Project Introduction

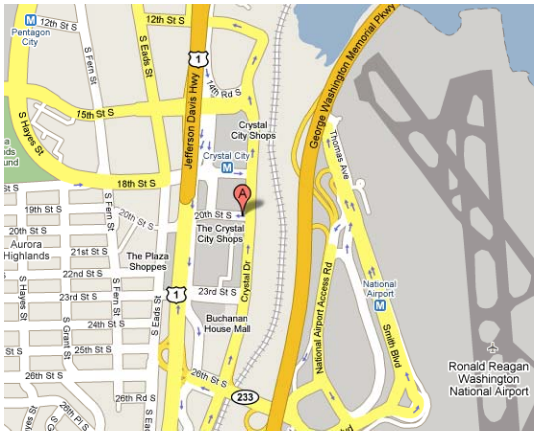


Figure 1 Crystal Plaza II location, 220 20th Street Arlington VA

Crystal Plaza II is a renovation and expansion of an existing 12 story building at 220 South 20th Street Arlington, VA, effectively adding eight additional stories, a rooftop pool and work out complex, and a street level commercial space to a once commercial office building, now turned multi-unit, high-end residential complex.

Crystal Plaza II is a development project by Vornado/Charles E. Smith Commercial Realty. The project began when Vornado/Charles E. Smith, the owner, approached Balfour Beatty Construction, the project general contractor, to provide preconstruction services for Crystal Plaza II, a 325,000 square foot facility, in the heart of a changing Crystal City. This project is only the beginning of a changing atmosphere in the Crystal City area, as Arlington County's Crystal City Public Forum researches a revised concept plan with a focused goal of providing "a greatly enhanced urban place without losing existing assets and amenities."(Crystal City Planning Process, 2008). The research has yielded six points for a revised master plan:

- Strong public realm
- Balance mix of uses
- Legible urban design/architecture
- Enhanced transportation connectivity (multi-modal)
- Transition to adjacent neighborhoods
- Economically, environmentally, and socially sustainable

Crystal Plaza II is a challenging project that faces many obstacles, including a congested site, public safety, a relatively short schedule, and multiple occupancy phasing requirements. The project is also pursuing a LEED Silver rating.

Figure 2 Crystal City Public Forum proposed master plan (Crystal City Planning Process, 2008)

Project Background

The original 12 story office building at 220 20th Street was to be demolished and replaced with a new, high-rise apartment building. However, after preconstruction and market research by Vornado/Charles E. Smith, it was determined to renovate the existing structure and add eight stories, nine including the new 13th floor which was demolished and reconstructed, to house the 266 residential units and supporting systems.

The original building was completed in 1969 as a 12 story office building by Robert H Smith Group, and after its transformation, by current owner Vornado/Charles E. Smith, into a 266 unit residential tower, it will be in a prominent location in Arlington County featuring connections to the metro, proximity to Ronald Reagan National Airport, and direct access to the Crystal City shops.

Figure 3 220 20th Street original office complex, southwest

The individual apartments range from studios to penthouse suites located on the uppermost floors. A two story lobby with direct access from 20th Street, Crystal City Shops, and the plaza located behind the building greets its occupants with colorful terrazzo flooring and stone finish work. Also inside the lobby will be a small retail area and a club room on the second level. An underground garage will be available for the building's tenants. The exterior design is a glass façade, constructed using a unitized curtain wall system. The new look creates a dynamic difference between the new Crystal Plaza II residential tower and the surrounding office buildings. Also distinguishing it from other residential areas is the overall building height, which towers 7 stories above all the surrounding structures. Construction began on the current project in January 2008 and is scheduled to be complete in August 2009.

Figure 4 Exterior precast façade, south, to be removed

Required Demolition

Given the project scope, much demolition was required at Crystal Plaza II. The demolition of the interior spaces was completed in the early stages of the project, prior to much of the construction beginning onsite. This included asbestos abatement of the primary occupant spaces, interior partitions, and primary mechanical/HVAC equipment, however, the remaining plumbing components located on the lower floors and some areas in the parking area needed abatement during construction. The precast exterior began removal in January 2008, as construction began, and finished in April 2008. Other demolition includes slab removal for stairs, elevators, and slab edges, exterior demolition of parking structure wall/plaza area, and complete removal of the northern section of the 2nd floor slab over the lobby.

Cast in Place Concrete

Floors 13-20 feature a cast in place, post tensioned slab. Concrete was placed on the reusable plywood formwork, supported by aluminum I-beams, using a 3 yard concrete bucket hoisted by the tower crane. About a floor a week was constructed in a two pour per floor sequence to allow material staging and forming. Each pour was approximately 200 CY and required a day to place and finish the concrete. Two different mixes, 5000 psi and 8000 psi, were used on each floor and required coordination between the concrete sub contractor, the supplier, and the general contractor. A "puddling" method was also used over critical columns that required 8000 psi concrete.

After the concrete was placed and work began on the second area, bracing, shoring, and formwork began erection over area one, typically within 24 hours, allowing a quicker floor sequence and a decreased schedule. The formwork for the pour was left in place until the concrete reached 75% of its 28 day strength. Re-shores were also used three floors below the active pour for four total levels of shoring to provide support of the construction loads, and the post tension cables were stressed when the concrete strength reached 3000 psi.

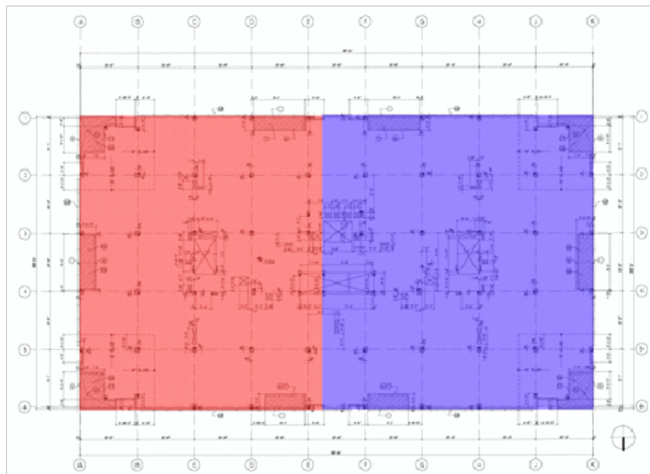


Figure 5 Typical slab pour sequence with area/pour 1 in red and area/pour 2 in blue

The columns for floors 13-20 were placed in much the same manner, utilizing reusable gang forms and feature four sloping columns. Columns were poured 1-3 days prior and were similarly broken into two pours. Interior concrete work, such as shear wall, infill, and stairs, from floors G2-13 was placed using concrete buggies and various form types. Stairs and infills used built in place plywood and the shear wall used a gang form system.

Figure 6 View of 13th floor west pour (area 2) from 14th floor east (area 1) framing, 2 days after 13th floor east pour (area 1)

Mechanical System

The building uses a fairly complex system in which fresh air is provided by four roof top units. Local settings are achieved in the individual units by using a water source heat pump sized specifically for that space. The water for the heat pump is pumped from the unit to the roof where it goes through a heat exchanger connected to one of the cooling towers. Hot water for the building is provided by four, condensing fire-tube, natural gas boilers. There are three primary rooms on the roof level devoted to mechanical equipment the first of which is for the pool equipment, including a gas heater and pump/filter system. Two additional rooms are located on the west side with one housing the boilers, heat exchangers, and pumps, and the other housing the hot water storage system. The 400 nominal ton, cross flow type cooling towers are located adjacent to these two rooms.

Electrical System

Apartment units will receive 120/208 V, 125 A service via 19 meter centers located on each floor in the electrical closet. Meter centers are broken into two supplies, from floors 2-10 and from 11-19. Meter centers are connected to a single, 3 phase, 5000 A switchboard by bus duct with a primary riser size of 2500 A and connection ducts of 600 A, all part of Dominion Virginia Power's grid. Estimated maximum load for this system is 1,514 KW. The 277/480 V system provides power to many of the buildings mechanical and fire suppression systems. The system is distributed through two switchboards with the first being the initial connection to service providing power to lower level systems such as the lobby and 2nd floor lighting/receptacles (via 150KVa transformer), 1st floor mechanical units, emergency systems, and the second switchboard located on the roof level. Estimated maximum load for this system on the initial switchboard is 1,831 KW and 1,294 KW on the second switchboard. Stand-by power is available through a 450 KW, diesel generator located on the roof in the machine room. Lighting in the apartments varies between incandescent A19, wall and surface mounted luminaires, MR-16 track lighting, and recessed PAR fixtures. A majority of the public areas utilize various types of florescent luminaires.

