 days	Thu 10/25/07	Wed 10/31/07
91	Perment Power Available	0 days	Mon 1/21/08	Mon 1/21/08
92	Sprinkler Mains & Branches	8 days	Thu 11/8/07	Mon 11/19/07
93	HVAC Start Up and Commissioning	10 days	Tue 1/22/08	Mon 2/4/08
94	Ceiling-Grid, HVAC drops, Sprinkler heads/Test, Lighting	25 days	Thu 8/28/08	Wed 10/1/08
95	Ceiling Tile, Finish paint, Flooring, & Doors/Hardware	10 days	Tue 9/16/08	Mon 9/29/08
96	Electircal System Devices	5 days	Fri 9/19/08	Thu 9/25/08
97	HVAC Test & Balancing	5 days	Tue 9/23/08	Mon 9/29/08
98	Clean up and Punchlist	10 days	Tue 9/30/08	Mon 10/13/08
99	**First Floor**	**320 days**	**Tue 8/7/07**	**Mon 10/27/08**
100	Pull Reshoring	2 days	Tue 8/7/07	Wed 8/8/07
101	Sprinkler, HVAC, Storm Risers	13 days	Wed 8/29/07	Fri 9/14/07
102	Electrical Power Service	10 days	Wed 8/29/07	Tue 9/11/07
103	Sanitary Waste & HVAC - Sprinkler Mains	28 days	Thu 9/27/07	Mon 11/5/07
104	Overhead Plumbing & Med/Gas Distribution	15 days	Thu 10/11/07	Wed 10/31/07
105	Electrical Wiring & Fire Alarm Rough In	22 days	Thu 9/13/07	Fri 10/12/07
106	Electrical Hook Up to HVAC & HVAC Termination	20 days	Thu 10/18/07	Wed 11/14/07
107	HVAC Start up & Commissioning	10 days	Thu 8/7/08	Wed 8/20/08
108	Wall Finishes (Drywall, Paint, Ceiling, Tile..)	42 days	Tue 6/24/08	Wed 8/20/08
109	HVAC Drops, Sprinklers Heads, Light Fixtures	13 days	Thu 9/11/08	Mon 9/29/08
110	Electrical System Wiring	20 days	Mon 8/11/08	Fri 9/5/08
111	Toilet Access., Doors & Harware & Flooring	20 days	Tue 9/2/08	Mon 9/29/08
112	Equipment Installation & Electrical & Plumbing Hook Ups	30 days	Tue 9/16/08	Mon 10/27/08



Project: Tech2 -Project Schedule
Date: Thu 11/1/07

Task		Progress		Summary		External Tasks		Deadline
Split		Milestone		Project Summary		External Milestone	

