Technical Report 3

Inova Fairfax Hospital South Patient Tower

Falls Church, VA

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Construction Management Option

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Executive Summary

In Technical Report 3, area of the project that are good candidates for research, alternative methods, value engineering, and schedule compression will be identified by further investigation. These will form the basis for the final thesis proposal.

Several construction process issues are examines and evaluated after interviewing with Turner Construction's project manager. These issues includes the constructability challenges, schedule acceleration scenarios, and value engineering topics.

The top three constructablity challenges can be identified as the BIM coordination for MEP system, Quality Assurance and design refinements, and the attachment to existing hospital towers. Turner Construcion has put a lot effort to overcome these challenges. Such as South Patient Tower-Existing Tower Buidling breakthrough plans and four-steps Quality Control Plan.

Schedule delays have occurred on multiple areas of the South Patient Tower during the construction process. They were caused by nature disasters, noncomprehensive consideration of construction plan, and drawing mistakes. More improvement can take place to avoid these delays and with any luck to smooth and accelerate the schedule.

Summary of the 2011PACE Roundtable meeting is provided in the report of the two sessions attended. The topics are focusing on the BIM services for owner and Integrated decisions for high performance retrofit projects.

Last part of the report is the problem idendification and technical analysis of the South Patient Tower. Several problematic features are identified that could be pursued through a more detailed analysis. The main points are BIM application in more broad areas of the project, construcion re-sequencing, and Sustainability of the buidling, which can be acheieved by improving or redesigning the roofing system of the South Patient Tower.

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Constructability Challenges

NO 1. Building Information Modeling (BIM) coordination above the ceilings

One of the most difficult tasks was the Building Information Modeling (BIM) coordination above the ceilings. As the South Patient Tower (SPT) project is tying into the Existing Tower Building (ETB), Turner Construction had to maintain the tight ceiling heights at these building transitions.

The South Patient Tower is on the INOVA Fairfax Hospital campus and will include 174, private intensive care and medical/surgical patient rooms for a total of 236,000 square feet, which will allow the hospital to meet future inpatient needs and provide flexibility in the event of a disaster. Note that the ETB was built in the 1950's when high ceilings were not a consideration. So, in coordinating the new SPT ceilings with the ETB ceilings, there is more above-ceiling equipments, supports, ductworks, conduits, and fixtures in SPT that weren't considered for a 1950's building. Thus, this has been one of the biggest challenges for the project.

It has taken Turner Construction' s MEP Manager more than a year to coordinate the ceilings (Figure1) with the Architect, the Engineers and the MEP Subcontractors to make everything fit in the tight ceilings that the SPT has. Here the Naviswork is utilized to review all the above ceiling layouts. And meetings are set up at least twice a week to figure out how everything will be routed in these tight conditions. The primary heating, air conditioning, and ventilation system for South Patient Tower is done through a Constant Air System with four 50,000 cfm air handlers(Figure2) located on the fifth floor's major mechanical space.

figure1. BIM coordinated MEP system

figure2. four 50,000CFM air-handlers on 5th floor mechanical space

Till now, the work is about 90% complete and Turner Construction is looking forward to being complete with this arduous task.

NO 2. Quality Assurance and design refinements

Quality Assurance and design refinements is another important challenge on the project.The Client has a team of Construction Field Representatives (CFRs) and Consultants who walk the job to review the installed work in place, to ensure that the original design intent was met. What we've done to help overcome this issue was to add a Quality Control Manager onto the project, to address the Owner's concerns for providing a high-level functional building.

Also, Turner Construction have implemented a 4-step Quality Control process to assure that they are installing the work as originally designed. The Quality Control Program has been focused on dividing the work into phases of control for the various feature of work, in order to simplify the daily tasks required to control the quality of work delivered by Turner and the Subcontractors.

As the South Patient Tower project begins, four phases of QC is exercised:

Step 1: Administration

Step 2: Preparatory

Step3: Initial Phase

Step 4: Follow Up

Administration Phase

The Administration Phase gives Turner the opportunity for a strong start to the project. The major task is to identify contract and specification provisions and determine the "inspectable" items related to project set-up for quality and integrate these provisions into Turner plan. It is imperative for the entire team to be engaged in this process by assisting in scope review, schedule set up and working with purchasing on subcontract buys.