Figure 7 Installed curtain wall, northeast

Curtain Wall

The curtain wall is a unitized system which features an operable window panel for the apartments. The curtain wall is an aluminum frame, low-e glass system that attaches to the slab via concrete imbeds. For the existing slab, a plate was attached to the slab to provide a connection point. The design of the system was the responsibility of a separate architect, and testing/quality control is performed by an independent consultant. To keep the project on schedule, the curtain wall was released for manufacture before construction began. The specialized pieces, such as corners, terrace walls, and come backs will be constructed after the given section of unitized pieces are in place. This provides a large risk to the project as it strives towards water tightness, especially with the limited capacity and location of the supplier/sub contractor in Buffalo, NY.

Constructability Challenges

The uniqueness of construction provides many challenges that must be overcome for a successful project. Matching estimates to budgets, quality work to tight schedules, and constructing on a site that may offer unknown conditions such as rocks, existing utilities, insufficient soils for bearing, and other unforeseen conditions are only a few of the challenges project managers, superintendents, and project engineers deal with on a daily basis. In fact, they make it their job to deal with uncertainty and risk. At Crystal Plaza II, all of these challenges have occurred, along with others associated with the type of project, the location, and the owner.

Renovation

The largest of these constructability issues is the project type and the age of the structure. The project is a renovation and addition to an existing, 12 floor office building that transforms it into a 20 story, high-end apartment complex with commercial space on the street level. The existing building was constructed over 40 years ago and has many deficiencies that have accrued over time. The most notable of these issues is with the concrete superstructure. The existing slab is a 10", two way reinforced, flat plate style that has started sagging from the long term loading of the previous tenant and failures to the Walker duct system. The sagging is noticeable and requires an intensive and time consuming floor leveling process. This process must be fitted into an already tight schedule, with preference of this activity before any framing begins, but after slab core drilling is complete. Also with the concrete, there are concerns over deterioration. The concern is heightened in areas requiring modification for structural uses, such as anchor points for the curtain wall and reinforcement around enlarged openings.

Figure 9 Existing precast façade to be removed

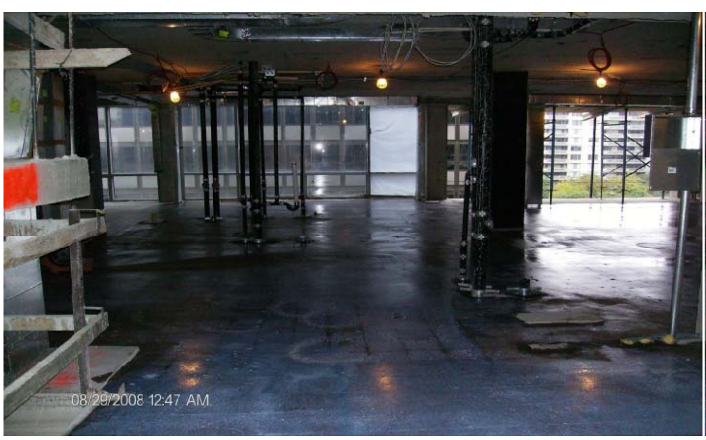


Figure 10 Slab leveling complete after installation of risers creating constructability issues

Figure 8 Rendering of finished project

As for the nature of the project, renovations provide challenges not usually found in new construction. Uncovering unforeseen conditions during demolition poses a difficult challenge. Unforeseen conditions at Crystal Plaza range from the sagging slabs and asbestos insulation missed during abatement process to broken drainage pipes in the underground parking area. The issues of sagging slabs and asbestos insulation were part of the pre-construction planning, however, the degree of sagging and unknown areas of asbestos that were missed needed to be dealt with in the beginning to prevent delays in the schedule as these activities took precedence over others. Also the sheer amount of demolition required to be completed in a short amount of time proved challenging. Some of the ways that the general contractor overcame these challenges was to install a temporary drainage and roof system on the 11th floor to allow the removal of the top floor and roof without causing water problems on site. Another tactic was to have the demolition subcontractor work six day weeks and install the tower crane, provided by the concrete subcontractor, two months ahead of schedule. This allowed for the work to be accelerated. The use of the tower crane proved invaluable as it allowed removal of the precast concrete skin in addition to the mobile cranes and could maneuver into the tight locations where the mobile cranes could not reach or would require multiple relocations and setups. The result of this action allowed the new floors to begin construction earlier, accelerating the concrete operation by three weeks.

Also, since the project had no excavation, superstructure construction of the additional floors and interior work on the existing could begin immediately, whereas with a typical new construction project there is time to review the submittals and shop drawings as the excavation and foundations are under construction. This drastically shortened the review time for submittals and shop drawings so work would not be delayed, but increased the need for correctness and review so construction mistakes and disputes could be eliminated.

Required Delivery

A final issue is from a discussion with the Project Superintendent and merits presentation. The project has a phased delivery of floors that requires multiple inspections and detailed coordination between all parties. However, of highest importance to the owner is the core and shell turnover of the first three floors. The challenge for the superintendent is to turnover three operable, occupancy allowable floors with the remaining floors to turnover within the following two months. This requires that all life safety components for the entire project be complete and online for the first turnover even with construction not complete on the upper floors. The plan of action was to “buy out” the electrical subcontractor for testing of the bottom half of the building early. This places an additional cost on the fire alarm panel reconfiguration once the whole building is online. However, this allowed the system to be tested early and to correct issues before the turnover. Also, with the early turnover, only three months of schedule was between finished framing on the top floors and the turnover. This left little time for completion of core and shell activities. The idea to solve this problem was to keep the floor cycle time the same, 10 days for framing, 10 days for rough in of each trade, and start all the subcontractors on the next floor five days into the cycle. This required larger crews, more supervision, and more coordination to avoid trade stacking, but allowed framing to be complete with 4 ½ months of schedule time to complete the core and shell activities

Reconfiguration

The second issue directly ties into the renovation topic described above and is due to the new building use. The existing building functioned as a commercial office building, supporting offices and open floor space for cubicles with centrally located mechanical and plumbing equipment. The electrical system was contained within a Walker duct system integrated into the concrete slab. The retrofit of these building systems for the new residential use, and the reconfiguration of the interior spaces, such as stair wells and elevators shafts, proved to be a large constructability issue.

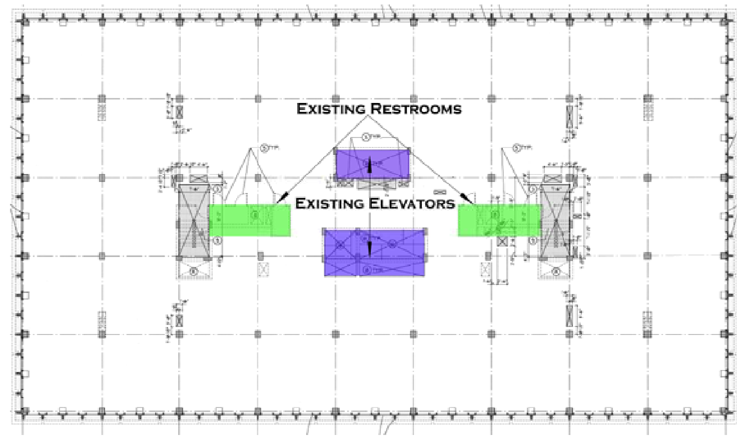


Figure 11 Existing floor layout with elevators in blue and restrooms in green

As for the mechanical, electrical, and plumbing (MEP) systems, new riser spaces were needed to supply the individual apartment units. New pipe and duct risers needed cut and cored through the existing slab while detailed information about the removed pieces was needed to calculate the amount of additional structural reinforcing. Approximately 25 new slab openings for duct risers and about 300 slab penetrations for plumbing were required. Electrical distribution via bus duct required slab cuts, but not nearly as many as the system remained centralized. A floor plan of slab cuts for ductwork and bus duct can be seen at right. These openings required a large amount of coordination as the slab cuts, mechanical and plumbing core drillings and electrical core drillings were all performed by different subcontractors. The sequencing was also a difficult challenge in that work below the cutting and coring operation was limited and the operation needed to be suspended multiple times because of the storage of curtain wall below the active slab.