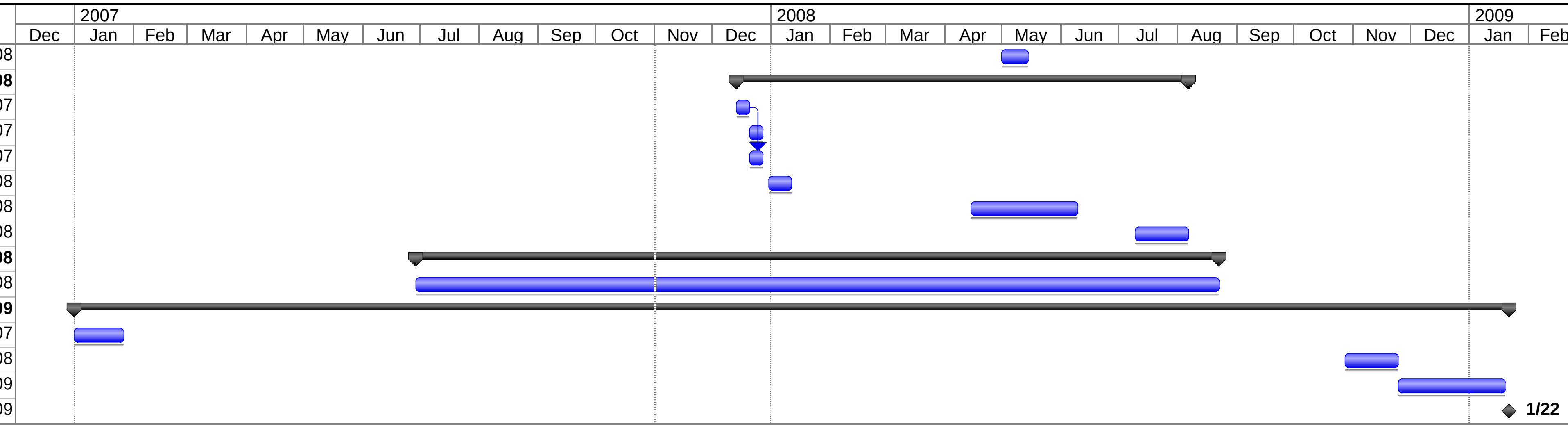
ID	Task Name	Duration	Start	Finish
113	Clean up and Punch list	10 days	Tue 10/14/08	Mon 10/27/08
114	**Second Floor**	**292 days**	**Wed 8/29/07**	**Thu 10/9/08**
115	Pull Reshoring	2 days	Tue 9/4/07	Wed 9/5/07
116	Sprinkler, HVAC, Storm Risers	16 days	Wed 8/29/07	Wed 9/19/07
117	Electrical Power Service	10 days	Thu 9/13/07	Wed 9/26/07
118	Sanitary Waste & HVAC - Sprinkler Mains	25 days	Thu 9/20/07	Wed 10/24/07
119	Overhead Plumbing & Med/Gas Distribution	20 days	Thu 10/25/07	Wed 11/21/07
120	Electrical Wiring & Fire Alarm R-I	37 days	Thu 9/27/07	Fri 11/16/07
121	In floor Heat Cable & Loading Dock Topping Slab	7 days	Thu 11/8/07	Fri 11/16/07
122	Loading Dock Doors	9 days	Fri 11/30/07	Wed 12/12/07
123	Electrical Hook Up to HVAC & HVAC Termination	15 days	Thu 11/8/07	Wed 11/28/07
124	HVAC Start up & Commissioning	10 days	Thu 7/10/08	Wed 7/23/08
125	Wall Finishes (Drywall, Paint, Ceiling, Tile..)	45 days	Wed 5/28/08	Tue 7/29/08
126	HVAC Drops, Sprinklers Heads, Light Fixtures	15 days	Mon 7/14/08	Fri 8/1/08
127	Electrical System Wiring	20 days	Mon 7/14/08	Fri 8/8/08
128	Toilet Access., Doors & Harware & Flooring	18 days	Mon 8/4/08	Wed 8/27/08
129	Equipment Installation & Electrical & Plumbing Hook Ups	21 days	Thu 8/28/08	Thu 9/25/08
130	Clean up and Punch list	10 days	Fri 9/26/08	Thu 10/9/08
131	**Third & Fourth Floor**	**252 days**	**Thu 9/13/07**	**Fri 8/29/08**
132	Pull Reshoring	2 days	Tue 9/18/07	Wed 9/19/07
133	Sprinkler, HVAC, Storm Risers	15 days	Thu 9/13/07	Wed 10/3/07
134	Electrical Power Service	10 days	Thu 9/27/07	Wed 10/10/07
135	Sanitary Waste & HVAC - Sprinkler Mains	25 days	Thu 10/4/07	Wed 11/7/07
136	Electrical Wiring & Fire Alarm R-I	30 days	Thu 10/11/07	Wed 11/21/07
137	Electrical Hook Up to HVAC & HVAC Termination	30 days	Fri 11/30/07	Thu 1/10/08
138	HVAC Start up & Commissioning	10 days	Wed 6/11/08	Tue 6/24/08
139	Electrical System Wiring	20 days	Fri 6/13/08	Thu 7/10/08
140	Toilet Access., Doors & Harware & Flooring	29 days	Fri 6/20/08	Wed 7/30/08
141	Equipment Installation & Electrical & Plumbing Hook Ups	25 days	Mon 7/14/08	Fri 8/15/08
142	Clean up and Punch list	10 days	Mon 8/18/08	Fri 8/29/08
143	**Fifth Floor**	**191 days**	**Thu 10/11/07**	**Thu 7/3/08**
144	Pull Reshoring	2 days	Thu 10/11/07	Fri 10/12/07
145	Sprinkler, HVAC, Storm Risers	12 days	Thu 10/11/07	Fri 10/26/07
146	Electrical Power Service	10 days	Thu 10/25/07	Wed 11/7/07
147	Sanitary Waste & HVAC - Sprinkler Mains	26 days	Thu 11/1/07	Thu 12/6/07
148	Electrical Wiring & Fire Alarm R-I	31 days	Thu 11/8/07	Thu 12/20/07
149	Electrical Hook Up to HVAC & HVAC Termination	33 days	Fri 12/21/07	Tue 2/5/08
150	HVAC Start up & Commissioning	10 days	Tue 4/15/08	Mon 4/28/08
151	Wall Finishes (Drywall, Paint, Ceiling, Tile..)	57 days	Mon 3/31/08	Tue 6/17/08
152	Fit Out Pool Equipment	40 days	Tue 4/22/08	Mon 6/16/08
153	Electrical System Wiring	20 days	Thu 4/17/08	Wed 5/14/08
154	Toilet Access., Doors & Harware & Flooring	19 days	Thu 5/8/08	Tue 6/3/08
155	Equipment Installation & Electrical & Plumbing Hook Ups	11 days	Thu 5/22/08	Thu 6/5/08
156	Clean up and Punch list	10 days	Fri 6/20/08	Thu 7/3/08
157	**Sixth Floor**	**150 days**	**Thu 10/18/07**	**Wed 5/14/08**
158	Layout Top Track	5 days	Fri 12/7/07	Thu 12/13/07
159	Storm Risers	5 days	Thu 10/18/07	Wed 10/24/07
160	Electrical Power Service	10 days	Fri 12/14/07	Thu 12/27/07
161	Sanitary Waste & HVAC - Sprinkler Mains	13 days	Mon 12/10/07	Wed 12/26/07
162	Electrical Wiring & Fire Alarm R-I	31 days	Mon 12/31/07	Mon 2/11/08
163	Electrical Hook Up to HVAC & HVAC Termination	15 days	Tue 1/22/08	Mon 2/11/08
164	HVAC Start up & Commissioning	10 days	Tue 4/1/08	Mon 4/14/08
165	Wall Finishes (Drywall, Paint, Ceiling, Tile..)	10 days	Tue 3/18/08	Mon 3/31/08
166	Electrical System Wiring	5 days	Tue 4/1/08	Mon 4/7/08
167	Toilet Access., Doors & Harware & Flooring	9 days	Thu 4/10/08	Tue 4/22/08
168	Electrical Systems Devices/Trim	5 days	Thu 4/17/08	Wed 4/23/08



