TURNBERRY TOWER ARLINGTON

ARLINGTON, VIRGINIA

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Construction Management

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Final Thesis Report

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TURNBERRY TOWER ARLINGTON

1881 North Nash Street
Arlington, Virginia

PROJECT FEATURES

Total Cost: $140 Million
Size: 750,000 Square Feet
Levels: 6 Underground Parking and 26 Above Ground
Method: Design-Bid-Build with GMP
Function: Luxury Condominiums
Duration: March 2007 - September 2009
LEED Rating: Certified

PROJECT TEAM

Owner: 1881 Rosslyn Associates, LLC c/o Turnberry Associates
General Contractor: Facchina-McGaughan, LLC.
Architect: BBG-BBGM Architects & Interiors
Structural Engineer: Smislova, Kehnemui & Associates, PA
MEP Engineer: GHT Limited
Civil Engineer: Vika Incorporated
LEED Consultant: Sustainable Design Consulting
Geotechnical Engineer: Langan Engineering
Landscape Architect: LaPierre Studio
Interior Design: Nick Luaces Design Associates

ARCHITECTURE

- Exterior skin is stone and glass on lower levels and curtain wall and window wall on upper floors
- Stone is Blue Pearl Granite that will be imported from Norway
- Floor-to-ceiling glass is all units for maximum sunlight and sightlines
- Private elevator lobbies for units
- Ceiling heights vary from 9 to 12 feet
- Access to fitness center, indoor pool and spa, café, social room, and media room
- Roof will be EPDM with tapered insulation

ELECTRICAL

- Power is supplied from Dominion Power under ground with two feeds into the transformers
- First feed is stepped down to 480Y/277V 3-phase power and is fed into a 4000 amp box for all public areas and elevators including lighting fixtures
- Second feed is stepped down to 208Y/120V 3-phase power and is fed into one of two 4000 amp boxes where it feeds units for receptacles and lumanaires

STRUCTURAL

- Continuous footings used for the perimeter wall and spread footings used for columns and shear walls
- Parking levels use 10,000 PSI concrete for columns and shear walls and 5,000 PSI for slabs
- Tower levels use two-way post-tension deck with varying PSI concrete for columns and shear walls and 5,000 PSI for slabs
- Flying form system used for faster erection of tower slabs
- Pump and tremie method used for pouring of concrete on tower levels

MECHANICAL

- All spaces in the lobby level will be serviced with one of three AHU's located in the ceiling space
- Each residential unit will have between one to three heat pumps depending on the size of the unit

Turnberry Tower
Arlington, Virginia

LAWRENCE WARNER - CONSTRUCTION MANAGEMENT
http://www.engr.psu.edu/ae/thesis/portfolios/2009/lpw5002

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3. Executive Summary

This senior thesis final report provides background information on Turnberry Tower Arlington, as well as examines the construction and technical aspects of the project. The different studies will discuss what was done during construction and what could be changed to help reduce the schedule or decrease the overall cost. The analysis will end with a recommendation of the success or failure of the proposed change.

The first analysis that will be investigated is the window wall attachment using reinforced concrete instead of the engineered post tension concrete decks. The post tension concrete decks failed during the installation of the window wall when banded tendons were hit. If reinforced concrete decks were used, it would eliminate the problem of striking post tension tendons. After designing the decks using reinforced concrete, it was determined that the decks needed to be 11 inches thick. When comparing the schedules, the analysis showed that the reinforced concrete construction would have no impact. The cost of the post tension decks was $20.6 million and the analysis showed that the reinforced concrete would cost $22.6 million. Because the two reinforced systems analyzed will cost more money than the cost of repairing the damage from the post tension failures, it is recommended that the existing post tension concrete be used over the proposed reinforced concrete decks.

The second analysis investigated was the supply water system that feeds each residential unit. The current system utilizes CPVC piping that connects to the copper pipe risers through the building. I wanted to introduce a new system in the building and see if it would improve the schedule or the cost of the project. The Propress system uses copper piping and an easily connected fitting that makes installation of the supply water system much faster than the typical soldering of copper pipe. Unlike the installation of CPVC, there is no glue necessary to connect the piping because the fittings are mechanically installed with a special tool, which would be a plus for LEED and sustainable construction. When the cost and schedule was analyzed, it was predicted the Propress system would cost $160,000 more. This was due to the fact that the cost of copper in 2006 was very high when the project was designed. The installation of the system would save 17 man hours per unit, but that cost is not offset by the cost increase of the system. It is recommended that since the project was designed in 2006 and the price of copper was high, the CPVC system be used for the supply water to each unit.

The third analysis looks at the current site logistics plan and the overtime cost that needed to be paid to load drywall into the building. There was a large area on the east side of the site that was not used. If the logistics plan used that side of the site during concrete construction to load drywall into the building, it was determined that there could be a cost savings on labor of $750 to $2000 per 1000 boards loaded. This project has 91,000 sheets of drywall to load into the building. The new logistics plan would not affect the SIP schedule and would only require one window wall not to be installed during concrete construction. After looking at the plan and seeing that it is possible to use this site logistics plan, it is recommended that this site logistics plan be used to help reduce the overtime cost needed to load drywall into the building during construction.

4. Project Introduction

The Turnberry Tower Arlington project is being built in the Rosslyn section of Arlington, Virginia. The building consists of 6 levels of below ground parking and 25 levels of residential units equating to approximately 740,000 square feet. The building is finished only in the below ground parking levels, lobby level, the kitchens and the bathrooms of the residential units.

In order for Turnberry Tower Arlington to attain a LEED Certified Certification for New Construction, certain points were obtained in designing the building as well as recycling materials during construction. All materials were sorted during demolition and sold to private parties so that it can all be reused. Luckily, no special measures were needed during demolition because no harmful asbestos or lead paint needed to be removed.

The project began in September of 2006 with the demolition of the existing hotel on site. Working through the SIPS schedule being utilized on this project and with the current work rate, a date of September 2009 has been set for the substantial completion.

Turnberry Tower Arlington's primary structural systems consist of two way post tension concrete with shear walls and columns. The building will house 11 elevators with almost 2 miles of rail. All units will have their own heat pumps with their own mechanical closets. A sovent system will be used for the plumbing that will help reduce the need for vent stacks.

The general contractor on the project is Facchina-McGaughan, with BBG-BBGM acting as the project architect and Turnberry Limited and Facchina Development as the owners. The building cost of $155 million is contracted under a guaranteed maximum price between Facchina-McGaughan and Turnberry Limited. The total project cost for this project is $250 million.

5. Project Team Overview

5.1 Client Information

Turnberry Limited are the primary owners of this project with Facchina Development as the secondary owners. The project was owned by Facchina initially and needed another party to come in, back the project and become the primary owner. Turnberry is known for picking sites that are "dramatic" and providing something that can't be duplicated. Some of their other sites include Paradise Island in the Bahamas and Las Vegas, Nevada. Further expansion includes on the water in Boston, Massachusetts.

This site was selected because of the views that will be offered. At the top, you will have unobstructed views to all of the District of Columbia and Georgetown and parts of the Anacostia River. The building has been outfitted since Turnberry has purchased the building to fit their décor. High ceilings in the lobby level with plenty of down light and magnificent finishes will greet guests as they enter the

building. Turnberry will also have installed two water features that will be noticed by anyone who passes by the building. These few features along with stone from Norway and the full height window walls will allow Turnberry Tower Arlington to become a symbol for the Rosslyn section of Arlington County.

Cost, quality, and schedule are the three most important factors in achieving a successful project. In the case of this project an interesting approach was taken. When Facchina sold the building to Turnberry and became the secondary owner, one stipulation was that Facchina's general contractor division would be used to build and manage the job. The hope was that by having the owner and general contractor work together and be one in the same that it would be possible to achieve cost, quality, and schedule which is not typical on most projects. When there was a delay from permitting problems, both sides worked together very well. The project fell behind three months and it did not sit well with any of the parties. Both sides worked together and were able to speed up the project to get back on the original schedule and they did this without increasing any cost or decreasing any quality.

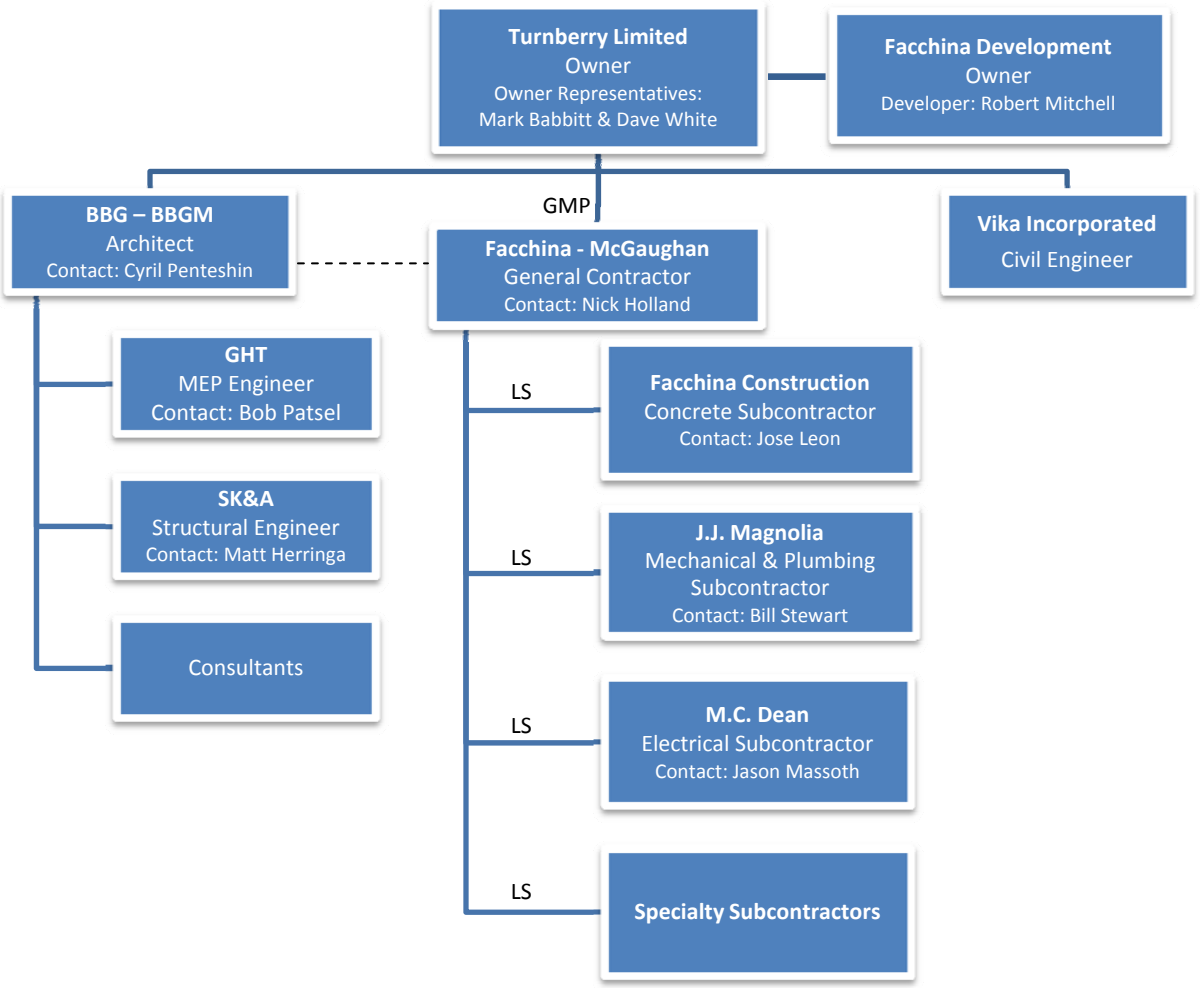
Throughout construction there was also constant communication between the owner and general contractor dealing with all changes. In an effort to keep costs down, quality high, and schedule on track, these parties would meet regularly to discuss any and all changes. This showed that when the general contractor has a vested interest in a project they will try to do what they can to keep cost, quality, and schedule in check.

When asked what safety expectations were required, the only answer from the owner was "100% at all times."

In order to complete this project so the owner is satisfied, all of the units must have the kitchens and bathrooms finished and have the rest of the unit roughed out with junction boxes for lights and power to the receptacles. The corridors on the typical floors must be finished as well. The lobby level will need to be completely finished including the pool, spa, gym, and mezzanine level. The parking garage will need to have all private garage doors installed. All the systems in the building must be commissioned, online and ready to work properly for turnover.

5.2 Project Delivery System

Turnberry Tower Arlington Organizational Chart



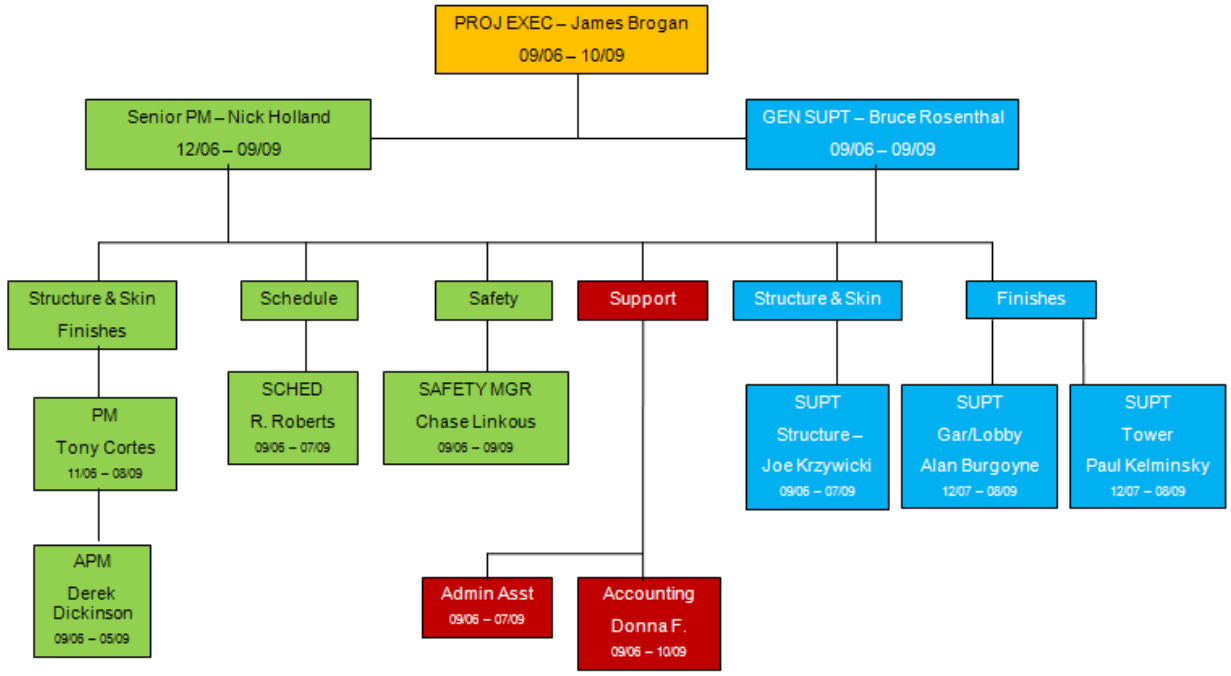
This project is being delivered in a design-bid-build approach. This was chosen because Turnberry wanted to the building to fit their exact needs so it could be a building they would be proud to own.

Between the owner and the general contractor there is GMP contract. In parts of the budget where items were not yet purchased or it was not decided what was exactly needed, an allowance was put in. A lump sum contract is used between the general contractor and subcontractors. The subcontractors were picked by the use of a hard bid. In some cases it was required for the subcontractor to bond 1.5% of their bid in the form of a payment and performance bond. The project uses a CCIP Insurance program so all subcontractors were required to participate in this program.

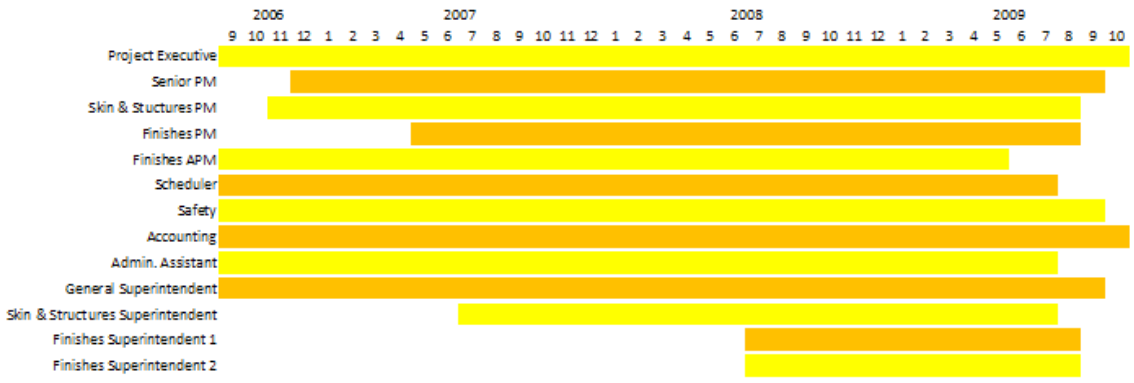
5.3 Project Staffing Plan

Below is the organization chart and the staffing plan for the Turnberry Tower Arlington project being used by the general contractor. The organization chart is set so there is one project executive that deals primarily with the owner while everyone else has who they should report to. Because of the flexibility of this project and the open communication between the owner and general contractor, everyone on the job is able to communication with everyone on the owner's side and vice versa. The staffing chart was set up before the job and describes what the job will need in regards to the onsite personal.

Facchina-McGaughan Organization Chart



Facchina-McGaughan Staffing Chart



6. Existing Conditions

6.1 Site Plan of Existing Conditions

A site plan of existing conditions was created. On the first diagram the limits of the property, garage, and proposed building are drawn. All adjacent buildings are labeled as well as all local roads running around the site. The covered walkway that will be up through the duration of construction is shown along with the temporary office trailers and other temporary facilities. The second diagram shows all existing utilities and how they will be routed into the new building.

6.2 Local Conditions

In the Washington D.C. Metropolitan area, post-tension concrete is most utilized due to the height restriction inside the District of Columbia. Although this height restriction is not enforced in Arlington, Virginia, the use of the post-tension concrete allows for larger bays between columns and a thinner floor slab which is a huge advantage in a condominium building. Combine these advantages to the efficiency the crews already have with using P-T concrete, it was deemed appropriate to use this system on this project.

Weather in the Washington D.C. area is quite extreme. Because of the location of swamp lands, the weather can change dramatically from day to day. In the winter months, very cold temperatures can be expected which can impact schedules with concrete pours and on this job with hanging exterior stone work. Parts of the exterior building and floors will have to be tented in and heated to allow for concrete and mortar to set.

The summer months for this project were also tough on the project and the workers. The summer of 2007 was especially hot with many days of 100% humidity. This is tough on workers to get the work done that is necessary to keep up with the schedule. Summer of 2008 proved not to be any easier. Along with many hot and humid days, there were many large thunderstorms that provided the area with much precipitation and knocked out power to the area for hours and even days. This weather also led to the area's public transportations system to be shut down and disabled for large amounts of time. Large construction the Metro's Orange Line led to an increase in traffic on all major roads and highways in the area. This traffic would lead to an increase in time for all deliveries and pickups from the site.

The site located at 1881 North Nash Street has some height restrictions because of the approach path of aircrafts landing at Reagan National Airport. The tower cranes are restricted to their height which makes it hard for critical picks for the heavy roof top machinery onto the building.

This site causes problems with traffic flow and patterns because of the adjacencies to a county "major roadway." Fort Myer Drive is designated as a main route as it allows the passage of cars through

Arlington County from both Interstate-66 and Georgetown. This restricts the site deliveries because they can't occur during rush hour traffic in the morning and afternoon.

The soils in the area are a combination of sand and clay for about 30' down for excavation and then disintegrated rock for the next 30'. This is typical in the Rosslyn section of Arlington County.

6.3 Demolition of Existing Building

Previously on this site was the Rosslyn Best Western which was 11 stories in height with an in-ground pool on the south of the site. The geotechnical engineer provided a Phase I and Phase II site assessment. In their findings there was no evidence of "recognized environmental conditions" as defined by ASTM were observed. The limited asbestos survey revealed the presence of Regulated Asbestos Containing Materials in the form of surface applied ceiling materials in the parking garage. Category I non-friable asbestos containing floor tiles were also detected in storage and linen rooms in the hotel structure. None of the asbestos found was harmful and out of regulatory limits so special precautions were not needed to remove it from the building.

In order to achieve a LEED certification, certain criteria needed to be met during demolition to achieve the required amount of LEED points. All the furniture and contents from the hotel were taken out of the building and sold off to private parties. The materials that made up the building including the structural steel and aluminum were recycled and sold off to be reused in another project. The concrete was also recycled where it was going to be made into new concrete.

7. Project Logistics

7.1 Project Schedule Summary

When the plans for 1881 North Nash Street were purchased by Turnberry Limited and Facchina Development in 2005, the process for developing a project schedule for the newly named Turnberry Tower Arlington began immediately. On September 26th, 2006, demolition on the existing building began. The schedule has a substantial completion date set for July 7th, 2009 and the owner expects to move in on September 4, 2009. The schedule that is attached in Appendix A breaks down the major activities into different phases including procurement, temporary construction, new construction, and project commissioning and testing.

Foundation

From the soil boring reports prepared by the geotechnical engineer, it was discovered that this site would have a significant amount of rock that would need to be removed. When the site was brought down to approximately elevation 70', dynamite was needed to bring the site down to approximately elevation 50'. Some over excavation was needed for the continuous footings that were poured for

under the perimeter wall. After the extra rock was removed, 2500 PSI lean concrete was needed to be poured and this was used for leveling the excavated hole to place the perimeter walls. This has a major impact on the schedule because of the amount of rock that needed to be removed (approximately 4200 BCY) as well as the limitations on how much could be blasted each day. On blast days all roads around the site would have to be closed for a period of time which caused traffic on major highways and roads. On site, it would put a stop to excavation because of the placement of live explosives.

Structure

The structure of this building is designed in two different ways; one in the parking levels and one in the tower levels. In the parking levels, two tower cranes with two separate crews were used to erect the concrete structure. This footprint of the parking level has a large enough area that allowed two crews to work independently of one another and still be fully efficient. They worked in a clockwise matter going from one zone to another until the parking level was complete.

The tower level of the building was done utilizing only one of those crews from the parking level erection and the use of one tower crane. The slabs were split into three zones and each would be poured on a separate day. The columns would be poured on a fourth day. At the rate the project was going and with the available man power, the project was averaging about a floor a week.

Finishing Sequences

This job uses the Short Interval Production Schedule or SIPS method to complete the interior of the building. Refer to Appendix A for the SIPS schedule for Turnberry Tower Arlington. Some of the finish activities include:

- Install curtain wall and window wall
- HVAC / Plumbing rough-in
- Electrical rough-in
- Drywall
- Install plumbing fixtures
- Install lighting fixtures
- Install doors, hardware, and toilet accessories
- Testing and balancing

These activities were all done in a sequence agreed upon by all the subcontractors involved before the start of construction and was created to maximize productivity. Although tweaking was needed during the first few floors of construction, this schedule is helping to keep everyone on track and responsible for their own work. The subcontractors can schedule crews at their discretion because they know how much work they will need to complete during the week.

7.2 Detailed Project Schedule

The schedule that has been created is based on the two phases of construction for Turnberry Tower Arlington. The first phase includes the erection of the 6 story underground parking garage and the second phase includes the erection of the 26 story residential tower. The detailed scheduled can be found in Appendix A. Below in *Table 7.I* you can find the abridged version of the detailed schedule which includes only the summary activities.

ID	Task Name	Duration	Start	Finish
1	**Preconstruction**	**218 days**	**Mon 1/30/06**	**Thu 11/30/06**
7	Soldier Piles and Underpinning	130 days	Tue 1/2/07	Mon 7/2/07
8	**Sheeting & Bracing**	**122 days**	**Tue 1/16/07**	**Wed 7/4/07**
15	Structure Excavation	136 days	Fri 1/12/07	Fri 7/20/07
16	**Building Structure**	**354 days**	**Wed 8/1/07**	**Mon 12/8/08**
50	**Building Rough-in**	**145 days**	**Thu 2/14/08**	**Wed 9/3/08**
57	**Condo Rough-in (MEP & Framing)**	**169 days**	**Thu 6/12/08**	**Tue 2/3/09**
82	**Window Wall / Curtain Wall**	**143 days**	**Mon 4/21/08**	**Wed 11/5/08**
107	**Drywall & Tape**	**136 days**	**Mon 7/7/08**	**Mon 1/12/09**
132	**Building Finishes**	**315 days**	**Thu 3/20/08**	**Wed 6/3/09**
164	**Condo Finishes (Kitchen & Bathrooms)**	**155 days**	**Mon 8/11/08**	**Fri 3/13/09**
189	**Elevators**	**247 days**	**Thu 9/18/08**	**Fri 8/28/09**
193	**General Items**	**323 days**	**Thu 2/14/08**	**Mon 5/11/09**
199	Substantial Completion	0 days	Sun 8/30/09	Sun 8/30/09

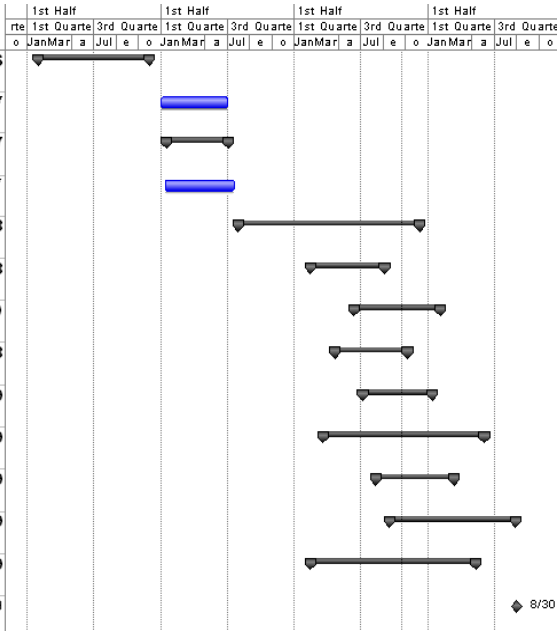


Table 7.I – Abridged Detailed Schedule

From the above schedule, some of the key completion dates for Turnberry Tower Arlington include:

Structure Excavation	July 2nd, 2007
Building Structure Erection	December 8th, 2008
Condo Rough-in (MEP & Framing)	February 3rd, 2009
Window Wall / Curtain Wall	November 5th, 2008
Building Finishes	June 3rd, 2009
Elevators	August 28th, 2009
Substantial Completion	August 30th, 2009

The schedule that has been created shows the Short Interval Production Schedule (SIPS) that is being used on this project. Building structure erection, rough-in, window wall / curtain wall, drywall, and finishes are broken down according to each level. Both the garage and the tower levels were grouped together where the same type of work would be taking place (concrete placement) and separated where different work would be occurring (different types of finishing). A copy of the SIPS being used on this job that was utilized to create the detailed schedule can be found in Appendix A. Durations and start dates for the activities in the detailed schedule were obtained from the general contractor.

7.3 Project Cost Evaluation

Below in *Tables 7.2 to 7.4* are the costs associated with the construction of Turnberry Tower Arlington.

Actual Cost

Actual Building Construction Cost (CC)

Construction Cost (CC)	$155,500,000
CC / SF	$210.14

Table 7.2 – Actual Building Construction Cost

Total Project Costs (TC)

Total Project Cost (TC)	$250,000,000
TC / SF	$337.84

Table 7.3 – Total Project Cost

Major Building Systems Cost (BSC)

Structural	$28,600,000
MEP	$33,200,000
Fire Protection	$2,300,000
Curtain Wall / Window Wall	$15,200,000
Major Building System Cost (BSC)	$79,300,000
BSC / SF	$105.73

Table 7.4 – Major Building Systems Cost

R.S. Means Square Foot Estimate

R.S. Means 2008 was used to develop an estimate for both the residential tower of the building as well as the parking deck. Once the square foot estimates were calculated, a total building estimate was created. An 8-24 story apartment building was used at 500,000 SF. Perimeter adjustments were calculated in the estimates. Additions include elevators and fully furnished kitchens. For the parking garage, a perimeter adjustment was needed and the typical height of the parking garage was kept the same. Below in *Table 7.5 and 7.6* are the calculated values and the details for the calculations can be found in Appendix B.