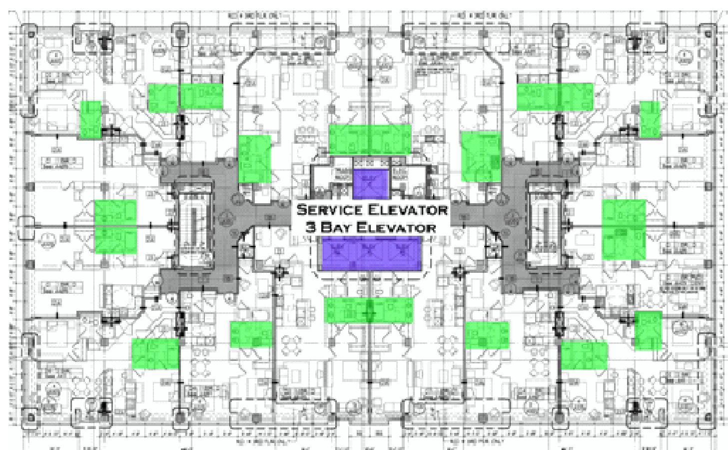


Figure 12 New floor layout with elevators in blue and restrooms in green

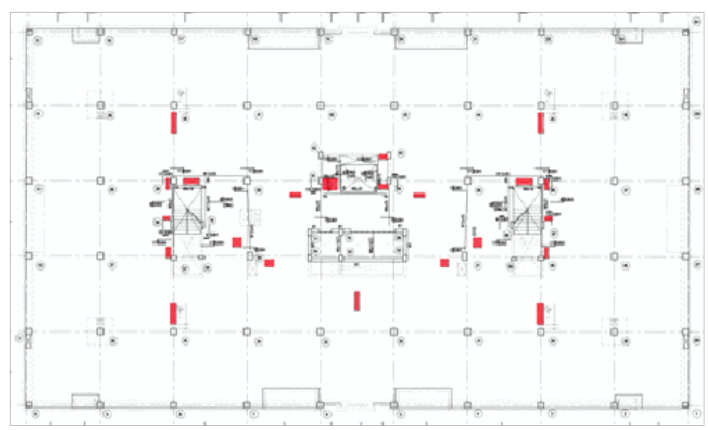


Figure 13 New slab cut locations for ductwork only. All plumbing fixtures require penetration

The other large openings posing issues were the new stairs and elevator shafts. After demolition of the existing stairs, the opening was enlarged and shifted to center the stair towers. The demolition included removal of upturned and regular concrete beams, thus requiring the need for additional structural support by means of W steel shapes, as seen below. The steel needed to be placed prior to the demolition and thus the need for proper sequencing becomes vital. The necessary process for installation of steel, inspections, demolition, and reconstruction needed to be detailed so as to not create a possible hazard or delay. A similar process was required for the elevator shafts.

Figure 14 Demo of existing stair tower

Figure 15 Structural steel reinforcing around stairs and elevators. Piece on lower left to be installed

Residential Curtain Wall

The third constructability issue was the use of curtain wall on a residential building. Typically curtain wall is used on commercial projects that have centrally located mechanical systems and require no need for balconies or operable windows. The curtain wall on Crystal Plaza II has both, and because the entire façade is curtain wall, it provides no vertical surface area for exhaust or intake vents for the mechanical system, much like a commercial office building.

Figure 16 Stored and installed curtain wall panels

The curtain wall for Crystal Plaza II is custom designed to include operable windows and spandrel panels to cover exterior bay columns. Also included is the need to integrate doors for use of the designed balconies. These details create issues of interface and weatherproofing and must be taken care of in the submittal review process. The long lead time for the curtain wall, especially due to its custom nature and the location of the manufacture not only present an issue, but put the curtain wall on the critical path. Also, as part of a renovation, the lower levels required field measurements of the structure to ensure a proper fit of the curtain wall panels.

As for mechanical exhaust and intake, all required duct work must go through or come from the roof, thus requiring more duct risers to preserve the continuous look of curtain wall on the façade. The operable windows help with maintaining a good indoor environment but increase the fabrication time of the wall panels.

Project Site

Crystal Plaza II is located in a very congested area within Crystal City, and therefore requires intense planning and organization for safety and workflow. The site layout at Crystal Plaza II changes little from its initial phase of demolition to its final phase of finishes. Limited space does not allow for the plan to change much between phases and use of available lay down areas between trades is common. The layout and nature as a renovation project can provide advantages however, especially in the use of existing utilities and spaces for temporary facilities such as job site offices and material storage.

As for the site conditions, many of the primary utilities feed from Crystal Drive to an underground area that supplies the building. The sanitary sewer exits from the 20th street side and connects to the main under Jefferson Davis Highway. Connections to the utilities were fairly easy given the existing connections to the previous building. General Condition's layout was the key in the layout of the site. Given the congestion of the site, it was decided to place as much parking, material storage, and site trailers in one, partial level of underground parking. This area had direct access to 20th Street and provided a secure, covered storage area that would otherwise be unobtainable. Material lay down areas also existed on the south side of the building near the material hoist, however this area was primary used by the concrete subcontractor for assembly of column rebar and material storage. Deliveries to the site were received on the northern side, closest to the tower crane. This allowed deliveries to be monitored by the general contractor, whose office was located at the bottom of the garage ramp, and for ease of unloading with the tower crane or forklifts as the sidewalk area was closed around the delivery area. The southernmost lane of 20th Street was closed to allow for multiple deliveries to arrive at the site, and as a temporary lay down area. As for safety and pedestrian traffic, an overhead walkway was constructed to allow pedestrian traffic to utilize the Crystal City Shops entrance near the parking garage entrance, although this needed to be closed on certain occasions to allow for material staging on upper floors.

The three major phases of the project, demolition, superstructure and glazing construction, and finishing are discussed below with their respective site layouts.

Figure 17 Exterior pre-cast facade to be removed

Demolition Phase

The first phase at Crystal Plaza is different from the common phase associated with construction. There is no excavation on the project as it is a renovation and addition to an existing building, with all the addition in new floors constructed on the existing structure. The plan, seen on the following page and in full size in Appendix A, has a few key elements to discuss.

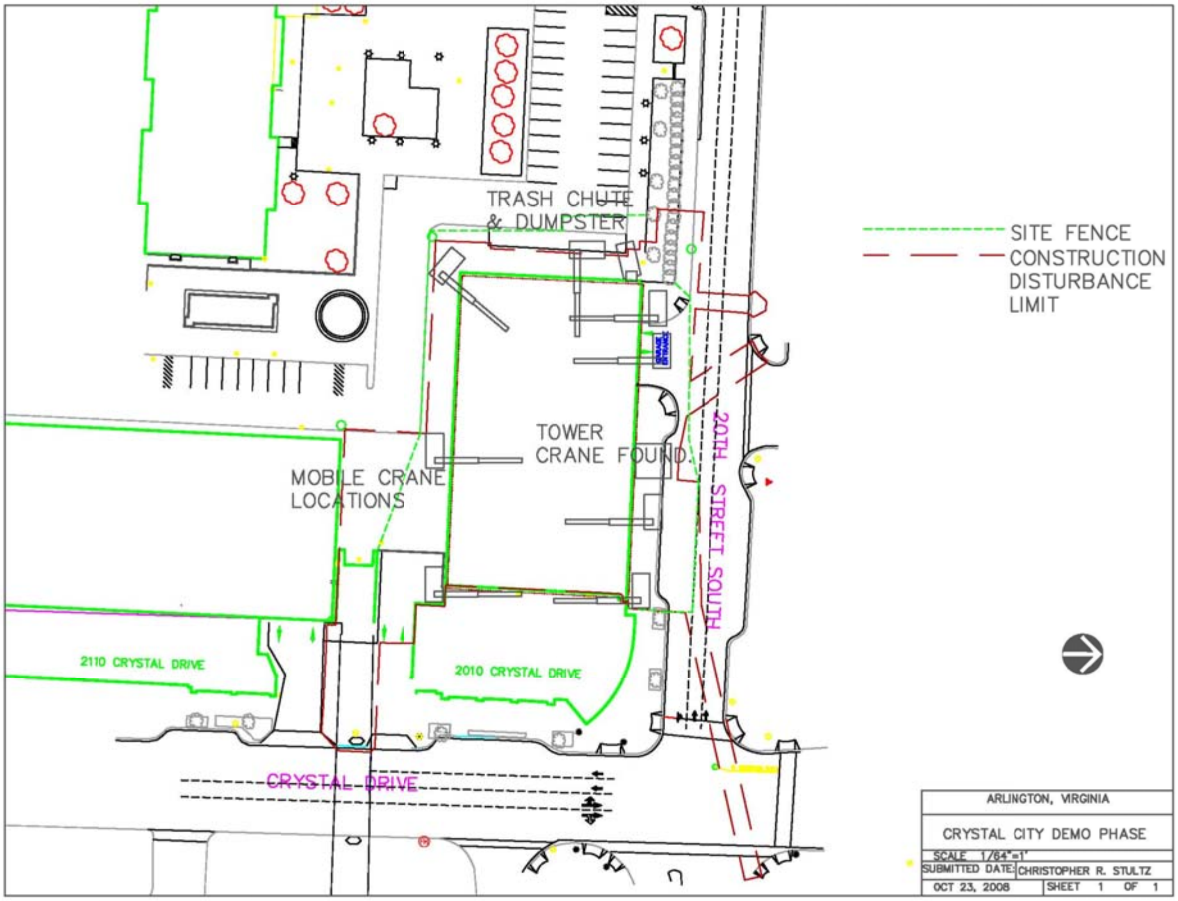


Figure 18 Demolition site plan

The first point to mention is the location of the site disturbance area and site fence. While not as crucial in this phase, the maximum area for lay down and storage becomes increasingly important as the project progresses. In this phase the precast façade is being removed, foundation work for the tower crane is under way, and demolition of building systems and interiors has begun. Of high concern is the precast façade elements located outside the mobile crane's reach on the east side of the building. These members will remain in place until the tower crane is erected and can remove them as its first objective. The mechanical equipment on the roof can also be removed by the tower crane.