Project: Tech2 -Project Schedule
Date: Thu 11/1/07

Task		Progress		Summary		External Tasks	
Split		Milestone		Project Summary		External Milestone	
Deadline							

ID	Task Name	Duration	Start	Finish
169	Clean Up and Punch List	10 days	Thu 5/1/08	Wed 5/14/08
170	**Penthouse**	**169 days**	**Fri 12/14/07**	**Wed 8/6/08**
171	Equipment Pads	5 days	Fri 12/14/07	Thu 12/20/07
172	Install Chillers and Boilers	5 days	Fri 12/21/07	Thu 12/27/07
173	Set AHU's and Cooling Towers	5 days	Fri 12/21/07	Thu 12/27/07
174	Install HVAC Pumps	10 days	Mon 12/31/07	Fri 1/11/08
175	Electrical Hook Up Of Equipment	40 days	Tue 4/15/08	Mon 6/9/08
176	Start Up testing and Commissioning HVAC	20 days	Thu 7/10/08	Wed 8/6/08
177	**Site Work**	**301 days**	**Fri 6/29/07**	**Fri 8/22/08**
178	Landscaping, Canopy, Foundation, Garden	301 days	Fri 6/29/07	Fri 8/22/08
179	**Close Out/Completion**	**538 days**	**Mon 1/1/07**	**Thu 1/22/09**
180	Punchlist	20 days	Mon 1/1/07	Fri 1/26/07
181	Final HVAC Testing & Commissioning	20 days	Tue 10/28/08	Mon 11/24/08
182	Project Close out	40 days	Tue 11/25/08	Mon 1/19/09
183	Project Complete	0 days	Thu 1/22/09	Thu 1/22/09

