November 29, 2010

Technical Assignment 3

Susquehanna Patient Tower Expansion

Williamsport, PA

Project 2012

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Executive Summary

Technical Assignment Three is a comprehensive report that investigates the difficult construction parameters associated with the Susquehanna Health Patient Tower Expansion. This 243,000 SF expansion to the Williamsport Hospital and Medical Center is a unique project that presented its own set of difficult problems which tested the construction manager as well as the design team. Hospitals are extremely sensitive places that demand the greatest level of care when operating in and around them. This technical assignment investigates the major challenges incurred by the construction team, the schedule's critical path, value engineering implemented, and observations made from interviews with the construction manager.

The results of my interview with Tom McHale the senior project manager identified the three major ***construction challenges*** on this project. These challenges included severe ICRA requirements associated with building onto an existing hospital, relocating the emergency department, and design features that incorporate strict seismic requirements. L.F. Driscoll was required to adhere to stricter ICRA requirements at the urging of Susquehanna Health. For the demolition of the three walkways that connect the new hospital addition to the existing hospital Susquehanna Health was especially nervous about harmful bacteria finding its way into the hospital. Coordinating the mechanical and electrical through the existing hospital and the new addition's foundations also proved to be quite a difficult challenge. ICRA requirements for the new emergency department were also problematic for the construction team. In addition to these requirements, the temporary emergency department also caused problems for the site logistic plans. Relocating the emergency department altered traffic patterns causing congestion. The third challenge addressed in this report came from the seismic design of the structural steel. The neurosurgery rooms located on the 4th level were designed to be very seismically isolated zones. These zones required were designed not only bigger beams but were also welded with full penetration welds. The amount of full penetration welds in this zone required L.F. Driscoll to add more time in their schedule.

In addition to the construction challenges this report also covers the ***critical path*** and underlines the water tight milestone as the biggest risk to the project. After establishing the critical path, an in-depth explanation of the ***schedule accelerating techniques*** that were implemented and purposed by L.F. Driscoll is provided. The last part of my interview with Tom covered all the value engineering implemented on this project. Value engineering implemented on this project included the spray on vapor barriers and the stick built windows. These were the only two value engineering opportunities purposed.

The second part of this report is a collection of my own personal observations and opportunities for possible thesis proposals. The several problems identified in this section will then be developed into possible thesis topics. The second part of this section expands upon these problems and identifies what type of technical analysis would have to be performed to either confirm or deny possible ways to solve these problems.

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Constructibility Challenges

Challenges Associated with Hospital Addition

Like any hospital construction project, infection control is one of the primary concerns of the owners. However, hospital additions complicate the situation even more due to the fact that the existing hospital still has patients inside. Construction and especially demolition may produce large amounts of dust and other airborne containments. Most people don't understand that dust usually doesn't harm the normal person but, it can contain aspergillus spores that can kill immune compromised patients. Once in the air, dust can circulate around the hospital with great ease as depicted in ***Figure 1***.