This is also the phase when trades begin to mobilize and set up job trailers on site. The owner has agreed, as part of the contract, to allow the contractors to use the first level, G1, of parking for office setup and as a limited storage area. As so, the contractors constructed temporary offices rather than set up mobile office trailers. This is all contained under the building footprint allowing for maximum lay down areas on the building perimeter.

Superstructure and Facade Construction

The construction of the superstructure and glazing is the next phase of construction at Crystal Plaza II. This phase encompasses the construction of the nine additional floors and the erection of the curtain wall system. The floor construction uses the tower crane as its primary mode of transporting materials for construction, while the curtain wall has its own system of swing stages, lifts, and jib cranes that are contained within the building to place the unitized pieces in place. The unitized pieces are transported to their respective floors using the material hoist located on the south side of the project. The hoisting equipment for the curtain wall are located on specified floors to avoid conflicts with other sub contractors as the equipment requires a large amount of space. The plan can be seen below and in full size in Appendix A.

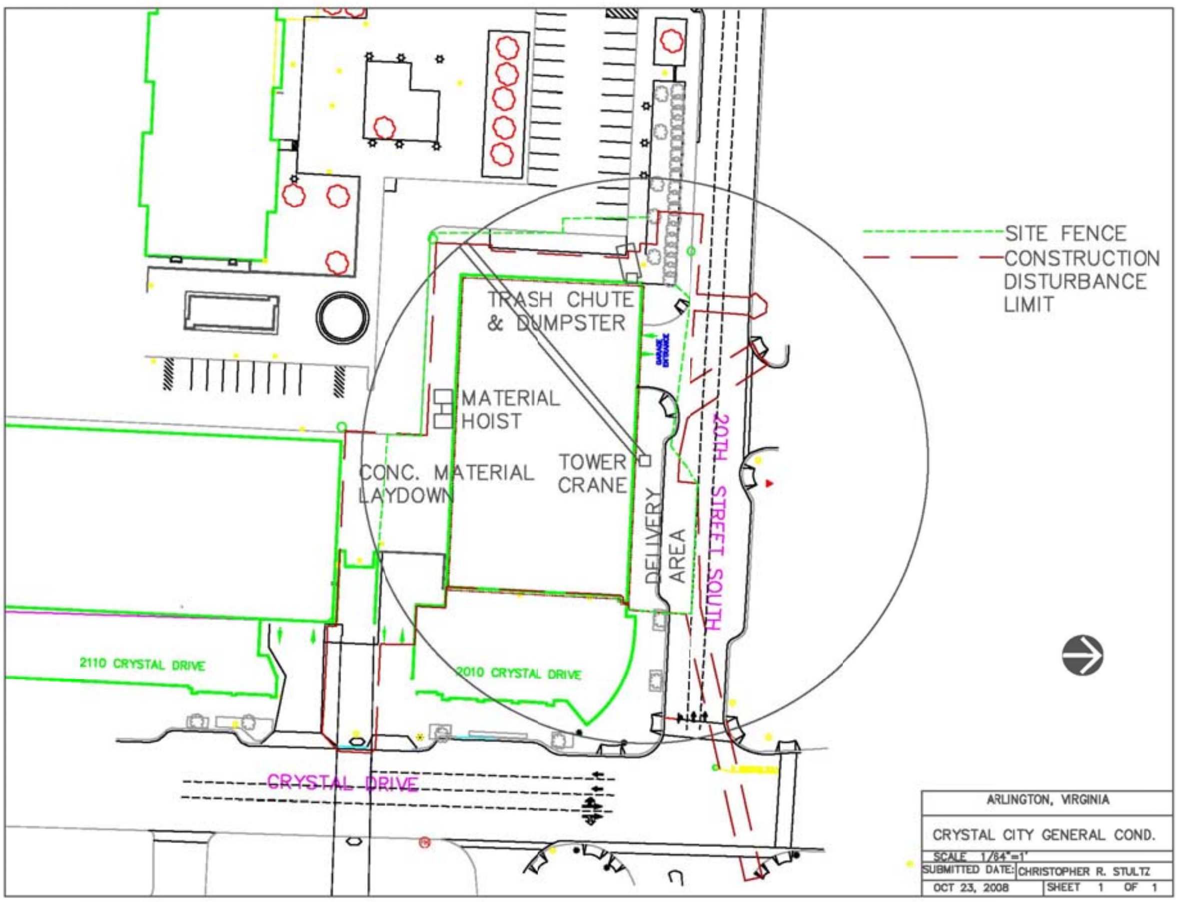


Figure 19 Superstructure and facade installation site plan

This is the phase were all available lay down and staging is taken advantage of. The site fence is moved to its maximum allowable location that still allows pedestrian flow around the site. A delivery area is set up for concrete at the north side of the project. Closure of one lane of South 20th Street is also apparent for this delivery area. This allows incoming concrete deliveries to be close to the tower crane in attempt to limit the cycling time between bucket pours. Also new to the site are material hoists on the south side. These are necessary as the existing vertical transportation system has been removed and a majority of the work and need for materials are on upper floors. Throughout these first two phases all material deliveries are to one of two areas, either the material lay down area on the south side or the delivery area on the north.

Figure 20 Superstructure and facade phase beginning

Finish Phase

After the installation of the curtain wall system and roof top mechanical components the tower crane is removed from the site, thus beginning the finishing phase. Also to be removed is the material hoist as the single bay service elevator becomes operational. The finish phase continues the construction process to closeout with the temporary facilities still housed in the G1 level of the parking garage below the structure. Many of the small, 3rd tier subcontractors do not have offices and utilize the office of the contractor that oversees them. Parking during this phase becomes a greater issue as more finish trades begin work. Strict parking regulations must be enforced to provide space for storage and site offices. The finishing plan can be seen below and in full size in Appendix A.

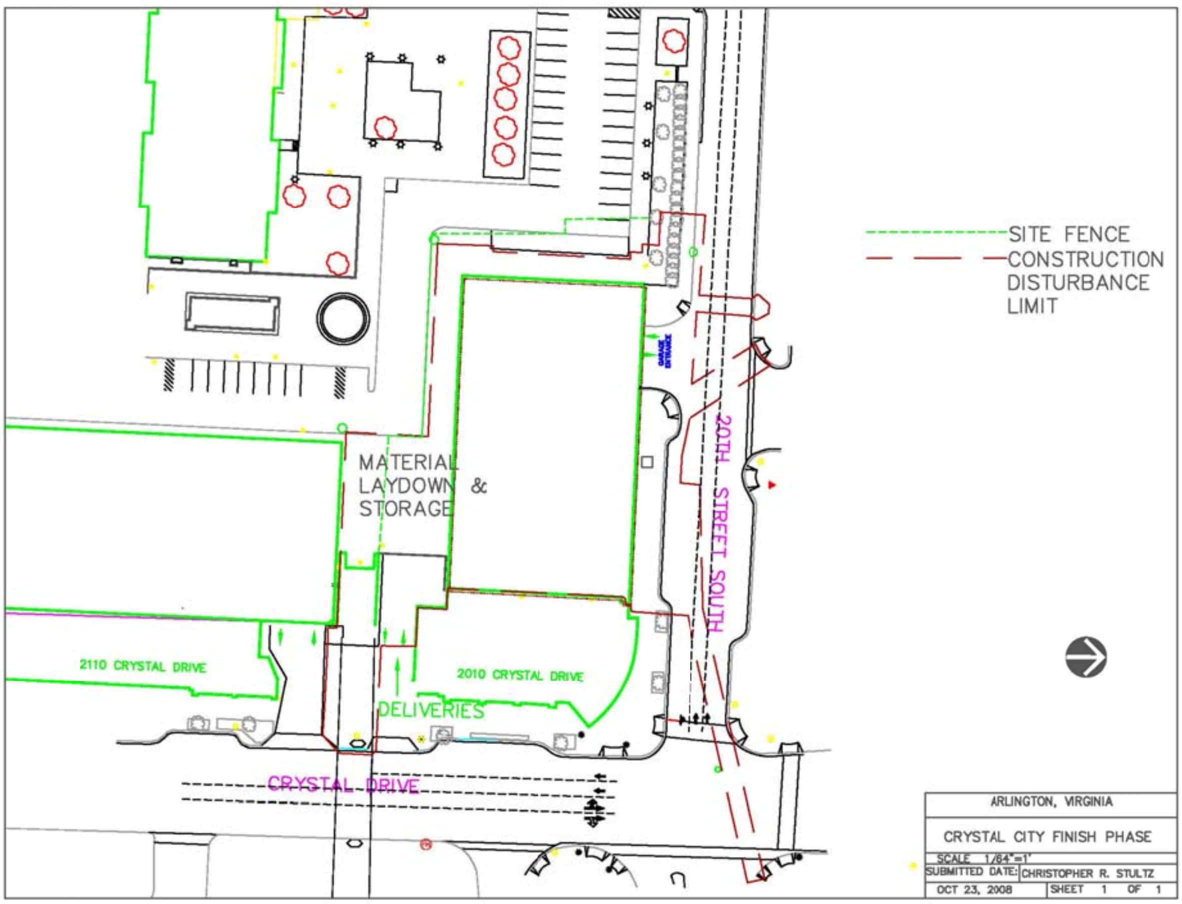


Figure 21 Finish site plan

As the project moves towards substantial completion, there are key differences on the site plan. The tower crane and material hoist have been removed and the previous concrete lay down area has been converted to a general material storage area. Site fencing on the north side of the project has been removed as the owner begins occupancy of the lower floors and the leasing office. Without the delivery area on the north side, all deliveries are now to the permanent loading dock located on the east side of the building. This dock is shared with neighboring buildings; therefore careful sequencing of deliveries requiring the dock is of vital importance. Use of the centralized trash system is also in effect as the trash chute has been removed. The site offices are still located beneath the structure, but are in limited space as residents begin to rent parking.