Additionally, field office setup, writing requisitions, establishing the Contract Items List(CIL), processing early submittals, developing equipment lists, material lists, fabrication. delivery dates and procedures for punch list and turnover are performed in the phase too.

Preparatory Phase

Upon completion of the Administration Phase, it is time for preparatory phase. This phase involves all the project management staffs from both Turner Construction Company and the Subcontractors. Turner will schedule a preparatory meeting with the subcontractor. The agenda of the meeting will address definable features of work, approved submittals and materials, preliminary(permits, surveys, etc.) and contiguous work, specifications(scope of work) clarification, testing, inspections and safety.

Initial Phase

During this phase, the implementation of work is initiated. Turner is practicing what they preach by using all the established checklists. Turner are to make sure that the preceding work is in place and correct, all inspections and test are occurring and/or have taken place so that the workmanship meets standards set by contract documents, mockups and approved submittals. At the same time, all accepted RFIs have been complied with and to check that safety practices are in accordance with the plan and approved JHAs.

Follow-up Phase

The follow-up phase is conducted during the basic daily work of project. On going activities will ve reviewed to ensure the established standard of quality is met and the approved materials are being used.If either of them is not in compliance, the activity must be stopped and the team needs to review the approved submittals, materials and standard of quality before restarting the activity.

NO 3. Tying into an existing active hospital

Lastly, tying into an existing active hospital is the last challenge on the project. A lot of detailed logistical planning for the breakthroughs from the SPT to the ETB requires close coordination with the Hospital staff to assure that the patients are comfortable during construction being done outside their patient rooms. We are following the Hospital's guidelines for maintaining the proper barriers between the construction zones and the operable hospital areas to minimize spread of construction dust and debris.

figure3. SPT tying to ETB

A South Patient Tower(SPT) to Existing Tower Building(ETB)(Figure3) breakthrough plan is create to deal with this challenging constructability issue.

A. Construction detail of SPT slab edge to existing structure

Existing slab elevations have been surveyed by both Dewberry/Davis and verified by Land Design for accuracy. Those elevations are being used to establish the SPT floor elevations. As each new elevation for the South Patient Tower is reached, the windows will be in filled with shaft wall and two layers of sheetrock. The outer layer will be Dens Glass for weather resistance. Shown as in figure4 below:

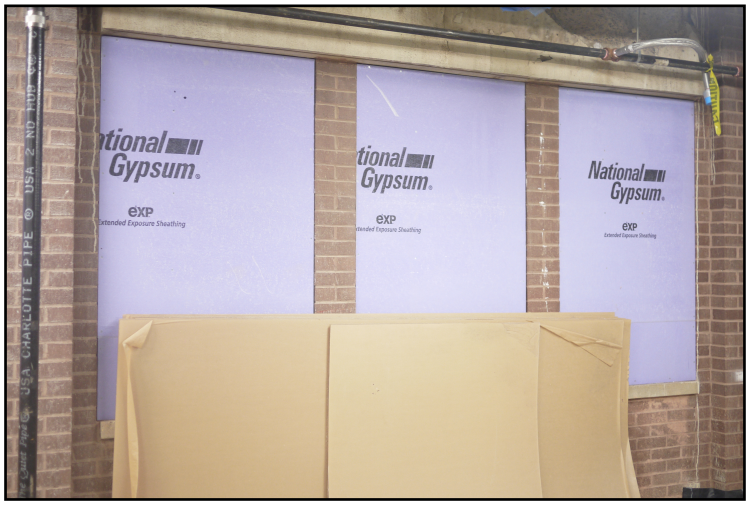

figure4. demolition place between SPT and ETB

B.Advance notification will be given to the hospital of the plan for temp partition construction as well as the procedure for monitoring/maintenance and what work will be taking place.

