TURNBERRY TOWER ARLINGTON

ARLINGTON, VIRGINIA

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Construction Management

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November 21, 2008

Technical Assignment 3

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Executive Summary

This technical assignment has been put together to further familiarize the reader with the Turnberry Tower Arlington Project in Arlington, Virginia. In this report you will find a summary on some of the constructability challenges that were faced by members of the general contractor on this project, different activities that helped to accelerate the schedule, and different value engineering topics that were both used and not used in the construction of this project. The reader will also learn about several problems that occurred during the construction of this building as well as some of the possible topics that can be used for my research in the next part of senior thesis.

Major constructability challenges occurred in this building during construction. The sunshade's biggest problem was it contained many diagonal and odd shaped pieces. In order for it to be connected to the building, it needed to be supported by the mullions in the exterior skin. This only allowed for less than 1/8" tolerance. The window wall supports were designed after the post tension concrete slabs were poured. This led to tendon failures on different floor slabs. In the residential units, MEP fit in led to conflicts in the field that led to delays on the schedule and change orders that cost the owner money.

In order to accelerate the schedule, key activities were targeted after the schedule fell behind. While many activities fell on the critical path including excavation and drywall installation, these activities also allowed for more workers on the job which would accelerate this activities. Activities such as exterior skin installation and obtain final permits caused the biggest risk to the schedule falling behind.

Value engineering topics came up on this project; some were used and some were not. Installation of the sovent system reduced one stack in each plumbing group by utilizing one pipe for drain, waste, and venting. Steel gauge size was reduced on metals used in ductwork and steel studs so the tonnage of steel went down. The idea to obtain products that were cheaper and provided the same performance specification desired by the architect was thrown out by the owner because they required certain products be used no matter the price.

Issues came up during construction that caused everyone involved to work together to find a solution. The site is so congested it caused for different phases of the site layout plan during construction. Dewatering was a problem due to insufficient waterproofing so holes were drilled to relieve the pressure from the water. The conflicts that arose during MEP coordination and fit out were fixed by onsite meetings that included the owner, architect, design team, and all subcontractors.

The problems on this project led to possible technical analysis topics. The window wall that led to failed post tension tendons would lead to a good analysis of a post tension structure versus a non post tension structure. The MEP coordination issues that arose may have not occurred if 3D clash detection software was used. During construction, site cleanliness was a problem. If an independent company was used to clean, then the site may have been safe and organized which may have led to more efficient construction practices.

I. Constructability Challenges

When a building is under construction, challenges come up that force the design and construction teams to come up with creative solutions. Turnberry Tower Arlington is no exception to the rule. During the construction phase, there have been a few constructability challenges that have forced the design and construction teams to work together for a workable solution.

Challenge 1 – Roof Coordination with Bris-de-Soleil

Above the top level of residential units on this building the architect has called for a bris-de-soleil. This metal awning will act as a sunshade and will be attached off of the spandrel glass that will span above that top floor. The sunshade is made up of two primary parts, an outrigger and supports. See *Figure I.I* for the architectural detail.