Figure 22 Final rendering of Crystal Plaza II

Conclusions

In conclusion, with the congested site, opportunistic lay down and temporary facility areas, and concern for public safety, the general contractor did as best as possible to provide an accessible and organized construction site. By keeping layouts relative similar, the general contractor was able to avoid confusion with phase changes and to keep materials on site, in storage. For projects in urban environments, site logistics is often the largest problem with the construction of the building, and with distinct phases and phase layouts, Crystal Plaza II was able to overcome these issues.

Project Schedule

The full size, Detailed Project Schedule can be found in Appendix A.

This schedule is a representation of the construction activities at Crystal Plaza II. The dates, durations, and lead/lag times have been slightly modified to reflect the combination of provided schedules from preconstruction, current construction on site, and typical construction sequencing. Key milestones are highlighted in the schedule and include:

- Review/Issue of Building Permit- March 15, 2007
- Federal Aviation Administration (FAA) Approval- May 18, 2007
- Demolition Substantial Completion- August 1, 2007
- Crane Erection/Removal- May 23-25, 2007 & January 4-8, 2008
- Material Hoist Erection/Removal- May 7, 2007 & January 7, 2009
- Individual Floor Sub Completion/Turnover/Occupancy- Varies
- Building Substantial Completion- August 31, 2009

A complicated sequence to note, although easier to see in the schedule, is the completion and turnover of the floors to the owner. The project has multi-phased occupancy which allows the owner to open the leasing office and lower level public spaces first, and then, in sets of three floors, rental units as they become available. This will create a dynamic situation as final construction on the upper floors is occurring as residents are beginning to occupy the lower floors. A visual of turnover/occupancy can be seen at right. Please note that the dates of turnover and occupancy are direct results from the detailed project schedule created for this report that can be found in Appendix A. Therefore, the dates of turnover and occupancy may differ from the actual dates on the original schedules.

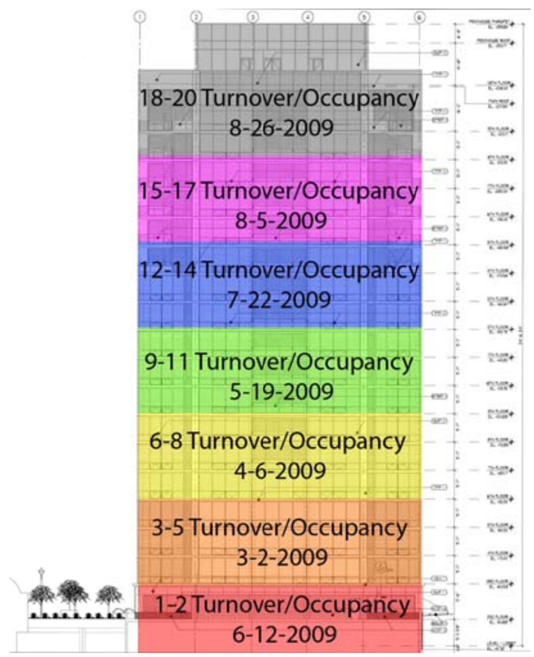


Figure 23 Turnover/Occupancy visual schedule

Schedule Acceleration Scenarios

The necessity to accelerate the schedule is often times employed on construction projects. Whether for unforeseen conditions that cause delays, extra time to complete complicated construction sequences, or bonuses for early finish the schedule is what finds itself at the forefront of the construction team's minds. At Crystal Plaza II a clear critical path is present for construction, and it is not the same as that planned in preconstruction. The following discussion with the Project Manager and Project Superintendent shows how the schedule has evolved throughout the project to its current state.

Preconstruction Critical Path

At the beginning of the project the critical path was though the fabrication and delivery of the curtain wall and glass package. This package was provided by a smaller company located 400 miles away in Buffalo, NY. The material had a four month lead time and could only be manufactured in groups because of the size of the order. The next activity on the critical path was the building dry in, or enclosure. This again deals with the curtain wall but also includes the waterproofing and roofing for a water tight structure and would need to be complete by November 2008 to ensure proper temporary heat for working conditions during the winter months. The need for dry in was to begin the interior trade work to meet the next goal on the critical path, final inspection and commissioning for occupancy. This activity is challenging as mentioned before due to the phasing required by the owner. The necessary inspections must occur seven times, once for each turnover to the owner.

Construction Critical Path

Not long after demolition began on Crystal Plaza II the project was placed on hold by the owner for four months. During this time the glass fabrication continued, thus allowing it to drop from the critical path. However, because of the delay, more activities became part of the critical path, especially after meetings with the owner discussing the finishing of the project.

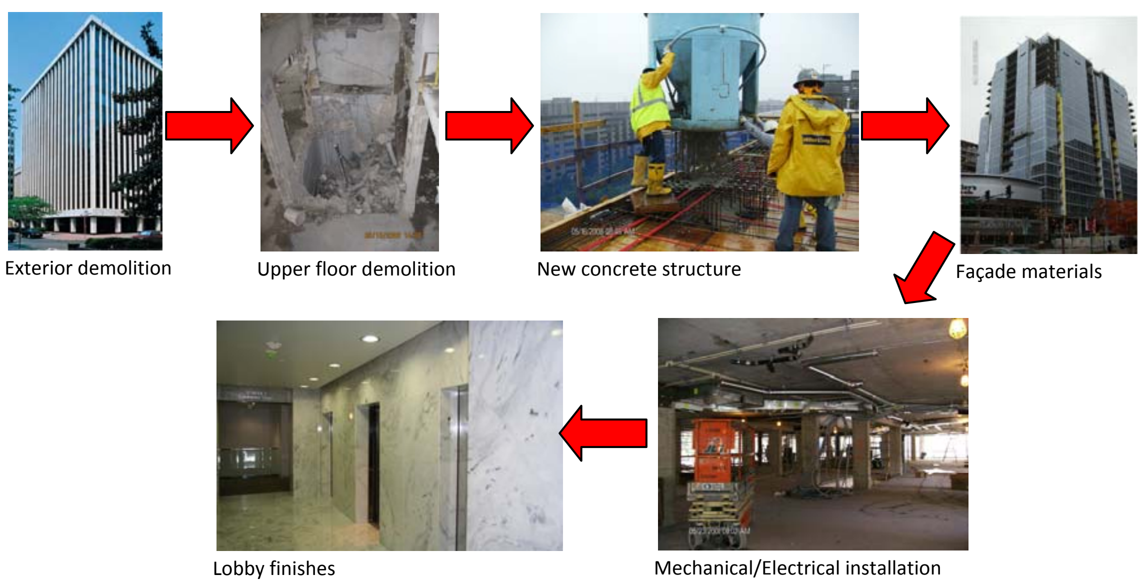
The first activity now on the critical path is demolition. The demolition of the exterior and top floors must be completed before construction can begin. This is where the use of the tower crane, having been installed two months early, to assist in removing components greatly helps. Following the completion of exterior demolition, concrete is next on the critical path. The interior demolition has some float due to the need of the existing stairs and the available area for trades to begin work, so it is not on the critical path. The concrete structure from floor 12 to 20 needs to be complete in order for curtain wall installation and interior framing and rough in to begin. The need for re-shoring and formwork storage limits the pace at which the other trades can move. Creation of a repetitious floor cycle of approximately four days helps this activity. The two primary risks with the concrete are proper placement of the stressing cables and imbeds as drilling will not be allowed because of the post tension cables, and the weather. A setback due to multiple days of bad weather can have a large impact on the schedule.

Following concrete is the installation of the curtain wall and weatherproofing systems for the building to be water tight. To expedite this activity, overhead protection was erected to begin installation of the curtain wall on the lower floors. The largest risk for this activity is the curtain wall itself. The ability for the manufacturer to keep up with construction is first on the list. The other risk is damage to the components because while many are repetitious, the curtain wall is a custom system.