Contingency plans will be established for the following:

- loss of negative pressure within the partition
- Repair of any physical damage to the partition
- Access to the construction area by engineering staff
- Noise/Vibration/Odor complaints and mitigation
- establish a rapid stop work procedure

C.Infection Control Risk Assessment

Assessment will be complete and submitted to the ICRA staff prior to beginning any work. Pre-work meeting will be hold with INOVA/ICRA staff to review the work plan and address any concerns. ICRA permit issuance will be the predecessor to work commencement.

D.Temp Partition Construction activities will be two weeks on each level.

a.Partitions will be constructed on three levels at the same time as follows:

- Basement-2nd
- 3rd-7th (5th mechanical floor is excluded due to the minimal impact to the patient environment of care. The temp partition for that level will be a plastic zip wall for dust control.
- 8th-11th

b.A temp plastic zip wall barrier will be erected to work within to construct the temp fixed drywall/FRP partition. This outer partition will be a dry walled and sealed surface partition. It will be sealed to the adjacent surfaces. A door will be installed for access. But it will be locked and the key is held by Turner Construction. Turner also decided to pre-fabricate these partitions to minimize the mess in the hospital.

c.HEPA filtration machine can be used to create a negative condition within the contained air space to isolate the construction building from the occupied hospital space.

d.A negative air monitor will be mounted with the pitot tubes in the occupied space and within the interstitial space to insure that a negative pressure is maintained relative to the occupied space.

E.Environmental Testing

Testing of each space will be conducted for Asbestos, Lead and any other Hazmat. A hazmat removal plan will be coordinated as well.

F. Disconnection and relocations of utilities

Prior to beginning demolition the areas of each floor, the MEP utilities that serve the demolition area as well as surrounding areas will be coordinated for localized shutdowns to allow construction to cut, cap and make safe in preparation for demolition.

Any circuiting that feed through the demo area to adjacent areas for lighting and power will be relocated by Truland. Shapiro & Duncan will shut off any HVAC returns, water lines, med gas that go through the demolition area. Grinnell will remove and cap the sprinkler heads that are within the demolition space.

G.Commencement of breakthroughs

Temp waterproofing in place at roof level is constructed for the breakthroughs to the ETB. Building substantially cosed in so that the exposed hospital can be protected from the weather. The Demolition wastes are removed from the site via the buck hoist.

New two hour walls will be installed along the ETB slab edge. The double egress door frames will be installed to achieve a two hour fire/smoke separation between ETB and SPT. These will be maintained until the completion of the build out on each floor.

Note: The materials above is provided by Turner Construction.

Schedule acceleration

Critical Path

As of right now, Tuner Construction are not working any overtime for the South Patient Tower project. Turner is allowing subcontractors to work on the weekends to help maintain the project schedule, but only at the subcontractors' cost. Turner is not paying for this overtime.

In the contract, there have six (6) milestones to track the South Patient Tower's scheduled progress:

1) topping out of the concrete;
2) building being watertight;
3) permanent power into the building;
4) plumbing and HVAC major components;
5) conditioned air;
6) Issuance of Certificate of Occupancy from local jurisdiction.

Schedule Risks

All the activities mentioned above are seen as the biggest risks for the South Patient Tower project. Every step is crucial in order to meet the schedule completion date. If these schedule milestones are not met, then Tuner Construction will have to pay liquidated damages for each specific milestone.

One of the biggest risks to the project completion date is the slight interruption with the Earthquake that occurred on August 23, 2011 and a Hurricane that we had to prepare for on August 27, 2007. As a result the crane was shut down the day after the Earthquake for a re-inspection and to repair water damage on the crane motors after the hurricane.

Also, There were coordination issues during the construction of first and second floor for the curved wall on south side of the South Patient Tower. The two curves did not match with each other due to the drawing on the architecture and engineering drawings. The schedule was delayed to cut and reshape the first floor.

figure5. South side of the SPT

Exterior Wall: The installation of the Light Gage Metal framing on the East elevation started this month and was stopped as a result of a redesign that will coordinate better with the Women's Hospital Construction. Currently the revised Engineered drawings are being prepared by the framing subcontractor. This work was started in September.

figure6. East Side of the SPT

The Air Handling Units on the 5th floor were scheduled to be delivered the weekend of August 27th and 28th but was moved to Labor Day Weekend because of the Hurricane.