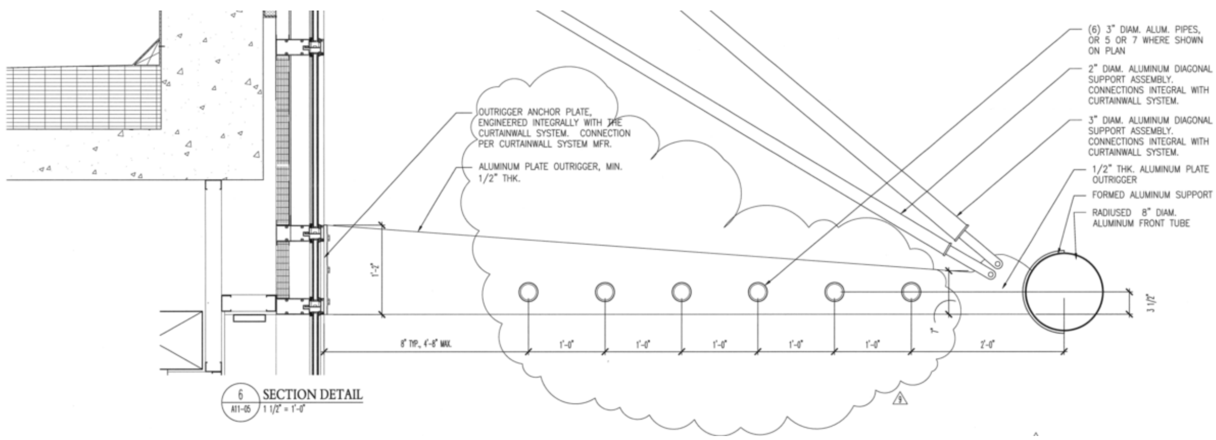

Figure I.I

This bris-de-soleil was covered under the contract of the miscellaneous metals subcontractor. Since there was no other details available for how to connect the bris-de-soleil to the building, extensive coordination was needed between the exterior skins subcontractor and the miscellaneous metals subcontractor. Also working against both subcontractors was the fact that there was not much time available to come up with a solution, since this conflict arose late in the construction process. The exterior skins subcontractor needed a resolution since their materials are fabricated before they arrive at the site and they had a fairly long lead time. The miscellaneous metals subcontractor needed the solution so they could fabricate the materials for the bris-de-soleil and attach any connections during fabrication to make installation fast and easy. Quickness is a key to the installation of the bris-de-soleil because the tower crane would be able to be taken down after installation. If the process took too long, the tower crane would need to be rented for a longer period of time and that cost would get charged to the project.

To overcome the issue, meetings were held between the architect, structural engineer, general contractor, and subcontractors. The solution that was agreed on was to have supports embedded in the mullions from the window wall frames. Because of the tolerance issues, the computer drawings that were used by the exterior skins subcontractor to fabricate their glass and mullions were used by the bris-de-soleil subcontractor to show where their embeds would have to go. These locations for the embeds needed to b almost 100% accurate since there was less than 1/8" tolerance for each embed. The two aluminum arms that hold the outrigger part of the bris-de-soleil would be connected to these embeds. What makes this process the most difficult is the shape and differing sizes of the outrigger and support arms as you can see in. These different angles and distances caused the coordination process to go through each support arm and outrigger to get exact dimensions on where each embed would be located.

Challenge 2 – Window Wall Attachment

On this project the exterior skin has two different types of glass; window wall and curtain wall (*Figure II.I*). The curtain wall was designed before the post-tension concrete slabs were poured, so an embed was placed during the concrete pours to help attach the curtain wall to the structure of the building. The window wall system was yet to be created because of conflicts in the design and the manufacturing of the materials.

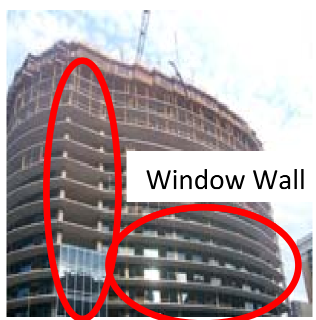

Figure II.I

Since the building is post-tension and no embeds were in place to attach the window wall system to the structure, lines were drawn on the slab by the concrete subcontractor in the location that the post-tension tendons were placed. This enabled the exterior skins subcontractor to come back after and drill into the slabs to attach the window wall to the structure. The lines also gave the exterior skins subcontractor enough knowledge as to where the tendons were placed so they would not have to x-ray the slab to find them. The process of x-raying to find tendons is a very costly and slow process that would have slowed down the installation process of the window walls which would have pushed the building enclose date farther away.

The use of the lines worked fine for the first few floors until problems started to arise. It was discovered later that the exterior skins subcontractor would lay out markers prior to installation of the window wall. The markers showed where to drill and attach the supports for the window wall. This process was done by workers that knew the risks of drilling into post-tension tendons. When other laborers came back through to actually attach the window wall, they would drill into the slabs wherever they wanted since some of the markers previously laid out were not in line with what was needed to attach the window wall.