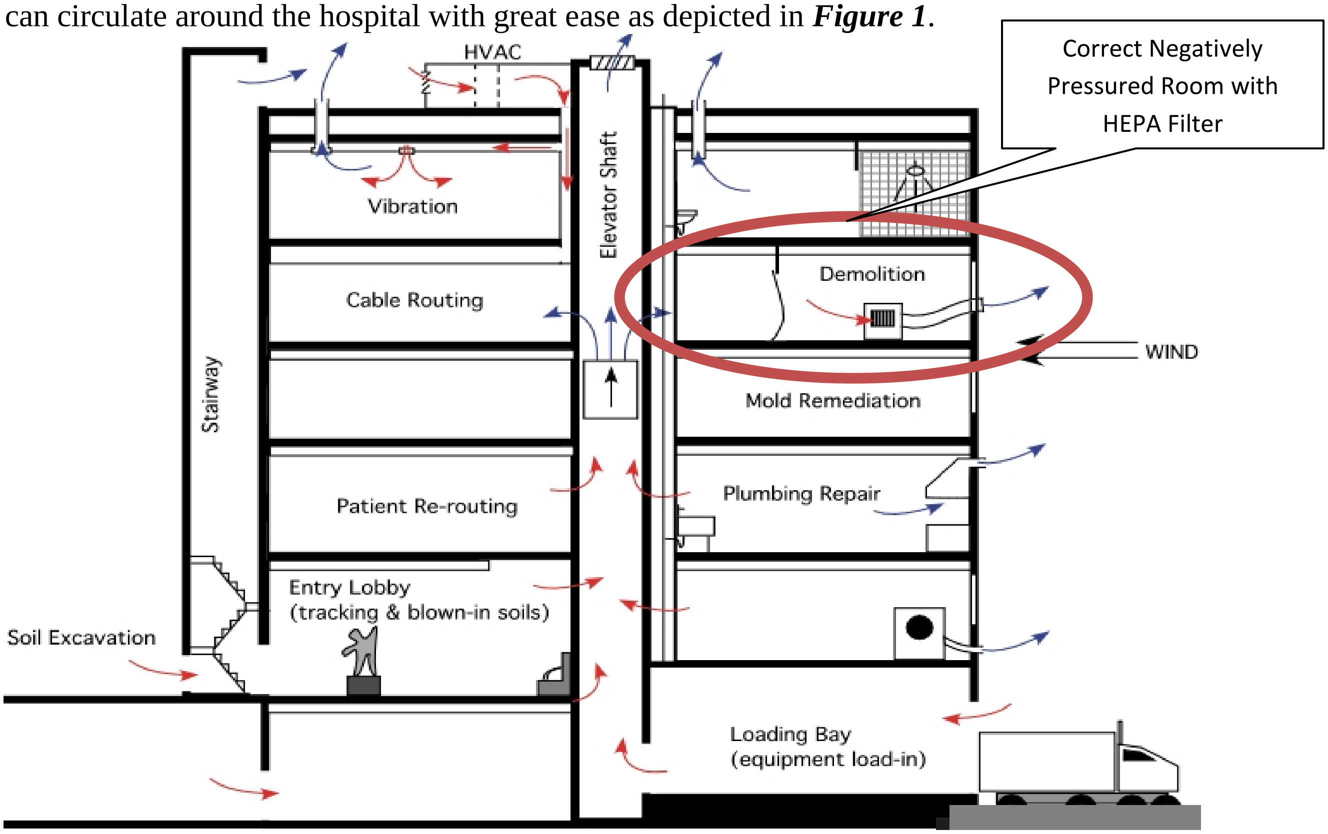


Figure 1: Air Movement in Hospitals
Picture Provided by Pacific Industrial Hygiene

As addressed in ***Technical Assignment 1***, three walkways connect the new addition to the existing Williamsport Hospital and Medical Center. Before construction of these walkways could start, sections of the existing hospital's façade had to first be removed. The actual demolition of façade was straight forward and simple however, the Infection Control Risk Assessment (ICRA) plans required by the owner were complicated. Susquehanna Health also requires that everyone on the construction team to undergo in house ICRA training. Before any of the existing structure could be touched, L.F. Driscoll had to have all ICRA plans approved by Susquehanna Health. This meant that careful planning had to be done well in advance to give Susquehanna Health sufficient time to review any possible threats to the sterile environment of the hospital. Demolition of this magnitude is usually identified as Class II work. Under this classification airborne dust must be prevented from dispersing into the atmosphere and HVAC system as well as the use of HEPA vacuums to clean surfaces. However, Susquehanna Health was concerned about how close the demolition was occurring to the mechanical rooms. For this reason, Susquehanna Health asked L.F. Driscoll to increase the demolition of these walkways to Class III. Class III work involves the implementation of full particle containment including the erection of enclosures with negative pressure and HEPA filtration. To ensure the safety of the patients in the existing hospital L.F. Driscoll fully complied with the CDC's recommendations for Class III work within hospitals. All demolition areas were sealed with ICRA barriers and negatively pressured.

Another construction challenge associated with the addition and the existing hospital deals with all of the electrical and plumbing lines that run through the new foundations of the addition to the existing hospital. These lines had to carefully navigate around all of the old and new foundations. The new foundations were easy to coordinate around because they were still on paper and just starting to be built at the time that. Having a good preconstruction plan also enabled L.F. Driscoll to run these lines around the new foundations with relative ease. On the other hand, the old foundations were a completely different story. Incorrect as-built drawings of the old foundations lead to a lot of starting and stopping. As with the façade demolition to the south façade, strict ICRA requirements also plagued the construction team. The only solutions to this problem was to keep on moving as fast as they could and not let snags in their plan get them down.

Relocating the Emergency Department

Figure 3: Existing and New Temporary Emergency Department
Figure Provided by Google Earth

Before any construction or site work could begin, the emergency department located on the south façade of the existing hospital had to be temporarily relocated. Emergency departments for hospitals must be operational 24 hrs a day 365 days a year. It is critical that absolutely no construction has any impact on this function of the hospital under any circumstances. In order to solve this problem a new emergency department had to be constructed far away from the major construction. The new emergency department is a small addition in the northwest corner of the existing hospital. This small project was particularly challenging due to the fact that it connects to a large area of the hospital. Similar to the demolition of the façade for the walkways and the routing of the pluming/electrical lines, the temporary emergency department produced dust, chemicals from fireproofing, and other airborne contaminants. ICRA plans for this addition were more in-depth and more complicated than those previously mentioned. Because the temporary emergency department was located next to surgery and patient rooms it had to be absolutely sterile. This small addition fell under Class IV ICRA category. To solve this constructability issue, L.F. Driscoll required all personnel to adhere to the strictest ICRA regulations. These requirements included building ICRA barriers with plastic lining, shoe and clothing covers, constructing anterooms, isolating HVAC ducts, negatively pressured work area, and the use of HEPA vacuums.