After reviewing material deliveries and fabrication schedules, Turner Construction have developed a plan to bring the schedule back to a June 21, 2012 completion date. The key to this success will be the building close-in. In addition they have resequenced the floor fit out and will have multiple floors in progress at the same time.

In order to keep the project within schedule requirement, as a team, they meet every week to review materials that have been released and when materials are being delivered to the job site; they are coordinated with the above milestone dates so that they all strive to meet these goals.

Potential acceleration options

The potential schedule accelerations options can be the following aspects based on the over look of the milestones and schedule risks mentioned above:

Based on the information provided by Turner Project Manager, it has taken them a year working on the BIM coordination of MEP system, which gives it a potential possibility to accelerate the schedule. Earlier and more cooperation and activities among the Turner Construction, electrical engineering, mechanical engineering should be introduced in the process.

Besides the BIM usage in MEP system, the usage in other aspects of the project may also help to accelerate the schedule. Such as for the building structures like exterior walls and atrium of the South Patient Tower to avoid some evitable mistakes and delays happend during the construction process.

Turner can also come up with some emergency nature disaster plans in response to the disaster such as hurricane and earthquake to ensure the construction team go back to proceed with work within the shortest time.

Related Cost and Techniques

The related cost can be the extra manpower fees and some software cost for the early design and BIM coordination. BIM software usually is sold per license. The BIM software platforms such as Autodesk's Revit Architecture and Graphisoft's ArchiCAD are the techniques, which can be implemented in the project.

Value engineering

Barton Malow was the previous General Contrator for the Inova Fairfax Hospital South Patient Tower. They have been working on the pre-construction work for almost one year. Therefore, Barton Malow could not make it at the bidding price. The South Patient Tower Project was re-competed. Turner Construction won the work finally at the price of $76 million. This is a negotiated lump sum contract.

The owner has evaluated through all the proposed value engineering concepts from Turner value engineers. Some of them are accepted and some are rejected. There are still some of the concepts pending. All the decisions are made based on the consideration of project cost, quality, over all schedule.

There are several aspects that Turner Construction Value Engineers has been working and focusing on:

- Life-cycle saving in long terms
- Optimizing the constructability
- Materials substitution

The value engineer works focusing on long term lifecycle saving under the risk of resulting a high initial cost. Turner has summarized the items into different building systems, such as site work, enclosure, Interior Construction, Specialties/Equipment, Vertical Transportation, Mechanical/plumbing/med gas, fire protection and electrical, which can help to ease the tracking of the impact of each building systems due to the changes.

Implemented value engineering concepts:

Interior Materials

Since the main function for South Patient Tower is intensive-care and medical/surgical patient rooms, the pattern for the floor layout are relatively linear. Value engineers has came up with the idea of changing the interior materials of the building. They decided to change the patterned sheet rubber floors show as in (Figure7) to the patterned 18”x18” shaped Vinyl Composition Tile (VCT) (Figure8) in patient rooms and corridors on Nursing floors as the finished flooring materials. The price for the sheet rubber is around $6.5 per square ft and the price for the VCT is around 2.5 per square ft which results a big saving for the total project cost. The square shape VCT will also save the construction waste since it will produce less edge cut waste than the sheet rubber floors. Manufacturer such as Congoleum and Armstrong Exelon line are considered.

Figure 7. Sheet Rubber Floor

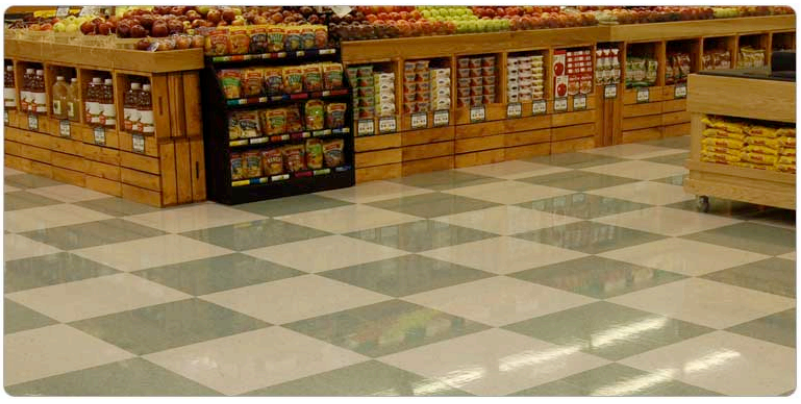

figure 8. VCT

The replacement of interior furnitures has been counted as a large portion of the cost savings which can be added up to $25,000 in terms of total cost. Such as replacing steel case natural footwalls with the built in millwork. Still, this change will increase the construction cost by $780,000.