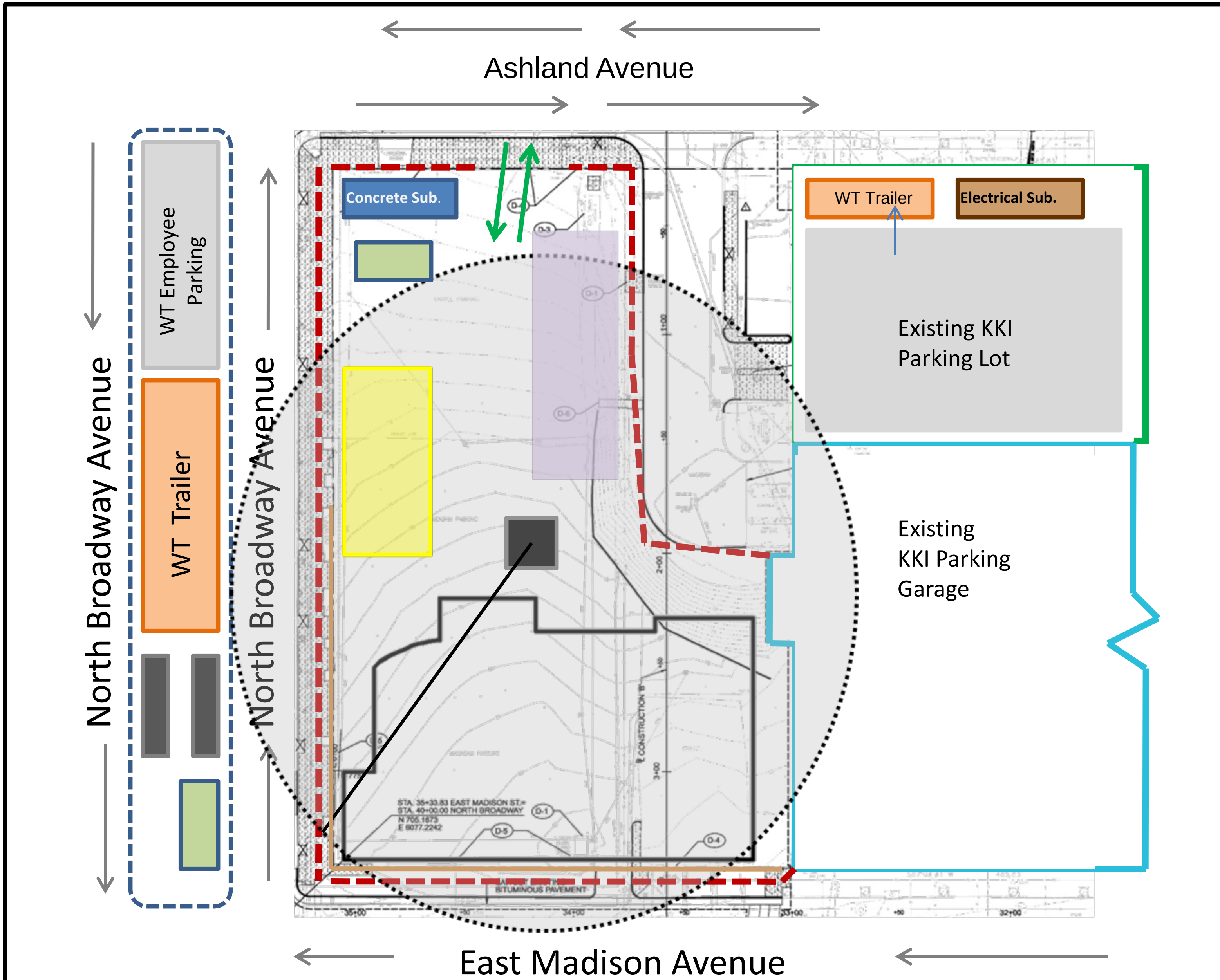


Project: Tech2 -Project Schedule
Date: Thu 11/1/07

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Appendix C

Site Layout



Kennedy Krieger Institute

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404-524-2200
fax 404-524-8610

RK+K
Civil Engineering

Mahan Rykiel Associates Inc.
Landscape Consultant

RMF Engineering, Inc.
Structural Engineer
Mechanical, Electrical, Plumbing & Fire Protection Engineers

Pool Consultant
Counsilman Hunsaker & Associates

Phase: Superstructure

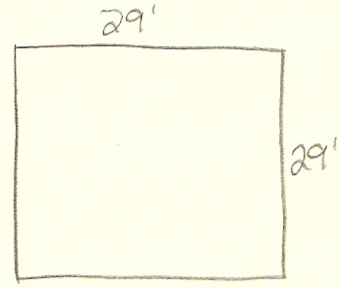
4C1

Formwork Lay down/Storage	Site Fence	Dumpsters
Reinforcing Lay down/Storage	Support for Excavation	Storage Units

Appendix D

Structural “Breadth” Analysis

STRUCTURAL STEEL CALCULATIONS



TYPICAL BAY SIZE = 29' x 29'

METAL DECK = 1½"

CONCRETE = 5" @ 150 PCF

CONCRETE: 150 PCF x $\frac{5''}{12''}$ = 62.5 psf

SUPERIMPOSED DEAD LOAD = 10 psf

DECK LOAD = 2 psf

TOTAL DEAD LOAD
62.5 psf
+ 10.0 psf
+ 2.0 psf
$\boxed{74.5 \text{ psf}}$

LIVE LOADS:
- SNOW LOAD = 30 psf
- ROOF LIVE LOAD = 20 psf
- FLOORS 2 & UP = 80 psf ← (FOR CORRIDORS: MOST CONSERATIVE)
- 1st FLOOR = 100 psf ← (FOR LOBBY AREAS)

MAX DEAD LOAD: 74.5 + 100 = 174.5 psf

FOR METAL DECKING: 18 GAGE INTERMEDIATE RIB DECK
SPACING = 3 BEAM (SPANS) FOR DECK

BEAMS

TRIBUTARY WIDTH = 4'10"