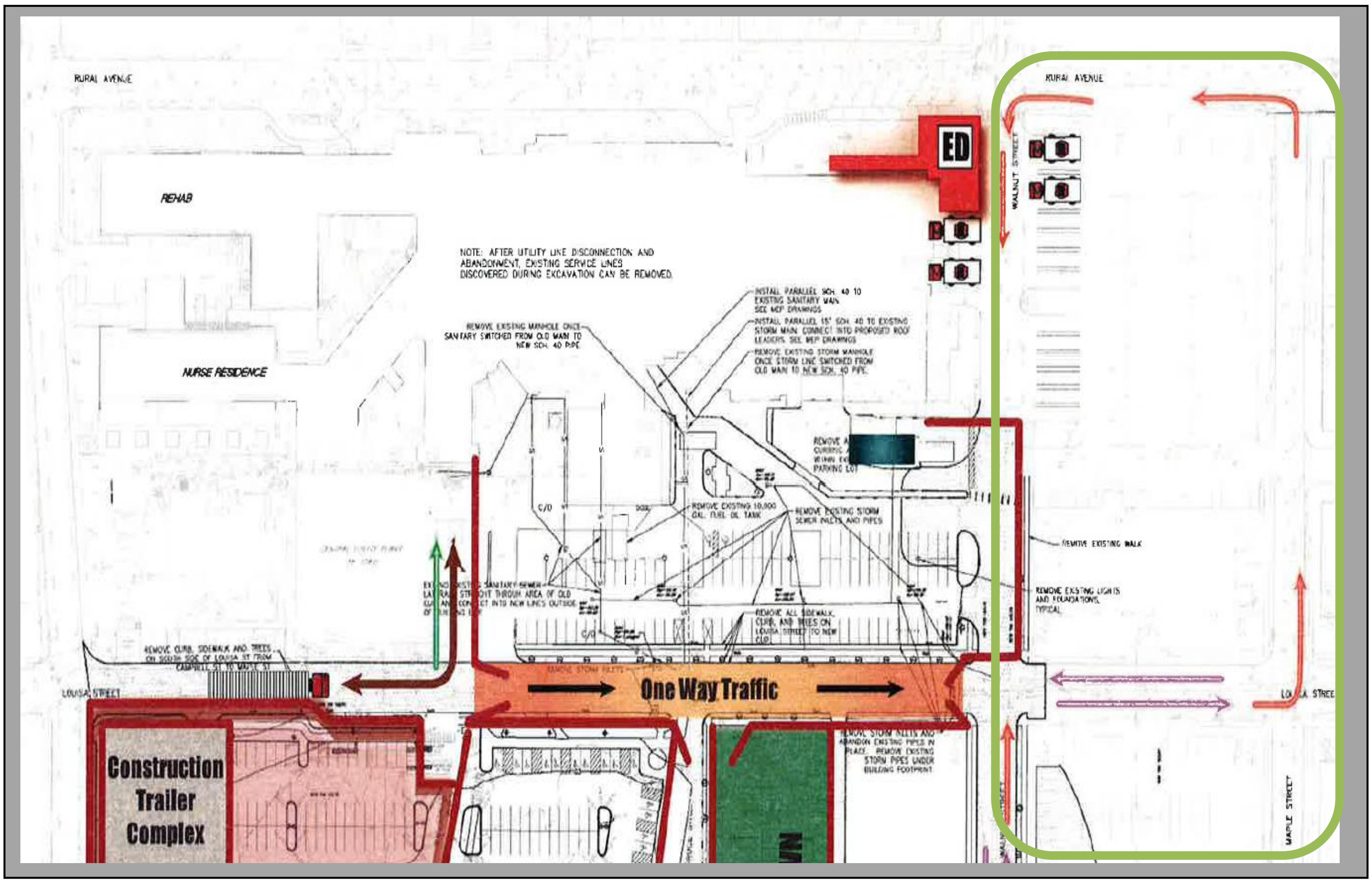


Figure 4: LFD Site Utilization Plan of Traffic Patterns
Provided By L.F. Driscoll

In addition to the strict ICRA requirements, this project also presented issues to the site logistics plan. Altering the location of the emergency department also altered traffic patterns. As seen in part of the site logistic plan provided by L.F. Driscoll, ambulance traffic had to be rerouted. This new traffic pattern in conjunction with public traffic posed a problem with getting deliveries to the site. L.F. Driscoll couldn't find a way around the public traffic congesting the area circled in green on Figure 4 above. However, they did move all construction traffic to primarily use High St. and Maple Ave. This alleviated some of the congestion and prevented any large deliveries to interfere with ambulance traffic for the most part.

Seismic Requirements

Vibration plays a very important factor not only when constructing hospitals but also when designing them. Sensitive areas such as the neurosurgery rooms located on the Level 4 require a more secure and stable design than other typical patient rooms. This floor is designed to be extremely seismically