R.S. Means SF Total Building Estimate

	Square Feet	Cost / SF	Total Cost
Residential Tower	500,000	$169.79	$84,895,000
Parking Garage	240,000	$77.90	$18,696,000
			$103,591,000
R.S. Means Location Factor (Arlington, VA)			1.04
		Total Estimate	$107,734,640

Table 7.5 – R.S. Means 2008 Estimate

Actual Building Construction Cost (CC) vs. R.S. Means 2008 SF Estimate

Estimate Type	Cost	Cost / SF
Building Construction Cost (CC)	$155,500,000	$210.14
R.S. Means Estimate	$107,734,640	$145.59
Difference in Estimates	**$47,765,360**	**$64.55**

Table 7.6 – Actual Building Cost vs. R.S. Means Estimate

To compare the R.S. Means estimate to the actual estimate, the total estimate was divided by the total square footage of the tower and garage. The estimate above shows $145.59/SF. When this is compared to the building construction cost obtained from the general contractor of $210.14/SF, this method is off by $64.55/SF. The reason for the error in calculation can be because of the following reasons:

- The use of post-tension concrete instead of reinforced concrete
- The actual building has varying ceiling heights
- The building has very high end kitchen appliances, tile floors, and bathroom accessories
- No fire suppression or life safety devices is included in the R.S. Means estimate
- Elevators for the additions in R.S. Means do not include the use of 3 hydraulic elevators

D4 Cost Analysis

In the database for D4 Cost 2002 there are no buildings that match Turnberry Tower Arlington. To get an approximate cost, 5 buildings that were the same type and above $15 million were used. Below in *Table 7.7* are the calculated values obtained by D4 Cost compared to the actual building construction cost. The details from the D4 Cost Analysis can be found in Appendix B.

Actual Building Construction Cost (CC) vs. D4 Cost 2002

Estimate Type	Cost	Cost / SF
Building Construction Cost (CC)	$155,500,000	$210.14
D4 Cost 2002	$95,416,943	$128.94
Difference in Estimates	**$60,083,057**	**$81.19**

Table 7.7 – Actual Building Cost vs. D4 Cost 2002

The estimate above gives $128.94/SF from the D4 Cost Analysis. When this is compared to the number obtained from the general contractor for building construction cost of $210.14/SF, there is a difference of $81.19/SF. Some of the possible errors in this estimate are:

- Buildings in the database are not close to the complexity or cost of finishes in the actual building
- There is a much more complex conveying system than the compared buildings
- The use of post-tension concrete instead of reinforced concrete
- The building has very high end kitchen appliances, tile floors, and bathroom accessories
- A 6-story underground parking garage

7.4 General Conditions Estimate

A general conditions estimate was created by the general contractor for the Turnberry Tower Arlington project. Because of the complexity of this project and the owner's expectation to pay close attention to cost, schedule, and quality, the general conditions are very specific. Appendix B has the complete breakdown of the general conditions estimate including the prices, percentages, units, unit costs, and cost per month. Some of the numbers have been slightly modified based on the request of the general contractor. *Table 7.8* below shows the main breakdown of the general conditions for this project.

General Conditions		
Item	Cost	% of GC
Staff	$5,881,000	43.62%
Site Work	$1,193,000	8.85%
Temporary Utilities	$1,300,000	9.64%
Site Office & Job Needs	$985,500	7.31%
Site Security	$491,000	3.64%
Contracts	$77,000	0.57%
Insurance	$3,555,000	26.37%
TOTAL	**$13,482,500**	**100%**

Table 7.8 – General Conditions Breakdown

The final estimate for the general conditions totals $13.5 million which is approximately 9% of the $150 million total project cost. There is a Contractor Controlled Insurance Policy (CCIP) for this job but there is still a need for the umbrella liability, general liability, and workers compensation insurance policies to be added to make the insurance complete. Although the general contractor's site offices will be housed inside of the future café of the building, a space needed to be rented out until such time that the café area was complete and enclosed by the window walls to make the space watertight. This explains why the cost of the site office is not lower than one would anticipate.

Like most general conditions on any given project, a majority goes towards paying the staff of the general contractor. This project is staffed so most of the people on the project team are on the project for the entire duration.

7.5 Detailed Structural System Estimate

Turnberry Tower Arlington's primary structural system is post-tension concrete for the tower level and cast in place concrete for the parking levels. A structural system estimate was created from takeoff notes for the entire structural system of the building. Below in *Table 7.9 through Table 7.11* are the results from the estimate. All takeoff notes can be found in Appendix B.

Total Material Cost		
Item	Amount	Total Cost
Concrete	37,351 CY	$4,668,875
Reinforcing Steel	3071 Tons	$3,071,000
Miscellaneous Items		$2,481,385
Total		**$10,221,260**
Total per CY		**$273.65**

Table 7.9 – Total Material Cost

Average Labor and Equipment			
Description	Labor	Equipment	Unit
Footings	$54.50	$0.33	CY
Columns	$435.00	$42.50	CY
Slab on Grade	$55.00	$0.41	CY
Slabs	$207.00	$19.60	CY
Beams	$490.00	$48.50	CY
Shear Walls	$430.00	$42.50	CY
Curbs, Pads, Toppings	$129.00	$1.78	CY
Average per CY	**$257.21**	**$22.23**	**CY**

Table 7.10 – Average Labor and Equipment Costs

Construction Cost of Concrete System for Turnberry Tower Arlington						
Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	37351	CY	$273.65	$257.21	$22.23	$20,658,837
				TOTAL	**$27.55**	**per SF**

Table 7.11 – Construction Cost of Structural System

R.S. Means 2008 Building Construction was used to find the average price of labor and materials that were needed to create this construction estimate. Prices for concrete per cubic yard, rebar per ton, and PT cable cost per pound were obtained directly from the subcontractor. Prices that were given include:

Concrete = $125 / cubic yard
Rebar = $1000 / ton
PT Cable = $1.15 / pound

These numbers were used with the takeoff values to obtain the material cost for the structural system which totaled $10,221,260. When this number is divided by the number of cubic yards of concrete for this project the total is $273.65 per cubic yard. This number was added to the average cost of labor

($257.21 per cubic yard) and equipment ($22.23 per cubic yard) and the total cost of $20,658,837 was obtained for the construction of the concrete structural system. This number, when divided by the projects 750,000 square feet, yields $27.55 per square foot (as seen in *Table 7.11*).

The price of $27.55 is a bit high for concrete construction. Normal construction averages $25 per square foot. Some of the reasons that this estimate may be high include:

1. Rise in prices for steel and rebar
2. Transportation costs to get the material to site
3. Cost of the automatic climbing formwork and flying formwork to gain time on the schedule
4. Post-tension steel cables
5. Much larger waste factor was calculated than was necessary

Figure 7.1 shows a typical tower level with rebar cages for shear walls and columns, part of a concrete deck poured, and exposed PT cables laid out and ready for a concrete pour. *Figure 7.2* shows the use of the Automatic Climbing System (ACS) for the core of the building.

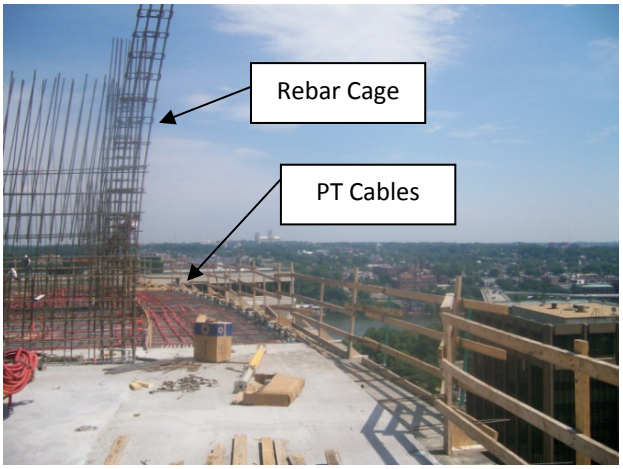


Figure 7.1 - Working Deck

Figure 7.2 – ACS Formwork for Core

8. Introduction to Thesis Analysis

Analysis 1 – Attachment of the Window Wall to Reinforced Concrete
Structural Breadth

This analysis will focus on the problems that occurred on the jobsite with attachment of the structural supports for the building's exterior window wall system to the post tension concrete decks. With lack of coordination between the design team and the contractors, drilling needed to occur in the post tension decks. Many tendons failed when they were struck during the drilling process. With this occurring halfway up the building, steps were immediately taken to remedy this process. The goal for this analysis is to go back to the preconstruction phase of the project and propose the use of reinforced concrete. This would help with all of the designs that were not yet in place and would reduce the risk of having to drill into post tension decks. I will compare the cost and schedule problems from failed post tension tendons to the same project if reinforced concrete had been used.

Analysis 2 – Supply Water System
Mechanical Breadth & Critical Industry Issue

During some of the value engineering that occurred in the beginning phases of construction, one idea that was utilized on this project was the use of the Sovent System which helped in sustainable construction for the waste piping. I will now look more closely at the supply water system and propose ways to make this system more sustainable while at the same time decreasing the cost and schedule for installation. Utilizing propress fittings and prefabrication, I plan to investigate to see if these construction methods would have been more beneficial for this project. I will then see if any of these construction methods could have helped to obtaining more LEED points for the project.

Analysis 3 – Site Logistics Plan

Turnberry Tower Arlington is surrounded on three sides by main roads. The country has put time restrictions on some of the roads so construction does not create more traffic during certain times of the day. With those restrictions, the site plan that was utilized throughout the project used one road for deliveries to the site. This one main passageway was also the road used when concrete was delivered and where the material hoist was accessed. The goal of this analysis is to redesign the site logistics plan and to utilize another part of the site for more deliveries, which will reduce the amount of overtime the drywall subcontractor needed for this project. Cost savings would occur if the drywall subcontractor did not have to accept as many deliveries on the weekends.

9. Analysis 1 – Window Wall Attachment with Reinforced Concrete

(Structural Breadth)

9.1 Introduction

Turnberry Tower Arlington's exterior skin is made up of both curtain wall and window wall. When the general contractor was given the contract documents during bidding, it was noted that the exterior skin system did not have a design in place showing how to connect it to the structure of the building. Because the building structure is post tension concrete, not having a design for the connections made it very difficult for a connection to be designed in the existing conditions. Any connection design could have had a large impact on the structure design and may have caused a redesign of the post tension slabs.

9.2 Problem Statement

As a result of not having the detail for the window wall connection design, drilling into the cured post tension decks had to occur to attach the window and curtain wall. This led to having more than 20 tendons hit and fail during the window wall installation process. After this had occurred, the exterior skin installer was forced to use a Ferroscan unit to scan the post tension decks before every bolt was installed. The result of the busted post tension tendons can be seen below in *Figure 9.1*.

Figure 9.1 - Failed Post Tension Tendons

9.3 Goal

The goal of this analysis to act as the general contractor during the preconstruction process and suggest the post tension concrete slabs be replaced with reinforced concrete decks. This will allow for more design flexibility in connecting the exterior skin to the building. Once redesigned, a cost and schedule analysis will be performed to see which design would be better taking in to account all of the problems that occurred from the post tension tendon blow outs. I will also find out why post tension concrete was used on this building.

9.4 Research Steps

1. Investigate why post tension concrete was used by talking to the architect, structural engineer, and developer and ask if reinforced concrete could have been an option.
2. Use the direct design method and the CRSI handbook to design the building using normal concrete (structural breadth).
3. Consult with the scheduler to determine the correct durations for the use of reinforced concrete construction on this project and see what other activities this may impact.
4. Price the project using reinforced concrete.
5. Compare both the schedule and cost for the two different structural systems
6. Conclusion & Recommendation

9.5 Tools

1. CRSI Handbook
2. ACI Handbook
3. Direct Design Method
4. Architectural Engineering Professors
5. General Contractor and Design Team
6. R.S. Means Cost Analysis
7. Primavera / Microsoft Project
8. Microsoft Excel

9.6 Expected Outcome

When this project was designed and given to the general contractor, certain subcontractors were not yet onboard, including the exterior skin subcontractor. By the time the package was picked up and all of the submittals were approved by the architect, there was not time to place an embed into the post tension decks that would support the window wall. This led to the problems of ruptured post tension tendons and having to x-ray all future window wall installations. All of these additional costs to the project should show that if a suggestion was made to use reinforced concrete instead of post tension concrete then time and money would have been saved.

9.7 Use of Post Tension Concrete

The first step in the research process was to investigate why post tension concrete was used for this project. While going through documents that were available during the preconstruction process, many design details, including the window wall supports, were not yet supported so it seemed like a good time to go ahead and use post tension concrete which would cause more of a problem than reinforced concrete.

The post tension concrete allowed the slab thickness on the typical residential levels 2 through 26 to be 7 inches. With the parking garage below the structure, the 10 foot ceilings in some of the units as desired by the owner, and the sunshade on the roof, the final height of the building is at elevation 409.70. The building is located in Arlington, Virginia in the Rosslyn District. This site is in close proximity to Reagan National Airport which gives the Federal Aviation Administration the final approval on how high the building can be. The FAA says the elevation of the building is within 1/8 of an inch of the allowable height.

With the elevation requirement that needed to be met, and with the County of Arlington requiring that the building meet the zoning requirements of the "C-O District," the only way for the building to get an extra floor with the desired floor heights would be to use post tension concrete. This extra floor that was able to be incorporated into the design allows the owner to gain $17.6 million of sales from the residential units. If the height of the building from the reinforced concrete becomes an issue, the option for taking out one floor of the building becomes very unlikely based on this price.

9.8 Redesigning the Floor Slabs Using Direct Design Method

To see if was even possible to use reinforced concrete on this project, first I needed to redesign the slabs to see what the impact there would be on the cost and schedule. I started out by taking a typical floor and dividing a section into typical bays that would give me a general representation. I used the following general assumptions:

- 20" x 20" columns
- Per ASCE 7-05 Table 4.1, Live Load = 40 psf
- Dead Load (Concrete Self Weight) = 137.5 psf
- The whole deck would be #6 Rebar at 60 ksi

The general bay that was used for this analysis is show in *Figure 9.2*:

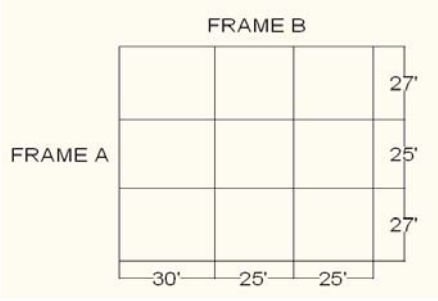


Figure 9.2 - Bay

To come up with the thickness of the slab, I used an equation from ACI 318 Building Code Chapter 9 Table 9.5c 2008, *Table 9.1* below.

fy, psi	Without Drop Panels			With Drop Panels		
	Exterior Panels		Interior Panels	Exterior Panels		Interior Panels
	Without Edge Beams	With Edge Beams		Without Edge Beams	With Edge Beams	
40,000	ln/33	ln/36	ln/36	ln/36	ln/40	ln/40
60,000	**ln/33**	ln/33	ln/33	ln/33	ln/36	ln/36
75,000	ln/28	ln/31	ln/31	ln/31	ln/34	ln/34

Table 9.1 – ACI Table 9.5c

Using the exterior panels without drop panels and without drop beams, the equation to use is ln/33. To be conservative, the largest bay size of 30 feet was chosen from the above *Table 9.1*. When the calculation is done, the thickness of the slab will be 11 inches.

The rest of the Direct Design Method helps to find the amount of steel and where it needs to be placed in the concrete slabs. The factored moment was found for both frames both within the column strip and in the middle strip. The steel was then divided between the positive and negative moments in both the column strips and middle strips. *Table 9.2 and Table 9.3* below summarize the results of the moments on the structure and *Table 9.4* shows the amount of steel that will be needed in each slab. The full structural analysis can be found in Appendix C including verification of the calculations.

Moments on Each Slab

FRAME A		
	+ Moment	- Moment
Column Strip	92 ft-k	214 ft-k
Middle Strip	62 ft-k	72 ft-k

Table 9.2- Moments in Frame A

FRAME B		
	+ Moment	- Moment
Column Strip	87 ft-k	201 ft-k
Middle Strip	58 ft-k	67 ft-k

Table 9.3 – Moments in Frame B

Amount of #6 Rebar per foot				
	FRAME A		FRAME B	
	+ Moment (Bottom Bars)	- Moment (Top Bars)	+ Moment (Bottom Bars)	- Moment (Top Bars)
Column Strip	8	13	8	12
Middle Strip	8	8	8	8

Table 9.4 – Rebar Required

9.9 Scheduling the Project: Post Tension Concrete vs. Reinforced Concrete

When observing the problems with post tension blowouts on this project, the first question that comes to mind is how many days were wasted on the schedule having to fix those decks? Upon further investigation of the schedule, this project was very fortunate that all of the repairs that needed to be done to the floor slabs did not affect the concrete work going on above and did not delay the interior trades on the SIP Schedule.

Next I wanted to look at was the formwork itself. The project was using a flying form system called the Peri Girder Truss Tables. These flying tables helped to speed up the erection of the tower, but they were designed for the post tension slabs that weigh less than the proposed reinforced concrete slabs. After talking to the concrete subcontractor, it was determined that the same formwork could handle the extra weight. That meant that there would be no delay in the construction from being forced to use other formwork or needing to move around more reshores.

After that I needed to investigate how the pour schedule for the reinforced concrete would compare to the pour schedule of the post tension concrete. To keep consistency between the two different types of decks, three zones were used to complete the pours. Each zone would take one day to pour. The post tension slabs utilized a 5 hour pour day and took between 10-11 days to complete. The reinforced concrete decks would need to use 8 hour pour days because of the thicker slabs and would need 12 days to complete (4 days for each zone). Below in *Table 9.5* is an abridged schedule that compares the pour schedules of post tension concrete slabs to the reinforced concrete slabs. The full schedule can be found in Appendix D**.**

Task Name	Duration	Start	Finish
Structure Tower Floor 2	32 days	Fri 12/28/07	Mon 2/11/08
Floor 2 - Reinforced Concrete	38 days	Fri 12/28/07	Tue 2/19/08
Structure Tower Floor 3	14 days	Wed 1/30/08	Mon 2/18/08
Floor 3 - Reinforced Concrete	16 days	Mon 2/4/08	Mon 2/25/08
Structure Tower Floor 4	11 days	Thu 2/14/08	Thu 2/28/08
Floor 4 - Reinforced Concrete	14 days	Thu 2/14/08	Tue 3/4/08
Structure Tower Floor 5	11 days	Wed 2/20/08	Wed 3/5/08
Floor 5 - Reinforced Concrete	13 days	Mon 2/25/08	Wed 3/12/08
Structure Tower Floor 6	10 days	Mon 3/3/08	Fri 3/14/08
Floor 6 - Reinforced Concrete	14 days	Mon 3/10/08	Thu 3/27/08
Structure Tower Floor 7	15 days	Mon 3/10/08	Fri 3/28/08
Floor 7 - Reinforced Concrete	14 days	Wed 3/19/08	Mon 4/7/08
Structure Tower Floor 8	15 days	Mon 3/17/08	Fri 4/4/08
Floor 8 - Reinforced Concrete	13 days	Thu 3/27/08	Mon 4/14/08
Structure Tower Floor 9	12 days	Mon 3/31/08	Tue 4/15/08
Floor 9 - Reinforced Concrete	12 days	Fri 4/4/08	Mon 4/21/08
Floors 10-17	52 days	Tue 4/8/08	Wed 6/18/08
Structure Tower Floor 18	8 days	Fri 6/13/08	Tue 6/24/08
Floor 18 - Reinforced Concrete	12 days	Wed 6/11/08	Thu 6/26/08
Structure Tower Floor 19	8 days	Fri 6/20/08	Tue 7/1/08
Floor 19 - Reinforced Concrete	12 days	Thu 6/19/08	Fri 7/4/08
Structure Tower Floor 20	8 days	Mon 6/30/08	Wed 7/9/08
Floor 20 - Reinforced Concrete	12 days	Fri 6/27/08	Mon 7/14/08
Structure Tower Floor 21	8 days	Wed 7/9/08	Fri 7/18/08
Floor 21 - Reinforced Concrete	12 days	Mon 7/7/08	Tue 7/22/08
Structure Tower Floor 22	10 days	Wed 7/16/08	Tue 7/29/08
Floor 22 - Reinforced Concrete	12 days	Tue 7/15/08	Wed 7/30/08
Structure Tower Floor 23	7 days	Mon 7/28/08	Tue 8/5/08
Floor 23 - Reinforced Concrete	12 days	Wed 7/23/08	Thu 8/7/08
Structure Tower Floor 24	7 days	Mon 8/4/08	Tue 8/12/08
Floor 24 - Reinforced Concrete	12 days	Thu 7/31/08	Fri 8/15/08
Structure Tower Floor 25	12 days	Mon 8/11/08	Tue 8/26/08
Floor 25 - Reinforced Concrete	12 days	Fri 8/8/08	Mon 8/25/08
Structure Tower Floor 26	12 days	Fri 8/22/08	Mon 9/8/08
Floor 26 - Reinforced Concrete	12 days	Mon 8/18/08	Tue 9/2/08

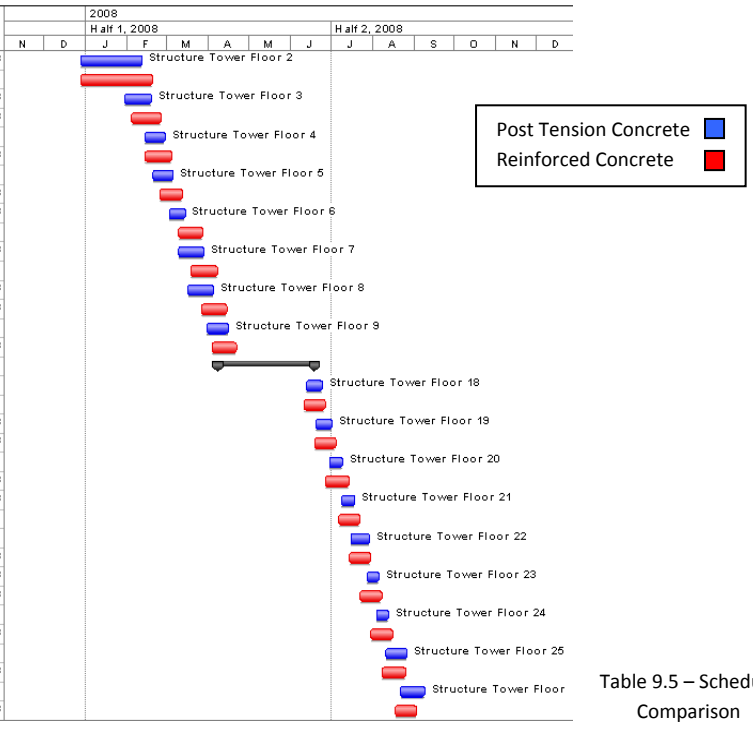


Table 9.5 – Schedule Comparison

9.10 Schedule Comparison

Taking a closer look at the schedules from *Section 1.9*, both the post tension concrete construction and the reinforced concrete construction would begin the erection of floor 2 on December 28th, 2007.

The post tension concrete will be a few days shorter for each floor in the beginning of the project than the reinforced concrete. The workers for the post tension concrete would need to get used to the layout of the post tension tendons and rebar, and how to stress the post tension tendons correctly. The reinforced concrete would have similar time adjustments needed for a learning curve by the workers, but the main factor they need to adjust to is the volume of concrete and rebar. Both structural systems would have a learning curve due to moving and setting up formwork, setting embeds, and getting use to the working conditions on the project.

The advantage that the reinforced concrete system has on the schedule is that workers will be able to accelerate the construction of those decks faster than the post tension decks. More workers could be put on to help move the formwork, set up rebar, and place concrete. The post tension is limited to how fast it can move because of the inspectors. The inspectors would have to approve the concrete to be tensioned and then again approve that the tensioning is satisfactory before the workers could move the formwork up to the next level. In the abridged schedule in *Table 9.5* and full schedule in Appendix D, it is noticeable at certain floors were additional days were required for post tension slabs.

In the end, the post tension concrete construction tops out at floor 26 on September 8th, 2008 and the reinforced concrete construction tops out at floor 26 on September 2nd, 2008. The difference is only 4 work days.

9.11 Cost Comparison between Post Tension Concrete Slabs and Reinforced Concrete Slabs

To compare the costs of the different structural systems, takeoffs were completed on three different options. The first option is what was actually done on the project and shows the cost for the post tension concrete. The next option shows the cost for reinforced concrete if one floor of the building is removed to meet the height requirements. The last option shows the cost for reinforced concrete if all the floors are built but the height of each floor is reduced to meet the building height requirement.

All of the estimates used R.S. Means 2008 Building Construction to find the average price of labor and materials and can be found below in *Table 9.6*.

Average Labor and Equipment			
Description	Labor	Equipment	Unit
Footings	$54.50	$0.33	CY
Columns	$435.00	$42.50	CY
Slab on Grade	$55.00	$0.41	CY
Slabs	$207.00	$19.60	CY
Beams	$490.00	$48.50	CY
Shear Walls	$430.00	$42.50	CY
Curbs, Pads, Toppings	$129.00	$1.78	CY
Average per CY	**$257.21**	**$22.23**	**CY**

Table 9.6 – Average labor and Equipment Costs

Prices for concrete per cubic yard, rebar per ton, and PT cable cost per pound were obtained directly from the subcontractor. Prices that were given included:

Concrete = $125 / cubic yard
Rebar = $1000 / ton
PT Cable = $1.15 / pound

9.11.1 Post Tension Concrete

The estimate for the post tension concrete system can be found below in *Table 9.7 through Table 9.10.* All of the takeoff notes can be found in Appendix B.

Reinforcing Steel			
Area	Amount (Ton)	Cost per Ton	Total Cost
Columns	916	$1,000	$916,000
Shear Walls	1402	$1,000	$1,402,000
Slabs	753	$1,000	$753,000
TOTAL	**3071**		**$3,071,000**

Table 9.7 – Rebar for Post Tension Concrete Slab

Miscellaneous Items			
Item	Amount	Cost per	Total Cost
Post Tension Cables	626,999 LBS	$1.15 / lbs	$721,049
Grout PT Ends	14,456 EA	$0.50 EA	$7,228
WWF 6x6 W1.4/W1.4	19,312 SF	$18.05 / CSF	$348,582
WWF 6x6 W2.1/W2.1	53,001 SF	$26.50 / CSF	$1,404,527
TOTAL			**$2,481,385**

Table 9.8 – Miscellaneous Items for Post Tension Concrete Slab

Total Material Cost		
Item	Amount	Total Cost
Concrete	37,351 CY	$4,668,875
Reinforcing Steel	3071 Tons	$3,071,000
Miscellaneous Items		$2,481,385
TOTAL		**$10,221,260**
TOTAL PER CY		**$273.65**

Table 9.9 – Total Material Cost

Construction Cost of Post Tension Concrete System						
Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	37351	CY	$273.65	$257.21	$22.23	$20,658,837
				TOTAL	**$27.55**	**per SF**

Table 9.10 – Construction Cost of Post Tension Structural System

The prices obtained for concrete per cubic yard, rebar per ton, and post tension tendons per pound were multiplied by the amount of these materials on the project and a total material price of $10,221,260 was calculated. When this number is divided by the number of cubic yards of concrete on the job you obtain $273.65 per cubic yard. This number was added to the average costs of labor and equipment and the total cost of $20,658,837 was obtained for the construction of the concrete structural system. This number when divided by the projects 750,000 square feet yields $27.55 per square foot (as seen in *Table 9.10* above).

Figure 9.3 shows a typical tower level with rebar cages for shear walls and columns, part of a concrete deck poured, and exposed PT cables laid out and ready for a concrete pour. *Figure 9.4* shows the use of the Automatic Climbing System (ACS) for the core of the building.

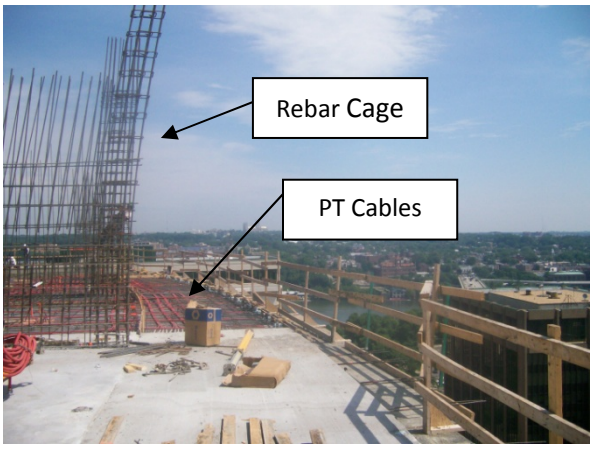


Figure 9.3 – Working Deck

Figure 9.4 – ACS Formwork for Core

9.11.2 Reinforced Concrete Removing One Story

The estimate for the first reinforced concrete system, which includes the removal of one story of the building, can be found below in *Table 9.11 through Table 9.14.* All of the takeoff notes can be found in Appendix D.