Mechanical system

With the consideration of long life-cycle saving, value engineers decided to reduce the number of heating convertors and hot water circulating pumps from four to three but increase the size of the pumps which is now 50% larger than the previous size. This concept will save $15,000 for the first cost. It will save the Owner more money in long run in terms of mechanical system operation cost.

Excavations and Foundations

Women' s Hospital will be the following new construction after the South Patient Tower which will be located on the east side of the South Patient Tower and will be connected to it. Value engineer have came up with the idea to excavate earth on east of SPT together with the excavation of SPT to leave the site excavated for the Women's Hospital. This change of activity will increase the construction cost by $65,600. Therefore this will save the owner $108,842 in total. Focusing on the total savings for the owners is one of the most important goals for Turner value engineers.

Following is the list of pre-bid accepted items provided by Turner Construction Value Engineer:

Site work
Plaza paving shown in detail (2) could be changed from brick paving to stamped concrete
Excavations and Foundations
Excavate earth on east of SPT. Leave excavated for WH
Change foundation design to spread footings for low rise structure based on geotechnical recommendations.
Structure
Delete requirement for 1/2" of fine graded material over stone in 03300-3.5.C.1
Enclosure
Change PH EW from Aluminum Composite Metal Panel to Profile Panel
Curtain wall from H-J.5 on column line 5 is future connection area for women's tower. Build temporary stucco wall ILO curtain wall at this location.
Eliminate glazed in vertical aluminum panels and replace with a 5" mullion
Eliminate intermediate horizontals at spandrel floor slab locations and supply fals horizontals
Omit "End Wings" at CW 20 and Curtain Wall on West Elevation between column lines D & G
Revise finish of aluminum window systems to anodized aluminum
Roofing and Waterproofing
Sloped high roof slab to reduce sloped insulation. Change slope to 1/8 per foot.
Change lower roof pavers to ballast stone on west side by mechanical units. South roof and rotunda roof will be changed to vegetative green roof.
Interior Construction
Change patterned sheet rubber floors to patterned VCT in patient rooms - manufacturer such as Congoleum and Armstrong Exelon line
Change patterned sheet rubber floors to patterned VCT in corridors on Nursing Floors - manufacturer such as Congoleum and Armstrong Exelon line
Change aluminum column covers in lobbies to GFRG
Eliminate rubber stair treads on interior stairs and use concrete sealer. Nosings will remain on interior stairs
Eliminate zolotone painting in stairwells to standard paint.
Delete Fountain at Rotunda

Solid surface work surface at care stations
Specialties and Equipment
Replace Patient Care Module with dialysis box, floor mounted toilet, wall hung sink, bed pan washer, grab bar, and toilet paper dispenser
Patient lifts - Cost to remove support structure and track
Replace Steel case Nuture footwalls with built in millwork
Vertical Transportation
Change elevator speed from 700 fpm to 350 fpm
Cab finishes -- Change from Forms & Surfaces to EMCO cab designs--Cab design pictures available upon request. (More standard design)
Mechanical, Plumbing, Med Gas
Delete one drain in patient toilets. Whole bathroom is a "shower" so second drain is not needed. Trap primer would not be needed for second drain
Need to build new portion of tunnel (from WH project) now for Chill Water, Steam and condensate instead of trying to tunnel under ETB slab
Galvanized pipe in lieu of Copper piping for anything 2.5" or larger on domestic water piping.
AHU Extended warranties (1 yr and 2 yr)
Reduce numer of heating convertors and hot water circulating pumps from 4 to 3. Three new pumps would need to be 50% larger than currently sized.
Change stainless steel tower construction to galvanized with a stainless steel basin
Delete requirement for duct board insulation in shafts. Use duct wrap insulation
Use plenum rated control wiring in lieu of EMT conduit system.
Fire Protection
Add flex head option for center of tile
Revise concealed sprinkler heads to semi-recessed
Electrical
Delete requirement for power logic PM-750 meters in each ATS