Following water tight is two activities. The first of which is to complete electrical installation to allow the next item on the critical path, permanent elevator service, to occur. The other activity is heating. The need for the heating system to be online is crucial since expected completion for water tight is near to the winter months and the interior work requires a stable, controlled environment. To accelerate these activities additional crew were required onsite. For the electrical rooms required on each floor, a larger crew and overtime helped accelerate the schedule. Also with the electrical rooms, the use of mold resistant drywall was implemented, and while at a higher cost, allowed the electrical rooms to be completed prior to the water tight milestone. Because the need for the mechanical system was realized early on, a crew of eight workers was able to work overtime for approximately two months to finish the system.

The next activity on the critical path is the lobby. The required finishes, their lead times, the intricate systems to be installed, and the design revisions place the lobby as the largest risk to the project. The linear process for construction in the lobby is not helped by the long lead times for the materials or the design changes. The lead time for the interior stone is about four months. To overcome this limitation the stone work was released early without the framing complete for field measuring. The layout due diligence of the general contractor will be the key to the success of this activity. The millwork will be on hold until framing is complete to allow field measuring, but may need to be accelerated by the manufacturer through overtime during fabrication and installation. Overall, the lobby activities may need to be accelerated if some of the discussed issues become problems. To do this, the general contractor plans to work overtime on site and possibly create a trade stack situation in which the next trade will be allowed to start their work as soon as possible, forcing multiple trades to work in the same space.

Visualization of critical path



Project Cost

Crystal Plaza II provided unique challenges in many aspects of construction, and as so the estimated cost for the project is high. Vornado/Charles E. Smith is justifying the additional costs of pursuing LEED silver, the unusual use of residential curtain wall, and the requirements for high end finish materials and appliances by targeting the top end of the residential renting market in northern Virginia. The overall GMP was set at $67.3 million, or $207/sf. The overall cost to Vornado/Charles E. Smith will be in the range of $82 million with consideration of the soft costs associated with the project. These include design, fees, bonds, permits, inspections, marketing, and interest on the construction loan. This value places the building at a value of $252/sf.

As for rental information concerning the project, Vornado/Charles E. Smith has proforma rent set at $2.80 per square foot at Crystal Plaza. This value is at a 2%-3% premium to the standard of the owner's typical competition in the area. The typical rent per square foot is about $2.60-$2.74 per square foot. The owner is justifying this higher cost through the projects location, amenities, and sustainability features. The focus is on the top 20% of the respective sub market.

The following is a breakdown of specific building systems in the Crystal Plaza II project. Each category is representative of a specification division and other items from varying divisions have been included as noted.

Mechanical System Cost: $13 Million
Mechanical System Cost/SF: $40/SF

Electrical System Cost: $7.5 Million
Electrical System Cost/SF: $23.08/SF

Structural System Cost (Concrete only): $4.1 Million
Structural System Cost/SF: $12.62/SF

Curtain Wall System (As part of Doors/Windows): $11.2 Million
Curtain Wall System Cost/SF: $34.46/SF

RS Means 2008 Cost Estimate

Fall research into the project background involved a RS Means estimate that is present here. The RS Means estimation calculations are based on RS Means Square Foot data for a Commercial/Industrial/Institutional Apartment, 8-24 stories in height with a ribbed, precast concrete panel supported by a reinforced concrete frame. This exterior wall system is assumed to be the closest to the curtain wall system of Crystal Plaza II in construction methods when compared to the other options of face brick and stucco. Values for cost per square foot, linear foot adjustment, and story height adjustment were calculated using interpolation of the given values in the chart. Additives to the estimate are shown below to help achieve higher accuracy and have the higher value in the common range to account for the quality level anticipated in apartment furnishings.

Crystal Plaza II Data
20 story apartment with 11' average story height
Building Area: 325,000 SF
LF of Perimeter: 560 ft
Number of Units: 254

Cost/SF:	$162.61/SF
Linear ft of Building:	546 (560-546 < 100, no adjustment needed)
Story Height:	10'6 (11'-10'6 < 1', no adjustment needed)
Location Factor:	0.92 (Arlington VA)
Adjusted Cost/SF:	$149.60/SF
Estimated Project Cost:	**$48,620,000**

Additives

Cooking Range, 30" Free Standing, 1 oven:	$2,175 EA
Dishwasher, 4 cycle:	$1,300 EA
Refrigerator, 20 c.f.:	$1,175 EA
Washer, 4 cycle:	$1,050 EA
Dryer, 16 lb. capacity:	$ 860 EA
Total cost/unit:	$6,560
Total cost ($6,560*266):	$1,744,960

Elevators:

3,000#, 21 stops (3):	$1,095,375
3,000#, 22 stops (1):	$373,000
Total Elevator Cost:	$1,468,375
Total Additives Cost:	**$3,134,615**
Total RS Means Estimate:	**$51,833,335**

This estimate is significantly lower than the project cost of $67,300,000. The difference in price may be the result of the expensive curtain wall system that was not an available option for this building type in RS Means. Also, the project is a partial renovation, which may increase the cost per square foot given the unknown nature of the project as it pertains to demolition and required modifications to the structure for the upper floor additions.

Detailed Structural Systems Estimate

Estimate Summary

The Detailed Structural System Estimate was created through take-offs performed on the structural drawings and using RS Means 2009 as a cost source as a requirement for research in the fall and is presented here. The result of the detailed estimate is approximately ***$2,580,000***, varying about $1.5 million from the value provided by the owner. The cost for the concrete package, both structural and non-structural, was about $4.1 million. Results of the estimate are below, broken down into various forms to show cost structure.

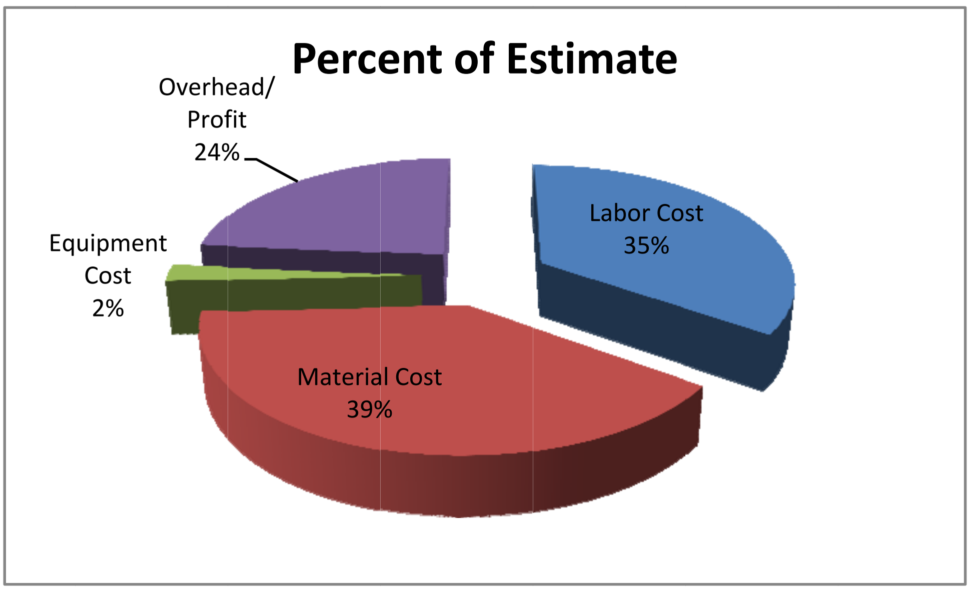
Estimate Assumptions

Many assumptions were used to complete the Detailed Structural Estimate and are as follows:

- Estimate is for new construction only and does not include any renovation work
- All slabs are rectangular, slab cut outs are ignored
- Elevator beams and curb/beams on the roof are ignored
- Floors are typical for all PT slabs unless otherwise noted
- Precast and cast in place stairs are not included
- All concrete is strength as listed, differing strengths in pours is not accounted for
- Tower crane is part of general conditions as it is used for other trades
- Total SFCA used for formwork, extra cost is for removal and re-installation
- No frictional losses for PT tendons over 120’, therefore no additional tendons
- Slab thickening at various points, such as 14th floor, is not included
- No shoring or re-shoring is included
- PT tendons linear weight is calculated using similar rebar linear weight (#4)
- PT tendons priced as un-grouted single strand for a 100’ slab with 25 kips force
- Equipment/labor costs are bare, do not include overhead or mark up
- Standard fee as used by RS Means
- Reinforcing members around openings, structural steel, is not included
- $5.25 per CY added for winter conditions in pours from November-February
- All price data from RS Means 2009, no time factor needed

Estimate Results

Cost Breakdown									
System	Overall Cost	Labor Cost	% of Total	Material Cost	% of Total	Equipment Cost	% of Total	Overhead/Profit	% of Total
Structural Columns	$412,059.34	$145,714.74	35.4%	$162,409.67	39.4%	$12,157.00	3.0%	$91,777.93	22.3%
Structural Framing	$34,572.16	$11,393.81	33.0%	$16,685.95	48.3%	$1,358.90	3.9%	$5,133.49	14.8%
Slabs	$2,096,401.34	$782,844.45	37.3%	$820,863.44	39.2%	$42,462.46	2.0%	$520,141.50	24.8%
Shear Wall	$219,550.62	$46,033.03	21.0%	$116,625.62	53.1%	$7,152.15	3.3%	$49,739.83	22.7%
Total	$2,762,583.46	$985,986.03	35.7%	$1,116,584.67	40.4%	$63,130.52	2.3%	$666,792.75	24.1%



*Please note costs on this page are not adjusted for location.