Reinforcing Steel			
Area	Amount (Ton)	Cost per Ton	Total Cost
Columns	354	$1,000	$354,200
Shear Walls	1944	$1,000	$1,944,000
Slabs	1065	$1,000	$1,065,000
TOTAL	**3363**		**$3,363,200**

Table 9.11 - Rebar for Reinforced Concrete Slab Removing One Story

Miscellaneous Items			
Item	Amount	Cost per	Total Cost
WWF 6x6 W1.4/W1.4	19,312 SF	$18.05 / CSF	$348,582
WWF 6x6 W2.1/W2.1	53,001 SF	$26.50 / CSF	$1,404,527
TOTAL			**$1,753,108**

Table 9.12 – Miscellaneous Items for Reinforced Concrete Slab Removing One Story

Total Material Cost		
Item	Amount	Total Cost
Concrete	43355 CY	$5,419,369
Reinforcing Steel	3363 Tons	$3,363,200
Miscellaneous Items		$1,753,108
TOTAL		**$10,535,677**
TOTAL PER CY		**$243.01**

Table 9.13 – Total Material Cost

Construction Cost of Reinforced Concrete System (Removing One Floor)						
Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	43355	CY	$243.01	$257.21	$22.23	$22,651,046
				TOTAL	**$30.20**	**per SF**

Table 9.14 – Construction Cost for Reinforced Concrete Slab Removing One Story

The prices obtained for concrete per cubic yard, rebar per ton, and post tension tendons per pound were multiplied by the amount of these materials on the project and a total material price of $10,535,677 was calculated. When this number is divided by the number of cubic yards of concrete on the job you obtain $243.01 per cubic yard. This number was added to the average costs of labor and equipment and the total cost of $22,651,046 was obtained for the construction of the concrete structural system. This number when divided by the projects 750,000 square feet yields $30.20 per square foot (as seen in *Table 9.14* above).

9.11.3 Reinforced Concrete Adjusting Story Heights

The estimate for the second reinforced concrete system, which includes the adjustment of story heights, can be found below in *Table 9.15 through Table 9.18.* All of the takeoff notes can be found in Appendix D.

Reinforcing Steel			
Area	Amount (Ton)	Cost per Ton	Total Cost
Columns	354	$1,000	$354,200
Shear Walls	1944	$1,000	$1,944,000
Slabs	1100	$1,000	$1,100,000
TOTAL	**3398**		**$3,398,200**

Table 9.15 - Rebar for Reinforced Concrete Slab Adjusting Story Height

Miscellaneous Items			
Item	Amount	Cost per	Total Cost
WWF 6x6 W1.4/W1.4	19,312 SF	$18.05 / CSF	$348,582
WWF 6x6 W2.1/W2.1	53,001 SF	$26.50 / CSF	$1,404,527
TOTAL			**$1,753,108**

Table 9.16 - Miscellaneous for Reinforced Concrete Slab Adjusting Story Height

Total Material Cost		
Item	Amount	Total Cost
Concrete	44072 CY	$5,508,994
Reinforcing Steel	3983 Tons	$3,398,200
Miscellaneous Items		$1,753,108
TOTAL		**$10,660,302**
TOTAL PER CY		**$241.88**

Table 9.17 – Total Material Cost

Construction Cost of Reinforced Concrete System (Adjusting Story Height)						
Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	44072	CY	$241.88	$257.21	$22.23	$22,975,867
				TOTAL	**$30.63**	**per SF**

Table 9.18 – Construction Cost for Reinforced Concrete Slab Adjusting Story Height

The prices obtained for concrete per cubic yard, rebar per ton, and post tension tendons per pound were multiplied by the amount of these materials on the project and a total material price of $10,660,302 was calculated. When this number is divided by the number of cubic yards of concrete on the job you obtain $241.88 per cubic yard. This number was added to the average costs of labor and equipment and the total cost of $22,975,867 was obtained for the construction of the concrete structural system. This number when divided by the projects 750,000 square feet yields $30.63 per square foot (as seen in *Table 1.18* above).

After calculating the cost differences in the systems, below in *Table 1.19* is a summary of the final cost for each structural system (both as a total cost and a cost per square foot). The table also lists how many units each structural system would allow to be built based on the total height restriction of the building.

Structural Systems Cost Comparison for Turnberry Tower Arlington			
Structural System	Residential Units	Total Structural Cost	Cost per SF
Post Tension Concrete	247	$20,658,837	$27.55
Reinforced Concrete (Removing 1 Story)	235	$22,651,046	$30.20
Reinforced Concrete (Adjusting Story Height)	247	$22,975,867	$30.63

Table 9.19 – Comparison of Costs for Structural Systems

Note: The cost per square foot is a bit higher than expected for this building (average is around $25/SF). This may be caused to the rise in prices for steel and material transportation to the site. The formwork used on this project is also more expensive than typical formwork.

9.12 Conclusion & Recommendation

From the schedule analysis, it was seen that all of the systems were basically identical and took the same amount of time to construct. Not enough time would be saved to come up with a definitive reason to use one system over another.

The post tension concrete option gives the best cost result. It will cost approximately $20.7 million and will provide the owner with all of the desired units at their desired heights. The next best option is the

reinforced concrete option with removing one story. This option will cost $22.7 million. Unfortunately this option has to cut 12 units out of the building. The most costly option will be the reinforced concrete with adjusting the story heights. This option will cost approximately $23 million and will provide all of the units desired by the owner, but at a reduced floor to ceiling height.

The more important items to compare are how much the reinforced concrete systems would cost compared to the post tension system, and the problems associated with its construction. The post tension concrete system cost approximately $20.7 million to construct, which includes $100,000 to fix and remediate the damage done by broken tendons. This is far less than the other systems proposed.

The other costs that go along with a tendon failure are not able to have a cost associated. Inspectors may feel obligated or pressured from local building officials to inspect the building more thoroughly. This could delay the construction schedule a few days. Broken tendons can lead to bad publicity in the construction industry. If a developer is thinking about putting up a new post tension building, and they have heard about the company's poor reputation in managing these types of buildings in the past, it could be the reason not to hire that company.

Luckily for Turnberry Tower Arlington, the local building officials did not delay the schedule significantly so no time was lost on construction. To make sure that the window wall subcontractor did not hit any more post tension tendons, they started to use a Ferroscan unit. This unit would tell the user precisely where all of the tendons and rebar were located in the slab. Everyone that was drilling into the slab was required to attend a training session on post tension tendons and how to properly use the Ferroscan unit.

If the decision was made to change to one of the reinforced concrete systems, the problem of the overall building height would need to be addressed. Because the reinforced concrete slabs would add 4 inches per floor to the building, the additional 9 feet would need to be taken into account. Presently with the post tension concrete design, the final building height would be at 409.70 feet, which is within 1/8 of an inch of the allowable height in the area.

The first thought is to attempt to make up the 9 feet by squeezing more space out of the plenum area. Unfortunately for this project, most of the space has vaulted ceilings that extend all the way to the slab above. That would mean that either of the scenarios would need to take place to use reinforced concrete; change the floor to ceiling heights in the units to make up the additional 9 feet, or take out one floor to make up the 9 feet.

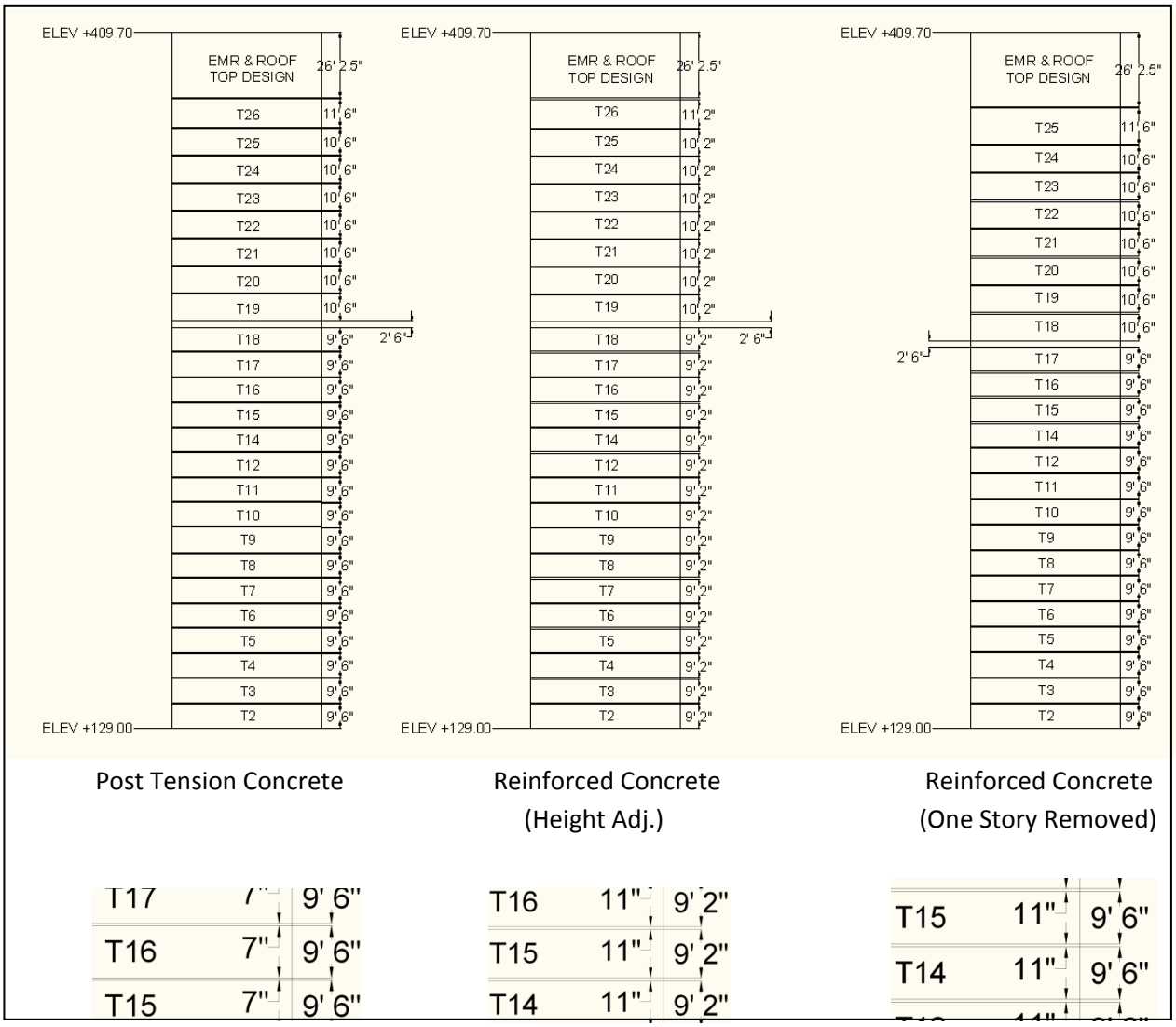


Figure 9.5 – Comparing Structural Systems

The above *Figure 9.5* compares the three different systems visually. The left structure is the tower erected in the post tension concrete with a floor to ceiling height of 9'6" with a 7" slab. This tower has 25 floors. The middle structure is the tower erected in reinforced concrete with a floor to ceiling height of 9'2" with an 11" slab. This tower has 25 floors. The structure on the right is the tower erected in reinforced concrete with a floor to ceiling height of 9'6" with an 11" slab. This tower has 24 floors. All three towers start at elevation +129.00 and end at +409.70 which is within the allowable limits.

If the structure in the middle is used, the cost will be greater and the owner will not get the desired ceiling to floor heights, which is a selling point for these units. If the tower on the right is used the owner will achieve the desired floor to ceiling heights, but will lose 1 level of rentable units will decrease their profits by $17.6 million.

After reviewing the results for both the schedule and the cost for all of the proposed alternative options (reinforced concrete), I believe that the best option is post tension concrete system, which is the system that was used. If the ceiling to floor height on each level is reduced, the owner will not be as happy because a major selling point of the building is the above average height in each apartment. This method will also add approximately $2.2 million to the building. This cost is more than the mistakes caused by the post tension blowouts. If one floor is removed from the building, all of the floor to ceiling heights will remain, but the owner will lose $17.6 million. This method also costs $2 million more than the post tension system.

Using the post tension system is the cheapest and most efficient way to gain the desired floor to ceiling heights and get the maximum amount of rentable units in the building.

10. Analysis 2 – Supply Water System

(Mechanical Breadth & Critical Industry Issue)

10.1 Introduction

When the developer obtained the finished set of plans from the architect, they went right to the general contractor for any value engineering ideas they had that may help to reduce cost or obtain more LEED points. A big VE item that was added was the Sovent System. This system helped to reduce the amount of waste pipe that was needed in the building by utilizing one stack for the drain, waste, and venting of waste products. I would like to take a closer look at VE ideas for the supply water.

10.2 Problem Statement

I would like to see if any value engineering ideas could have been used on the supply water piping. Then I would like to see if these materials could have saved time on the schedule, reduced the cost of the project, or helped to use fewer harmful products and make the project more LEED friendly.

10.3 Goal

I will start out the research by looking extensively at the existing system in the building which supplies the water to the different units. This system is a hybrid system that uses both copper and CPVC pipe. I will look at both methods of the pipes and see what can be done to speed up the installation process and lower the cost of installation. I will look at an alternative method of soldering the copper pipes, especially with Propress fittings, and see if prefabrication is an option for this project.

After the redesign of the system is proposed, I will check this new system to the existing system and see if there is any cost saving or schedule reduction. A LEED analysis will be performed to see how beneficial the new system may be, and what impact it played on gaining points.

10.4 Research Steps

1. Research the existing system by interviewing the MEP Engineer, general contractor, and the owner's representatives. I will also look at construction progress photos to learn as much as possible.
2. Speak with other members of the construction and design community to learn about what products could be used to help speed up and/or reduce project cost.
3. Redesign the system using these new products and possible prefabrication options (Mechanical Breadth & Critical Industry Issue).
4. Compare the two systems in a cost and schedule analysis.
5. Learn what impact the redesigned system would have on obtaining LEED points.
6. Recommendation & Conclusion

10.5 Tools

1. LEED Point Checklist
2. R.S. Means Cost Analysis
3. Microsoft Excel
4. Websites & Engineering Journals
5. Arlington Country tax rebate information
6. National Plumbing Code
7. MEP Engineer, General Contractor, and Owner's Representatives

10.6 Expected Outcome

I expect that by using materials such as the Propress fittings, and utilizing construction techniques such as prefabrication, the schedule should accelerate the installation of the supply water system. I do think that the initial cost will increase because the Propress fittings will be more expensive, but I believe that the cost for the fittings will be offset by the labor cost for installation. I do expect to gain more LEED points because the harmful glues and soldering that contains VOC's will not have to be used if the Propress fittings are used.

10.7 Existing Supply Water System - CPVC

The supply water system that was constructed for Turnberry Tower Arlington was a hybrid of copper pipe and CPVC pipe. The CPVC branches off of the copper riser pipes and runs directly into the residential units.

The CPVC pipe varies in size in the units between ½", ¾" and 1" diameter pipes. The pipe is connected with different elbows, tees, and reducers that are cemented together with glue. The glue has a VOC content that was said to be within the limits to achieve a LEED rating.

The pipes that are running above the finished ceiling in the units are connected with hangers. These hangers are connected to the above concrete deck with the use of the embeds that were placed during concrete erection. The picture below in Figure 10.1 shows the CPVC supply water pipe with hangers

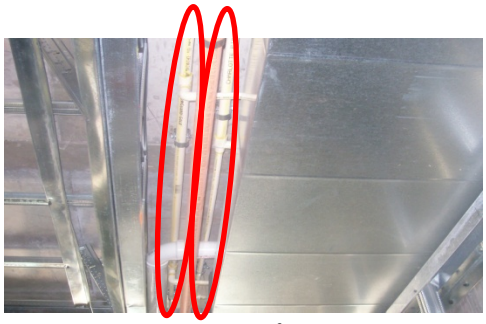


Figure 10.1 – Use of CPVC Pipe

10.8 Use of Propress Supply Water System

An alternative system that is becoming well known is the Propress system. This system, in place of a traditional PVC or CPVC piping system, uses copper pipes to run water throughout the building. *Figure 10.2* shows different parts of the system that can be used.

Figure 10.2 – Propress System

What makes the Propress system different from the traditional copper pipe system is that it eliminates the need for soldering the pipes. The fittings are a clean and simple way to connect the pipe and they only need the use of a special drill to complete the connection. This eliminates the use of an expensive person to solder which in turn saves money . It also saves time on scheduling in order to complete the installation. This will save time and money since much more piping can be installed in the same amount of time. *Figure 10.3* shows the three stop process to connect ends of pipes.

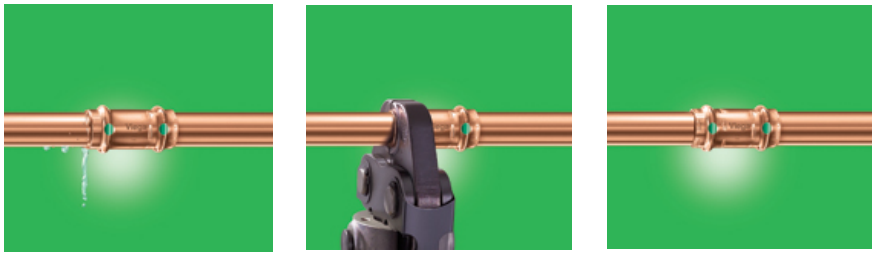


Figure 10.3 – Installing Propress Fittings

10.9 Redesigning the CPVC System Utilizing the Propress System

With the help of the mechanical subcontractor, I was able to redesign the supply water system using the Propress system for a typical residential unit in the building. The takeoff notes can found below in *Table 10.1*. The complete takeoff notes can be found in Appendix E. The price used for copper was $3.10 which was the price of copper in 2006 when the original bids were estimated for this project.

Propress System (2006)				
Item	Mat. Cost	Total Hrs.	Labor Cost	Total Cost
Pipe	$956.42	10	$648	$1,604
Fittings	$2,010.92	41	$2,735	$4,746
Hanger Components	$405.87	34	$2,261	$2,667
Misc. Compenents	$54.57	0	$0	$55
Total	$3,427.78	85	$5,644	**$9,072**

Table 10.1 – Propress System Takeoff Notes Summary

10.10 Comparing the CPVC System vs. Propress System

After taking a look at the numbers I see both systems will utilize the same amount of pipe and same components to make the systems work. The material cost of the CPVC system will be $1670 and the material cost of the Propress System will be $3428. The material cost increase for the Propress System is because of the price of the actual copper.

The material cost is slightly made up for in the installation of the system. The installation of the CPVC system would be $6754, and it would take 102 man hours to complete each residential unit. The Propress system would cost $5644 and would take 85 man hours to complete. The total cost of the CPVC supply water system to install (with labor) per residential unit will be $8424 and the total cost of the Propress system to install (with labor) per residential unit will be $9072. The results can be found below in *Table 10.2*. The price for copper used came from the 2006 cost of copper which was $3.10 per pound. The price for CPVC was approximately the same in 2006 as it is today.

Comparing CPVC vs. Propress Supply Water Systems (Per Typical Unit)									
CPVC System					Propress System (2006)				
Item	Mat. Cost	Total Hrs.	Labor Cost	Total Cost	Item	Mat. Cost	Total Hrs.	Labor Cost	Total Cost
Pipe	$856.48	10	$649	$1,505	Pipe	$956.42	10	$648	$1,604
Fittings	$350.26	58	$3,844	$4,194	Fittings	$2,010.92	41	$2,735	$4,746
Hanger Components	$405.87	34	$2,261	$2,667	Hanger Components	$405.87	34	$2,261	$2,667
Misc. Compenents	$56.90	0	$0	$57	Misc. Compenents	$54.57	0	$0	$55
Total	$1,670	102	$6,754	**$8,424**	**Total**	$3,428	85	$5,644	**$9,072**

Table 10.2 – Comparing Systems

The mechanical subcontractor has used the Propress system before so there would be no cost incurred for the tools to install the equipment and no time lost to account for the learning curve to use the equipment.

10.11 LEED Impact

The CPVC was being assembled and connected using glues and cement agents that give off harmful Volatile Organic Compounds (VOC's). To qualify for the Indoor Air Quality Credit 4.1 (Low Emitting Materials: Adhesives & Sealants), the VOC level given off needed to be below the LEED required levels that were:

Adhesive Primer for Plastic	550 g/L
Contact Adhesive	80 g/L

The actual materials used were not able to be found, but were said to be below the required VOC levels set forth by the specifications and LEED.

Since the products used to connect the CPVC pipes were below the LEED required levels, using the Propress system will not have an impact on gaining LEED points. There is not another point that is able to be obtained for using a product that does not give out a VOC level. Indoor Air Quality Credit 4.1 (Low Emitting Materials: Adhesives & Sealants) will be obtained if either system is utilized.

10.12 Conclusion & Recommendation

The first item to compare is the cost difference between both systems. A takeoff was performed for the supply water system using both the CPVC system and the proposed Propress system for a typical residential unit. The takeoff included material cost, labor hours to install, and installation costs for the entire system per unit. The total cost for the CPVC system would be $2,080,728 and the total cost for the Propress system would be $2,240,784, as seen below in *Table 10.3*.

Cost of Supply Water System to Units in Turnberry Tower Arlington							
CPVC System				Propress System (2006)			
Cost Per Unit	Total Cost for 247 Units	Man Hours per Unit	Total Hours for 247 Units	Cost Per Unit	Total Cost for 247 Units	Man Hours per Unit	Total Hours for 247 Units
$8,424	$2,080,728	102	25,194	$9,072	$2,240,784	85	20,995
Time Savings Using Propress System over CPVC System (Man Hours)							**4,199**
Cost Savings Using Propress System over CPVC System ($)							**($160,056)**

Table 10.3 – Total Cost Comparing Systems

There is a cost increase of approximately $160,000 if the Propress system is used for Turnberry Tower Arlington. The bulk of the cost increase comes from the price of copper in the third quarter of 2006. Even though on average, 17 man hours is saved per residential unit, the cost savings from the less labor does not offset the high cost of copper.

The reason believed that this system was not used was because of the fast rising cost of copper. As the cost of copper keeps rising, so does the likelihood that it will disappear off the site and be stolen. This construction site was constantly monitored so the expensive supplies and materials such as copper would not be stolen. On this project, a dedicated room was built and fit with an alarm so if someone did try to break in and steal the copper they would be caught. In addition, a security guard was on duty after hours to protect the site from theft and damage.

Even if the Propress system was used and the mechanical subcontractor, general contractor, and architect wanted to take the chance that copper would not have been stolen, the project would cost much more than the CPVC system. At the beginning of construction in 2006, the price of copper was around $3.10 a pound. No one could tell if the price of copper was going to continue to rise or start to decrease because of the huge construction boom in both the Unites States as well as overseas in places like Dubai and China.

Since Turnberry Tower Arlington is going for a LEED certication, a reason to pay the additional $160,000 would be to gain the extra LEED point that may have come with using the Propress system. To obtain the Indoor Air Quality Credit 4.1 (Low Emitting Materials: Adhesives & Sealants), the VOC level of the adhesive materials used to connect the piping needed to be below the given levels. The Propress system utilizes a mechanical bond so no VOC's are released in the air, but the adhesives and cement products that would be used for the CPVC system would be below the required LEED levels. Thus, both systems would meet the LEED requirements so that would mean to go with the less expensive system.

Even though the Propress system was a viable option during the beginning of construction, because of the price of copper in 2006, using CPVC Pipe for the supply water system of Turnberry Tower Arlington was the right decision. Currently in the first quarter of 2009, the cost of copper is significantly lower, and when the numbers are run the cost of the Propress system would be significantly less. Thus, if Turnberry Tower Arlington was being designed today, I would recommend using the Propress system for the supply water system.

11. Analysis 3 – Site Logistics Plan for Drywall Deliveries

11.1 Introduction

Every construction project requires a site logistics plan that enables the building to be built. The site logistics plan for this project utilizes one road on the north side of the site for most of the site deliveries, as well as the access road for all of the concrete trucks to stage. During certain times of the week while deliveries and trucks are trying to move around, traffic around the site was slowed down which caused law enforcement in the area to get involved. Stop work orders by the county were threatened a few times.

11.2 Problem Statement

There were always problems with drywall deliveries. The drywall deliveries would always need to be planned to occur around the concrete deliveries. This was due to the fact that there was so much drywall on this project; many of the deliveries had to occur outside the normal work day. This caused overtime to be paid to the workers that were forced to work during night and weekend deliveries.

11.3 Goal

I would like to research why the site logistics plan was created the way it was and explore other options that would allow for drywall to deliveries to occur simultaneously while concrete is being delivered. Utilizing the other parts of the site should allow for this to be possible.

11.4 Research Steps

1. Speak to the superintendent who created the site logistics plan and learn about their logic.
2. Talk to Arlington County in Virginia and learn about local ordinances and requirements for construction sites and see if another loading dock would be allowed.
3. Propose another site plan that would help deliveries for the drywall subcontractor.
4. Compile the research and compare the new site plan to the existing site plan and see if it would help to reduce overtime costs.
5. Conclusion & Recommendation

11.5 Tools

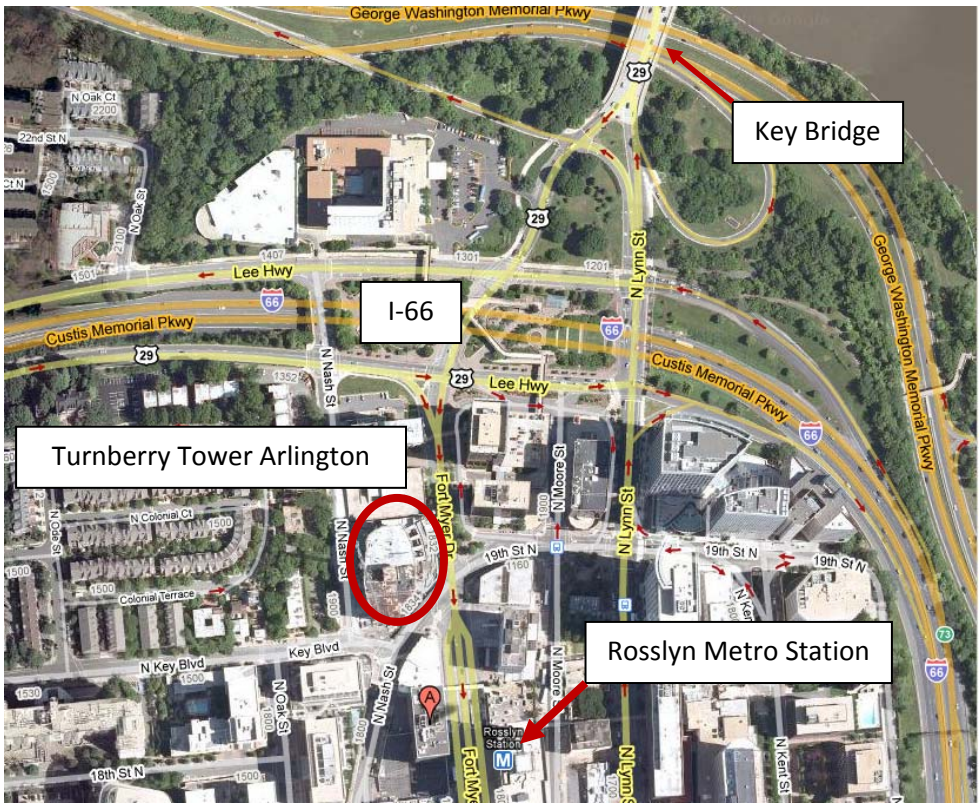
1. General Contractor Personnel
2. Drywall Subcontractor
3. Arlington County Code Officials
4. Microsoft Powerpoint
5. Adobe Fireworks

11.6 Expected Outcome

After working on the project site for two summers and seeing how congested the delivery lane was because of all the deliveries, I believe re-evaluating the site logistics plan would increase material delivery during the normal work day. Utilizing the other main road that surrounds the site, another site logistics plan can be developed that allows for more deliveries including the drywall, which would then reduce the need for deliveries on the weekends and reduce the cost of overtime.

11.7 Understanding the Existing Site Plan

To better understand the area, below in *Figure 11.1* is an image from googlemaps.com that shows the surrounding Rosslyn area of Arlington Virginia.



Below in *Figure 11.2* is the site plan that was used for the construction of Turnberry Tower Arlington. (An enlarged version of the site plan below can be found in Appendix F.)