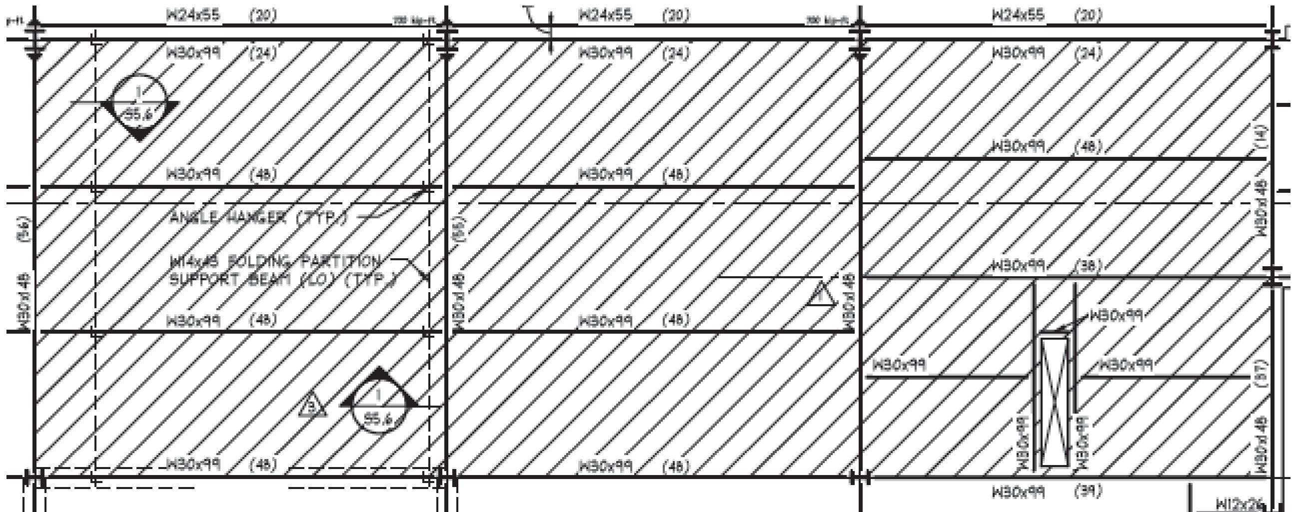
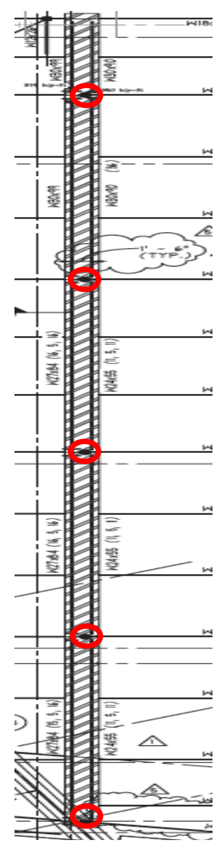


Figure 5: 4th and 6th Level Framing Above and Below Neurosurgery Rooms

isolated. To meet all of the seismic requirements set by the third party consultant, O'Donnell & Naccarato increased beam size as well as the number of beams on the third, fourth, sixth, and roof levels. ***Figure 5*** represents the structural steel framing that supports the two neurosurgery operating rooms on the fourth level. Similar framing can also be found on level six that is directly above the above the neurosurgery operating rooms. Most of the steel beams in this area are W30X99 which are significantly bigger that the W16X26 beams located on the third floor. The increased size doesn't affect the constructability very much however all welds in these areas are full penetration welds. The vast amount these welds added a significant amount of time and resources. All structural steel framing was constructed in the winter of 2009-2010 which was one of the worst that Pennsylvania has experienced in years. This inclement weather also added to the difficulty of and time it took to complete these welds. To solve this problem L.F. Driscoll brought on an extra welder and allotted an extra two weeks in the schedule.



In addition to increased beam and girder sizes, all beam to girder connections require full depth double angle connections to satisfy the vibration criteria put together by a third party consultant. The figure to the right is a snap shot of the girders that run north and south on the third, fourth, sixth, and roof levels. Like the other seismic sensitive regions, these areas also require full penetration welds and added time to the schedule. In addition to the full depth double angle connections this section also contains slip bearing connections. These connections are circled in red to the right and were also very time consuming. All of these seismic areas were identified early in the preconstruction phase and accounted for by adding extra time in the schedule.

Schedule Acceleration Scenarios

Project Critical Path

The critical path for this project is comprised of six major activities and includes foundations, super structure, achieving their water tight milestone, MEP Equipment delivery and installation, finishes, and final commissioning. The rough sequencing of these critical path activities can be seen in ***Figure 6*** below. Above all it is absolutely imperative that L.F. Driscoll hits each one of these target dates