Remove requirement for conduit system and utilize FPL rated MC cable for fire alarm annunciation devices only
Consider allowing connections to transformers and other vibrating equipment such as air handlers and fan motors (i.e. equipment in non-wet locations) in flexible steel conduit in lieu of liquid tight.
Reduce the requirement for spare lamps, diffusers, ballasts, and guards. The specification as it is now written will result in the Owner having to store a substantial amount of materials that could be furnished on an as-needed basis through a maintenance contract.
Allow use of Sheet metal boxes in lieu of cast boxes for exposed areas not subject to severe damage.
Allow use of Sch 40/80 PVC conduit in lieu of requirements for PVC-coated GRS conduit.
Allow alternate manufacturers for the ATS switches.
Allow alternate suppliers/same manufacturer for the Fire Alarm System.
Use THHN-THWN single conductor in lieu of XHHW for above grade Emergency Feeders.

Critical Industry Issues

The PACE Roundtable meeting provides an opportunity for building industry professionals and students to share perspectives on the most current challenges facing the industry and critical topics in building construction industry. Through out the day, students and the building industry practitioners were broken into groups to examine specific topics in the following three main topics:

1. Sustainability and green building
2. Process Innovation
3. Technology applications

The two sessions I have attended are the Building Information Modeling(BIM) servies for the Owner- the role of the design and construction professional and Integrated decisions for high performance retrofit projects.

First Session:Building Information Modeling(BIM) servies for the Owner- the role of the design and construction professional:

Prior the discussion, professionals and students have reached a consensus that the two main benefits of using BIM are the reducing of change orders and the cost saving. Therefore, many barriers and problems have come up.

Building information modeling(BIM) is changing the way buildings are designed and constructed.The use of BIM has been around for approximately 10 years. It continues to grow. But not all the architects, engineers, manufactures, or construction professionals are eager to jump on board.

One of the problem mention in the discussion is the lag between technological capability and user adoption. When looking at the use of BIM from the owners' perspective, they are usually confused. For most of the time they do not know what they want at the end. Many BIM requirements are not very clear. BIM is implemented into the project sometimes just because it is out there and it is a new technology.

Is BIM changing how buildings are operated and maintained? The introduction of BIM in facility management is also mentioned in the discussion. The majority of the life-cycle cost of a building does not come from the design and construction phase, but from operating the building over 20 to 50 years. BIM can be a helpful tool for performing facility management during the operational phase of a building's life cycle, which can extend over decades to enhance buildings' performance and manage operations more efficiently. It is very tough to specify the level of details of the model is

Separate groups must get together for BIM coordination, which results in another challenge of risks and liabilities. Since a lot of sharing information and coordinations are needed through the whole process. It is quite crucial to draw distinction between each groups when addressing the responsibilities.

When BIM is introduced into a project, challenge at subcontractor level must also be considered. It is difficult for smaller firms to keep up with the technology maintenance. Current workforce need to be educated and retrained to adopt BIM. Companies need a series of training programs to assit training their workers. Behavioral barriers make the more practical and appealing use of BIM implementation a long term process.

The Construction Operations Building Information Exchange(COBIE) is also mentioned as an example of growing emphasis on capturing and transmitting digital building information that can be reused during building operations.

Second Session: Integrated decisions for high performance retrofit projects

Pre-condition surveys, early involvement are some key solutions for high performance on building projects. One of the main difference of the process integrated process is that the architect is not the only form giver, but a broader team of experts should participant in exploring alternative ideas in earlier process. Every person is a co-learner in the process.

GSA-General Services Administration was mentioned in the discussion, which has established the National 3D-4D-BIM program. GSA is now exploring the use of BIM technology in the following areas throughout the life cycle of building projects: laser scanning, 4D phasing, security validation and so forth. All these new tools would contribute in integrated high performance projects.