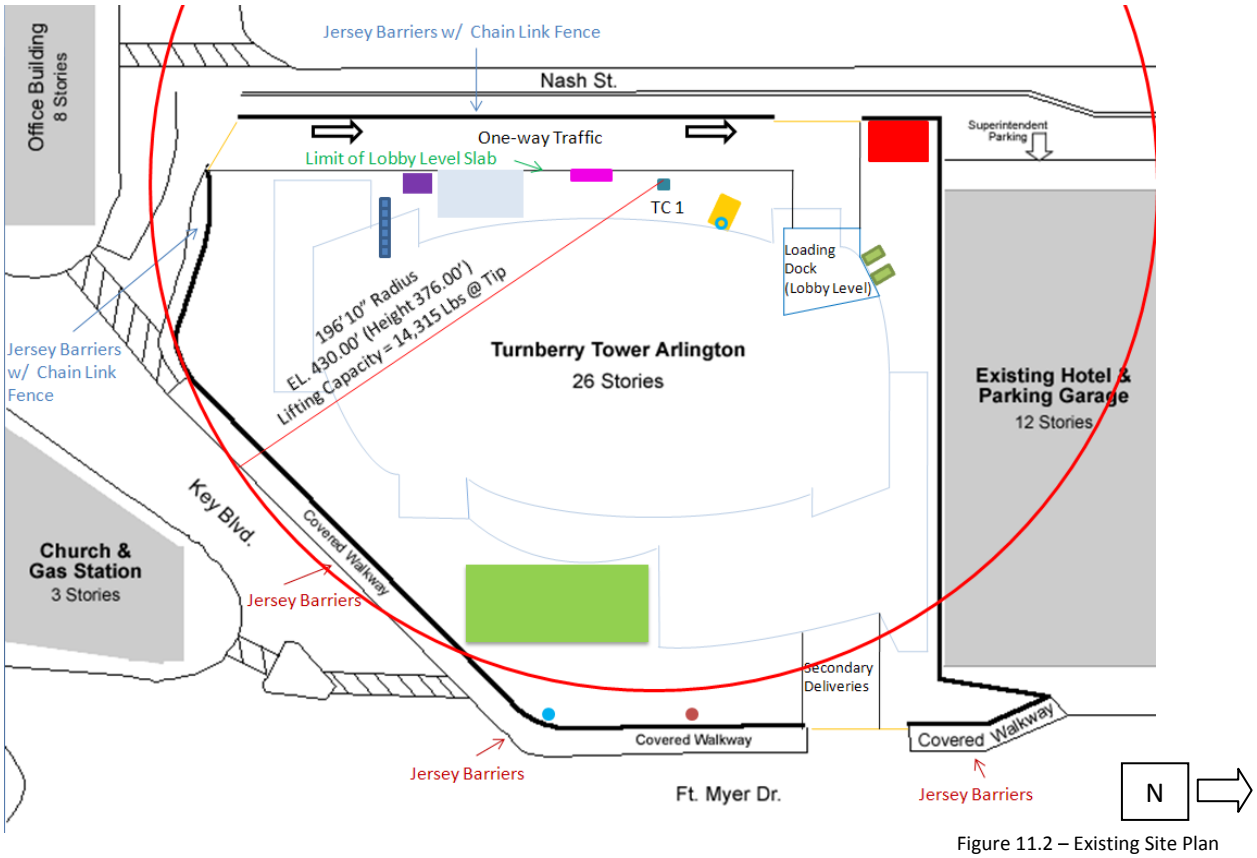


Figure 11.2 – Existing Site Plan

Looking at the satellite image and the site plan, it is easy to see that this site is in a very congested neighborhood with tall buildings and main roads that help connect this area directly to Washington, D.C. The ability to close roads and sidewalks in the area required constant communication with traffic officials working for the County of Arlington at a hefty cost.

In order to maximize productivity around the site and allow for the least disturbance to traffic flow around the site, the sidewalk on the construction site side of Fort Myer Drive was covered over and included behind the temporary covered sidewalk. Additionally, one lane of traffic was closed on Fort Myer Drive and the temporary covered sidewalk was built to allow for undisturbed pedestrian flow around the construction site.

Since Fort Myer Drive is a heavily traveled road, the covered sidewalk was built with jersey barriers and 4x4's place 18 inches on center with a 20 year built up roof, which you can see below in *Figure 11.3*.

Figure 11.3 – Covered Walkway

On the west side of the site there were three lanes, one lane of parking and two travel lanes. The general contractor decided to rent out the lane of parking meters on a renewable one year lease and then rerouted the traffic into the other two lanes that were available. The rented out parking meters allowed for the material delivery lane that can be seen in Figure 11.2.

The site was secured completely around the perimeter. On the north side was an existing parking garage that belonged to the hotel next door. On the east and south of the site was the covered walkway that can be seen in *Figure 11.3* above. On the west of the site, where the material delivery lane was located, jersey barriers were installed which contained 12 foot high chain link fence with barbed wire on top.

The site plan that is seen in Figure 11.2 was used for two primary reasons. The county was very strict with enforcing that vehicular traffic could not be impacted, especially during rush hour. That eliminated the use of Fort Myer Drive as a main point of access because deliveries would need to brought to site starting early in the day. Losing two hours during the designated rush hour would greatly affect the schedule. By using Nash Street on the west side of the site, deliveries would be allowed to begin earlier.

The second reason that this site plan was used was because of the location of the building on the west side of the site. This side led directly into the building's main lobby without having to deal with the slope of the land and gave access to the building's loading dock. If you were to stand on grade on the Fort Myer Drive side of the building, you would actually be 3 levels below the lobby as seen below in Figure 11.4.

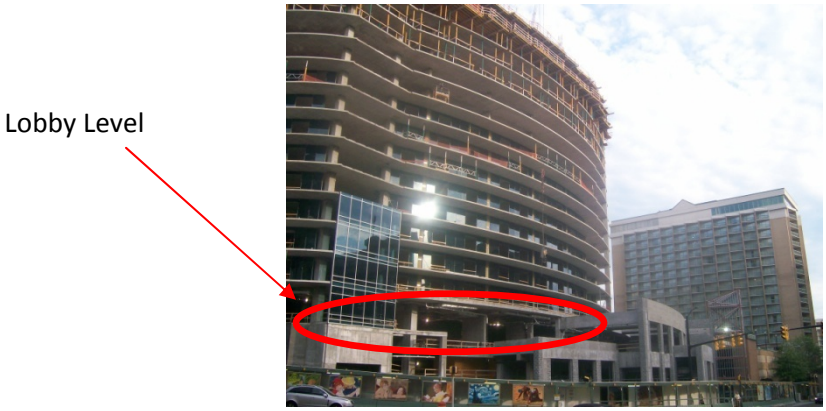


Figure 11.4 – Standing on Fort Myer Drive

Using Nash Street was the best way to utilize the lay of the land and the features of the building being constructed. The loading dock was used to take deliveries that semi-trucks were able to back into the loading dock. The material hoist was located on top of the material hoist. As you can see from the site plan above in Figure 11.2, all of the necessary services for material deliveries were located around this material delivery lane.

11.8 Referring to Arlington County About Logistic Changes

Fort Myer Drive is deemed by Arlington County as a main access road because it leads directly from Key Bridge into Arlington County. This road is heavily used at all times of the day and backed up during peak hours which include rush hour in both the morning and afternoon.

In order to be able to use Fort Myer Drive to accept any deliveries on a regular basis, a plan would need to be developed that would assure county officials that more vehicular traffic would not be created. The county was very upset during excavation of the site because the Fort Myer Drive side of the site was used as the main access point for all dump trucks entering and exiting the site.

These dump trucks would start early in the morning, during rush hour, and would cause delays that would extend back all the way over Key Bridge. This brought law enforcement on the site who threatened to shut down the site with a stop work order. Thus, any logistic plan would be very carefully reviewed by the county and would be subject to suspension if any problems occurred that caused traffic.

11.9 Modifying the Site Plan for the Drywall Subcontractor

After studying the site plan used and noticing how much overtime was being put in by some of the trades to stock materials, especially the drywall subcontractor, I have come up with a modification of the existing site plan that utilizes the space on Fort Myer Drive more efficiently.

Below in *Figure 11.5* is the proposed modification to the existing site plan. As you can see, the Fort Myer Drive section has been modified with 2 swing gates that will allow semi-trucks to enter and exit the site with no problems. This site plan can also be found in Appendix F.

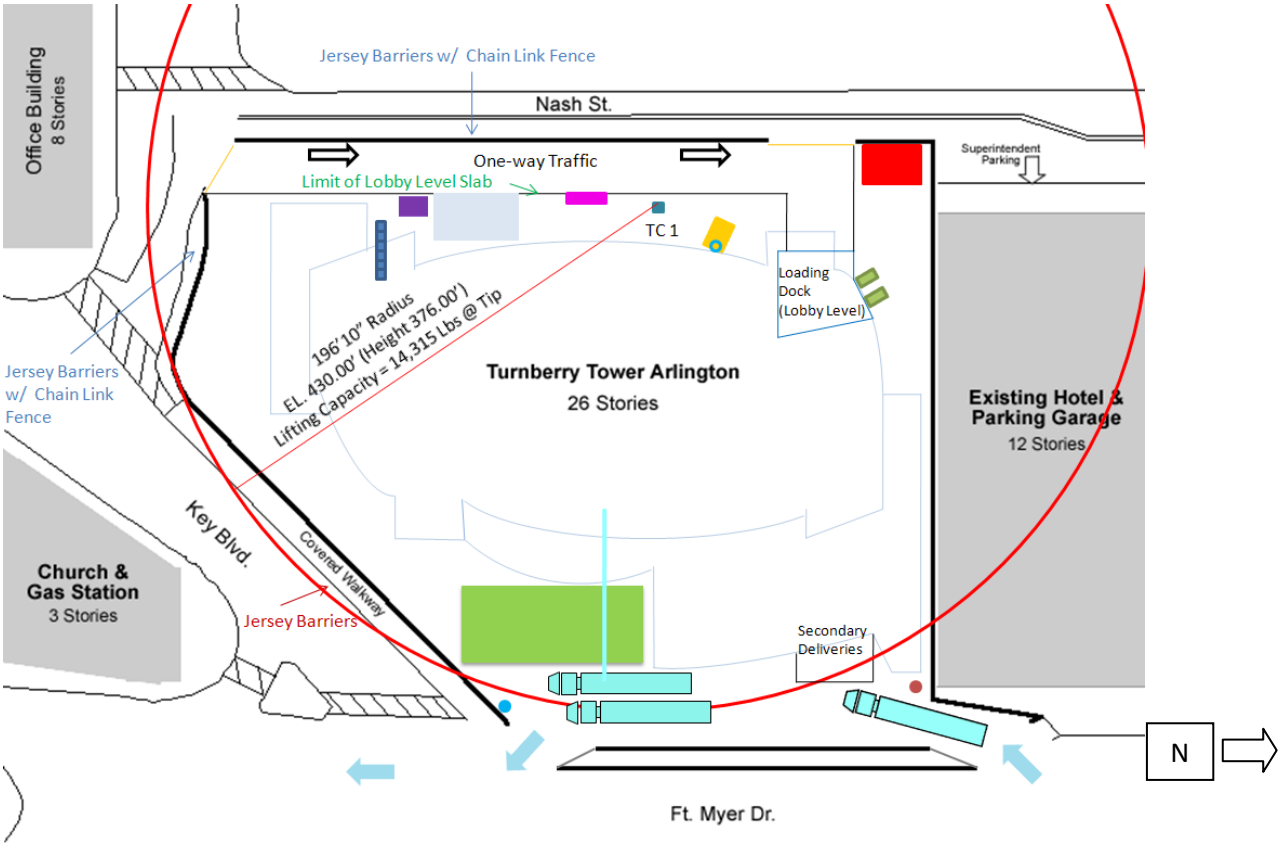


Figure 11.5 – Modification to Existing Site Plan

The material hoists are located on the other side of the building so there is no way to loads the drywall directly into the building at this level. The solution to this problem is to load the drywall on the crane on the back of a 42' drywall truck. As you can see in the above Figure 11.5, the drywall truck will stay stationed on site while drywall is being delivered via other flatbed trucks.

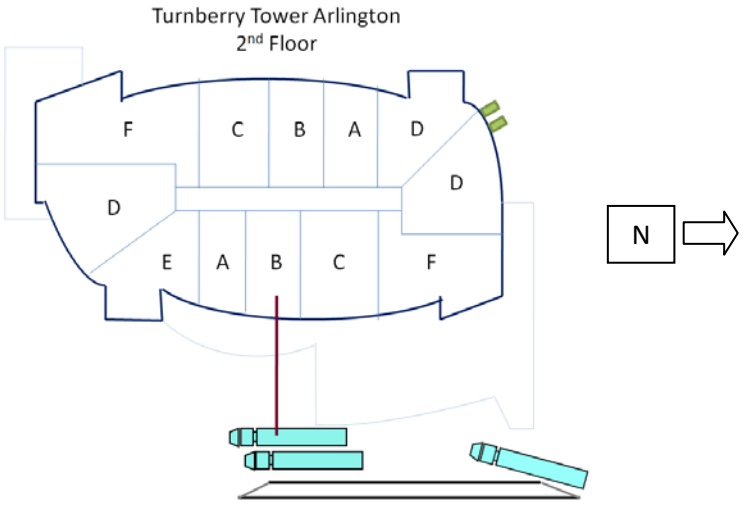


Figure 11.6 – 2nd Floor of Turnberry Tower Arlington

As can be seen in *Figure 11.6* above, the materials will be lifted up to the 2nd floor of the building into residential unit B East. To allow for the materials to be loaded through this unit, the exterior railing and the window wall for this unit will not be installed until after the concrete erection is complete and the drywall can be delivered to site via the material delivery lane. In place of the window wall, heavy plastic will be hung to keep out moisture from the inside of the building and OSHA certified rope will be hung in the place of the railing.

Above in *Figure 11.6*, it shows where the material will be brought into the 2nd floor of the building, but there exists a problem in being able to get the drywall from the access point to the material hoists. The material hoists are in the upper right hand corner and colored green. Below, *Figure 11.7* shows how I plan to get the drywall to the material hoists.

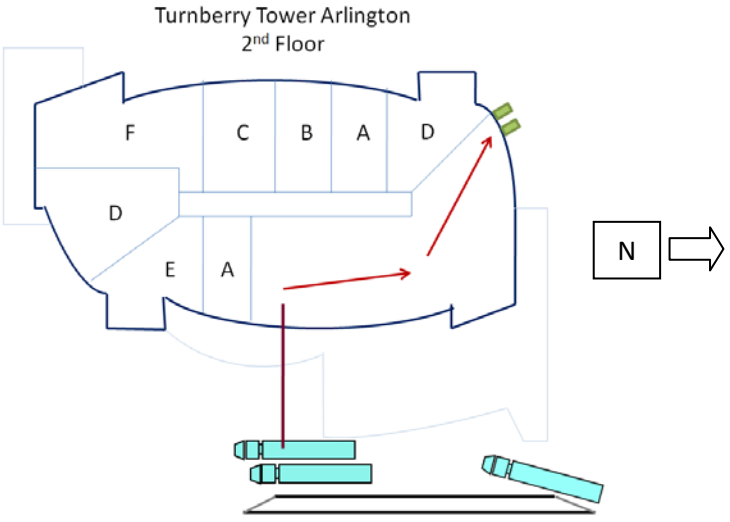


Figure 11.7 – Propose 2nd Floor of Turnberry Tower Arlington during Drywall Delivery

By not framing out and completing some of the units on the 2nd floor, it will allow for the drywall to be carted from the point where it is dropped off from the crane to the access point for the material hoists. Once the concrete erection is complete and the drywall can be delivered via the material delivery lane, the 2nd floor can be finished. Both *Figure 11.6 and 11.7* can be found in Appendix F.

11.10 Comparing Site Plans

The existing site plan that was used for construction of the building only allowed for one main delivery lane. Concrete had the primary use over this lane to erect the concrete decks. When the concrete was not being brought to site, other trades could bring in their materials. While concrete was being erected and other trades needed to bring in materials to keep up with the schedule, trades like the drywall subcontractor resorted to stocking the building with drywall after normal working hours or during the weekends. This resulted in having to pay out overtime in some cases.

If the proposed site logistics plan is used by the drywall subcontractor and helps to reduce the amount of overtime needed, it will help save money. Below in *Table 11.1* is an example of how the proposed site logistics plan would help this project for stocking a certain amount of drywall boards. A standard labor rate of $22 per person per hour is used and time and half is used for overtime. It is assumed that the modified site logistics plan only increases the productivity of stocking materials by 200 drywall boards during a regular 40 hour week and the remainder of the work is done in an overtime period. In this example, the overtime for the proposed site logistics plan would be 1/3 less based on the productivity done during the 40 hour work week.

Existing Site Logistics Plan			
# of Boards Stocked During 40 Hour Week	Cost for 4 Man Crew (Standard Wage)	# of Boards Stocked During Overtime	Cost for 4 Man Crew (1.5 Standard Wage)
400	$22 per person per hour	600	$33 per person per hour
Total Cost for 4 Man Crew for 1000 Boards:			$5,632
Proposed Site Logistics Plan			
# of Boards Stocked During 40 Hour Week	Cost for 4 Man Crew (Standard Wage)	# of Boards Stocked During Overtime	Cost for 4 Man Crew (1.5 Standard Wage)
600	$22 per person per hour	400	$33 per person per hour
Total Cost for 4 Man Crew for 1000 Boards:			$4,880

Table 11.1 - Existing vs. Proposed Site Plan (OT needed for Proposed Site Plan)

Assuming the productivity only increases by 20% during the 40 hour work week, a savings on labor over $750 will be credited to the project per 1000 boards. This project has 91,000 sheets of drywall to load into the building.

If the site logistics plan works and can save the project from having to pay any overtime to stock drywall, the results can be seen below in *Table 11.2*.

Existing Site Logistics Plan			
# of Boards Stocked During 40 Hour Week	Cost for 4 Man Crew (Standard Wage)	# of Boards Stocked During Overtime	Cost for 4 Man Crew (1.5 Standard Wage)
400	$22 per person per hour	600	$33 per person per hour
Total Cost for 4 Man Crew for 1000 Boards:			$5,632
Proposed Site Logistics Plan			
# of Boards Stocked During 40 Hour Week	Cost for 4 Man Crew (Standard Wage)	# of Boards Stocked During Overtime	Cost for 4 Man Crew (1.5 Standard Wage)
1000	$22 per person per hour	0	$33 per person per hour
Total Cost for 4 Man Crew for 1000 Boards:			$3,520

Table 11.2 – Existing vs. Proposed Site Plan (No OT for Proposed Site Plan)

A savings can be seen in this example of a little more than $2000 per 1000 drywall boards. This project has 91,000 sheets of drywall to load into the building.

It is seen in the above examples that on a building such as Turnberry Tower Arlington that requires drywall to be constantly stocked that if another access point is created to deliver drywall during the normal 40 hour week that it will save the project overtime costs tremendously.

The biggest comparison to the two site plans is that the proposed site plan, seen in Figure 11.5, requires 2 new access points to allow these drywall trucks to enter and exit the site. This will require the need for a flagman to help these trucks exit the site onto the heavily trafficked Fort Myer Drive.

10.11 Conclusion & Recommendation

The biggest hurdle to overcome that would make it possible to modify the existing site logistics plan would be to get Arlington County to approve the plan and agree that it would not create any more traffic around the site than there already is. Once the county is satisfied with the modified plan, the analysis shows how another delivery point for drywall would help.

Not completing part of the 2nd level of the building will make the 3rd level of the building all that much more important. The 2nd level was going to be used as the mock up to identify and MEP clashes and have them corrected on the upper floors. If the modified site plan is used, the third floor would have to be the first floor completed on the SIP Schedule.

The SIPS was created so that concrete erection was above a few floors above the deck that was to be roughed in with drywall tracks. Even though risers were attached, this process eliminated the chance that reshores would be in the way of drywall studs and MEP could be installed with nothing in the way.

Since the reshores only had to be placed 3 floors below the working deck, the existing SIPS has the first activity occurring on the 2nd floor when the 7th floor is being erected. If instead work began on the 3rd floor during this week, the 2nd floor could be complete later on in the project and no time will be lost on the SIPS. This would allow the modified site plan to be used with no schedule impact.

The material hoist time would need to be divided up a little more thoroughly. With the existing site plan, whichever trade is in the loading dock would have access to the material hoist. If there are two points were materials are being delivered, the time on the hoist would need to be divided, or since there are two hoists each material would get only one hoist instead of two. Luckily for the drywall, if this modified site plan is used, the second floor will remain relatively empty which will allow for some material storage. This can allow for use of the material hoist while concrete erection is occurring and there are no other deliveries.

Looking at the examples that show money could be saved, and showing that the schedule would not be impacted from this modified site plan, I recommend that this site plan be implemented on this project if Arlington County approves the plan.

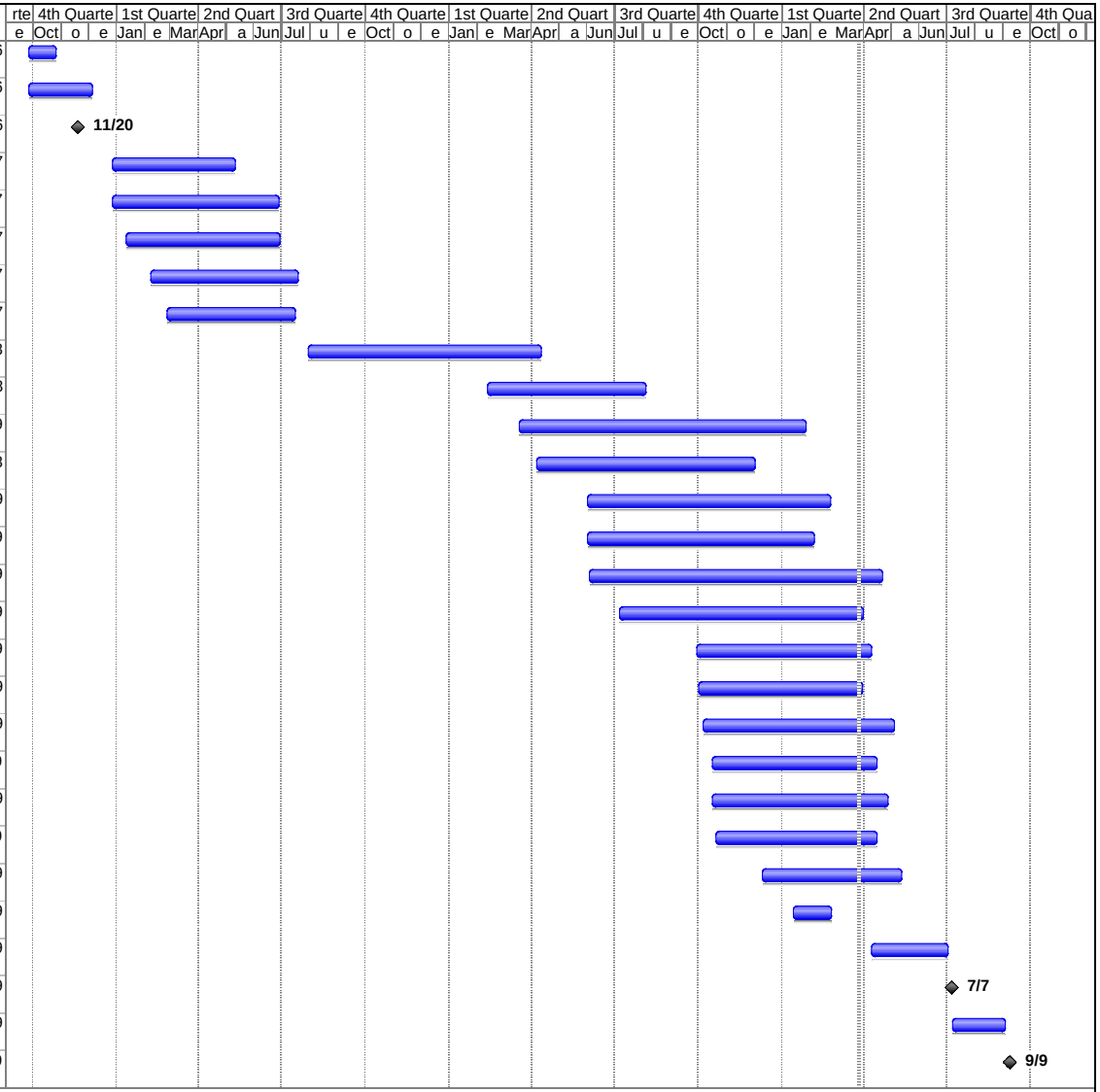
Appendix A

Project Schedules

Contents:

- Project Summary Schedule
- Short Interval Production Schedule (SIPS)
- Detailed Project Schedule

ID	Task Name	Duration	Start	Finish
1	Abatement - Existing Structure	22 days	Wed 9/27/06	Thu 10/26/06
2	Demolition - Existing Structure	50 days	Wed 9/27/06	Tue 12/5/06
3	Notice to Proceed	0 days	Mon 11/20/06	Mon 11/20/06
4	Line Drill & Pile Work	97 days	Thu 12/28/06	Fri 5/11/07
5	Soldier Piles and Underpinning	131 days	Thu 12/28/06	Thu 6/28/07
6	Sheet & Bracing - Elevation 110 to Subgrade	121 days	Fri 1/12/07	Fri 6/29/07
7	Structure Excavation	116 days	Thu 2/8/07	Thu 7/19/07
8	Soil & Rock Excavation 90 to subgrade	101 days	Mon 2/26/07	Mon 7/16/07
9	Concrete Foundation through Level 1	184 days	Tue 7/31/07	Fri 4/11/08
10	Masonry	124 days	Wed 2/13/08	Mon 8/4/08
11	MEP Rough In / Risers	225 days	Wed 3/19/08	Tue 1/27/09
12	Concrete Level 2 through Roof	172 days	Mon 4/7/08	Tue 12/2/08
13	Curtain Wall	191 days	Mon 6/2/08	Mon 2/23/09
14	Drywall	179 days	Mon 6/2/08	Thu 2/5/09
15	Waste & Recycle System Installation	230 days	Wed 6/4/08	Tue 4/21/09
16	MEP Horizontal and Trim	192 days	Mon 7/7/08	Tue 3/31/09
17	Tower Elevators	138 days	Tue 9/30/08	Thu 4/9/09
18	Doors and Hardware	128 days	Thu 10/2/08	Mon 3/30/09
19	Painting	150 days	Tue 10/7/08	Mon 5/4/09
20	Install Kitchen and Vanity Cabinets	129 days	Fri 10/17/08	Wed 4/15/09
21	Tile Walls and Floors	137 days	Fri 10/17/08	Mon 4/27/09
22	Stone Counter Tops (Kitchen and Bathroom)	127 days	Tue 10/21/08	Wed 4/15/09
23	Install Signs & Identification	109 days	Thu 12/11/08	Tue 5/12/09
24	Install Roof - Building Watertight	30 days	Wed 1/14/09	Tue 2/24/09
25	Life Safeties and Building Commisioning	60 days	Fri 4/10/09	Thu 7/2/09
26	Substancial Completion	0 days	Tue 7/7/09	Tue 7/7/09
27	Post Completion Testing & Commissioning	42 days	Wed 7/8/09	Thu 9/3/09
28	Certificate of Occupancy	0 days	Wed 9/9/09	Wed 9/9/09



Turnberry Tower Arlington
Project Summary Schedule

Task	Summary	Rolled Up Progress	Project Summary		
Progress	Rolled Up Task	Split	Group By Summary		
Milestone	Rolled Up Milestone	External Tasks	Deadline		

Facchina-McG

Turnberry Tower 1881 N. Nash St

9/5/2008

	2008																					
FLOOR	2/25/08	3/3/08	3/10/08	3/17/08	3/24/08	3/31/08	4/7/08	4/14/08	4/21/08	4/28/08	5/5/08	5/12/08	5/19/08	5/26/08	6/2/08	6/9/08	6/16/08	6/23/08	6/30/08	7/7/08	7/14/08	7/21/08
Weeks	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
26																						
25																						
24																						
23																						
22																						SV
21																					SV	FL
20																				SV	FL	FL
19																			SV	FL	FL	WL/H1
18																		SV	FL	FL	WL/H1	H1
17																	SV	FL	FL	WL/H1	H1	H1
16																SV	FL	FL	WL/H1	H1	H1	WD
15															SV	FL	FL	WL/H1	H1	H1	WD	WD
14														SV	FL	FL	WL/H1	H1	H1	WD	WD	WD
12													SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD
11												SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2
10											SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2
9										SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP
8									SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3
7								SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1
6							SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2
5						SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD
4					SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT
3				SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT
2			SV	FL/WL	FL/WL	WL/H1	H1	H1	WD	WD/HR	WD/HR	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT
Weeks	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Structural Build-out	T5	T6	T7	T8	T9	T10	T11	T12	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	MR
												SW										
												SD										

T8

	2008																					
FLOOR	7/28/08	8/4/08	8/11/08	8/18/08	8/25/08	9/1/08	9/8/08	9/15/08	9/22/08	9/29/08	10/6/08	10/13/08	10/20/08	10/27/08	11/3/08	11/10/08	11/17/08	11/24/08	12/1/08	12/8/08	12/15/08	12/22/08
Weeks	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
26				SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	
25			SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	
24		SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	
23	SV	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	
22	FL	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	
21	FL	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	
20	WL/H1	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	
19	H1	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	
18	H1	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	P	P	D2	V1	V2/EH	
17	WD	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	
16	WD	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	
15	WD	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	
14	WD	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB	
12	S1/H2	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB		
11	S1/H2	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB			
10	FP	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB				
9	H3	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB					
8	E1	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB						
7	E2	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB							
6	I/GD	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB								
5	DT	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB									
4	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB										
3	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB											
2	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB									TE			
Weeks	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
Structural Build-out	EF	ER																				

	2008	2009																				
FLOOR	12/29/08	1/5/09	1/12/09	1/19/09	1/26/09	2/2/09	2/9/09	2/16/09	2/23/09	3/2/09	3/9/09	3/16/09	3/23/09	3/30/09	4/6/09	4/13/09	4/20/09	4/27/09	5/4/09	5/11/09	5/18/09	5/25/09
Weeks	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
26	DT	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB										
25	DT	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB											
24	D1	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB												
23	H4/P	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB													
22	P	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB														
21	D2	V1	V2/EH	ET	T1	CL/PL	PS/TB															
20	V1	V2/EH	ET	T1	CL/PL	PS/TB																
19	V2/EH	ET	T1	CL/PL	PS/TB																	
18	ET	T1	CL/PL	PS/TB																		
17	T1	CL/PL	PS/TB																			
16	CL/PL	PS/TB																				
15	PS/TB																					
14																						
12																						
11																						
10																						
9																						
8																						
7																						
6																						
5																						
4																						
3																						
2						FE												TCO1				
Weeks	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
Structural Build-out																						