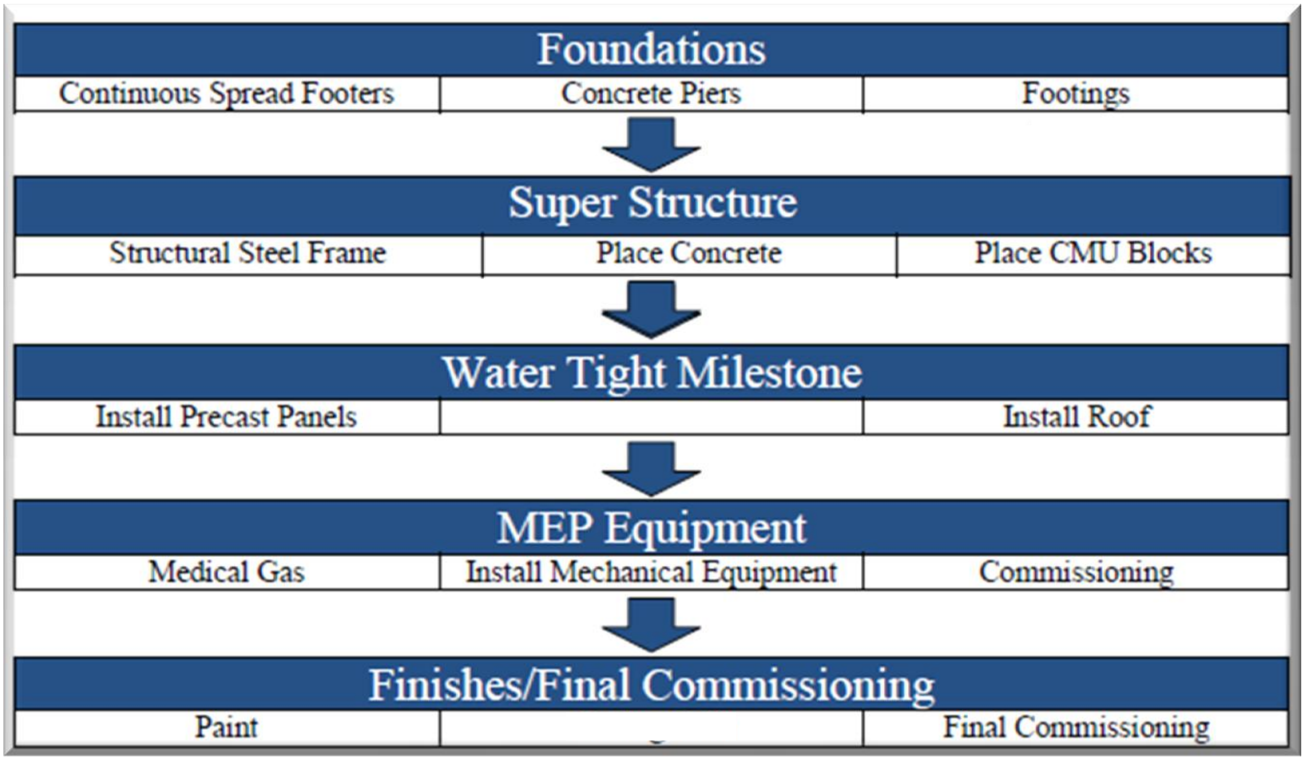


Figure 6: Critical Path Sequencing

and finish the project on time. Failure to hit their DOH occupancy date will result in massive congestion in the existing Williamsport Hospital and Medical Center. Moving patients from the existing hospital to the new expansion requires massive amounts of coordination with the hospital staff, the owners, and also the construction manager. It is critical that nothing delays the commissioning of the mechanical systems or hitting their water tight milestone. Commissioning is an extremely important and drawn out process for this particular project due impart because immune compromised patients will be entering the building as soon as it is being turned over. Unlike commissioning done on other project, there is a very small learning curve with hospitals. Failure for systems to work as designed can lead to prolonged illness or even death on such sensitive project as this. Allowing sufficient time for the building to dry out and test/balance the mechanical systems of each floor will prevent any type of spores, molds, or funguses to develop in the building. It is for these reasons and more that nothing delays the either the commissioning of the mechanical systems or the façade. The key to both of these being completed on time is sealing the building up and hitting the water tight milestone.

As addressed above, the biggest risk to the hospital not meeting its DOH occupancy date is the water tight milestone. Critical activities within the water tight milestone include delivery and installation of precast panels, window installation, metal panel installation, and curtain wall erection. Each precast panel was lifted directly off the truck and installed due to their sheer weight and size. Delivery coordination was a paramount concern for the construction team. Not hitting this critical milestone will result in delays to most if not all interior phases of construction. If interior trades started construction before the building was dry, the new addition would be a breeding ground for harmful bacteria. A delay to the interior trades such as the HVAC or medical gas contractor will then intern also delay the commissioning, testing, and balancing of each floor. Some of the challenges that L.F. Driscoll faced, when trying to achieve their goals include manpower allocation, sheet metal and metal panel deliveries, and severe weather. Of these three challenges, the sheet metal deliveries for the HVAC ducts proved to be the influential. Although this trade has nothing to do with the water tight milestone it does directly affect the commissioning. In addition to late deliveries this subcontractor also had insufficient manpower on the job to install it once it got to the job.

Project Acceleration Techniques

As previously stated in this report, one of the major schedule drivers were the mechanical trades. From the very beginning, L.F. Driscoll was concerned about the amount of manpower that this subcontractor could offer. To prevent this trade from delaying the other trades, L.F. Driscoll divided the building into two zones. Dividing the project in this fashion allowed other trades to work around them in the event that they fell behind. It also allowed the mechanical trades to maximize the manpower they had available at critical times. Although this didn't reduce the schedule it did allow for act as a failsafe in the event of a delay.