LOAD ON BEAM:
4'10" x (1.2x74.5 + 1.6 x 80) = 1.05 K/ft

MOMENT ON BEAM (PINNED CONNECTION)

$$M = \frac{WL^2}{8} = \frac{1.05^{K/ft}(29^{ft})^2}{8} = 110^{K\text{-}ft}$$

MOMENT ON BEAM (FIXED CONNECTION)

$$M = \frac{WL^2}{12} = \frac{1.05^{K/ft}(29^{ft})^2}{8} = 74^{K\text{-}ft}$$

BEAMS

LIVE LOAD DEFLECTIONS:

$$L/360 = \Delta_{LL} = \frac{5wL^4}{384EI}(1728)$$

$$\frac{(12'')(29')}{(1')(360)} = \frac{5[(80 \times 4'10'') \div 1000](29')^4(1728)}{(384)29000 \cdot I}$$

$$I = 220 in^4$$

$$L/240 = \Delta_{LT} = \frac{5wL^4(1728)}{384EI}$$

$$\frac{(12'')(29')}{(1')(240)} = \frac{5[(154.5 \times 4'10'') \div 1000](29')^4(1728)}{(384)29000 \cdot I}$$

$$I = 282 in^4$$

BEAM SIZE: 16×26 $I = 301$ $\phi M_n = 166$

- ASSUMING BEAM IS FULLY BRACED.

GIRDERS

TRIBUTARY WIDTH = 14.5' + 10.5' = 25'

LOAD ON GIRDER:

$$25' \times (1.2 \times 74.5 + 1.6 \times 80) = 5.44^{k/1}$$

MOMENT ON GIRDER: (PINNED CONNECTION)

$$M = \frac{wL^2}{8} = \frac{5.44^{k/1}(29')^2}{8} = 572^{k1}$$

MOMENT ON GIRDER = (FIXED CONNECTION)

$$M = \frac{wL^2}{12} = \frac{5.44^{k/1}(29')^2}{12} = 283^{k1}$$

GIRDERS

LIVE LOAD DEFLECTIONS:

$$L/360 = \Delta_{LL} = \frac{5wL^4(1728)}{384EI}$$

$$\frac{(12'')(29')}{(1')(360)} = \frac{5(2)(29)^4(1728)}{(384)(29000)I} \Rightarrow I = 1135 \text{ in}^4$$

$$L/240 = \Delta_{LT} = \frac{5wL^4(1728)}{384EI}$$

$$\frac{(12'')(29')}{(1')(240)} = \frac{5(3.86)(29')^4(1728)}{384(29000)I} \Rightarrow I = 1461 \text{ in}^4$$

GIRDER SIZE: 21 x 68 $\quad I = 1480 \quad \phi M_n = 600$

COLUMNS

TRIBUTARY AREA (A_T) = 29' x 25' = 725 SF
INFLUENCE AREA (A_I) = 29'(2) x (50) = 2900 SF

$$L = 80\left(.25 + \frac{15}{\sqrt{A_i}}\right) \Rightarrow \begin{aligned} L_{6th} &= 0.45(80) \\ L_{5th} &= 0.41(80) \\ L_{4th} &= 0.40(80) \\ L_{3rd} &= 0.40(80) \\ L_{2nd} &= 0.40(80) \\ L_{1st} &= 0.40(80) \end{aligned}$$

LIVE LOAD (1^{st}):
L = 0.4(80)(5 floors)(725) + 150 psf (725) + 30 psf (725)
L = 246,500 # = 246.5^k

DEAD LOAD:
74.5(725 SF)(7 floors) = 378,088 # = 378.1^k

TOTAL LOAD:
$1.2(D) + 1.6(L) = 1.2(378.1) + 1.6(246.5) = 848.12^k$

1^{st} FLOOR 18' HIGH: COLUMN SIZE: 14 x 90 $\quad \phi P_n = 928$

• ASSUME FLOOR SLABS ARE CONSISTANT FOR ALL FLOORS.