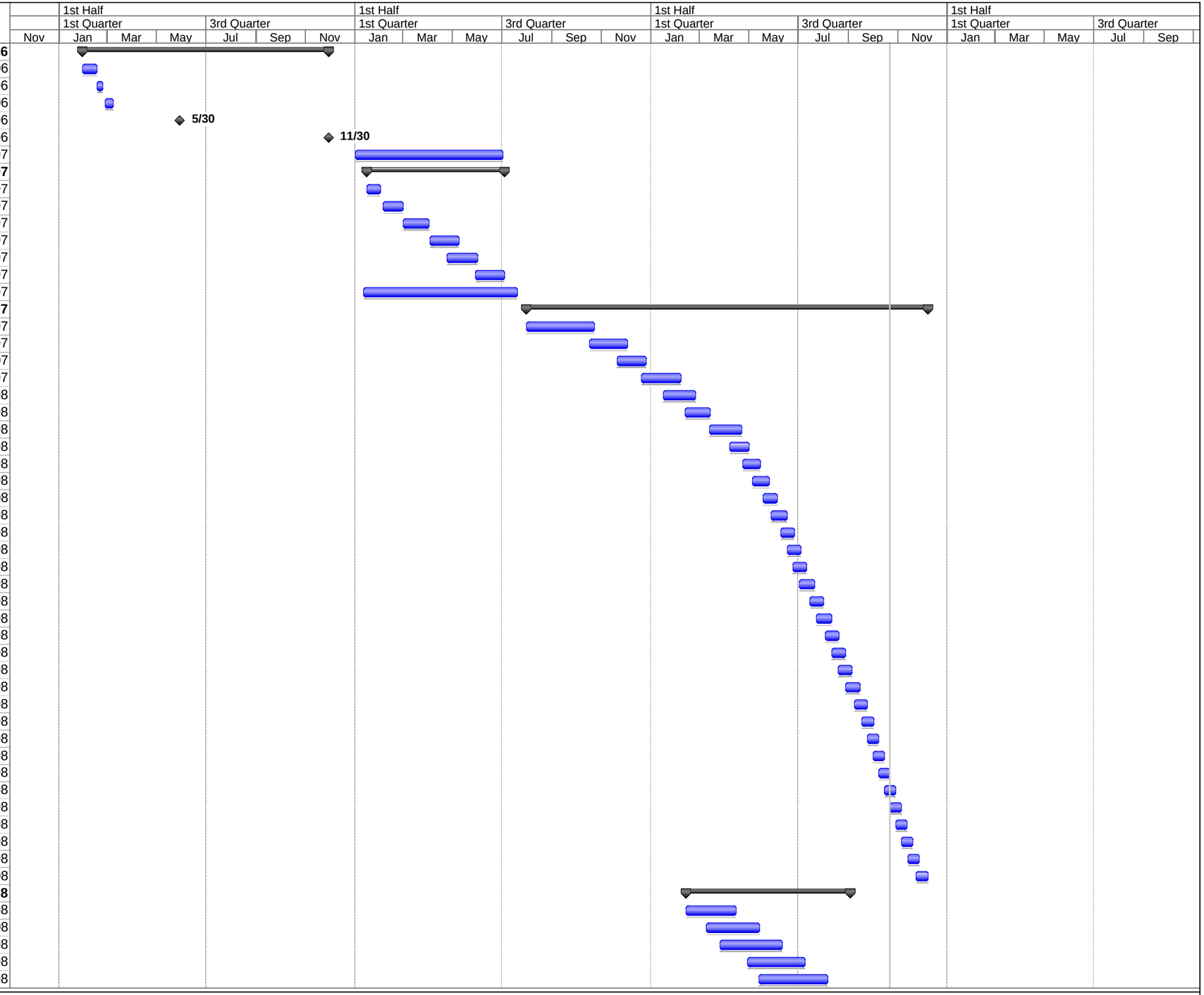
SV	SV = SURVEYOR FOR PRIMARY CONTROL
FL	FL = FLOOR LAYOUT, INSTALL TOP TRACK
WL	WL = WINDOW LAYOUT
H1	H1 = DUCT WORKS ROUGH-INS, HVAC/ PLUMBING ROUGH-INS
WD	WD = INSTALL WINDOW WALLS, CURTAIN WALL
HR	HR = INSTALL BALCONY RAILING/ DIVIDERS
S1	S1 = FRAME, BLOCKING, DOOR FRAME CORR.
H2	H3 = SET TUBS
FP	FP = SPRINKLER ROUGH-IN UNITS/CORRIDOR
H3	H3 = PLUMBING WALL ROUGH-INS, SET SHOWER DIVERTERS
E2	E2 = ELECTRICAL WALL RI, CONTROL WIRING TO FCU STAT
E2	E2 = ELECTRICAL WALL RI, CONTROL WIRING TO HP STAT
I	I = INSPECTIONS, WALL INSULATION, INSULATE PLMB DW RISERS

DT	DT = DRYWALL & TAPE; 3RD WEEK WINDOW TRIMS
D1	D1 = PRIME PAINT WALLS/ UNIT CEILINGS/ DOORS
H4	T1 = SET AND HOOK UP HP'S, WATER HEATERS
P	P = INSTALL TILE FLOORS & WALLS
D2	D2 = INSTALL VANITIES & KITCHEN CABINET FRAMES
V1	V1 = INSTALL STONE VANITY TOPS/ KITCHEN STONE TOPS, SHOWER ENCLOSURES & MIRRORS
V2	V2 = INSTALL PLUMBING FIXTURES
EH	EH = ELECTRICAL TRIM-OUT, WIRE HP'S, WIRE WATER HEATERS AND FIXTURES, GRSD'S, ATC TRIMS
ET	ET = INSTALL APPLIANCES, CABINETS FACES/DOORS/DRAWERS
T1	T1 = INSTALL DOORS, HARDWARE & TOILET ACCESSORIES
PL	PL = CONTRACTOR PUNCH
PS	PS =SIGNS, FIRE EXTINGUISHERS at CORRIDORS
TB	TB = TEST & BALANCE

MILESTONE LEGEND

TCO	TCO = 1st TCO
SW	SW = Milestone to have shaft ready for first lift rails
TE	TE = Temp Elevator Ready for Use
FE	FE = All Elevators Ready for Use
SD	SD = Seal Deck @ T14

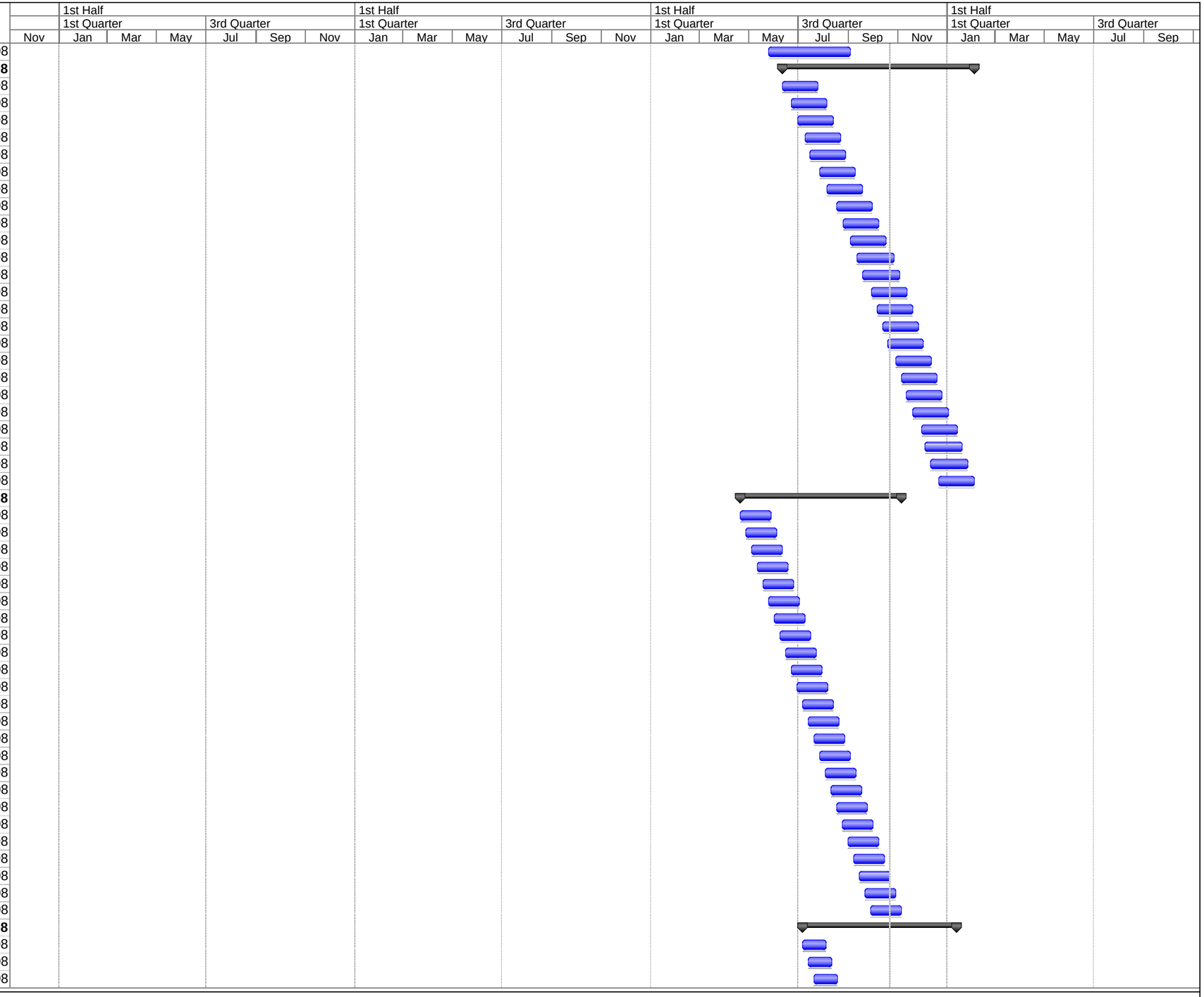
ID	Task Name	Duration	Start
1	**Preconstruction**	**218 days**	**Mon 1/30/06**
2	Phase 1 Bid Packages	14 days	Mon 1/30/06
3	Phase 2 Bid Packages	5 days	Fri 2/17/06
4	Phase 3 Bid Packages	8 days	Mon 2/27/06
5	Project Award	0 days	Tue 5/30/06
6	Project Notice to Proceed	0 days	Thu 11/30/06
7	Soldier Piles and Underpinning	130 days	Tue 1/2/07
8	**Sheeting & Bracing**	**122 days**	**Tue 1/16/07**
9	Sheeting+Bracing - Elev 110 to 99 [P1]	13 days	Tue 1/16/07
10	Sheeting+Bracing - Elev 99 to 90 [P2]	19 days	Mon 2/5/07
11	Sheeting+Bracing - Elev 90 to 81 [P3]	22 days	Fri 3/2/07
12	Sheeting+Bracing - Elev 81 to 72 [P4]	26 days	Wed 4/4/07
13	Sheeting+Bracing - Elev 72 to 63 [P5]	28 days	Wed 4/25/07
14	Sheeting+Bracing - Elev 63 & Below [P6]	26 days	Wed 5/30/07
15	Structure Excavation	136 days	Fri 1/12/07
16	**Building Structure Erection**	**354 days**	**Wed 8/1/07**
17	Concrete and Foundation - Level P6	60 days	Wed 8/1/07
18	Concrete - Level P5	33 days	Thu 10/18/07
19	Concrete - Level P4	26 days	Wed 11/21/07
20	Concrete - Level P3	35 days	Fri 12/21/07
21	Concrete - Level P2	28 days	Thu 1/17/08
22	Concrete - Level P1	23 days	Wed 2/13/08
23	Concrete - Floor 01 (Lobby)	28 days	Fri 3/14/08
24	Concrete - Floor 02	18 days	Tue 4/8/08
25	Concrete - Floor 03	16 days	Thu 4/24/08
26	Concrete - Floor 04	15 days	Tue 5/6/08
27	Concrete - Floor 05	14 days	Mon 5/19/08
28	Concrete - Floor 06	14 days	Thu 5/29/08
29	Concrete - Floor 07	13 days	Tue 6/10/08
30	Concrete - Floor 08	13 days	Wed 6/18/08
31	Concrete - Floor 09	13 days	Wed 6/25/08
32	Concrete - Floor 10	13 days	Thu 7/3/08
33	Concrete - Floor 11	13 days	Wed 7/16/08
34	Concrete - Floor 12	13 days	Thu 7/24/08
35	Concrete - Floor 14	13 days	Mon 8/4/08
36	Concrete - Floor 15	13 days	Tue 8/12/08
37	Concrete - Floor 16	13 days	Wed 8/20/08
38	Concrete - Floor 17	12 days	Fri 8/29/08
39	Concrete - Floor 18	12 days	Tue 9/9/08
40	Concrete - Floor 19	11 days	Thu 9/18/08
41	Concrete - Floor 20	10 days	Thu 9/25/08
42	Concrete - Floor 21	10 days	Thu 10/2/08
43	Concrete - Floor 22	10 days	Thu 10/9/08
44	Concrete - Floor 23	10 days	Thu 10/16/08
45	Concrete - Floor 24	10 days	Thu 10/23/08
46	Concrete - Floor 25	10 days	Thu 10/30/08
47	Concrete - Floor 26	10 days	Thu 11/6/08
48	Concrete - Main Roof Level	10 days	Fri 11/14/08
49	Concrete - Machine Room Roof Level	11 days	Mon 11/24/08
50	**Building Rough-in**	**145 days**	**Thu 2/14/08**
51	Level P6	44 days	Thu 2/14/08
52	Level P5	48 days	Mon 3/10/08
53	Level P4	55 days	Thu 3/27/08
54	Level P3	51 days	Wed 4/30/08
55	Level P2	61 days	Wed 5/14/08



Project: Project1.mpp
Date: Wed 10/22/08

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

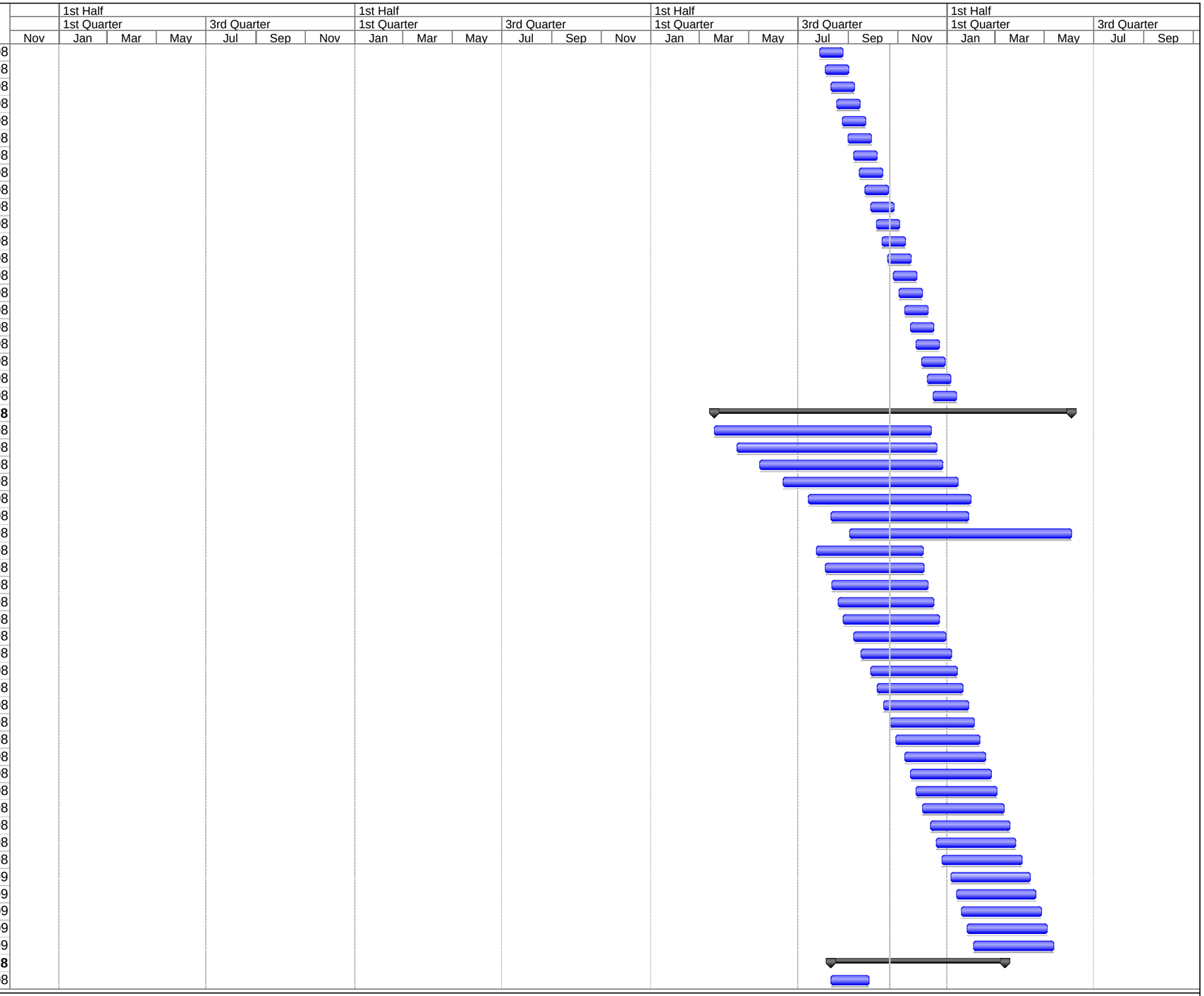
ID	Task Name	Duration	Start
56	Level P1	73 days	Mon 5/26/08
57	**Condo Rough-in (MEP & Framing)**	**169 days**	**Thu 6/12/08**
58	Floor 02	32 days	Thu 6/12/08
59	Floor 03	32 days	Mon 6/23/08
60	Floor 04	32 days	Tue 7/1/08
61	Floor 05	32 days	Thu 7/10/08
62	Floor 06	32 days	Wed 7/16/08
63	Floor 07	32 days	Mon 7/28/08
64	Floor 08	32 days	Wed 8/6/08
65	Floor 09	32 days	Mon 8/18/08
66	Floor 10	32 days	Tue 8/26/08
67	Floor 11	32 days	Thu 9/4/08
68	Floor 12	32 days	Fri 9/12/08
69	Floor 14	32 days	Fri 9/19/08
70	Floor 15	32 days	Tue 9/30/08
71	Floor 16	32 days	Tue 10/7/08
72	Floor 17	32 days	Tue 10/14/08
73	Floor 18	32 days	Mon 10/20/08
74	Floor 19	32 days	Thu 10/30/08
75	Floor 20	32 days	Thu 11/6/08
76	Floor 21	32 days	Wed 11/12/08
77	Floor 22	32 days	Thu 11/20/08
78	Floor 23	32 days	Mon 12/1/08
79	Floor 24	32 days	Fri 12/5/08
80	Floor 25	32 days	Fri 12/12/08
81	Floor 26	32 days	Mon 12/22/08
82	**Window Wall / Curtain Wall**	**143 days**	**Mon 4/21/08**
83	Floor 02	28 days	Mon 4/21/08
84	Floor 03	28 days	Mon 4/28/08
85	Floor 04	28 days	Mon 5/5/08
86	Floor 05	28 days	Mon 5/12/08
87	Floor 06	28 days	Mon 5/19/08
88	Floor 07	28 days	Mon 5/26/08
89	Floor 08	28 days	Mon 6/2/08
90	Floor 09	28 days	Mon 6/9/08
91	Floor 10	28 days	Mon 6/16/08
92	Floor 11	28 days	Mon 6/23/08
93	Floor 12	28 days	Mon 6/30/08
94	Floor 14	28 days	Mon 7/7/08
95	Floor 15	28 days	Mon 7/14/08
96	Floor 16	28 days	Mon 7/21/08
97	Floor 17	28 days	Mon 7/28/08
98	Floor 18	28 days	Mon 8/4/08
99	Floor 19	28 days	Mon 8/11/08
100	Floor 20	28 days	Mon 8/18/08
101	Floor 21	28 days	Mon 8/25/08
102	Floor 22	28 days	Mon 9/1/08
103	Floor 23	28 days	Mon 9/8/08
104	Floor 24	28 days	Mon 9/15/08
105	Floor 25	28 days	Mon 9/22/08
106	Floor 26	28 days	Mon 9/29/08
107	**Drywall & Tape**	**136 days**	**Mon 7/7/08**
108	Floor 02	21 days	Mon 7/7/08
109	Floor 03	21 days	Mon 7/14/08
110	Floor 04	21 days	Mon 7/21/08



Project: Project1.mpp
Date: Wed 10/22/08

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

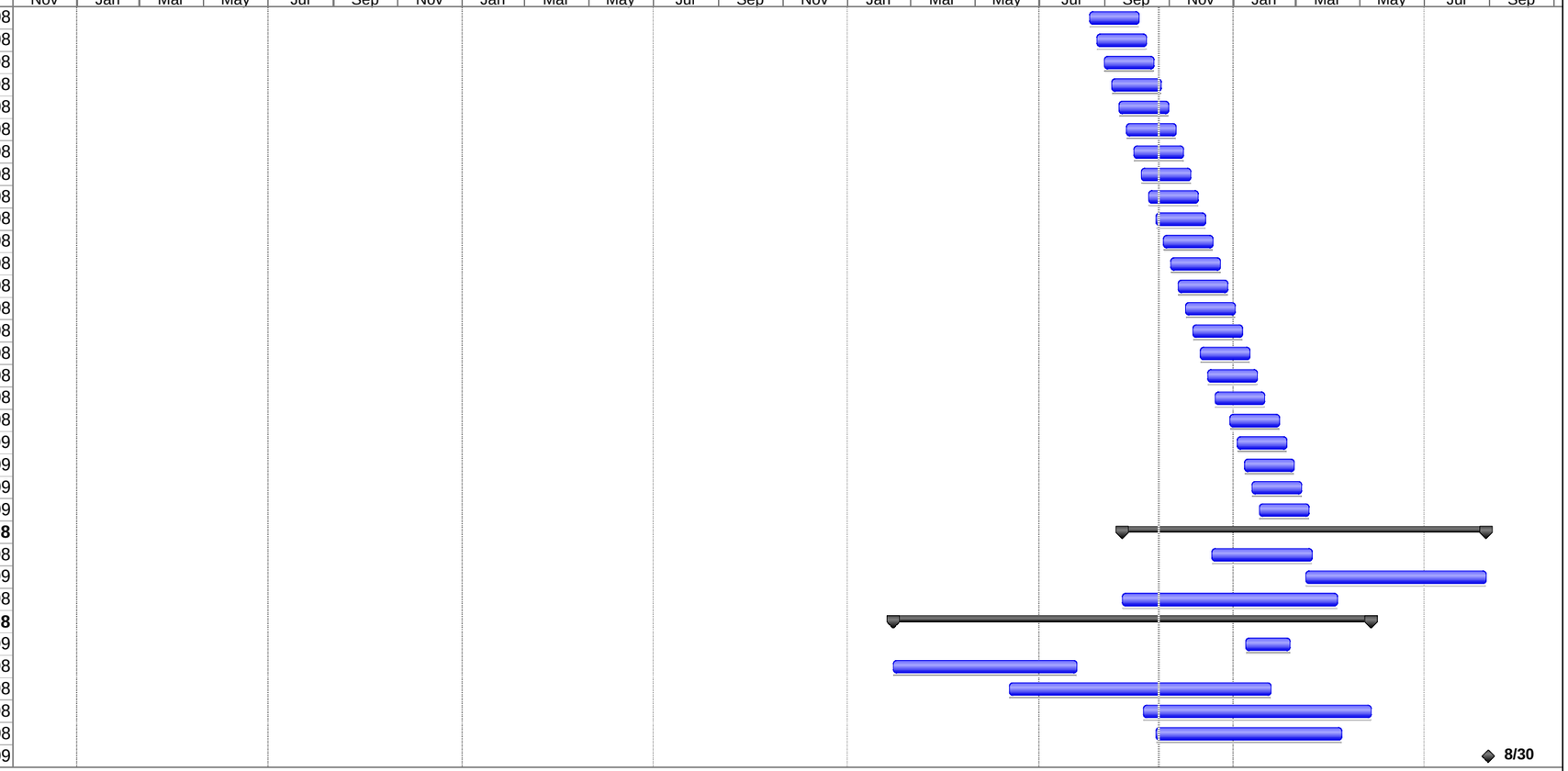
ID	Task Name	Duration	Start
111	Floor 05	21 days	Mon 7/28/08
112	Floor 06	21 days	Mon 8/4/08
113	Floor 07	21 days	Mon 8/11/08
114	Floor 08	21 days	Mon 8/18/08
115	Floor 09	21 days	Mon 8/25/08
116	Floor 10	21 days	Mon 9/1/08
117	Floor 11	21 days	Mon 9/8/08
118	Floor 12	21 days	Mon 9/15/08
119	Floor 14	21 days	Mon 9/22/08
120	Floor 15	21 days	Mon 9/29/08
121	Floor 16	21 days	Mon 10/6/08
122	Floor 17	21 days	Mon 10/13/08
123	Floor 18	21 days	Mon 10/20/08
124	Floor 19	21 days	Mon 10/27/08
125	Floor 20	21 days	Mon 11/3/08
126	Floor 21	21 days	Mon 11/10/08
127	Floor 22	21 days	Mon 11/17/08
128	Floor 23	21 days	Mon 11/24/08
129	Floor 24	21 days	Mon 12/1/08
130	Floor 25	21 days	Mon 12/8/08
131	Floor 26	21 days	Mon 12/15/08
132	**Building Finishes**	**315 days**	**Thu 3/20/08**
133	Level P6	192 days	Thu 3/20/08
134	Level P5	177 days	Thu 4/17/08
135	Level P4	162 days	Thu 5/15/08
136	Level P3	154 days	Fri 6/13/08
137	Level P2	145 days	Mon 7/14/08
138	Level P1	122 days	Mon 8/11/08
139	Floor 01 (Lobby)	196 days	Wed 9/3/08
140	Floor 02	94 days	Thu 7/24/08
141	Floor 03	88 days	Mon 8/4/08
142	Floor 04	85 days	Tue 8/12/08
143	Floor 05	84 days	Wed 8/20/08
144	Floor 06	85 days	Tue 8/26/08
145	Floor 07	82 days	Mon 9/8/08
146	Floor 08	80 days	Wed 9/17/08
147	Floor 09	77 days	Mon 9/29/08
148	Floor 10	76 days	Tue 10/7/08
149	Floor 11	75 days	Wed 10/15/08
150	Floor 12	74 days	Thu 10/23/08
151	Floor 14	74 days	Thu 10/30/08
152	Floor 15	72 days	Mon 11/10/08
153	Floor 16	72 days	Mon 11/17/08
154	Floor 17	72 days	Mon 11/24/08
155	Floor 18	73 days	Tue 12/2/08
156	Floor 19	70 days	Fri 12/12/08
157	Floor 20	70 days	Fri 12/19/08
158	Floor 21	71 days	Fri 12/26/08
159	Floor 22	70 days	Tue 1/6/09
160	Floor 23	70 days	Tue 1/13/09
161	Floor 24	71 days	Mon 1/19/09
162	Floor 25	71 days	Mon 1/26/09
163	Floor 26	71 days	Tue 2/3/09
164	**Condo Finishes (Kitchen & Bathrooms)**	**155 days**	**Mon 8/11/08**
165	Floor 02	35 days	Mon 8/11/08



Project: Project1.mpp
Date: Wed 10/22/08

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

ID	Task Name	Duration	Start
166	Floor 03	35 days	Mon 8/18/08
167	Floor 04	35 days	Mon 8/25/08
168	Floor 05	35 days	Mon 9/1/08
169	Floor 06	35 days	Mon 9/8/08
170	Floor 07	35 days	Mon 9/15/08
171	Floor 08	35 days	Mon 9/22/08
172	Floor 09	35 days	Mon 9/29/08
173	Floor 10	35 days	Mon 10/6/08
174	Floor 11	35 days	Mon 10/13/08
175	Floor 12	35 days	Mon 10/20/08
176	Floor 14	35 days	Mon 10/27/08
177	Floor 15	35 days	Mon 11/3/08
178	Floor 16	35 days	Mon 11/10/08
179	Floor 17	35 days	Mon 11/17/08
180	Floor 18	35 days	Mon 11/24/08
181	Floor 19	35 days	Mon 12/1/08
182	Floor 20	35 days	Mon 12/8/08
183	Floor 21	35 days	Mon 12/15/08
184	Floor 22	35 days	Mon 12/29/08
185	Floor 23	35 days	Mon 1/5/09
186	Floor 24	35 days	Mon 1/12/09
187	Floor 25	35 days	Mon 1/19/09
188	Floor 26	35 days	Mon 1/26/09
189	**Elevators**	**247 days**	**Thu 9/18/08**
190	Set Temporary Elevators	67 days	Fri 12/12/08
191	Use Temporary Elevators	123 days	Wed 3/11/09
192	Tower Elevators	146 days	Thu 9/18/08
193	**General Items**	**323 days**	**Thu 2/14/08**
194	Building Water-tight	30 days	Tue 1/13/09
195	Building Masonry	124 days	Thu 2/14/08
196	Drywall (Lobby & Public Areas)	178 days	Tue 6/3/08
197	Painting (Public Areas)	154 days	Wed 10/8/08
198	Tile Walls & Floors	126 days	Mon 10/20/08
199	Substantial Completion	0 days	Sun 8/30/09