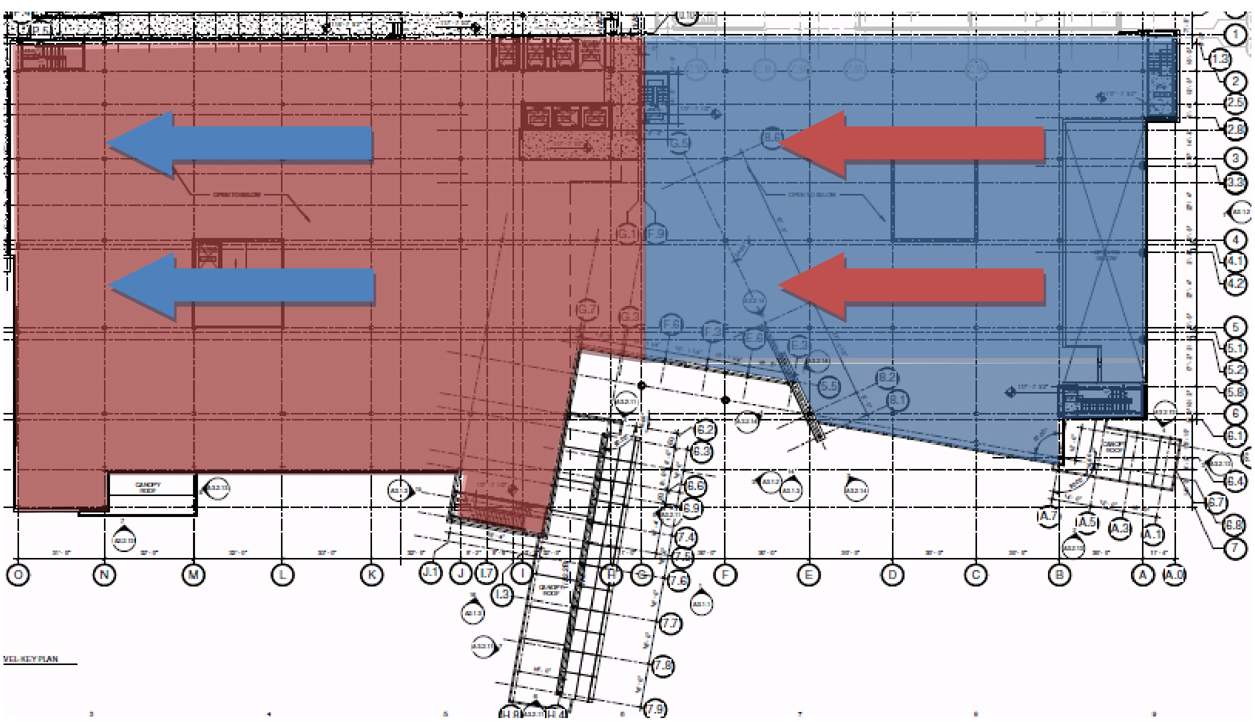


Figure 7: Steel Erection, Concrete, and Mechanical Sequence

To accelerate the schedule of the mechanical trades as well as other trades, the whole project team implemented BIM coordination. L.F. Driscoll even went so far as to hire a specialist in MEP coordination to run the entire BIM process. Although there aren't exact figures to determine the amount of time that was reduced from the schedule through the use of BIM, it was very apparent to the construction team that the savings were significant. After a brief interview with Walt Smith, the Senior Superintendent on the job, it was clear that the only way the mechanical trades could complete their work in time frame given was through the implementation of BIM. No stranger to hospital construction, Walt has worked on multiple hospital projects including the Children's Hospital of Pennsylvania. He said that this addition was one of the most difficult projects that he has ever encountered as far as MEP work is concerned. Walt also went on to say that this is the first project that he was ever on that used BIM and was surprised how much it helped. Even the project managers were surprised at the low number of RFI's and change orders that were submitted. Thinking about RFI's in the bigger picture, first the problem is identified in the field, the superintendent is notified, the superintendent then notifies the project manager who then intern has to submit it to the architect. This is a long drawn out process that was eliminated before it ever even became a problem. So far it is clear to the owners and construction team that the large upfront costs associated with BIM were well worth the reduction in change orders, schedule and RFI's.

The other schedule acceleration tactic was purposed by L.F. Driscoll was the use of a tower crane as opposed to mobile cranes. Using a tower crane would have accelerated the complete superstructure phase of construction as well as the installation of precast panels, AHUs on the roof, and the curtain wall. The stationary tower crane would have also eliminated the amount of time it took to move each mobile crane into place. However, the tower crane would have resulted in a larger cost than the mobile cranes. The installation of a tower crane would have also required a material and man hoist to be installed. Between the costs of the crane and the man hoist, the owner decided that this roughly $350,000 increase in cost wasn't worth the time that it would have accelerated schedule.

Value Engineering

L.F. Driscoll performed very little value engineering on the Patient Tower Expansion project. However, the value engineering that they did performed originated from constructability issues and past experience. The two design features that L.F. Driscoll decided to value engineer where the windows and the vapor barriers.

When issued, the original drawings specified that an in place stick built windows were to be constructed throughout the building. However, these windows have very poor performance and it has been L.F. Driscoll's experience that for projects of this magnitude a more robust window is needed. It has also been their past experience that the windows originally called out in the drawings and specifications leak and have poor thermal properties. The original windows cost $267,700 and the total value for the new windows cost $281,286.00. This resulted in an increase in price of $13,586. The new windows did cost more but when Susquehanna realized how much of a better quality product they were getting they approved this change in design. One of the main goals of Susquehanna Health is build an energy efficient building that wastes as little energy as possible. Over the life of the building, the better insulated windows will save Susquehanna Health a significant amount of money in heating costs. This design change also resulted in achieving more LEED points. Even through the new windows fell short of their cost expectations they did exceed their LEED expectations. The window schedule was also able to be reduced by reduced by nine days through assembling much of the window off-site. This was also another key advantage that was gained by value engineering the windows.