Luckily the workers that were doing the drilling got away with this for a few floors. Once they reached the 10th floors some problems arose. While drilling, they noticed that some of the plastic that wrapped around the tendons started to come up in their drill bits. They did not alert the foreman and this went unreported until one day when 22 cables snapped. There was extensive damage done to one floor including several bunches of banded tendons that had snapped. Immediate remediation was needed including an investigation to what had exactly happened and who was to blame. It was discovered that these workers were drilling wherever they wanted and were not drilling according to the lines drawn on the slabs by the concrete subcontractor.

To fix the problem, the floors that had snapped post-tension cables were evaluated and fixed to the structural engineers specifications. As soon as the cables had snapped, all installation of the exterior skins was stopped until a plan of action could be established to ensure this did not happen again. The exterior skins subcontractor decided to fully educate all of their workers on the risks of what they were doing. They also decided to x-ray the slabs from here on out to ensure they do not hit any more tendons.

Challenge 3 – MEP Coordination in Residential Units

This building has two different primary layouts that were used for residential units. Floors 2 through 18 have 12 units on each floor and floors 19 through 26 have 8 units on each floor. All of these different units will have different coordination issues. Mock up units were not in any of the contracts for this project, so this made MEP coordination more important. The project used a SIP schedule and with the project having such a tight schedule, this did not allow for many MEP conflicts in the residential units. If the units started to fall behind schedule, the floors would fall behind schedule and then the SIPS would fall behind and start to create other delays with finishes.

MEP coordination was done using AutoCad. A file was sent from trade to trade starting with the mechanical subcontractor and moving its way from them to other subcontractors including the electrical fire sprinkler subcontractors. When the file was complete, the general contractor took the file and would review it and mark the conflicts. A meeting was then held to resolve any of the conflicts. Once resolved, the drawings would be signed off on by all the subcontractors and would be used as the field drawing for construction.

The process was straight forward, but no one knew how effective it would be until work began in the units on fitting and roughing-in the pipe, wire, and ductwork. This meant that the second floor became a test floor to see how many conflicts would arise. When the subcontractors went through and began their work, they would flag every conflict in each unit. When the floor was complete and the conflicts were all marked, the general contractor, subcontractors, owner, and members of the design team went through to resolve all the issues. Some of the biggest conflicts that arose were caused by both the lack of attention from the fire sprinkler subcontractor and the lack of ceiling space given by the architect to place the MEP equipment. After the walk through with all of the parties, the conflicts were resolved and construction worked hard to get back on schedule.

II. Schedule Acceleration

When the demolition of the existing hotel was complete, it signaled the beginning of construction for Turnberry Tower Arlington. Throughout the project certain activities will create the critical path that will drive the project to its completion date. Below are the activities that made up the critical path for this project:

- Obtaining Permits
- Soldier Pile Installation
- Excavation
- Concrete Placement
- Exterior Skin
- Temporary Elevator
- Elevators
- Permanent Power
- Life Safeties

Each one of the above activities is on the critical path of the project for different reasons. The next section will describe why it was on the critical path for this project.

<u>Obtaining Permits</u>

The process that needed to be performed to obtain certain permits always took longer than expected and extra time needed to be added into the schedule to account for the worst possible scenario. Arlington County was very busy with permits for all different kinds of projects, so in an attempt to speed up the process of obtaining permits, an independent company was hired as a permit expeditor.

As well as the county permits, permission was needed from the property owner in the adjacent site to allow for tiebacks to be installed under their building. Negotiations and talks took a very long time and when a deal was struck, the project began three months behind schedule.

<u>Soldier Pile Installation</u>

One of the first activities performed after the demolition of the existing building was the installation of the soldier piles that would be used to aid in the excavation phase. This activity appeared on the critical path because without the soldier piles installed, lagging and tiebacks could not be used. Without lagging and tiebacks, excavation would not be possible.

Excavation

The largest unknown in any project is what you cannot see. With excavation, one never can be 100% and know exactly what is below the ground. On this project, there was dirt and clay that needed to be removed along with approximately 30 feet of rock that needed to be blasted through. With the weather cooperating and having a good blast crew, excavation did not ever fall far behind schedule.

Concrete Placement

After excavation was completed, concrete work began right away. Most of the way up the building the concrete work drove the schedule. If any of the concrete work fell behind, it would push all succeeding activities to a later start date.