Project: Project1.mpp
Date: Wed 10/22/08

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

Appendix B

Project Estimates

Contents:

- R.S. Means 2008 Estimate
- D4 Cost 2002 Estimate
- General Conditions Estimate
- Structural System Estimate (Post Tension Concrete)

R.S. Means 2008 Data

Tower

Exterior Wall	S.F Area	400,000	500,000	600,000
	L.F. Perimeter	570	600	630
Ribbed Precast Concrete Panel	R/ Concrete Frame	$159.10	$156.98	$154.85
	Perimeter Adjustment	$2.35	$1.93	$1.50
	Story Height Adjustment	$1.25	$1.08	$0.90

Additions	Cost Per Unit	Total Cost
Appliances	$8,625	$2,233,875
Elevators	N/A	$2,228,000
Elevator Additional Stops	N/A	$1,323,000
Total Additions		$5,784,875
Cost per Square Foot		$11.57

Square Foot Estimate	$156.98
Perimeter Adjustment	$1.24
Additions	$11.57
Total per SF	$169.79

Parking Levels

Exterior Wall	S.F Area	40,000
	L.F. Perimeter	600
Ribbed Precast Concrete Panel	R/ Concrete Frame	$73.00
	Perimeter Adjustment	$2.45
	Story Height Adjustment	$1.45

Square Foot Estimate	$73.00
Perimeter Adjustment	$4.90
Total per SF	$77.90

Total

	Square Feet	Cost per SF	Total Cost
Residential Tower	500,000	$169.79	$84,895,000
Parking Garage	240,000	$77.90	$18,696,000
			$103,591,000
R.S. Means Location Factor (Arlington, VA)			1.04
		Total Estimate	$107,734,640

D4 COST 2002

Sunday, September 21, 2008

Statement of Probable Cost

Turnberry Tower Arlington - Sep 2009 - VA - Arlington

Prepared By:	Larry Warner	Prepared For:	
, Fax:		, Fax:	
Building Sq. Size:	500000	Site Sq. Size:	853426
Bid Date:		Building use:	Residential
No. of floors:	31	Foundation:	CON
No. of buildings:	1	Exterior Walls:	CUR
Project Height:	210	Interior Walls:	GYP
1st Floor Height:	10	Roof Type:	EPD
1st Floor Size:	20000	Floor Type:	CON
		Project Type:	NEW

Division		Percent	Sq. Cost	Amount
00	**Bidding Requirements**	**2.33**	**4.45**	**2,223,882**
	Bidding Requirements	2.33	4.45	2,223,882
01	**General Requirements**	**7.50**	**14.31**	**7,155,875**
	General Requirements	7.50	14.31	7,155,875
02	**Site Work**	**4.36**	**8.32**	**4,162,246**
	Site Work	4.36	8.32	4,162,246
03	**Concrete**	**6.67**	**12.73**	**6,365,136**
	Concrete	6.67	12.73	6,365,136
04	**Masonry**	**4.09**	**7.81**	**3,904,365**
	Masonry	4.09	7.81	3,904,365
05	**Metals**	**0.93**	**1.77**	**882,877**
	Metals	0.93	1.77	882,877
06	**Wood & Plastics**	**6.34**	**12.10**	**6,049,079**
	Wood & Plastics	6.34	12.10	6,049,079
07	**Thermal & Moisture Protection**	**4.19**	**8.00**	**3,999,200**
	Thermal & Moisture Protection	4.19	8.00	3,999,200
08	**Doors & Windows**	**3.34**	**6.37**	**3,183,470**
	Doors & Windows	3.34	6.37	3,183,470
09	**Finishes**	**9.77**	**18.65**	**9,324,642**
	Finishes	9.77	18.65	9,324,642
10	**Specialties**	**0.61**	**1.17**	**585,671**
	Specialties	0.61	1.17	585,671
11	**Equipment**	**1.30**	**2.48**	**1,240,021**
	Equipment	1.30	2.48	1,240,021
12	**Furnishings**	**0.77**	**1.46**	**731,467**
	Furnishings	0.77	1.46	731,467
13	**Special Construction**	**0.29**	**0.55**	**273,867**
	Special Construction	0.29	0.55	273,867
14	**Conveying Systems**	**1.47**	**2.81**	**1,403,343**
	Conveying Systems	1.47	2.81	1,403,343
15	**Mechanical**	**13.26**	**25.31**	**12,654,937**
	Mechanical	13.26	25.31	12,654,937
16	**Electrical**	**8.39**	**16.01**	**8,002,735**
	Electrical	8.39	16.01	8,002,735
21	**Fire Suppression**	**1.25**	**2.38**	**1,191,954**
	Fire Suppression	1.25	2.38	1,191,954

Sunday, September 21, 2008 Page 2

22	**Plumbing**	**4.42**	**8.44**	**4,218,617**
	Plumbing	4.42	8.44	4,218,617
23	**HVAC**	**7.64**	**14.57**	**7,287,076**
	HVAC	7.64	14.57	7,287,076
26	**Electrical**	**6.58**	**12.56**	**6,281,739**
	Electrical	6.58	12.56	6,281,739
27	**Communications**	**0.48**	**0.92**	**457,780**
	Communications	0.48	0.92	457,780
28	**Electronic Safety and Security**	**0.12**	**0.24**	**118,191**
	Electronic Safety and Security	0.12	0.24	118,191
31	**Earthwork**	**1.87**	**3.57**	**1,787,112**
	Earthwork	1.87	3.57	1,787,112
32	**Exterior Improvements**	**1.40**	**2.68**	**1,337,766**
	Exterior Improvements	1.40	2.68	1,337,766
33	**Utilities**	**0.62**	**1.19**	**593,894**
	Utilities	0.62	1.19	593,894
Total Building Costs		**100.00**	**190.83**	**95,416,943**
Total Non-Building Costs		**100.00**	**0.00**	**0**
Total Project Costs		**--**	**--**	**95,416,943**

General Conditions Estimate					
Item	Price	% of GC	Units	Cost Per Unit	Cost Per Month
Staff					
Project Managers	$2,500,000	18.54%	3	$833,333	$65,789
Superintendents	$1,300,000	9.64%	3	$433,333	$34,211
Safety Man	$379,000	2.81%	1	$379,000	$9,974
Accountant	$250,000	1.85%	1	$250,000	$6,579
Secretary	$455,000	3.37%	1	$455,000	$11,974
Purchase Agent	$225,000	1.67%			$5,921
Scheduler	$113,000	0.84%	1	$113,000	$2,974
Laborers	$350,000	2.60%			$9,211
Carpenters	$95,000	0.70%			$2,500
Safety Labor	$31,000	0.23%			$816
Elevator / Hoist Operations	$183,000	1.36%	2	$91,500	$4,816
Total	**$5,881,000**	**43.62%**			**$154,763**
Site Work					
Pre-Survey	$22,000	0.16%	1	$22,000	$579
Surverys	$175,000	1.30%	1	$175,000	$4,605
Permits	$379,000	2.81%	13	$29,154	$9,974
Progress Photos / Webcam	$17,000	0.13%	1	$17,000	$447
Dewatering	$17,000	0.13%			$447
Exterior Cleaning	$94,000	0.70%	1	$94,000	$2,474
Final Clean	$120,000	0.89%	1	$120,000	$3,158
Cleanup	$72,000	0.53%			$1,895
Access Roads / Parking	$50,000	0.37%			$1,316
Miscellaneous Tools	$10,000	0.07%			$263
Facility Operation	$118,000	0.88%			$3,105
Temporary Toilets	$119,000	0.88%	20	$5,950	$3,132
Total	**$1,193,000**	**8.85%**			**$31,395**

Temporary Utilities					
Temporary Power	$300,000	2.23%	1	$300,000	$7,895
Temporary Heat	$220,000	1.63%	1	$220,000	$5,789
Telephone / Data / Nextel	$112,000	0.83%	14	$8,000	$2,947
Temporary Water	$13,000	0.10%	1	$13,000	$342
Temporary Utilities	$10,000	0.07%	1	$10,000	$263
Temporary Hoist	$245,000	1.82%	2	$122,500	$6,447
Rubbish Chute	$78,000	0.58%	1	$78,000	$2,053
Temporary Elevators	$22,000	0.16%	1	$22,000	$579
Rubbish Removal	$300,000	2.23%			$7,895
Total	**$1,300,000**	**9.64%**			**$34,211**

Site Office & Job Needs					
Temporary Office	$200,000	1.48%	2	$100,000	$5,263
Office Set Up	$55,000	0.41%	2	$27,500	$1,447
Field Office Furniture	$40,000	0.30%	1	$40,000	$1,053
Project Signs	$5,000	0.04%			$132
Postage	$35,000	0.26%			$921
Copier	$35,000	0.26%	1	$35,000	$921
Job Office Supplies	$53,000	0.39%			$1,395
Travel	$20,000	0.15%			$526
Vehicles	$161,000	1.19%	5	$32,200	$4,237
Telephone	$13,500	0.10%	14	$964	$355
Computer	$23,000	0.17%	14	$1,643	$605
Blueprints	$55,000	0.41%			$1,447
Job Signs	$5,000	0.04%			$132
Gross Receipts Tax	$240,000	1.78%			$6,316
Closeout Submittals	$35,000	0.26%			$921
Fill Pool	$10,000	0.07%	1	$10,000	$263
Total	**$985,500**	**7.31%**			**$25,934**

Site Security					
Pest Control	$2,500	0.02%			$66
Site Fence	$11,500	0.09%			$303
Security	$10,500	0.08%			$276
Watchman Services	$280,000	2.08%			$7,368
Temporary Barriers & Enclosures	$75,000	0.56%			$1,974
Safety Material	$16,500	0.12%			$434
Temporary Protection	$95,000	0.70%			$2,500
Total	**$491,000**	**3.64%**			**$12,921**

Contracts					
Legal Services	$10,000	0.07%			$263
Miscellaneous Contracts	$10,000	0.07%			$263
Constructware	$57,000	0.42%	1	$57,000	$1,500
Total	**$77,000**	**0.57%**			**$2,026**
Insurance					
Umbrealla Liability Insurance	$1,110,000	8.23%	1	$1,110,000	$29,211
Genereal Liability Insurance	$1,095,000	8.12%	1	$1,095,000	$28,816
Workers Compensation Insurance	$1,350,000	10.01%	1	$1,350,000	$35,526
Total	**$3,555,000**	**26.37%**			**$93,553**
General Conditions Total	**$13,482,500**				**$354,803**

Structural System Takeoff Notes and Estimates

COLUMN REBAR					
Column Number	# of Bars	Bar Number	LBS / FT	Total Height (ft)	Total LBS
101	10	9	3.4	330.83	11248
102	10	9	3.4	330.83	11248
103	10	9	3.4	124.75	4242
	10	11	5.313	60.5	3214
	14	11	5.313	50.41	3750
	22	11	5.313	20.17	2358
	26	11	5.313	75	10360
104	16	9	3.4	312.83	17018
	16	11	5.313	9	765
	20	11	5.313	9	956
105	8	10	4.303	330.83	11388
106	8	10	4.303	124.75	4294
	12	11	5.313	50.42	3215
	20	11	5.313	60.49	6428
	24	11	5.313	20.17	2572
	22	11	5.313	57	6663
	30	11	5.313	18	2869
107	12	9	3.4	255.83	10438
	12	11	5.313	57	3634
	20	11	5.313	18	1913
108	10	9	3.4	255.83	8698
	10	10	4.303	75	3227
109	8	9	3.4	260.37	7082
	8	10	4.303	75	2582
110	8	9	3.4	260.37	7082
	8	10	4.303	75	2582
111	12	9	3.4	134.83	5501
	12	11	5.313	50.42	3215
	16	11	5.313	40.33	3428
	26	11	5.313	87.25	12053
	36	11	5.313	18	3443
112	12	9	3.4	134.83	5501
	12	11	5.313	50.42	3215
	16	11	5.313	40.33	3428
	26	11	5.313	87.25	12053
	36	11	5.313	18	3443
113	8	9	3.4	260.37	7082
	8	10	4.303	75	2582

114	8	9	3.4	260.37	7082
	8	10	4.303	75	2582
115	12	9	3.4	255.83	10438
	12	11	5.313	57	3634
	20	11	5.313	18	1913
116	8	10	4.303	124.75	4294
	12	11	5.313	50.42	3215
	20	11	5.313	60.49	6428
	24	11	5.313	20.17	2572
	22	11	5.313	57	6663
	30	11	5.313	18	2869
117	8	10	4.303	330.83	11388
118	10	9	3.4	124.75	4242
	10	11	5.313	60.5	3214
	14	11	5.313	50.41	3750
	22	11	5.313	20.17	2358
	26	11	5.313	75	10360
119	10	9	3.4	285.83	9718
	10	11	5.313	45	2391
120	10	9	3.4	285.83	9718
	10	11	5.313	45	2391
				Subtotal	325987
201	12	11	5.313	75	4782
202	12	11	5.313	75	4782
203	12	11	5.313	75	4782
204	20	11	5.313	18.5	1966
	22	11	5.313	56.5	6604
205	20	11	5.313	18.5	1966
	22	11	5.313	56.5	6604
206	20	11	5.313	18.5	1966
	22	11	5.313	56.5	6604
207	20	11	5.313	75	7970
208	8	8	2.67	75	1602
209	8	8	2.67	75	1602
210	8	8	2.67	75	1602
211	8	8	2.67	75	1602
212	8	8	2.67	75	1602
213	8	10	4.303	75	2582
214	8	8	2.67	18.5	395
215	8	8	2.67	18.5	395
				Subtotal	59406

301	10	9	3.4	56.54	1922
302	10	9	3.4	56.54	1922
303	10	9	3.4	56.54	1922
304	6	8	2.67	56.54	906
305	6	8	2.67	56.54	906
306	6	8	2.67	56.54	906
307	6	8	2.67	56.54	906
308	10	9	3.4	56.54	1922
309	10	9	3.4	56.54	1922
310	10	9	3.4	56.54	1922
311	10	9	3.4	56.54	1922
312	6	8	2.67	56.54	906
313	10	9	3.4	56.54	1922
314	8	8	2.67	56.54	1208
315	8	8	2.67	56.54	1208
316	8	8	2.67	56.54	1208
317	8	8	2.67	56.54	1208
318	8	8	2.67	56.54	1208
319	8	8	2.67	56.54	1208
320	8	8	2.67	56.54	1208
321	4	9	3.4	45	612
322	8	8	2.67	56.54	1208
323	8	8	2.67	56.54	1208
324	8	8	2.67	56.54	1208
325	8	8	2.67	56.54	1208
326	8	8	2.67	56.54	1208
327	8	8	2.67	56.54	1208
328	8	8	2.67	56.54	1208
329	8	8	2.67	56.54	1208
330	8	8	2.67	56.54	1208
331	8	8	2.67	56.54	1208
332	8	8	2.67	56.54	1208
333	8	8	2.67	56.54	1208
334	8	8	2.67	56.54	1208
335	8	8	2.67	56.54	1208
336	8	8	2.67	56.54	1208
337	8	8	2.67	20.5	438
338	8	8	2.67	20.5	438
				Subtotal	47965
				Rebar Columns (LBS)	433358
				Waste Factor (5%)	1.05
				TOTAL REBAR FOR COLUMNS (Lbs)	455026
				TOTAL REBAR FOR COLUMNS (Ton)	**228**

Concrete Slabs				
Level	Area (Ft^2)	Thickness (Ft)	Volume (CF)	Volume (CY)
P-6	40,000	0.67	26800	993
P-5	40,000	0.67	26800	993
P-4	40,000	0.67	26800	993
P-3	40,000	0.67	26800	993
P-2	40,000	0.67	26800	993
P-1	40,000	0.67	26800	993
L	25,000	1	25000	926
2	20,100	0.583	11718.3	434
3	20,100	0.583	11718.3	434
4	20,100	0.583	11718.3	434
5	20,100	0.583	11718.3	434
6	20,100	0.583	11718.3	434
7	20,100	0.583	11718.3	434
8	20,100	0.583	11718.3	434
9	20,100	0.583	11718.3	434
10	20,100	0.583	11718.3	434
11	20,100	0.583	11718.3	434
12	20,100	0.583	11718.3	434
14	20,100	0.583	11718.3	434
15	20,100	0.583	11718.3	434
16	20,100	0.583	11718.3	434
17	20,100	0.583	11718.3	434
18	20,100	0.583	11718.3	434
19	20,100	0.583	11718.3	434
20	20,100	0.583	11718.3	434
21	20,100	0.583	11718.3	434
22	20,100	0.583	11718.3	434
23	20,100	0.583	11718.3	434
24	20,100	0.583	11718.3	434
25	20,100	0.583	11718.3	434
26	20,100	0.583	11718.3	434
MPH	20,100	0.583	11718.3	434
			Total (CY)	17732
			Waste Factor (5%)	1.05
			TOTAL CONCRETE FOR SLABS (CY)	**18618**

Concrete					
Column Number	Length (ft)	Width (ft)	Depth (ft)	Volume (CF)	Volume (CY)
101	7	7	3.33	163.33	6
102	7	7	3.33	163.33	6
103	8	6	3.33	160	6
104	10.5	6	3.67	231	9
105	7	7	3.33	163.33	6
106	8	8	4.00	256	9
107	8.5	8.5	5.00	361.25	13
108	8	6	3.33	160	6
109	7	7	3.33	163.33	6
110	7	7	3.33	163.33	6
111	8	6	3.67	176	7
112	8.5	8.5	5.00	361.25	13
113	7	7	3.33	163.33	6
114	7	7	3.33	163.33	6
115	8.5	8.5	5.00	361.25	13
116	8	8	4.00	256	9
117	8	6	3.33	160	6
118	8	6	3.33	160	6
119	10.5	6	3.33	210	8
120	10.5	6	3.33	210	8
201	8	8	4.00	256	9
202	8	8	4.00	256	9
203	8	8	4.00	256	9
204	8	8	4.00	256	9
205	8	8	4.00	256	9
206	8	8	4.00	256	9
207	9	7	4.00	252	9
208	4	4	4.00	64	2
209	4	4	4.00	64	2
210	4	4	4.00	64	2
211	4	4	4.00	64	2
212	4	4	4.00	64	2
213	4	4	4.00	64	2
301	5	5	2.00	50	2
302	5	5	2.00	50	2
303	5	5	2.00	50	2

304	4	4	2.00	32	1
305	4	4	2.00	32	1
306	4	4	2.00	32	1
307	4	4	2.00	32	1
308	6	6	2.83	102	4
309	6	6	2.83	102	4
310	6	6	2.83	102	4
311	6	6	2.83	102	4
312	3	3	2.00	18	1
313	6	6	2.83	102	4
314	4	4	2.00	32	1
315	4	4	2.00	32	1
316	4	4	2.00	32	1
317	4	4	2.00	32	1
318	4	4	2.00	32	1
319	4	4	2.00	32	1
320	4	4	2.00	32	1
321	4	4	2.00	32	1
322	4	4	2.00	32	1
323	4	4	2.00	32	1
324	4	4	2.00	32	1
325	4	4	2.00	32	1
326	4	4	2.00	32	1
				Concrete for Columns (CY)	281
				Waste Factor (5%)	1.05
				TOTAL CONCRETE FOR COLUMNS (CY)	**296**

Post Tension Tendons			
Floor	Amount of PT (Lbs)	Cost Per Lb	Total Cost
2	25835	$1.15	$29,710
3	25835	$1.15	$29,710
4	25835	$1.15	$29,710
5	25835	$1.15	$29,710
6	25835	$1.15	$29,710
7	25835	$1.15	$29,710
8	25835	$1.15	$29,710
9	25835	$1.15	$29,710
10	25835	$1.15	$29,710
11	25835	$1.15	$29,710
12	25835	$1.15	$29,710
14	25835	$1.15	$29,710
15	25835	$1.15	$29,710
16	25835	$1.15	$29,710
17	25835	$1.15	$29,710
18	25835	$1.15	$29,710
19	25835	$1.15	$29,710
20	25835	$1.15	$29,710
21	25835	$1.15	$29,710
22	25835	$1.15	$29,710
23	25835	$1.15	$29,710
24	25835	$1.15	$29,710
25	25835	$1.15	$29,710
26	25835	$1.15	$29,710
MPH	6959	$1.15	$8,003
TOTAL	**626999**		**$721,049**

Reinforcing Steel			
Area	Amount (Ton)	Cost per Ton	Total Cost
Columns	228	$1,000	$228,000
Shear Walls	1944	$1,000	$1,944,000
Slabs	899	$1,000	$899,000
TOTAL	**3071**		**$3,071,000**

Miscellaneous Items			
Item	Amount	Cost per	Total Cost
Post Tension Cables	626,999 LBS	$1.15 / lbs	$721,049
Grout PT Ends	14,456 EA	$0.50 EA	$7,228
WWF 6x6 W1.4/W1.4	19,312 SF	$18.05 / CSF	$348,582
WWF 6x6 W2.1/W2.1	53,001 SF	$26.50 / CSF	$1,404,527
TOTAL			**$2,481,385**

Total Material Cost		
Item	Amount	Total Cost
Concrete	37,351 CY	$4,668,875
Reinforcing Steel	3071 Tons	$3,071,000
Miscellaneous Items		$2,481,385
TOTAL		**$10,221,260**
TOTAL PER CY		**$273.65**

Average Labor and Equipment			
Description	Labor	Equipment	Unit
Footings	$54.50	$0.33	CY
Columns	$435.00	$42.50	CY
Slab on Grade	$55.00	$0.41	CY
Slabs	$207.00	$19.60	CY
Beams	$490.00	$48.50	CY
Shear Walls	$430.00	$42.50	CY
Curbs, Pads, Toppings	$129.00	$1.78	CY
Average per CY	**$257.21**	**$22.23**	**CY**

Construction Cost of Concrete System for Turnberry Tower Arlington						
Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	37351	CY	$273.65	$257.21	$22.23	$20,658,837
				TOTAL	**$27.55**	**per SF**

Appendix C

Structural Calculations

Contents:

- Charts from the ACI 318-08 Building Code Requirements for Structural Concrete
- Calculations to design reinforced concrete slabs

CODE

9.5.3.2 — For slabs without interior beams spanning between the supports and having a ratio of long to short span not greater than 2, the minimum thickness shall be in accordance with the provisions of Table 9.5(c) and shall not be less than the following values:

(a) Slabs without drop panels as defined in 13.2.5 ..... 5 in.;
(b) Slabs with drop panels as defined in 13.2.5 ..... 4 in.

9.5.3.3 — For slabs with beams spanning between the supports on all sides, the minimum thickness, h, shall be as follows:

(a) For α_{fm} equal to or less than 0.2, the provisions of 9.5.3.2 shall apply;

(b) For α_{fm} greater than 0.2 but not greater than 2.0, h shall not be less than

$$h = \frac{\ell_n\left(0.8 + \frac{f_y}{200{,}000}\right)}{36 + 5\beta(\alpha_{fm} - 0.2)} \qquad (9\text{-}12)$$

and not less than 5 in.;

(c) For α_{fm} greater than 2.0, h shall not be less than

$$h = \frac{\ell_n\left(0.8 + \frac{f_y}{200{,}000}\right)}{36 + 9\beta} \qquad (9\text{-}13)$$

and not less than 3.5 in.;

(d) At discontinuous edges, an edge beam shall be provided with a stiffness ratio α_f not less than 0.80 or the minimum thickness required by Eq. (9-12) or (9-13)

TABLE 9.5(c)—MINIMUM THICKNESS OF SLABS WITHOUT INTERIOR BEAMS*

	Without drop panels†			With drop panels‡		
	Exterior panels		Interior panels	Exterior panels		Interior panels
f_y, psi	Without edge beams	With edge beams§		Without edge beams	With edge beams§	
40,000	$\ell_n/33$	$\ell_n/36$	$\ell_n/36$	$\ell_n/36$	$\ell_n/40$	$\ell_n/40$
60,000	$\ell_n/33$	$\ell_n/33$	$\ell_n/33$	$\ell_n/33$	$\ell_n/36$	$\ell_n/36$
75,000	$\ell_n/28$	$\ell_n/31$	$\ell_n/31$	$\ell_n/31$	$\ell_n/34$	$\ell_n/34$

*For two-way construction, ℓ_n is the length of clear span in the long direction. For values of f_y between the values given in the table, minimum thickness shall be determined by linear interpolation.
†Drop panels as defined in 13.2.5.
‡Slabs with beams between columns along exterior edges. The value of α_{fm} for the edge beam shall not be less than 0.8.

COMMENTARY

R9.5.3.2 — The minimum thicknesses in Table 9.5(c) are those that have been developed through the years. Slabs conforming to those limits have not resulted in systematic problems related to stiffness for short- and long-term loads. These limits apply to only the domain of previous experience in loads, environment, materials, boundary conditions, and spans.

R9.5.3.3 — For panels having a ratio of long to short span greater than 2, the use of Eq. (9-12) and (9-13), which express the minimum thickness as a fraction of the long span, may give unreasonable results. For such panels, the rules applying to one-way construction in 9.5.2 should be used.

The requirement in 9.5.3.3(a) for α_{fm} equal to 0.2 made it possible to eliminate Eq. (9-13) of the 1989 Code. That equation gave values essentially the same as those in Table 9.5(c), as does Eq. (9-12) at a value of α_{fm} equal to 0.2.

9

CODE

13.6.3.2 — In an interior span, total static moment, M_o, shall be distributed as follows:

Negative factored moment	0.65
Positive factored moment	0.35

13.6.3.3 — In an end span, total factored static moment, M_o, shall be distributed as follows:

	(1)	(2)	(3)	(4)	(5)
			Slab without beams between interior supports		
	Exterior edge unrestrained	Slab with beams between all supports	Without edge beam	With edge beam	Exterior edge fully restrained
Interior negative factored moment	0.75	0.70	0.70	0.70	0.65
Positive factored moment	0.63	0.57	0.52	0.50	0.35
Exterior negative factored moment	0	0.16	0.26	0.30	0.65

COMMENTARY

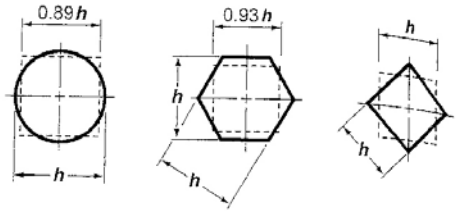


Fig. R13.6.2.5—Examples of equivalent square section for supporting members.

R13.6.3.3 — The moment coefficients for an end span are based on the equivalent column stiffness expressions from References 13.18, 13.19, and 13.20. The coefficients for an unrestrained edge would be used, for example, if the slab were simply supported on a masonry or concrete wall. Those for a fully restrained edge would apply if the slab were constructed integrally with a concrete wall having a flexural stiffness so large compared to that of the slab that little rotation occurs at the slab-to-wall connection.

For other than unrestrained or fully restrained edges, coefficients in the table were selected to be near the upper bound of the range for positive moments and interior negative moments. As a result, exterior negative moments were usually closer to a lower bound. The exterior negative moment strength for most slab systems is governed by minimum reinforcement to control cracking. The final coefficients in the table have been adjusted so that the absolute sum of the positive and average moments equal M_o.

For two-way slab systems with beams between supports on all sides (two-way slabs), moment coefficients of Column (2) of the table apply. For slab systems without beams between interior supports (flat plates and flat slabs), the moment coefficients of Column (3) or (4) apply, without or with an edge (spandrel) beam, respectively.

In the 1977 Code, distribution factors defined as a function of the stiffness ratio of the equivalent exterior support were used for proportioning the total static moment M_o in an end span. The approach may be used in place of values in 13.6.3.3.

CODE

13.6.3.4 — Negative moment sections shall be designed to resist the larger of the two interior negative factored moments determined for spans framing into a common support unless an analysis is made to distribute the unbalanced moment in accordance with stiffnesses of adjoining elements.

13.6.3.5 — Edge beams or edges of slab shall be proportioned to resist in torsion their share of exterior negative factored moments.

13.6.3.6 — The gravity load moment to be transferred between slab and edge column in accordance with 13.5.3.1 shall be $0.3M_o$.

13.6.4 — Factored moments in column strips

13.6.4.1 — Column strips shall be proportioned to resist the following portions in percent of interior negative factored moments:

ℓ_2/ℓ_1	0.5	1.0	2.0
$(\alpha_{f1}\ell_2/\ell_1) = 0$	75	75	75
$(\alpha_{f1}\ell_2/\ell_1) \geq 1.0$	90	75	45

Linear interpolations shall be made between values shown.