The second design feature that was value engineered were the vapor barriers that are located in the precast panels. The design called for spray on vapor barriers however these barriers present constructability issues that were brought to the construction management team's attention during mockup construction. These particular vapor barriers cannot be installed with the insulation called out in the specifications. In addition to the vapor barrier and insulation not working well together, another constructability issue arose when it was determined that the 1" foam insulation board would have to be installed after the spray on vapor barrier was installed on the precast wall. However, this poses a problem because there isn't enough room to install the insulation. This area is circled in ***Figure 8***.

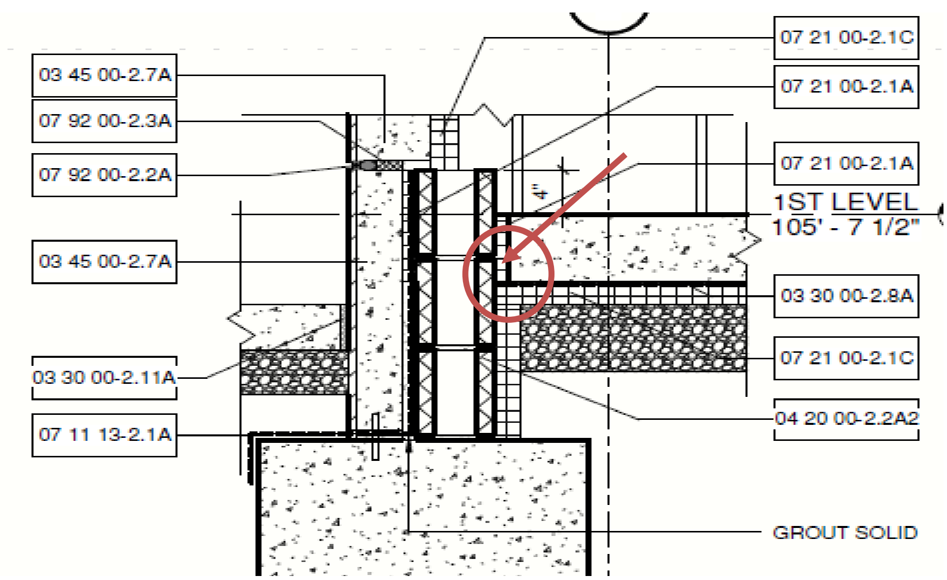


Figure 8: Typical Precast to Slab Detail
Figure Provided By L.F. Driscoll

What Granary Associates didn't take into account was that the joints can't be installed between the slab edge and the precast panel after the insulation was installed. The solution that L.F. Driscoll proposed was to switch the spray on vapor barrier to the more traditional plastic vapor barrier. Even before these constructability issues arose L.F. Driscoll was considering value engineering the spray on vapor barriers due to their complexity and cost. The original cost of the spray on vapor barriers totaled $52,296. The cost of the traditional vapor was much less and only came to $44,265 resulting in a credit back to the owner of $8,031. This credit back made the owner happy and didn't take away from any of the goals established at the beginning of the project.

Problem Identification

Site Logistic Issues

Due to the complex nature of the site logistics plan certain compromises had to be made between L.F. Driscoll and the owner. One of these compromises includes closing of Walnut St. to allow for material lay down and crane placement. This intern altered the traffic patterns congesting some of the surrounding streets with public, ambulance, and construction traffic. The emergency department relocation also caused some site logistic issues as well as altering the ambulance traffic.

Strict Seismic Requirements

As stated in previous technical assignments, strict seismic requirements forced the structural engineer to increase the beam sizes and number of steel beams in seismic sensitive areas. Neurosurgery operating rooms located on the 4th level of this project are where the primary seismic sensitive areas. These areas also require full penetration welds which take more time than other welds. There is also a section of beams and girders that run north and south that are designed in the same fashion. These beams and girders are located on every floor. The connections on the west side of this section require full slip bearing connections which were also problematic to the construction team.

Water Tight Milestone

The water tight milestone was one of the biggest risks to the schedule. Hitting this milestone was critical however little was done to accelerate the schedule make sure that it happened. This was identified as a problem due to the many different types of facades that are incorporated into the design. The façade of the Patient Tower Expansion is comprised precast panels, windows, curtain walls, ribbon glass, metal panels, and CMUs. The coordination of all these trades was a difficult task. Accelerating the schedule either before or during these activities would lock in this milestone.

Schedule Acceleration to Quicker Commissioning

In addition to the water tight milestone, commissioning was also considered another major risk to the schedule. This long and drawn out process happens at the completion of each floor. Before the building could be fully turned over, final commissioning of the whole building had to take occur. Not hitting this date could would lead to serious delays. Because this activity happens at the completion of each floor and at the end of the project, nothing could be done afterwards to fix the schedule.

LEED Certification

LEED Certification for Healthcare was a goal of the owner from the very beginning of the project. However, due to the large costs associated with becoming LEED certified, the owner decided to reinvest that money back into the building. This building is designed to be LEED certified but will never officially become LEED certified. This building incorporates some LEED features that could have been pursued more thoroughly if the building was going to receive the official LEED seal. The power source and mechanical systems where the only LEED features that were fully pursued.