Exterior Skin

When the exterior skin began to be put on the side of the building, it started to drive the beginning of the SIP schedule that was going to be used throughout the rest of the project. It was decided that a temporary roof would not placed on this building, so most of the building finishes were scheduled based on when the building would become enclosed. Without the building enclosed, the finishes including millwork, cabinets, and tile could not be installed.

Temporary Elevator

This elevator played into the finishing of the building enclosure. The temporary elevator would start to be assembled when the building was topped out and the equipment was on the roof. When the temporary elevator was up and running, the temporary exterior material hoist was no longer needed. This is important because while the temporary hoist was running the exterior skin could be finished. Without the exterior skin finished, building finishes could not begin.

Elevators

When all of the elevators are in place and they are up and running, it will create another means of transportation for materials and manpower. It will also signal that the entire elevator rail is installed. This is quite a milestone on a project of this size which has over 2 miles of rail.

Permanent Power

When the building is put on permanent power supply, it will mean that all of the electrical equipment is installed and is ready to be used. This can also help to power certain utilities in the building that might not be able to be powered by the temporary electric that was supplied. This building does have two different feeds including 480Y/277V and 208Y/120V powering different utilities and equipment including the heavy rooftop mechanical units and the high-tech trash chute.

Life Safeties

The last activity that might have a lengthy duration is the final life safety check. In order to receive a certificate of occupancy, all of the building life safety devices need to be installed and ready to go. The lobby level contains the building support staff offices which are the location of such life safety devices as the fire control devices. In order for the lobby level to be signed off, the whole building must be on line, connected, and working properly. When the building is checked off and passes its' life safety test, the building will be about ready to be turned over to the owner.

Risks Potentially Affecting Final Completion Date

The biggest risks to the project being finished on time was obtaining the proper permits, the excavation, and getting the exterior skin installed. Before the excavation could begin, the owner needed to obtain permission from the property owner in the adjacent property to allow the project to dig under their building to install tiebacks. After a lot of meetings and a lengthy negotiation process, a deal was finally agreed on, but this put the schedule three months behind schedule.

With the project already being behind, excavation began. Excavation was another activity that had the potential to fall behind based on the amount of unknowns, especially with having to blast and remove rock. Lucky for this project, the soils report given for the site proved to be correct and the weather in the Washington D.C. area for that summer was very cooperative. The lost time from obtaining the permits was gained in accelerating and pushing the subcontractors during the excavation phase. That allowed for the schedule to get back on schedule by the time concrete pours had begun.

The final activity that posed the biggest risk for delaying the finish date for the project was the installation of the exterior skin. There were major problems with the lack of designs for the supports for the systems which caused the fabrication of the materials to be pushed to a later date. There was also a problem with the installation of the window wall which caused an immediate work stop when 22 post tension cables were hit and failed due to a concrete blow out. As well, the sliding glass doors were not fabricated in time and plywood had to be put in its place temporarily. All of these problems led to a later date that building could be enclosed which led to a later date for the start of finishes.

Activity Acceleration

In order to make up for lost time during the project, certain activities needed to be accelerated. Drywall was a large activity that was determined it could be compressed. Instead of three weeks per floor, there was going to be two weeks given for each floor by increasing the amount of workers. This acceleration would be able to push each succeeding activity up to an earlier start date than there would have been because of the delays from the building enclosure. Adding more workers to the job is an acceleration tactic that is tough and is only able to be done based on the amount of space there is for each worker and if the company has enough workers at the time available to work. In this project the drywall subcontractor was able to meet the needs of the project.

Along with accelerating the drywall, the building was sealed and waterproofed at certain levels which allowed for the floors below to start drywall installation before the building was completely watertight. This cost money to seal the floors, but because the cost is less than if the project is not completed on time it was a good option.