Appendix E

Cost Calculations

	# of bays	# columns	#of Griders	# of beams	Total Pieces/fl
1st Floor	14	24	18	89	131
2nd Floor	22	35	27	157	241
3rd Floor	20		24	126	170
4th Floor	24	35	28	150	237
5th Floor	22		21	138	181
6th Floor	22	30	21	138	189
Total	124	124	139	798	1149
					42.6

20 to 30 pieces per day

original 86 days for concrete

new 43 days for steel

schedule ahead = 43days ~ 2months

Sizes		Unit Cost	# of	Length	Total Cost
Beam	16x26	35.41	798	29	819458.22
Grider	21x68	118.09	139	25	410362.75
Column	14x90	114.29	124	30	425158.8
					1654979.77
Metal Decking		116,100 sf	$2.11/sf		244,971
				Total Steel $	1,899,951

Shear Walls :Concrete		
East wall	99,792	Between column 1a.1 and 2a.1
Mat Foundation	32,000	24" deep
Elevator Shaft	256,500	3 sides of the shaft with 30' section of wall @ column A between 1 & 2
Total	388,292	

Concrete flooring	406,350	Assume 5" Thick with WWM

Tower Crane = 34,700 /month	
For two months=	69400

Fire Proofing (spray)					
Beams and Columns	110,000sf	$1.25/sf	137,500		
Floor Decks	110,000sf	$2.00/sf	0	B/c concrete to provide enough protection	
Roof	16,990sf	$2.10/sf	35,679		
		Total Fire proofing	173,179		

Project Re-design Cost:

	$1,899,951
	$388,292
	$406,350
	$69,400
	$173,179
Total	**$2,937,172**
Total + Mech	**$2,937,172**

Appendix F

Mechanical “Breadth” Analysis

System Checksums

By PSUAE

EXISTING (1-3)

System - 001

Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK

Peaked at Time: Mo/Hr: 7 / 15
Outside Air: OADB/WB/HR: 91 / 77 / 118

CLG SPACE PEAK

Mo/Hr: 7 / 16
OADB: 91

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	CLG Space Peak: Space Sensible Btu/h	CLG Space Peak: Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	0	0	0.00	0	0.00
Glass Solar	897,453	0	897,453	30.30	950,942	46.18
Glass Cond	281,413	0	281,413	9.50	274,713	13.34
Wall Cond	65,897	21,696	87,592	2.96	63,740	3.10
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	450,465		450,465	15.21	151,910	7.38
Sub Total ==>	1,695,228	21,696	1,716,924	57.96	1,441,305	69.99
Internal Loads						
Lights	369,430	92,357	461,787	15.59	369,430	17.94
People	126,000		126,000	4.25	70,000	3.40
Misc	153,929	0	153,929	5.20	153,929	7.47
Sub Total ==>	649,359	92,357	741,716	25.04	593,359	28.81
Ceiling Load	25,255	-25,255	0	0.00	24,691	1.20
Ventilation Load	0	0	377,545	12.75	0	0.00
Ov/Undr Sizing	0		0	0.00	0	0.00
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			125,962	4.25		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	2,369,842	88,798	2,962,146	100.00	2,059,354	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1
OADB: 5

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	0	0.00
Glass Solar	0	0	0.00
Glass Cond	-870,661	-870,661	38.35
Wall Cond	-86,648	-115,446	5.08
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	-459,434	-459,434	20.24
Sub Total ==>	-1,416,743	-1,445,542	63.67
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-14,843	0	0.00
Ventilation Load	0	-385,062	16.96
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-439,804	19.37
Additional Reheat		0	0.00
Grand Total ==>	-1,431,586	-2,270,408	100.00

TEMPERATURES

	Cooling	Heating
SADB	52.9	106.7
Plenum	70.8	66.5
Return	70.8	66.5
Ret/OA	71.9	55.9
Fn MtrTD	0.1	0.0
Fn BldTD	0.2	0.0
Fn Frict	0.7	0.0

AIRFLOWS

	Cooling	Heating
Vent	5,600	5,600
Infil	6,682	6,682
Supply	108,405	32,521
MinStop/Rh	32,521	32,521
Return	102,805	26,921
Exhaust	0	0
Rm Exh	12,282	12,282
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	5.2	17.2
cfm/ft²	1.08	0.32
cfm/ton	439.16	
ft²/ton	406.02	
Btu/hr·ft²	29.56	-22.65
No. People	280	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	246.9	2,962.2	2,364.2	106,280	71.9	59.9	58.4	51.8	49.8	50.3
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	246.9	2,962.2								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	100,224		
Part	0		
ExFlr	0		
Roof	0	0	0
Wall	51,840	24,365	47

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-1,979.7	32,521	51.8	106.7
Aux Htg	0.0	0	0.0	0.0
Preheat	-290.7	5,600	5.0	51.8
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-2,270.4			

Existing (2-3)