HVAC Trade Schedule Problems

The HVAC trades caused major problems and frustration for the construction management team. In particular the sheet metal subcontractor caused the most delays on this project. Deliveries and the small workforce that they had available to them caused major delays that resounded throughout the entire project. Delaying the HVAC installation also delayed the commissioning for each floor. Once the ductwork and other HVAC equipment finally did reach the project it laid on each floor until installed. This caused major congestion for all other trades working inside the building.

Technical Analysis Methods

Technical Analysis Method: Site Logistic Issues

Because hospitals are extremely busy areas the site logistics proved to be quite challenging for the construction team. One of the biggest problems proved to be the traffic patterns between public, construction, and ambulance traffic. The closing of Walnut St. directly affected the traffic patterns and congested the area around the construction gate located on the western side of the site. Walnut St. was closed primarily because the mobile crane wasn't able to pick the precast panels over the steel structure already in place. To solve this problem a tower crane could be implemented and Walnut St. could be left open for the ambulance traffic going to the emergency department. This solution will also require a man hoist which also alters the site logistics plan. Safety and manpower research will be needed to establish if the man hoist is adding any site logistical problems. Another solution could be relocating the temporary emergency department to the north eastern corner of the Williamsport Hospital and Medical Center. To analyze these possible solutions an in-depth site logistics plan would have to be developed. Additional research would be needed to fist establish the volume of traffic that was flowing through each of the critical choke points around the building. Construction deliveries would also need to be mapped out for each phase of construction. Knowing the pattern and frequency of the construction deliveries will also help to develop a more effective plan.

Relocating the emergency department would eliminate some of the congestion around the eastern side of the building allowing construction deliveries to flow in and out more effectively. The mechanical and electrical loads of the new emergency room would have to be calculated to see if the existing building could handle the loads in the new location.

Technical Analysis Method: Strict Seismic Requirements

Strict seismic requirements for the neurosurgery rooms caused additional beams to be increased in size. These requirements then intern lead to an increase in cost and schedule for the entire project. Moving these rooms down to the ground level will reduce the seismic vibration and allow for the steel to be reduced. Cost comparisons will then be done to see how much reducing the steel will save the project. A structural analysis for the section being examined will have to be done to ensure that the structural integrity will be preserved. An architectural analysis will also have to be done on the first floor to see if this design change is acceptable. The owner, architect, and structural engineer will all have to be interview to establish if this design change meets their expectations and goals.

A section of the building in the center also contains beams and girders moving north and south that are seismically designed with slip bearing connections. These connections take more time than a normal bolted connection. Switching these connections to a bolted connection will reduce the schedule and reduce the cost of the project. A structural analysis of this section will have to also be done ensure the structural integrity wasn't compromised.

Technical Analysis Method: Water Tight Milestone

The biggest risk to the schedule of this project is not hitting the water tight milestone. Possible solutions to this problem include either accelerating the schedule before or during the construction of the façade. Possible solutions to accelerate the schedule and ensure this critical milestone include adding an extra crane to the project and simplifying the façade. Adding an extra crane to the project will significantly accelerate the superstructure schedule which will then intern lead to earlier start dates for the various facades. Additional research that will have to be conducted include how many pieces of steel the crew could set a day, the cost of each crew per day/week, and the cost of the extra crane rental. After this research has been done, the total cost increase and schedule reduction can be calculated.

Simplifying the façade could also accelerate the schedule for the water tight milestone. The research that will first be needed is the duration for each of the different facades. One façade that will be looked in-depth is the metal panels installed towards the top of the south face of the building. This trade was particularly difficult to manage due to bad material deliveries. If a façade change is incorporated into the design, structural analysis will have to be done as well as an architectural analysis.

Technical Analysis Method: Schedule Acceleration to Quicker Commissioning

As previously stated in the section above commissioning was one of the major activities on the critical path. After each floor is completed commissioning is done. Speeding up the interior of building will allow more time for commissioning. During the 2010 PACE Roundtable Conference Professor Bechtel brought up how a hospital used pre-constructed typical patient rooms to accelerate the schedule. Utilizing this concept could be used for this project because there are quite a few typical patient rooms. Research of the hospital project mentioned by Professor Bechtel will be needed to compare it with the Patient Tower Expansion. From this comparison the amount of time that can be reduced from the schedule can be estimated. A structural analysis will have to be done on a typical bay of the project to ensure that no additional load is being added and if so if it falls within an acceptable range.

Technical Analysis Method: LEED Certification

As addressed in **Technical Assignment 1** this project incorporates four different roofs. However, only three out of the four roofs are designed to be green roofs. One thesis analysis includes determining if the fourth roof not designed to be a green roof could be converted into a green roof. A structural analysis would have to be done to determine if this last roof could take the additional load. Additional information that would have to be collected would be reasons why the last roof wasn't designed to be a green roof. This information would have to come from the owner and the architect.

Technical Analysis Method: HVAC Trade Schedule Problems

Major delays were incurred by the mechanical trades on this project due to poor deliveries and lack of manpower. Possible ways to correct these problems is to prefabricate major assemblies so that as soon as they are delivered it can be installed immediately. This will also solve the problem of vast amounts of HVAC equipment cluttering the interior of the building and delaying the other interior trades. The mechanical equipment could also then be tested and balanced before even reaching the site. L.F. Driscoll is currently doing another hospital project at the Hershey Medical Center that is employing the same concept and is projected to save them time on their schedule.