III. Value Engineering Topics

Turnberry Tower Arlington had a few ideas that were talked about during preconstruction that could be used as value engineering ideas for construction. What made it difficult was that the owner had specific design intents for the building and only wanted to use the finest and most expensive materials because of the cliental that they wanted to attract. The success of other buildings the owner has that have the same design have done very well in other parts of the country. The finishes of the building were most important and no substitutions would be accepted unless the owner in Florida was given sufficient data to show that the new product would be exactly the same as the first specified product. In some cases no substitutions were allowed. For example, the exterior stone was only to be from one quarry in Norway and there were no exceptions.

The original plumbing in the building called for a typical two stack system; one for drain and waste and one for venting. To reduce the amount of pipe and eliminate the need for one of the stacks, the use of the Sovent System was presented. This system utilizes one stack for drain, waste, and venting. The device, seen below in Figure III.I, was installed on each level in the stack. The device makes it possible for the waste to go down and vent the air up in the same stack through the properties of suction and pressure. This system, when installed, did exactly what it was suppose to do by reducing the need for one stack which saved on the cost of material and installation.

An easy way for any project to save money is to look at the products and materials specified and see if cheaper products could be used that will yield the same design intent. Since metal studs and sheet metal is paid for by the ton, one way to reduce money on this project was to use smaller gauge steel than was original specified by the architect and design team. By reducing both the metal stud thickness and the ductwork thickness by one gauge size each, money was saved by the owner and the same design result was obtained.

The stairway pressurization system that was designed for the building used a separate riser that was enclosed in fire rated gypsum board because of fire codes. The owner and general contractor discussed ways to try and get the same result of the pressurization system, but at the same time try to change the system to save money on the amount of ductwork that was needed for the riser. After discussions with the MEP Engineer and meeting with the county and fire inspectors, it was determined that a different pressurization system than the one designed would be more costly based on new design costs and the amount of time that would be lost during the design and approval.

IV. Problem Identification

There are several parts of Turnberry Tower Arlington that could be redesigned or reassessed which would lead to a faster, more cost effective, high quality final product. Some of the following topics will be discussed in future proposals and reports.

Site Layout Plan

The site of 1881 North Nast Street is a very congested site based on its location with major county roads having only having access on two sides of the site. On Figure IV.I below, you can notice that North Nash Street and Fort Myer Drive are the only streets that have access to the site. Fort Myer Drive is a major county road that allows vehicular traffic from the Georgetown area of Washington D.C. and would not be able to be closed or blocked during rush hours. The current site plan calls for one permanent lane closure to allow for the covered walkway that is currently constructed. On North Nash Street, the parking meter spots have been rented out to allow for a lane that is used only for construction traffic. The loading dock is located near the material hoists on the west side of the site. This location makes it hard for deliveries that arrive on large trucks since there is not enough room for the trucks to back into the loading dock. It takes time to close the street to other traffic so the trucks can back into the loading dock.

Since the site is so congested, redesigning the site layout plan could allow for easier deliveries to the site and easier mobilization for certain trades. It would also help to reduce ( ) the many complaints made by the general public to the county police which can lead to stop work orders issued by the county.

MEP Coordination

The project had many conflicts between the coordinated drawings done by the general contractor and the workers that were out on the field. Time was lost due to having many meetings on site with the owner, subcontractors, and design team that corrected the field conflicts.

Coordination is one of the toughest parts of the MEP process, but with all of the new technology available, the general contractor still did coordination by using large plots of the plans and trying to find the field busts by going through the drawings by hand. An analysis should be done to see how much time and / or money would have been saved if the coordination for MEP was done in 3-D clash detection software.

RFI's From Drawing Conflicts

The construction documents on this project had many conflicts between the architectural drawings versus the structural, landscape, and interior design drawings. On the architectural versus structural drawings, there would be different sizes for the concrete columns and they would be located in slightly different locations. On the architectural versus interior design drawings, there were different ceiling heights for the same locations in the residential units and in the lobby.

Just like the MEP coordination, if these spaces were modeled in 3-D it would reduce the amount of drawing conflicts which would reduce the amount of RFI's for clarification on which drawing should be followed.