Estimate Conclusion

The estimate of $2.6 million has many reasons as to its value below the given value of $4.1 million. While only the structural concrete was accounted for on the new floors, additional concrete was installed below floor 12. This includes slab infills, stairs, and a raised slab in the lobby. This work requires more reinforcing, splicing, backfill, custom formwork, and labor to complete, causing an increase in price. Another possible area is the use of epoxy coated rebar in areas where the underside of the slab is exposed and rebar in the beam/curbs that were not included in the estimate. Also, the job utilized many Saturday deliveries to accelerate the schedule that was not accounted for in this estimate, as well as more laborers than the crews listed in RS Means. Another logical price difference can be accounted for in the rise of steel prices. Prices for reinforcing may have escalated and caused the actual cost to be higher. Final observations include the omission of the tower crane. It may have been included with the concrete price as it was only on site for a month after topping out, and was primarily used by the concrete subcontractor.

The cost per square foot of the Detailed Structural Estimate is $7.94/SF and the percentage of total contract value is 3.8%. However, the cost per square foot is deceiving given only 9 new slabs were poured on the project. This is also about $5 short of the value per square foot provided by the owner

General Conditions Estimate

Overview

The general conditions estimate for Crystal Plaza II is a compilation of general personnel and equipment used on site. The availability of a general conditions estimate will become critical to calculate cost savings/losses if the schedule is accelerated or delayed. The entire estimate is located in this section with visual breakdowns of the general conditions and the general conditions versus the overall project cost.

Estimate Assumptions

The following assumptions were considered during the general conditions estimate:

- The Administrative Manager is equal to a minimum Field Engineer
- Scheduled time is approximately 20 months
- To compute time in various units, a multiplier of 4.33 weeks per month, and 7 days per week was used
- Only personnel on site are included, upper management from the home office is considered part of the home office overhead and not part of this estimate
- Site offices are not listed as these are one time construction costs and require no renting
- All lifts and equipment other than the man/material hoist and tower crane will be provided by the respective subcontractor

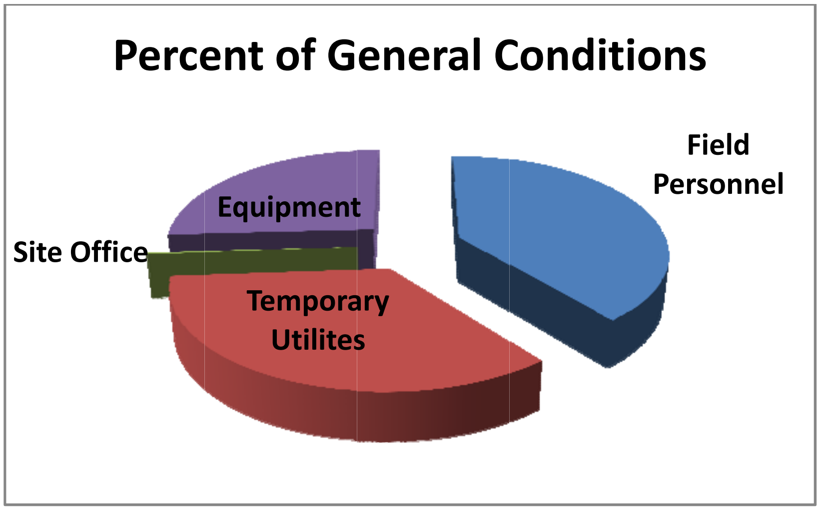
Estimate Results

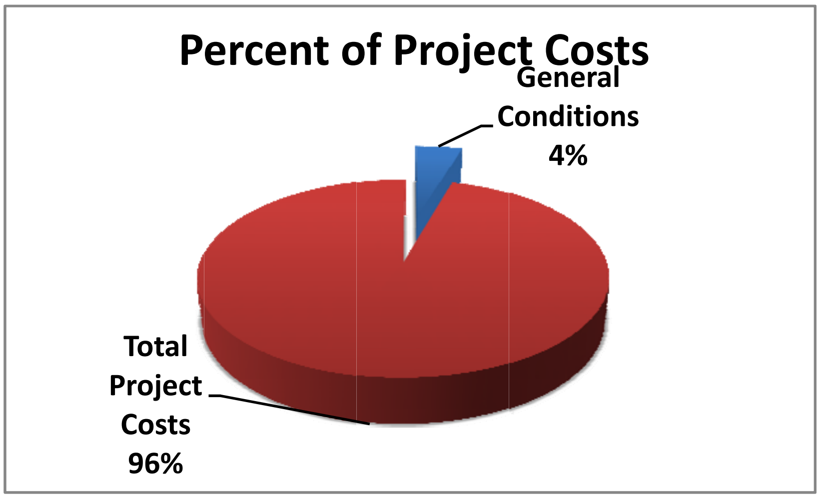
Field Personnel				
Description	**Quantity**	**Unit**	**Price/Unit**	**Amount**
Administrative Manager	87	weeks	$835.00	$72,645.00
Layout Engineer	65	weeks	$1,085.00	$70,796.25
Field Engineer	87	weeks	$1,250.00	$108,750.00
Field Engineer	87	weeks	$1,250.00	$108,750.00
Field Engineer	12	weeks	$1,250.00	$15,000.00
Project Manager	87	weeks	$1,775.00	$154,425.00
Project Manager	87	weeks	$2,025.00	$176,175.00
Assistant Superintendent	87	weeks	$1,650.00	$143,550.00
Superintendent	87	weeks	$1,875.00	$163,125.00
General Purpose Laborer	87	weeks	$1,150.00	$100,050.00
General Purpose Laborer	87	weeks	$1,150.00	$100,050.00
			Total	$1,213,316.25

Temporary Utilities				
Description	**Quantity**	**Unit**	**Price/Unit**	**Amount**
Lighting	3250	CSF	$121.00	$393,250.00
Heating	3250	CSF	$16.10	$680,225.00
			Total	$1,073,475.00

Site Office				
Description	**Quantity**	**Unit**	**Price/Unit**	**Amount**
Office Equipment	20	MO	$165.00	$3,300.00
Office Supplies	20	MO	$105.00	$2,100.00
Office Lights & HVAC	20	MO	$121.00	$2,420.00
			Total	$7,820.00

Equipment				
Description	**Quantity**	**Unit**	**Price/Unit**	**Amount**
Tower Crane	8	MO	$14,700.00	$117,600.00
Tower Crane Crew	243	days	$1,550.00	$376,650.00
80 Ton Truck Crane Crew	61	days	$1,214.00	$74,054.00
80 Ton Truck Crane	2	MO	$8,750.00	$17,500.00
Man/Material Hoist	19	MO	$11,300.00	$214,700.00
			Total	$800,504.00
			Grand Total	$3,095,115.25