MONTHLY ENERGY CONSUMPTION

By PSUAE

Alternative: 1 No Economizer

------- Monthly Energy Consumption -------

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Electric													
On-Pk Cons. (kWh)	45,891	41,332	54,081	51;162	68,299	80,376	78,286	83,816	63,555	55,582	51,040	44,748	718,168
Off-Pk Cons. (kWh)	16,863	15,216	18,708	19,546	31,591	40,354	50,933	42,246	34,127	21,062	18,699	16,677	326,022
On-Pk Demand (kW)	239	254	308	327	428	499	522	497	460	345	314	249	522
Off-Pk Demand (kW)	190	192	194	206	233	250	272	259	241	210	202	194	272
Gas													
On-Pk Cons. (therms)	946	850	635	233	0	0	0	0	0	301	417	634	4,015
Off-Pk Cons. (therms)	2,290	2,038	1,321	969	734	452	239	534	657	1,071	1,150	1,620	13,075
On-Pk Demand (therms/hr)	23	23	23	23	0	0	0	0	0	23	23	23	23
Off-Pk Demand (therms/hr)	24	24	23	23	23	23	17	23	23	23	23	23	24

Building Energy Consumption = 52,610 Btu/(ft2-year)
Source Energy Consumption = 124,635 Btu/(ft2-year)
Floor Area = 100,224 ft2

EXISTING (3-3)

MONTHLY UTILITY COSTS

By PSUAE

Alternative: 1

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Electric													
On-Pk Cons. ($)	4,022	3,623	4,740	4,484	5,986	7,776	7,574	8,109	6,149	4,872	4,474	3,922	65,731
Off-Pk Cons. ($)	1,196	1,079	1,327	1,386	2,240	2,815	3,553	2,947	2,381	1,494	1,326	1,183	22,926
On-Pk Demand ($)	932	987	1,199	1,275	1,667	3,607	3,773	3,592	3,326	1,342	1,222	969	23,889
Off-Pk Demand ($)	557	561	567	601	682	1,355	1,474	1,401	1,306	615	590	567	10,277
Total ($):	6,707	6,250	7,833	7,746	10,575	15,554	16,374	16,049	13,162	8,323	7,612	6,640	122,824
Gas													
On-Pk Cons. ($)	890	799	597	219	0	0	0	0	0	282	392	596	3,774
Monthly Total ($):	7,596	7,049	8,430	7,965	10,575	15,554	16,374	16,049	13,162	8,605	8,003	7,236	126,598

REDESIGN (1-3)

System Checksums
By PSUAE

System - 001

Variable Volume Reheat (30% Min Flow Default)

COOLING COIL PEAK

Peaked at Time: Mo/Hr: 7 / 16
Outside Air: OADB/WB/HR: 91 / 75 / 110

CLG SPACE PEAK

Mo/Hr: 7 / 16
OADB: 91

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	0	0	0.00	0	0.00
Glass Solar	950,942	0	950,942	36.58	950,942	46.20
Glass Cond	274,713	0	274,713	10.57	274,713	13.35
Wall Cond	63,740	20,999	84,739	3.26	63,740	3.10
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	407,719		407,719	15.68	151,910	7.38
Sub Total ==>	1,697,114	20,999	1,718,113	66.09	1,441,305	70.03
Internal Loads						
Lights	369,430	92,357	461,787	17.76	369,430	17.95
People	126,000		126,000	4.85	70,000	3.40
Misc	153,929	0	153,929	5.92	153,929	7.48
Sub Total ==>	649,359	92,357	741,716	28.53	593,359	28.83
Ceiling Load	23,527	-23,527	0	0.00	23,526	1.14
Ventilation Load	0	0	3,417	0.13	0	0.00
Ov/Undr Sizing	0		0	0.00	0	0.00
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			136,217	5.24		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	2,369,999	89,830	2,599,463	100.00	2,058,190	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1
OADB: 5

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	0	0.00
Glass Solar	0	0	0.00
Glass Cond	-870,661	-870,661	44.09
Wall Cond	-86,648	-115,454	5.85
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	-459,434	-459,434	23.27
Sub Total ==>	-1,416,743	-1,445,549	73.20
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	0	0	0.00
Sub Total ==>	0	0	0.00
Ceiling Load	-14,341	0	0.00
Ventilation Load	0	-3,851	0.20
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		-525,287	26.60
Grand Total ==>	-1,431,085	-1,974,687	100.00

TEMPERATURES

	Cooling	Heating
SADB	53.9	104.4
Plenum	70.7	66.6
Return	70.7	66.6
Ret/OA	70.7	66.5
Fn MtrTD	0.1	0.0
Fn BldTD	0.2	0.0
Fn Frict	0.7	0.0