Dewatering

The bottom level of this building is located below the water table of the site. Well points were not dug to lower the water table, but the thought was by completely water proofing the areas that were located below the water table there would not be any problems. The elevator pits are located below the water table and since the waterproofing not completely work, water came through cracks that were created in the concrete by hydraulic pressure of the water pushing up. To fix the problem, holes were drilled to relieve the pressure. After the pressure was relieved, the holes were grouted and sealed. This process was quite costly and took a while to fix the problem. The worst part of the problem was that without the pits being completely water free, elevator construction could not begin.

An analysis could assess what the cost to install well points would have been versus what was spent to fix the problems they had one site. Taking a risk to hope the water proofing might work is a cheaper solution, but in this case spending the money up front to lower the water table might have been the better solution.

V. Technical Analysis Methods

From the previous section, Problem Identification, the following areas will be researched and analyzed further. Each analysis topic will include the problem statement, research that will be needed, and the proposed solution. Each analysis will try to incorporate constructability reviews, effect on the schedule, and ways value engineering could be used.

Use of Normal Weight Concrete

Problem Statement:

Post-tension concrete is expensive and can lead to problems when block outs or embeds are not poured with the slab. On this project, problems occurred when the design of the window wall system was not complete and the frames needed to be secured into the slab after the slab had been poured. You can compare the two systems in building height with thicker slabs, cost impact from not using post-tension cables and not needing to tension the cables, and effect on the schedule.

Research Needed:

- Redesign the slabs and columns
- Costs and time needed to tension and grout post-tension cables
- Obtain information on when normal concrete decks can be loaded versus post-tension decks
- Schedule impact
- Cost of concrete
- Effect on formwork
- Fireproofing requirements

Proposed Solution:

Provide information to analyze both systems and decide if the cost and schedule duration of the normal concrete system would be cheaper or the same versus the post-tension system.

Clash Detection System

Problem Statement:

The use of 2-D computer drawings were used to coordinate the MEP layout for each level. Problems occurred on the first level of the residential units when field clashes were detected by the field workers. Each problem area on the entire floor was marked with red type. When all the problems were marked, a walkthrough was performed by the subcontractors, design team, and owner. If clash detection software was used instead of 2-D computer drawings, there could have been a savings on time and cost of fixing field changes

Research Needed:

- MEP clash detection software; how it works

- 3-D model of MEP materials including ductwork and pipes
- Cost of training workers how to use software
- Cost analysis of using the software versus not using the software
- Schedule effect

Proposed Solution:

Provide a cost analysis and schedule update to the effects of using clash detection software correctly versus the traditional way of conducting MEP coordination with large plans.

<u>Site Cleanliness and Safety</u>

Problem Statement:

The key to any safe and productive site is to have everything clean and organized. When materials are scattered around the floors and working decks, workers are more likely to injure themselves by tripping over these materials. Productivity will also decrease as workers spend more time trying to locate the materials that they need while at the same time trying to get around materials scattered around the floor.

On this project, certain trades would not clean up after themselves and after completing work they would throw garbage on the floors and not down the trash chute. Trades would also leave food rubbish all around the site which made the site vulnerable to a rodent infestation. To reduce these chances, a composite cleanup crew was assembled. This crew was made up of a laborer from each trade, and their job was to go around and clean the site floor by floor. Also, food was not permitted on site and workers would have to eat off site each day until food rubbish on site decreased.

Although this was to be a temporary solution to the problem, trades still did not clean up after themselves. Even though each trades subcontract required them to clean up after themselves this did not happen. Each trade was threatened continually if they did not clean up the site. They were told that a private party would be hired to come in to clean up the site or the site would be shut down two hours early every day so everyone could clean up. The cleanliness of the site would affect the amount of work that could be done each day.

Research Needed:

- Cost analysis of hiring a private company to clean versus making trades clean
- Morale of workers
- Effect on project schedule

- Safety violations / citations if site was not compliant
- Accident prone locations due to negligence
- Accidents reported due to cleanliness issues
- Amount of restaurants around the site to feed workers / how much time this would take away from working on project
- Cost analysis of workers productivity versus having to find somewhere to eat everyday

Proposed Solution:

To see if it would be more cost effective for the trades to have a deductive change order written to hire the private company to come in and clean so they can continue to work the same way they are or would it be cheaper to start cleaning up after themselves as they do their work.