13.6.4.2 — Column strips shall be proportioned to resist the following portions in percent of exterior negative factored moments:

ℓ_2/ℓ_1		0.5	1.0	2.0
$(\alpha_{f1}\ell_2/\ell_1) = 0$	$\beta_t = 0$	100	100	100
	$\beta_t \geq 2.5$	75	75	75
$(\alpha_{f1}\ell_2/\ell_1) \geq 1.0$	$\beta_t = 0$	100	100	100
	$\beta_t \geq 2.5$	90	75	45

Linear interpolations shall be made between values shown, where β_t is calculated in Eq. (13-5) and C is calculated in Eq. (13-6).

$$\beta_t = \frac{E_{cb}C}{2E_{cs}I_s} \quad (13\text{-}5)$$

$$C = \sum \left(1 - 0.63\frac{x}{y}\right)\frac{x^3 y}{3} \quad (13\text{-}6)$$

The constant C for T- or L-sections shall be permitted to be evaluated by dividing the section into separate rectangular parts, as defined in 13.2.4, and summing the values of C for each part.

COMMENTARY

R13.6.3.4 — The differences in slab moment on either side of a column or other type of support should be accounted for in the design of the support. If an analysis is made to distribute unbalanced moments, flexural stiffness may be obtained on the basis of the gross concrete section of the members involved.

R13.6.3.5 — Moments perpendicular to, and at the edge of, the slab structure should be transmitted to the supporting columns or walls. Torsional stresses caused by the moment assigned to the slab should be investigated.

R13.6.4, R13.6.5, and R13.6.6 — Factored moments in column strips, beams, and middle strips

The rules given for assigning moments to the column strips, beams, and middle strips are based on studies[13.21] of moments in linearly elastic slabs with different beam stiffness tempered by the moment coefficients that have been used successfully.

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For the purpose of establishing moments in the half column strip adjacent to an edge supported by a wall, ℓ_n in Eq. (13-4) may be assumed equal to ℓ_n of the parallel adjacent column to column span, and the wall may be considered as a beam having a moment of inertia I_b equal to infinity.

R13.6.4.2 — The effect of the torsional stiffness parameter β_t is to assign all of the exterior negative factored moment to the column strip, and none to the middle strip, unless the beam torsional stiffness is high relative to the flexural stiffness of the supported slab. In the definition of β_t, the shear modulus has been taken as $E_{cb}/2$.

Where walls are used as supports along column lines, they can be regarded as very stiff beams with an $\alpha_{f1}\ell_2/\ell_1$ value greater than 1. Where the exterior support consists of a wall perpendicular to the direction in which moments are being determined, β_t may be taken as zero if the wall is of masonry without torsional resistance, and β_t may be taken as 2.5 for a concrete wall with great torsional resistance that is monolithic with the slab.

CODE

13.6.4.3 — Where supports consist of columns or walls extending for a distance equal to or greater than $(3/4)\ell_2$ used to compute M_o, negative moments shall be considered to be uniformly distributed across ℓ_2.

13.6.4.4 — Column strips shall be proportioned to resist the following portions in percent of positive factored moments:

ℓ_2/ℓ_1	0.5	1.0	2.0
$(\alpha_{f1}\ell_2/\ell_1) = 0$	60	60	60
$(\alpha_{f1}\ell_2/\ell_1) \geq 1.0$	90	75	45

Linear interpolations shall be made between values shown.

13.6.4.5 — For slabs with beams between supports, the slab portion of column strips shall be proportioned to resist that portion of column strip moments not resisted by beams.

13.6.5 — Factored moments in beams

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13.6.5.1 — Beams between supports shall be proportioned to resist 85 percent of column strip moments if $\alpha_{f1}\ell_2/\ell_1$ is equal to or greater than 1.0.

13.6.5.2 — For values of $\alpha_{f1}\ell_2/\ell_1$ between 1.0 and zero, proportion of column strip moments resisted by beams shall be obtained by linear interpolation between 85 and zero percent.

13.6.5.3 — In addition to moments calculated for uniform loads according to 13.6.2.2, 13.6.5.1, and 13.6.5.2, beams shall be proportioned to resist all moments caused by concentrated or linear loads applied directly to beams, including weight of projecting beam stem above or below the slab.

13.6.6 — Factored moments in middle strips

13.6.6.1 — That portion of negative and positive factored moments not resisted by column strips shall be proportionately assigned to corresponding half middle strips.

13.6.6.2 — Each middle strip shall be proportioned to resist the sum of the moments assigned to its two half middle strips.

13.6.6.3 — A middle strip adjacent to and parallel with a wall-supported edge shall be proportioned to resist twice the moment assigned to the half middle strip corresponding to the first row of interior supports.

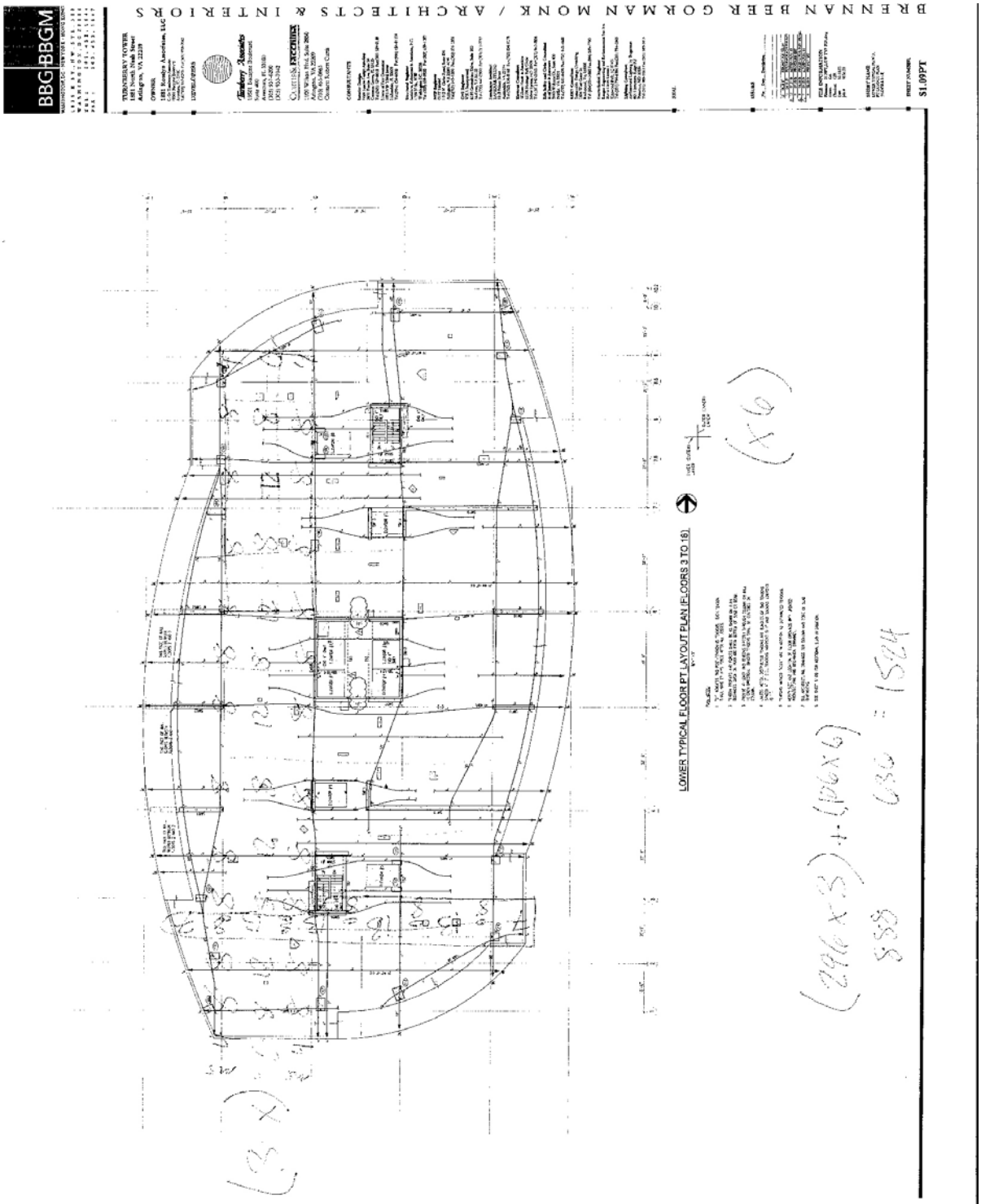
COMMENTARY

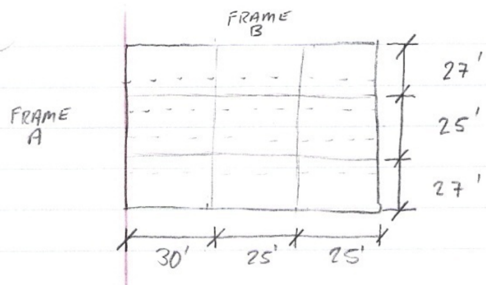
R13.6.5 — Factored moments in beams

Loads assigned directly to beams are in addition to the uniform dead load of the slab; uniform superimposed dead loads, such as the ceiling, floor finish, or assumed equivalent partition loads; and uniform live loads. All of these loads are normally included with q_u in Eq. (13-4). Linear loads applied directly to beams include partition walls over or along beam centerlines and additional dead load of the projecting beam stem. Concentrated loads include posts above or hangers below the beams. For the purpose of assigning directly applied loads, only loads located within the width of the beam stem should be considered as directly applied to the beams. (The effective width of a beam as defined in 13.2.4 is solely for strength and relative stiffness calculations.) Line loads and concentrated loads located on the slab away from the beam stem require consideration to determine their apportionment to slab and beams.

TABLE A.5a
Flexural resistance factor: $R = \rho f_y\left(1 - 0.588\,\frac{\rho f_y}{f'_c}\right)$ psi

	f_y = 40,000 psi				f_y = 60,000 psi			
	f'_c, psi				f'_c, psi			
ρ	3000	4000	5000	6000	3000	4000	5000	6000
0.0005	20	20	20	20	30	30	30	30
0.0010	40	40	40	40	59	59	60	60
0.0015	59	59	60	60	88	89	89	89
0.0020	79	79	79	79	117	118	118	119
0.0025	98	99	99	99	146	147	147	148
0.0030	117	118	118	119	174	175	176	177
0.0035	136	137	138	138	201	204	205	206
0.0040	155	156	157	157	229	232	233	234
0.0045	174	175	176	177	256	259	261	263
0.0050	192	194	195	196	282	287	289	291
0.0055	211	213	214	215	309	314	317	319
0.0060	229	232	233	234	335	341	345	347
0.0065	247	250	252	253	360	368	372	375
0.0070	265	268	271	272	385	394	399	403
0.0075	282	287	289	291	410	420	426	430
0.0080	300	305	308	310	435	446	453	457
0.0085	317	323	326	329	459	472	479	485
0.0090	335	341	345	347	483	497	506	511
0.0095	352	359	363	366	506	522	532	538
0.0100	369	376	381	384	529	547	558	565
0.0105	385	394	399	403	552	572	583	591
0.0110	402	412	417	421	575	596	609	617
0.0115	419	429	435	439	597	620	634	643
0.0120	435	446	453	457	618	644	659	669
0.0125	451	463	471	476	640	667	684	695
0.0130	467	480	488	494	661	691	708	720
0.0135	483	497	506	511	681	714	733	746
0.0140	499	514	523	529	702	736	757	771
0.0145	514	531	540	547	722	759	781	796
0.0150	529	547	558	565	741	781	805	821
0.0155	545	563	575	582	760	803	828	845
0.0160	560	580	592	600		825	852	870
0.0165	575	596	609	617		846	875	894
0.0170	589	612	626	635		867	898	918
0.0175	604	628	642	652		888	920	942
0.0180	618	644	659	669		909	943	966
0.0185	633	660	676	686		929	965	989
0.0190	647	675	692	703		949	987	1013
0.0195	661	691	708	720		969	1009	1036
0.0200	675	706	725	737		988	1031	1059


BRENNAN BEER GORMAN MONK / ARCHITECTS & INTERIORS
BBG|BBGM
LOWER TYPICAL FLOOR PT LAYOUT PLAN (FLOORS 3 TO 16)



ASSUMPTIONS

20" x 20" COLUMNS

LIVE LOAD = 40 psf TABLE 4-1 ASCE 7-05

DEAD = 137.5

6 BARS

THICKNESS OF SLAB - ACI 318 Building Code Chpt 9 9.5(c) 2008

W/o DROP PANEL

W/o EDGE BEAMS $= l_n/33$

60 Ksi STEEL

* TO BE CONSERVATIVE, PICK LARGEST BAY ∴ = 30'

$= \frac{30 \times 12}{33} = 10.9'' = 11''$

FIND MOMENT

$M_o = 1/8\, W_u\, l_2\, l_u^2$ $W_u = 1.2D + 1.6L$

$\frac{27+25}{2}$ $20'' = 1.67'$ $\frac{30}{2} + \frac{25}{2} = 27.5'$

FRAME A $= 1/8\,(0.202)(26)(25.83)^2$ $= 1.2\,(\frac{11}{12} \times 150) + 1.6\,(40)$ $l_2 = 26'$ $l_u = 27.5 - 1.67$

$= 438$ K-ft $= 137.5 + 64$ $= 25.83$

$= 202$ psf $= 0.202$ ksf

FRAME B $M_o = 1/8\,(0.202)(27.5)(24.33)^2$ $W_u = 0.202$ ksf $l_2 = 27.5$ $l_u = 26 - 1.67$

$= 411$ K-ft $= 24.33$

CHART 13.6.3.2

NEG FACTORED MOMENT = 0.65 $\alpha = \frac{\text{Beam}}{\text{Column}} \cdot \frac{0\, l_2}{l_1} = 0$

POS FACTORED MOMENT = 0.35 $\beta_t = \frac{EC}{2EI} = 0$ TORSION CONSTANT OF TRANSVERSE BEAM

FRAME A $l_2/l_1 \Rightarrow 26/27.5 = 0.945$

13.6.4.1 ∴ 75% IN COLUMN STRIP, 25% IN MIDDLE STRIP (− MOMENT) ∴ 60% IN COLUMN STRIP, 40% IN MIDDLE STRIP (+ MOMENT) 13.6.4.4

FRAME B $l_2/l_1 \Rightarrow 27.5/26 = 1.06$

∴ 75% IN COLUMN STRIP, 25% IN MIDDLE STRIP (− MOMENT) ∴ 60% IN COLUMN STRIP, 40% IN MIDDLE STRIP (+ MOMENT)

- MOMENT = TOP BAR
+ MOMENT = BOTTOM BAR

FRAME A - MOMENT: $(M_o \times 0.65)$ + MOMENT: $(M_o \times 0.35)$

$(438)(0.65) = 284.7$ $(438)(0.35) = 153.3$

$(284.7)(0.75) = M_n$ $(284.7)(0.25) = M_n$ $(153.3)(0.60) = M_n$ $(153.3)(0.40) = M_n$

$M_n = 214$ ft-k (CS) $M_n = 72$ ft-k (MS) $M_n = 92$ ft-k (CS) $M_n = 62$ ft-k (MS)

FRAME B - MOMENT: $(M_o \times 0.65)$ + MOMENT: $(M_o \times 0.35)$

$(411)(0.65) = 268$ $(411)(0.35) = 144$

$(268)(0.75) = M_n$ $(268)(0.25) = M_n$ $(144)(0.60) = M_n$ $(144)(0.40) = M_n$

$M_n = 201$ ft-k (CS) $M_n = 67$ ft-k (MS) $M_n = 87$ ft-k (CS) $M_n = 58$ ft-k (MS)

	+ Moment	- Moment
COLUMN STRIP	92 ft-k	214 ft-k
MIDDLE STRIP	62 ft-k	72 ft-k

FRAME A

	+ MOMENT	- MOMENT
COLUMN STRIP	87 ft-k	201 ft-k
MIDDLE STRIP	58 ft-k	67 ft-k

FRAME B

COLUMN STRIP - FRAME B

ITEM	DESCRIPTION	-M	+M
1	MOMENT (M_n)	201	87
2	Cs - SLAB WIDTH (b (in))	165	165
3	EFFECTIVE DEPTH (d (in))	9	9
4	$M_u = M_n / 0.9$	223	97
5	$M_n \times 12 / b$	14.62	6.33
6	$R = \frac{M_u \times 12000}{bd^2}$	200	87
7	ρ = FROM A.5a	0.0034	0.0015
8	$A_s = \rho bd$	5.05	2.23
9	$A_s = 0.0018 bt$	3.27	3.27
10	LARGER 8 OR 9 / 0.44	12	8
11	$N_{min} = \#2 / 2t$	8	8
F	LARGER 10 OR 11	12	8

$\frac{27.5 \times 12}{2}$

MIDDLE STRIP - FRAME B

ITEM	DESCRIPTION	-M	+ M
1	MOMENT (M_n)	67	58
2	Cs - SLAB WIDTH (b (in))	165	165
3	EFFECTIVE DEPTH (d (in))	9	9
4	$M_u = M_n / 0.9$	74.44	64.44
5	$M_n \times 12 / b$	4.87	4.22
6	$R = \frac{M_u \times 12000}{bd^2}$	67	58
7	ρ = FROM A.5a	0.0011	0.001
8	$A_s = \rho bd$	1.634	1.485
9	$A_s = 0.0018 bt$	3.27	3.27
10	LARGER 8 OR 9 / 0.44	8	8
11	$N_{min} = \#2 / 2t$	8	8
F	LARGER 10 OR 11	8	8

CHECK

ONE WAY SHEAR

FRAME A

$V_u = W_u(1')\left(\ell_2 - \frac{\text{column}/12}{2} - \frac{d}{12}\right)$

$= 0.202(1)\left(27.5 - \frac{20/12}{2} - 9/12\right)$

$= 5.24$

$\phi V_c = \frac{0.75(2)\sqrt{5000}(12)\,d}{1000}$

$= 11.46$

$V_u < \phi V_c \therefore$ OK ✓

FRAME B

$V_u = 0.202(1)(26 - 20/12/2 - 9/12)$

$= 4.93$

$\phi V_c = 11.46$

$V_u < \phi V_c \therefore$ OK ✓

PUNCHING SHEAR

$V_c = 4\sqrt{f'c}\, b_o d$

$V_c = \left(2 + \alpha_s/\beta_c\right)\sqrt{f'c}\, b_o d$

$V_c = \left(\alpha_s/b_o/d + 2\right)\sqrt{f'c}\, b_o d$

$\alpha_s = 40$

b_o = perimeter of column (in)

d = Eqn

$\beta_c = 1$ b/c square column

$V_c = 4(\sqrt{5000})(29\times4)(9) = 295$ K

$V_c = 6\sqrt{5000}(29\times4)(9) = 443$ K

$V_c = 5.1(\sqrt{5000})(29\times4)(9) = 377$ K

$b_o = (20 + 4.5 + 4.5) = 29$ (b, d/2, d/2)

295 x 0.75 (SAFETY FACTOR)

$= 221$ K

$V_c > V_u \therefore$ OK ✓

$V_u = (\text{AREA OF SLAB} \times W_u) - \text{column}^2/144$

$= (26 \times 27.5 \times 0.202) - 20^2/144/2$

$= 143$ K

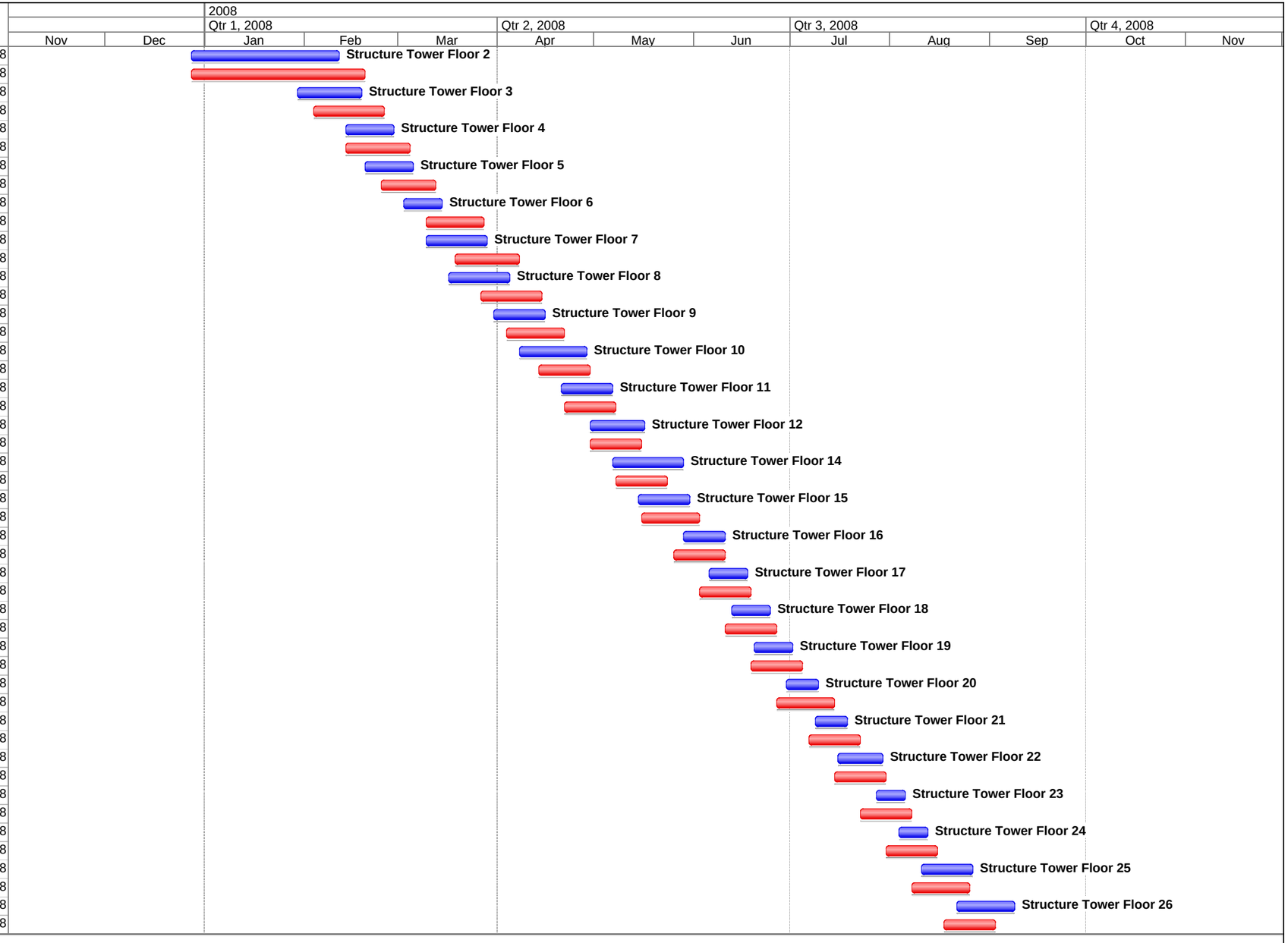
Appendix D

Structural System Schedule and Cost Estimates

Contents:

- Post Tension Concrete Schedule vs. Reinforced Concrete System
- Reinforced Concrete Option 1 (Removing One Story) Takeoff Notes & Cost Analysis
- Reinforced Concrete Option 2 (Story Height Adjustment) Takeoff Notes & Cost Analysis
- Comparing Cost of 3 Concrete Systems

ID	Task Name	Duration	Start	Finish
1	Structure Tower Floor 2	32 days	Fri 12/28/07	Mon 2/11/08
2	Floor 2 - Reinforced Concrete	38 days	Fri 12/28/07	Tue 2/19/08
3	Structure Tower Floor 3	14 days	Wed 1/30/08	Mon 2/18/08
4	Floor 3 - Reinforced Concrete	16 days	Mon 2/4/08	Mon 2/25/08
5	Structure Tower Floor 4	11 days	Thu 2/14/08	Thu 2/28/08
6	Floor 4 - Reinforced Concrete	14 days	Thu 2/14/08	Tue 3/4/08
7	Structure Tower Floor 5	11 days	Wed 2/20/08	Wed 3/5/08
8	Floor 5 - Reinforced Concrete	13 days	Mon 2/25/08	Wed 3/12/08
9	Structure Tower Floor 6	10 days	Mon 3/3/08	Fri 3/14/08
10	Floor 6 - Reinforced Concrete	14 days	Mon 3/10/08	Thu 3/27/08
11	Structure Tower Floor 7	15 days	Mon 3/10/08	Fri 3/28/08
12	Floor 7 - Reinforced Concrete	14 days	Wed 3/19/08	Mon 4/7/08
13	Structure Tower Floor 8	15 days	Mon 3/17/08	Fri 4/4/08
14	Floor 8 - Reinforced Concrete	13 days	Thu 3/27/08	Mon 4/14/08
15	Structure Tower Floor 9	12 days	Mon 3/31/08	Tue 4/15/08
16	Floor 9 - Reinforced Concrete	12 days	Fri 4/4/08	Mon 4/21/08
17	Structure Tower Floor 10	15 days	Tue 4/8/08	Mon 4/28/08
18	Floor 10 - Reinforced Concrete	12 days	Mon 4/14/08	Tue 4/29/08
19	Structure Tower Floor 11	12 days	Mon 4/21/08	Tue 5/6/08
20	Floor 11 - Reinforced Concrete	12 days	Tue 4/22/08	Wed 5/7/08
21	Structure Tower Floor 12	13 days	Wed 4/30/08	Fri 5/16/08
22	Floor 12 - Reinforced Concrete	12 days	Wed 4/30/08	Thu 5/15/08
23	Structure Tower Floor 14	16 days	Wed 5/7/08	Wed 5/28/08
24	Floor 14 - Reinforced Concrete	12 days	Thu 5/8/08	Fri 5/23/08
25	Structure Tower Floor 15	12 days	Thu 5/15/08	Fri 5/30/08
26	Floor 15 - Reinforced Concrete	12 days	Fri 5/16/08	Mon 6/2/08
27	Structure Tower Floor 16	9 days	Thu 5/29/08	Tue 6/10/08
28	Floor 16 - Reinforced Concrete	12 days	Mon 5/26/08	Tue 6/10/08
29	Structure Tower Floor 17	8 days	Fri 6/6/08	Tue 6/17/08
30	Floor 17 - Reinforced Concrete	12 days	Tue 6/3/08	Wed 6/18/08
31	Structure Tower Floor 18	8 days	Fri 6/13/08	Tue 6/24/08
32	Floor 18 - Reinforced Concrete	12 days	Wed 6/11/08	Thu 6/26/08
33	Structure Tower Floor 19	8 days	Fri 6/20/08	Tue 7/1/08
34	Floor 19 - Reinforced Concrete	12 days	Thu 6/19/08	Fri 7/4/08
35	Structure Tower Floor 20	8 days	Mon 6/30/08	Wed 7/9/08
36	Floor 20 - Reinforced Concrete	12 days	Fri 6/27/08	Mon 7/14/08
37	Structure Tower Floor 21	8 days	Wed 7/9/08	Fri 7/18/08
38	Floor 21 - Reinforced Concrete	12 days	Mon 7/7/08	Tue 7/22/08
39	Structure Tower Floor 22	10 days	Wed 7/16/08	Tue 7/29/08
40	Floor 22 - Reinforced Concrete	12 days	Tue 7/15/08	Wed 7/30/08
41	Structure Tower Floor 23	7 days	Mon 7/28/08	Tue 8/5/08
42	Floor 23 - Reinforced Concrete	12 days	Wed 7/23/08	Thu 8/7/08
43	Structure Tower Floor 24	7 days	Mon 8/4/08	Tue 8/12/08
44	Floor 24 - Reinforced Concrete	12 days	Thu 7/31/08	Fri 8/15/08
45	Structure Tower Floor 25	12 days	Mon 8/11/08	Tue 8/26/08
46	Floor 25 - Reinforced Concrete	12 days	Fri 8/8/08	Mon 8/25/08
47	Structure Tower Floor 26	12 days	Fri 8/22/08	Mon 9/8/08
48	Floor 26 - Reinforced Concrete	12 days	Mon 8/18/08	Tue 9/2/08



Turnberry Tower Arlington
Post Tension vs. Reinforced

Task | Milestone | Rolled Up Task | Rolled Up Progress | External Tasks | Group By Summary
Progress | Summary | Rolled Up Milestone | Split | Project Summary | Deadline