Estimate Conclusion

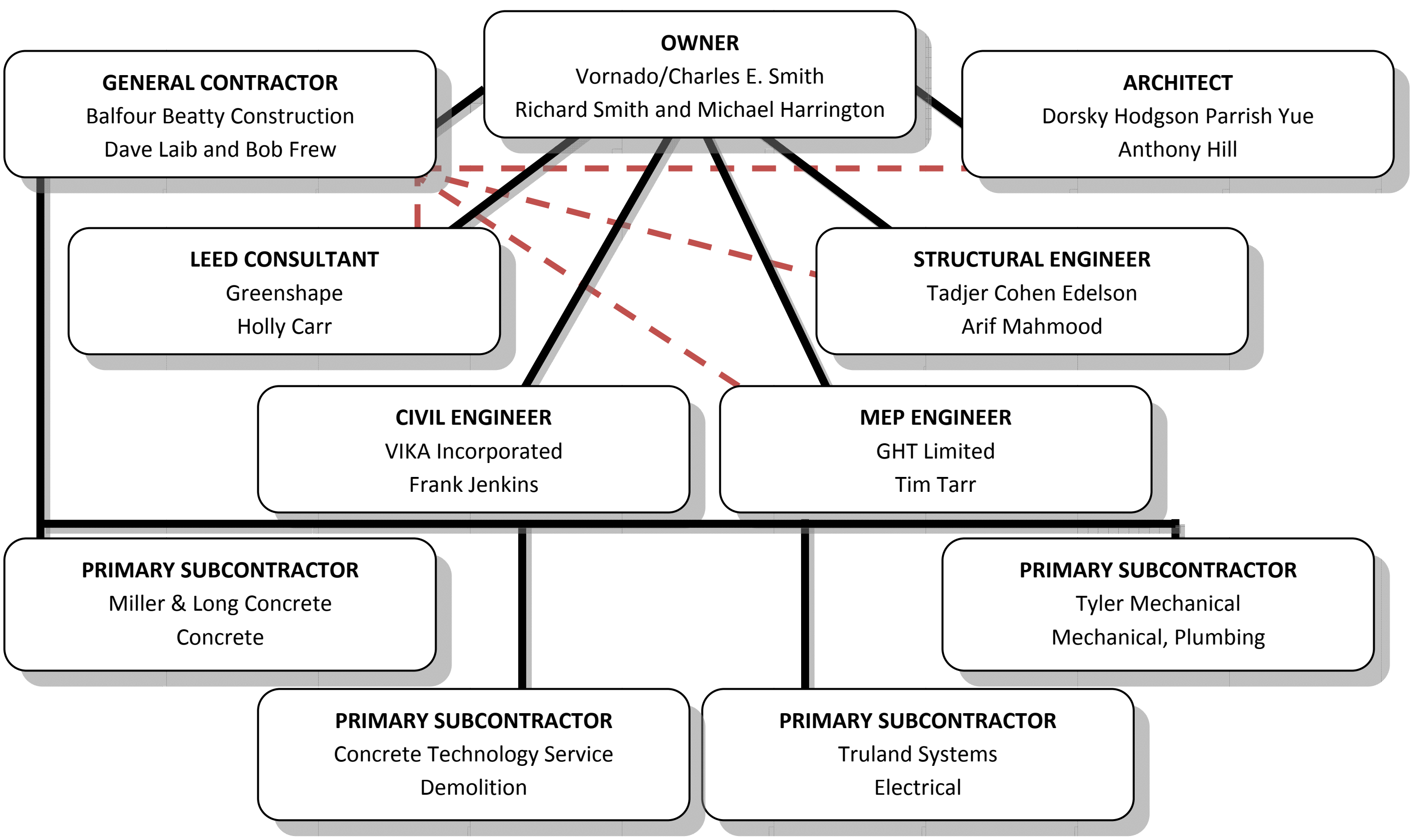
In conclusion, the general conditions fall within the acceptable range of typical projects accounting for approximately 4% of total project costs with a value of just over $3 million. The project specific amount for general conditions as provided by the general contractor is approximately $3 million, a very close amount when compared with the estimate completed. Results of research in topics that affect the general conditions' cost may have an overall impact on the cost of the project, however, because the general conditions only encompass a small percentage of project costs, the savings may be minimal or cause the general conditions to become a larger percent of total project costs.

Project Delivery System and Staffing

Project Delivery System

For Crystal Plaza II, Balfour Beatty acts as a general contractor that was brought onto the project team during final design phases providing preconstruction services to the owner. The preconstruction services for the project lasted approximately 2 years as issues with the project were resolved and changes made to the original plan. The final outcome was a guaranteed maximum price contract for general contractor services between Balfour Beatty Construction and Vornado/Charles E. Smith. This type of contract utilized allowances based on estimations for parts of the project that were still incomplete when the contract was signed. This type of contract is subject to change orders, however, Balfour Beatty has included contingency to cover some of the unknown costs.

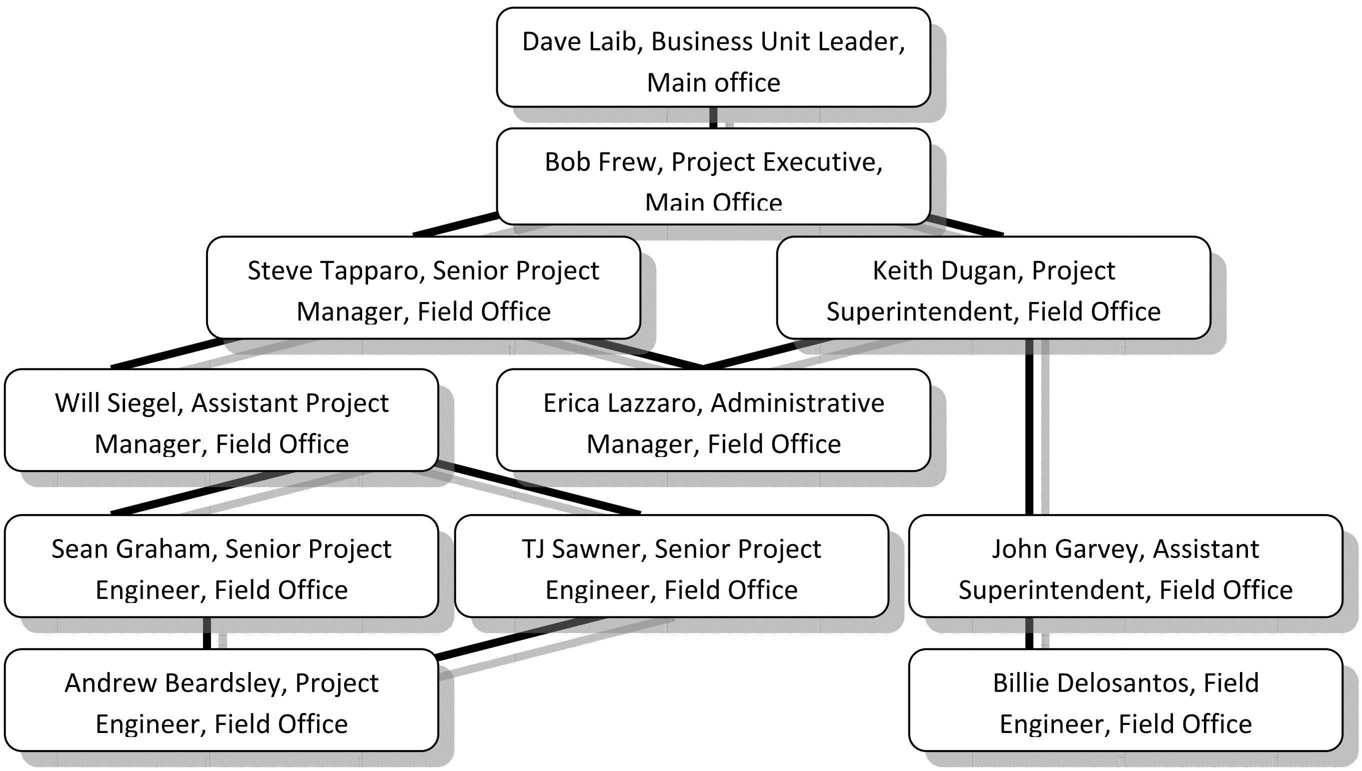
The contracts between the owner and the remaining project team members is assumed to be similar in fashion to that with Balfour Beatty Construction, given the past history of working with the selected team members and the use of a preconstruction period with those members. Parties that hold no contract but have key communication are linked below using red, dashed lines. As for Balfour Beatty Construction's subcontractors, the primary selection method was lump sum bid. These subcontractors were also responsible for their own bonds and insurance, as no CCIP or OCIP was provided on the project.



The use of lump sum contracts for Balfour Beatty Construction is typical in the industry and a clear way to track cost and schedule. Again, the use of this contract type may also produce unwanted change orders that will need to be assessed and paid for either from contingency or the owner.

Staffing Plan

The staffing plan at Crystal Plaza is fairly straight forward. Beginning at the top is the Business Unit Leader, very similar to a Senior Project Executive, which visits the site about every 2 weeks for review, and on an intermittent basis for key meetings. His primary focus is on the client's requests and current state of construction (on schedule, behind schedule, etc.). He is responsible for multiple jobs, primarily those that are multi-unit residential in the Washington, D.C. area.



The next individual is the Project Executive, responsible for 3-4 jobs at any given time, usually in different phases, with primary focus of keeping the job running on schedule. The superintendent side of operations, in the field, is headed by the Project Superintendent, responsible for all the day to day construction activities and site safety. They are assisted by the Assistant Superintendent, similar responsibilities, and a Field Engineer, responsible for layout. On the engineering side of the project is the Senior Project Manager, responsible for the finances on the project, submittals, RFI's, and the administrative requirements. This branch is organized more like a flat organization, rather than hierarchical, with each member taking on responsibility of sub contractors and RFI's. The Administrative Manager is responsible for processing pay applications, financial planning, and general office management. The Assistant Project Manager is responsible for project schedule and current project finances. The final places are occupied by Project and Senior Project Engineers who are responsible for sub contractors, processing submittals, RFI's, posting RFI solutions, site documentation, as well as minor parts of project financing and schedule updating.