Main contacts:

Spencer H. Brott managing Director from Trammell Crow Company.

Ideas on utilizing BIM and coordinate safety issue into BIM application are conducted through the discussion between the main contact and we students.

Problem Identification

After the detailed study and analysis of the constructability challenges, schedule acceleration scenarios and the value engineering topics along with the interview with Turner Construction's project manager, several problematic features of the Inova Fairfax Hospital South Patient Tower are identified. The following features can be pursued in further research and studies.

Limited Application of Building Information Modeling(BIM)

Building Information Modeling (BIM) was used in South Patient Tower building as a tool to help coordinate the complex MEP system for this healthcare project. This has greatly helped to minimized problems during the installation process. Therefore after the in-depth discussions and more researches at the 2011 PACE Roundtable Conference, even more ideas and benefits of BIM application are presented. As a new innovated medical project, South Patient Tower has the capability and should pursue a higher level of technology implementation. Combining the facility management with BIM could be a great way to help Inova healthcare system to win in a long run.

Schedule Acceleration

Inova Fairfax Hospital South Patient Tower is a new construction building tying to the existing Medical/ Surgical Tower and is also surrounded by other buildings such as Heart and Vascular Institute, Emergency Department and Women's center and Children's Hospital. This has results the expectation of minimum impact to the neighborhood. The sooner completion, the better. Many delays due to the drawing mistakes, nature disasters and belated actions have occurred during the construction process, which should be able to avoided if more pre-project planning are made. Even though a lot of effort have been taken by Turner Construction and they are able to bring the schedule back to June 21, 2012 completion date.

Sustainability

In order to keep with Inova' s commitment to sustainability, the design of the South Patient Tower has included many environmentally sustainable features to seek Silver Certification from the Leadership in Energy & Environmental Design (LEED) building certification system, such as a "green" roof, water cisterns and rain gardens. The design also incorporates a highly efficient energy system and insulation, as well as low or no volatile organic compounds (VOCs) paints, carpets and furniture.

However, today more owners desire sustainable solution not only for the cost effective but also the protection of environment, saving of water and energy. The focus of sustainability idea should be able to assist the owners with a life cycle cost effectiveness. More features and improvements could be incorporated to South Patient Tower project to accomplish at its full extension for LEED Silver Certification.

Technical Analysis options

Identify and Recommend Other Potential Areas of BIM Application

Utilizing BIM for other areas of the project can by identified in further research. These specific areas can be pre-construction phase, facility management, and even a fully developed strategy for the owner's future use on its projects. BIM 3D AND 4D modeling can make great contribution to communications between owners, designers, and contractors.

Benefits from BIM in facility Management has taken project construction technology to the next level. Inova health system can benefit from BIM post-construction to visualize the space, review layout changes, analyze energy use data, allocate asset and maintain facilities.

Re-Sequencing of Construction Process

Re-sequencing the process of construction can be think over under the consideration of cost saving and schedule acceleration. Weather and other unpredictable variables such as some unforeseen changes that may affect the construction sequence schedules should be considered in advance.

Changing in structure component design may take place in respond to the change of construction sequence. More structure elements may be replaced by the pre-fabricate elements to ease the work on site and hopefully to reduce the cost.

Roofing system for sustainability

So far, green roof and highly insulated white roof which can reduce the urban heat island effect and lower the air conditioning costs are incorporated in the design for South Patient Tower to reduce impact on human and wildlife habitat. A more effective roofing can be considered to have a better pursue of LEED Silver Certified project.

A redesign of roofing system for the South Patient Tower can be achieved in later thesis analysis. Roofing can be one of the most important component in building sustainable design. The roof can be designed for solar hot water and PV installation. Photovoltaic panels can be added to provide some percent of the lighting/electrical use in the hospital.

Another aspect of roof sustainability consideration can be the snow and rainwater reuse of roof. These water can be collected and used for the green roofs, rain gardens, and other landscape irrigation.

More innovational materials can be discovered as a alternation for roofing design and sustainability. For example, the Duro-Last Cool Zone roofing system, which can exhibit a solar reflectance of over 86%.