Reinforced Concrete Option 1 (Removing One Story) Takeoff Notes & Cost Analysis

Concrete Slabs (Reinforced Concrete)				
Level	Area (Ft^2)	Thickness (Ft)	Volume (CF)	Volume (CY)
P-6	40,000	0.67	26800	993
P-5	40,000	0.67	26800	993
P-4	40,000	0.67	26800	993
P-3	40,000	0.67	26800	993
P-2	40,000	0.67	26800	993
P-1	40,000	0.67	26800	993
L	25,000	1	25000	926
2	20,100	0.917	18425	682
3	20,100	0.917	18425	682
4	20,100	0.917	18425	682
5	20,100	0.917	18425	682
6	20,100	0.917	18425	682
7	20,100	0.917	18425	682
8	20,100	0.917	18425	682
9	20,100	0.917	18425	682
10	20,100	0.917	18425	682
11	20,100	0.917	18425	682
12	20,100	0.917	18425	682
14	20,100	0.917	18425	682
15	20,100	0.917	18425	682
16	20,100	0.917	18425	682
17	20,100	0.917	18425	682
19	20,100	0.917	18425	682
20	20,100	0.917	18425	682
21	20,100	0.917	18425	682
22	20,100	0.917	18425	682
23	20,100	0.917	18425	682
24	20,100	0.917	18425	682
25	20,100	0.917	18425	682
26	20,100	0.917	18425	682
MPH	20,100	0.917	18425	682
			Total (CY)	23259
			Waste Factor (5%)	1.05
TOTAL CONCRETE FOR REINFORCED SLABS (CY)				**24422**

Concrete			
Area	Amount (CY)	Cost per CY	Total Cost
Footings (Columns)	296	$125	$37,000
Footings (Shear Walls)	1,075	$125	$134,375
Columns	2,192	$125	$274,038
Slab On Grade	1,043	$125	$130,331
Mud Slab	85	$125	$10,625
Floor Slabs	23,380	$125	$2,922,500
Beams	5,878	$125	$734,750
Shear Walls	8,491	$125	$1,061,375
Curbs, Pads, Toppings	915	$125	$114,375
TOTAL	**43,355**		**$5,419,369**

Reinforcing Steel			
Area	Amount (Ton)	Cost per Ton	Total Cost
Columns	354	$1,000	$354,200
Shear Walls	1944	$1,000	$1,944,000
Slabs	1065	$1,000	$1,065,000
TOTAL	**3363**		**$3,363,200**

Miscellaneous Items			
Item	Amount	Cost per	Total Cost
WWF 6x6 W1.4/W1.4	19,312 SF	$18.05 / CSF	$348,582
WWF 6x6 W2.1/W2.1	53,001 SF	$26.50 / CSF	$1,404,527
TOTAL			**$1,753,108**

Total Material Cost		
Item	Amount	Total Cost
Concrete	43355 CY	$5,419,369
Reinforcing Steel	3363 Tons	$3,363,200
Miscellaneous Items		$1,753,108
TOTAL		**$10,535,677**
TOTAL PER CY		**$243.01**

Concrete Total Cost

Description	Method of Placement	Qty	Unit	Material	Labor	Equipment	Total Cost
Spread Footings (Columns)	Crane and Bucket	296	CY	$125.00	$24.50	$11.95	$47,789
Spread Footings (Shear Walls)	Crane and Bucket	1,075	CY	$125.00	$24.50	$11.95	$173,559
Columns	Pumped	2,192	CY	$125.00	$24.00	$8.80	$345,898
Slab on Grade	Crane and Bucket	1,043	CY	$125.00	$17.00	$8.25	$156,711
Mud Slab	Crane and Bucket	85	CY	$125.00	$17.00	$8.25	$12,771
Floor Slabs	Pumped	23,380	CY	$125.00	$13.55	$4.94	$3,354,796
Beams	Pumped	5,878	CY	$125.00	$24.00	$8.80	$927,548
Shear Walls	Pumped	8,491	CY	$125.00	$19.75	$7.20	$1,290,207
Curbs, Pads, Toppings	Hauled	915	CY	$125.00	$20.58	$9.33	$141,743
TOTAL		**43,355**	**CY**				**$6,451,022**

Average Labor and Equipment

Description	Labor	Equipment	Unit
Footings	$54.50	$0.33	CY
Columns	$435.00	$42.50	CY
Slab on Grade	$55.00	$0.41	CY
Slabs	$207.00	$19.60	CY
Beams	$490.00	$48.50	CY
Shear Walls	$430.00	$42.50	CY
Curbs, Pads, Toppings	$129.00	$1.78	CY
Average per CY	**$257.21**	**$22.23**	**CY**

Construction Cost of Concrete System for Turnberry Tower Arlington

Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	43355	CY	$243.01	$257.21	$22.23	$22,651,046
				TOTAL	**$30.20**	**per SF**

Reinforced Concrete Option 2 (Story Height Adjustment) Takeoff Notes & Cost Analysis

Concrete Slabs (Reinforced Concrete)				
Level	Area (Ft^2)	Thickness (Ft)	Volume (CF)	Volume (CY)
P-6	40,000	0.67	26800	993
P-5	40,000	0.67	26800	993
P-4	40,000	0.67	26800	993
P-3	40,000	0.67	26800	993
P-2	40,000	0.67	26800	993
P-1	40,000	0.67	26800	993
L	25,000	1	25000	926
2	20,100	0.917	18425	682
3	20,100	0.917	18425	682
4	20,100	0.917	18425	682
5	20,100	0.917	18425	682
6	20,100	0.917	18425	682
7	20,100	0.917	18425	682
8	20,100	0.917	18425	682
9	20,100	0.917	18425	682
10	20,100	0.917	18425	682
11	20,100	0.917	18425	682
12	20,100	0.917	18425	682
14	20,100	0.917	18425	682
15	20,100	0.917	18425	682
16	20,100	0.917	18425	682
17	20,100	0.917	18425	682
18	20,100	0.917	18425	682
19	20,100	0.917	18425	682
20	20,100	0.917	18425	682
21	20,100	0.917	18425	682
22	20,100	0.917	18425	682
23	20,100	0.917	18425	682
24	20,100	0.917	18425	682
25	20,100	0.917	18425	682
26	20,100	0.917	18425	682
MPH	20,100	0.917	18425	682
			Total (CY)	23942
			Waste Factor (5%)	1.05
TOTAL CONCRETE FOR REINFORCED SLABS (CY)				**25139**

Concrete			
Area	Amount (CY)	Cost per CY	Total Cost
Footings (Columns)	296	$125	$37,000
Footings (Shear Walls)	1,075	$125	$134,375
Columns	2,192	$125	$274,038
Slab On Grade	1,043	$125	$130,331
Mud Slab	85	$125	$10,625
Floor Slabs	24,097	$125	$3,012,125
Beams	5,878	$125	$734,750
Shear Walls	8,491	$125	$1,061,375
Curbs, Pads, Toppings	915	$125	$114,375
TOTAL	**44,072**		**$5,508,994**

Reinforcing Steel			
Area	Amount (Ton)	Cost per Ton	Total Cost
Columns	354	$1,000	$354,200
Shear Walls	1944	$1,000	$1,944,000
Slabs	1100	$1,000	$1,100,000
TOTAL	**3398**		**$3,398,200**

Miscellaneous Items			
Item	Amount	Cost per	Total Cost
WWF 6x6 W1.4/W1.4	19,312 SF	$18.05 / CSF	$348,582
WWF 6x6 W2.1/W2.1	53,001 SF	$26.50 / CSF	$1,404,527
TOTAL			**$1,753,108**

Total Material Cost		
Item	Amount	Total Cost
Concrete	44072 CY	$5,508,994
Reinforcing Steel	3983 Tons	$3,398,200
Miscellaneous Items		$1,753,108
TOTAL		**$10,660,302**
TOTAL PER CY		**$241.88**

Concrete Total Cost

Description	Method of Placement	Qty	Unit	Material	Labor	Equipment	Total Cost
Spread Footings (Columns)	Crane and Bucket	296	CY	$125.00	$24.50	$11.95	$47,789
Spread Footings (Shear Walls)	Crane and Bucket	1,075	CY	$125.00	$24.50	$11.95	$173,559
Columns	Pumped	2,192	CY	$125.00	$24.00	$8.80	$345,898
Slab on Grade	Crane and Bucket	1,043	CY	$125.00	$17.00	$8.25	$156,711
Mud Slab	Crane and Bucket	85	CY	$125.00	$17.00	$8.25	$12,771
Floor Slabs	Pumped	24,097	CY	$125.00	$13.55	$4.94	$3,457,679
Beams	Pumped	5,878	CY	$125.00	$24.00	$8.80	$927,548
Shear Walls	Pumped	8,491	CY	$125.00	$19.75	$7.20	$1,290,207
Curbs, Pads, Toppings	Hauled	915	CY	$125.00	$20.58	$9.33	$141,743
TOTAL		**44,072**	**CY**				**$6,553,905**

Average Labor and Equipment

Description	Labor	Equipment	Unit
Footings	$54.50	$0.33	CY
Columns	$435.00	$42.50	CY
Slab on Grade	$55.00	$0.41	CY
Slabs	$207.00	$19.60	CY
Beams	$490.00	$48.50	CY
Shear Walls	$430.00	$42.50	CY
Curbs, Pads, Toppings	$129.00	$1.78	CY
Average per CY	**$257.21**	**$22.23**	**CY**

Construction Cost of Concrete System for Turnberry Tower Arlington

Description	Qty	Unit	Material	Labor	Equipment	Total Cost
Cast In Place Concrete including placing and stripping formwork, placing rebar, placing concrete, and finishing concrete	44072	CY	$241.88	$257.21	$22.23	$22,975,867
				TOTAL	**$30.63**	**per SF**

Comparing Cost of 3 Concrete Systems

Structural Systems Cost Comparison for Turnberry Tower Arlington			
Structural System	Residential Units	Total Structural Cost	Cost per SF
Post Tension Concrete	247	$20,658,837	$27.55
Reinforced Concrete (Removing 1 Story)	235	$22,651,046	$30.20
Reinforced Concrete (Adjusting Story Height)	247	$22,975,867	$30.63

Appendix E

Supply Water System Takeoff Notes and Estimates

Contents:

- Propress System Takeoff Notes and Estimate (Typical Unit)
- Comparing Cost of Propress System vs. CPVC System

Propress System Takeoff Notes (Typical Unit)

Pipe (Copper - Type L - PP)

Item	Size	Quantity	Price	Mat. Cost	Unit Labor Hr	Total Hrs.	Labor Cost	Total Cost
Hard Tube	1/2	280	$1.96	$437.93	0.02	6	$391	$829
	3/4	94	$3.12	$234.05	0.02	2	$131	$365
	1	76	$4.69	$284.45	0.03	2	$126	$410
Totals		**450**		**$956.42**		**10**	**$648**	**$1,604**

Fittings (Copper - Propress - PP)

Item	Size	Quantity	Price	Mat. Cost	Unit Labor Hr	Total Hrs.	Labor Cost	Total Cost
45 Degree Elbow	1/2	12	$3.30	$75.77	0.41	5	$329	$405
	3/4	3	$4.05	$23.25	0.41	1	$82	$105
90 Degree Elbow	1/2	27	$2.84	$146.71	0.41	11	$740	$887
	3/4	18	$4.80	$165.29	0.41	7	$493	$658
	1	17	$9.62	$312.86	0.09	2	$104	$417
Coupling	1/2	13	$2.55	$63.42	0	0	$0	$63
	3/4	7	$3.87	$51.83	0	0	$0	$52
	1	5	$7.82	$74.80	0	0	$0	$75
Reducer	3/4 x 1/2	17	$11.60	$377.27	0.21	4	$233	$610
	1 x 3/4	10	$13.30	$254.44	0.25	2	$164	$418
Tee	3/4	8	$7.64	$116.93	0.62	5	$329	$446
	1	7	$13.76	$184.28	0.14	1	$64	$248
Tee Reducing	3/4 x 3/4 x 1/2	6	$6.42	$73.69	0.31	2	$123	$197
	1 x 1 x 1/2	2	$15.75	$60.27	0.37	1	$49	$109
	1 x 1 x 3/4	1	$15.75	$30.14	0.37	0	$25	$55
Totals		**153**		**$2,010.92**		**41**	**$2,735**	**$4,746**

Hanger Components

Item	Size	Quantity	Price	Mat. Cost	Unit Labor Hr	Total Hrs.	Labor Cost	Total Cost
Fig 65 Clevis	1-1/2	56	$5.14	$138.16	0.46	26	$1,720	$1,858
	2	30	$5.50	$79.20	0.27	8	$541	$620
Allthread-Galv.	3/8	344	$3.86	$132.78	0	0	$0	$133
Wedge Anchors	3/8	86	$1.35	$55.73	0	0	$0	$56
Totals		**516**		**$405.87**		**34**	**$2,261**	**$2,667**

Misc. Components								
Item	Size	Quantity	Price	Mat. Cost	Unit Labor Hr	Total Hrs.	Labor Cost	Total Cost
Washers - Galv.	3/8	258	0.39	$10.06	0	0	$0	$10
Nuts - Galv.	3/8	258	0.25	$44.51	0	0	$0	$45
Totals		**516**		**$54.57**		**0**	**$0**	**$55**

	Mat. Cost	Total Hrs.	Labor Cost	Total Cost
PROPRESS SYSTEM GRAND TOTALS (TYP. UNIT)	**$3,428**	**85**	**$5,644**	**$9,072**

Comparing CPVC vs. Propress Supply Water Systems (Per Typical Unit)									
CPVC System					Propress System (2006)				
Item	Mat. Cost	Total Hrs.	Labor Cost	Total Cost	Item	Mat. Cost	Total Hrs.	Labor Cost	Total Cost
Pipe	$856.48	10	$649	$1,505	Pipe	$956.42	10	$648	$1,604
Fittings	$350.26	58	$3,844	$4,194	Fittings	$2,010.92	41	$2,735	$4,746
Hanger Components	$405.87	34	$2,261	$2,667	Hanger Components	$405.87	34	$2,261	$2,667
Misc. Compenents	$56.90	0	$0	$57	Misc. Compenents	$54.57	0	$0	$55
Total	$1,670	102	$6,754	**$8,424**	**Total**	$3,428	85	$5,644	**$9,072**

Cost of Supply Water System to Units in Turnberry Tower Arlington							
CPVC System				Propress System (2006)			
Cost Per Unit	Total Cost for 247 Units	Man Hours per Unit	Total Hours for 247 Units	Cost Per Unit	Total Cost for 247 Units	Man Hours per Unit	Total Hours for 247 Units
$8,424	$2,080,728	102	25,194	$9,072	$2,240,784	85	20,995
Time Savings Using Propress System over CPVC System (Man Hours)							**4,199**
Cost Savings Using Propress System over CPVC System ($)							**($160,056)**

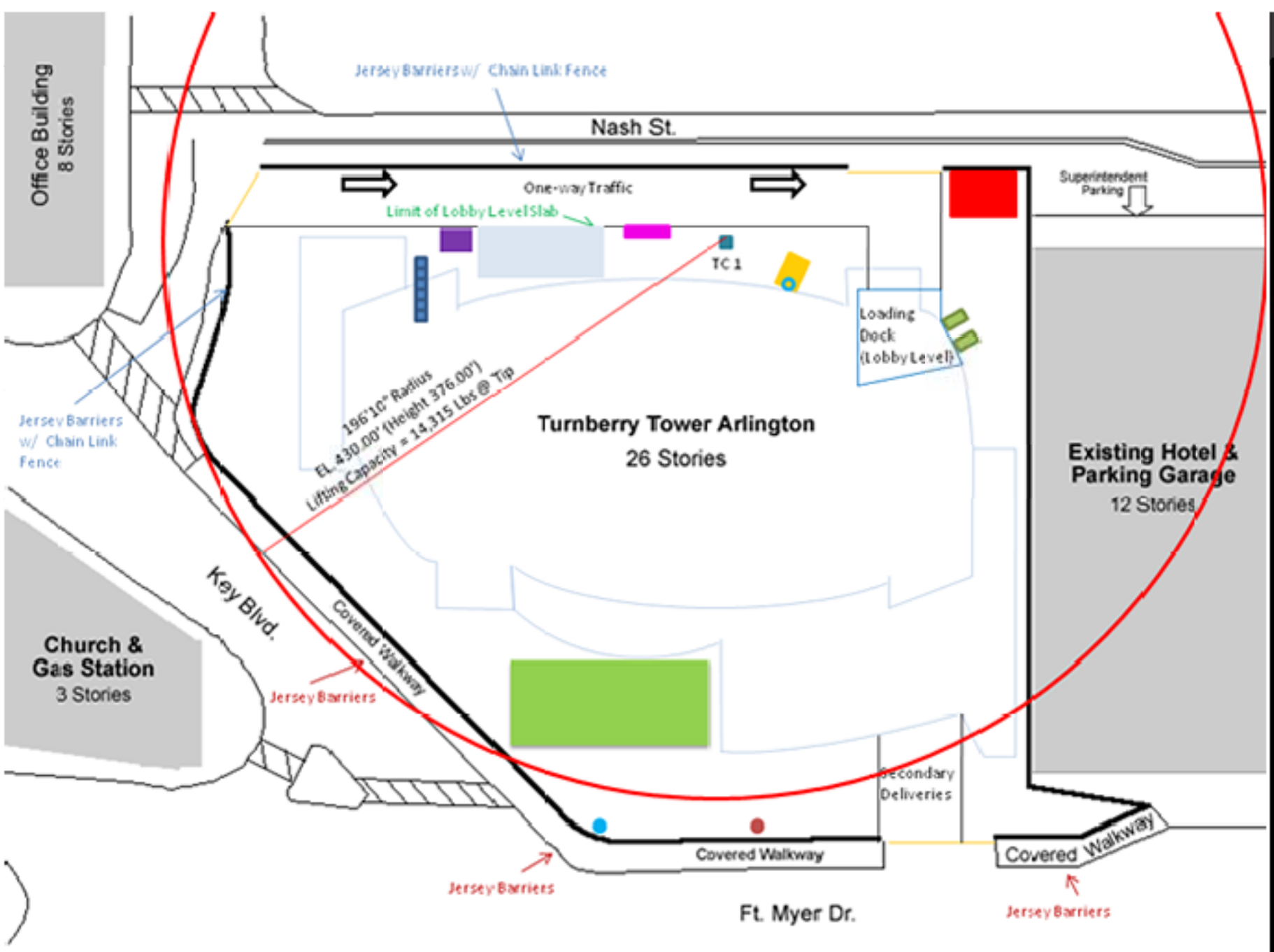
Note: This comparison is using prices from 2006

Appendix F

Site Logistics Plan for Material Delivery

Contents:

- Original Site Logistics Plan
- Modified Site Logistics Plan
- Flow of drywall through level 2 of the building



Turnberry Tower

Turnberry Tower Arlington
Site Plan - Tower Erection

Revisions

Date	No.	Description

Seal

Legend

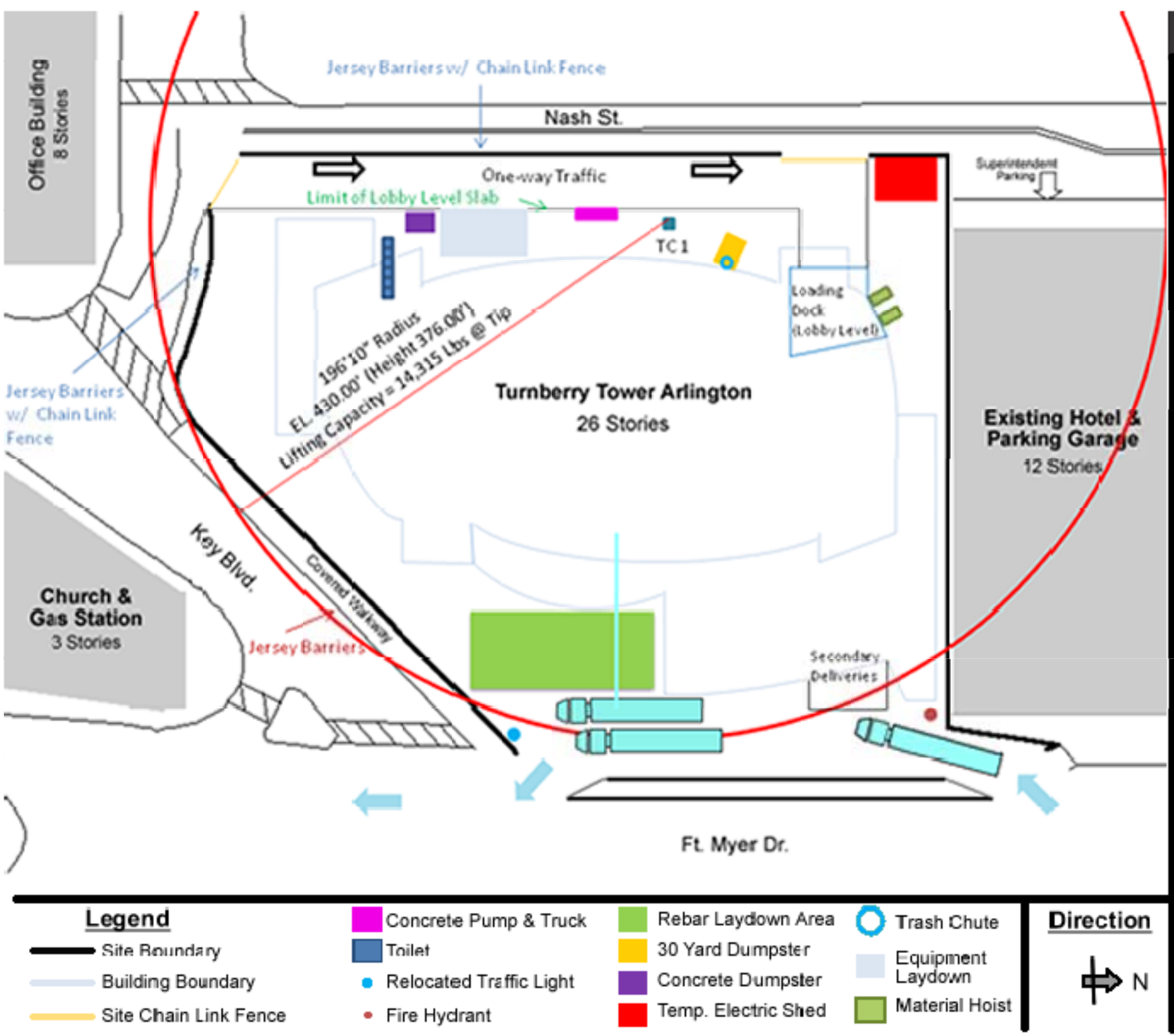
- Site Boundary
- Building Boundary
- Site Chain Link Fence
- Concrete Pump & Truck
- Toilet
- Relocated Traffic Light
- Fire Hydrant
- Rebar Laydown Area
- 30 Yard Dumpster
- Concrete Dumpster
- Temp. Electric Shed
- Trash Chute
- Equipment Laydown
- Material Hoist

Direction

N

Drawn by: Larry Warner
Date: 10/24/2008

Sheet Number
96 OF 99



Turnberry Tower

Turnberry Tower Arlington
Site Plan - Tower Erection

Revisions

Date	No.	Description

Seal

Drawn by: Larry Warner

Sheet Number
97 OF 99

Legend

- Site Boundary
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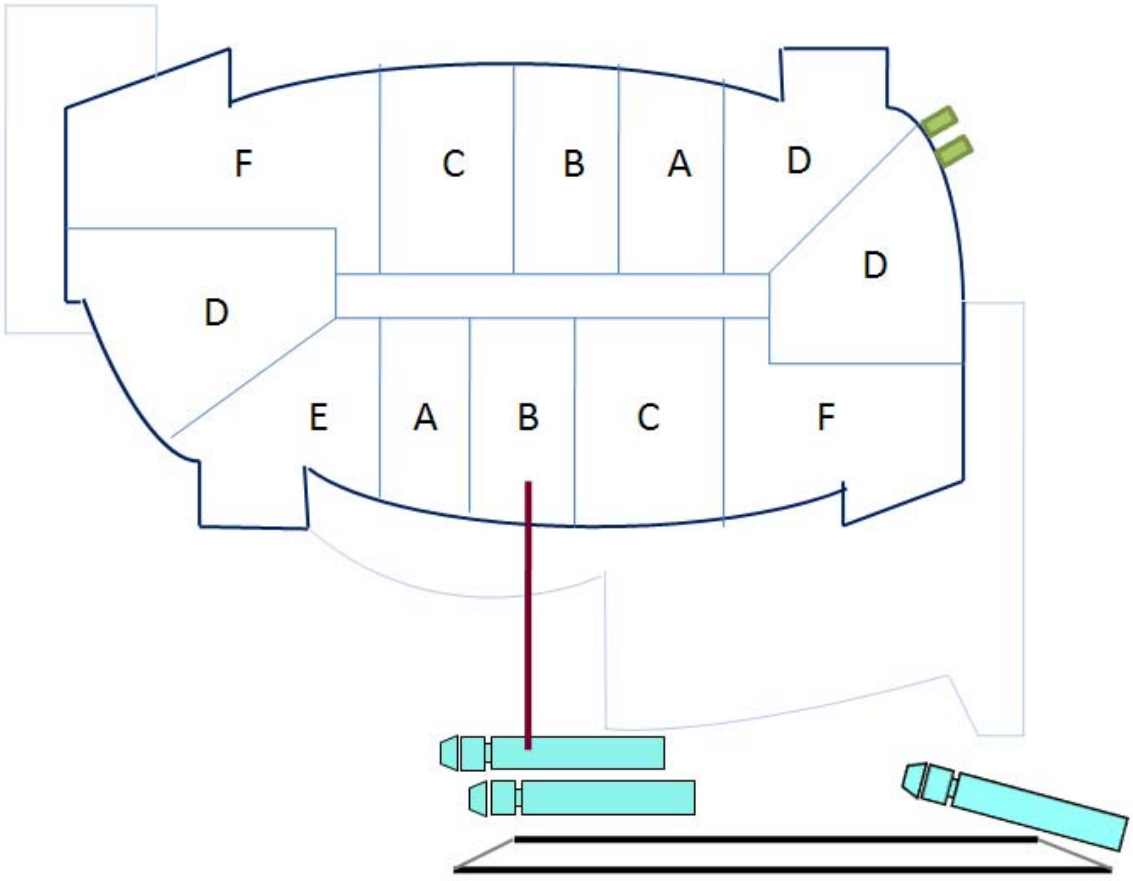
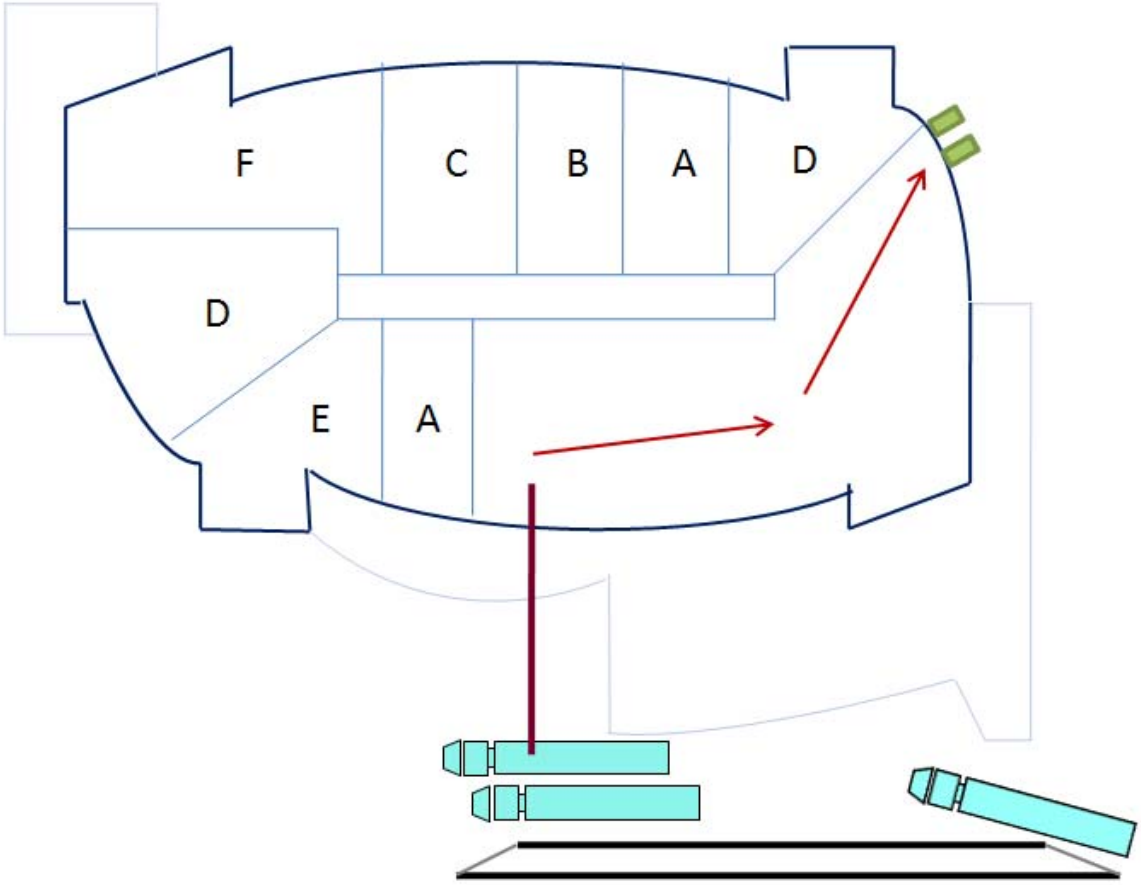
- Concrete Dumpster
- Temp. Electric Shed
- Trash Chute
- Equipment Laydown
- Material Hoist

Direction

N

2nd Floor Deliveries




F
C
B
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