AIRFLOWS

	Cooling	Heating
Vent	5,600	5,600
Infil	6,682	6,682
Supply	114,933	34,480
MinStop/Rh	34,480	34,480
Return	109,333	28,880
Exhaust	0	0
Rm Exh	12,282	12,282
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	4.9	16.2
cfm/ft²	1.15	0.34
cfm/ton	530.57	
ft²/ton	462.67	
Btu/hr·ft²	25.94	-19.70
No. People	280	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB/WB/HR °F	Enter °F	Enter gr/lb	Leave DB/WB/HR °F	Leave °F	Leave gr/lb
Main Clg	216.6	2,599.5	2,285.5	~~114,933~~	70.7	58.7	55.0	52.8	50.4	51.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	216.6	2,599.5								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	100,224		
Part	0		
ExFlr	0		
Roof	0	0	0
Wall	51,840	24,365	47

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-1,974.7	34,480	52.8	104.4
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-1,974.7			

REDESIGN (2-3)

MONTHLY ENERGY CONSUMPTION

By PSUAE

Alternative: 2 Wheel

------- Monthly Energy Consumption -------

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Electric													
On-Pk Cons. (kWh)	46,290	41,670	54,883	51,506	67,516	77,664	74,558	80,813	62,419	55,799	51,542	45,321	709,981
Off-Pk Cons. (kWh)	16,756	15,084	18,749	19,673	30,835	37,123	44,401	38,422	32,355	21,048	18,775	16,492	309,714
On-Pk Demand (kW)	239	253	307	329	420	483	495	480	451	347	314	250	495
Off-Pk Demand (kW)	193	190	194	207	231	241	253	245	235	212	203	192	253
Gas													
On-Pk Cons. (therms)	924	831	599	208	0	0	0	0	0	274	386	610	3,832
Off-Pk Cons. (therms)	2,009	1,792	1,265	935	707	438	226	515	634	1,030	1,101	1,482	12,134
On-Pk Demand (therms/hr)	23	23	23	23	0	0	0	0	0	23	23	23	23
Off-Pk Demand (therms/hr)	23	23	23	23	23	23	16	23	23	23	23	23	23

Building Energy Consumption = 50,655 Btu/(ft2-year)
Source Energy Consumption = 120,953 Btu/(ft2-year)
Floor Area = 100,224 ft2

REDESIGN (3-3)

MONTHLY UTILITY COSTS

By PSUAE

Alternative: 2

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Electric													
On-Pk Cons. ($)	4,057	3,652	4,810	4,514	5,918	7,514	7,213	7,819	6,039	4,891	4,518	3,972	64,917
Off-Pk Cons. ($)	1,188	1,070	1,330	1,395	2,187	2,590	3,097	2,680	2,257	1,493	1,331	1,170	21,788
On-Pk Demand ($)	932	985	1,195	1,281	1,636	3,494	3,576	3,469	3,260	1,352	1,221	974	23,375
Off-Pk Demand ($)	563	555	566	605	674	1,306	1,371	1,327	1,276	619	593	562	10,018
Total ($):	6,740	6,262	7,901	7,796	10,414	14,903	15,258	15,296	12,833	8,355	7,663	6,677	120,098
Gas													
On-Pk Cons. ($)	869	782	563	196	0	0	0	0	0	257	363	573	3,602
Monthly Total ($):	7,608	7,044	8,464	7,991	10,414	14,903	15,258	15,296	12,833	8,612	8,026	7,250	123,700

Appendix G

Sample Survey

Implementing 3D Design Coordination with MEP systems for clash detection: Survey

Name: ____________________ Company: _______________

Position:_______________

1. Does the following information need to be confidential?

☐ Yes ☐No ☐ Only Information given below, no Name or Company.

2. Does your company use 3D design coordination programs? (Such as AutoCAD, Revit, or NAVISworks)

☐Yes ☐No

If No please briefly explain why not?

3. If your company does not use 3D design coordination, what do you see in the future for your company?

3. If your company does use 3D design coordination, what does it take to implement it on projects?

4. What are the difficulties of using 3D design coordination?

5. Do employees need to be trained in 3D design?

☐Yes ☐No

6. Is there an extra cost for your company to use 3D design?

☐Yes ☐No

If yes, what is the added cost?

____

7. Is 3D design coordination used all on projects in your company or just a select few?

☐All Projects ☐Select Few

If only a select few projects, what type of projects? (Such as office buildings, hospital, .)

8. Is it difficult to get other subcontractors on board with using 3D design Coordination?

☐Yes ☐No

If Yes, Briefly explain why?

9. What are the steps needed to implement 3D Design Coordination with MEP systems for clash detection?

10. What would you say to a small company who was looking into implementing 3D design coordination on their project?

11. What would you say are advantages to using 3d Design Coordination?

12. What would you say are disadvantages to using 3d Design Coordination?

I would like to take this moment to say Thank You for your participation with this survey.
I greatly appreciate your time. Thanks again.

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